LBA CCS TRANSPORT AND STORAGE PROJECT

POINT OF AYR TO SATELLITE PLATFORMS

OFFSHORE POWER CABLE PROTECTION REQUIREMENT

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HOLD RECORD

1.	Fishing Vessel Risk Assessment and Detailed Anchoring Study
2.	Geotechnical Survey Data Report

ASSUMPTIONS RECORD

1.	Concrete Mattress Impact Resistance – Assumed 15kJ Impact Capacity

Contents

1.0 INTRODUCTION

1.1 Project Overview

Refer to Offshore Project Basis of Design, document 1025H0BGRB09002 [Ref.1].

1.2 Purpose and Scope

The scope of this report is to present the selected protection requirements, both along the route and local to the platform location for the offshore power cable to be installed as part of the LBA CCS T&S Project. The report includes a dropped object study to determine the effect of dropped object on the subsea cables approaching the platforms.

2.0 BATTERY LIMITS

The battery limits covering the offshore cables are defined as follows:

Outside Diameter Nominal Size	Description	From	To
150mm	Power Cable	Point of Ayr (Nearshore)	J-tube Douglas CCS
150mm	Power Cable	J-tube Douglas CCS	J-tube Hamilton North
150mm	Power Cable	J-tube Douglas CCS	J-tube Hamilton Main
150mm	Power Cable	J-tube Douglas CCS	J-tube Lennox

Table 2-1 – Battery Limit

3.0 DEFINITIONS AND ABBREVIATIONS

3.1 Definitions

The following definitions, terminology and abbreviations are applicable for the Project and used throughout this document:

COMPANY/CLIENT	The party that initiates the project and ultimately pays for its design and construction i.e. Eni UK. The COMPANY/CLIENT will generally specify technical requirements. The term "COMPANY/CLIENT" also includes agents or consultants authorized to act for and on behalf of COMPANY/CLIENT. Eni UK is the Client for LBA CCS Transport and Storage
CONTRACTOR	A person or organisation that undertakes responsibility for the execution of a CONTRACT. EniProgetti is responsible for execution of the Scope of work agreed with the COMPANY/CLIENT
CONTRACT	An acceptance of legal relations between two or more parties for the transfer of goods or services for value.
Project or Plant:	LBA CCS Transport and Storage
WORK	shall mean all work that CONTRACTOR is required to carry out in accordance with the provisions of CONTRACT including all related services and resources to be provided in accordance with the CONTRACT
SHALL	A mandatory provision
Should	An advisory provision

3.2 Abbreviations

A&R	Abandonment and Recovery
CCS	Carbon Capture and Storage
CBRA	Cable Burial Risk Assessment
DA	Accommodation Platform
DC	Direct Current
DD	Production Platform
DNV	Det Norske Veritas
DP	Dynamic Positioning
DW	Wellhead Platform
EIAPP	Engine International Air Pollution Prevention Certificate
FEED	Front-End Engineering Design
FIV	Field Installation Vessel
FMEA	Failure Mode and Effects Analysis
FEED	Front End Engineering Design
GIS	Geographic Information System
HAZID	Hazard Identification
HAZOP	Hazard and Operability Analysis
H&M	Hull and Machinery

HOC	Hamilton Oil COMPANY/CLIENT
IACS	International Association of Classification Societies
IMO	International Maritime Organization
IMCA	International Marine CONTRACTOR Association
IOPP	International Oil Pollution Prevention
ISO	International Organization for Standardization
ISPS	International Ship and Port Facility Security Code
LBA	Liverpool Bay Asset
MRW	Marine Warranty Surveyors
MSL	Mean Sea Level
MTPA	Million Ton Per Annum
OTDR	Optical Time Domain Reflectometer
OVID	Offshore Vessel Inspector Database
P&I	Protection and Indemnity
PoA	Point of Ayr
ROV	Remotely Operated Vehicle

4.0 REFERENCES

4.1 Project Documents

[Ref.1] 1025H0BGRB09002, Basis of Design Offshore 4.5 MTPA (Gas Phase) – FEED &10 MTPA (Dense Phase) – Feasibility
[Ref.2] 102100BESB09003, Project List of Applicable Codes and Standards
[Ref.3] 1025H0BEST40801, Technical Specification for Submarine Cable
[Ref.4] 1025H0BSSA84109, Offshore Power Cable Trenching and Backfilling Specification
[Ref.5] 1025H0BSSA84108, Offshore Power Cable Installation Specification
[Ref.6] 1025H0BSRA84106, Offshore Power Cable On-bottom Stability Study
[Ref.7] 1025H0BSDG84104, Offshore Power Cable - Field Layout
[Ref.8] 1025H0BSDN84112, Offshore Power Cable - Approach Drawings
[Ref.9] 1025DSBSCZ84173, Offshore Cables Preliminary Crossing Design Report
[Ref.10] 1025H0BGRV09420, Phase 2c Nearshore Engineering Geological Ground Model
[Ref.11] 1023DSBSRA84018, Preliminary Pipelines and Tie-In Spools Protection Requirement Study

4.2 COMPANY/CLIENT Specifications

COMPANY/CLIENT Specifications to comply with [Ref.2].

[Ref.12] 23025.ENG.PLI.PRG, Design of Offshore Pipelines

4.3 International Codes and Standards

International Codes and Standards to comply with [Ref.2].

[Ref.13] ISO 13628-5 – Petroleum and natural gas industries – Design and operation of Offshore production systems – Part 5: Offshore Cables
[Ref.14] DNV-RP-0360 – Offshore Power Cables in shallow Water
[Ref.15] DNV-RP-F107 – Risk Assessment of Pipeline Protection
[Ref.16] DNV-RP-F114 – Pipe-soil interaction for submarine pipelines

4.4 Previous Project Documents

[Ref.17] D-500-LN-027 (L-500065-S01-REPT-001) – Local Operating Instruction, Liverpool Bay Asset. Vessel Traffic Survey (VTS) and Collision Risk Assessment (CRA), Rev.03 (2020).
[Ref.18] H-280-LR-005 – Fishing Vessel Risk Assessment, Hamilton East, Rev. 02 (2000)
[Ref.19] D-529-SE-001.00 – DP/DA Bridge – West Bridge – General Arrangement, Rev. 03 (1994)
[Ref.20] D-523-SE-001.00 – DP/DA Bridge – North Bridge – General Arrangement, Rev. 03 (1994)
[Ref.21] H-000-QR-025 – Pipelines Annual Report 2017
[Ref.22] H-000-QR-026 – Pipelines Annual Report 2018
[Ref.23] H-000-QR-027 – Pipelines Annual Report 2019
[Ref.24] H-000-QR-028 – Pipelines Annual Report 2020

4.5 Other

[Ref.25] ICPC Recommendation No. 6, Issue: 10A, Recommended Actions for Effective Cable Protection (Post Installation), 2020 International Cable Protection Committee (ICPC Ltd).
[Ref.26] P G Allan, Selecting Appropriate Cable Burial Depths A Methodology, IBC Conference on Submarine Communications, The Future of Network Infrastructure, Cannes, November 1998.
[Ref.27] P G Allan & Comrie R., The Selection of Appropriate Burial Tools and Burial Depths.
[Ref.28] Carbon Trust (2015). CTC835 Cable Burial Risk Assessment Methodology - Guidance for the Preparation of Cable Burial Depth of Lowering Specification.

[Ref.29] Rességuier S, Bendzovski R, Strom PJ, Wathne H, Vigsnes M, Holme J (2009) Assessment of trawl board and anchor penetration in different soils for use in selection of a burial depth to protect submarine cables or pipelines OMAE20099-79170. Proceedings of the 28th International Conference on Ocean, Offshore and Arctic Engineering 2009. v.7, Offshore Geotechnics Petroleum Technology.2009.

[Ref.30] Sotra Anchor Data Sheet (https://www.sotra.net/?produkter=hall-anchor)

[Ref.31] Design and Installation of Marine Pipeline Installation, by Mikael Braestrup, Jan B. Andersen, Lars Wahl Andersen, Mads B. Bryndum, Niels-J Rishøj Nielsn.

[Ref.32] Zhuang Y, Li Y, Su W (2016) Influence of Anchoring on Burial Depth of Submarine Pipelines. PLoS ONE 11(5): e(0) 154954.

4.6 Order of Precedence

Should conflict arise between the statements of different rules, codes or standards, the following list of precedence SHALL be respected:

1. Law and National Standards
2. Design Basis, Project Specifications and Drawings
3. COMPANY/CLIENT Specifications
4. International Codes and Standards

If conflicts arise the most stringent requirement SHALL apply in its entirety of the specific topic. In all cases of conflict, the COMPANY/CLIENT SHALL be informed.

5.0 SUMMARY & RECOMMENDATIONS

5.1 Summary

This report provides a comprehensive analysis of the subsea cable protection study conducted for the Liverpool Bay CS T&S project area. The study utilizes both qualitative and quantitative approaches to assess the various hazards that could potentially affect the integrity of subsea cables. By evaluating the study area and the activities expected near the platforms and cable route, several principal hazards were identified. These hazards include:

- Coastal changes at the Point of Ayr landfall;
- High fishing intensity and potential interaction with fishing gear;
- Risks associated with shipping lanes and dropped anchor interaction; and
- Possibility of dropped objects from platforms on subsea cables.

As per the observations presented in Section 9.1, it has been determined that the risk of damage from dropped objects is most significant for two specific subsea cables:

- Power Cable No. 1 from Point of Ayr to Douglas CCS at the Douglas CCS platform approach; and
- Power Cable to Lennox from the Douglas CCS at the Lennox platform approach.

This conclusion takes into account the proximity of the davit to the entire length of the subsea cable and the water depth. To assess the potential risks, a probabilistic evaluation was conducted using the methodology outlined in DNV-RP-F107 [Ref.15]. Furthermore, the report also considers the accidental dropping of objects or anchors from infield vessels. The assessment results indicate that, with the application of a single layer of concrete mattresses for protection, the likelihood of impact damage from dropped objects / anchors is within acceptable limits for the power cables approaching the Douglas CCS platform and all other satellite platforms (Hamilton Main, Hamilton North, and Lennox).

Section 8.3 of the report highlights the presence of significant fishing activity in the LBA study area. By considering the intensity of fishing and its potential impact on the subsea cables, it is determined that there is a high probability of fishing gear interaction incidents occurring. Research conducted by multiple authors has revealed that trawl boards, a type of fishing gear, can penetrate the seabed up to a maximum depth of 300mm. Consequently, it is recommended that the cables be buried along the entire cable route to mitigate the risks posed by fishing activities.

Section 8.4 emphasizes the risk posed by shipping vessels in the Liverpool Bay study area, particularly during emergency anchoring situations, and suggests addressing this risk by relying on soil cover alone for protection since the cable itself cannot withstand external accidental forces. Based on the assessment results presented in Section 10.2.2, it is determined that a minimum soil cover of 1.9m is necessary to mitigate the risk posed by dropped anchors.

Furthermore, using the CBRA methodology, the penetration depth caused by a dragged anchor has been calculated as 0.7 times the anchor fluke length. It is crucial to recognise the cable's limited ability to withstand impacts, and direct interaction with anchors should be avoided. To ensure accidental contact is prevented, an additional safety margin of 1.5 is included when estimating anchor penetration depths. Consequently, the maximum penetration depth is determined to be 1.9m as presented in Section 10.2.3.

Based on the aforementioned findings, it is recommended to have a minimum target cable burial depth (top of cable) of 2 meters along the cable route. This depth will help ensure that the risks associated with fishing and shipping vessel interactions are kept as low as reasonably practicable.

Additionally, based on the observations detailed in Section 8.1, it has been noted that there is excessive movement of seabed sediment at the Point of Ayr (POA) landfall area. Minor changes have been observed in the morphology of the north-western side of the West Hoyle Spit. A comparison of available bathymetry datasets indicates erosion on the West Hoyle Spit, with the channel being infilled and no longer visible in the latest dataset.

In light of these findings, it is recommended to increase the burial depth of the subsea cable approaching the POA landfall area to 3 meters. By burying the cable deeper, an extra layer of protection can be provided, effectively mitigating potential risks (cable exposure) associated with the sediment movement in this specific area.

To ensure the overall integrity and protection of the cables at the crossing locations, it is crucial to follow the specific recommendations outlined in Offshore Cables Crossing Design Report [Ref.9]. This will ensure that the chosen protection measure aligns with the site-specific conditions and mitigates potential risks effectively.

The recommended protection measures are summarised below in Table 5-1.

<table>
<tr><th>Parameter</th><th colspan="2">Location</th><th>Unit</th><th>Value</th></tr>
<tr><td>Concrete Mattress Cover</td><td colspan="2">Platform approach zones and trench transition zones</td><td>-</td><td>Single layer mattress [Note 3]</td></tr>
<tr><td>Minimum Target Cable Burial Depth
(Top of Cable)</td><td colspan="2">Main cable route</td><td>m</td><td>2.0 [Note 2]</td></tr>
<tr><td rowspan="3">Minimum Target Cable Burial Depth
(Top of Cable)</td><td rowspan="3">POA Landfall area</td><td>West Hoyle Spit</td><td rowspan="3">m</td><td>3.0 [Note 1,2]</td></tr>
<tr><td>Welsh Channel</td><td>3.0 [Note 1,2]</td></tr>
<tr><td>Inter-tidal Beach Crossing</td><td>3.0 [Note 1,2]</td></tr>
<tr><td colspan="5">Note 1: Increase burial depth to account for changing seabed morphology at this location reference is made to Pipelines Annual Report [Ref.21] to [Ref.24] and [Ref.10].
Note 2: Burial depth shall be confirmed once the following studies are completed and available
• Fishing Vessel Risk Assessment and Detailed Anchoring Study; and
• Geotechnical Survey Data Report.
Note: 3: Alternatively, rock dump can be considered as per specification shown in Figure 6-3.</td></tr>
</table>

Table 5-1 – Preliminary FEED Cable Burial Depth and Protection Measure

The Table 5-2 presents the tentative length and quantity of concrete mattresses required for the protection of all cables at platform approach zones based on the results in this study.

<table>
<tr><th rowspan="2">Power Cable</th><th rowspan="2">Platform Approach</th><th rowspan="2">Protection Length (m)</th><th colspan="2">Mattress Quantity (Nos.)</th></tr>
<tr><th>Post Lay</th><th>Pre-Lay</th></tr>
<tr><td>Power Cable No.1 from Point of Ayr to Douglas CCS</td><td>Douglas CCS</td><td>108m</td><td>18</td><td>0</td></tr>
<tr><td>Power Cable No.2 from Point of Ayr to Douglas CCS</td><td>Douglas CCS</td><td>162m</td><td>27</td><td>0</td></tr>
<tr><td rowspan="2">Power Cable from Douglas CCS to Hamilton North</td><td>Douglas CCS</td><td>222m</td><td>37</td><td>0</td></tr>
<tr><td>Hamilton North</td><td>144m</td><td>24</td><td>0</td></tr>
<tr><td rowspan="2">Power Cable from Douglas CCS to Hamilton Main</td><td>Douglas CCS</td><td>420m</td><td>70</td><td>4</td></tr>
<tr><td>Hamilton Main</td><td>216m</td><td>36</td><td>0</td></tr>
<tr><td rowspan="2">Power Cable from Douglas CCS to Lennox</td><td>Douglas CCS</td><td>240m</td><td>40</td><td>0</td></tr>
<tr><td>Lennox</td><td>120m</td><td>20</td><td>0</td></tr>
</table>

Table 5-2 – Tentative Concrete Mattress Quantity and Protection Lengths

The quantity of mattresses mentioned does not include the number required for protecting the cable crossings, except for the power cable connecting Douglas CCS to Hamilton Main, as all the crossings for this power cable are situated in the platform approach section. Based on Table 5-2, a total of 272 concrete mattresses have been determined as the requirement. This quantity is based on using a single layer of concrete mattresses for protection.

