SUBSEA 7 LIMITED
HYWIND SCOTLAND PILOT PARK PROJECT
ASSESSMENT OF 2ND PASS KP4.612 – KP11.350

Project	Hywind Scotland Pilot Park Project	**Positioning**	Starfix G2+/HP DGNSS (surface) HiPAP500 (subsea)
Subject	Assessment of 2nd Pass KP4.612 – KP11.350	**Date**	29/08/2017
Originator	S. MacCoinneach	**FSSL Doc Ref**	FSSL-150499-Assessment of 2nd Pass KP4.612 – KP11.350
Client Company	Subsea 7 Limited	**SS7 Doc Ref**	-
Representative	L. Morrice & P. Linden Frost	**Revision**	01
Issued from	TSV Fugro Saltire	**Geodesy**	WGS84, UTM30N, LAT

1. SUMMARY

The area considered in this memo is between KP4.612, which is the end of Boulder Area 7 (see *Field Memo FSSL-150499-Boulder Areas 6 and 7 Rev0*), up to KP11.350 which is the start of the target DOL being met with reasonable consistency.

This memo outlines the challenges that will be faced by returning to this area to conduct a 2nd pass of burial in an attempt to improve DOL and considers the soil and seabed conditions experienced to date, the tool arrangement as well as the opportunity to generate slack.

2. SOIL & SEABED CONDITIONS

The soil and seabed conditions between KP4.612 and KP11.350 are very challenging for burial operations; numerous surface boulders were identified in the burial corridor from the pre-trench survey as well as numerous sub-surface obstructions encountered during burial operations.

See Section 6 for a list of the surface boulders identified in the Pre-Trench Survey.

Sub-surface obstructions are identified during burial operations, these are possible to identify from the feedback received from the Q1400 cutting tool. The trenching operators will see a spike in pressure in the cutting tool, the cutting tool will then stall at 350 Bar. These stalls are a direct result of sub-surface obstructions, Figure 1 shows the cutting tool pressure experienced between KP4.612 and KP11.350.

When this is compared with the cutting tool pressure experienced between KP14.000 and KP16.000 (see Figure 2), it can be seen that the number of sub-surface obstructions experienced by the cutting tool between KP4.612 and KP11.350 is considerable.

As you would expect, the DOL between KP14.000 and KP16.000 met the target of 0.5 m for the vast majority of the region. The target DOL between KP4.612 and KP11.350 was rarely met.

No change in the soil or seabed conditions will be observed during a 2nd pass of this area and a similar result to the 1st pass of burial operations is highly likely.

