2015

REPLACEMENT METALLIC RETURN CONDUCTORS CABLE BURIAL ASSESSMENT PLAN

Doc Ref: MRC-MIL-RPT-007

July 2015

08 July 2015

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1 INTRODUCTION

1.1 Background

The Moyle Interconnector consists of two separate 250 MW dual monopole HVDC links with integrated return conductor cables. It links the electricity grids of Northern Ireland and Great Britain through land and submarine cables running between converter stations at Ballycronan More in Islandmagee, County Antrim and Auchencrosh in Ayrshire, Scotland and is owned and operated by Moyle Interconnector Ltd (Moyle), a subsidiary of Mutual Energy Ltd.

Following a number of cable faults over the last five years on the low voltage (LV) metallic return component within these cables, a decision has been taken to lay two new Metallic Return Conductors (MRCs) – denoted North and South – to restore operation of the link to full capacity. These separate medium voltage cables will replace the existing metallic return element within the existing cables.

The MRCs are being manufactured, installed and commissioned by the Norwegian company Nexans. The cables, each with a length of approximately 54km, are of single core stranded copper design, XLPE insulation, with an outer layer of galvanised steel armour.

The installation will be performed using the cable laying vessel C/S Nexans Skagerrak in two campaigns with the North cable installation due to begin in August 2015. Whilst the North cable is being installed, the South cable will be manufactured, with installation scheduled to begin during October 2015.

The planned route of the MRCs follows the route of the existing cables between Currarie Port in Scotland and Port Muck in Northern Ireland, with the cables being installed within a 100 m wide consented corridor to the south of the existing north cable and to the south of the existing south cable.

1.2 Licensing Introduction

The Moyle Interconnector crosses the jurisdictions of Northern Ireland and Scotland is thus obliged to consult with the licencing authorities for both regions.

Moyle Interconnector Limited has been issued the following licences from the Department of the Environment, Northern Ireland (DoE NI), Marine Division and Marine Scotland Licencing Operations Team (MS-LOT) respectively:

- Marine Construction Licence – Licence for Installation of two separate Metallic Return Conductors within Northern Ireland Inshore Region. Licence Number: 52/13; and
- Licence for Marine Cable Installation Works, Licence Number: 05401/15/0.

1.3 Purpose & Structure of Report

Both licences, amongst a number of conditions, require submission of a document to the licensing authorities to describe various aspects of the cable installation (termed a ‘Cable Burial Assessment

Plan' by DoE NI and a 'Cable Plan' by MS-LOT) at least 28 days prior to the commencement of cable lay operations. At the time of writing the laying of the north cable is scheduled to commence on 04 August 2015 and the laying of the south cable on the 18 October 2015.

The purpose of this document is to fulfil this condition of both licences and it has the following structure:

- **Section 2** details specific consent conditions from each licence and references the relevant section of this report which fulfils it.
- **Section 3** provides the required information including *inter alia*: location; cable laying techniques; details of the surveys works untaken and its effect on cable routing; burial risk assessment; post-lay survey methodology and programme; and reporting.

This document has been termed a 'Cable Burial Assessment Plan' in line with the terminology used in the DoE NI marine licence.

2 MARINE LICENCE CONDITIONS

The conditions of each marine licence which stipulate the requirement for the Cable Burial Assessment Plan (Cable Plan) are reproduced in **Table 2-1** and for ease of reference.

Table 2-1: Cable Burial Assessment Plan – Licence Requirement Conditions

Licensing Authority	Licence Ref.	Condition
DoE	Licence Number: 52/13, Condition No 16	The licensee(s) shall provide a **Cable Burial Assessment Plan** to the licensing authority for their written approval, at least **28 days** prior to the commencement of cable laying or by prior agreement with the licensing authority. In granting approval, the licensing authority may consult any such other advisors, stakeholders or organisations as may be required.
MS	Licence Number: 05401/15/0, Condition No 5	The licensee shall submit to the licensing authority for their written approval a cable plan (CaP) **at least 28 days** prior to the commencement of cable laying operations, or later subject to the prior written agreement of the licensing authority. In granting such approval, the licensing authority may consult any such other advisors, organisations or stakeholders as may be required at their discretion. The CaP shall be in accordance with the application and supporting information. No works shall commence prior to the granting of such written approval.

In addition the content of the Cable Burial Assessment Plan is specified in each licence. Condition 17 of the DoE marine licence stipulates the required content of the Cable Burial Assessment Plan. **Table 2-2** reproduces each requirement and cross-references the location within this document where the required information is provided.

Likewise Condition 6 of the MS marine licence performs the same function for the MS marine licence. See **Table 2-3**.

Table 2-2: DoE Marine Licence, Condition 17 – Requirements

Condition Ref.	Requirement	Location Provided
17a	Details of the location and cable laying techniques for the cable.	Section 3.1 and 3.2
17b	Estimates of the quantity and type of material to be deposited during the cable laying operations.	Section 3.4
17c	Reports of geophysical survey work, which will help inform cable routing.	Section 3.3
17d	A burial risk assessment to ascertain if target burial depths can be achieved, as set out in the supporting information provided to the licensing authority. In locations where this is not possible then suitable protection measures shall be provided in line with industry best practice and guildlines. The Crown Estate FLOWW guildlines should also be followed, where applicable.	Section 3.3 & 3.4
17e	A method statement including: - Risk-based post lay survey programmes, to ensure safety of navigation and other legitimate uses of the sea, and with particular relevance to fishing activity; - Measures to ensure that snagging of the fishing gear does not occur in areas of cable protection. The licensing authority may request additional surveys and/or trails to demonstrate the adequacy of mitigation against snagging;	Section 3.5

	snagging; - Survey methodologies to address the post lay cable inspection requirement of any cable sections along the route to include buried and unburied sections and also crossings; and - The frequency, timing, scope and details of the reporting timescales and reporting format or post lay cable surveys, to be agreed with the licencing authority. The requirement for further surveys will be agreed with the licensing authority and any such advisors the licensing authority may decide, at their discretion.	

Table 2-3: MS Marine Licence, Condition 6 – Requirements

Condition Ref.	Requirement	Location Provided
6a	Details of the location and cable laying techniques for the cable	Section 3.1 & 3.2
6b	Reports of geophysical survey work, which will help inform cable routing.	Section 3.3
6c	A burial risk assessment to ascertain if burial depths can be achieved. In locations where this is not possible then suitable protection measures shall be provided in line with best industry practices and guidelines and with reference to Crown Estate FLOWW guidelines where they appropriately apply.	Section 3.3 & 3.4
6d	Methods, including risk-based post survey programme, to be taken to ensure safety of navigation and other legitimate users of the sea, and with particular relevance to fishing activity, in line with industry best practice. Such methods shall include provision for post cable/lay/trenching sweeps using appropriately modified and tested fishing gear including scallop dredges and chain mats where advised by the licensing authority in consultation with the Scottish Fishermen's Federation (SFF) and Fishery Liaison Officer (FLO).	Section 3.5
6e	Survey methodologies to address the post lay cable inspection requirement of any cable sections along the entire route to include buried and unburied sections of the routes including crossings. Such methodologies shall detail the frequency (yet to be agreed with the licensing authority but it is recommended that these should be after six months and eighteen months following completion or part completion of the licensed cable laying works), timing, scope and details of the reporting timescales and format. The requirement for further surveys beyond eighteen months will be agreed following discussions between the licensing authority, MIL [Moyle Interconnector Limited] and any such advisors the licensing authority may decide at their discretion.	Section 3.5

3 REQUESTED INFORMATION

3.1 Location

The Route Position Lists (RPLs) for the North and South replacement MRC cables are still being finalised and will not be available until immediately prior to the commencement of installation works. This is to take account of final micro-routing adjustments that need to take into account detailed interpretation of the pre-installation survey results. In addition the final as-laid RPLs will be provided after completion of the post-trenching route surveys.

However, the consented corridors extend from the existing assets to 100 m south of each asset and there are a number of fixed points, including the landfalls and offshore crossing locations, which the two replacement MRCs will be required to pass through. An overview of the existing assets, the consented installation corridors and the fixed reference points is provided in **Figure 3-1** and the coordinates of each reference point for the North Cable route and South Cable route are provided in **Table 3-1** and **Table 3-2** respectively.

Table 3-1: North Cable Route Reference Points

ID	Easting	Northing	LAT_DDdd	LON_DDdd	LAT_DMmm	LON_DMmm	LAT_DMS	LON_DMS	Depth	KP	CableName	Comment
1	369521.432	6103432.174	55.05932	-5.042794	55° 3.559056	-5° 2.567640	55° 3' 33.543"	-5° 2' 34.058"	0.00	0.146	Moyle_2015_1_7_A	LP Scotland
2	368329.782	6103796.275	55.06227	-5.061605	55° 3.736377	-5° 3.696321	55° 3' 44.183"	-5° 3' 41.779"	-22.00	1.395	Moyle_2015_1_7_A	22 m Scotland
3	356281.20	6103322.18	55.05468	-5.24986	55°3.28054	-5°14.99177	55°3'16.83227"	-5°14'59.5064"	-68.77	13.476	Moyle_2015_1_7_A	In Service Cable Crossing Lanis
4	338659.20	6091338.68	54.94169	-5.51869	54°56.50161	-5°31.12158	54°56'30.09649"	-5°31'7.29464"	-145.37	35.344	Moyle_2015_1_7_A	In Service Cable Crossing Hibernia
5	337204.10	6090113.02	54.93021	-5.54069	54°55.81284	-5°32.44128	54°55'48.77061"	-5°32'26.47699"	-151.00	37.253	Moyle_2015_1_7_A	Planned Cable Crossing Western Link
6	334873.30	6088618.87	54.91601	-5.57615	54°54.96082	-5°34.5687	54°54'57.64926"	-5°34'34.12228"	-145.04	40.049	Moyle_2015_1_7_A	In Service Cable Crossing Sirius
7	330647.025	6086436.138	54.89503	-5.64073	54°53.70164	-5°38.44439	54°53'42.098"	-5°38'26.663"	-120.63	45.149	Moyle_2015_1_7_A	In Service Pipeline Crossing SNIP
8	325960.996	6081098.822	54.84551	-5.710501	54° 50.730566	-5° 42.63008	54° 50' 43.834"	-5° 42' 37.805"	-22.00	52.79	Moyle_2015_1_7_A	22 m Ireland
9	325316.776	6081249.564	54.84664	-5.7206129	54° 50.798296	-5° 43.23678	54° 50' 47.898"	-5° 43' 14.207"	0.00	53.485	Moyle_2015_1_7_A	LP Ireland

Easting and northing Coordinates in ED50 UTM 30N

GCS Coordinates in European Datum 1950

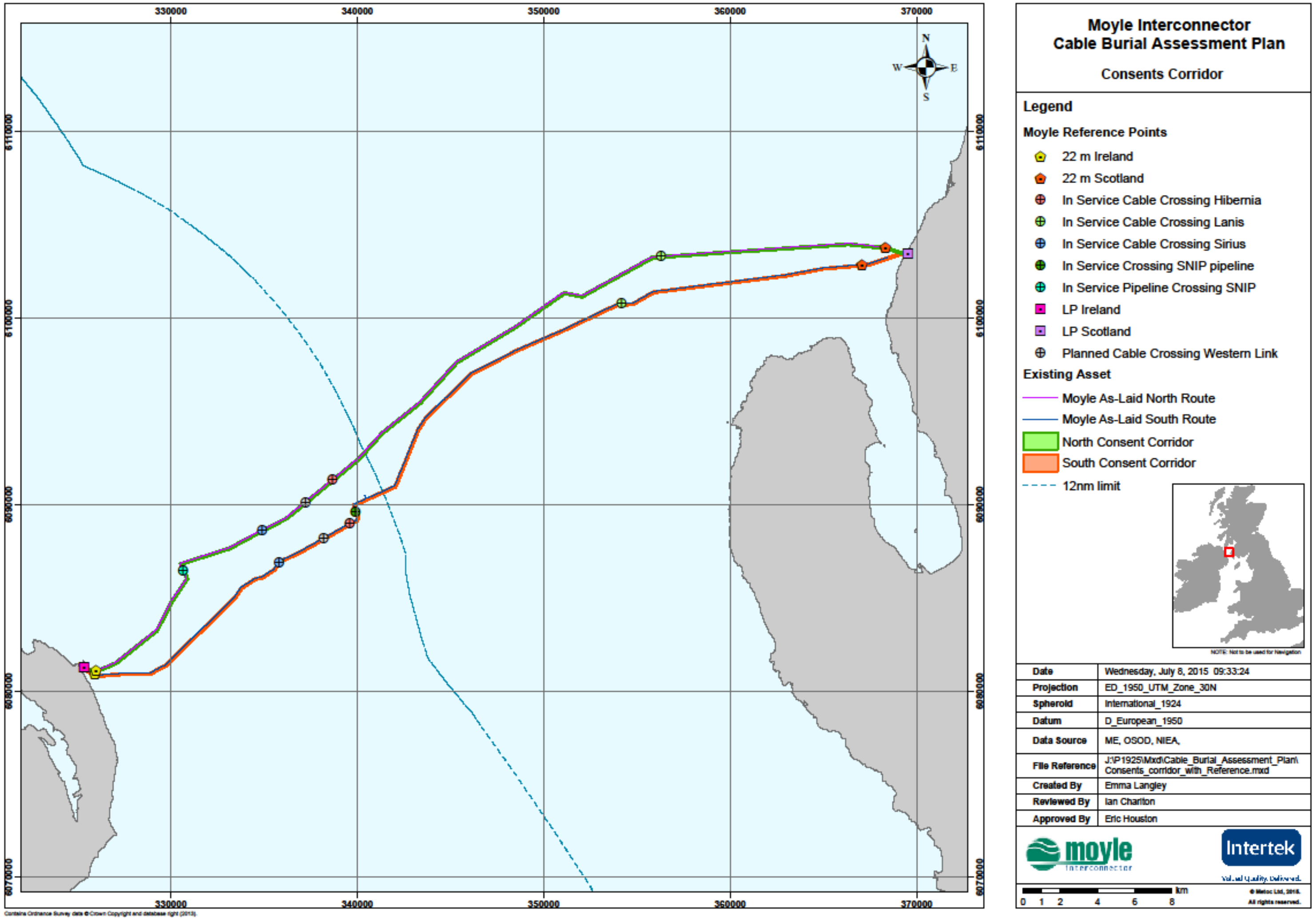
Table 3-2: South Cable Route Reference Points

ID	Easting	Northing	LAT_DDdd	LON_DDdd	LAT_DMmm	LON_DMmm	LAT_DMS	LON_DMS	Depth	KP	CableName	Comment
1	369521.304	6103430.198	55.05929982	-5.042795	55° 3.557989	-5° 2.56771	55° 3' 33.479"	-5° 2' 34.062"	0.00	0.149	Moyle_2015_2_8_A	LP Scotland
2	367075.93	6102838.12	54.84363515	-5.7110191	54° 50.61811	-5° 42.6612	54° 50' 37.087"	-5° 42' 39.669"	-22.00	2.713	Moyle_2015_2_8_A	22 m Scotland
3	354166.513	6100760.028	55.031056	-5.281627	55° 1.863	-5° 16.898	55° 1' 51.802"	-5° 16' 53.856"	-62.62	15.904	Moyle_2015_2_8_A	In Service Cable Crossing Lanis
4	339891.628	6089608.365	54.926570	-5.498526	54° 55.594	-5° 29.912	54° 55' 35.653"	-5° 29' 54.695"	-144.07	35.377	Moyle_2015_2_8_A	In Service Crossing SNIP pipeline
5	339580.362	6088983.589	54.920846	-5.503013	54° 55.251	-5° 30.181	54° 55' 15.044"	-5° 30' 10.846"	-142.46	36.338	Moyle_2015_2_8_A	In Service Cable Crossing Hibernia
6	338180.515	6088173.869	54.913123	-5.524375	54° 54.787	-5° 31.463	54° 54' 47.242"	-5° 31' 27.752"	-148.12	37.957	Moyle_2015_2_8_A	Planned Cable Crossing Western Link
7	335798.245	6086904.369	54.900954	-5.560778	54° 54.057	-5° 33.647	54° 54' 3.435"	-5° 33' 38.802"	-147.70	40.664	Moyle_2015_2_8_A	In Service Cable Crossing Sirius
8	325919.681	6080891.616	54.84662258	-5.7206057	54° 50.79735	-5° 43.2363	54° 50' 47.841"	-5° 43' 14.180"	-22.00	52.879	Moyle_2015_2_8_A	22 m Ireland
9	325317.175	6081247.801	55.05333482	-5.0807765	55° 3.20009	-5° 4.84659	55° 3' 12.005"	-5° 4' 50.795"	0.00	53.585	Moyle_2015_2_8_A	LP Ireland

Easting and northing Coordinates in ED50 UTM 30N

GCS Coordinates in European Datum 1950

Figure 3-1: Location of North and South Cable Route Corridors



3.2 Installation Programme

The key dates for installation phases for the North and South cable are outlined below:

Table 3-3: Installation Programme

	Start	Finish
North cable		
Laying of North Cable	04 August 2015	12 August 2015
Diver operated protection post installation Scotland & Northern Ireland	12 August 2015	11 September 2015
Nearshore rock dumping (Split barge)	12 August 2015	22 August 2015
Protection CAPJET (Skagerrak)	12 August 2015	29 September 2015
Rock dumping fall pipe vessel	22 September 2015	29 October 2015
South cable		
Laying of South Cable	18 October 2015	26 October 2015
Diver operated protection post installation Scotland & Northern Ireland	26 October 2015	25 November 2015
Nearshore rock dumping (Split barge)	26 October 2015	05 November 2015
Protection CAPJET (Skagerrak)	27 October 2015	14 December 2015
Rock dumping fall pipe vessel	07 December 2015	13 January 2016

3.3 Cable Installation Methodology

A summary of the proposed MRC cable installation methodology is provided below. More detailed information is provided in the Contractor Burial Protection Assessment Plan provided in full in Appendix A.

Installation will begin with the North cable being pulled up to the transition jointing pit in Northern Ireland. This will be achieved by positioning the vessel close to shore and floating the cable towards the beach. Cast iron shells (CIS) shall be installed during floating of the cable. The cable will then be pulled up into the transition jointing pit once it has reached shore.

The transition arrangement for connecting the new MRC cable onto the land IRC cable shall consist of a buried and enclosed separation unit. Oil will be supplied to the separation unit to seal the insulated HVDC poles which run through the centre of the IRC cables. Oil shall be supplied to the separation unit via conduits from directly buried oil tanks. A small over-ground kiosk shall form part of the transition arrangement for maintenance and control purposes. This arrangement is reciprocated for both the North and South IRC cables at both onshore works site locations at Currarie Port in Scotland and Port Muck in Northern Ireland.

Following pull in, the cable will then be laid within a trench onshore and offshore installation will commence towards Scotland. Within 22 meters of water depth the cable will be installed within 4 meters of the existing MOYLE asset. The cable will then be laid across the sea and pulled into the jointing pit in Scotland for connection into the existing land IRC cable via the second transition jointing pit.

The cable laying vessel will then be used as a trenching vessel with the Nexans CAPJET trenching system used after the cable laying operation. The CAPJET will be employed at depths of greater than 22 meters. Each cable shall be buried to protect against anchor damage however the intended depth will differ across the route owing to the variances in geotechnical conditions across the route. The burial depth achieved during the original Moyle cable installation in 2002 will be given due consideration when determining burial depths between KPs (Kilometre Posts).

The CAPJET will be used for installation of protection works for the main cable length. The burial depth achievable across the route varies based on the findings of the geotechnical survey works. Trenching will be achieved by the front swords of the CAPJET with two separate systems (System A and System B) being used depending on burial depth requirements at different points on the route.

Alternative protection methods will be used as the cables approach landfall. Within 10 meters of water depth the cables shall be protected with cast iron shells and rock installation. Rock dumping is planned in areas where the cable cannot be trenched. The cables will be protected with a 0.6m high rock berm within 22 meters of water depth at both landfall sites and where burial cannot be achieved. Rock dumping will also be employed at the four asset crossings, one gas pipeline and three cable crossings.

The onshore installation of the North MRC cable is expected to be complete by November 2015 following completion of the North cable onshore transition joint at Currarie Port in Scotland. This will allow for the North cable to be commissioned, with the HVDC link operating as a single pole with a separate metallic return and return the Moyle Interconnector capacity to 500MW during the winter of 2015/16.

Once the North cable has been laid and trenched and whilst the North cable protection works is in progress, the C/S Skagerrak will then collect the South cable from Halden ready for the second installation and laying campaign followed by the trenching and protection in the same way as the North cable.

This will then allow for the South cable transition jointing works to proceed. The onshore installation of the South cable is expected to be complete by June 2016 following completion of the South cable onshore transition joint at Currarie Port in Scotland.

3.4 Survey Results & Route Development

3.4.1 Survey Works

Nexans contracted Gardline Geosurvey Ltd (Gardline) to perform a pre-installation geophysical survey on behalf of Moyle along two proposed cable route corridors parallel to the two existing cables running between landfalls at Currarie Bay, Scotland and Portmuck, Northern Ireland. The two cable survey routes were each an approximate length of 53km between Scotland and Northern Ireland.

The objective of the survey was to chart a hazard-free route for emplacement of the new cables with the aim that the cables are laid on the seabed or trenched close to the existing cables but avoid obstructions, debris and possible Unexploded Ordnance (UXO’s).

The route surveys were to comprise analogue geophysical surveys using multi beam echo sounder (MBES) single beam echo sounder (SBES), sub bottom profiler (SBP), side scan sonar (SSS) followed by a magnetometer survey to detect metalliferous targets. A third stage of the survey used an ROV to investigate visual targets at seabed to determine any UXOs, debris or obstructions close to the proposed route and to assist re-routing.

The surveys were undertaken by Gardline using the survey vessel, MV 'Ocean Reliance' for the offshore work programme and MV 'Titan Explorer' for the nearshore landfall surveys off Scotland and Northern Ireland.

The Titan Explorer mobilised Stranraer, Scotland 23 March 2015 and completed the nearshore survey off the Scotland-end landfall by 07 April allowing transfer to Carrickfergus Marina, Northern Ireland to commence the remaining section of nearshore survey. This was completed 16 April.

The Ocean Reliance was mobilised in Greenock, Scotland 01 April 2015 and commenced transit to site on 02 April. The survey works completed by 14 May 2015 when the vessel demobilised at Greenock.

The Survey Report is currently under development and will be provided as a separate document before commencement of installation works.

3.4.2 Route Development

The results from the offshore survey are being used in combination with the results from the installation of the original cable assets in 2001 to finalise the route of the replacement cables. However, for the majority of the route the metallic return conductors will need to be installed within 50 m of the existing asset on the north and south route respectively. Routing options are therefore restricted by the requirement to install the replacement cables in a limited pre-defined corridor adjacent to the existing cables. The 2015 survey data is however being used to inform final micro-routing of the MRCs within the consented corridor. The final RPL will take into account data for critical areas along the route, including the results of the magnetometer and UXO survey for the area to the north of Beaufort's Dyke and discrete areas where the 2015 survey data has provided additional data on seabed slope.

3.5 Cable Burial and Protection

3.5.1 Burial Assessment

The EPC contractor, Nexans has produced a Burial Protection Assessment Plan (Nexans 2015). The latest draft is provided in Appendix A. The cable burial protection values that Nexans will operate to under the contract are derived from minimum burial depths specified in the Employer's Requirements and informed by a separate cable burial risk assessment commissioned by Moyle (UTEC, 2014). These values are reproduced below in Table 3-4 and Table 3-5 for ease of reference.

Table 3-4: Minimum Burial Depth – Northern Cable

KP		Section Length (km)	Section ID	Minimum Burial Depth (m ToC*)
From	To			
0.00	0.275	0.275	1	0.4
0.275	1.025	0.75	2	0.4
1.025	2.40	1.375	3	0.6
2.40	2.525	0.125	4	0.6
2.525	3.05	0.525	5	0.6
3.05	3.80	0.75	6	0.6
3.80	4.90	1.10	7	0.6
4.90	5.45	0.55	8	0.6
5.45	5.60	0.15	9	0.6
5.60	5.75	0.15	10	0.6
5.75	6.90	1.15	11	0.6
6.90	7.20	0.30	12	0.6
7.20	11.00	3.80	13	1.5
11.00	12.10	1.10	14	0.6
12.10	15.50	3.40	15	0.6
15.50	19.50	4.00	16	0.4
19.50	20.50	1.00	17	0.4
20.50	21.25	0.75	18	0.4
21.25	24.00	2.75	19	0.4
24.00	24.50	0.50	20	0.4
24.50	29.50	5.00	21	0.4
29.50	31.00	1.50	22	0.4
31.00	31.85	0.85	23	0.4
31.85	32.85	0.40	24	0.4
32.25	34.00	1.75	25	0.4
34.00	34.75	0.75	26	0.4
34.75	39.4	4.65	27	0.6
39.4	40.4	1	28	0.4
40.4	45.4	5	29	0.6
45.4	46.1	0.7	30	0.4
46.1	48.5	2.4	31	0.6
48.5	51.35	2.85	32	1.0
51.35	52.6	1.25	33	1.0
52.6	53.3	0.7	34	1.0

*ToC = Top of Cable

Table 3-5: Minimum Burial Depth – Southern Cable Route

KP		Section Length (km)	Section ID	Minimum Burial Depth (m ToC*)
From	To			
0.00	0.28	0.28	1	0.6
0.28	0.50	0.22	2	0.6
0.50	0.70	0.20	3	0.6
0.70	0.90	0.20	4	0.6
0.90	1.08	0.18	5	0.6
1.08	1.35	0.27	6	0.6
1.35	1.92	0.57	7	0.6
1.92	2.40	0.48	8	0.6
2.40	4.40	2.00	9	0.6
4.40	6.75	2.35	10	0.6
6.75	8.00	1.25	11	0.6
8.00	10.00	2.00	12	1.2
10.00	11.20	1.20	13	1.2
11.20	12.30	1.10	14	0.6
12.30	17.00	4.70	15	0.6
17.00	19.75	2.75	16	0.4
19.75	20.75	1.00	17	0.6
20.75	23.25	2.50	18	0.6
23.25	23.80	0.55	19	0.6
23.80	26.00	2.20	20	0.4
26.00	28.25	2.25	21	0.4
28.25	28.60	0.35	22	0.4
28.60	29.50	0.90	23	0.3
29.50	30.10	0.60	24	0.4
30.10	30.60	0.50	25	0.4
30.60	36.10	5.50	26	0.3
36.10	36.90	0.80	27	0.4
36.90	40.75	3.85	28	0.6
40.75	45.75	5.00	29	0.4
45.75	46.75	1.00	30	0.4
46.75	48.00	1.25	31	0.4
48.00	50.40	2.40	32	0.4
50.40	51.50	1.10	33	1.5
51.50	52.10	0.60	34	1.5
52.10	52.75	0.65	35	1.5

*ToC = Top of Cable

Using the minimum burial depths as a basis for protection Nexans are currently working with Moyle to define Combined Protection Requirements which will be the lesser of the minimum values specified in Table 3-4 and Table 3-5 for for the achieved burial results of the 2001 installation of the existing cables at each route section.

Where the minimum burial depths cannot be achieved the Combined Protection Requirements will be met with remedial protection. The Burial Protection Assessment Plan (Nexans 2015 – Appendix A) specifies the agreed Combined Protection Requirements and installation methods to be deployed to achieve the remedial protection level required along each section of the route.

Section **3.5.2** provides summary details of the installation methods to be deployed to achieve the remedial protection level and the expected location and quantities of rock to be deposited on the cable.

3.5.2 Remedial Protection Techniques

Where minimum burial depths cannot be achieved the following remedial protection methods will be deployed.