This study demonstrates that although physical protection can provide some level of safeguarding against certain hazards, there are still credible hazards that cannot be realistically prevented for subsea cables. In such cases, the most practical approach is to mitigate the risk of these events by implementing a combination of procedural controls and physical protection measures.

5.2 Recommendation

The depth of burial shall be studied during detailed design engineering by applying a risk-based approach. The assessment shall take into consideration the HSE studies and site conditions (soil properties, sediment mobility) along the cable route (Hold 2). Seabed stability assessment shall also be carried out during detailed design engineering to confirm the burial depth along the cable route. The burial design shall also include the suitable trenching tools available in the market.

Additionally, the following recommendations are made:

- It is recommended that guard vessels patrol the power cable route for the duration where the systems will lie exposed on the seabed;
- During the service life of the systems, it is recommended that annual surveys be carried out to assess the condition of the protection measures implemented and to ensure that they have not been displaced or removed;
- During the service life of the systems, it is recommended the use of automated identification systems ("AIS") and vessel monitoring systems ("VMS") on vessels at all times to monitor the security of the offshore cables;
- Suitable remedial measures may be required in the future if the protection measures have been damaged or removed (i.e., displaced concrete mattresses);
- Lifting procedures shall be developed by CONTRACTOR to mitigate the risk of dropped objects during these operations;
- Implementation of robust and stringent procedures for vessels undertaking planned activities in the field;
- Application of weather restrictions to inspection, maintenance, construction activities, and lifting and anchor handling operations;
- Introduction a 500m exclusion zone around the platforms to deter fishing and commercial shipping;
- Advise Marine users of the presence of the new infrastructure and notification of the relevant bodies, such as the Sea Fish Industry Authority (SFIA) and the UK Hydrographic Office.

In addition, it recommended the following activities are carried out during detailed design:

- Quantitative Risk Assessment;
- Lifting and Dropped Object Study.

6.0 DESIGN DATA

All data summarized in this Section is taken from Basis of Design [Ref.1] unless stated otherwise.

6.1 Design Life

Design life of new power cables is 25 years.

6.2 Cable Routes

Following figures are extracted New Offshore Power Cable and Fibre Optic Field Layout (Offshore Section) [Ref.7].

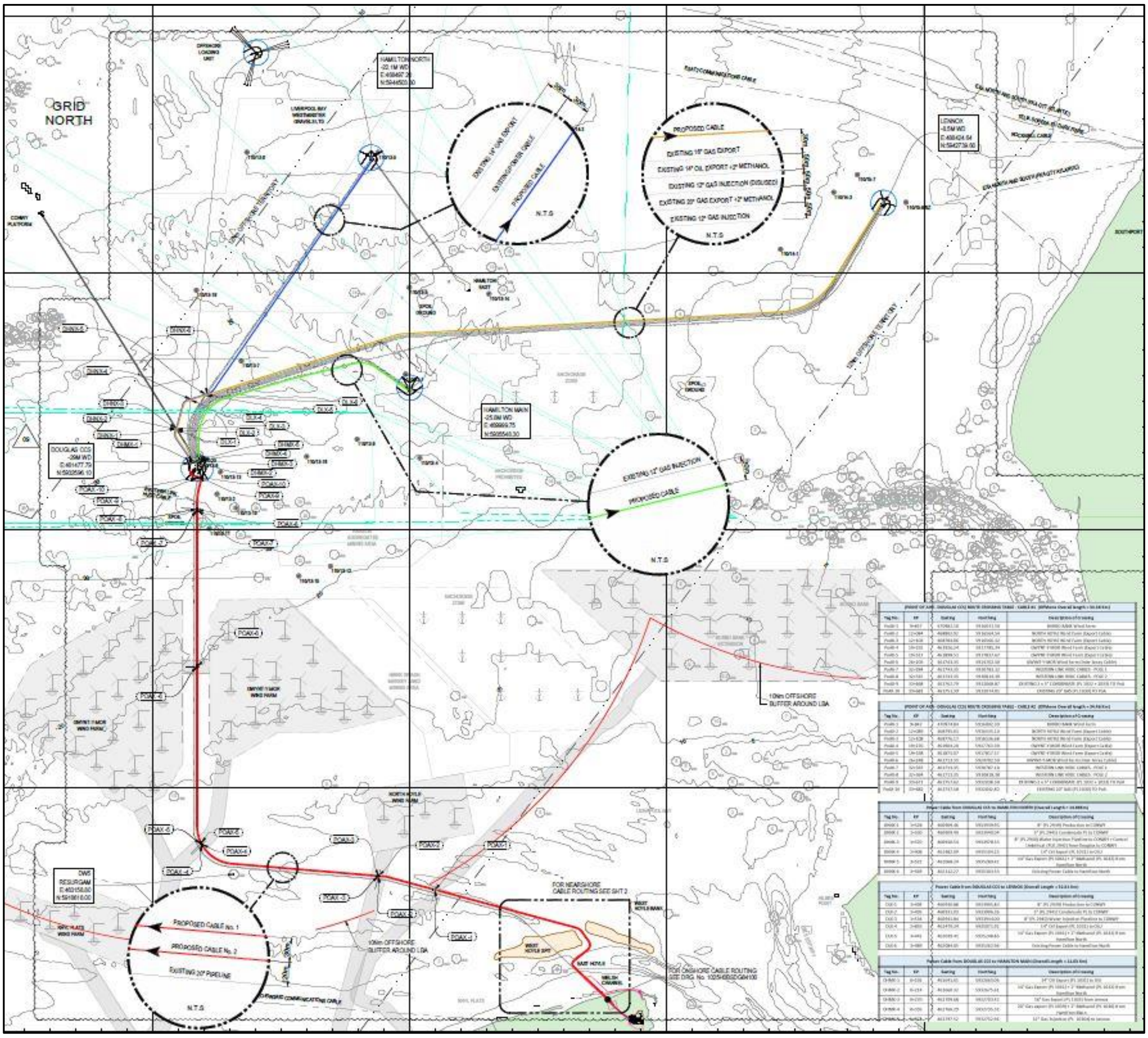


Figure 6-1 – Power Cable Route

6.3 Water Depths

Following Table 6-1 and Table 6-2 summarises the Water depth and sea water levels along the cable route.

Power Cable	KP Note 1		Water Depth Note 2	
	from	to	Min.	Max
	[km]	[km]	[m]	[m]
PoA to Douglas CCS Platform	0.0	33.93	0	29
Douglas CCS to Hamilton North Platform	0.0	15.10	22	29
Douglas CCS to Hamilton Main Platform	0.0	11.06	25	29
Douglas CCS Platform to Lennox Platform	0.0	32.55	8.5	29

Note 1: KP are approximate
Note 2: Water Depth is in LAT

Table 6-1 – Water Depth along the routes

Sea Surface Elevations (Tide and Surge)	Units	Hamilton North Field	Douglas Field	Hamilton Main Field	Lennox Field
Chart Datum	m	LAT	LAT	LAT	LAT
Highest Astronomical Tide (HAT)	m	9.43	9.20	9.46	9.66
Lowest Astronomical Tide (LAT)	m	0.00	0.00	0.00	0.00
Mean Sea Level (MSL)	m	4.67	4.56	4.68	4.79
1 Year Surge	m	1.01	0.98	1.02	1.08
10 Year Surge	m	1.40	1.37	1.42	1.50
100 Year Storm Surge	m	1.77	1.73	1.98	1.90

Table 6-2 – Sea Water levels

6.4 Cable Data

Following Table 6-3 summarises cable data (assumed based on previous project experience).

Parameters	Unit	Value
Outside Diameter	[mm]	150
Dry Weight	[kg/m]	45

Table 6-3 – Cable Data

6.5 Soil Data

The new power cable routes follow the existing pipeline/cable corridor where possible. Due to unavailability of geotechnical survey data for the new proposed cable routes, soil properties have been assumed as SAND [Hold 2]. Based on the available data, soils are dominantly sand, ranging from loose to dense sand with clay later below.

Variable	Unit	Value
Soil Type	[-]	Sand
Sub. Weight	[kN/m^3]	10

Table 6-4 – Soil Data

6.6 Concrete Mattress Specification

The recommended mattress specification for crossing design of the cables is presented below:

Length	Width	Thickness	Density	Density Edge Block	Typ. Weight in Air	Typ. Weight in Water
[m]	[m]	[m]	[kg/m3]	[kg/m3]	[Tonnes]	[Tonnes]
6	3	0.3	2400	3600	10.08	6.62

Table 6-5 Recommended Mattress Specification

The concrete mattress impact resistance is given as 5 – 20 KJ per a mattress in DNV-RP-F107 [Ref.15]. As the impact resistance capacity is unknown, conservatively the capacity is assumed as 15kJ per mattress. A typical schematic is show in Figure 6-2.

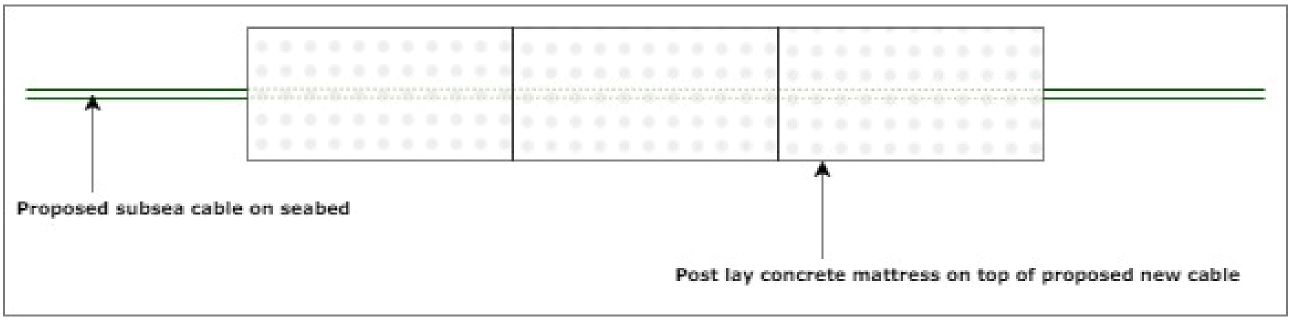


Figure 6-2 – Typical concrete mattresses based protection schematic

6.7 Rock Berm Specification

The rock berm height is taken as 1.0m, with the following tentative rock berm cross section as shown in Figure 6-3.

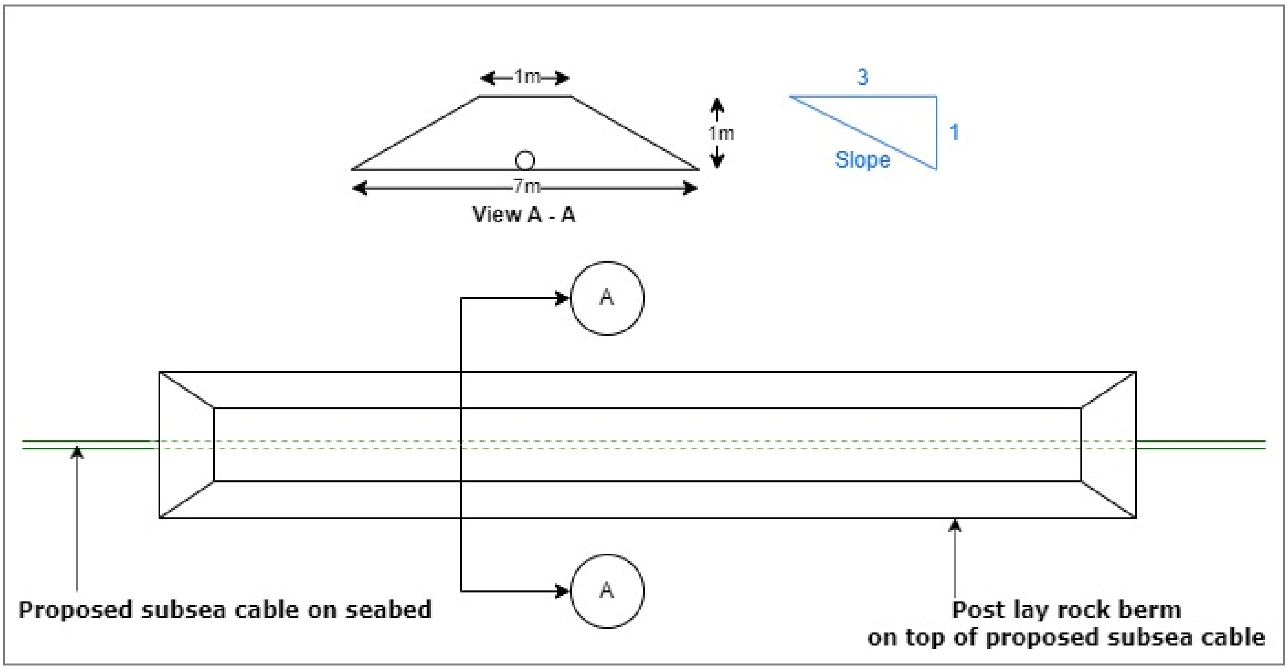


Figure 6-3 – Typical rock dump based protection schematic

6.8 Anchor Properties

6.8.1 Shipping Vessels

The routine traffic assessment study provided a breakdown of vessel DWT in the LBA area as presented in Table 8-2. Typical anchor weights have been extracted based on the vessels DWT according to vessel DWT to Anchor weight graph in Figure 6-4 [Ref.28].

