Projects & Technology
Pipelines Discipline Support

Curlew Pipelines and Moorings Emerging Recommendations Report

Project	Curlew Decommissioning Project
Client	Shell U.K.
Document Number	CDP-PT-S-LA-3323-00005
Security Classification	Restricted
ECCN	EAR 99
Client Number (if applicable)	

Revision History is shown next page

Rev #	Date of Issue	Status Description	Originator	Checker	Approver
A04	30/04/2018	Consultation Draft sent for Public Consultation	Dan Beadnall	Trevor Crowe	Trevor Crowe
A03	16/03/2018	Updated (Interim) with Comments IFR-Issued for BEIS Review	Dan Beadnall	Trevor Crowe	Trevor Crowe
A02	12/02/2018	Updated (Interim) with Comments IFR-Issued for BEIS Review	Dan Beadnall	Trevor Crowe	Trevor Crowe
A01	31/10/2017	IFR-Issued for BEIS Review	Dan Beadnall	Trevor Crowe	Trevor Crowe

R03	04/10/2017	IFR-Issued for Review	Dan Beadnall	Trevor Crowe	Trevor Crowe
R02	05/04/2017	IFR-Issued for Review	Dan Beadnall	Trevor Crowe	Trevor Crowe
R01	26/09/2016	IFR-Issued for Review	Dan Beadnall	Trevor Crowe	Trevor Crowe

Revision History

Rev #	Reason for Issue / Change
R01	Issued for review.
R02	Re-issued for review, following incorporation of comments.
R03	Issued for internal review (emerging recommendations).
A01	Issued for BEIS review (emerging recommendations).
A02	Issued for external stakeholder review.
A03	Re-Issued for external stakeholder review.
A04	Consultation Draft sent for Public Consultation

List of Holds

Hold #	Reason for Hold

Stakeholders consulted during Comparative Assessment Process

- Scottish Fisheries Federation (SFF);
- Department of Business, Energy and Industrial Strategy (BEIS) (Observers);
- Joint Nature Conservation Committee (JNCC);
- Marine Scotland;
- Exxon Mobil;
- BMT Cordah (Shell appointed Environmental Advisor and author of Environmental Impact Assessment).

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1. Executive Summary

This document provides a record of the comparative assessment (CA) of feasible decommissioning options, carried out for the Curlew pipelines, umbilicals and mooring system (trenches and piles). It presents the emerging recommendations for review by external stakeholders prior to submission of the draft Decommissioning Programme to the BEIS and the statutory and public consultation which will follow.

The Curlew field, located in the UK Continental Shelf (UKCS), consist of three separate subsea clusters and a gas export pipeline.

The Curlew B field consists of a single well tied back to the FPSO by a flexible pipeline and is controlled by a subsea umbilical. The Curlew B pipeline and umbilical are trench and buried in separate trenches.

The Curlew C field consists of a single well tied back to the FPSO by a rigid production pipeline and is controlled by a subsea umbilical. Gas lift is also provided to the well by a gas lift pipeline which is piggybacked to the production pipeline. The production pipeline, gas lift pipeline and umbilical are all laid in the same trench and then blanket rock covered.

The Curlew D field consists of 4 wells tied back to the FPSO by a two flexible production pipelines and they are controlled by a subsea umbilical. The pipelines and umbilicals are trench and buried in separate trenches.

Gas is exported from the Curlew field via a 12" pipeline laid in a trench. The pipeline ties into the Fulmar gas pipeline at the Curlew Deep Gas Diverter.

The mooring system consisted of a 3 x 3 mooring system, which has left 9 mooring trenches within the touchdown zones. Suction anchors are provided at the end of each mooring line.

A summary of the recommendations for each of the pipelines, umbilicals and the mooring system are presented as follows:

- Recommendation for the Curlew B pipeline and umbilical: decommission in-situ with no intervention, i.e. flush pipelines and leave in-situ. Pipeline/umbilical ends and spools/jumpers are considered separately.

- Recommendation for the Curlew C pipelines and umbilical: decommission in-situ with no intervention, i.e. flush pipelines and leave in-situ. Pipeline/umbilical ends and spools/jumpers are considered separately.

- Recommendation for the Curlew D pipelines and umbilical: decommission in-situ with minimal intervention, i.e. flush pipelines and leave in-situ, install spot rock cover in areas of exposure. Pipeline/umbilical ends and spools/jumpers are considered separately.

- Recommendation for the Curlew gas export pipeline (KP0 – KP10): decommission in-situ with minimal intervention, i.e. flush pipelines and leave in-situ, install spot rock cover at the two exposures identified.