0 – 10 m Water Depth: Cast Iron Shells

From 0 m water depth to 10 m water depth a 120 mm ID Cast Iron Shell (CIS) will be used on both cables. The CISs will protect the cables and give extra stability in highly turbulent nearshore areas due to the increased weight. See **Figure 3-2** for example of technique.

Figure 3-2: Cast Iron Shells Enclosing a Cable

5 – 10 m Water Depth: Split Barge

From 5 – 10 m water, where remedial protection is required, rock installation will be performed with a splitbarge system in combination with a small tug. The tug is used for survey and to assist in control of the bow during the installation. When loaded the split barge has a draught of approximately 3 m loaded. See **Figure 3-3** for an example of a split barge in operation.

Figure 3-3: Split Barge in Operation

Deeper than 10 m Water Depth: Fallpipe Vessel

For all rock installation deeper than 10 m a fallpipe vessel is planned. It is likely the vessel Rockpiper (see **Figure 3-4**) will be deployed although the vessel Seahorse is an alternative.

Figure 3-4: Fallpipe Vessel – Rockpiper

3.5.3 Material Deposit Quantities

As outlined in **Section 3.5.2** rock will be deposited on sections of cable where the trenching process has achieved insufficient burial depth. The estimated worst case quantity of rock that will be required for the North and South Cable routes, including a 30% contingency is shown in **Table 3-6**.

South cable route protection design and rock protection requirements will be informed by the results and trenching success of the North Cable installation works.

Table 3-6: Material Deposit Quantities

NORTH CABLE calculated with Min requirements OR achieved results 2001				
5-10 m split barge 0.6 m berm	430	m	4,300	tonnes
10-22 m 0.6 m berm	1,220	m	6,100	tonnes
String-dumping 3 t/m	7,880	m	23,640	tonnes
SUM			34,040	tonnes
SOUTH CABLE calculated with Min requirements OR achieved results 2001				
5-10 m split barge 0.6 m berm	440	m	4,400	tonnes
10-22 m 0.6 m berm	1,850	m	9,250	tonnes
String-dumping 3 t/m	7,470	m	22,410	tonnes
SUM			36,060	tonnes

	Estimate of rock protection requirements (tonnes)	30% Contingency (tonnes)	Total (tonnes)
North Cable	34,040	10,212	44,252
South Cable	36,060	10,818	46,878

3.5.4 Hazards – Mitigation and Remediation

Nexans and Moyle Interconnector Ltd will take all practicable steps to remove and / or remediate any hazards to fishing activity that are created during the construction and operation of the cable.

Removal and remediation measures will include, as appropriate:-

a) The use of cable protection and burial methods that minimise impacts on the seabed, wherever possible.
b) Removal of hazards from the seabed where this is practicable.
c) In-situ remediation measures (such as sweeping (with appropriate gear such as chain mats) or use of rock mattresses and / or rock armour) to render hazards over-trawlable.
d) Marking the location of hazards that cannot be removed or remediated with appropriate navigational marks at sea and/or on hydrographic charts.
e) Notification to UK Hydrographic Office and Kingfisher Information Service.
f) Informing fishermen of any specific areas where additional protection using rock placement and/or mattressing were used (by direct communication using e-mail, internet and other media to inform representative bodies along the route, and also to inform fishermen who have registered their interest in the project with the CFLO).

Within 4 weeks of becoming aware of any danger to navigation or risk to any legitimate user of the sea, a mitigation plan shall be produced and shall be submitted to the licensing authority for approval.

Further details are provided in the Fisheries Liaison and Mitigation Action Plan which is provided separately. Any further requirements on protection design will be discussed with the Northern Ireland and Scotland Fisheries Organisations at the appropriate time and further to consultation on this Cable Burial Assessment Plan.

In addition, all installation procedures are governed by the Construction Environmental Management Plan (CEMP) for Marine Installation. (Doc. Ref: 0674-TQA-TQ-31031) which provides a working document which will be used as reference and guidance to ensure construction is carried out in line with the mitigation commitments made in the Environmental Appraisal (EA) and formalised in the Environmental Mitigation Schedule produced by the employer. Production of, and adherence to, this CEMP will ensure fulfilment of conditions placed by the regulating authority Department of Environment, Northern Ireland and Marine Scotland through the Marine Licences and also the separate Marine Scotland Marine EPS Licence and Northern Ireland Marine Wildlife Licence, and will ensure the work is carried out in compliance with applicable environmental requirements including contractual requirements as well as to provide information about equipment and materials that would be available on the vessel to undertake appropriate immediate remedial actions.

3.6 Post-Lay Inspection Survey Method Statement

3.6.1 Marine Survey of Group Assets

Mutual Energy apply a risk-based inspection programme to their submarine assets (gas transmission pipelines and submarine power cables) which includes geophysical survey at a frequency determined on a risk based assessment of the results.

The primary objective of geophysical survey is to assess the asset's position (relative to its as laid position) and any change to the seabed environs which have or could have the potential to impinge upon the integrity the asset. A secondary output from the geophysical surveys is that if there are any pipeline spans or cable exposures which could pose a risk to navigation or fishing are notified to industry via the KIS-ORCA (Kingfisher Information service).

3.6.2 Experience to date with existing Moyle Cables

The existing Moyle cables were specified to have a minimum target burial depth to achieve the necessary level of protection, both to the cable asset and to other third-party interests. Where burial within the seabed could not be achieved (due to difficult ground conditions, crossing of other assets, landfalls etc) the cables were protected by rock berm of a conventional design which has been industry proven not to create a snagging risk for fishing.

The cables were installed in 2001 and the first geophysical as-laid survey was executed in 2002.

Typically a combination of side scan sonar, multi beam echo sounding, video and still camera photography are used to inspect the cables to give a snapshot of condition of the:

- **Seabed bathymetry & scouring:** The seabed provides the load bearing grounding which supports the cables – significant movement could undermine the cable and lead to spans

- **Depth of Burial and Cable exposure:** At certain key points such as landfalls and shipping channels burial offers the primary protection to the pipeline and it is important, to avoid damage to the asset, that the original protection (burial and rock berm) remains through the life of the asset.
- **Identification of seabed scars:** This could be indicative of fishing activity or one off incidents such as anchor drags.
- **Damage:** Perhaps a pulled or exposed cable with obvious signs of third party interaction but which has not yet failed.
- **Spanning:** If the cable is left with no underlaying support and spanning like a beam there are two potential hazards
    - The spanning section is subject to its own weight and potentially third party loads from fishing gear which could cause it to yield and fail
    - The passage of currents over the spanning section can cause oscillation – if oscillation were to the natural frequency of the cable section it could over time fail by fatigue
    - Small spans on the pipeline assets do not pose a failure risk but are notified to industry. Small spans on the cable will usually require remedial action such as rock placement.
- **Boulders:** Significantly sized boulders lying directly on top of the point where the cable is buried underneath could create a load bearing force which could damage the cable.
- **Other Debris**: Debris such as snagged fishing gear could indicate third party interaction with the cables.

Survey of the **offshore** sections the cables are typically carried out by a large vessel and specialist contractors operating generally in the North Sea.

Figure 3-5: Typical Offshore Survey Vessel

Survey of the **nearshore** cables are carried out by a smaller vessel.

Figure 3-6: Typical Survey Vessel (Nearshore)

Mutual Energy typically tender the survey works as one job and the offshore contractor typically leads as principal contractor. This reduces management interface and delivers one complete shore-to-shore set of results.

After the initial as-laid survey, surveys on Moyle cables were carried out biennially (2004, 2006 & 2008) and then, following analysis of the 2008, results and largely related to the fact that the cable burial was on an improving and there were only three very small (maximum 8m) exposures it was recommended the frequency of subsequent survey be pushed to every four years. Subsequently survey was carried out in 2012 and is planned for 2016 on the existing Moyle Cables.

3.6.3 Proposal for the Replacement Metallic Return Conductors

The proposed metallic return conductor (MRC) cables are to be buried at a minimum target burial depth to achieve the necessary the necessary level of protection, both to the cable asset and to other third-party interests. Where this cannot be achieved rock placement to a conventional design will be employed using a burial protection index approach. For the nearshore sections of the cables cast iron shells may be deployed.

An end-to-end initial as-laid survey will be carried out on the protected cables system following completion of all burial and protection works, possibly in 2016.

Assessment of the results of the initial as-laid survey will define the subsequent survey regime on the new MRC assets.

Where possible synergy will be sought with the survey regimes being employed on the existing cable assets (IRC cables) and Mutual Energy gas pipeline assets.

3.6.4 Planned Post-Lay Inspection Survey Schedule

Table 3-1 provides a summary of the planned post-lay survey schedule.

Table 3-7: Summary of Survey

Asset	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17
Survey of existing IRC cables																
Survey of new MRC cables																

Key

Completed Survey

Schedules Survey

3.6.5 Post-Lay Inspection Survey Concluding Statement

Mutual Energy will employ a risk-based inspection programme to the new MRC cables. It is good practice and something that is necessary to allow the group to take important decisions in relation to the integrity of the asset and is obligatory for stakeholders such as insurers (keen to know of any changes to the risk of third party interference) and the industry in general (keen to know of any changes to the risk of their own interaction with the assets).

REFERENCES

- **Department of Energy (2015),** *Marine Construction Licence - Licence for Installation of two separate Metallic Return Conductors within Northern Ireland Inshore Region*. Licence Number: 52/13;
- **Moyle Interconnector Limited (2015),** *Fisheries Liaison and Mitigation Action Plan;*
- **Marine Scotland,** *Licence for Marine Cable Installation Works*, License Number: 05401/15/0;
- **Nexans (2015),** *Burial Protection Assessment Plan.* Doc. Ref.: 60674-EIMT-TD-30691;
- **Nexans (2015),** *Construction Environmental Management Plan (CEMP) for Marine Installation.* 60674-TQA-TQ-31031;
- **UTEC Geomarine (2014),** *Moyle Replacement Cable Burial Assessment Report*. Doc Ref.: GM-ITK0001-002-0

Appendix A: Nexans (2015) Burial Protection Assessment Plan

Document type: **METHOD STATEMENT**	Nexans
Project: **Moyle Return Cables**	Nexans document number: **60674-EIMT-TD-30691**

Document title:	Page:	Category:
Burial Protection Assessment Plan	**1 of 54 (+appendices)**	**EXT**

Scope:

The purpose of this document is to describe the recommended protection method(s) and equipment setup for the different sections for the MRC South and MRC North Cable.

It also describes the various environmental factors along the route, and eventual consequence for the equipment setup.

Rev:	Company Rev	Date:	Document status:	Prepared:	Checked:	Approved:	Released:
R3	2	2014-06-06	Re-issued for Company Review	HSN	OYH	ATU	ATU
R2	1	2014-22-05	Issued for Company Review	HSN	OYH	ATU	STU
D1		2014-07-05	Issued for IDC	HSN	KUS		
D0		2015-03-17	Issued for DIC	HSN	KUS		

Company:	Company contract no.: **15001CBN**
moyle interconnector	Company document no.: **TBA**

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Revision Record

Rev	Comp. Rev.	Date	Comment sheet ref no	Comments
D0		2015-06-05		Issued for DIC
D1		2015-07-05		Issued for IDC
R2	1	2015-12-05		Included comments from IDC
R3	2	2015-06-08	2 3 5 6 9 11 12	Text is updated in section 3.2 . Updated section 3.4 Updated 3.6 Updated section 3.7 Included reference in 5.5 Included reference in section 6. Updated section 7.

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1 Introduction

1.1 General

The Moyle Interconnector physically links the Scottish and Irish electrical transmission networks. The interconnector is currently operating at half capacity due to a number of similar recurring faults in the Integrated Return Conductor (IRC) Insulation of the HVDC MI IRC Cable. The Employer will reinstate the Moyle Interconnector to its installed capacity of 500MW by an emergency replacement of the two existing integrated return conductors with two new metallic return conductor (MRC) cables, each with a typical rating of 1kV by 1000 Amps. This will secure full capacity of the Moyle Interconnector for the winter 2015/16. Nexans has been awarded the contract to supply and install the two replacement MRC submarine cables from Port Muck, County Antrim to Currarie Port, South Ayrshire.

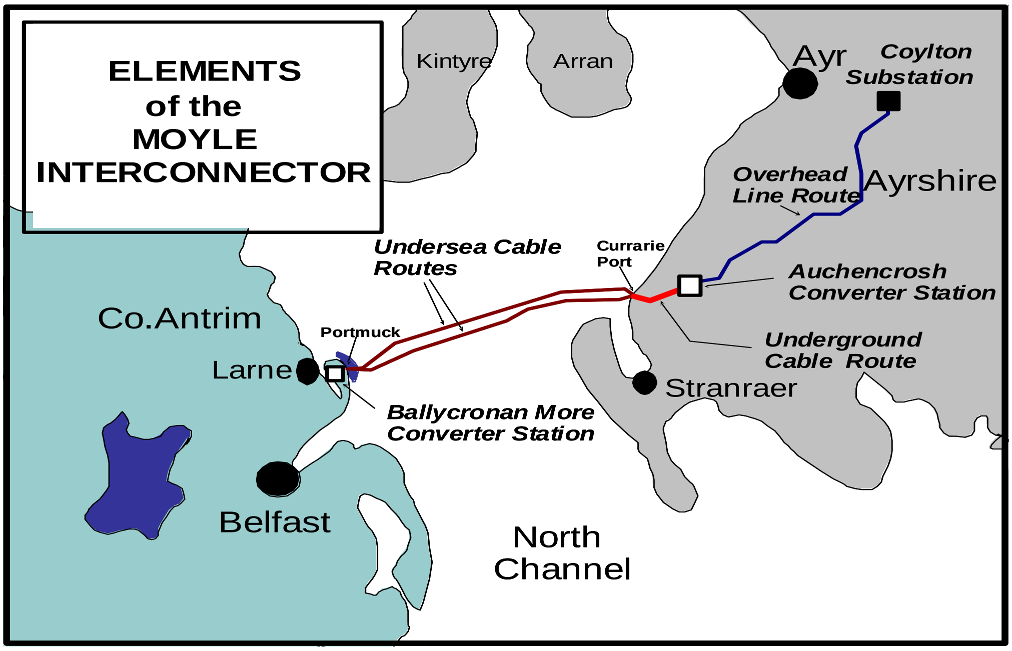


Figure 1 Overview of the Moyle Interconnector

1.2 Purpose of Document

The purpose of this document is to describe the recommended protection method(s) and equipment setup for the different sections for the MRC South and MRC North Cable.

It also describes the various environmental factors along the route, and eventual consequence for the methods.

1.3 SOW Overview

The section from 0 to 10 m water depth on both sides will be protected with Cast Iron Shells, rock installation with the use of a splitbarge and burial by divers.

From 10 to 22 m where the cables are surface laid with max 4 m separation from the HV, the cables will be protected with a 0.6 m rock berm. The installation will be performed with a fallpipe vessel.

For the main length from 22 m from Ireland to Scotland, the protection will be performed by the CAPJET system and string dumping performed by a fallpipe vessel.

Crossing will be protected by rockdumping with 0.6 m cover. PPL Duct or URADUCT will be installed on the cable for the crossing of the cables.

2 References and Definitions

2.1 Internal References

[1] Asbuilt 2001 - BAS-RD 2015 27042015.xlsx

[2] Trawlboard/anchor penetration study for NEXANS (DNV)

2.2 External References

Ref.	Document No.	Document Title
[3]	GM-ITK0001-002-0	Moyle Replacement Cable Burial Assesment Report
[4]		MetOcean study for Moyle Cable Route-Western Location
[5]		MetOcean study for Moyle Cable Route-Central Location
[6]		MetOcean study for Moyle Cable Route-Eastern Location
[7]		F14_UTEC Geomarine report for Moyle 020714

2.3 Definitions, Abbreviations and Acronyms

HVDC	High Voltage Direct Current
FO	Fibre optic
UG	Underground Cable
MI	Mass impregnated
MRC	Metallic Return Conductor
IRC	Integrated Return Conductor
Employer	Moyle Interconnector LTS
NXN	Nexans
SEPA	Scottish Environment Protection Agency
CAR	Controlled Activities Regulations
CIS	Cast Iron Shells

3 Conditions along Route

3.1 Topography

The areas from 0-10 m on both landfalls are rocky boulder areas. The section from 5 to 10 m (and deeper) is also rockdumped on the Scottish side. On the Irish side it is excavated a trench with the use of divers and ejector.

From approx 5 m water depth and to beach on either side, the HV cable is installed in a PE pipe.

3.2 Landfall Landfall Scotland– Currarie Port

The cable position is based on the DTM data where the cable is placed within the rockberm or the trenches.

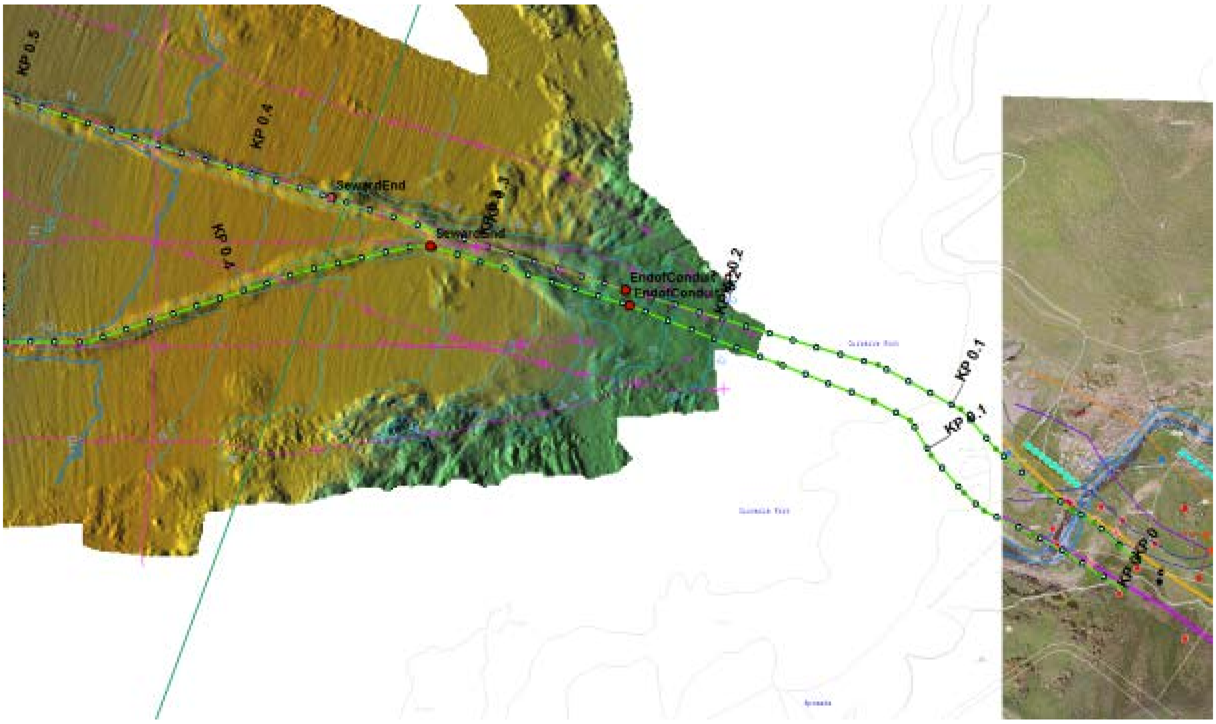


Figure 2 Landfall Scotland Currarie

3.1 Landfall Landfall Ireland– Port Muck

Final mapping will be performed during installation. The position of the cable is based on the MIKA survey performed in 2001.

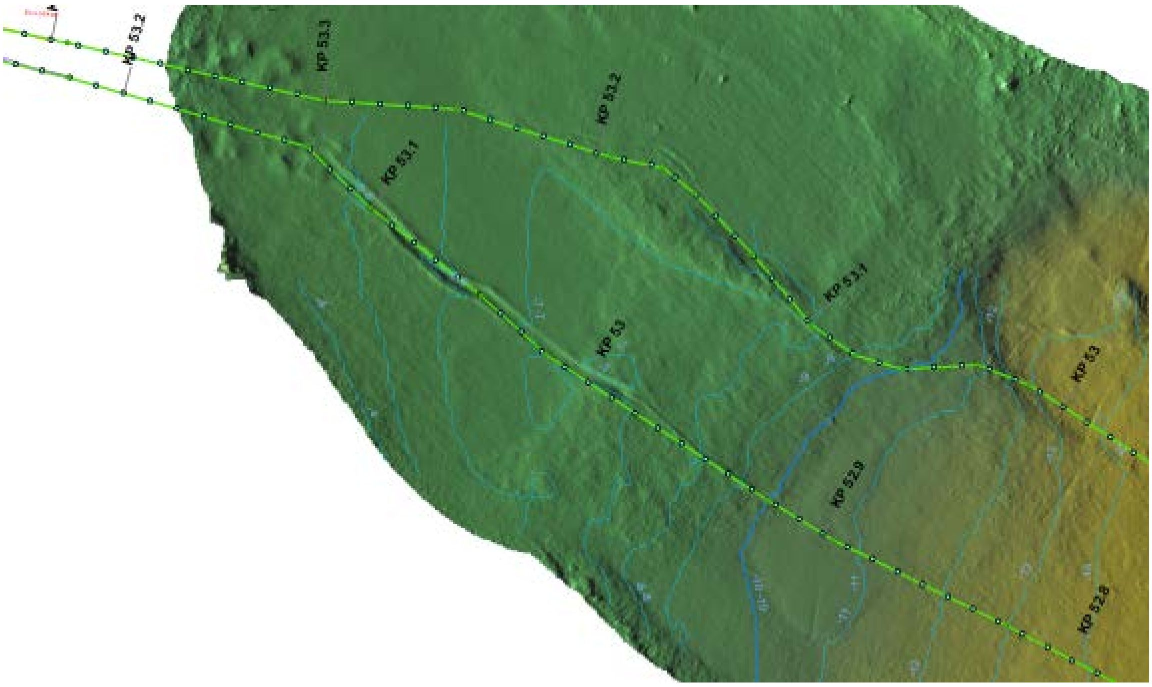


Figure 1 Landfall Ireland Port Muck

3.2 North Cable Topography and Gradient

2

There are no gradient along the last RPL on the North route which will impact the performance or the setup of the CAPJET trenching system. However, there has been made some rerouting to avoid some steep slopes with close to 10 degrees in both planes.

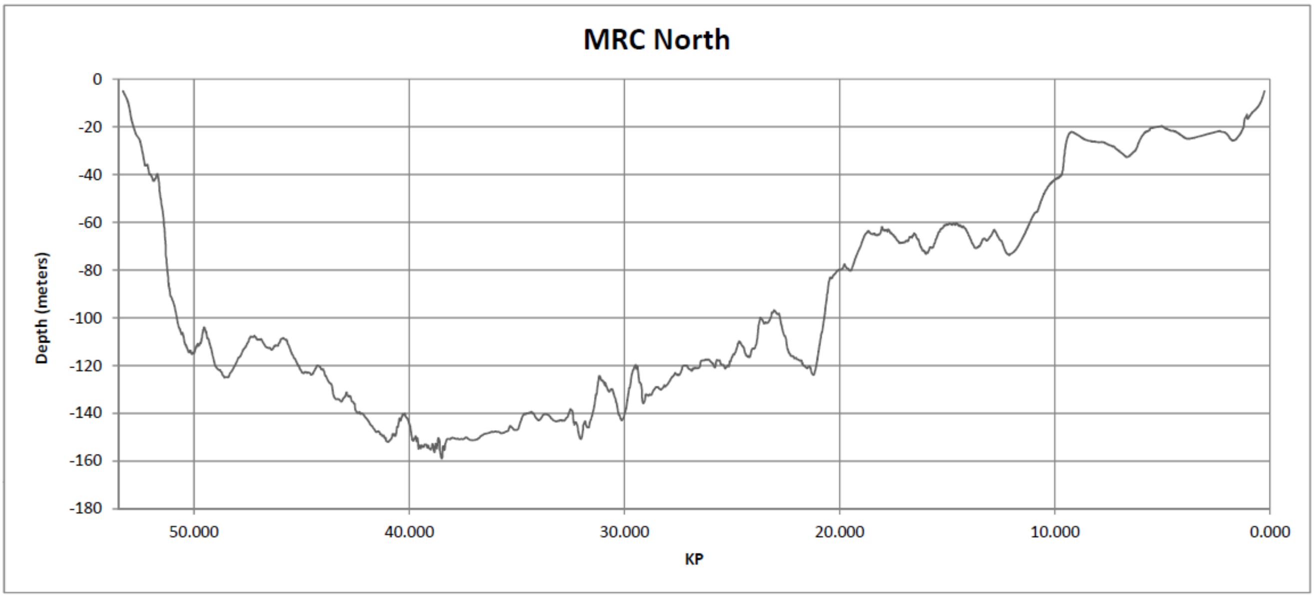


Figure 3 Profile MRCN

3.3 South Cable Topography and Gradient

As for the North cable, there are no gradient along this route which will impact performance or setup of the CAPJET system.

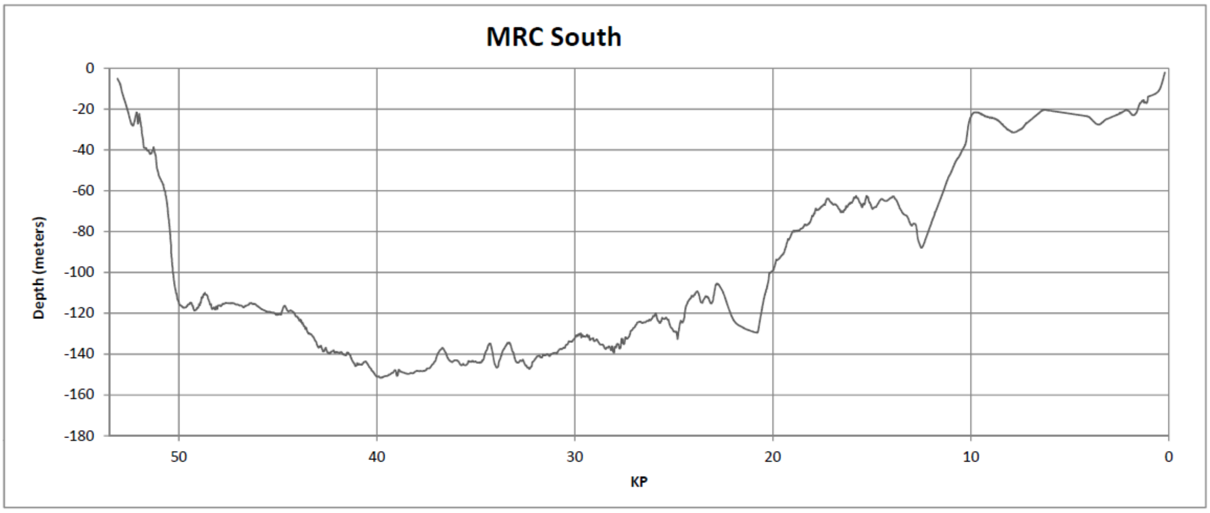


Figure 4 Profile MRCS

3.4 Geology

The route contains several section with glacial till and hard clay. Several section of the clay is in the range of 500 KPa and is also referred to as mudstone. It is also section with calcareous cemented soil, referred to as marl bedrock. The route is highly diversified and with rapidly changing conditions.

Each landfall to approx 10 m is rocky and boulder area.

For the evaluation of soil conditions, it is based on results from 2001. The original soil survey and measurement made in the field in 2001, is used to establish undrained shear strength values for the analysis. There is not made new geotechnical measurements in 2015, but the old data is verified against the new the new hydrographical data. Especially thickness and areas of sandwave area will be crosschecked.