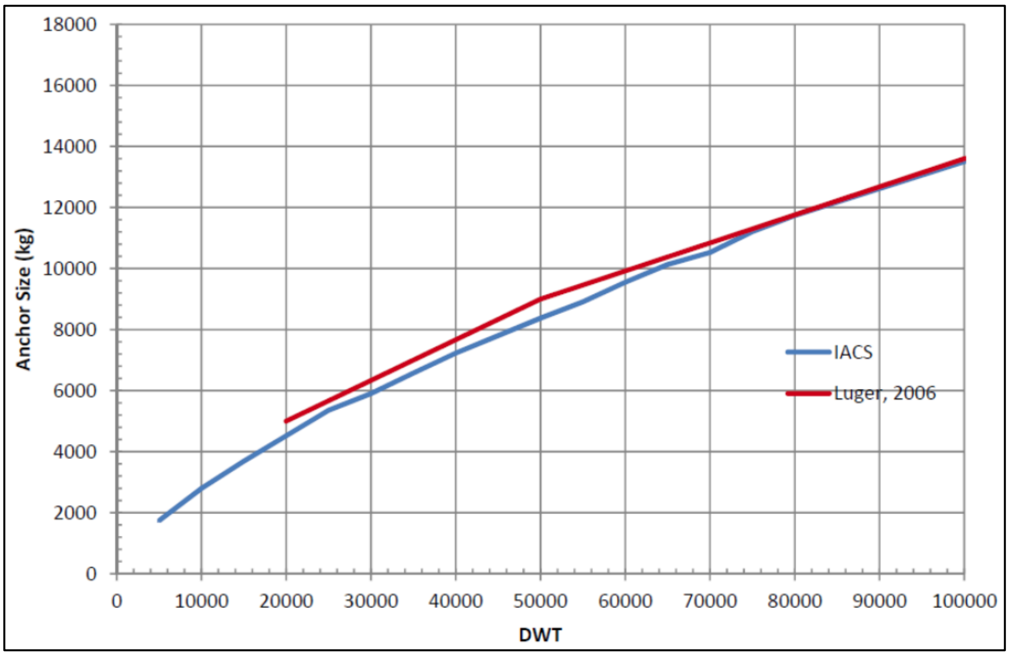


Figure 6-4 – Vessel Anchor Size in relation to Vessel DWT

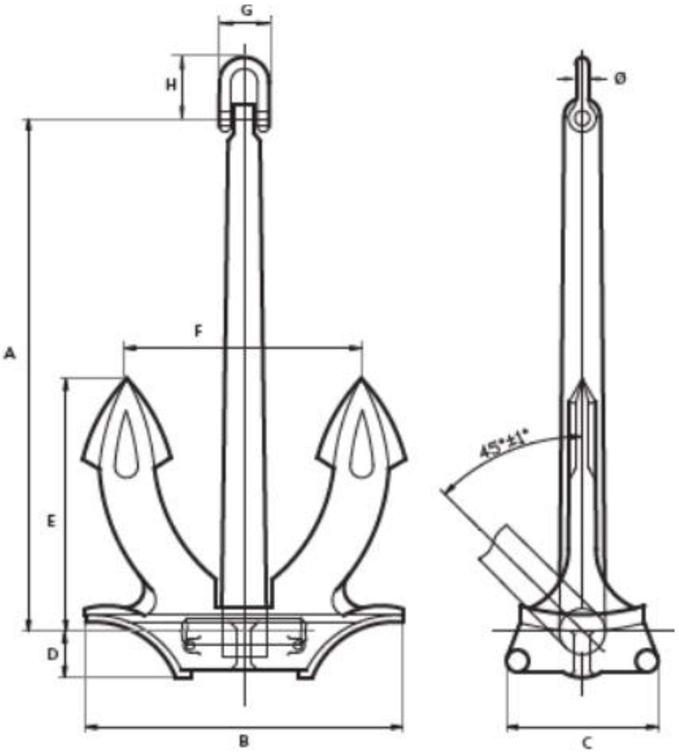


Figure 6-5 – Typical Vessel Anchor

Typical anchor weights have been extracted based on the vessels DWT according to Figure 6-5 relation. The dimensions of the anchors including the anchor fluke length (as illustrated in Figure 6-5 as dimension E) has been taken from Vendor Data Sheet [Ref.30] for each DWT vessel categories and is presented in Table 6-6 below.

DWT Category	Number of vessels	Percentage	Anchor Weight	Anchor Fluke Length	Anchor Bottom Length	Anchor Impact Width
[t]	[-]	[%]	[kg]	[mm]	[mm]	[mm]
0 - 1500	1285	8.3	660	769	1096	506
1500 - 5000	3120	20.2	1590	1035	1475	677
5000 - 7500	5991	38.7	2460	1194	1700	784
7500 - 10000	771	5.0	2850	1253	1787	822
10000 - 12500	767	5.0	3300	1317	1880	862
12500 - 15000	332	2.1	3540	1349	1926	883
15000 - 40000	862	5.6	7350	1717	2444	1129
40000+	1198	7.7	8300	1788	2545	1176
Unknown	1153	7.4	-	-	-	-

Table 6-6 – Estimated Anchor Specifications

6.8.2 Infield Vessels/ Supply Vessels Anchor

In accordance with DNV-RP-F107 [Ref.15] the typical weight of an anchor for a supply vessel is 2 tonnes. It is assumed that all infield vessels (DSV/ ROV/Construction/Supply Vessels) to the normally unmanned platforms have a maximum anchor weight of 2 tonnes.

6.9 Dropped Object Data Related to Transport Between Support Vessels and Platform

Data on the number of lifts to the normally unmanned platforms is currently unknown. It is expected as platforms are normally unmanned, the number of lifts to the platforms will be low during the operational phase for Douglas CCS, Hamilton Main, Hamilton North, and Lennox. As a result, for the purpose of the dropped object assessment it is assumed the following lift from the supply vessels to the platform is as per Table 6-7 below. The dropped object breakdown is as per the methodology presented in DNV-RP-F107 [Ref.15]. Loading to the platforms is via a 2-tonne max capacity davit, therefore all the lifts to the platforms are limited to 2 tonnes.

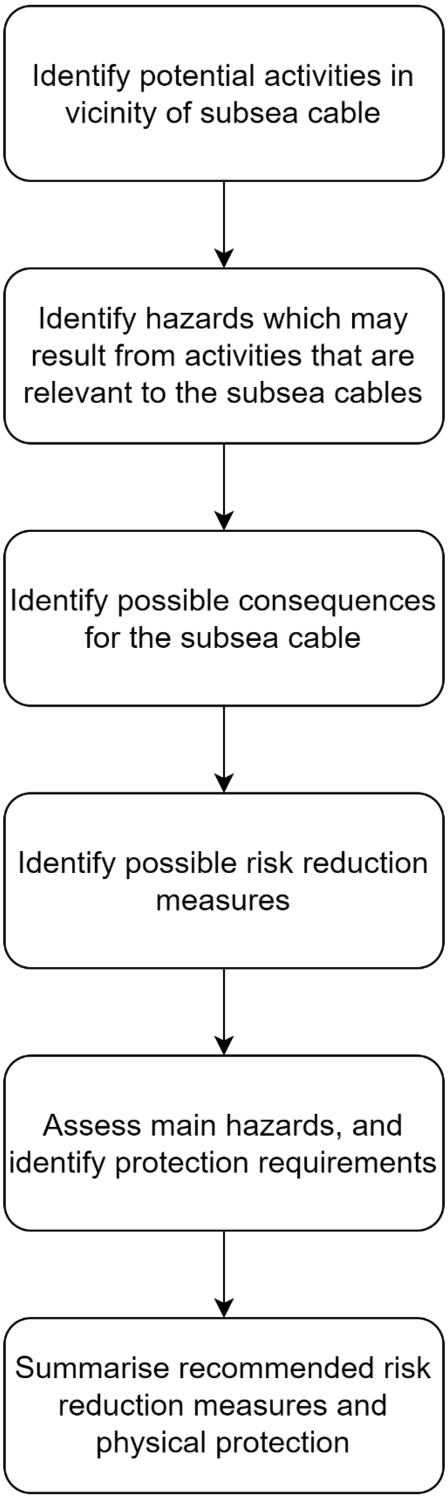
No.	Description	Weight in air (tonnes)	Typical Objects	Number lifted per year
1	Flat/Long Shaped	<2	Drill Collar/Casing, Scaffolding	2
2		2-8	Drill Collar/ Casing	0
3		>8	Drill Riser, Crane Boom	0
4	Box/Round Shaped	<2	Container (food, spare parts), Basket, Crane Block	2
5		2-8	Container (Spare parts), Basket, Crane Block	0
6		>8	Container (Equipment), Basket	0
7		>>8	Massive Objects such as BOP, Pipe Reel etc	0

Table 6-7 Dropped Objects – Transport Between Support Vessels and Platform

7.0 PROTECTION REQUIREMENT STUDY

7.1 General

The preliminary protection requirement study will be developed as follows.



The potential activities in the vicinity of the LBA CCS T&S Project, the possible hazards, and potential consequences are presented in Table 7-1. The assessment of the main hazards identified is undertaken in Sections 9.0 and 10.0. Recommended risk reduction measures and physical methods of protection are summarised in Section 5.0.

7.2 Hazard Identification

Table 7-1 – lists the activities and operations which are anticipated in the vicinity of the new LBA CCS T&S Project subsea cable network. It identifies the potential hazards arising from these activities which may damage the facilities, and the possible consequences which may result [Ref.15].

Operation/Activity	Hazard Possible	Possible Consequence to Cables or facilities
Installation of new cable	Loss of tension, dropped cable	Damage to cable
Platform based lifting activity	Drop of objects into the sea	Impact to cable or J tube
Installation/Planned construction work/subsea operations)	Drop of objects into the sea Dropped Anchor	Impact to cable or J tube
Trawling/Fishing Activities	Trawl board impact, pull-over or hooking	Impact or pull-over of cable
Anchor Handling activities	Dropped anchor	Impact on cable
	Dragging chain	Abrasion of cable
	Dragged anchor	Impact and/or hooking of cable
Supply vessel and commercial shipping traffic	Collision (powered or drifting)	Impact of J tube
	Emergency anchoring.	Impact and/or hooking of cable
	Sunken ship	Impact on cable

Table 7-1 – Possible external Hazard

7.3 Risk Reduction

The risk associated with an activity can be reduced by:

- Reducing the frequency of the event;
- Reducing the consequence of the event.

Potential risk measures are listed in Table 7-2.

Action	Reduction	Comments
Limiting lifting to certain zones, sectors, areas	Frequency	This reduces/eliminates the frequency of the hazard.
Limit the type of object lifted in certain zones	Frequency	Often used when lifting heavy objects, reduces the frequency of the most critical objects
Introduce safety distance / 500m exclusion zone and safe areas	Frequency	Activity of certain types not allowed within a specified area, reduces/eliminates the risk efficiently

Action	Reduction	Comments
Change Field layout	Frequency	By careful routing the same effect as for safety distance can be achieved for some parts of the cable.
J-tubes protected by external structure	Consequence	Increased protection to J-tube from dropped objects.
Weather restrictions for operations	Frequency	Frequency increases with worsening weather conditions
Increase the protection	Consequence	Increased protection may reduce the damage to the cable. Noting that some solutions could themselves pose risks during installation
Alert other Marine users to presence of new subsea cables and liaison with bodies such as Sea Fish Industry Authority (SFIA) and notification of UK Hydrographic Office.	Frequency	This reduces/eliminates the frequency of the hazard

Table 7-2 – Risk Reduction Measures

However, the hazards identified cannot be completely eliminated, and therefore need to be assessed to determine whether protection against them is possible and/or practicable. The hazards identified repeatedly in Table 7-1 will be addressed in the sections which follow under three main headings:

- Fishing interaction;
- Dropped objects;
- Anchor interaction.

8.0 IDENTIFIED HAZARDS

This section presents the hazards which have been identified in the LBA CCS T&S region.

8.1 Costal Change Model at Point of Ayr Landfall

This section presents an assessment of coastal changes at the Point of Ayr landfall. This is required to understand how the cable landfalls may be affected by coastal changes during the lifetime of their operation.

There are minor morphological changes to the shape of the north-western side of the West Hoyle Spit. Comparison of the 2016 imagery [Figure 8-1] and 2021 imagery [Figure 8-2], shows that there has been an eastward growth of the spit/ storm beach and outer spit. Comparison of the available bathymetry datasets does show erosion on the West Hoyle Spit and the development of a channel up to 3.5 m deep in the 2019 bathymetry data compared to the 1993 bathymetry profile. This channel has subsequently been infilled and is not observable in the 2022 dataset.

Other changes can be observed at the eastern end of the West Hoyle spit, with changes of elevation of up to 3m observed between 2019 and 2022 caused by the eastward migration of the spit and the infilling of a channel feature. Further details can be found in Phase 2C Nearshore Engineering Geological Ground Model Report by Fugro[Ref.10].