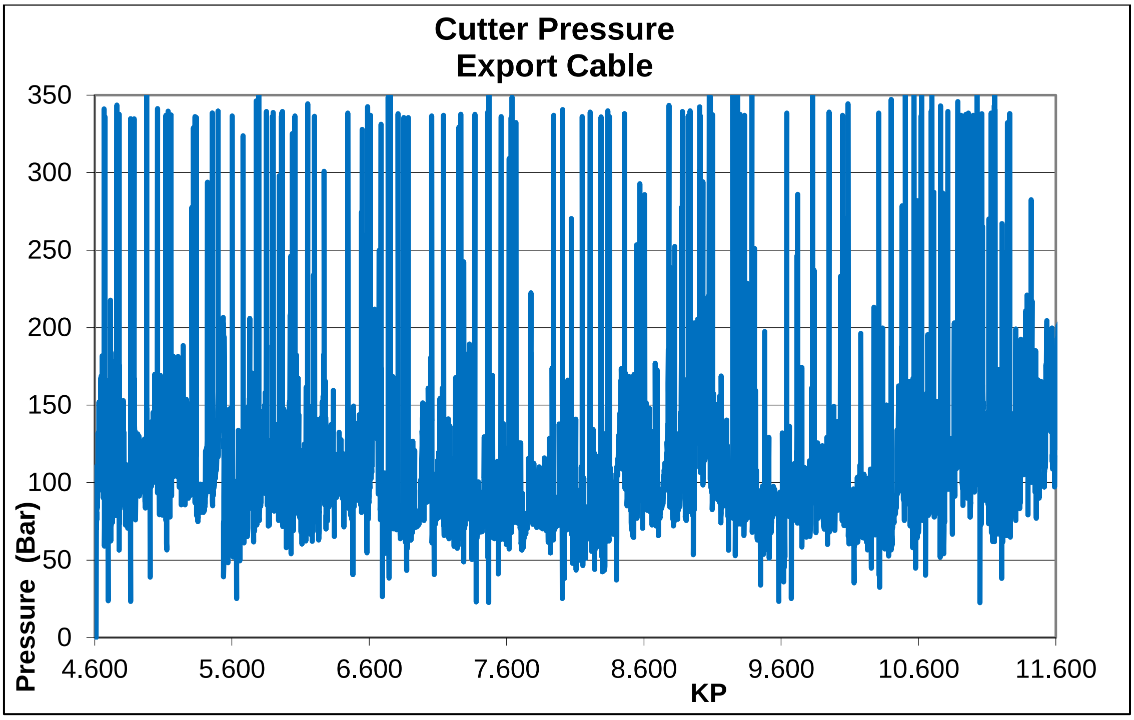

Figure 1: Cutting Tool Pressure KP4.600 - KP11.350

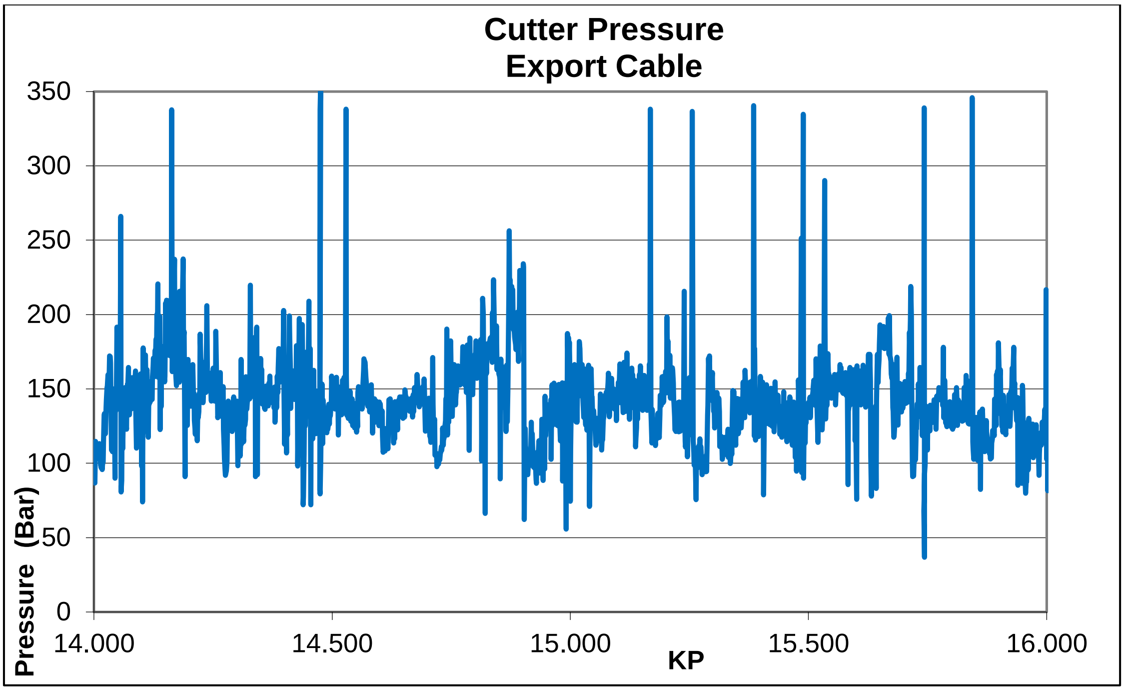

Figure 2: Cutting Tool Pressure KP14.000 - KP16.000

3. CUTTING CONFIGURATION

FSSL carried out trials in 2013 with the intention of comparing the efficiency of the Cutting Tool in the current 'scoop' arrangement against the hybrid 'scoop/pick' arrangement. The purpose of the trial was to determine the most efficient tool arrangement as well as to determine the tool arrangement which was most capable of dealing with sub-surface obstructions i.e the tool which suffered least chain stalls.