There is made isopatches which lists where the top "loose" soil layer is less than 0.5 m and there is also contours which list the bed rock (or mudstone) with depth. This is compared to the data from 2001. On several locations there is a reasonable good match, se enclosed picture. The white lines gives where the looser top soil is 0.5 m. From the example there can be seen that there is a good match from 2001 and also the dataset in the spreadsheet.

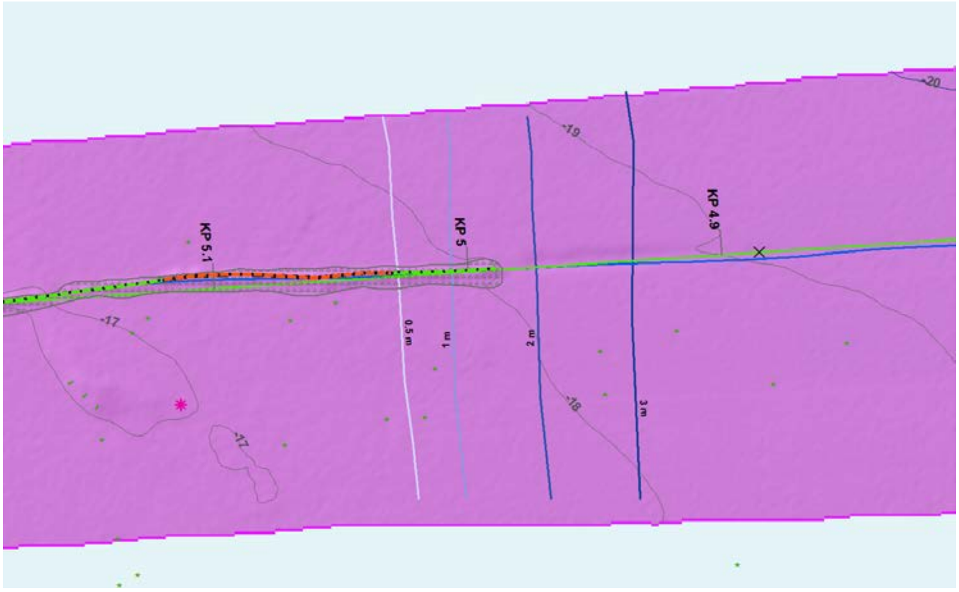
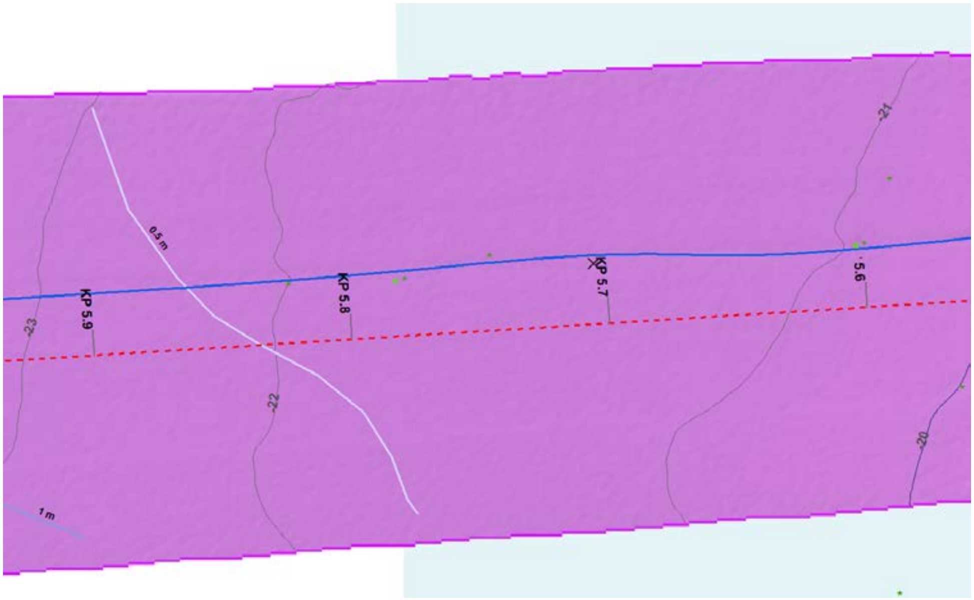


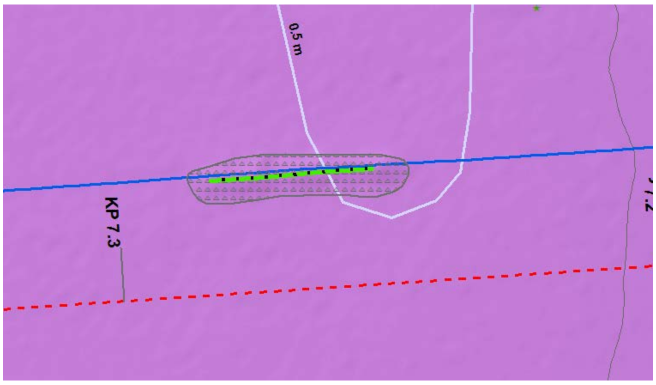
Figure 5 2001 and 2015 data set



5.813	0.67				
5.823	0.78				
5.833	0.55				
5.843	0.48				
5.853	0.74				
5.863	0.54				
5.873	0.65				
5.883	0.43				
5.893	0.59				
5.903	0.65				
5.913	0.72				
5.923	0.93			10	
5.933	0.89			10	
5.943	1.00			10	
5.953	1.06			10	
5.963	1.12			10	

2 From the second data set above the actual contour on the 0.5 m seems to closer to KP 5.9 than in 2015 survey. However, the 2015 survey still detects the change of the top soil layer. The planning is still based on the 2001 dataset where the data is clearly not correlating.

A good data match is shown below. However, it is quite clear the 2001 is approx 20 m off the 2015 data. In this case the planning and system setup will still be based on 2001 data.



There is listed the soil condition in the [1] as well as in the detail listing in the spreadsheet for every 10 m.

3.4.1 Geotechnical Samples

There is taken a high no of soil samples along the route. Samples made in 1994 and 1993 by Ocenoics and Geoconsult. There was also made a high no of field test during the actual work, basically confirming the very high value of shearstrength higher than 300 KPa.

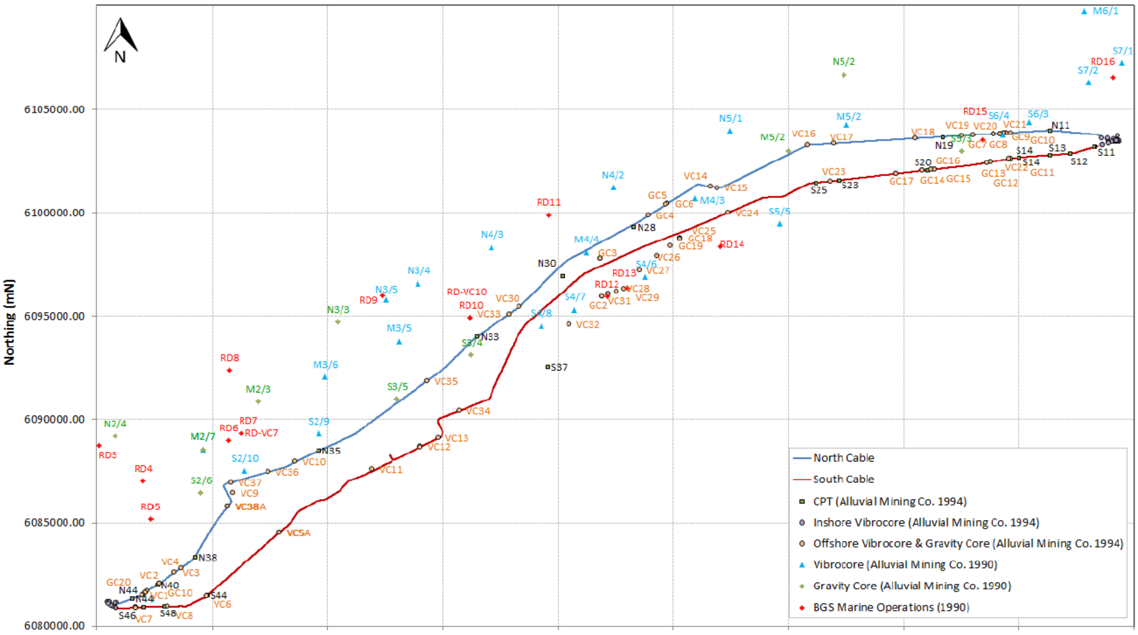


Figure 6 Soil samples

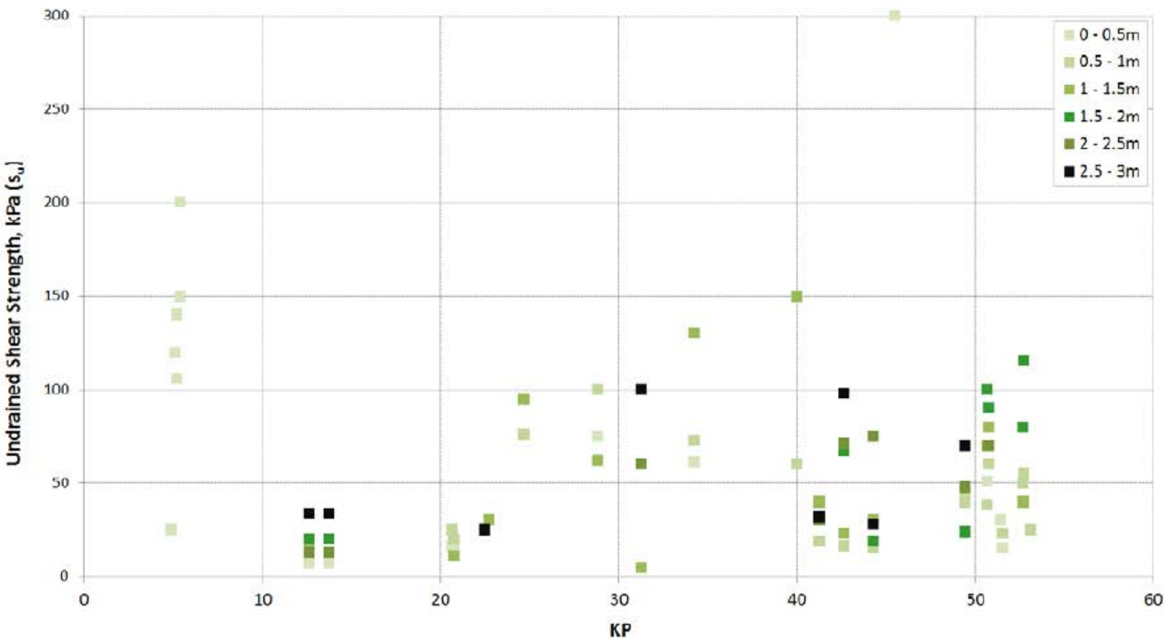


Figure 7 Su Values ref /[7] /

3.4.2 Summary of Soil Conditions

This is based on Oceonics 1994 and Geoconsult 1993.

KP FROM	KP To	
0	0.275	Rock with Patchy sand
0.275	1.025	GLACIAL TILL (Cobbles and boulders with patchy GRAVEL) (Cobbles and boulders with patchy GRAVEL)
1.025	2.4	Silty SAND & occ. soft CLAY at base (Intermittent boulders)
2.4	2.525	Layered Unconsolidated Sediments
2.525	3.05	Silty SAND
3.05	3.8	Silty SAND & Layered Unconsolidated Sediments
3.8	4.9	SAND (Loose to dense) (Intermittent boulders)
4.9	5.45	GLACIAL TILL (Cobbles and boulders with patchy GRAVEL)
5.45	5.6	SAND (Cobbles and boulders with patchy GRAVEL)
5.6	5.75	Silty SAND over soft to firm CLAY
5.75	6.9	Silty SAND
6.9	7.2	SAND over GLACIAL TILL (Intermittent cobbles and boulders)
7.2	11	SAND (Loose to very dense) (Sandwaves & trawl scars
11	12.1	SAND (Loose to very dense) (Sandwaves & trawl scars
12.1	15.5	SAND / GRAVEL over CLAY (Clay is very soft to soft) (Intermittent boulders & trawl scars)
15.5	19.5	Silty SAND / SAND (Intermittent cobbles and boulders)
19.5	20.5	SAND
20.5	21.25	MIXED SEDIMENTS (SAND, SILT &GRAVEL) with potential subcropping MARL BEDROCK
21.25	24	MARL BEDROCK under variable surficial sand layer (Cobbles and boulders with patchy GRAVEL)
24	24.5	SAND
24.5	29.5	MARL BEDROCK / SILTSTONE under variable surficial sand layer (Cobbles and boulders with patchy GRAVEL)
29.5	31	Likely shallow MARL bedrock
31	31.85	GLACIAL TILL (Cobbles and boulders with patchy GRAVEL)
31.85	32.25	Silty gravelly SAND (Potential subcropping MARL bedrock)
32.25	34	MARL BEDROCK under variable surficial sand layer (Cobbles and boulders with patchy GRAVEL)
34	34.75	Gravelly SAND (Cobbles and boulders with patchy GRAVEL)
34.75	39.4	Soft to firm CLAY? under sand veneer (Potential shallow MARL bedrock)
39.4	40.4	MARL BEDROCK under variable surficial sand layer (Cobbles and boulders with patchy GRAVEL)
40.4	45.4	Soft to firm CLAY under variable surficial sand / gravel layer
45.4	46.1	GLACIAL TILL
46.1	48.5	Soft to firm CLAY under sand / gravel veneer
48.5	51.35	GLACIAL TILL (Cobbles and boulders with patchy GRAVEL)
51.35	52.6	GLACIAL TILL (Cobbles and boulders with patchy GRAVEL)
52.6	53.3	GLACIAL TILL (Cobbles and boulders with patchy GRAVEL)

3.5 Route Survey

The main source of information is the burial results obtained in 2001 and with the interpreted soil data from the original soil survey. There is also used the data from NEXANS route survey in 2015, especially in shallow water. However, the final data especially for the UXO and final rerouting is still not obtained and will be updated in a later revision of the report.

The NSEA Route survey from 2012 is used in combination with the 2015 survey as it overlaps on sidescan and bathymetric data.

The interpretation of sub bottom profile is mainly to evaluate seabed movement and thickness of sand layer in areas with sandwaves.

During the work in 2001, several samples were recovered and measured in the range of 500 KPA – classified as mudstone. However, the soil is much more complex than listed in the table above with several small section of mudstone/till within the listed sections of sand and soft clay.

2

3.6 Route Clearance

There is not performed any grapnel run along the cables. From the operation in 2001 there were not made any findings along the route. If there is findings during the cable lay it will either removed with the ROV or reported.

3.7 UXO

During the work in 2001 there were not observed any UXO during burial and second pass burial of both of the routes (during trenching). Neither was there observed any UXO during the as trenched survey. There was however, found one single round of small arms ammunition, 50 cal, during the work. The main focus in 2001 was phosphorous and the eventual HSE impact if physical in contact. There was not made any observation of phosphorous during the whole operation.

2

The cable is rerouted due to UXO, and except for five location has acheieved a 10 m safety distance.

The following location are still being discussed of further survey or use of URADUCT.

ID ref	KP
34	21.9
33	22.7
31	23.6
27	25.2
21	28.9

3.8 Crossing

There are three cable crossings and one crossing of a Gas pipeline on each cable.

4 Protection Methods

The main method of protection is with the CAPJET 1MW system. It will be setup with front swords of 1.2 m.

The CAPJET is able to perform trenching in between 1.5 and 2 knots, but start to have a sideways roll.

4.1 CAPJET1MW System A

The CAPJET will be setup with low pressure pumps. The setup will be with 2x420 KW 10-16 bar pumps. Both high pressure and low pressure was used for the work in 2001. The experience was that the cut mostly were cut with both pumps setups, but there was not adequate fluidization the soil. Example below is the trench cut in mudstone (500 KPa)- measured at KP 52.8 on the Northern Cable.

Figure 8 CAPJET A- example of mudstone from Moyle 2001

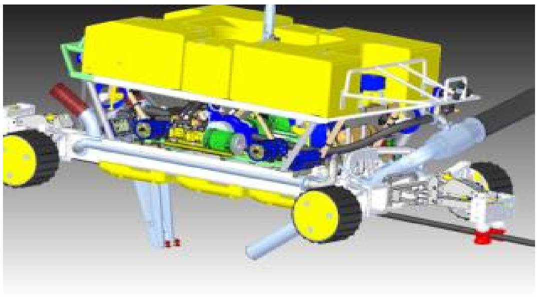
4.2 CAPJET1MW System B

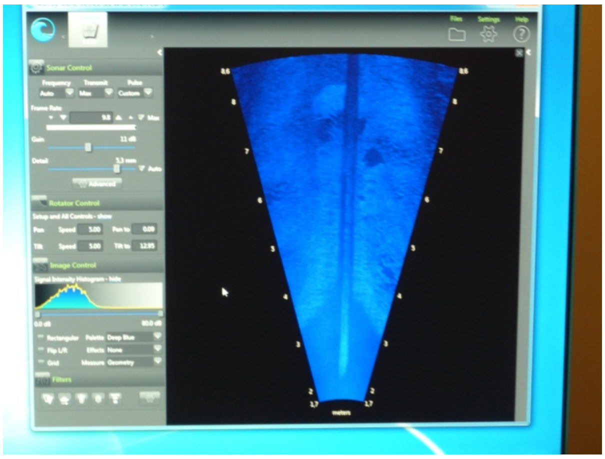
Based experience from Moyle and some other project, the harder soil typically from 50 KPa will not fluidize. However, the experience was that the soil was relatively easy cut, but will form lumps similar to gravel/pebble.

The System B is designed as combined ejector and jetting machine.

The system is designed to have the cable run outside of the jetting/cutting sword, which leaves the whole area of the trench accessible to a 300 mm ejector system. The cable is guided into the trench with the use of the aft arm after the ejector. In addition to using high pressure pump for cutting, more energy is directed to the cutting. And extra 135 KW pump is used to power the ejector system. Boulders less than 200 mm will pass through the ejector, but larger boulder will not pass through the ejector. As seen from photos below, there are several sections with boulders-both in the upper layer and surface boulders.

There is a high quality real time imaging sonar which monitors the cable aft of the CAPJET. The pictures below are taken during the rockcutting in Mallorca Ibiza this year.





4.3 Rock Installation

From 10 m to 5 the rock installation will be performed with a splitbarge system. For all rock installation deeper than 10 m there will be used a fallpipe vessel, for example the BOSKALIS ROCKPIPER.

4.3.1 Fallpipe Vessel

A typical datasheet of a fall pipe vessel is included in Appendix 2. It is planned for all rock installation deeper than 10 m. An alternative vessel is the SEAHORSE.

Figure 9 ROCKPIPER

4.3.2 Splitbarge

For the rock installation from 10 to 5 m it is used a splitbarge in combination with a small tug. The tug is used for survey and to assist in control the bow during the installation. A data sheet is included in Appendix B. The split barge has a draft of approx 3 m loaded.

Figure 10 BOSKALIS Splitbarge

4.4 Cast Iron Shells

A 120 mm ID Cast Iron shell will be used on both cables from 10 m to 0 m. It is a ductile cast iron with 15% elongation. It has a minimum specification of 4 Kilo Joule impact load. Nexans internal testing shows an impact capacity of approx 7 KJ, this is a 20 mm hammer head with a 700 kg weight dropped from 1 m height. Datasheet and test report is included in Appendix E. The Cast Iron Shells also gives extra stability due to the increased weight.

Figure 11 CIS at landfall

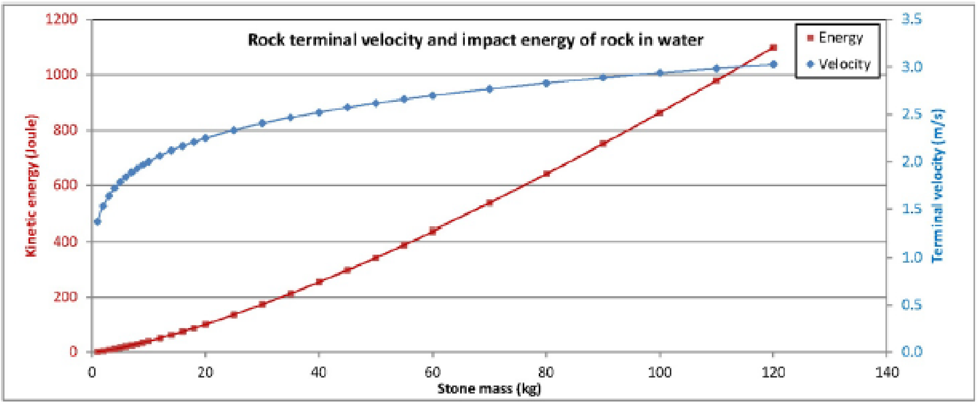
Figure 12 Cyclonic waves at landfall (le Reunion 2012)

Figure 13 Testing of CIS

Figure 14 Testing of tension

2

The typical impact from the 8" rock during installation is less than 100 J. From the table below a 8" rock is 20 kg stone.



4.5 URADUCT

The PURADUCT is a product used for crossing of other product before other protection (as rockdumping). However, it is also product used for protection of the cable without any other external protection- similar to the Cast Iron Shells. It does have a negative impact on stability, so is normally not used in shallow water.

Figure 15 URADUCT

4.6 Ejector Burial/Dive Work

The work between 5 to 0 m (intertidal area) will be performed with a shallow draft trimaran vessel (1 m draft). The vessel will be moored during the work. All work will be from 5 to 0 m (working on high tide). The smaller boulders and gravel will be removed with an ejector while the larger boulder will be removed by the divers using lift bags.

The ejector system is powered by 150 HP water pumps and during the work it is planned to have one or two divers in the water.

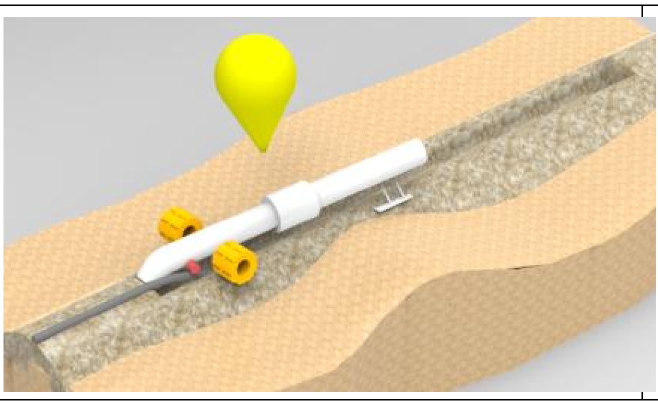


Figure 16 Ejector system for shallow water diving

5 Evaluation KP 0 to KP 53 MRC North and South

In this section the seabed conditions, requirements have been looked into in detail and protection methods have been recommended. This evaluation is based mainly on the results from 2001 with the actual data from Nexans survey in 2015. The latter is the main source for the shallow water area up to 10 m of water.

In addition the data from NSEA survey 2012 is used as additional source of information. However, burial data is only based on NEXANS data as it was measured with a TSS350 system. The NSEA survey was made with a TSS440 system.

To be able to match old datasets, the basis for the KP is the NEXANS 2001 KP which is the same as used by NSEA. However, there is some known discrepancies on the KP close to the Irish side.

The detailed evaluation in deeper water is made only for the North Cable. The general areas are the same, but this will be updated after the burial of the North Cable.

5.1.1 Protection Requirements

The cable shall be protected throughout the whole cable route with jetting with CAPJET1MW or rock installation with a fallpipe vessel.

5.1.2 Requirements

Requirements for protection are given in the contract. The requirements are given as minimum burial requirements in combination with results obtained in 2001, whichever is the lesser.

The results from 2001 and combination with the minimum requirements is presented as combined requirement.

5.1.3 Requirements North Cable Employers and Combined Requirements

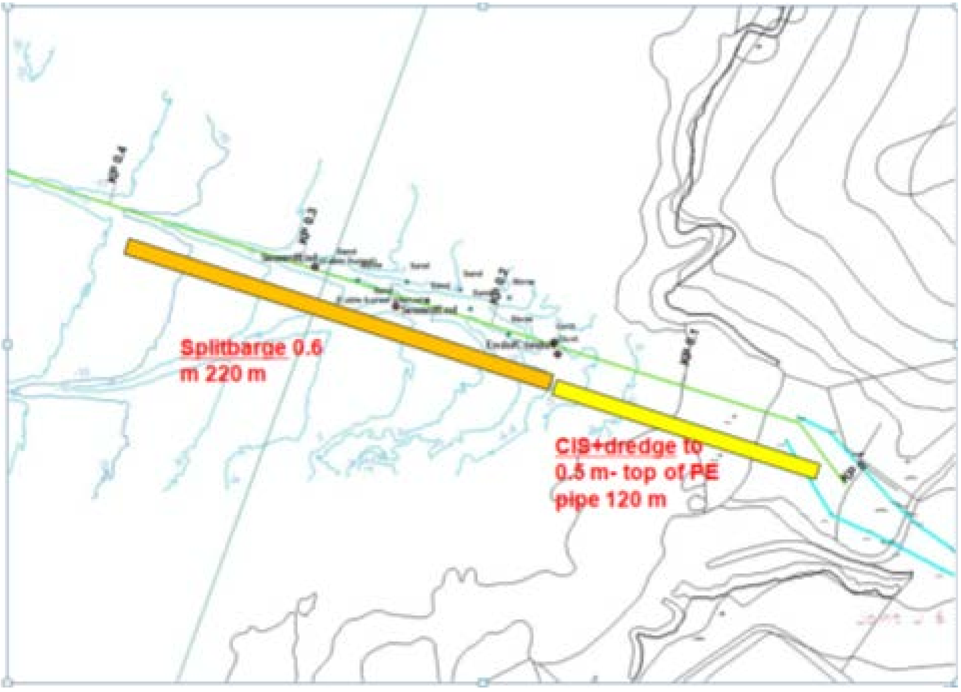
KP		Section Length (km)	Section ID	Minimum Burial Depth (m ToC)	Comb. requirements
From	To				
0	0.28	0.28	1	0.6	0.5
0.28	0.5	0.22	2	0.6	0.5
0.5	0.7	0.2	3	0.6	0.5
0.7	0.9	0.2	4	0.6	0.5
0.9	1.08	0.18	5	0.6	0.5
1.08	1.35	0.27	6	0.6	0.5
1.35	1.92	0.57	7	0.6	0.5
1.92	2.4	0.48	8	0.6	0.5
2.4	4.4	2	9	0.6	0.5
4.4	6.75	2.35	10	0.6	0.5
6.75	8	1.25	11	0.6	0.5
8	10	2	12	1.2	1
10	11.2	1.2	13	1.2	1
11.2	12.3	1.1	14	0.6	0.5
12.3	17	4.7	15	0.6	0.5
17	19.75	2.75	16	0.4	0.4
19.75	20.75	1	17	0.6	0.5
20.75	23.25	2.5	18	0.6	0.5
23.25	23.8	0.55	19	0.6	0.5
23.8	26	2.2	20	0.4	0.4
26	28.25	2.25	21	0.4	0.4
28.25	28.6	0.35	22	0.4	0.4
28.6	29.5	0.9	23	0.3	0.3
29.5	30.1	0.6	24	0.4	0.4
30.1	30.6	0.5	25	0.4	0.4
30.6	36.1	5.5	26	0.3	0.3
36.1	36.9	0.8	27	0.4	0.4
36.9	40.75	3.85	28	0.6	
40.75	45.75	5	29	0.4	0.4
45.75	46.75	1	30	0.4	0.4
46.75	48	1.25	31	0.4	0.4
48	50.4	2.4	32	0.4	0.4
50.4	51.5	1.1	33	1.5	0.5
51.5	52.1	0.6	34	1.5	0.5
52.1	52.75	0.65	35	1.5	0.5

5.1.4 Requirements South Cable Employers and Combined Requirements

KP		Section Length (km)	Section ID	Minimum Burial Depth (m ToC)	Comb. requirements
From	To				
0	0.275	0.275	1	0.4	0.4
0.275	1.025	0.75	2	0.4	0.4
1.025	2.4	1.375	3	0.6	0.5
2.4	2.525	0.125	4	0.6	0.5
2.525	3.05	0.525	5	0.6	0.5
3.05	3.8	0.75	6	0.6	0.5
3.8	4.9	1.1	7	0.6	0.5
4.9	5.45	0.55	8	0.6	0.5
5.45	5.6	0.15	9	0.6	0.5
5.6	5.75	0.15	10	0.6	0.5
5.75	6.9	1.15	11	0.6	0.5
6.9	7.2	0.3	12	0.6	0.5
7.2	11	3.8	13	1.5	1
11	12.1	1.1	14	0.6	0.5
12.1	15.5	3.4	15	0.6	0.5
15.5	19.5	4	16	0.4	0.4
19.5	20.5	1	17	0.4	0.4
20.5	21.25	0.75	18	0.4	0.4
21.25	24	2.75	19	0.4	0.4
24	24.5	0.5	20	0.4	0.4
24.5	29.5	5	21	0.4	0.4
29.5	31	1.5	22	0.4	0.4
31	31.85	0.85	23	0.4	0.4
31.85	32.85	0.4	24	0.4	0.4
32.25	34	1.75	25	0.4	0.4
34	34.75	0.75	26	0.4	0.4
34.75	39.4	4.65	27	0.6	0.5
39.4	40.4	1	28	0.4	0.4
40.4	45.4	5	29	0.6	0.5
45.4	46.1	0.7	30	0.4	0.4
46.1	48.5	2.4	31	0.6	0.5
48.5	51.35	2.85	32	1	0.5
51.35	52.6	1.25	33	1	0.5
52.6	53.3	0.7	34	1	0.5

5.2 Nearshore KP 0-KP 0.350 Down to 10 m Water Depth Scottish Side

The intertidal areas are planned with excavator and 10 to 5 m section with splitbarge and the remaining section with diver and ejector. All methods have been planned with overlapping to give some flexibility during the protection work.