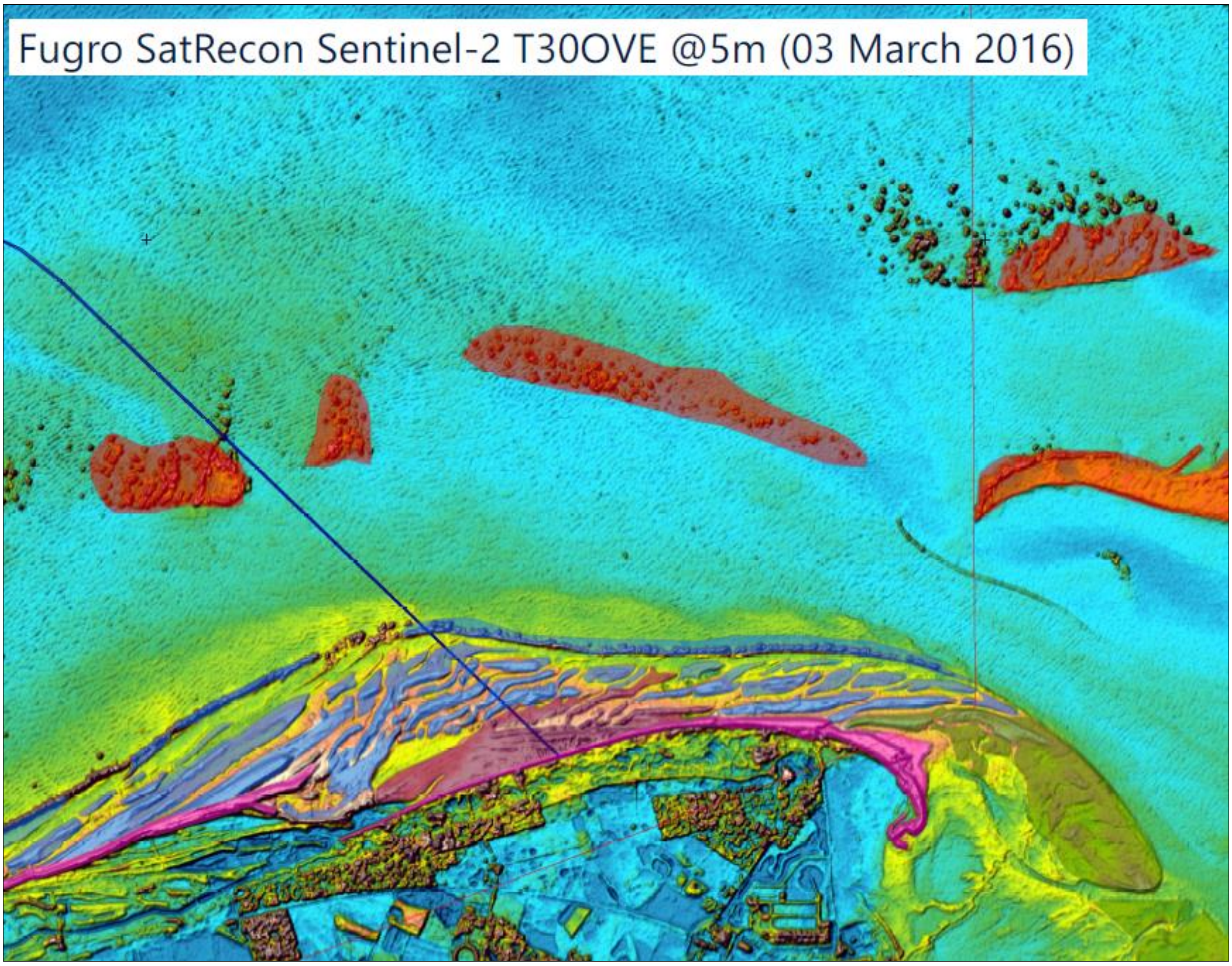


Figure 8-1 – Fugro SatRecon Imagery 2016

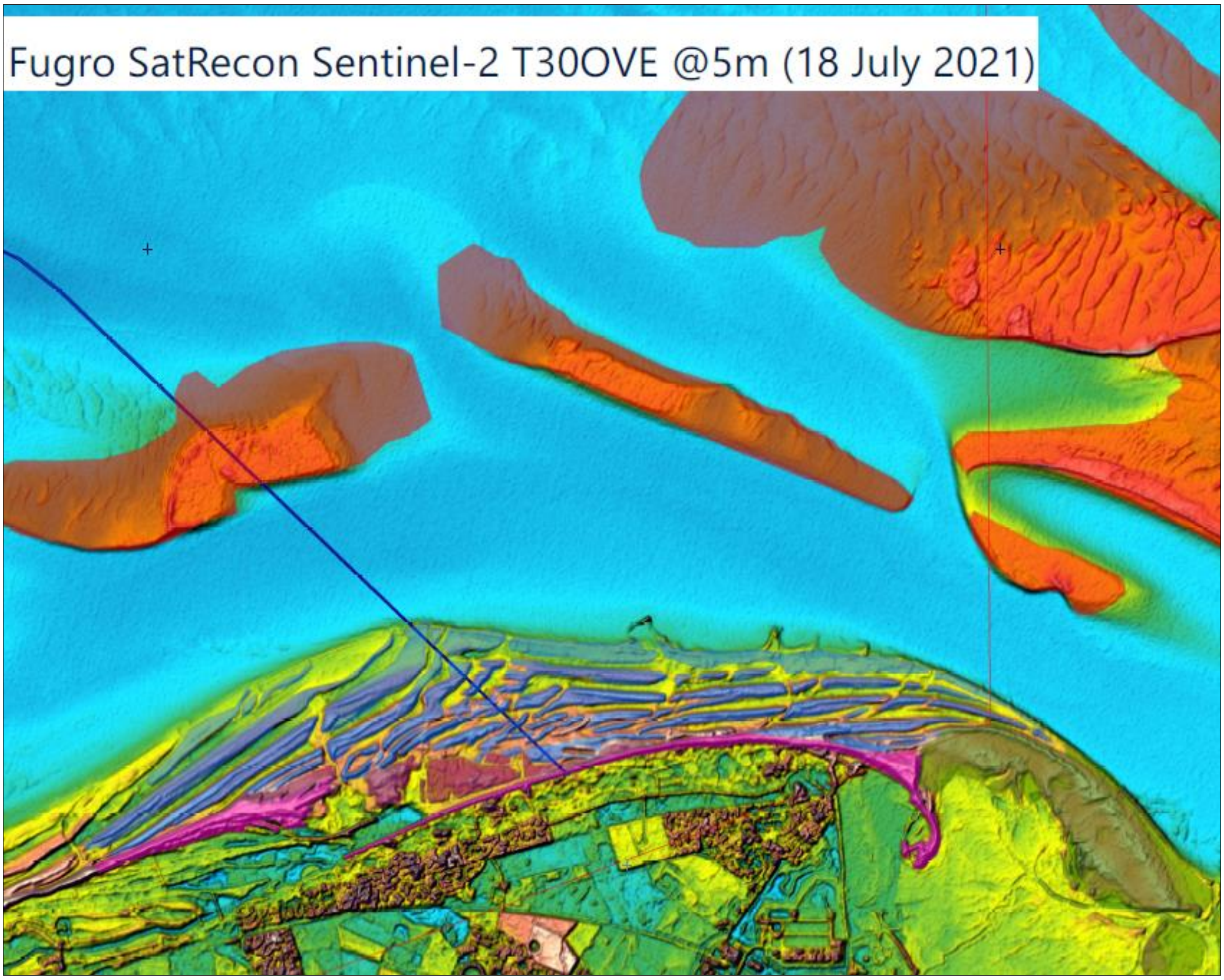


Figure 8-2 – Fugro SatRecon Imagery 2021

8.2 Dropped Objects

The activities that may take place at Liverpool Bay area which might result in objects being dropped on the subsea cables associated with the LBA CCS T&S are as follows:

- Lifting operations at the platforms involving the crane/davit;
- Supply vessel lifting operations;
- Vessel activities associated with subsea construction, maintenance, or inspection operations;
- Commercial marine traffic.

Al the above listed activities are credible scenarios with various degree of dropped object sizes, frequencies, impact, and consequences. A detailed dropped object study shall be conducted based on risk assessment of dropped object sizes, estimated frequency, and impact energies on subsea cables calculated to the acceptable level following the methodology presented in DNV-RP-F107 [Ref.15].

The location of crane/davit for the Douglas CCS, Hamilton Main, Hamilton North, and Lennox platforms are shown in Figure 8-3, Figure 8-4, Figure 8-5, and Figure 8-6.

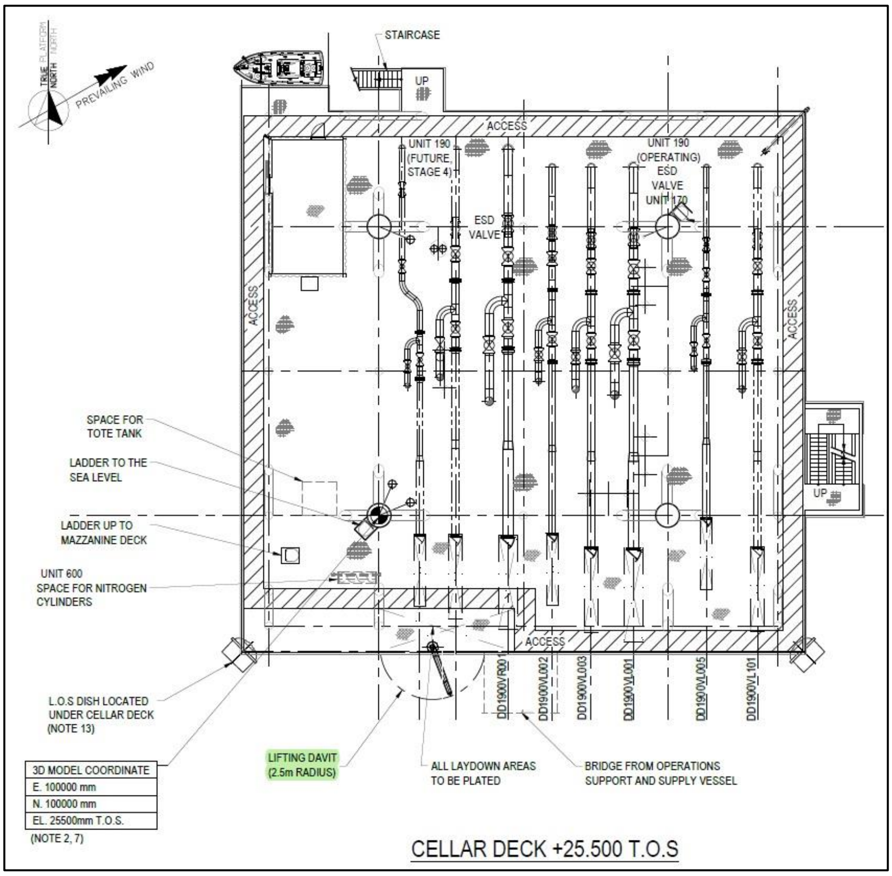


Figure 8-3 – Location of Davit at Douglas CCS Platform

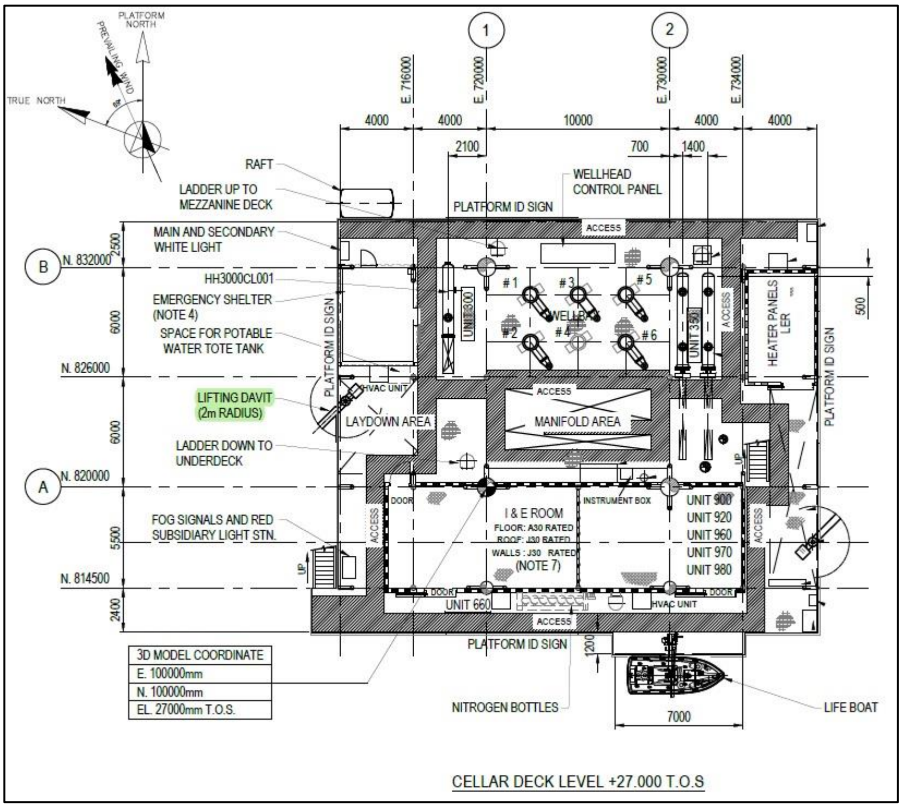


Figure 8-4 – Location of Davit at Hamilton Main Platform

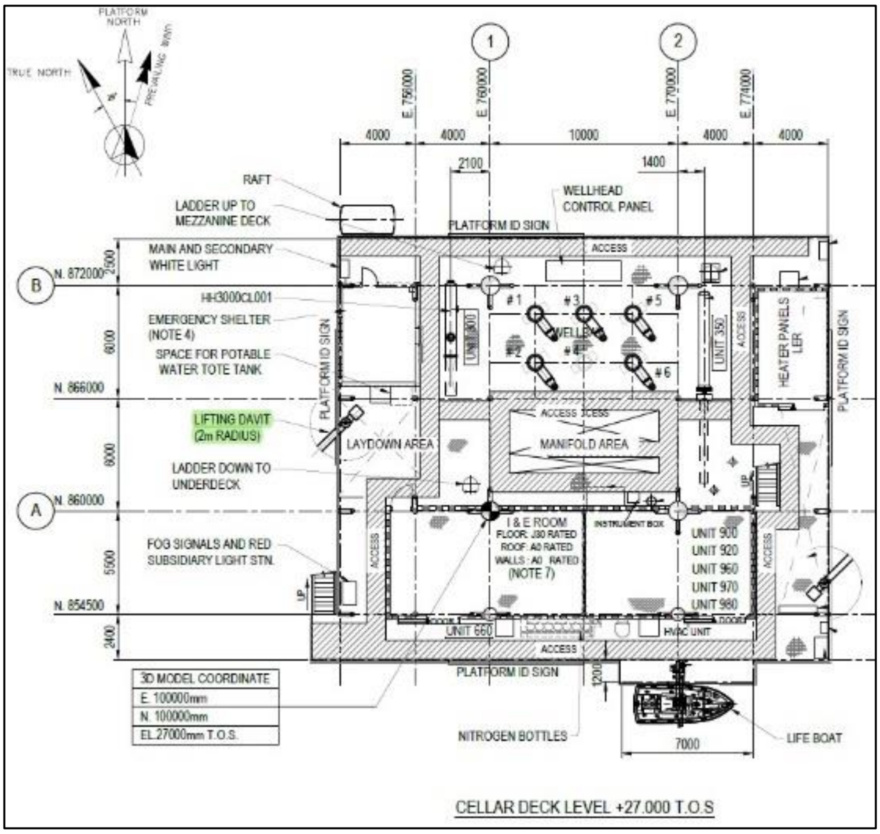


Figure 8-5 – Location of Davit at Hamilton North Platform

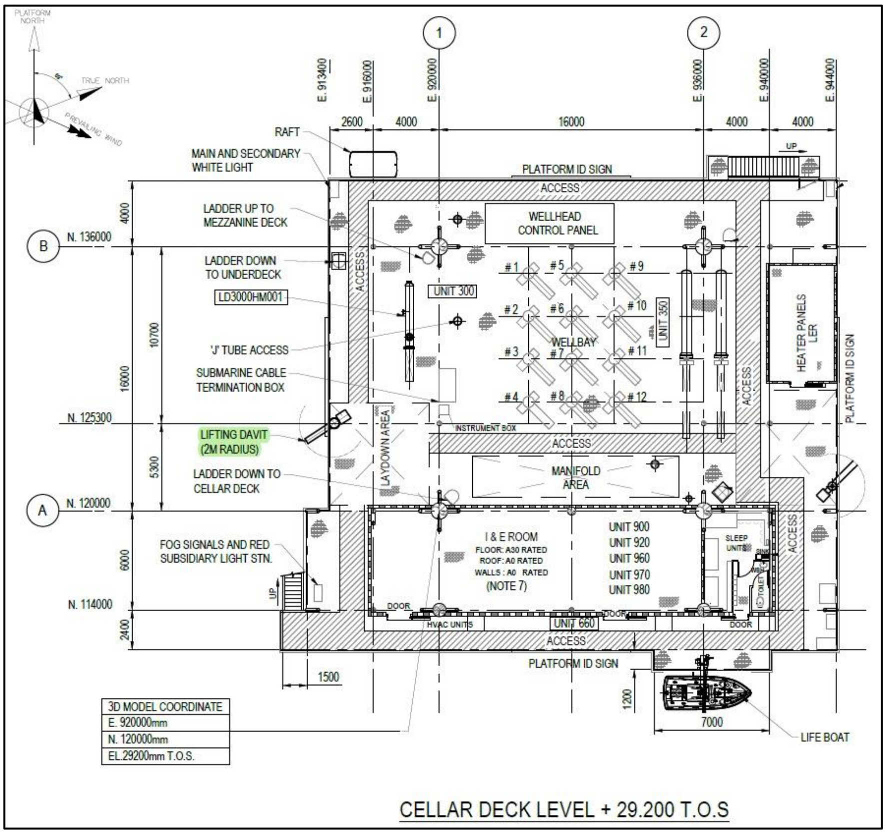


Figure 8-6 – Location of Davit at Lennox Platform

Further risk of dropped objects common to the entire development arise from survey vessels during inspection of subsea facilities (cables, pipelines, subsea isolation valves, pipeline spools etc). There is a risk of objects being dropped from vessels conducting inspection surveys. In general, these vessels do not carry heavy equipment and it is expected that dropped objects will be limited to small items such as hand tools or rigging. There is however a very small risk of an inspection vehicle, such as an ROV, being lost if they were to become severed.