A description of the trial locations can be seen below in Figure 3, it can be seen that locations D and H East were trialled with both the scoop arrangement and hybrid pick/scoop arrangement. Both locations showed frequent surface boulders with high strength clay.

No	Route	Distance [m]	Comment	Chain Type	Average Trenching Speed [m/h]		Expected Clay Undrained Shear Strength [kPa]		Expected Boulder/debris < 1 m density	# Chain Stalls per 100 m route length
					excl. stops	incl. stops	min	max		
1	D	290	Straight route with turn at the end of route	Scoops	87	68	100	200	frequent	7.6
2	E	290	Straight route with turn at the end of route	Scoops	90	77	110	150	occasional	2.4
3	H West	412	Bi-linear route. Located inside scarplough remediated area incl. crossover	Hybrid	128	100	100	125	frequent	4.4
4	H East	310	Bi-linear	Hybrid	103	75	100	125	frequent	7.7
5	D South	180	Straight route with turn at the end	Hybrid	35	33	100	200	frequent	18.3
6	I	304	Circular route	Scoops	91	72	unknown	unknown	occasional	2.0
7	H East	179	Bi-linear	Scoops	117	95	100	125	frequent	7.3
8	K	149	Straight route with turn at the end of route	Scoops	59	50	150	150	occasional	6.0

Figure 3: Trial Locations

A comparison between these two areas is summarised below in Figure 4, it can be seen that the scoop arrangement performed better in terms of speed of operation in both locations. The pick/scoop hybrid tool had on average twice as many stalls in Location D, indicating a higher susceptibility to sub-surface obstructions. No significant difference between the number of chain stalls experienced in Location H can be seen between the two arrangements.

	Trial Locations	Scoop	Pick Hybrid
Average speed [m/h]	D	87	35
	H	117	103
Chain stall average distance [m]	D	10	5
	H	13	12

Figure 4: Comparison between Scoops and Pick Hybrid

In summary, the trials conducted show that the current scoop arrangement is the most efficient option for the Q1400 cutting tool both in terms of speed of operations and ability to manage sub-surface obstructions.

4. CABLE SLACK GENERATION

Slack is required in order to be able to lower the depressor during burial operations. The trenching team utilise opportunities to generate slack where possible, this is generally during an alter course where the trencher is able to cut the corner, thereby generating slack in order to lower the depressor. See Figure 5 below showing an example of an opportunity to generate slack during the export route, the annotated trencher path is exaggerated to illustrate the intention of the operation.