5.3 Nearshore KP 0-KP 0.4 MRC and KP North and MRC South K 53.280 to 53.300

The section from KP 0 to KP 0.4 (NEXANS 2001 KP) is the intertidal area, section marked in red on the photo below. The cable is protected with Cast Iron Shell (CIS) and the cable will be buried with excavator directly in the existing trench of the buried PE pipe. The burial depth is limited by the existing PE pipe. Max burial depth is 0.5 m.

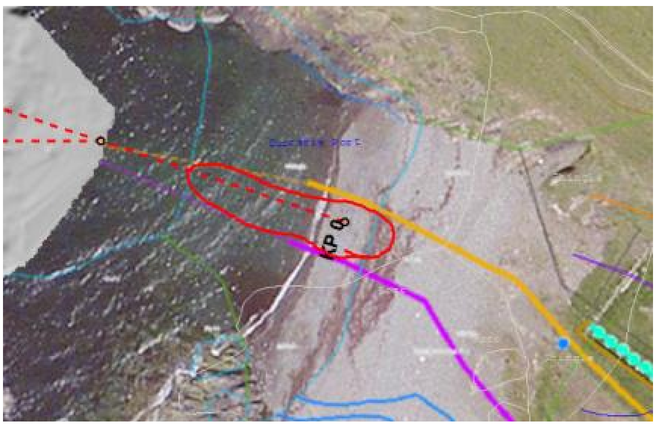


Figure 17 Intertidal area Scotland

In Ireland the intertidal sone is shorter- 20 m- and more rocky.

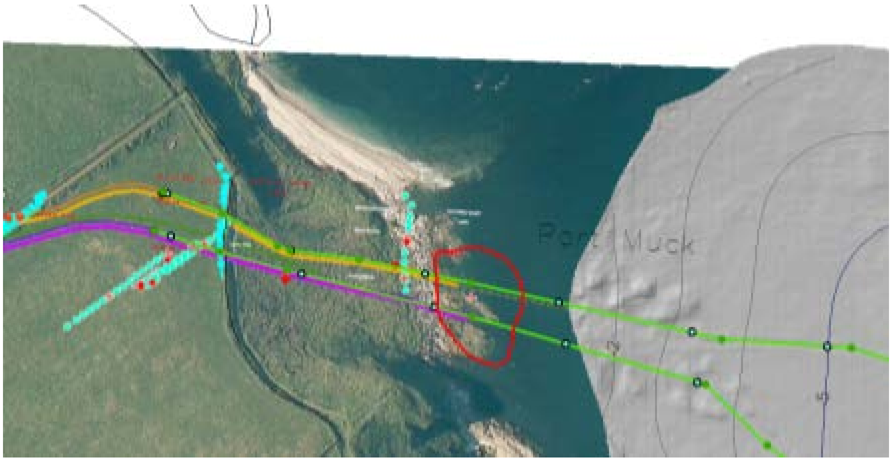


Figure 18 Intertidal Scotland

The CIS by itself is adequate protection. In addition the cable is buried to 0.5 m depth.
Test reports of CIS (same material property is included in Appendix E.

5.4 Nearshore KP 0.4 to KP 0.120 Scotland and KP 53.16 to KP 53.280 (MRCS)

This is the section from the intertidal to the 5 m contour on both sides.

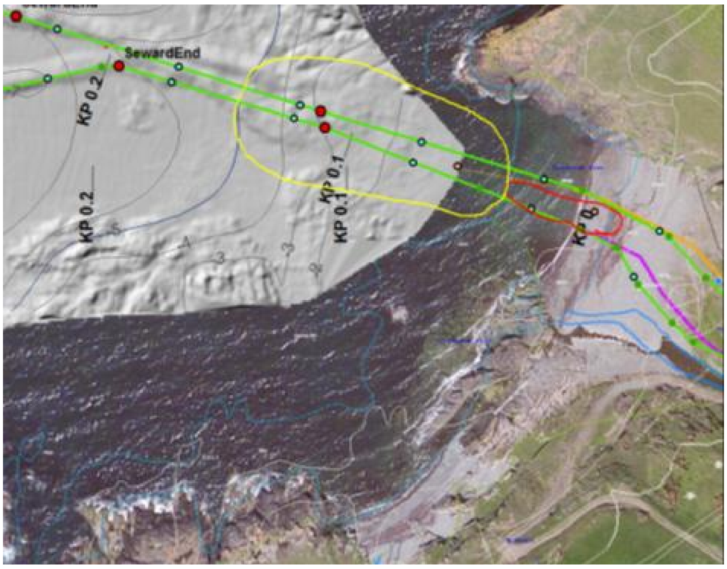


Figure 19 Port Currarie diver area

The area is protected with CIS and buried with diver into the old trench of the PE pipe. It is planned to bury down to the top of the PE pipe- typically 0.5 m.

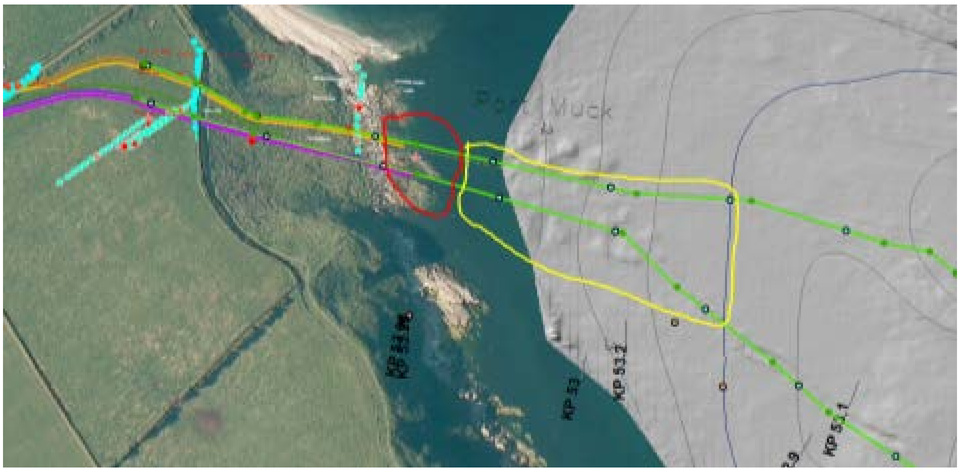


Figure 20 Port Muck area with diver burial (marked in yellow)

5.5 Nearshore KP 0.4 to KP 0.34 (MRC N and MRC S) – From 5m Depth to 10 m contour

The cable will be laid on the flat top section of the rockberm.

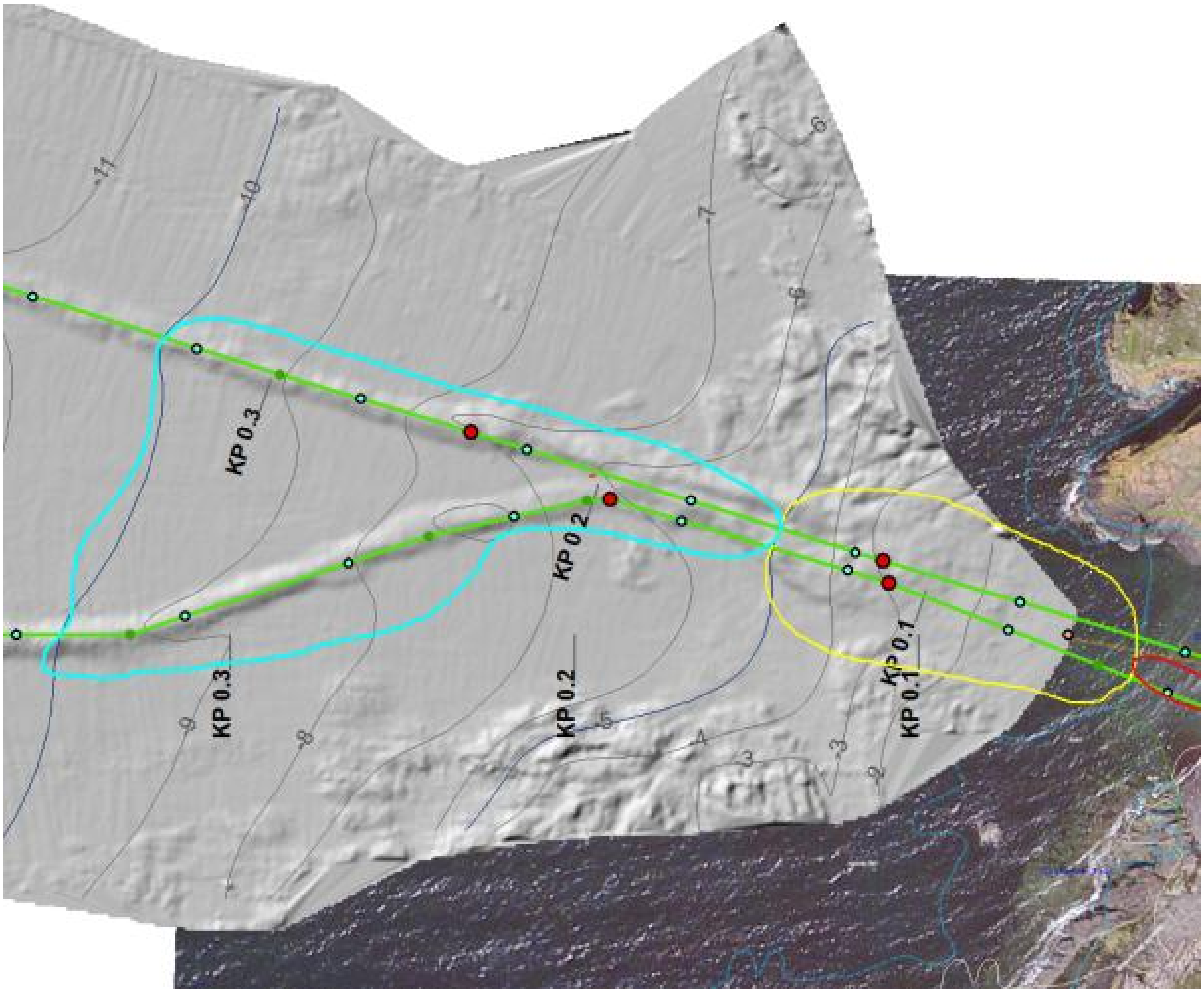


Figure 21 Splitbarge area-marked in cyan.

2

The section is also protected by the use of Cast Iron Shells. The section will rockdumped with the use of a splitbarge with a 0.6 m cover. There will be no filter layer, and it will be dumped rock of 1-8" grading. This due to stability requirement, and was same rock grading as used in 2001. This has also proved to be stable based on proven results (survey of 2015). The same weather parameters apply on both landfalls and same stability requirement apply (Metoceandata in 4 to 6)

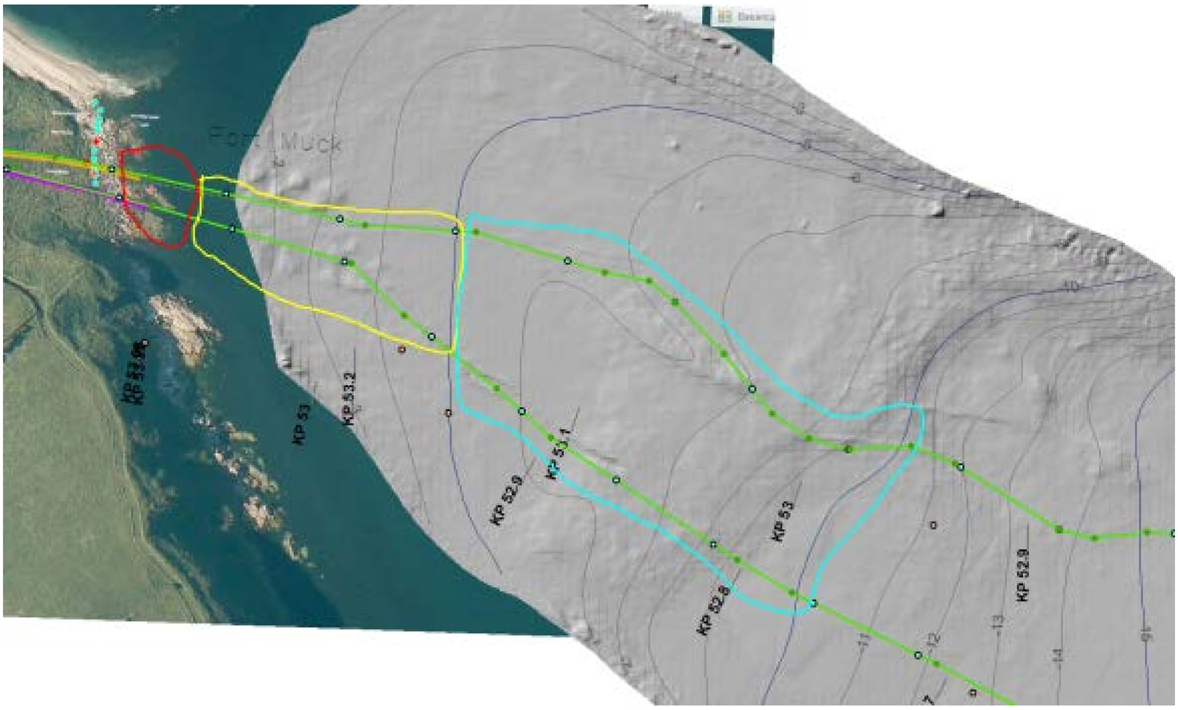


Figure 22 Splitbarge area Port Muck-marked in cyan

For the area in Ireland, the same protection applies. The cable is protected with CIS and 0.6 m cover from 10 to 5m. However, there is no existing rockberm in Ireland. The cable will be laid 0-4 m separation and rockdumped with splitbarge.

5.6 Nearshore 10 m to 22 m Water Depth Scotland and Ireland

This is KP 0.34 to KP 1.3 MRCN and KP 1.85 MRCS KP 52.640 to 52.95 MRCN and KP 52.4 to 52.76

For the North cable it is intermittent rockdumped to KP 0.6 for the MRCN and to 0.5 for MRCS. There are also some rockdump at KP 1 –MRCN-and at 0.7-0.9 and MRCS.

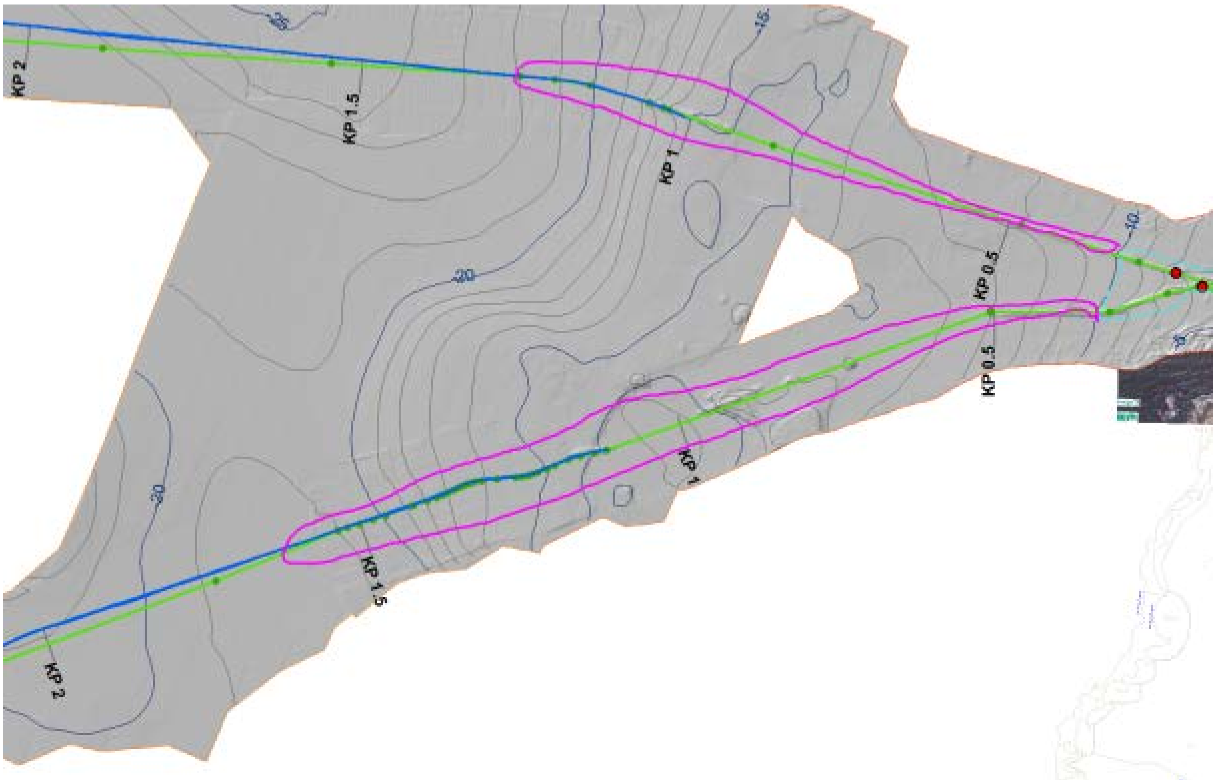


Figure 23 10-22 m cable separation less than 4 m

As seen below the berm size is wide, close to 10 m. The cable need to be placed at the side of the berm.

It will be protected with a 0.6 m cover rock berm with 1-5″ rock.

On the Irish side, there is very little rockberm, and the existing rockberm is stringdumped trench and is hardly visible on the profiles.

For the Irish side the cable is laid 0-4 m from the existing cable and protected with a 0.6 m rockberm 1-5″ rock.

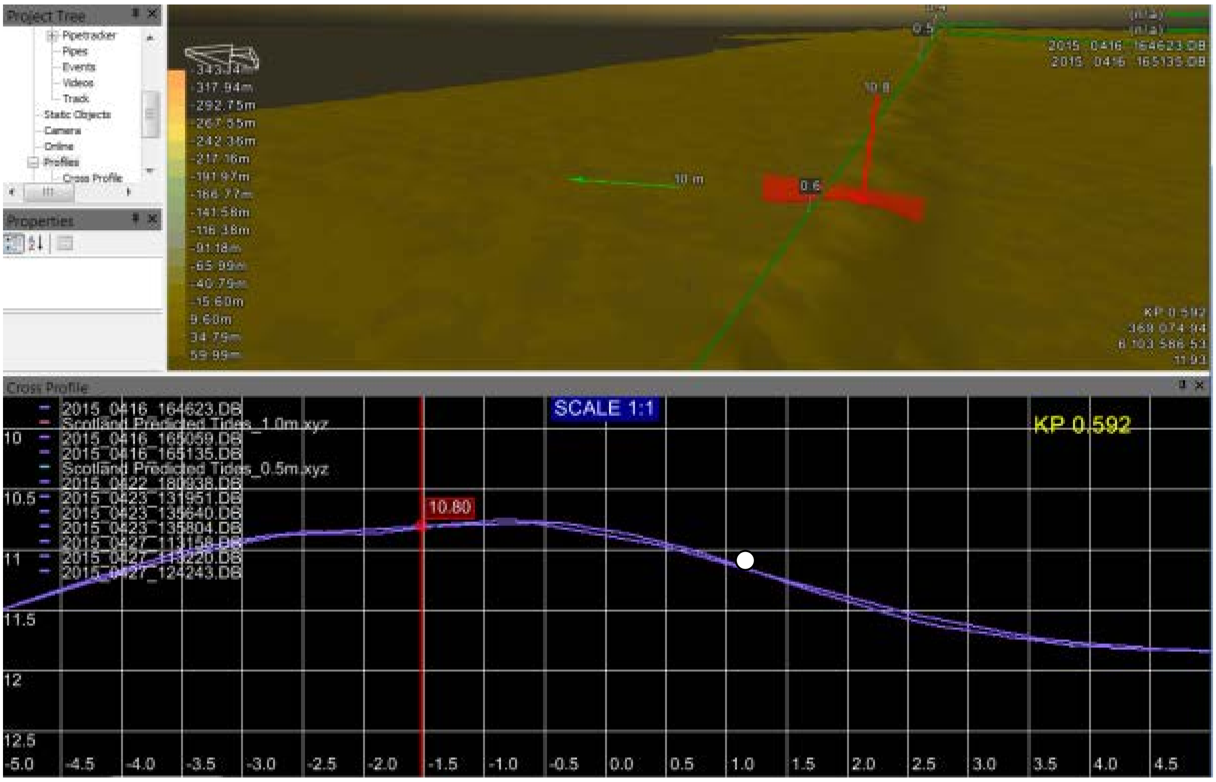


Figure 24 Berm profile

Figure 25 10-22 m Irish side

At the Irish side there are two sections with berm from 10 to 22 m. They are both 150 and 170 m. For this section the cable will be placed at the base of the rockberm.

Figure 26 Berm size Irish side

For the remaining section on both MRCN and MRCS the cable will be surface laid and there will be 0.6 m cover berm with 1-5 inch rock.

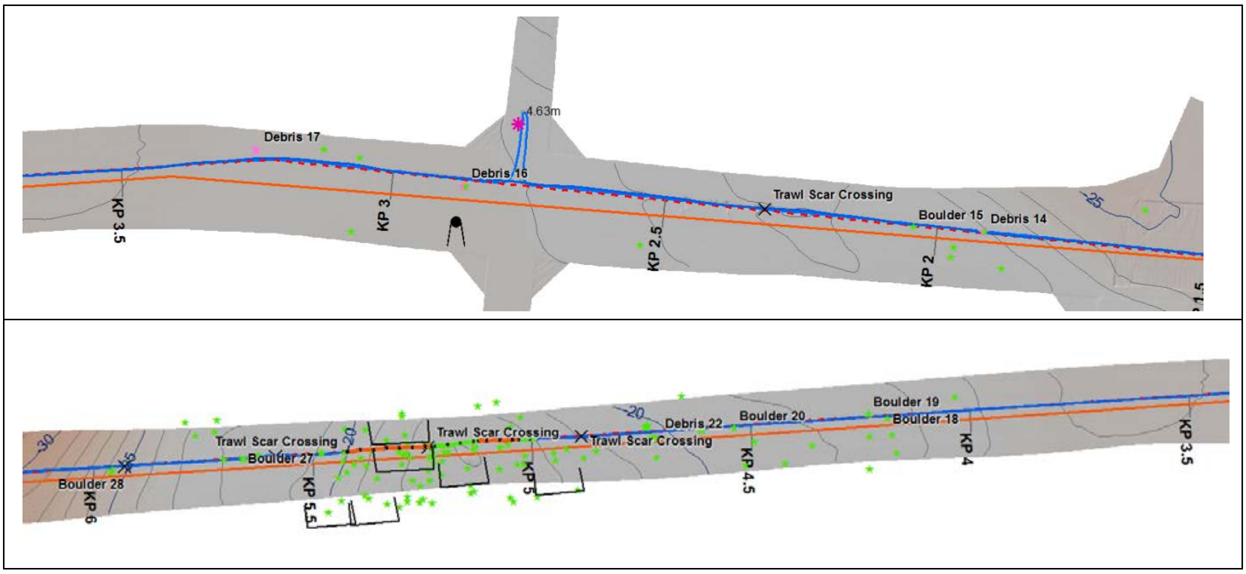
5.6.1 Offshore Deeper than 22 m KP 1.3 to KP 52.65

The deepwater section can be dived into several sections. For reference it used the KP of MRCN.

The detailed KP and system use is detailed in the spreadsheet. The summary below is a listing of the main section.

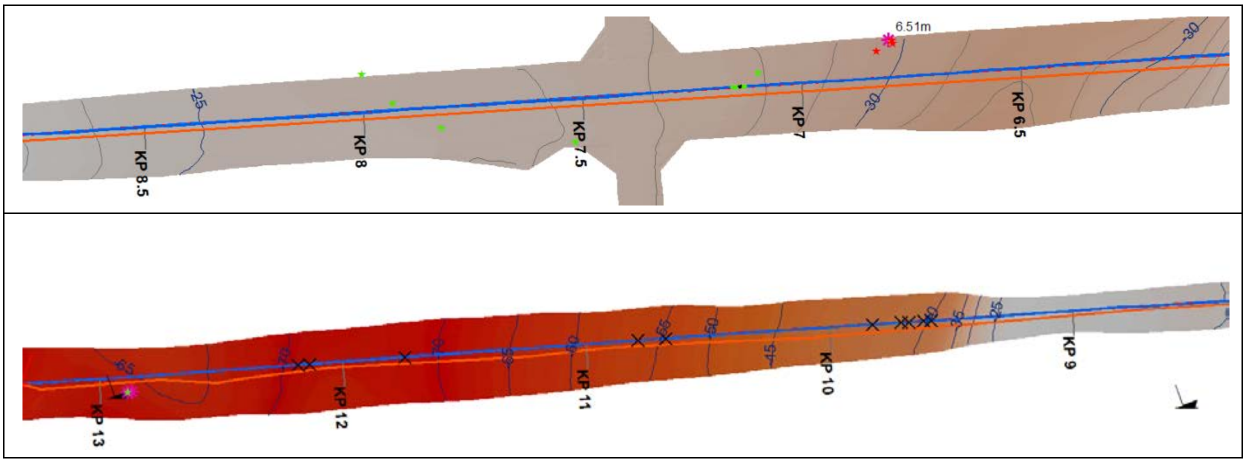
5.6.2 KP 1.3 to KP 6

Expect to bury to more than 1 m for most of this section. The CAPJET System A will be used with swords for burial depth of 1.2 m and deeper. Mostly sandy soil along this section. Expect to have some shorter section (400 m) with difficult conditions from KP 5 to KP 5.4 on North Cable and with shorter section on the MRCS (200 m). The hard section are dense with pebbles and some boulders.