8.3 Fishing Vessel Traffic

8.3.1 General

The LBA CCS T&S cables and platforms (Hamilton Main, Hamilton North, Lennox, Douglas CCS) is located in the International Council for Exploration of the Sea (ICES) rectangle VIIa (Irish sea) as depicted in Figure 8-7. The LBA CCS cables lies within the sub-group rectangle of 36E6 and as per Fishing Vessel Risk assessment report carried out in the year 2000, [Ref.17] demersal fishing i.e. fishing that targets fish that live on or near the seabed are prominent in this area and therefore poses a greater risk on interactions with the cables on the seabed. The assessment from the Fishing Vessel Risk Assessment is historic and a new fishing vessel assessment with up-to-date data on fish in the LBA is expected. [HOLD 1].

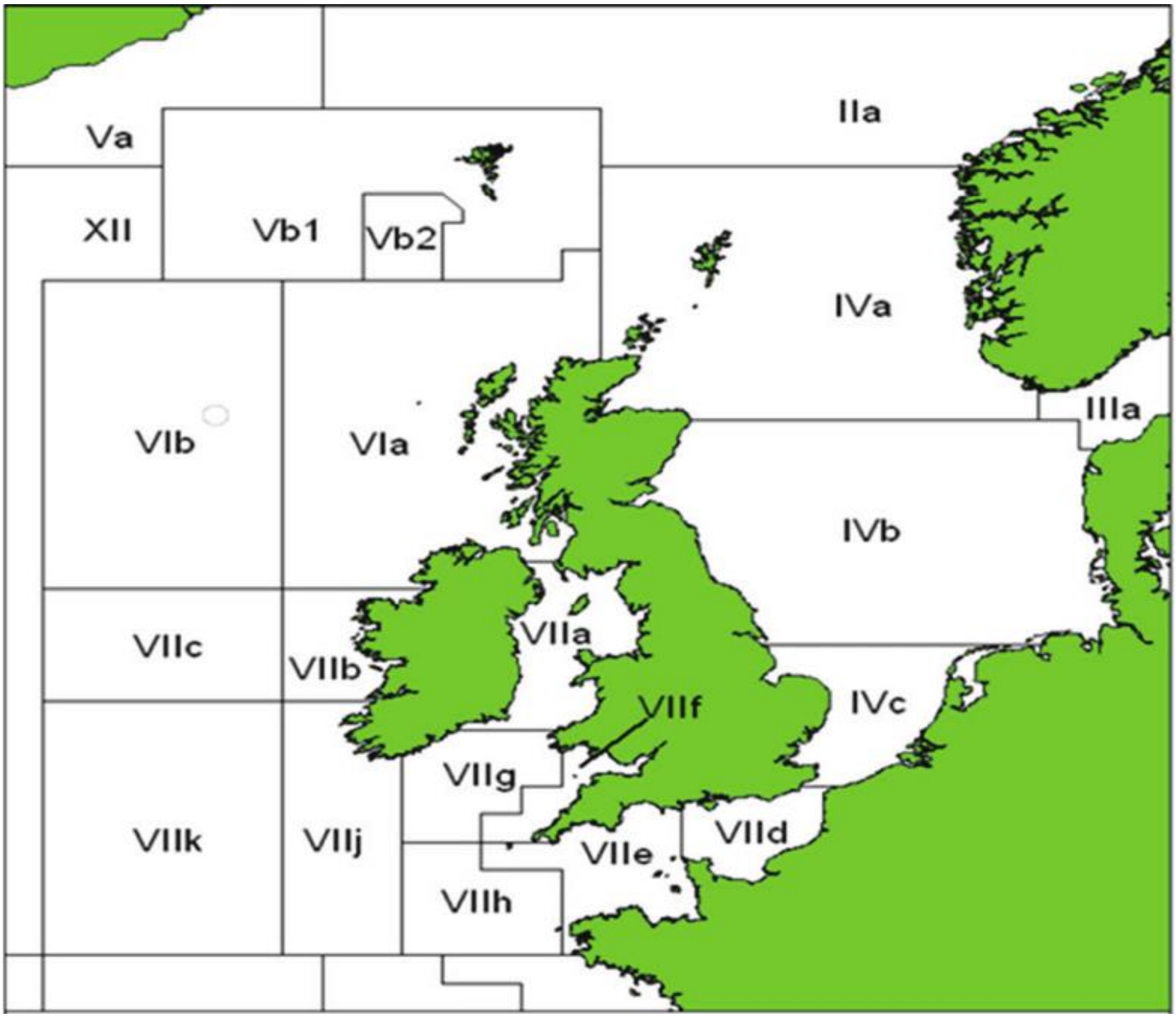


Figure 8-7 – ICES Fishing Areas Around the UK Coastline [Ref.17]

8.3.2 Fishing Intensity in Study Area

A fishing traffic assessment study carried out in 2020 for the Liverpool Bay area [Ref.18], shows vessel tracks from all fishing vessels identified within the 10 nm study area see Figure 8-8. As indicated in [Ref.17] the presence of fishing vessels does not necessarily indicate the presence of fishing activity in the study area and may represent vessels in transit. However, the Irish Sea is an area of intense fishing activity, and that demersal fishing, i.e., otter trawls and trawl beams, is the predominant method used in these waters, [Ref.17].

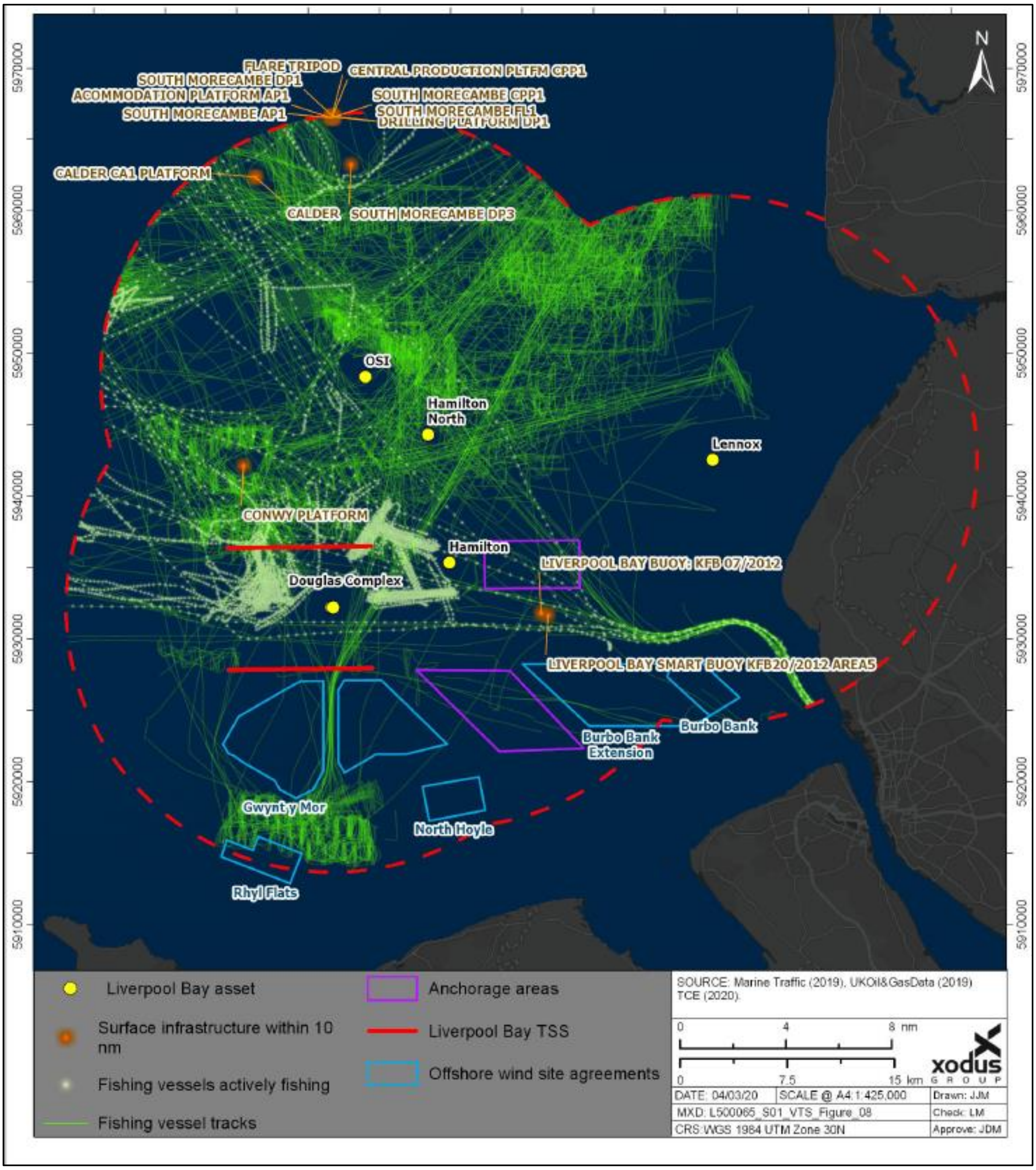


Figure 8-8 – Fishing activity within LBA 10 nm study area [Ref.17]

In accordance with [Ref.17], Fishing activity in the LBA study area is concentrated to the north west, and an area of actively fishing vessels is focussed between the LBA assets Hamilton, the Douglas Complex, Hamilton North and the buoy moored Oil Storage Installation (OSI).

Additionally, there is an area of fishing activity to the south of the LBA study area, between Gwynt y Mor and Rhyl Flats wind farms. The area immediately surrounding Lennox shows very little fishing activity. Figure 8-8 also shows that fishing vessels avoid the Douglas Complex and (OSI).

8.3.3 Fishing Gear Interaction

The demersal fishing gears and its features which could potentially interfere with cables on the seabed are highlighted in Table 8-1 below.

Gear	Features	Impact
Trawling (otter trawl, beam trawl etc.)	Comprise a large net which is towed along the seabed with its “mouth” held open by either a system of weights and floats or by a metal frame weighing up to 5 tonnes.	• Impact loads if fishing gear hits and is stopped by the cable/structure; • Pullover loads if fishing gear does not become caught on the cable /structure; • Snag loads when gear is hooked on the cable or structure as the vessel is stopped; • Recovery loads if the vessel attempts to retrieve the hooked fishing gear
Netting	Method relies on laying out long warps to surround an area of seabed with a net similar to a trawl with extended wings	
Dredging	The dredge is towed along the seabed at slow speed for periods of around 1.5 hours or until the netting is filled with catch or debris.	

Table 8-1 – Demersal fishing gears and features potentially interfering with cables

Based on the intensity of fishing in the study area as shown in Figure 8-8 and possible impact on the cables as highlighted in Table 8-1, the probability of occurrence is high, and the LBA CCS cables will unlikely be able to survive the loads generated during fishing interaction incidents, hence the cables needs to be protected.

8.4 Routine Vessel Traffic (Shipping Lane and In-Field Traffic)

A routine traffic assessment study carried in 2020 for the Liverpool Bay area [Ref.17], shows vessel tracks from all routine and in-field vessels identified within the 10 nm study area.

The majority of routine vessel tracks (88.1%) within the whole Liverpool Bay Assets study area are associated with shipping lane traffic, compared with only 12% in-field traffic (In-field traffic is defined as vessels operating within the hydrocarbon field complex, and in this case include safety vessels, supply vessels and other in-field vessels).

Of the 27 shipping lanes identified within in the study area, lane 6 was the busiest lane with 31.3% of all shipping lane traffic (4,270 tracks) across the whole LBA study area. Lane 6 (Liverpool to Dublin) was closest to Hamilton at a mean distance of 1.02 nm from the asset.

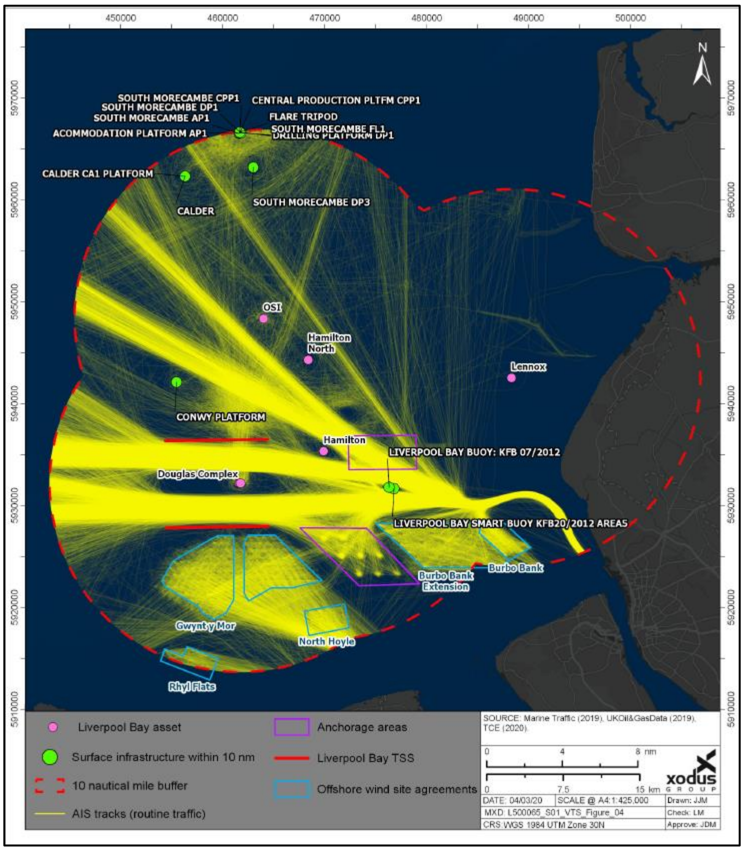


Figure 8-9 – Routine Vessel tracks within LBA 10 nm study area [Ref.17]