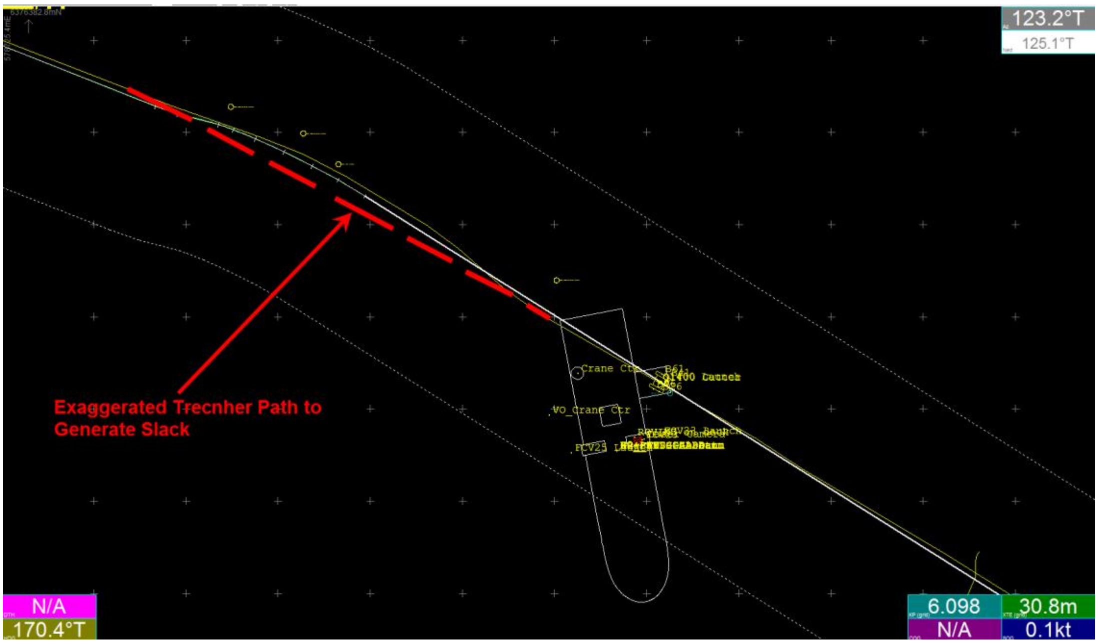

Figure 5: Trencher Generating Slack on Export Route

A concern of returning to KP4.612 to conduct a 2nd pass of up to KP11.350 is that there will be very little slack in the cable in order to load the cable initially and then be able to lower the depressor. The Q1400 will have used all available slack during the 1st pass.

It is likely that very little slack will be available to the Q1400 during a 2nd pass of trenching.

5. CONCLUSIONS

In conclusion, it is believed that the soil and seabed conditions experienced on site to date between KP4.612 and KP11.350 would indicate that there is very little chance of achieving the specified or improved DOL.

The current tool arrangement using scoops is the most efficient arrangement available to FSSL.

It is also believed that there will be little opportunity to generate slack during a 2nd pass of trenching meaning that the Q1400 will struggle to lower the depressor during operations.

Returning to conduct a 2nd pass would also introduce an increased risk to the cable due to the increased handling required and the potential for unloading the cable onto boulders which would require ROV intervention to resolve.

6. SURFACE BOULDERS IDENTIFIED

Boulder	KP	DCC	Approx. Size (LxWxH)	Comment
1.	4.667	-0.92	0.64 x 0.70 x 0.42	Boulder
2.	4.762	1.94	0.99 x 0.91 x 0.23	Boulder
3.	4.908	-2.26	0.98 x 0.58 x 0.30	Boulder
4.	4.966	0.03	0.71 x 0.38 x 0.15	Boulder
5.	5.210	-0.34	0.43 x 0.67 x 0.18	Boulder
6.	5.702	-4.59	0.55 x 0.66 x 0.36	Boulder
7.	5.865	-3.35	0.62 x 0.91 x 0.43	Boulder
8.	5.950	-4.96	0.40 x 0.77 x 0.27	Boulder
9.	5.964	0.99	0.79 x 0.80 x 0.29	Boulder
10.	5.991	-5.12	0.81 x 0.37 x 0.18	Boulder
11.	6.031	4.75	1.53 x 1.26 x 0.75	Boulders
12.	6.103	1.47	0.57 x 0.46 x 0.48	Boulder
13.	6.465	-0.41	0.86 x 0.52 x 0.38	Boulder
14.	6.468	-3.67	0.58 x 0.49 x 0.35	Boulder
15.	6.655	1.22	0.61 x 0.70 x 0.26	Boulder
16.	6.708	-3.72	0.82 x 0.55 x 0.31	Boulder
17.	6.712	-1.13	0.81 x 0.64 x 0.45	Boulder
18.	6.749	1.87	0.91 x 0.85 x 0.29	Boulder
19.	6.755	3.01	0.91 x 0.67 x 0.49	Boulder
20.	6.802	1.45	1.27 x 0.91 x 0.56	Boulder
21.	6.841	4.77	0.94 x 0.54 x 0.30	Boulder
22.	6.853	-0.44	0.38 x 0.35 x 0.28	Boulder
23.	6.869	-1.96	0.81 x 0.40 x 0.26	Boulder
24.	7.315	-4.21	0.76 x 0.87 x 0.18	Boulder
25.	7.368	-0.87	0.74 x 0.38 x 0.24	Boulder
26.	7.482	-1.64	21.71	Start of Boulder Field
27.	7.501	-1.77	21.71	End of Boulder Field
28.	7.550	-1.81	0.77 x 0.86 x 0.29	Boulder
29.	7.572	-3.85	0.68 x 0.68 x 0.26	Boulder
30.	7.594	-6.74	1.00 x 0.63 x 0.25	Boulder
31.	7.618	-4.89	1.07 x 0.81 x 0.39	Boulder
32.	7.637	-2.41	0.56 x 0.33 x 0.20	Boulder
33.	7.682	-1.29	0.79 x 0.56 x 0.58	Boulder
34.	7.689	-1.39	27.01	Start of Boulder Field
35.	7.716	-1.42	27.01	End of Boulder Field
36.	7.877	3.13	0.53 x 0.63 x 0.37	Boulder
37.	7.905	-0.56	0.67 x 0.58 x 0.34	Boulder
38.	8.464	-1.64	0.60 x 0.36 x 0.14	Boulder
39.	8.493	-1.15	0.73 x 0.36 x 0.42	Boulder
40.	8.494	0.27	0.73 x 0.38 x 0.33	Boulder
41.	8.558	-1.36	0.61 x 0.63 x 0.18	Boulder
42.	8.596	-3.11	0.73 x 0.55 x 0.17	Boulder
43.	8.597	-1.84	0.75 x 0.50 x 0.17	Boulder
44.	8.610	-2.49	0.90 x 0.77 x 0.30	Boulder
45.	8.799	-0.05	0.68 x 0.22 x 0.32	Boulder
46.	8.910	-4.87	0.89 x 0.58 x 0.41	Boulder
47.	8.914	-1.37	0.65 x 0.44 x 0.37	Boulder
48.	9.117	-2.57	0.90 x 0.63 x 0.33	Boulder
49.	9.131	-1.70	35.69	Start of Boulder Field
50.	9.167	-0.86	35.69	End of Boulder Field
51.	9.175	-2.43	1.04 x 1.04 x 0.32	Boulder
52.	9.292	-1.68	0.75 x 0.37 x 0.15	Boulder