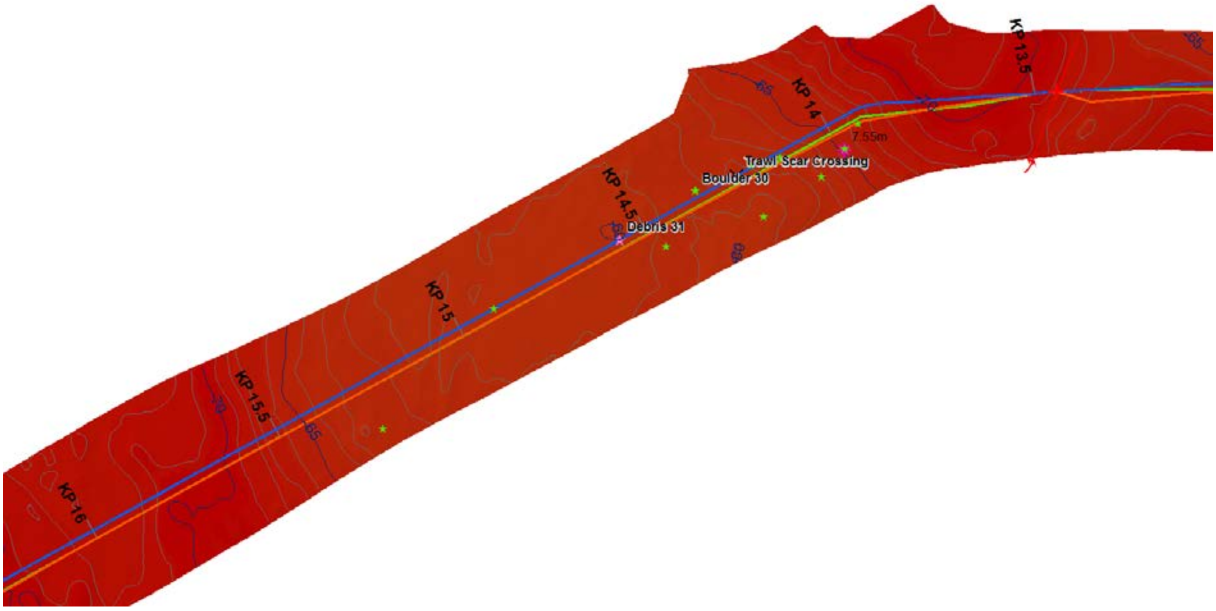
5.6.3 KP 6 to KP 13.3

Expect to bury most of this section to between 0.5 to 1 m. Some harder section with reduced burial depth. Section is planned with CAPJET System A



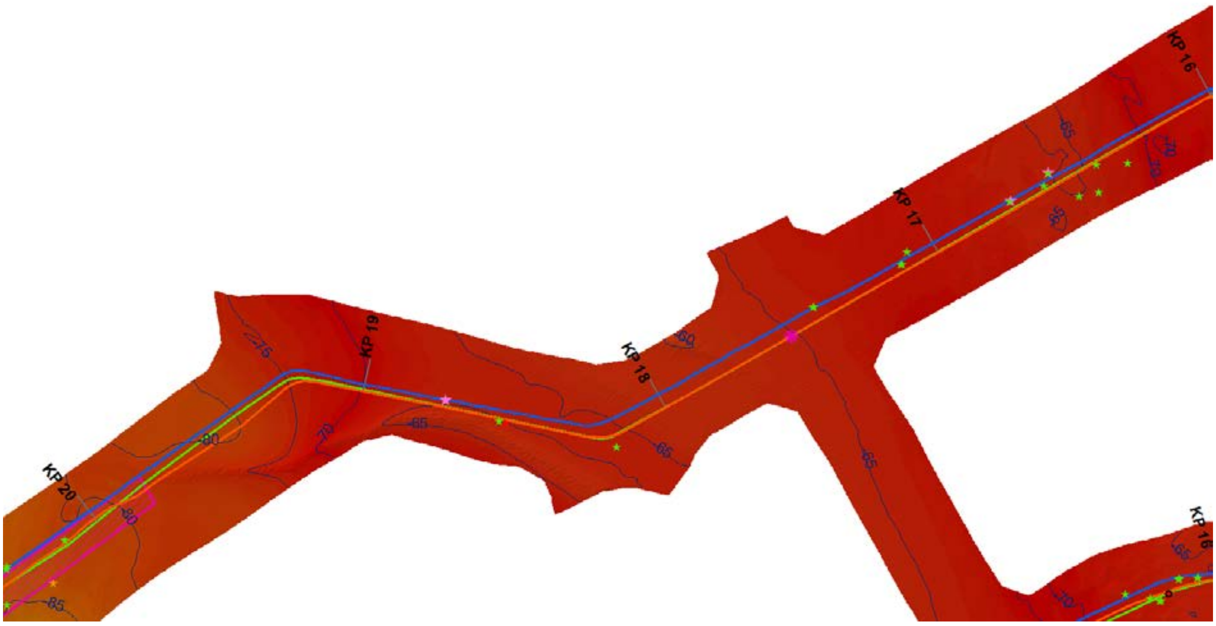
5.6.4 KP 13.3 to KP 16.3 – 3 km

Expect to bury most of this section to between 0.5 to 1 m. Some harder section with reduced burial depth. No rockdumping was performed in this section. Section is planned with CAPJET System A. The LANIS cable crossing is at KP 13.440.



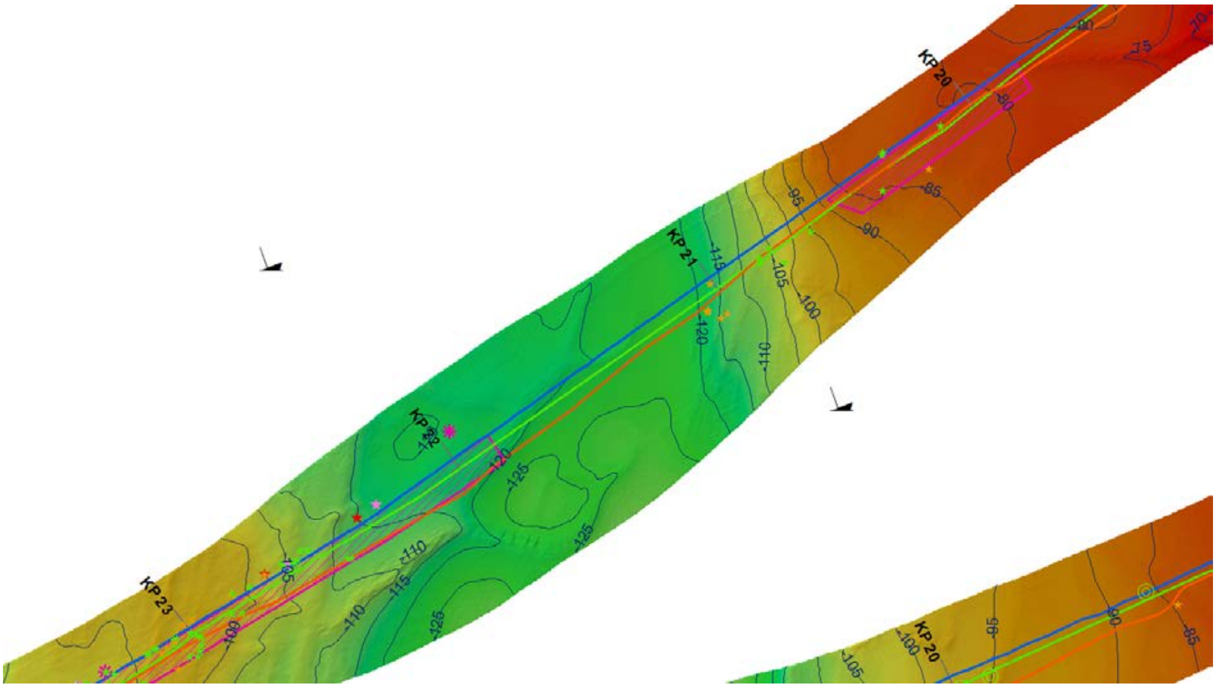
5.6.5 KP 16.3 to KP 20

Section is expected to be buried to 0.5 m and more than 1 m for most of the section. Section from 16.3 to KP 17.1 is planned with System B.



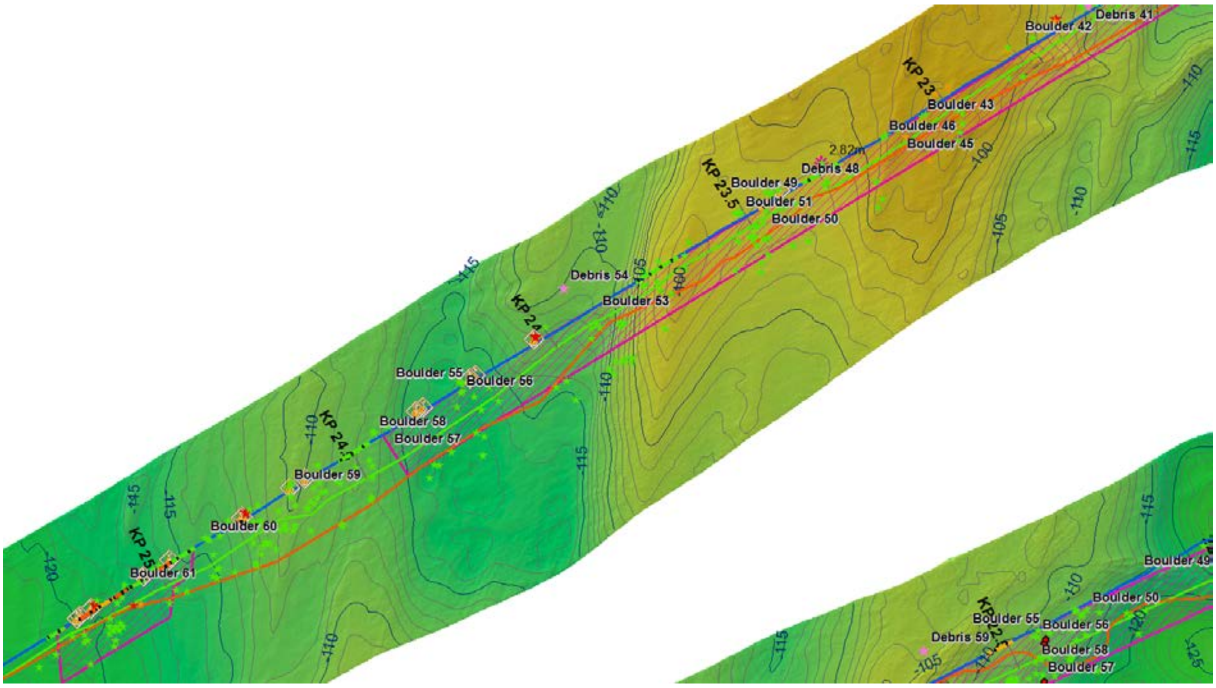
5.6.6 KP 20 to KP 23

Section is planned with System A. Some smaller sections – less than 100 m with expected very hard soil.



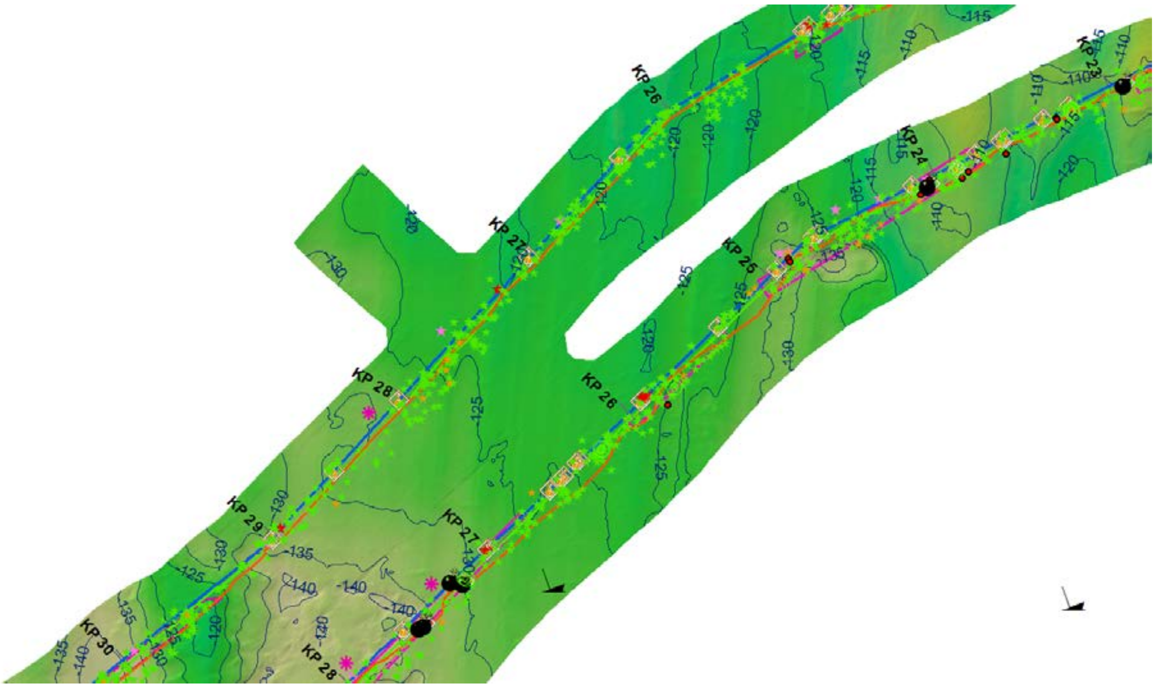
5.6.7 KP 23 to KP 25.2

Section is planned with System B. Some smaller sections – with expected burial depth of more than 1m.



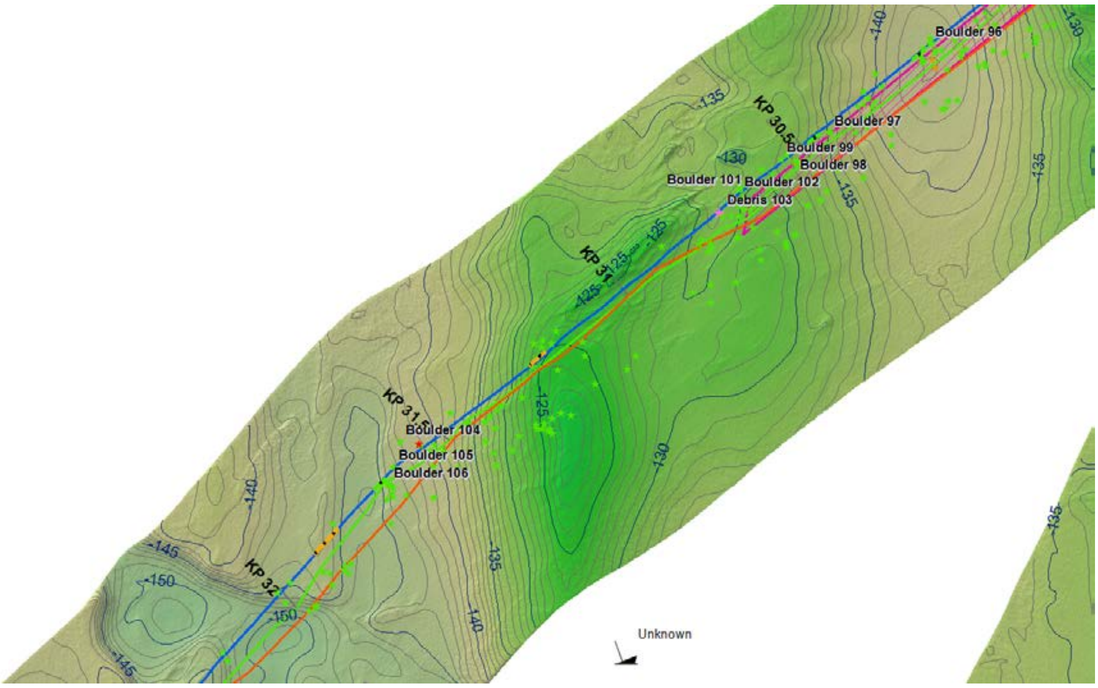
5.6.8 KP 25.2 to KP 29.7

Section is planned with System B. Some smaller sections – with expected burial depth of more than 1m.



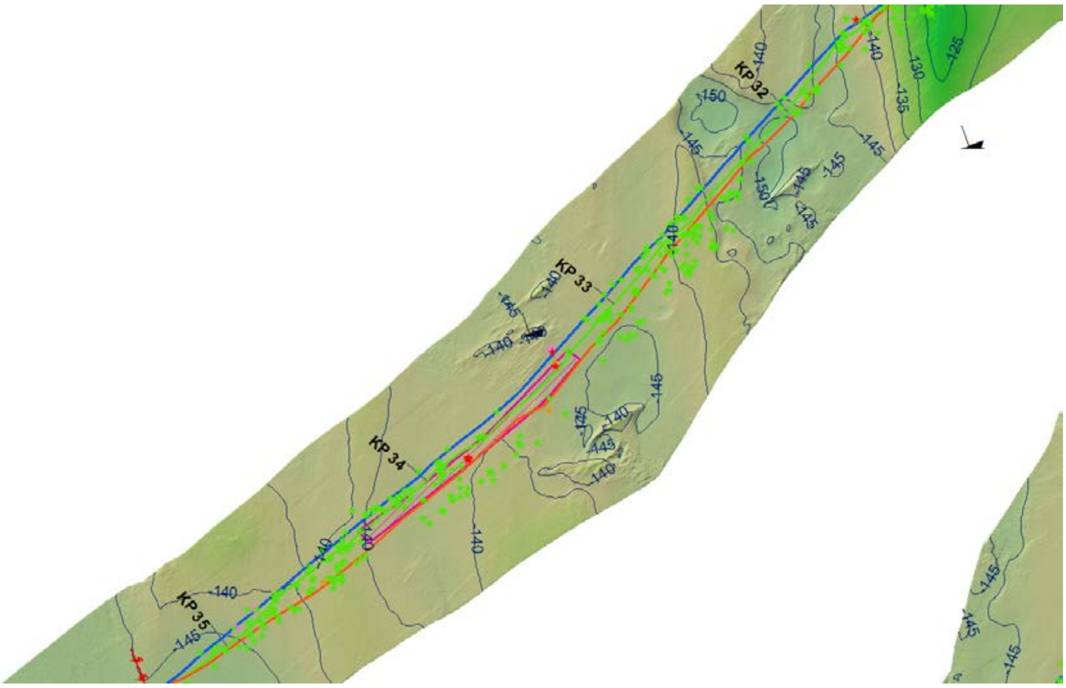
5.6.9 KP 29.7 to KP 32.3

Planned with System A. Some smaller section with hard soil within section.



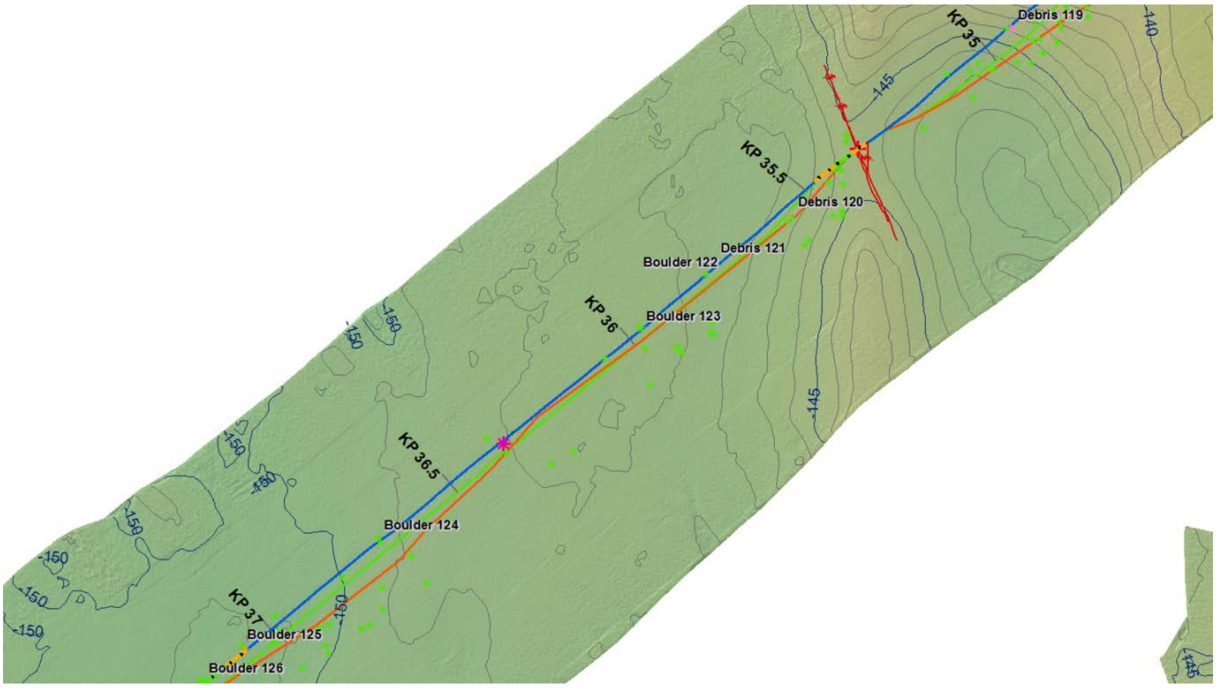
5.6.10 KP 32.3 to KP 35

Planned with System B. General very hard section.



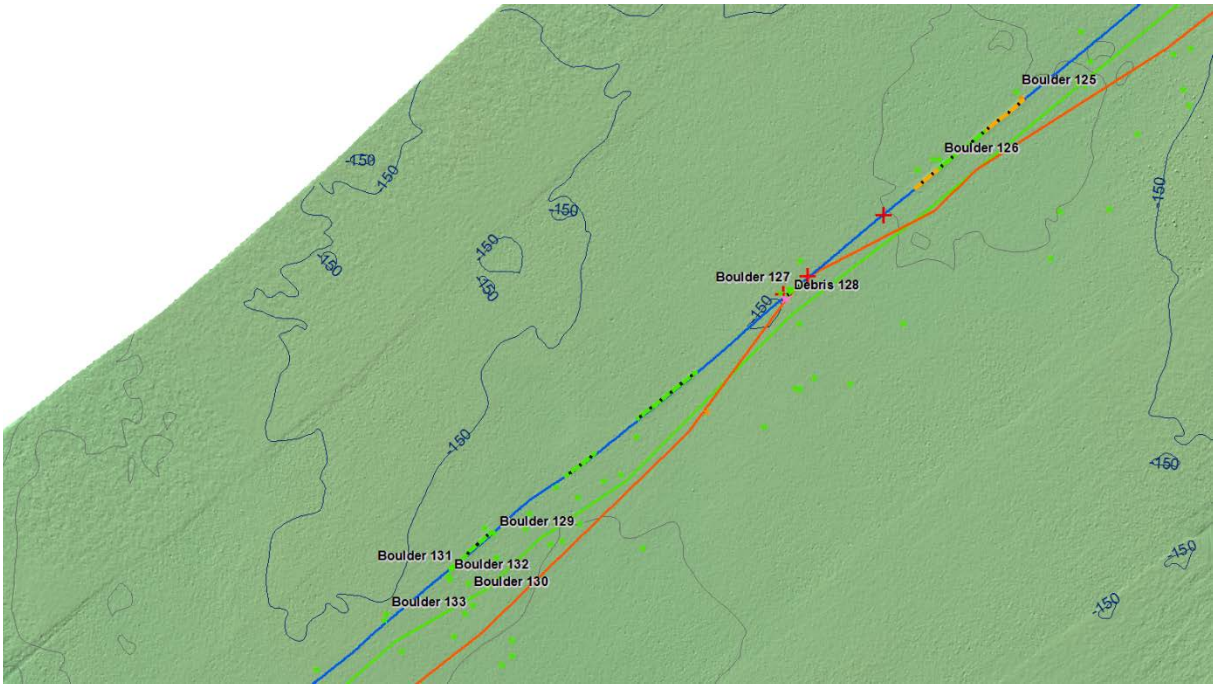
5.6.11 KP 35 to KP 37

Planned with System A. Relatively hard section. Expect less than 1 m burial.



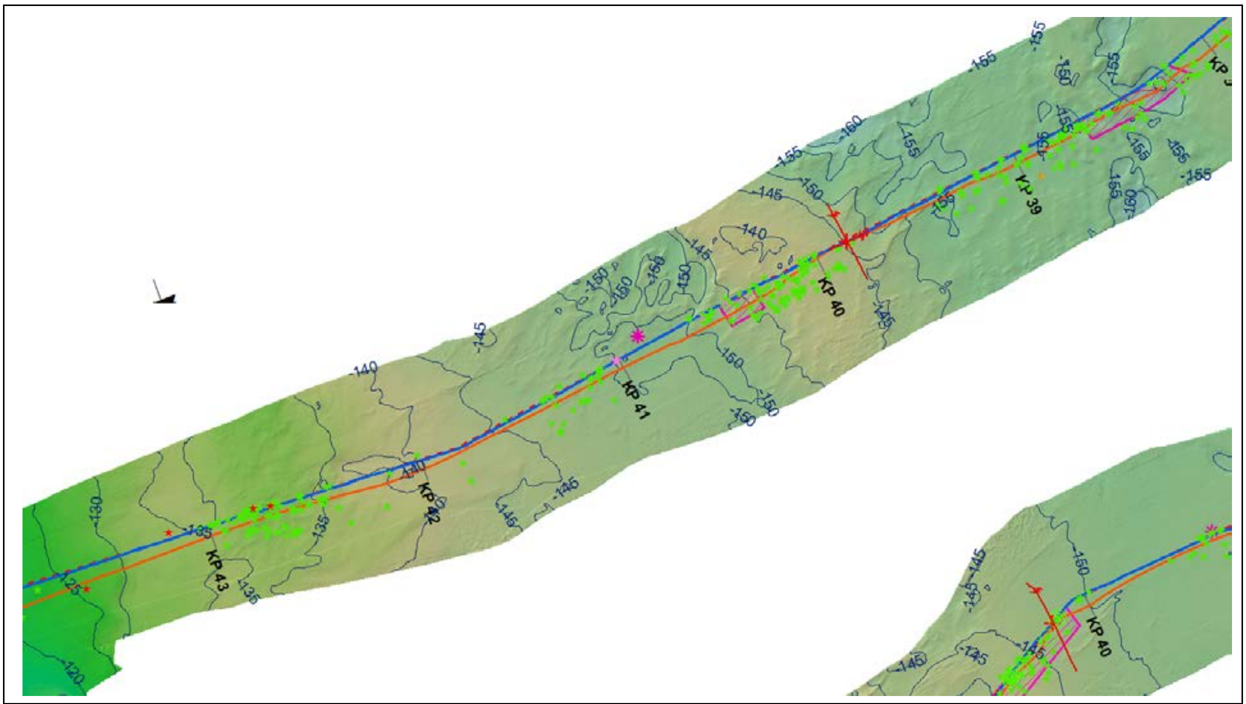
5.6.12 KP 37 to KP 38

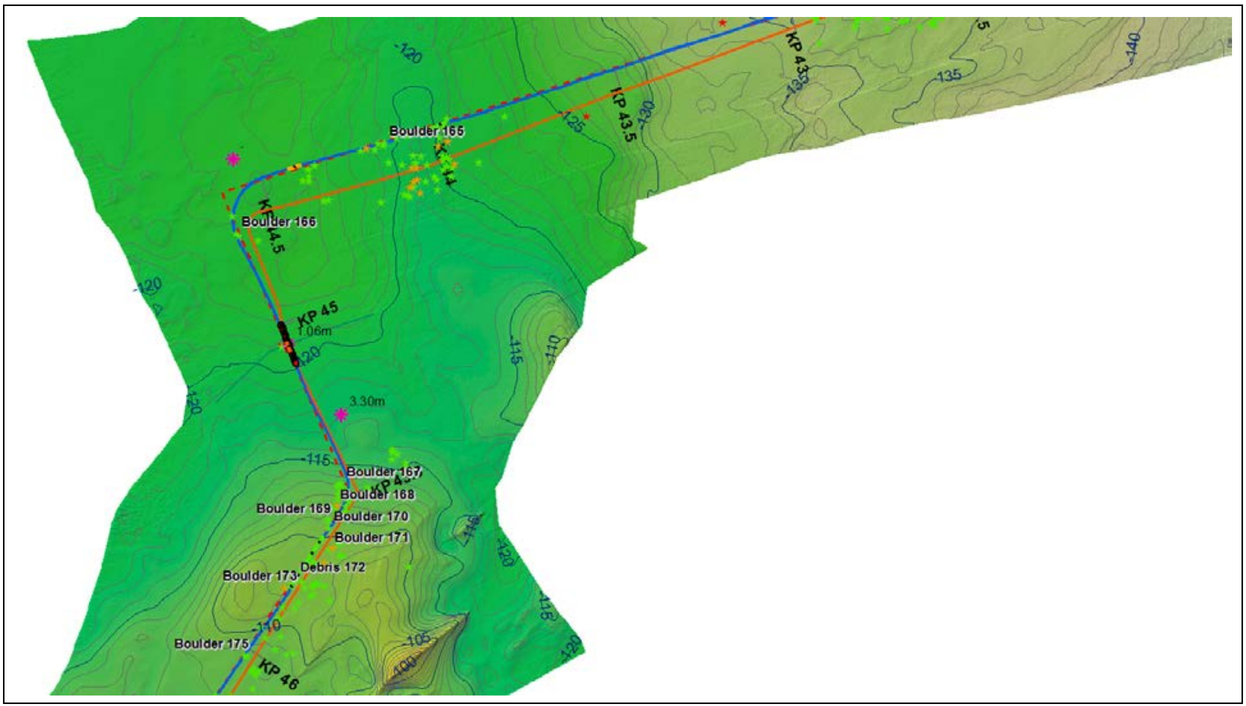
Planned with System B. Gravelly soil- mostly expect burial between 0.5 to 1 m.