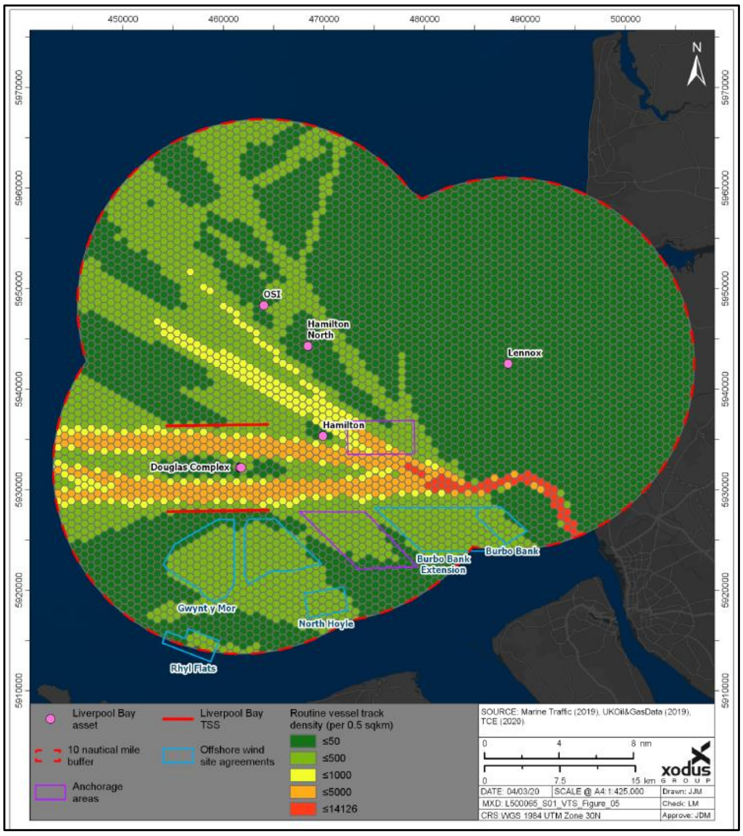


Figure 8-10 – Routine Vessel tracks within LBA 10 nm study area [Ref.17]

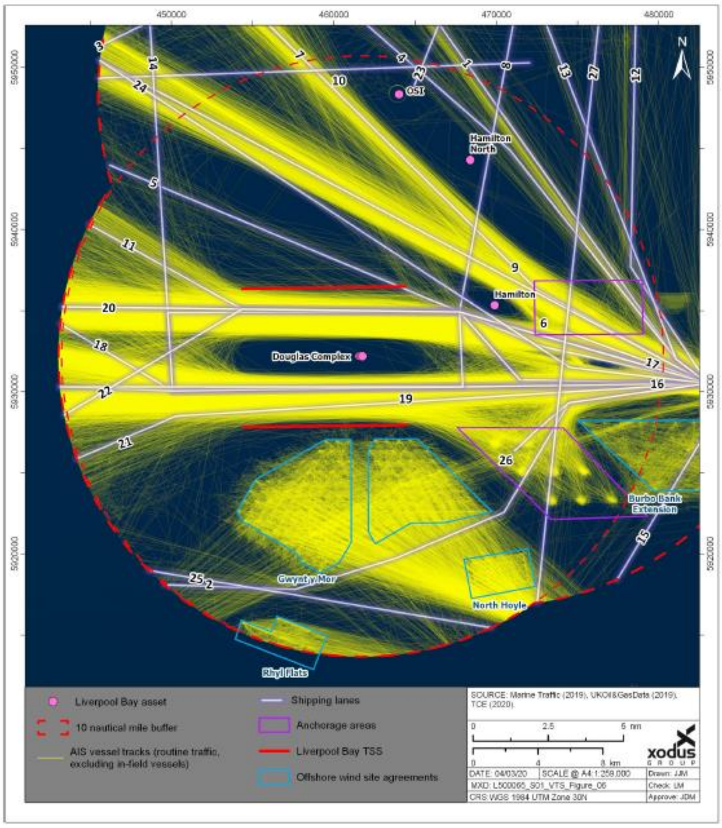


Figure 8-11 – Shipping Vessel Lane Traffic within Douglas Complex 10 nm study area [Ref.17]

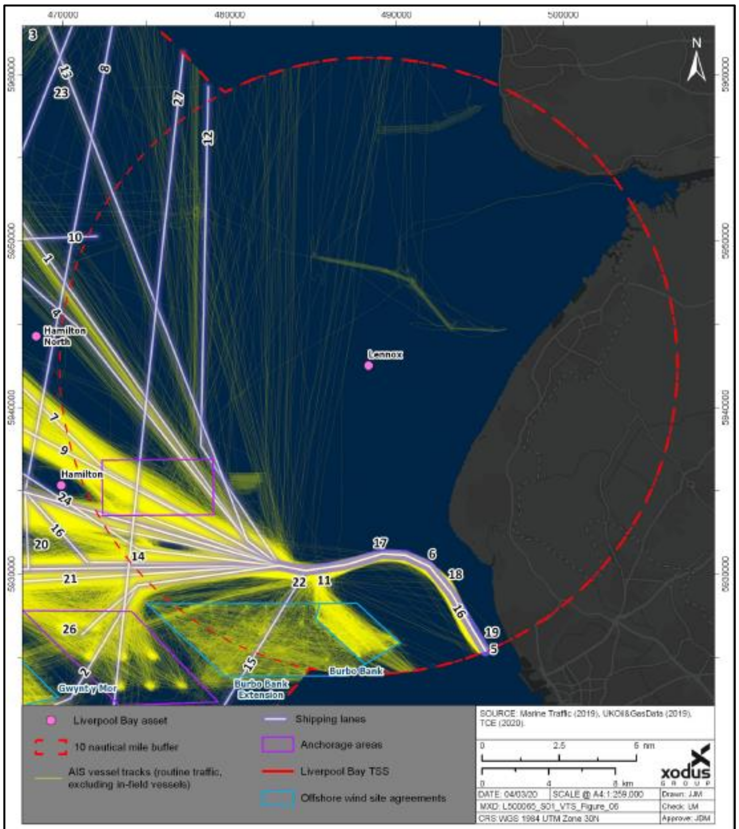


Figure 8-12 – Shipping Vessel Lane Traffic within Lennox Complex 10 nm study area [Ref.17]

Table 8-2 presents the breakdown of routine vessel tracks by DWT in the whole LBA Study area [Ref.17].

DWT Category	Number of vessels	Percentage
[t]	[-]	[%]
0 - 1500	1285	8.3
1500 - 5000	3120	20.2
5000 - 7500	5991	38.7
7500 - 10000	771	5.0
10000 - 12500	767	5.0
12500 - 15000	332	2.1
15000 - 40000	862	5.6
40000+	1198	7.7
Unknown	1153	7.4

Table 8-2 – Routine Vessel Tracks by DWT in the Whole LBA Study Area

With this information, the vessels are categorised into two group with regards to potential operational or accidental anchor operations

- Commercial Shipping/ Fishing Vessels;
- DSV/ROV/Construction Vessel/ Supply Vessels.

8.4.1 Commercial Shipping/fishing

As stated above, this account for 88.1% within the shipping lane [Ref.17] and poses a threat to the subsea cable in the event of emergency anchoring to control a drifting ship. Subsea cable would be in danger of impact damage during anchoring operations, abrasion from a dragged anchor chain or hooking.

8.4.2 DSV/ROV/Construction/Supply Vessels

Vessels carrying out routine inspection or maintenance activities and platform supply vessels would operate along the cable route and within the 500m exclusion zone. These generally operate in dynamic positioning (DP) mode and therefore would not normally utilise anchors. However, anchoring may be required, and typical reasons for a dropped anchor during an anchoring operation are human error, failure of the chain braking system, or loss of power supply to the chain braking system. In these circumstances the dropped anchor might cause impact, dragged chain could cause abrasion, and there is a risk of hooking.

9.0 PROTECTION PHILOSOPHY & METHODOLOGY

The protection principal criteria for the power cable system are based upon the need for a safe system, such that all risks are reduced to a level where they are As Low As Reasonably Practicable (ALARP principal). To achieve this, it is necessary to protect against the potential hazards associated with the platform and non-platform related activities that the power cable could be exposed to.

The possible potential causes of damage could be listed as follows:

- Dropped objects from platforms;
- Miscellaneous dropped objects from drilling rigs or supply boats;
- Anchors, anchor chains or cables;
- Seabed fishing activity; and
- Subsea operations.

Damage to subsea infrastructure from each of these loadings can be minimised by limiting the risks, if possible, or by preventing damage during the service life of the system with an appropriate protection philosophy. The philosophy which should be maintained consists of both mechanical protection and procedures for operation and work-over events in the vicinity of the subsea infrastructure.

Most of the existing subsea architecture in waters off the Coast of the UK, including the Irish and North Seas, possesses a similar protection philosophy. Consequently, the protection measures adopted for the Liverpool Bay CCS power cables are consistent with general industry practice and are not based on the results of a field specific design study.

9.1 Dropped Object

The philosophy adopted, to mitigate the risk presented by dropped objects, is to minimise handling of objects over the power cables and, where necessary, provide protection and adopt strict handling procedures.

The dropped object assessment shall be assessed with the methodology presented in DNV-RP-F107 [Ref.15]. A probabilistic assessment will be carried out considering the power cable No. 1 and No. 2 from Point of Ayr to Douglas CCS at Douglas CCS platform approach and power cable from Douglas CCS to Satellite platforms at satellite platform approaches. It has been identified that the risk of damage from dropped objects is highest for two subsea cables (Power Cable No. 1 from Point of Ayr to Douglas CCS at Douglas CCS approach and Power Cale to Lennox from Douglas CCS at Lennox platform approach) considering the proximity of the davit to the entire length of the subsea cable and the water depth, see Figure 9-1and Figure 9-2.

The frequency, size and location of potential dropped objects at the Douglas CCS Platform and Lennox Platform will be accounted for to calculate:

- The probability of dropped object impact;
- The potential damage from each type of dropped object;
- The energy absorbed by the concrete mattresses if applicable;
- The overall risk to the subsea cables.

The overall risk will be compared to the safety class requirements of DNV-RP-F107 [Ref.15] to determine the requirements for mitigation.

9.1.1 Subsea Cable Risk Assessment – Douglas CCS Platform Location

For the Douglas CCS platform, the closest subsea cable at risk of a drop object is the power cable no. 1 from Point of Ayr to Douglas CCS. Power cable no. 2 from Point of Ayr to Douglas CCS also possess a small risk of dropped object. The three cables to satellite platforms are located on the northern face of the platform and possess no risk to dropped object as shown in Figure 9-1.

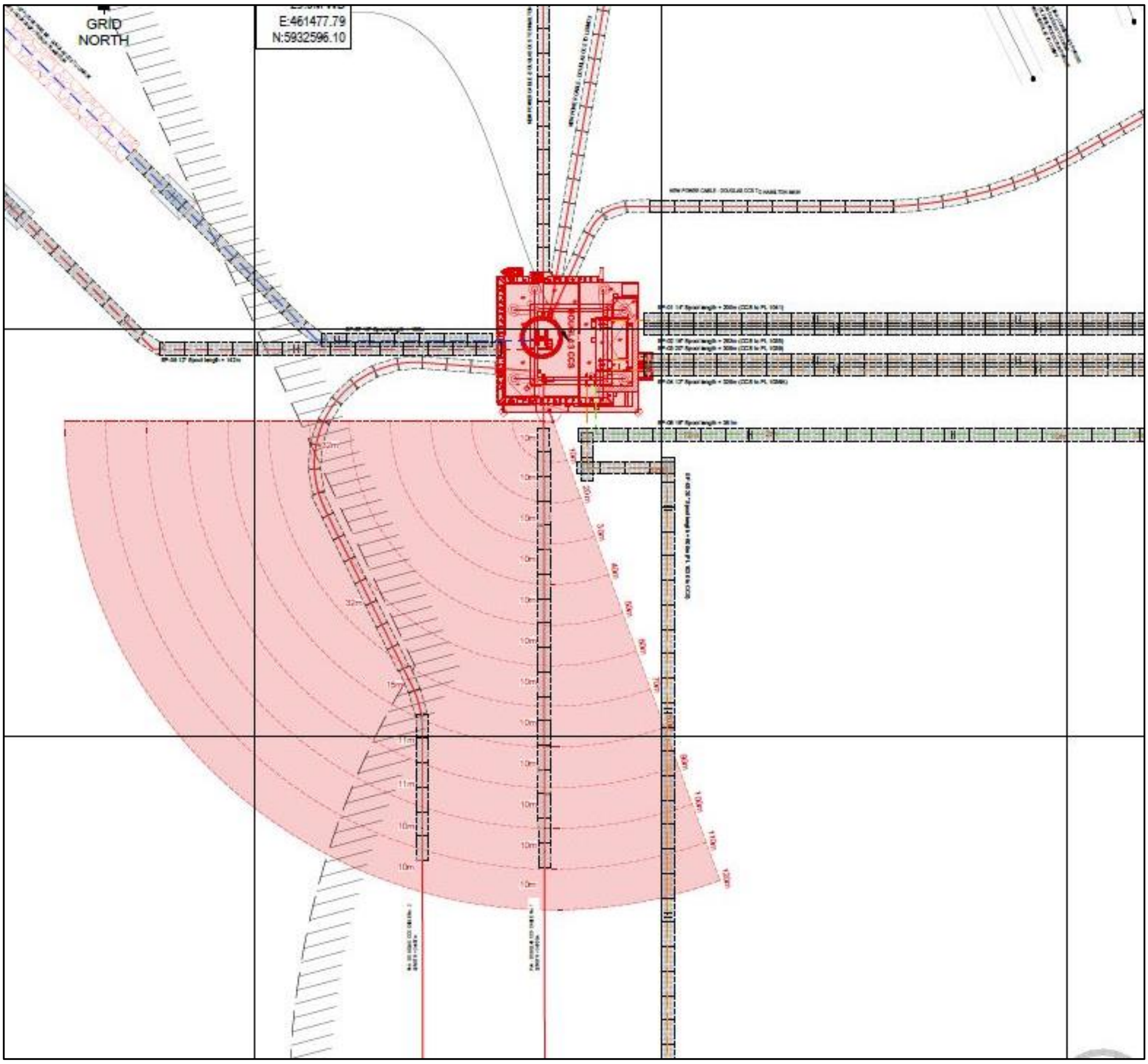


Figure 9-1 – Drop Point Location with indication of 10-metre interval rings – Douglas CCS Platform

The length of the subsea cable from Point of Ayr to Douglas CCS at the Douglas CCS platform within each section is given in Table 9-1 – and Table 9-2.

Interval Rings	0 - 10	10 - 20	20 - 30	30 - 40	40 – 50	50 – 60	60 - 70	70 - 80	80 - 90	90 - 100	100 - 110	110 - 120
Length (m)	10	10	10	10	10	10	10	10	10	10	10	10

Table 9-1 – Length of Cable within each of 10m interval rings - Power Cable No. 1 at Douglas CCS

Interval Rings	0 - 10	10 - 20	20 - 30	30 - 40	40 – 50	50 – 60	60 - 70	70 - 80	80 - 90	90 - 100	100 - 110	110 - 120
Length (m)	0	0	0	0	0	32	32	15	11	11	10	10

Table 9-2 – Length of Cable within each of 10m interval rings - Power Cable No. 2 at Douglas CCS

9.1.2 Subsea Cable Risk Assessment – Lennox Platform Location

For the Lennox platform, the subsea cable from Douglas CCS platform possesses risk of dropped objects as shown in Figure 9-2.