53.	9.321	-0.83	0.59 x 0.35 x 0.25	Boulder
54.	9.520	-0.39	1.16 x 0.63 x 0.23	Boulder
55.	9.654	1.76	1.00 x 0.62 x 0.24	Boulder
56.	9.658	-0.98	0.63 x 0.48 x 0.38	Boulder
57.	9.666	-1.47	0.34 x 0.47 x 0.21	Boulder
58.	9.74	1.78	0.70 x 0.63 x 0.23	Boulder
59.	9.93	-4.13	0.71 x 0.48 x 0.29	Boulder
60.	9.95	-2.23	0.60 x 0.75 x 0.12	Boulder
61.	10.02	-4.26	0.90 x 0.83 x 0.46	Boulder
62.	10.06	-4.47	0.86 x 1.04 x 0.50	Boulder
63.	10.10	-5.76	0.83 x 0.89 x 0.58	Boulder
64.	10.15	-0.62	0.85 x 0.50 x 0.25	Boulder
65.	10.28	-4.77	0.48 x 0.63 x 0.23	Boulder
66.	10.37	2.38	0.64 x 0.70 x 0.30	Boulder
67.	10.39	-1.90	0.47 x 0.68 x 0.18	Boulder
68.	10.41	-3.33	0.63 x 0.69 x 0.30	Boulder
69.	10.41	0.15	0.37 x 0.44 x 0.23	Boulder
70.	10.42	-2.56	0.65 x 0.78 x 0.48	Boulder
71.	10.59	-1.50	0.47 x 0.47 x 0.20	Boulder
72.	10.63	-3.00	0.78 x 1.29 x 0.22	Boulder
73.	10.67	1.54	0.45 x 0.50 x 0.28	Boulder
74.	10.69	-1.53	30.56	Start of Boulder Field
75.	10.72	-1.96	30.56	End of Boulder Field
76.	10.80	-3.53	0.70 x 0.37 x 0.24	Boulder
77.	10.81	-3.88	0.64 x 0.75 x 0.37	Boulder
78.	10.95	2.80	0.64 x 0.63 x 0.28	Boulder
79.	11.00	2.28	0.72 x 1.20 x 0.42	Boulder
80.	11.02	3.71	1.15 x 0.78 x 0.33	Boulder

END OF DOCUMENT