5.6.13 KP 38 to KP 46.6

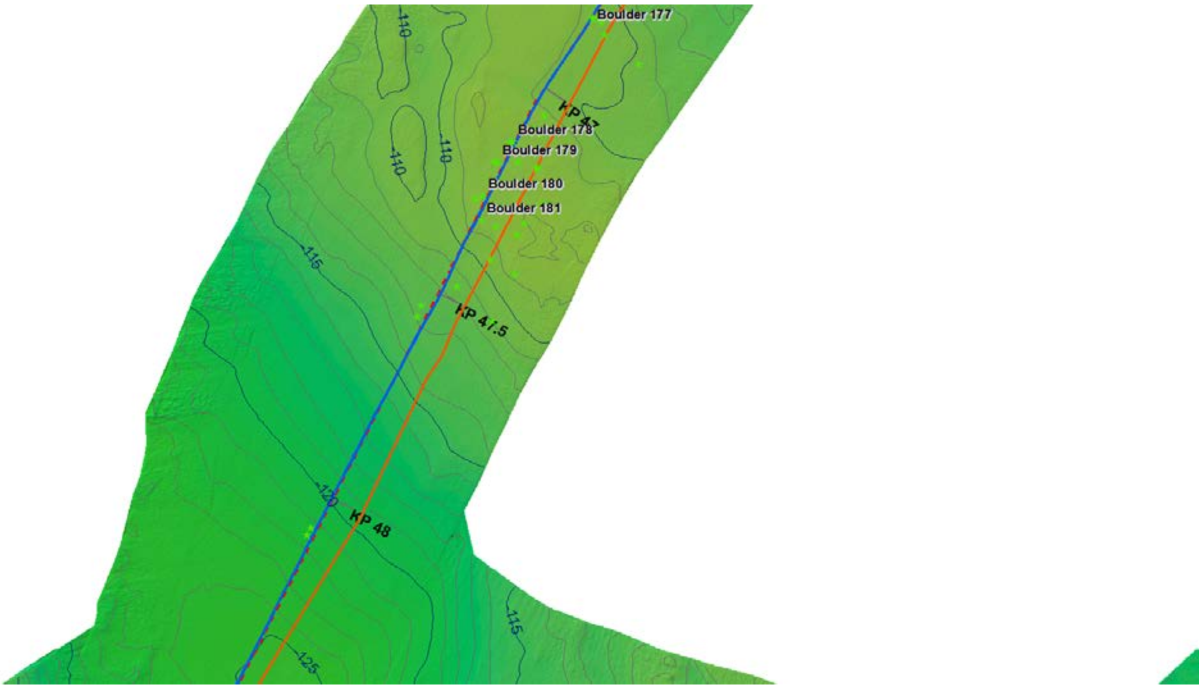
Most of section with expected burial of 0.5 to 1 m with some deep sections in between. Smaller section with harder soil. Section is planned with CAPJET B. This section also included the Sirius cable crossing at KP 39.8 and the pipeline crossing at KP 45.050.





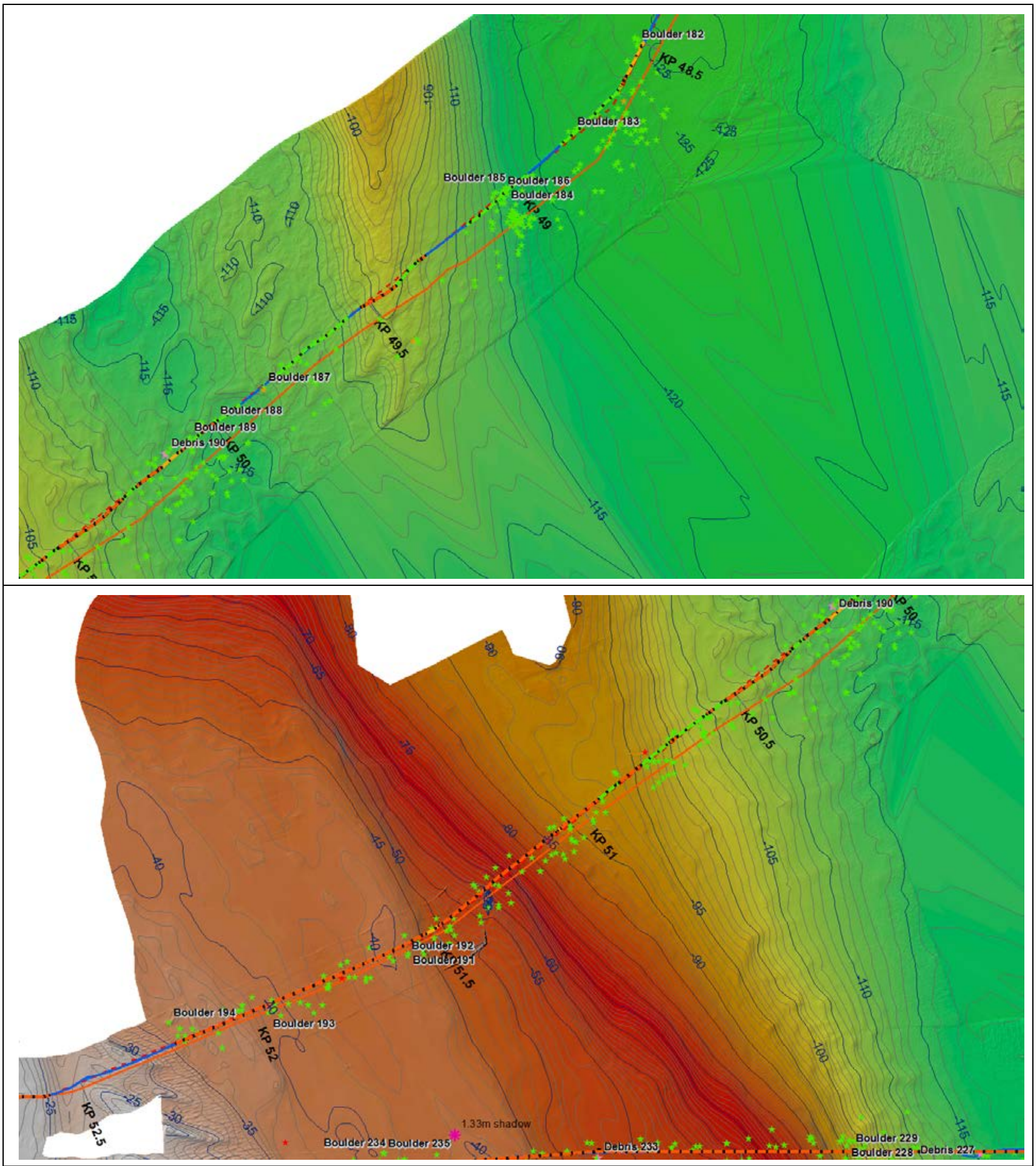
5.6.14 KP 46.6 to KP 48.5

Planned with CAPJET A. Some harder smaller sections.



5.6.15 KP 48.5 to KP 52.630

Entire section is very hard clay- partly mudstone. Smaller softer section with sand near the 22 m contour on the Irish side.



5.6.16 Nearshore KP52.63 to K53.000 -22 m to 10 m

The section from the 22 m contour to the 10 m contour will be rockdumped with 0.6 m berm and 1-5" rock. Contour of rockberm is described above.

5.6.17 Nearshore KP 53.000 to KP 53.180 10-5 m

Section will be rockdumped with the use of a splitbarge. It will approx 10t/m, and 0.6 m berm. The rock will be 1-8" rock. The entire section will also be protected with CIS. There is no rockdump in this area from 2002 as on the Scottish side.

5.6.18 Nearshore KP 52.180 (5m) to Low Water Mark

The section will be protected with CIS. In addition it will be buried in the old trench on top of the PE pipe.

5.6.19 Nearshore Low Water Mark to High Water Level

The section is protected with CIS and will be buried with excavator to approx 0.5 m depth. Burial depth is limited by the existing PE pipe.

5.7 Crossings

There are three cable crossings the Hibernia, Lanis and the Sirius cable and the crossing of the MOYLE gas pipeline.

All crossing are rockdumped during the installation in 2001.

The crossing of the cables will be installed with URADUCT or PPLDUCT and then rockdumped after the installation. The crossing of the pipeline will be made on the existing rockdump

5.7.1 Pipeline Crossing

The cable will be laid on top of the existing rock dump.

For the pipeline, the cable will be installed on the existing rockdump.

The cable will be protected with a 0.6 m cover berm in a length of max 50 m for each crossing including run in and run out.

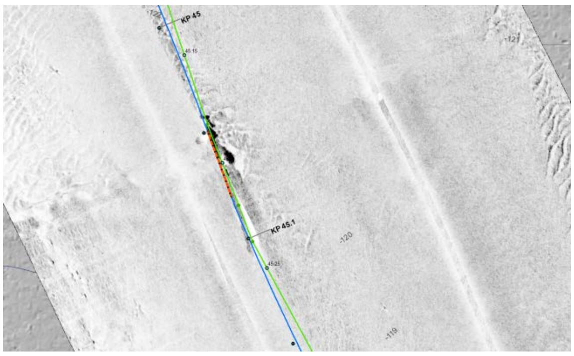


Figure 27 Pipeline crossing North

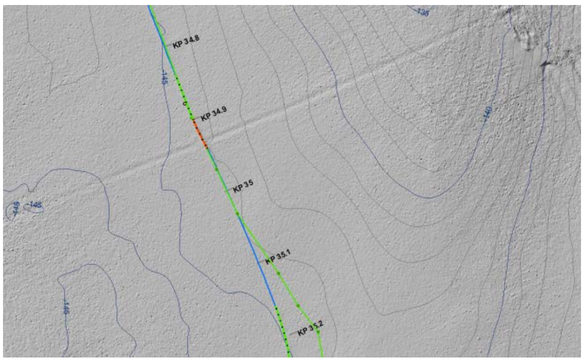


Figure 28 Pipeline crossing South

5.7.2 Sirius Crossing

On all cable crossing there will be installed a 50 m section of PPLDUCT.

Figure 29 Installation of PPLDUCT on cable

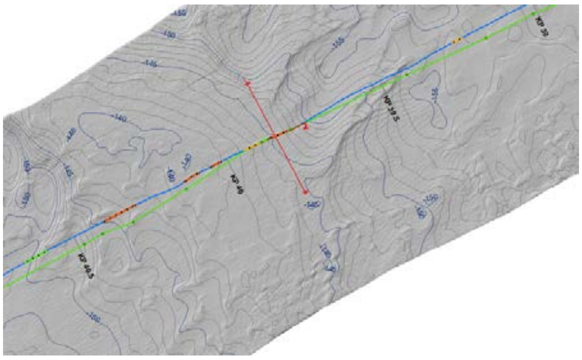


Figure 30 Sirius North

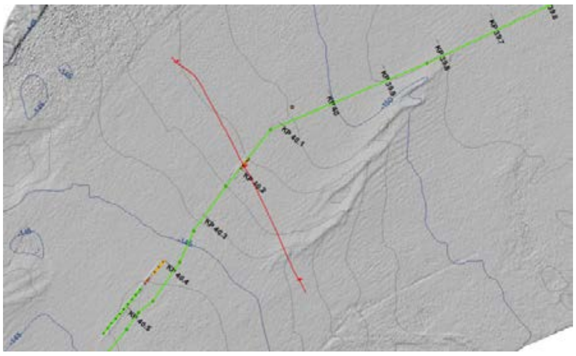


Figure 31 Sirius South

The rockdump length of the Sirius cable crossing is 20 m. The cable will be covered with 0.6 m cover berm after installation. The planned total length of the berm is 30 m including run in and run out.

5.7.3 Hibernia Crossing

The existing rockdump is 30 m and 50 m (North and South).

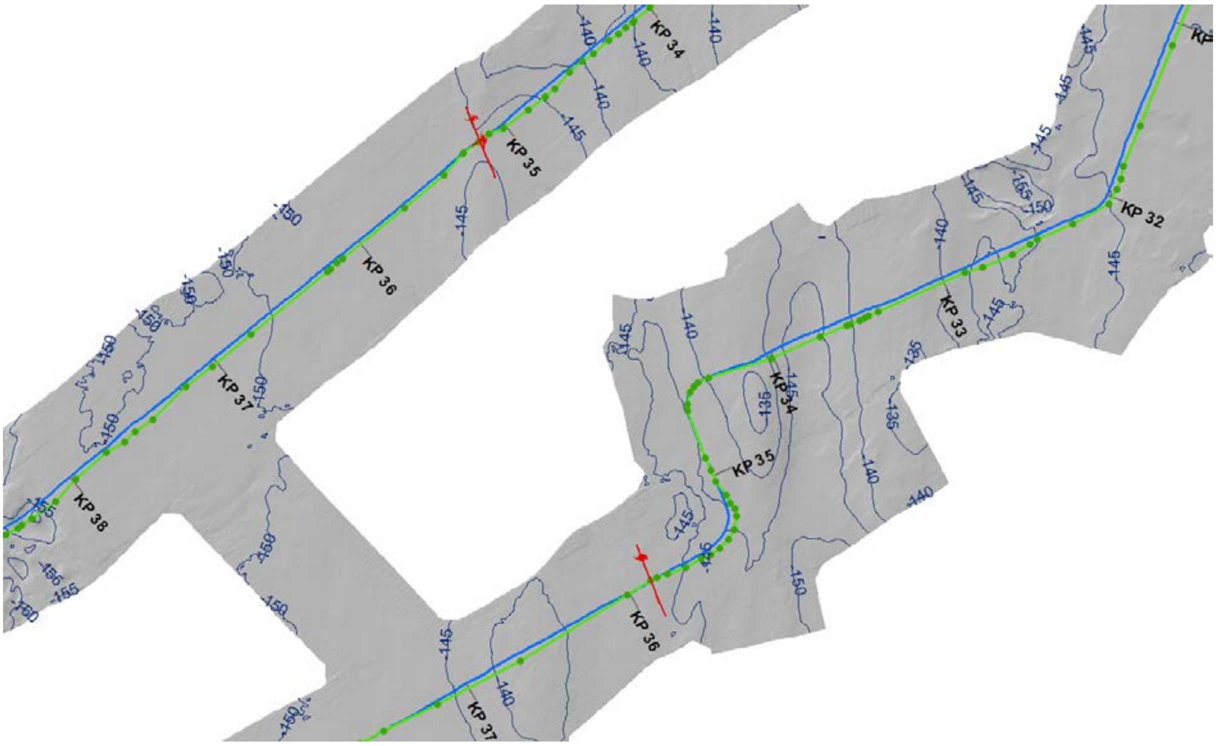


Figure 32 Hibernia Crossing

5.7.4 Lanis Crossing

There is not mapped any rockdump on the LANIS North Crossing. On the South Crossing there is mapped a 10 m long rockdump.

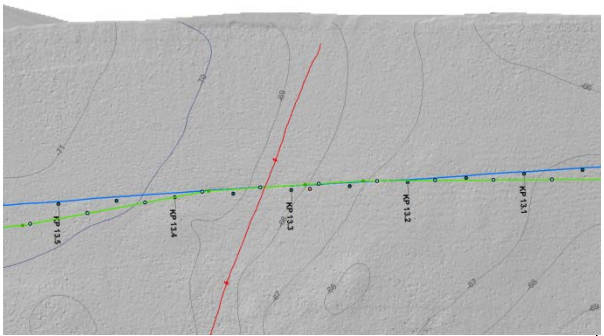


Figure 33 LANIS North crossing

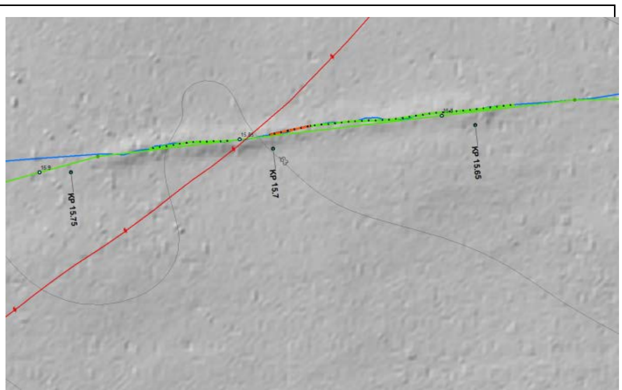


Figure 34 Lanis South Crossing

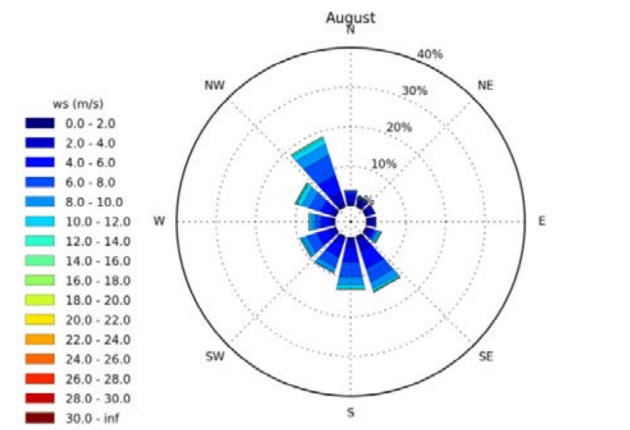
6 Environmental Conditions

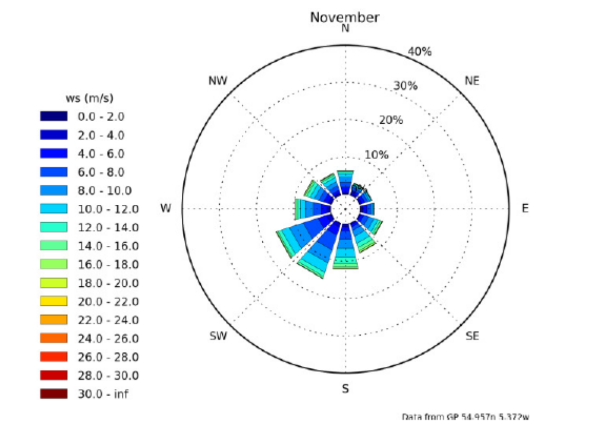
There are detailed statistical data for the East-Central and Western Location based on Metocean data set [4] to [6].

6.1 Wind / Waves

The relevant months are listed. From experience during the repair in 2011-12 and in 2014, the wind has been more southerly than shown in the statistics. However, it experience correlates well the data for the Eastern location on direction. There were also several measured winds of more than 50 knots during all repair periods. However, the periods are relatively short (often less than 12 hrs). It seems as the statistics under represent the short periods of very strong wind.

6.1.1 Wind Data West Location





Aug ws (m/s)	Direction (from) 345-<15	15-<45	45-<75	75-<105	105-<135	135-<165	165-<195	195-<225	225-<255	255-<285	265-<315	315-<345	Total
0-<2	0.8	0.7	0.8	0.8	0.7	0.9	0.7	0.4	0.5	0.4	0.5	1.0	8.3
2-<4	1.7	1.0	0.9	0.8	1.0	2.9	2.1	1.8	1.6	1.2	1.3	2.8	19.2
4-<6	0.8	0.4	0.5	0.5	0.7	4.6	3.6	3.2	2.9	2.0	2.3	4.5	26.0
6-<8	0.6	0.4	0.2	0.2	0.6	3.5	3.9	2.7	2.7	1.5	2.9	5.4	24.6
8-<10	0.1	0.2	0.1	0.2	0.5	1.8	2.0	1.3	1.3	1.0	2.0	2.8	13.4
10-<12	0.1	0.0	0.1	0.1	0.4	0.6	0.9	0.2	0.3	0.6	1.3	1.5	6.1
12-<14	0.0	0.0	0.0	0.0	0.2	0.2	0.3	0.0	0.1	0.1	0.3	0.5	1.8
14-<16	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.1	0.6
16-<18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
18-<20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20-<22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22-<24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>=24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	4.2	2.7	2.6	2.5	4.3	14.8	13.4	9.7	9.5	6.8	10.8	18.7	100.0

Table 2.3.9 Joint frequency analysis of mean wind speed and direction – August

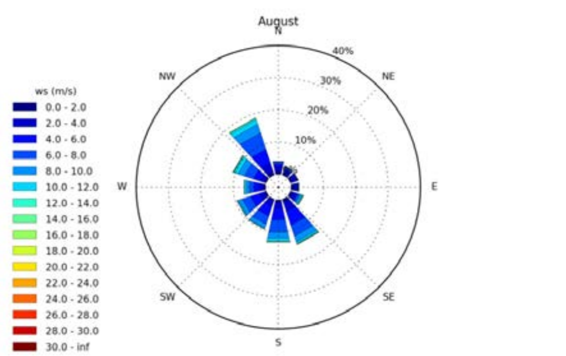
Nov ws (m/s)	Direction (from) 345-<15	15-<45	45-<75	75-<105	105-<135	135-<165	165-<195	195-<225	225-<255	255-<285	285-<315	315-<345	Total
0-<2	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.2	1.6
2-<4	0.5	0.6	0.5	0.7	0.3	0.3	0.6	1.0	1.2	0.7	0.7	0.5	7.5
4-<6	1.5	0.7	0.9	1.1	0.8	0.7	1.2	2.3	2.4	1.7	1.3	0.8	15.4
6-<8	1.3	0.8	0.8	1.2	1.4	1.0	2.2	4.2	4.2	2.2	1.4	1.3	21.8
8-<10	1.3	0.5	0.6	0.5	1.5	1.7	2.5	3.7	4.0	2.1	1.3	1.1	20.8
10-<12	1.1	0.3	0.4	0.2	1.1	2.0	2.5	2.7	2.2	1.5	1.2	1.2	16.3
12-<14	0.5	0.3	0.1	0.1	0.6	1.2	1.7	1.1	1.1	0.7	1.0	0.7	9.0
14-<16	0.2	0.1	0.1	0.0	0.5	0.9	1.0	0.5	0.3	0.5	0.5	0.3	5.0
16-<18	0.1	0.1	0.0	0.0	0.1	0.5	0.3	0.1	0.2	0.1	0.3	0.2	1.9
18-<20	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.1	0.1	0.5
20-<22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
22-<24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>=24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	6.6	3.4	3.5	3.8	6.5	8.4	12.4	15.6	15.8	9.8	7.8	6.2	100.0

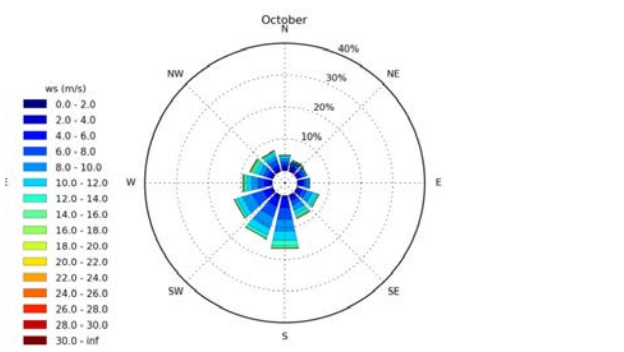
Table 2.3.12 Joint frequency analysis of mean wind speed and direction – November

The port Muck location is both exposed to all wind direction except West. And the dry section on the pictures is only on low tide, so the area is exposed to both waves and current. The majority of all waiting for the dive work was at the Irish side in 2001.