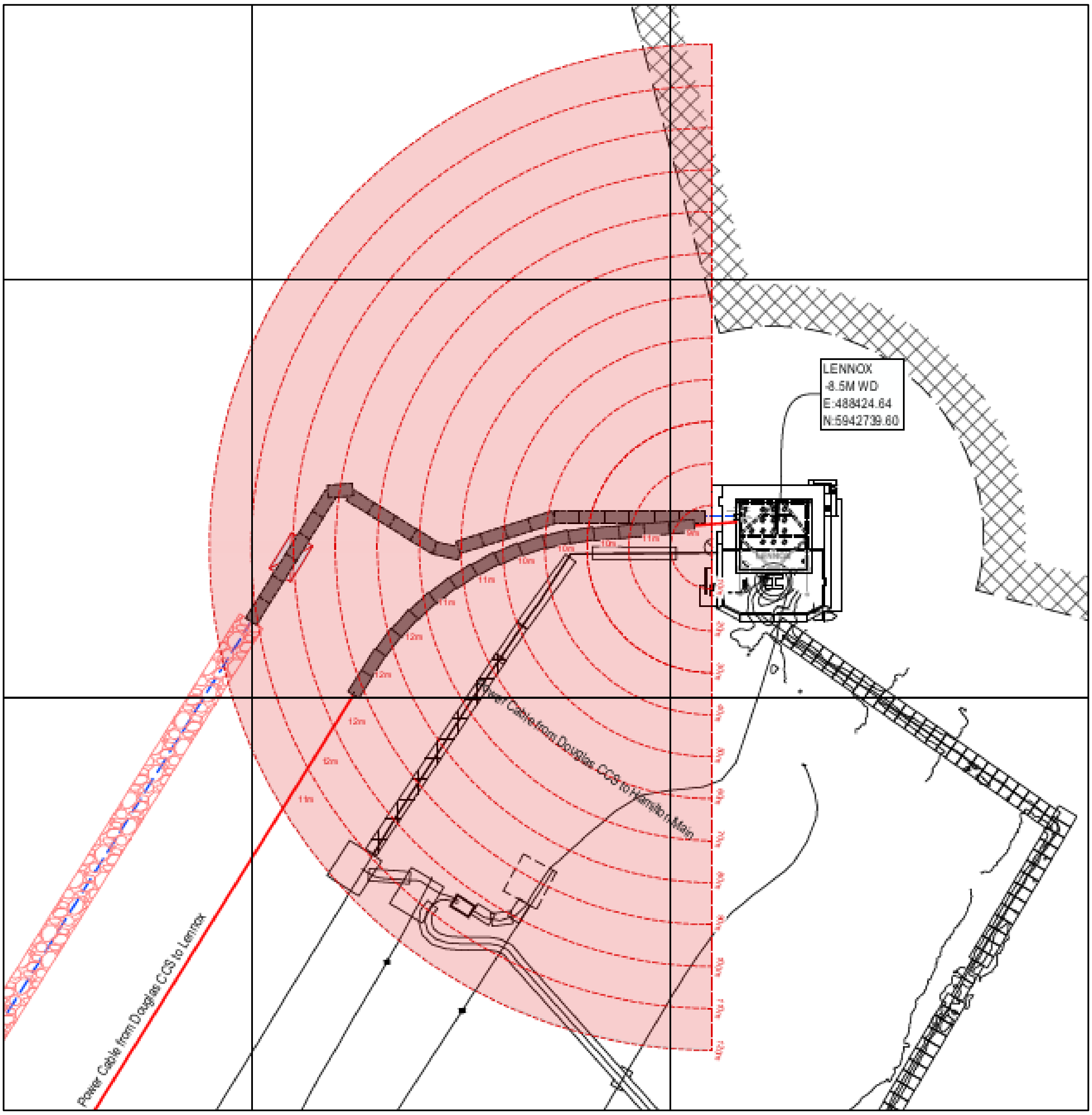


Figure 9-2 – Drop Point Location with indication of 10-metre interval rings – Lennox Platform

The length of the subsea cable from Douglas CCS to Lennox at the Lennox platform within each section is given in Table 9-3.

Interval Rings	0 - 10	10 - 20	20 - 30	30 - 40	40 – 50	50 – 60	60 - 70	70 - 80	80 - 90	90 - 100	100 - 110	110 - 120
Length (m)	9	11	10	10	10	11	11	12	12	12	12	11

Table 9-3 – Length of Cable within each of 10m interval rings - Power Cable at Lennox Platform

9.1.3 Subsea Cable Risk Assessment – Hamilton Main Platform Location

For the Hamilton Main platform, the subsea cable from Douglas CCS platform possesses relatively lower risk of dropped objects as shown in Figure 9-3.

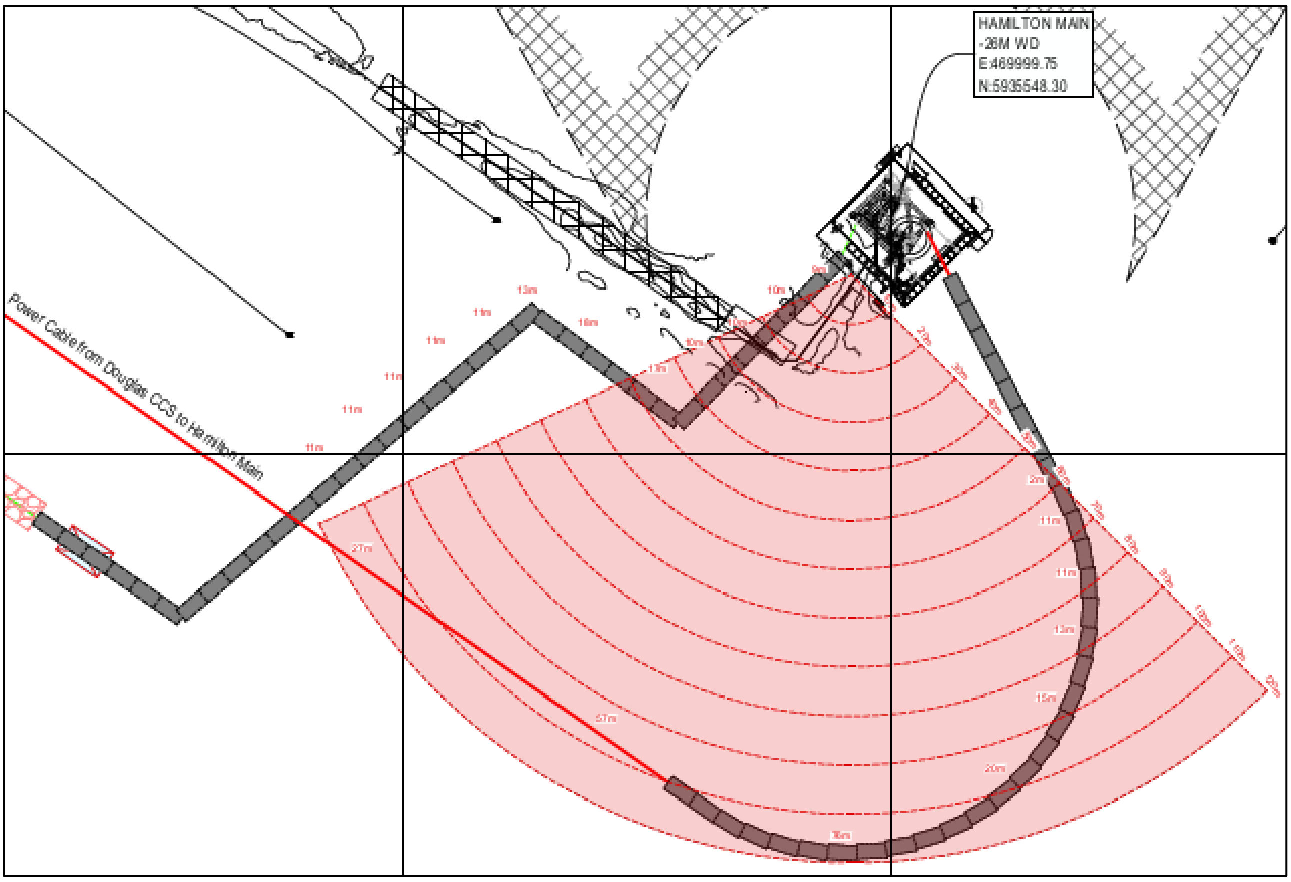


Figure 9-3 – Drop Point Location with indication of 10-metre interval rings – Hamilton Main Platform

The length of the subsea cable from Douglas CCS to Hamilton Main at the Hamilton Main platform within each section is given in Table 9-4.

Interval Rings	0 - 10	10 - 20	20 - 30	30 - 40	40 – 50	50 – 60	60 - 70	70 - 80	80 - 90	90 - 100	100 - 110	110 - 120
Length (m)	0	0	0	0	0	2	11	11	13	15	20	76

Table 9-4 – Length of Cable within each of 10m interval rings - Power Cable at Hamilton Main Platform

9.1.4 Subsea Cable Risk Assessment – Hamilton North Platform Location

For the Hamilton North platform, the subsea cable from Douglas CCS platform possesses relatively lower risk of dropped objects as shown in Figure 9-1.

The length of the subsea cable from Douglas CCS to Hamilton North at the Hamilton North platform within each section is given in Table 9-5.

Interval Rings	0 - 10	10 - 20	20 - 30	30 - 40	40 – 50	50 – 60	60 - 70	70 - 80	80 - 90	90 - 100	100 - 110	110 - 120
Length (m)	0	0	0	0	0	0	0	8	11	11	13	15

Table 9-5 – Length of Cable within each of 10m interval rings - Power Cable at Hamilton North Platform

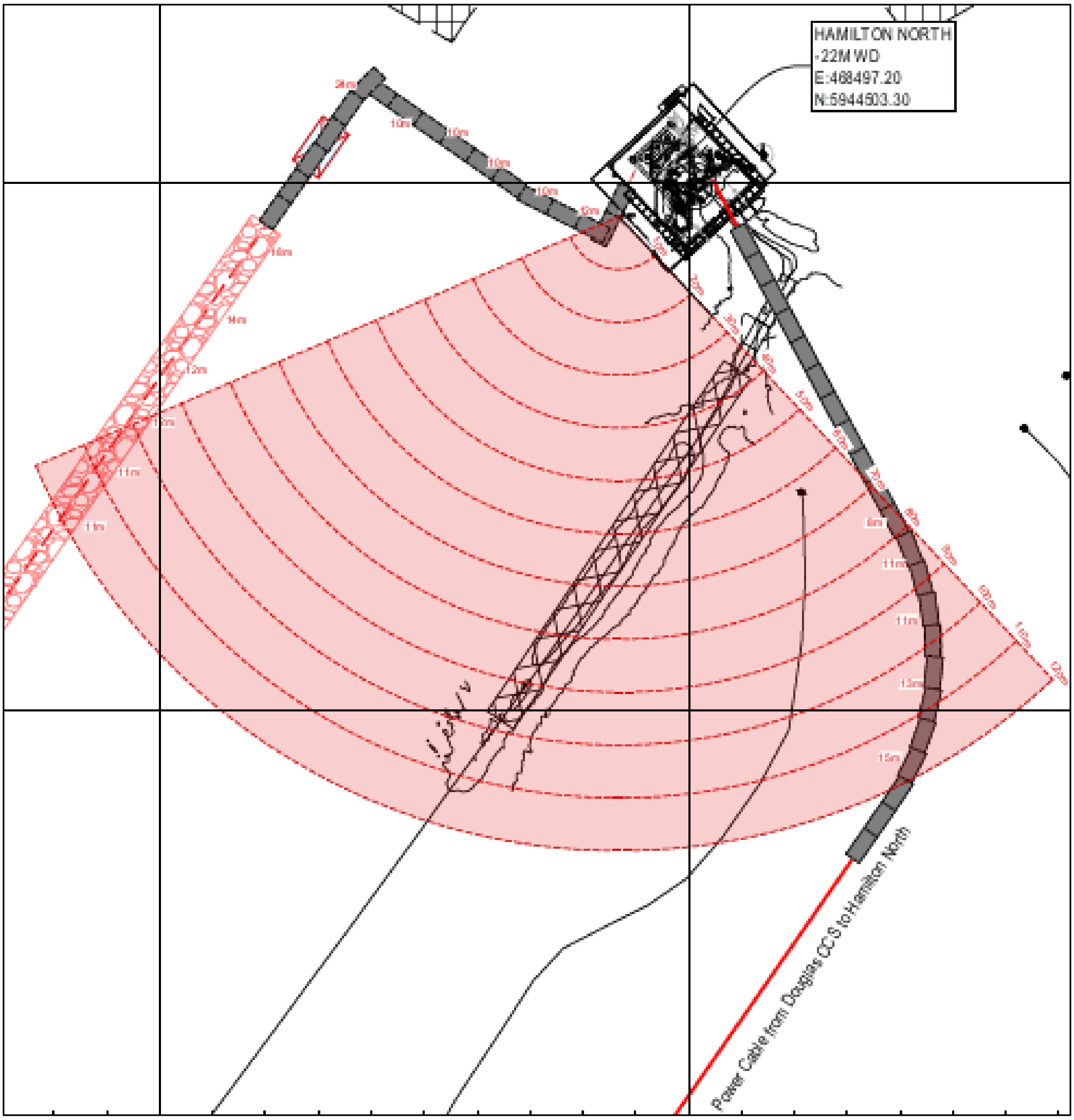


Figure 9-4 – Length of Cable within each of 10m interval rings - Power Cable at Hamilton North Platform

9.2 Anchor Interaction

9.2.1 Anchor Drop Assessment

Anchor drop assessment will consider the impact energy of a ship anchor dropped vertically from a vessel directly onto the subsea cable. The anchor drop speed will be calculated according to the formula in the Influence of Anchoring on Burial Depth of Submarine Pipelines paper [Ref.32] and energy absorbed by the soil cover, as per DNV-RP-F107 [Ref.15] and DNV-RP-F114 [Ref.16] where appropriate.

To calculate the soil cover by the backfill soil, DNV-RP-F114 [Ref.16] presents calculations for a corner impact and a side impact. It is considered that, for the soil cover depths presented in this report, that an impact anchor would rotate whilst pushing through the soil cover such that a side impact will result. As such the energy absorbed by the soil cover is assessed only according to equation 7.5 of DNV-RP-F114 [Ref.16] and not equation 7.6 in order not to be overly conservative.

This method gives a conservative burial depth to avoid damage, but the depth of subsea cable burial shall be selected to provide protection against the practical limitation of subsea cable burial and the largest anchors which the vessel could carry.

9.2.2 Dragged Anchor

In addition, the subsea cables are to be assessed for dragged anchor. Design and Installation of Marine Pipelines Book, Mikael Braestrup, [Ref.31] includes Figure 9-5 showing a relationship between anchor penetration (in m) vs anchor weight (in kg). Where the typical penetration is considered to be approximately 0.7 times the fluke length based on relatively high stiff soil. The dragged anchor penetration is highly dependent on the soil type and the soil stiffness, where softer soils will result in increased penetration.