- Recommendation for the Curlew gas export pipeline (KP10 – KP25): decommission in-situ with minimal intervention, i.e. flush pipelines and leave in-situ, verify that pipeline is not a snagging hazard by

performing overtrawl trials. If issues arise from over trawl trials then create gateways. Pipeline ends and spools are considered separately.

- Recommendation for the pipeline / umbilical ends not located near to rock: cut and lower ends below seabed to safe depth and fill with rock to mean seabed level.

- Recommendation for the pipeline / umbilical ends located near to rock: cut and lower ends below seabed to safe depth and fill with rock to mean seabed level. For ends where the pipeline is located on the seabed and protected by rock the end will be cut and the rock berm extended to protect the end. The Curlew C production pipeline will be capped and not cut, however the end will still be lowered and then covered with rock, to prevent it presenting a snagging hazard.

- Recommendation for the pipeline / umbilical spools / jumpers: spools and jumpers will be cut and removed along with any protection equipment i.e. concrete mattresses, grout bags.

- Recommendation for the mooring trenches: fill trenches with rock to 0.5 m (given accuracy of operation this will be between 0.5 m and 1 m) below mean seabed level and verify there is no safety hazard to other users of the sea by overtrawl trials. If a snagging hazard is identified then fill with rock to mean seabed level.

- Recommendation for the mooring anchor piles: Remove the suction anchor piles. In the event that the anchor piles cannot be removed, cut the pile at mean seabed level and cover with rock. The buried chain associated with the pile would be treated as per pipeline end if the suction pile cannot be removed.

All other infrastructure (outwith the scope of the comparative assessment) will be removed during the decommissioning works:

- The production wells will be plugged and abandoned; and the trees and protection structures will be removed and recovered to shore;
- All mooring chains and chain attachments on the seabed will be removed and returned to shore for recycling;
- All risers will be removed and returned to shore for recycling;
- All subsea structures in scope will be removed and returned to shore for recycling;

It is intended that all mattresses, concrete protection structure and grout bags will be removed to shore; however, in the event of practical difficulties, BEIS will be consulted.

2. Introduction

2.1. Purpose

The purpose of this report is to present the emerging recommendations from the comparative assessment for the Curlew pipelines and mooring system (mooring anchor piles and touchdown trenches) in support of the Curlew Decommissioning Programme.

The following is included within this document:

- Description of the infrastructure to be decommissioned;
- Description of decommissioning options considered;
- Comparative assessment methodology;
- Emerging recommendations from the comparative assessment.

The decommissioning options for the pipelines/umbilicals (including all stabilisation materials) and mooring system have been subjected to a process of comparative assessment in order to determine the method of decommissioning in compliance with the DECC (now BEIS) guidance notes.

As well as the mooring system anchor piles and touchdown trenches, the following pipelines are included in the comparative assessment:

PL Number	Name	Diameter (inch)	Approx. Length (km)
PL1455A	Curlew - FGL (DG Diverter) - 12" Gas Export Riser	12	0.5
PL1455B	Curlew - FGL (DG Diverter) - 12" Gas Export Pipeline	12	26.6
PL1450	Curlew - Curlew B 5.5" Oil	5.5	2.7
PL1451	Curlew - Curlew B Umbilical	N/A	2.6
PL1798B	Curlew - Curlew C Riser Base (Riser - ex Kyle)	12	0.3
PL2523	Curlew - Curlew C 8" Oil	8	6.1
PL2524	Curlew - Curlew C 3" Gas Lift	3	6.2
PLU2525	Curlew - Curlew C UTA Umbilical	N/A	6.3
PLU2525 1.04	Curlew C UTA - Curlew C Well P1 Umbilical Hydro/Chem/Electrical	N/A	<0.1
PL1452	Curlew - Curlew D 8" Wet Gas	8	1.6
PL1453	Curlew - Curlew D 8" Wet Gas	8	1.6
PL1454	Curlew - Curlew D Umbilical	N/A	1.7
PL2452	Curlew D Production Manifold - Well P1 6" Wet Gas	6	<0.1
PL1728	Curlew D Production Manifold - Well P2 6" Wet Gas	6	<0.1
PL1727	Curlew D Production Manifold - Well P3 8" Wet Gas	8	0.1
PL2453	Curlew D Production Manifold - Well P4 6" Wet Gas	6	0.1
PL1454 1.08	Curlew D SDU - Well P1 Umbilical	N/A	<0.1
PL1454 1.03	Curlew D SDU - Well P2 Umbilical	N/A	<0.1
PL1726	Curlew D Well P2 - Well P3 Umbilical	N/A	0.2
PLU2455	Curlew D SDU - Well P3 Umbilical (Replacement)	N/A	0.2
PLU2454	Curlew D SDU - Well P4 Umbilical	N/A	0.1
PLU2455 JCDPM	Curlew D Production Manifold - Well P3 Umbilical	N/A	0.1
PLU2454 JCDPM	Curlew D Production Manifold - Well P4 Umbilical	N/A	0.1