Figure 35 Port Muck

6.1.2 Wind Data Central Location





Aug	Direction (from)												
hs (m)	345-<15	15-<45	45-<75	75-<105	105-<135	135-<165	165-<195	195-<225	225-<255	255-<285	285-<315	315-<345	Total
0.0-<0.5	0.9	0.6	0.2	0.1	0.2	1.5	6.0	3.4	2.2	3.2	15.0	4.6	38.1
0.5-<1.0	0.4	0.4	0.1	0.2	0.2	2.0	12.8	3.6	2.8	3.1	9.7	6.7	42.0
1.0-<1.5	0.0	0.1	0.0	0.0	0.1	0.7	4.7	0.9	0.9	0.9	3.4	2.4	14.2
1.5-<2.0	0.0	0.0	0.0	0.0	0.0	0.4	1.4	0.0	0.1	0.2	1.5	0.7	4.3
2.0-<2.5	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.0	0.0	0.1	0.2	0.2	1.0
2.5-<3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.1	0.3
3.0-<3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.5-<4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0-<4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.5-<5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>=5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	1.4	1.1	0.4	0.4	0.5	4.6	25.5	7.9	6.0	7.5	30.0	14.8	100.0

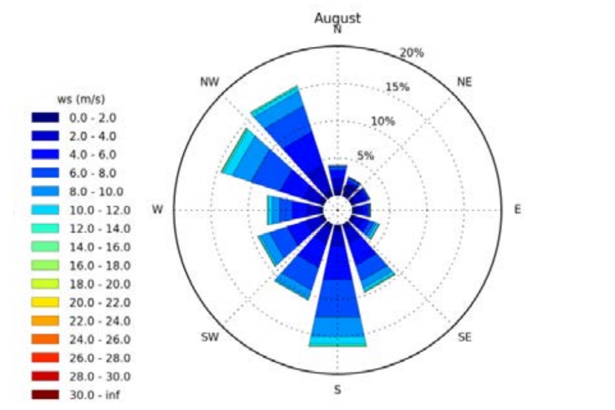
Table 3.3.9 Joint frequency analysis of significant wave height and direction– August

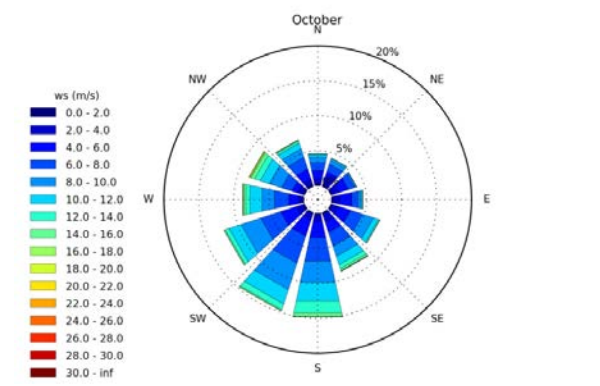
Oct	Direction (from)												
hs (m)	345-<15	15-<45	45-<75	75-<105	105-<135	135-<165	165-<195	195-<225	225-<255	255-<285	285-<315	315-<345	Total
0.0-<0.5	0.6	1.1	0.2	0.3	0.4	1.0	1.8	1.5	0.9	1.3	4.7	2.2	16.0
0.5-<1.0	1.3	1.3	0.4	0.3	0.7	3.7	7.8	3.6	2.6	3.2	6.9	4.0	35.9
1.0-<1.5	0.8	0.3	0.1	0.1	0.4	2.9	7.3	3.1	2.4	2.4	3.7	2.1	25.5
1.5-<2.0	0.2	0.1	0.0	0.0	0.0	1.0	4.8	1.3	0.7	1.3	2.4	1.1	12.9
2.0-<2.5	0.0	0.0	0.0	0.0	0.0	0.4	2.9	0.5	0.2	0.4	1.3	0.5	6.2
2.5-<3.0	0.0	0.0	0.0	0.0	0.0	0.1	1.1	0.0	0.1	0.1	0.6	0.3	2.3
3.0-<3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.3	0.1	0.7
3.5-<4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.4
4.0-<4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1
4.5-<5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>=10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	3.1	2.8	0.7	0.7	1.6	9.2	26.1	9.9	6.8	8.7	20.2	10.3	100.0

Table 3.3.11 Joint frequency analysis of significant wave height and direction– October

6.1.3 Wind and Waves Eastern Location

The change to southerly direction correlates well with on site observation from October November work.





Aug ws (m/s)	Direction (from) 345-<15	15-<45	45-<75	75-<105	105-<135	135-<165	165-<195	195-<225	225-<255	255-<285	285-<315	315-<345	Total
0-<2	0.8	0.8	0.6	0.5	0.6	0.7	0.7	0.7	0.5	0.5	0.7	0.9	7.9
2-<4	1.5	1.0	1.2	1.0	1.1	2.0	2.2	2.0	2.0	1.7	2.1	3.5	21.3
4-<6	1.2	0.5	0.5	0.6	0.8	3.1	4.6	3.4	2.6	2.1	3.3	4.7	27.5
6-<8	0.5	0.4	0.2	0.2	0.7	2.2	5.1	3.2	2.5	1.7	4.1	3.6	24.4
8-<10	0.1	0.1	0.1	0.1	0.4	1.0	2.7	1.2	1.3	1.0	2.6	2.1	12.7
10-<12	0.0	0.0	0.0	0.0	0.3	0.4	1.1	0.2	0.3	0.6	1.3	0.6	4.8
12-<14	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.0	0.1	0.1	0.2	0.2	1.2
14-<16	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.2
16-<18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18-<20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20-<22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22-<24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>=24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	4.2	2.7	2.6	2.5	4.0	9.6	16.7	10.7	9.3	7.6	14.5	15.6	100.0

Table 2.3.9 Joint frequency analysis of mean wind speed and direction – August

Oct ws (m/s)	Direction (from) 345-<15	15-<45	45-<75	75-<105	105-<135	135-<165	165-<195	195-<225	225-<255	255-<285	285-<315	315-<345	Total
0-<2	0.3	0.3	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.3	0.3	2.8
2-<4	0.7	0.9	0.9	1.1	0.9	1.1	0.9	0.9	1.0	0.6	0.7	0.8	10.6
4-<6	1.2	1.0	1.5	1.8	1.8	1.6	2.4	2.4	2.4	1.5	0.9	1.5	20.0
6-<8	1.1	1.1	0.9	0.9	1.8	2.0	3.4	4.1	3.0	2.1	1.5	1.8	23.8
8-<10	0.9	0.6	0.2	0.4	1.6	1.6	3.1	4.0	3.0	1.8	1.8	1.3	20.3
10-<12	0.4	0.2	0.1	0.2	0.7	1.3	2.7	2.2	1.8	1.8	1.4	0.9	13.6
12-<14	0.1	0.0	0.0	0.0	0.2	0.6	1.7	0.9	0.6	0.6	0.9	0.3	5.9
14-<16	0.0	0.0	0.0	0.0	0.0	0.3	0.6	0.2	0.2	0.3	0.5	0.2	2.3
16-<18	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.2	0.0	0.4
18-<20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.3
20-<22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22-<24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>=24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	4.7	4.3	3.9	4.6	7.4	8.8	15.2	14.8	12.1	9.0	8.3	7.0	100.0

Table 2.3.11 Joint frequency analysis of mean wind speed and direction – October

Figure 36 landfall in Scotland

For the landfall in Scotland, it will be difficult to do any dive work or splitbarge work with Westerly or Northernly wind direction.

Especially the dive work will be very limited by the wind and waves, both due to vessel sixe and operation from 5 to 0 m of water.

6.2 Current

The current on the Scottish side is moderate and in general less than 1 knots. There is performed current measurement for the repair work in 2014, and it shows very moderate current. This was also confirmed during the actual dive work with no waiting dive due to current during one months work.

At the Irish side the current is very strong and will impact both shallow and deepwater operation. The system setup on CAPJET is also planned to make it handle the strong current. There is also expected some hours of waiting every day for the operation closer to Ireland.

All-year Surface Current Spd (m/s)	Direction (towards)												
	345-<15	15-<45	45-<75	75-<105	105-<135	135-<165	165-<195	195-<225	225-<255	255-<285	285-<315	315-<345	Total
0.0-<0.1	0.9	0.6	0.5	0.6	0.9	0.9	0.6	0.4	0.3	0.4	0.6	0.9	7.5
0.1-<0.2	1.3	0.2	0.1	0.2	1.3	2.8	0.6	0.1	0.1	0.2	0.8	2.5	10.3
0.2-<0.3	0.6	0.0	0.0	0.0	0.8	4.2	0.2	0.0	0.0	0.0	0.6	3.9	10.3
0.3-<0.4	0.2	0.0	0.0	0.0	0.4	5.2	0.0	0.0	0.0	0.0	0.5	4.9	11.2
0.4-<0.5	0.0	0.0	0.0	0.0	0.2	5.9	0.0	0.0	0.0	0.0	0.4	5.5	12.0
0.5-<0.6	0.0	0.0	0.0	0.0	0.1	6.1	0.0	0.0	0.0	0.0	0.2	5.5	12.0
0.6-<0.7	0.0	0.0	0.0	0.0	0.0	5.7	0.0	0.0	0.0	0.0	0.1	5.1	11.0
0.7-<0.8	0.0	0.0	0.0	0.0	0.0	4.9	0.0	0.0	0.0	0.0	0.1	4.3	9.3
0.8-<0.9	0.0	0.0	0.0	0.0	0.0	3.9	0.0	0.0	0.0	0.0	0.0	3.7	7.5
0.9-<1.0	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	2.6	5.1
1.0-<1.1	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.0	1.5	2.7
1.1-<1.2	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.7	1.0
1.2-<1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.2
1.3-<1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.4-<1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>=1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	3.0	0.8	0.6	0.9	3.6	43.5	1.5	0.5	0.4	0.6	3.3	41.3	100.0

Table 4.2.1 Joint Frequency distribution of surface current speed and direction – All-year

Figure 37 Current Western Location

All-year Surface Current Spd (m/s)	Direction (towards)												
	345-<15	15-<45	45-<75	75-<105	105-<135	135-<165	165-<195	195-<225	225-<255	255-<285	285-<315	315-<345	Total
0.0-<0.1	1.6	0.9	0.5	0.5	0.7	1.3	1.5	1.2	0.7	0.7	0.8	1.4	11.7
0.1-<0.2	4.0	0.4	0.1	0.1	0.2	2.0	4.4	1.3	0.4	0.4	0.6	2.3	16.3
0.2-<0.3	5.8	0.1	0.0	0.0	0.1	1.4	6.8	1.0	0.2	0.1	0.2	2.1	17.8
0.3-<0.4	6.6	0.0	0.0	0.0	0.0	0.5	7.7	0.6	0.0	0.0	0.0	1.6	17.1
0.4-<0.5	6.3	0.0	0.0	0.0	0.0	0.1	6.7	0.4	0.0	0.0	0.0	0.9	14.4
0.5-<0.6	5.4	0.0	0.0	0.0	0.0	0.0	4.8	0.2	0.0	0.0	0.0	0.3	10.8
0.6-<0.7	4.2	0.0	0.0	0.0	0.0	0.0	2.6	0.1	0.0	0.0	0.0	0.1	7.0
0.7-<0.8	2.5	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	3.5
0.8-<0.9	1.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	1.1
0.9-<1.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
1.0-<1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1-<1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>=1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	37.8	1.5	0.6	0.5	1.0	5.4	35.6	4.7	1.4	1.1	1.7	8.7	100.0

Table 4.2.1 Joint Frequency distribution of surface current speed and direction – All-year

Figure 38 Current Central Location

All-year Surface Current Spd (m/s)	Direction (towards) 345-<15	15-<45	45-<75	75-<105	105-<135	135-<165	165-<195	195-<225	225-<255	255-<285	285-<315	315-<345	Total
0.0-<0.1	20.1	0.0	0.0	0.0	0.0	0.0	27.8	0.0	0.0	0.0	0.0	0.0	47.9
0.1-<0.2	15.1	0.0	0.0	0.0	0.0	0.0	21.4	0.0	0.0	0.0	0.0	0.0	36.5
0.2-<0.3	8.2	0.0	0.0	0.0	0.0	0.0	5.3	0.0	0.0	0.0	0.0	0.0	13.5
0.3-<0.4	1.9	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	2.0
0.4-<0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>=0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	45.3	0.0	0.0	0.0	0.0	0.0	54.7	0.0	0.0	0.0	0.0	0.0	100.0

Table 4.2.1 Joint Frequency distribution of surface current speed and direction – All-year

Figure 39 Current Eastern Location

The current will be a limiting factor for the dive work in Port Muck. The work operation has to be planned according the tidal table. And as can be seen from the photos during the nearshore survey, the area is very exposed to current-also from North. It is protected only on low water from current through the strait.

Figure 40 Current and wind in Port Muck

Figure 41 Current in Port Muck

6.3 Tide

The tide difference is from 2.5 to more than 3 m. Thw work has to be planned according to tidal tables, but this is mostly due to the corresponding current (in PortMuck). It was also experienced waiting time on current both for the fallpipe vessel, the cable lay and the CAPJET operation.

Figure 42 Intertidal zone in Ireland

6.4 Mobile Sediment

It given graphs with results from various survey in the Utech Report /[7]/

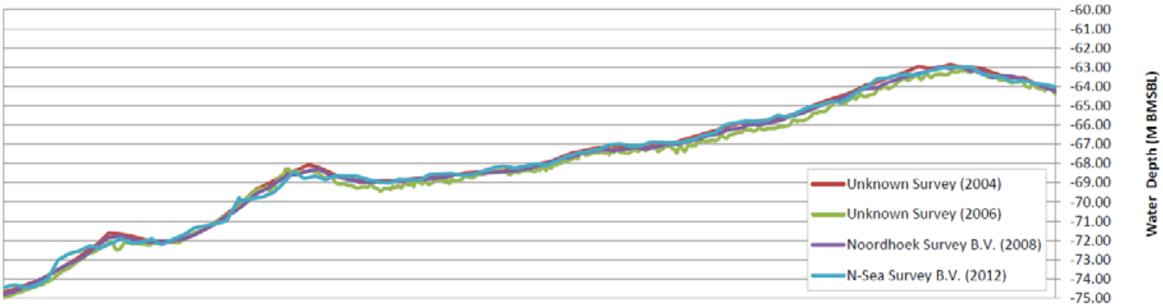
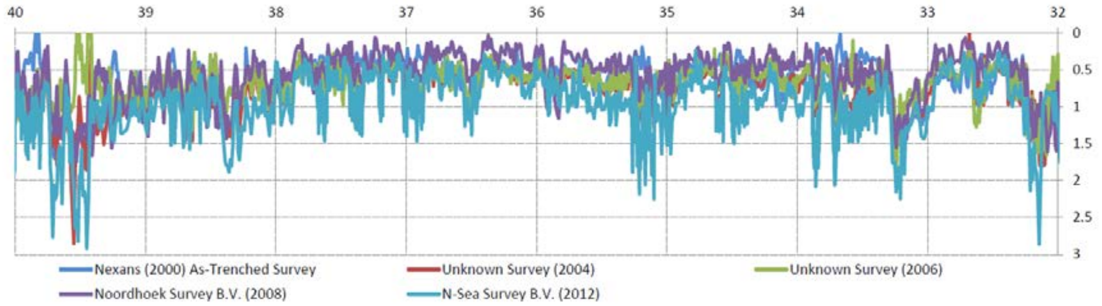


Figure 4-4: Example Southern Cable Bathymetry Data Comparison (KP17 to KP18)



As it is concluded in the report, the deviation mostly can be described as survey inaccuracy. The only survey performed with TSS350, was the Nexans survey in 2001. Other survey were performed with TSS440, which has very strong limitation beyond 1m burial depth.

However, there are very clear sections along the route wind sandwaves. The sandwaves did not present any practical problems during the installation in 2001, neither for laying or trenching.

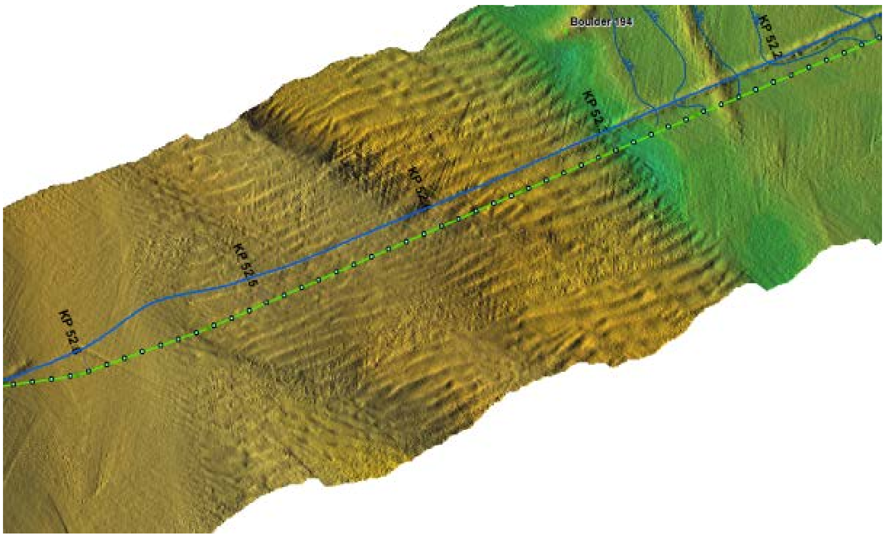


Figure 43 Mobile sediment MRCNOrth

2

7 Fishing and Shipping

The main fishing activity and relevant risk assessment is listed in F14_UTEC Geomarine report for Moyle 020714 ref [[7]].

Below is a very brief abstract from the report which give high dernsity area near Scotland and Ireland. There is also high density of scallop dredging at the Scottish side. The cable is very well protected by the equipment used on these fishing shipping vessel.

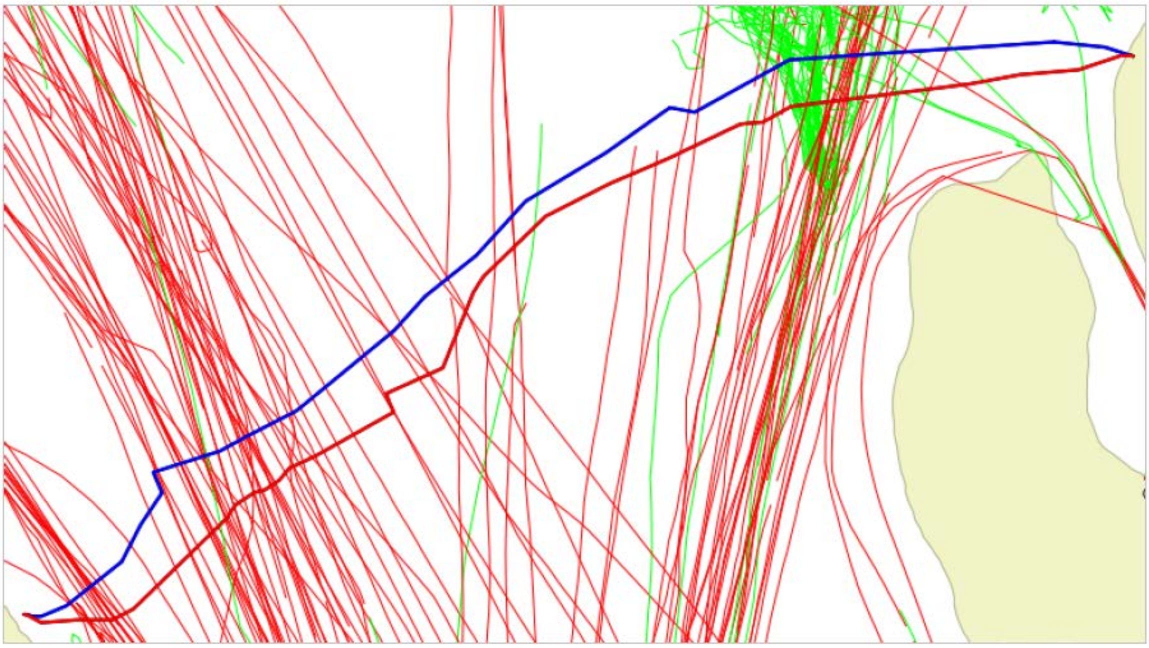


Figure 44 AIS fishing vessel tracks /ref UTECH Report/[[7]]/

Cable	KP	Predominant Risk	Fishing Intensity	Seabed Geology	Estimated Gear Penetration (m)
North	0.00 – 7.20	Beam & Otter Trawlers	Low	Variable (SAND, CLAY, GLACIAL TILL & MARL)	Negligible to 0.3
	7.20 - 12.10	Beam & Otter Trawlers	Medium	SAND	0.1 to 0.3
	12.10 – 15.50	Beam & Otter Trawlers	High	SAND & GRAVEL	0.1 to 0.3
	15.50 – 53.30	Beam & Otter Trawlers	Low	Variable (SAND, CLAY, GLACIAL TILL & MARL)	0.1 to 0.3

Figure 45 Penetration depth of trawlers ref UTECH Report /[7]

The values correlates well with the results from the DNV Report on anchor/trawlboard penetration, ref [1]

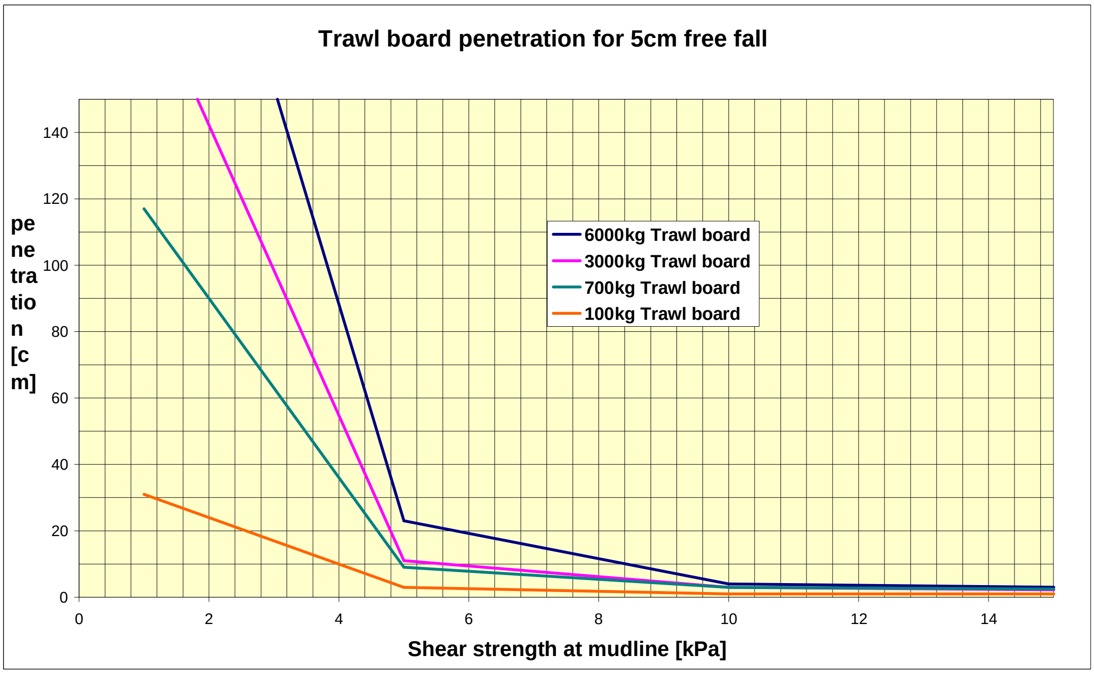


Figure 46 Trawl board penetration depth when passing a 5 cm unevenness

The figure above correlates well to observation of trawlmarks in very soft clay. They are often observed to have more than 0.5 m depth.

7.1 Shipping

A detailed analysis is made of the ships traffic. This is presented in the UTECH Report /[7] / and the traffic plotted in the picture below. It basically presents the high density of the ferry traffic crossing the cable.

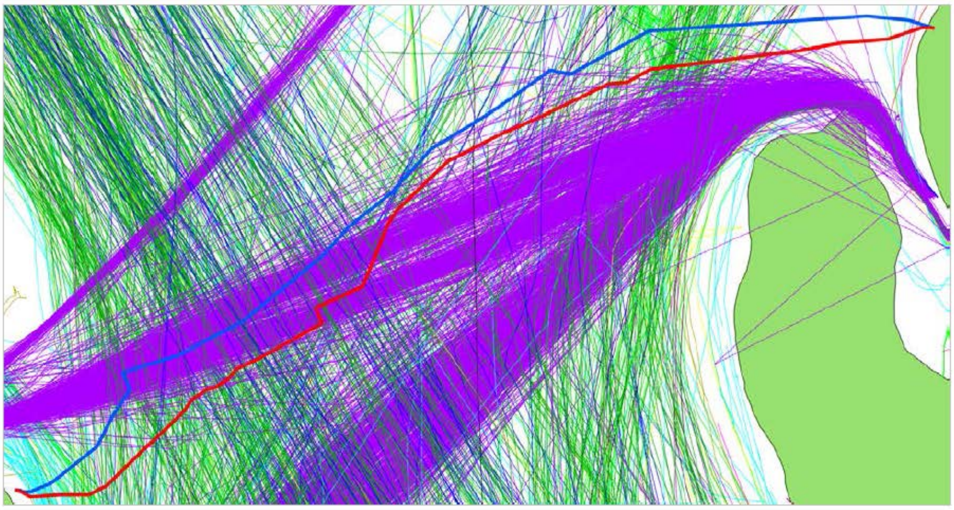


Figure 47 AIS track from shipping ref [7]

7.1.1 Anchor Size

Typical anchor sizes are listed below with typical anchor size for the various sections along the route.

	Northern Cable - Vessel DWT Statistics (KP)					
	<9.0	9.00 to 15.25	15.25 to 33.00	33.00 to 44.75	44.75 to 45.75	45.75 to 53.25
Mean	875	4,756	24,622	11,584	3,578	4,025
Anchor kg	816	1,633	4,974	2,934	1,391	1,483
Standard Deviation	699	2,922	41,777	24,144	825	2,544
Median	-	-	3,589	4,156	2,845	151
Mode	-	-	-	2,845	4,331	-
Minimum	-	-	-	-	-	-
Maximum	2,845	14,907	181,408	171,978	4,988	15,126
Range	2,845	14,907	181,408	171,978	4,988	15,126
90TH Percentile	2,170	8,306	103,603	26,526	4,331	5,802
Anchor kg	1,095	2,331	9,909	5,227	1,546	1,843
Count	22	163	208	743	289	177

Based on the DNV report ref [2] the following table gives the soil strength versus anchor size.

Though the strength of the soil along the route is very diversified and complex, the table below shows that in general the cable is protected against a 2 t anchor.

The data from table above on anchor size and KP and the DNV report, gives good documentation of protection on most anchor sizes except from the Ireland Scotland ferries.

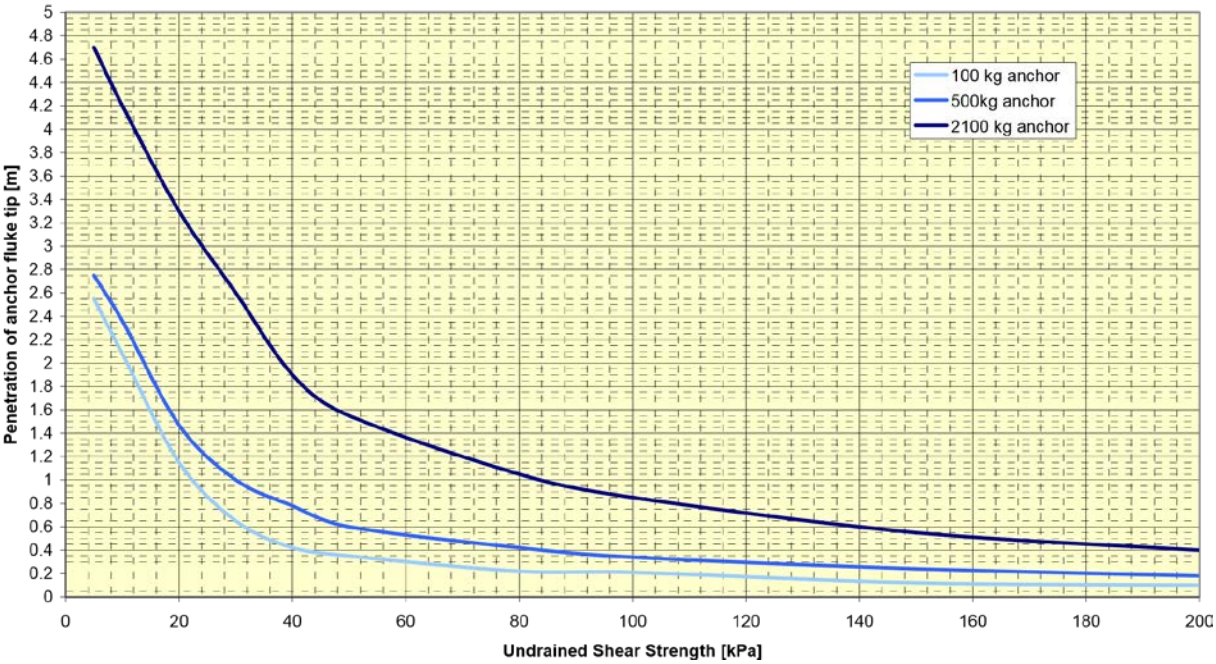


Figure 48 Anchor size versus soil strength

8 List of Appendices

Appendix no.	Title	Total number of pages
1	Stability Analysis	4
2	Specification RockPiper and Splitbarge	4
3	Datasheet CAPJET 1MW	2
4	Datasheet Cast Iron Specification and Impact Test Report	2
5	KP –burial listing HV South and North	Spreadsheet file

Table 9-1 List of Appendices

Appendix 1

Stability Analysis

Moyle Submarine MRC Shallow water, Preliminar evalution per 27/5-2015

Calculate Wd 0 - 5m over 120m either side

1.1 Input and Assumptions

Gap between cable and seabed; $Ed := 0$

Flow velocity, design current, estimated; $U := 0.5\frac{m}{s}$

Period of oscillatory flow tbc; $Tosc := 6.1s$

Cable diameter; $D := 0.068m$

Unit mass in air: $ma := 24.1\frac{kg}{m}$

Unit mass in water; $mw := 18.1\frac{kg}{m}$

Significant wave height; $Hs := 5.4m$

Peak period; $Tp := 5.0s$

JONSWAP Spectrum, Peak enhancement factor; $\gamma3 := 3.3$

Keulegan - Carpenter number: $KC := \frac{U \cdot Tosc}{D}$ $KC = 44.853$

Specific W of seawater: $\rho := 1025\frac{kg}{m^3}$

Drag and lift forces on the cable $Umn2 := 2.45\frac{m}{s}$

Dragcoefficient $Cd := 1.0$

$Umn1 := 2.31\frac{m}{s}$

Liftcoefficient $Cl := 1.0$

$Umw1 := 3.61\frac{m}{s}$

Drag force $Fd := 0.5 \cdot \rho \cdot Cd \cdot D \cdot Umn2 \cdot Umn2$ $Fd = 209.187 \cdot \frac{N}{m}$

Lift force $Fl := 0.5 \cdot \rho \cdot Cl \cdot D \cdot Umn2 \cdot Umn2$ $Fl = 209.187 \cdot \frac{N}{m}$

Maximum wave heights, Hmax given for water depts between 6.1 and17.3m. The maximum wave heights follw closely the general breaking wave height limit in shallow water, taken as 0.78 times the local water depth. Ref. /3/. For smaller water depthstowards the shore it has been assumed that the maximum wave height can be extrapolated by fitting a second order polynominal to the given data. Hence, the maximun wave height at the shore line comes out as 1.55m, a breaking wave running up the shore.