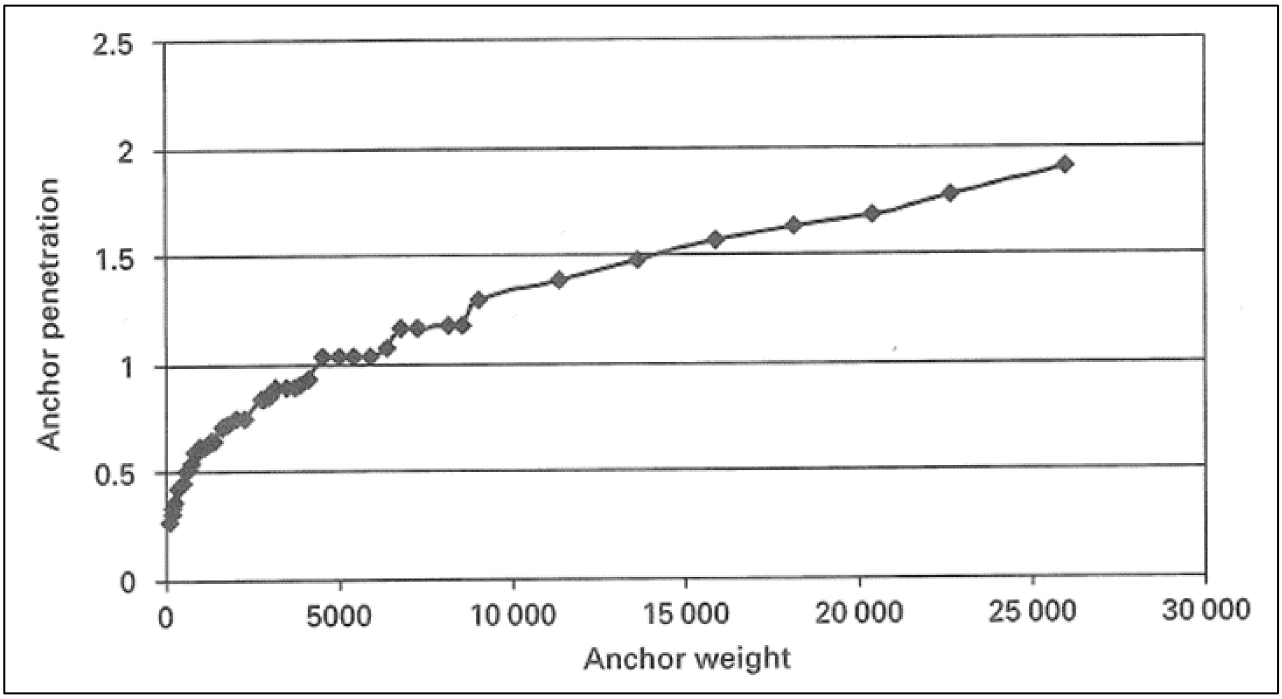


Figure 9-5 – Anchor Penetration (in m) vs Anchor Weight (in kg)

The soil data along the cable route has been assumed, therefore this approach of 0.7 x fluke length will be used until soil data is available along the subsea cable route. Furthermore additional 1.5 safety factor has been added on top of the calculated value.

9.2.3 Anchor Mooring Lines

It is not practicable to design for dropped mooring chains. However, ensuring that the cables under the mooring lines are provided with either backfill, rock dump or mattresses would provide a level of protection against minor abrasion, in the event that adequate clearance is not to be maintained between the mooring chains and the infrastructure when the mooring anchors were being deployed or retrieved.

9.3 Fishing Interaction (Trawling)

The buried cables will need to be assessed against fishing as there is a high potential risk of interference of fishing gear with the subsea cables, as stated in section 6.0.

The penetration of fishing gear into the seabed has been studied in detail by a number of authors. Research work has identified the expected maximum penetration depth for trawl boards is 300mm in accordance with [Ref.28] and as shown in Table 9-6.

Penetration Depth	Reference	Gear type	Substratum
100-150 mm	Arntz and Weber, 1970	Otter boards	muddy fine sand
a thin layer of top substrate	Bridger, 1970	Otter trawl ticklers	sand
80-100 mm	Margetts and Bridger, 1971	Beam trawls	muddy sand
100-200 mm	Houghton et al., 1971	Beam trawls	sand
0-27 mm	Bridger, 1972	Beam trawls	mud
rather limited	de Clerck and Hovart, 1972	Beam trawls	rough ground
few centimetres	Caddy, 1973	Otter boards	sandy sediment
10-30 mm	de Groot, 1984	Beam trawls	mud, sand
200 mm	Khandriche, et al., 1986	Otter board	mud
a few centimetres	Blom, 1990	Beam trawls	sand
= 60 mm	Bergman et al., 1990	Beam trawls	fine to medium hard sand
5-200 mm 20-50 mm	Krost et al, 1990	Otter board rollers on foot rope	mud, sand
200 mm	Laane et al., 1990	Beam trawls	mud, sand
20-300 mm	Rauck, 1988	Beam trawls	mud, sand
5-170 mm	Rumohr (in Krost et al, 1990)	Otter board	mud, sand
40-70 mm	Laban and Lindeboom, 1991	Beam trawls	fine sand
50-60 mm	BEON, 1991	Beam trawls	fine sand
few cm. - 300 mm	Jones, 1992	Otterboards	deepest in soft mud
20-40 mm	Santbrink and Bergman, 1994	Beam trawls	fine to medium sand sediment
15-70 mm	de Groot, 1995	Beam trawls	substratum dependant
~ 140 mm	Lindeboom and de Groot (edit.), 1998	Otterboards in the Irish Sea	mud

Table 9-6 – Observed Fishing Gear Penetration

10.0 RESULTS

The following section presents the results of the assessments carried out as per the protection methodology detailed in Section 9.0.

10.1 Dropped Object Probabilistic Assessment

The results of the probabilistic assessments are presented in the following from Table 10-1 – to Table 10-5. The risk assessment is carried out by considering the additional protection from one layer of concrete mattresses.

Damage Class			Failure Frequency		Result
D1	D2	D3	D2+D3	Acceptance Criteria	
Minor	Moderate	Major	Moderate & Major		
9.60E-06	9.60E-06	1.92E-05	2.84E-05	1.00E-03	Pass

Table 10-1 – Damage Class Result for the Power Cable No. 1 from Point of Ayr to Douglas CCS at Douglas CCS Platform

Damage Class			Failure Frequency		Result
D1	D2	D3	D2+D3	Acceptance Criteria	
Minor	Moderate	Major	Moderate & Major		
2.26E-18	2.66E-18	4.53E-18	1.20E-11	1.00E-03	Pass

Table 10-2 – Damage Class Result for the Power Cable No. 2 from Point of Ayr to Douglas CCS at Douglas CCS Platform

Damage Class			Failure Frequency		Result
D1	D2	D3	D2+D3	Acceptance Criteria	
Minor	Moderate	Major	Moderate & Major		
1.03E-05	1.03E-05	2.07E-05	3.10E-05	1.00E-03	Pass

Table 10-3 – Damage Class Result for the Power Cable from Douglas CCS to Lennox at Lennox Platform

Damage Class			Failure Frequency		Result
D1	D2	D3	D2+D3	Acceptance Criteria	
Minor	Moderate	Major	Moderate & Major		
2.75E-12	2.75E-12	5.50E-12	8.52E-12	1.00E-03	Pass

Table 10-4 – Damage Class Result for the Power Cable from Douglas CCS to Hamilton North at Hamilton North Platform

Damage Class			Failure Frequency		Result
D1	D2	D3	D2+D3	Acceptance Criteria	
Minor	Moderate	Major	Moderate & Major		
1.43E-14	1.43E-14	2.86E-14	4.30E-14	1.00E-03	Pass

Table 10-5 – Damage Class Result for the Power Cable from Douglas CCS to Hamilton Main at Hamilton Main Platform

The results above show that for the power cables approaching the Douglas CCS platform and all other satellite platforms (Hamilton Main, Hamilton North, Lennox), the likelihood of impact damage from the drop objects is within the allowable limit considering one layer of concrete mattresses protection.

It should be noted that the assessments have considered that a single concrete mattress has an assumed impact resistance of 15kJ as detailed in Section 6.6, [ASSUMPTION 1], as a result it is possible that additional mattresses may be required.

10.2 Anchor Interaction Assessment

The direct impact of the anchor has been assessed for the case i.e., non-probabilistic approach for the cables on seabed protected with concrete mattresses and for the buried cables.

10.2.1 Dropped Anchor Assessment at Platform Zones

The results for the 2-tonne dropped anchor on the subsea cables protected with one layer of concrete mattresses are presented in the Table 10-6 below.

Platform	Anchor Weight	Impact Energy	Energy Capacity	Result
[-]	[kg]	[kJ]	[kJ]	[Pass / Fail]
Douglas CCS	2000	15	15	Pass
Lennox	2000	15	15	
Hamilton Main	2000	15	15	
Hamilton North	2000	15	15	

Table 10-6 – Results of Dropped Anchor Direct Impact Assessment for Subsea Cables – Platform Zones

The table above shows that the subsea cables with a single layer concrete mattress provide sufficient impact protection against a 2-tonne anchor drops. It should be noted that the assessments have considered that a single concrete mattress has an assumed impact resistance of 15kJ as detailed in Section 6.6, [ASSUMPTION 1], as a result it is possible that additional mattresses may be required.

10.2.2 Dropped Anchor Assessment along the Cable Route

The direct energy impact assessment results for the buried subsea cables considering an anchor weight of 8300 kg corresponding to a 40,000 DWT vessel is presented in Table 10-7 below.

Water Depth	Anchor Weight	Impact Energy	Energy Capacity for Cover Depth		Result for Cover Depth	
			1.8m	1.9m	1.8m	1.9m
[m]	[kg]	[kJ]	[kJ]	[kJ]	[Pass / Fail]	[Pass / Fail]
20	8300	367	335.6	416.6	Fail	Pass
25	8300	378				
30	8300	385				
35	8300	389				
40	8300	391				

Table 10-7 – Results of Dropped Anchor Direct Impact Assessment for Subsea Cables – Along the Route

It was found that the minimum soil cover required for subsea cables is 1.9m. This cover height will provide sufficient protection against a direct impact of an 8.3 tonne dropped anchor, which is the largest anchor identified from the routine traffic assessment study [Ref.17]. The soil data along the route for the subsea cables has been assume, therefore the soil cover required maybe subject to change when soil data becomes available.

10.2.3 Dragged Anchor Assessment

Based on the simplified approach described in the CBRA methodology [Ref.28] the maximum anchor penetration has been calculated according to the type of Soil (SAND). The anchor penetration depth has been estimated as 0.7 times the anchor fluke length.

According to the pipeline protection report [Ref.11], the pipeline has the ability to endure minor incidents caused by external interference. However, it is important to note that the cable's ability to resist impacts is quite weak, and it should not be directly engaged with anchors. To prevent any unintentional contact with the cable, an extra safety margin of 1.5 is considered when calculating the estimated anchor penetration depths.

Typical anchor weights have been extracted based on the vessels DWT according to Figure 6-4 relation. The dimensions of the anchors including the anchor fluke length (as illustrated in Figure 6-4 as dimension E) has been taken from Vendor Data Sheet [Ref.30] for each DWT vessel categories.

DWT Category	Number of vessels	Percentage	Estimated Anchor Weight	Anchor Fluke Length	Estimated Anchor Penetration Note 1
[t]	[-]	[%]	[kg]	[m]	[m]
0 - 1500	1285	8.3	660	0.769	0.8
1500 - 5000	3120	20.2	1590	1.035	1.1
5000 - 7500	5991	38.7	2460	1.194	1.3
7500 - 10000	771	5.0	2850	1.253	1.3
10000 - 12500	767	5.0	3300	1.317	1.4
12500 - 15000	332	2.1	3540	1.349	1.4
15000 - 40000	862	5.6	7350	1.717	1.8
40000+	1198	7.7	8300	1.788	1.9
Unknown	1153	7.4	-	-	-
Note 1: Anchor penetration considers 70% of anchor fluke length to embed in soil. Additional 1.5 Safety factor has been considered on top of that.					

Table 10-8 – Estimated Anchors Penetration

The required cable burial depth has been sized according to highest anchor penetration without considering the impact probability described in the CBRA methodology. This approach is conservative as it assumes that any hazardous event with largest vessel identified in the routine traffic assessment study [Ref.17].

11.0 PROTECTION MEASURE RECOMENDATIONS

The following section presents the recommended protection measure along the entire cable route in order to mitigate or minimise the risks that are relevant to the subsea cables associated with the LBA CCS T&S.

11.1 Along the Cable Route – Trench and Backfill

Based on assessments conducted in Section 10.0, it has been determined that due to the high fishing intensity and busy Shipping Lane, it is necessary to trenched and backfilled to protect the entire subsea cable route outside the 500m exclusion zone to minimize the risk. The assessments have indicated that a cable burial depth of 2 meters is required to adequately protect the cable from potential risks in this area.

Furthermore, at the POA landfall area, there has been excessive seabed sediment movement observed as detailed in Section 8.1. As a result, it is recommended to increase the cable burial depth to 3 meters for the subsea cable approaching the POA. This deeper burial depth will provide an additional layer of protection and help mitigate any potential risks associated with the sediment movement in this specific area.

11.2 Platform Approach Zones – Concrete Mattress or Rock Dump

Based on the assessments conducted in section 10.0, it is recommended to protect the cables exposed on the seabed at the platform approach zone to minimize the risk from dropped objects and infield vessel movement. The recommended methods for protection are either using a concrete mattress cover or a rock dump.

The results of the assessments indicate that a single layer of concrete mattress cover will provide adequate protection against all identified risks. This means that by using a concrete mattress cover, the cables will be shielded from potential damage caused by dropped objects or vessel movement in the infield area.

11.3 Cable Protection Measure at Crossing Locations

It is recommended to select the appropriate protection measure at the cable crossing based on site-specific conditions. Various options such as mechanical supports, mechanical bridging mechanisms, grout bags, concrete mattresses, rock dumps, or similar methods can be considered for cable protection at the crossings.

It is important to note that the detailed design of the cable crossings is not covered in this report, as it has been addressed in the Offshore Cables Preliminary Crossing Design Report [Ref.9]. Therefore, the recommended protection measure at the crossing location should be determined based on the guidelines and recommendations provided in the Offshore Cables Preliminary Crossing Design Report.

To ensure the overall integrity and protection of the cables at the crossing locations, it is crucial to follow the specific recommendations outlined in Crossing Design Report [Ref.9]. This will ensure that the chosen protection measure aligns with the site-specific conditions and mitigates potential risks effectively.

12.0 ATTACHMENTS

In this section the following sample calculations are presented.

- Dropped Object Probabilistic Assessments for Power Cable No. 2

Dropped Object_Probabilistic D

- Dropped Anchor Direct Energy Assessment For 2000kg Anchor

Dropped Anchor 2000kg.pdf

- Dropped Anchor Direct Energy Assessment For 8300kg Anchor

Anchor Drop 8300kg-Energy-WD40

- Impact Resistance for 1.9m Cover Depth

Dropped Anchor Impact Resistance 1.9