Breaking waves are generally classified as spilling, plunging and surging breakers depending on the value of the non dimensional parameter β = Hb / gT2m

Breaking wave height
Beach slope
Acceleration of gravity=g

$Hb := 6m$

$mslo := \frac{5}{120}$ $mslo = 0.042$

$\beta := \frac{Hb}{g \cdot Tp^2 \cdot mslo}$ $\beta = 0.59$

The wave period corresponding to the maximum wave height is calculated with the following formula from DNV - RP - C205:

$Hmax := 6m$

Tp Corresponding to to Hmax: $Tmax := 2.94 \cdot \sqrt{Hmax}$ $Tmax = 7.201\ m^{0.5}$

For h < 6.00 wave break completely into flow velocity: $Uclps := \sqrt{g \cdot Hb}$ $Uclps = 7.671\ \frac{m}{s}$

A design currentof 0.5m/s is applied.It is assumedthat this current propagates normal to the cable axis. The waves are assumed coming into the beach with maximum angle of 30degr .This means that the flow velocity normal to the cable is calculated as:

Unorm= Ucurr + Uwave*sin (30degr)

The cable has a net buoyancy per unit length in water Fb:

$Fb := -mw \cdot g$ $Fb = -177.5 \cdot \frac{N}{m}$

Hmax / Wd [m]

$$x := \begin{pmatrix} 5.0 \\ 4 \\ 3 \\ 2 \\ 1 \\ 0 \end{pmatrix} \qquad y := 0.0114 \cdot x^2 + 0.5039 \cdot x + 1.5533 \qquad y = \begin{pmatrix} 4.36 \\ 3.75 \\ 3.17 \\ 2.61 \\ 2.07 \\ 1.55 \end{pmatrix}$$

$$hbfakt := x \cdot \begin{pmatrix} 1.23 \\ 2.23 \\ 1.22 \\ 1.2 \\ 1.14 \\ 1 \end{pmatrix} \qquad hb := \begin{pmatrix} 5.36 \\ 4.61 \\ 3.87 \\ 3.13 \\ 2.36 \\ 1.55 \end{pmatrix} \cdot m \qquad Umw := \sqrt{g \cdot hb} \qquad Umw = \begin{pmatrix} 7.25 \\ 6.72 \\ 6.16 \\ 5.54 \\ 4.81 \\ 3.90 \end{pmatrix} \frac{m}{s}$$

$$Umnorm := U + Umw \cdot \sin(30°) \qquad Umnorm = \begin{pmatrix} 4.13 \\ 3.86 \\ 3.58 \\ 3.27 \\ 2.91 \\ 2.45 \end{pmatrix} \frac{m}{s}$$

$$FL := Umnorm^2 \cdot \rho \cdot Cl \cdot D \cdot 0.5 + Fb \qquad FL = \begin{pmatrix} 415.51 \\ 342.25 \\ 269.21 \\ 195.18 \\ 116.68 \\ 31.58 \end{pmatrix} \cdot \frac{N}{m}$$

$$FD := Umnorm^2 \cdot \rho \cdot Cd \cdot D \cdot 0.5 \qquad FD = \begin{pmatrix} 593.01 \\ 519.75 \\ 446.71 \\ 372.68 \\ 294.18 \\ 209.08 \end{pmatrix} \cdot \frac{N}{m}$$

Protectorshell: eqvivalent OD

Area in ID: $ID := 120 \cdot mm$ $AID := \pi \cdot ID^2 \cdot 0.25$ $AID = 1.131 \times 10^4 \cdot mm^2$

$PSmassair := 37.4 \cdot \frac{kg}{m}$ $\rho st := 7850 \frac{kg}{m^3}$

$PSmassWater := 32.0 \frac{kg}{m}$

$AOD := \frac{PSmassair}{\rho st} + AID$ $AOD = 1.607 \times 10^4 \cdot mm^2$

$ODeqv := \sqrt{\frac{AOD}{\pi \cdot 0.25}}$ $ODeqv = 143.06 \cdot mm$

$wt := \frac{ODeqv - ID}{2}$ $wt = 11.53 \cdot mm$

Protectorshell with Cable:

$BundMassAir := ma + PSmassair$ $BundMassAir = 61.5 \frac{kg}{m}$

$BundWeightWater := mw + PSmassWater$ $BundWeightWater = 50.1 \frac{kg}{m}$

Bundle buoyancy:

$Fbps := -BundWeightWater \cdot g$ $Fbps = -491.313 \cdot \frac{N}{m}$

$FLp := Umnorm^2 \cdot \rho \cdot Cl \cdot ODeqv \cdot 0.5$ $FLp = \begin{pmatrix} 1247.58 \\ 1093.47 \\ 939.81 \\ 784.05 \\ 618.90 \\ 439.87 \end{pmatrix} \cdot \frac{N}{m}$

$zp := 0.5$ $rpenz := 1 - 1.3 \cdot (zp - 0.1)$ $rpenz = 0.48$

$rpeny := 1.0 - 1.4 \cdot zp$ $rpeny = 0.3$

$FLpr := FLp \cdot rpenz$

$FLpr = \begin{pmatrix} 598.84 \\ 524.87 \\ 451.11 \\ 376.35 \\ 297.07 \\ 211.14 \end{pmatrix} \cdot \frac{N}{m}$

$FLpsr := FLpr + Fbps$

$$FLpsr = \begin{pmatrix} 107.52 \\ 33.55 \\ -40.21 \\ -114.97 \\ -194.24 \\ -280.18 \end{pmatrix} \cdot \frac{N}{m}$$

$FDps := Umnorm^2 \cdot \rho \cdot Cd \cdot ODeqv \cdot 0.5$

$$FDps = \begin{pmatrix} 1247.58 \\ 1093.47 \\ 939.81 \\ 784.05 \\ 618.90 \\ 439.87 \end{pmatrix} \cdot \frac{N}{m}$$

$FDpsr := FDps \cdot rpeny$

$$FDpsr = \begin{pmatrix} 374.27 \\ 328.04 \\ 281.94 \\ 235.22 \\ 185.67 \\ 131.96 \end{pmatrix} \cdot \frac{N}{m}$$

Appendix 2

Specification RockPiper and Splitbarge

Boskalis
Dredging & Marine Experts

EQUIPMENT SHEET

CORK SAND & LONG SAND
HOPPER AND TRANSPORTATION BARGES

CONSTRUCTION/CLASSIFICATION

Built by	Slob B.V. - Papendrecht, The Netherlands
Year of construction	1988
Classification	B.V. Split hopper barge - Coastal area dredging within 15 miles from shore, or within 20 miles from port.

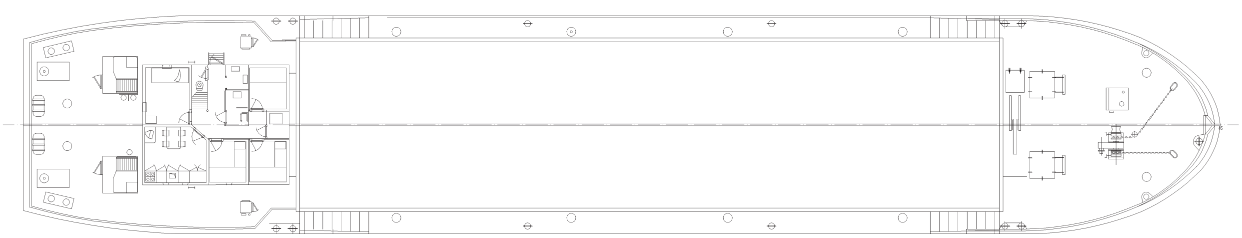
MAIN DATA

Type	Self propelled hopper barges
Gross tonnage	955
Length overall	65 m
Moulded breadth	11.8 m
Moulded depth	4.3 m
Draught empty	1.98 m
Draught loaded	3.7 m
Carrying capacity (D.W.)	1,896 t
Hopper capacity	1,040 m^3
Discharge System	Split hopper (bottom doors/ pump ashore/rainbow)
Sailing speed loaded	7 kn
Total installed power	1,013 kW
Propulsion power sailing	750 kW
Bow thruster	149 kW

Boskalis
Dredging & Marine Experts

CORK SAND & LONG SAND
HOPPER AND TRANSPORTATION BARGES

SIDE VIEW



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www.boskalis.com

EQUIPMENT SHEET

ROCKPIPER
DYNAMICALLY POSITIONED FALLPIPE VESSEL

CONSTRUCTION/CLASSIFICATION

Built by	Keppel Singmarine Pte Ltd
Year of construction	2011
Classification	Bureau Veritas

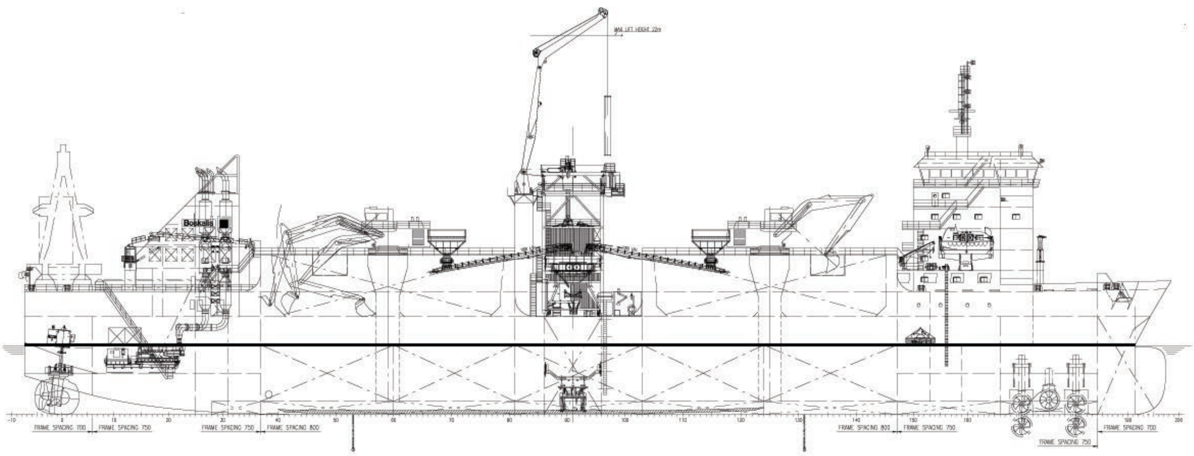
FEATURES

- Completely new ship design, fallpipe system and rock dumping system.
- Rock dumping capacity abt. 2,000 t/h.
- Dumping depth 1,500 m through fallpipe with inner diameter of abt. 700 mm.
- Diesel electric propulsion system comprising three main diesel generator sets and one auxiliary diesel generator set.
- Accommodation on fore ship, complement 60 persons.
- Engine room in aft ship.
- Rock dumping system and moonpool in mid ship.
- Innovative fall pipe ROV with integrated survey ROV.

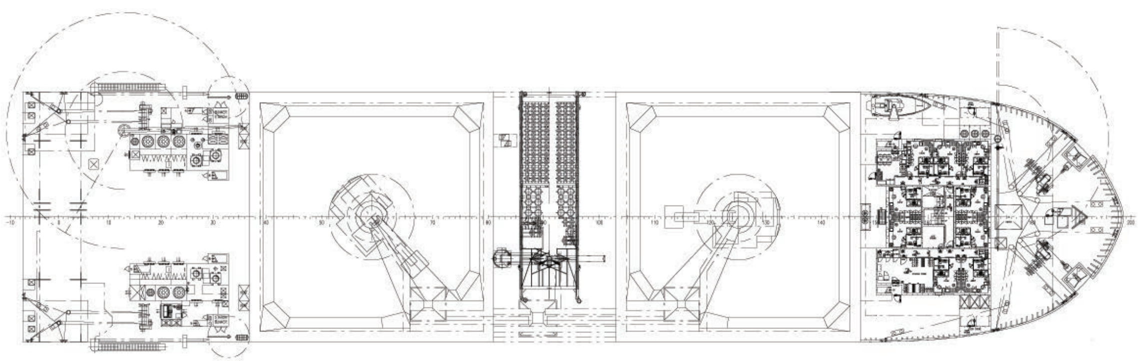
MAIN DATA

Dynamic positioning system	DP-2
Subsea positioning system	HIPAP
Length overall	158.60 m
Breadth	36.00 m
Moulded depth	13.50 m
Design draught	9.40 m
Cargo carrying capacity	24,000 t
Cargo hold capacity	15,500 m³
Sailing speed loaded	13.5 kn
Total installed power	15,192 kW (3x4,500kW + 1x1,200kW + 1x492kW)
Main engines	3 x 4,500 kW (3x main generator sets)
Main propellers	2 x 4,500 kW (2x azimuth thrusters)
Azimuth thrusters	2 x 1,500 kW (2x retractable thrusters)
Bow thruster	1 x 1,000 kW
	7,000 kW
	2 x 1,250 kW + 2 x 1,000 kW

ROCKPIPER
DYNAMICALLY POSITIONED FALLPIPE VESSEL



SIDE VIEW



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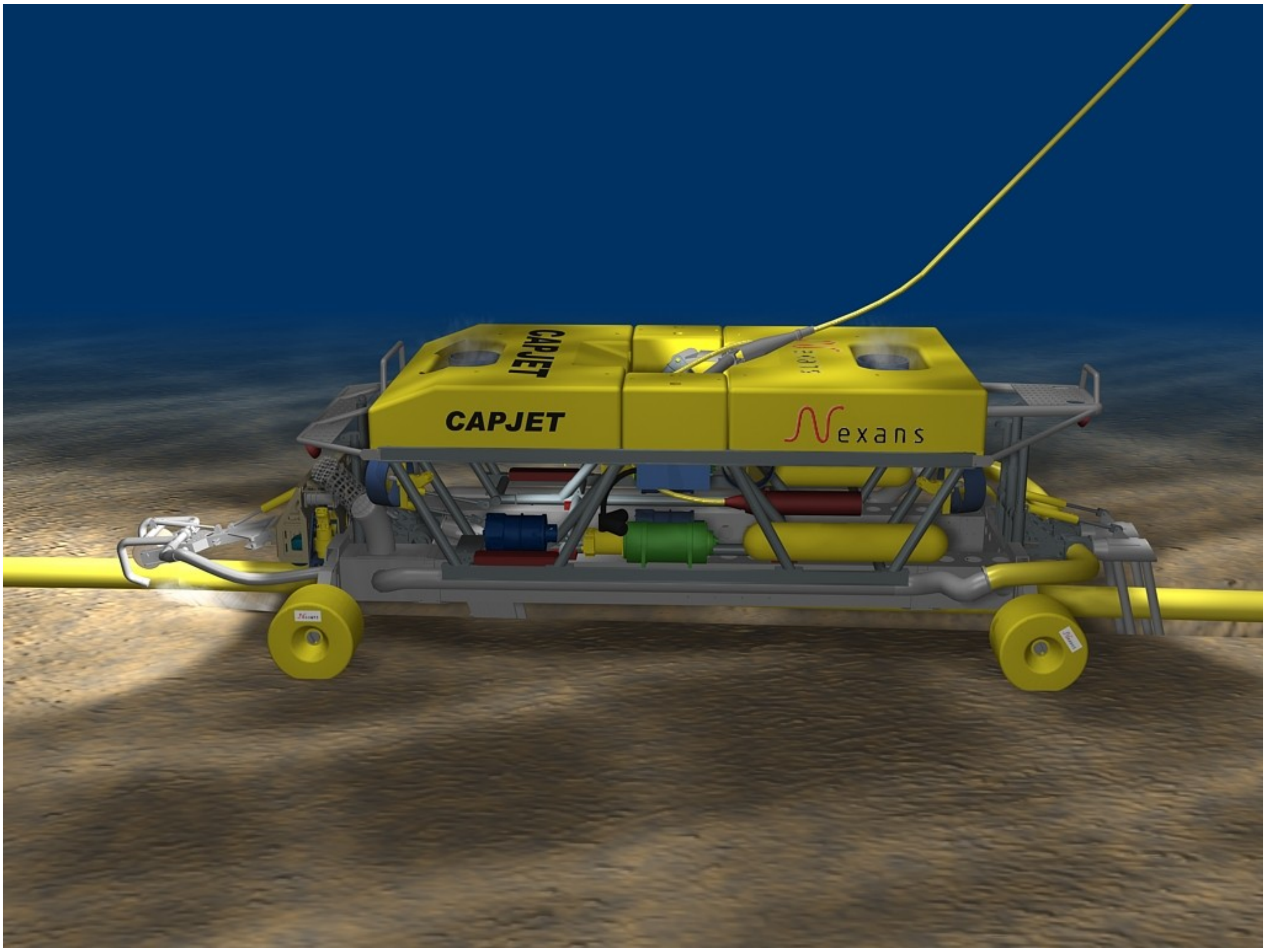
Appendix 3

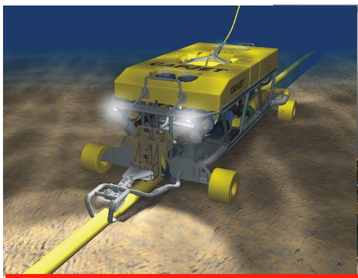
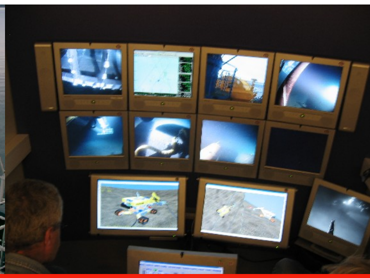
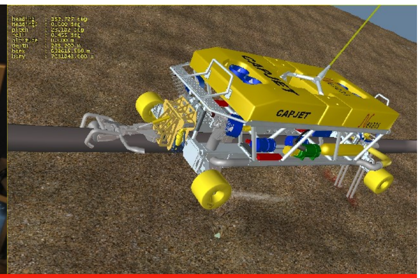
Datasheet CAPJET 1MW

NEXANS CAPJET
trenching system



Nexans

Installation Services Section



The CAPJET systems was originally developed as a cable burial tool for shallow water. In 1987 the shallow water system was further developed, and the first remote controlled jetting trencher went into operation in 1988. The system was further developed for deeper water and the CAPJET performed the first offshore operation in 1989. The requirement for burial in harder soil and trenching of flowlines required more power available for the jetting pumps. The CAPJET 500 1 MW with more than 1 MW of power was developed and started operation in 1993. It operated together with the smaller CAPJET 1000 until 1999, when the CAPJET 650 MW 1 was developed and built. With the development of the SPIDER system and the conversion of SPIDER to CAPJET system, Nexans have four MW trenching system complete with handling systems and frequency controlled electrical umbilical winches.

Size & weight

- Control container 20´, 7 t
- Workshop 1 x 20´, 4 t each
- Transformer container 1 x 20´, 13 t
- Storage container 20´, 7 t
- Generators (optional) 2 x 20´, 15-18 t each
- Umbilical winch 4.4 x 3 x 2.8 m, 30 t (1000m typ)
- LARS 16 t SWL DAF 3.75. 3.5 x 5 x 11 42 T
- Capjet 8 x 4 x 2.5 m, 14.5 t

Hydraulic system

- 2 x 150 HP HPU redundant systems
- 1 x 6 HP dirty hydraulic
- 10 x 17" thrusters (each 550 kg)

Bollard pull

- Forward approx 2000 kg
- Lateral 1000 kg
- Vertical 1000 kg

all HPUs pressure software controlled

Trench module and water pumps

- Adjustable front and aft swords
- Vertical lifting 600 mm
- Horizontal adjustment of sword opening 200 mm
- 2 x 420 KW water pumps
- Pressure from 10 to 16 bar dependent of project requirement.

Electronic/data

27 Gbit uplink/175 baud download w 5xRS232 and 5xRS485/422, 6 x video and 2 x imaging sonar links, Ethernet w 3 x 10 Mbits links Typical 16 extra Rs232 on Ethernet 1 Ghz main computer on control system.

Handling system

- Operation up to Hs 3.5 m vessel dependent
- Constant tension winch

Frame and lift structure

- Titanium air filled structure
- pressure rating 2000 m
- Buoyancy (for North Sea operation) 1000 m or 1550 m.

Control system

All data are collected on a serial to Ethernet drop down network which gives "local" control of all sensors and valvepacks. The latest control system technology as OPC, distributed data collection, touchscreens and WEB based monitoring and support tools. The system can be fully supported through the internet and low speed connections. Realtime control system for transformer control and LARS and umbillical winch control and monitoring.

Trench modules

Special trench modules for :

- Flexible pipeline trenching with software controlled speed control and measurement
- Steel flowline
- Backfill plough
- Ejector system
- Cable trenching to 3 m burial depth
- Tension system for all modules

Sensors (Typical)

- Six color video cameras
- Two mesotech 1000 sonar
- Mesotech SM2000 imaging sonar
- Digiuquarts pressure sensor
- Digital yoke sensor
- Mesotech digital altimerer
- Octans fiberoptical survey gyro
- Three off electrical P&T units
- Linear sensors 8 off (typical)

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Nexans

Appendix 4

Datasheet Cast Iron Specification and Impact Test Report

Engineering **Qualification X** **Acceptance**	**TEST RESULT SHEET** **Impact Test**	Nexans
NK-27336-4-06 MTC-2013-028	Test stage: Prior to dissection	Nexans Norway AS Mechanical Test Centre. 1/1

Project:	**Evia Attica**
Customer:	**Marine Installation**

Test object:	Cast Iron Shells (CIS)	Cable length(m): N/A
Test procedure:	27336-EIT-ST-00000	Start date : 08.02.2013
Test site:	Nexans Halden Plant	End date : 08.02.2013

Test Equipment :	Reg. no.	Calibration date
Load Cell 50 kN	*D0151*	*13.12.2012*
Tape measure	-	-
Impact rig-Round hammer-Ø20mm		

Drop No.	Drop Load	Drop height	Impact Energy	Impact location	Bedding
	Kg	mm	kJ		
1	920	222	2	Mid Position	Steel
2	920	332	3	Mid Position	Steel
3	920	443	4	Mid Position	Steel
4	920	554	5	Mid Position	Steel
5	920	665	6	*Mid Position*	Steel
6	920	776	7	*Mid Position*	Steel

Note : g=9,81 m/s2

Acceptance criteria met: YES		
Test Eng. : Lars Jordal Nexans Norway AS	Internal : Joachim Bakke Nexans Norway AS	External:

NOTES: Breakdown on CIS at 7kJ impact.

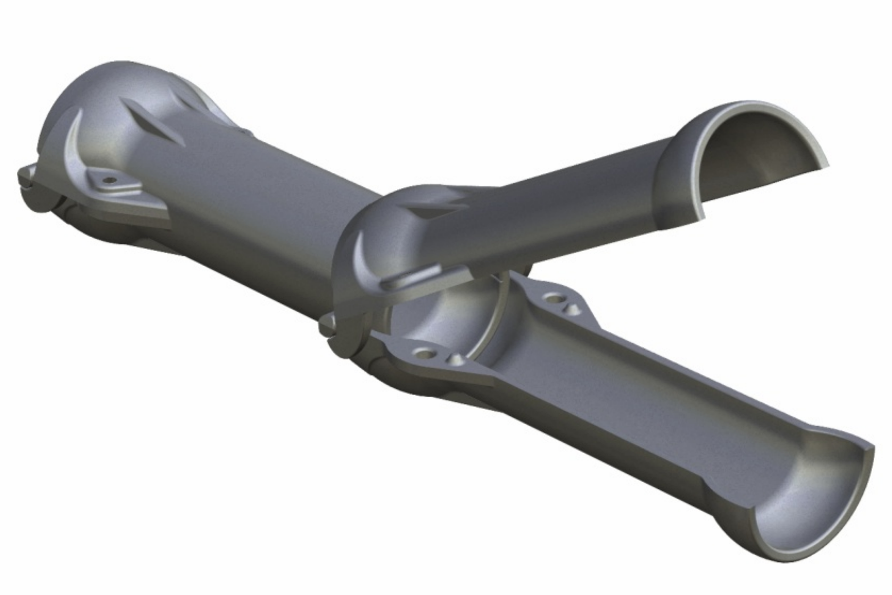
Protectorshell

Protectorshell Articulated Pipe has been developed to provide shallow water abrasion and impact protection for submarine cables.

Protectorshell is unique in that it clips together, avoiding the nuts and bolts of traditional articulated pipe. This clip together feature allows quick real time application during laying and a much simplified diver installation onto pre-laid cables.

The **Protectorshell** system comprises two different cast segments which are identified as uppers and lowers. Each successive pair of segments clips over and retains the end of the preceding pair.

A wide range of adaptors and attachments are available for use with **Protectorshell** Articulated Pipe. These adaptors and attachments allow the reversal of application direction and interfacing with other cable protection measures such as directionally drilled pipes, pipe flanges and concrete abutments.



PS120/460/09

Specifications	
Segment Length - Overall	525mm
Effective Installed Length/segment pair	460mm
Minimum Internal Diameter	120mm - for cables up to 108mm diameter
Maximum External Diameter	225mm
Wall Thickness	9mm
Material	Ductile Iron to ISO 1083
Tensile Strength / Elongation	400MPa / 15% elongation
Impact Resistance	12m Drop test or 26kg
Minimum Bend Diameter	4.0m
Weight per Segment	16.7kg
Weight per installed metre (air)	36.3kg
Weight per installed metre (water)	31.8kg
Fasteners	M12x50 Bolt and M12 Nyloc Nut – Material: Stainless Steel G316/A4 Recommended usage: 1 pair per 10 metres of installed pipe

Protectorshell SL
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MSD SERVICES

Appendix 5

KP –burial listing HV South and North

Please see separate native file