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PLU2455JW3	Curlew D SDU - Well P3 Umbilical (Replacement 2)	N/A	0.2
PL3568	Curlew D SDU - Well P1 Umbilical (Replacement)	N/A	<0.1
PL3569	Curlew D SDU - Well P4 Umbilical (Replacement)	N/A	<0.1

Notes:

1. For a diagrammatic view of the above table please see section 7.1.

Table 2-1 – Pipelines and umbilicals subject to comparative assessment

2.2. Givens

Givens for the comparative assessment:

- Risers and associated infrastructure (MWA, buoyancy modules, clump weights etc.) will be recovered as part of the overall decommissioning programme.
- All structures and trees will be recovered as part of the overall decommissioning programme. Spools and jumpers are classed as pipelines and are not included in the removal of the structures and will be subject to the comparative assessment process.
- Pipeline and umbilical flushing will be performed prior to the tow away of the FPSO.
- Mooring lines visible on or above the seabed will be removed (including mooring line ancillaries (clump weights etc.), this comparative assessment will only consider the anchor piles and a short section of the mooring line from the anchor pile to the seabed, this is described further in a following section. In all cases an attempt to remove the anchor pile will be made and only on failure of removal will the decommissioning option be used for anchor piles.

2.3. Regulatory Context

The decommissioning of offshore oil and gas installations and pipelines on the United Kingdom Continental Shelf (UKCS) is controlled through the Petroleum Act 1998, as amended by the Energy Act 2008. The UK's international obligations on decommissioning are governed principally by the 1992 Convention for the Protection of the Marine Environment of the North East Atlantic (OSPAR Convention). Agreement on the regime to be applied to the decommissioning of offshore installations in the Convention area was reached at a meeting of the OSPAR Commission in July 1998 (OSPAR Decision 98/3). The BEIS (Formerly DECC) Guidance Notes provide further information on OSPAR Decision 98/3.

Pipelines currently do not fall within the remit of OSPAR Decision 98/3 but the BEIS Guidance Notes state that all feasible decommissioning options should be considered and a comparative assessment made.

Because of the widely different circumstances of each case, BEIS do not predict with any certainty what decommissioning strategy may be approved in respect of any class of pipeline. Each pipeline must therefore be considered on its merits and in the light of a comparative assessment (CA) of the feasible options, taking into account the safety, environmental, technical, societal and cost impacts of the options. Cost may only be a determining factor when all other criteria emerge as equal.

2.4. General Definitions

The following table specifies the meaning of wording in this report when it is used in a general context to avoid any confusion or doubt.

Wording	Definition for the purposes of this assessment
Riser	Pipeline or umbilical section from the seabed to the FPSO.
Pipeline	When pipeline is used in the general text, this should be assumed to mean pipeline in general and may also reference the pipeline system (including spools, cathodic protection etc.), e.g. this can refer to a rigid pipeline, flexible pipeline or umbilical. If a specific pipeline is referenced, then this may also include "rigid" or "flexible" pipeline.
Umbilical	When umbilical is referenced this will generally be a long conduit for the transportation of chemicals, hydraulic fluids, power and signal in separate cores.
Structure	When structure is referenced this will be either an SSIV, mid-water arch, valve skid or manifold. The structures related to Curlew are: • Gas Export SSIV; • Curlew D Midwater arch and associated hold down system; • Curlew D production manifold; • Curlew D subsea distribution unit (SDU); • Mooring Suction Anchor Piles.
Protection	If protection is referenced this will refer to either concrete mattresses or grout bags, any other protection will be specifically referenced.
Route Length / End / Spool/Jumper	A single pipeline is split into 3 different sections for the purpose of this comparative assessment. The route length, which can generally be described as the section of pipe on the bottom of the trench. The end of a pipeline / umbilical in general is the section between the trench transition (as the line comes out of a trench) and the tie-in to the structure (including spools). Finally, the spool or jumper which is the section of pipe lain on the seabed and facilitates the tie-in to any structures. The diagram below illustrates the differences between the different sections:

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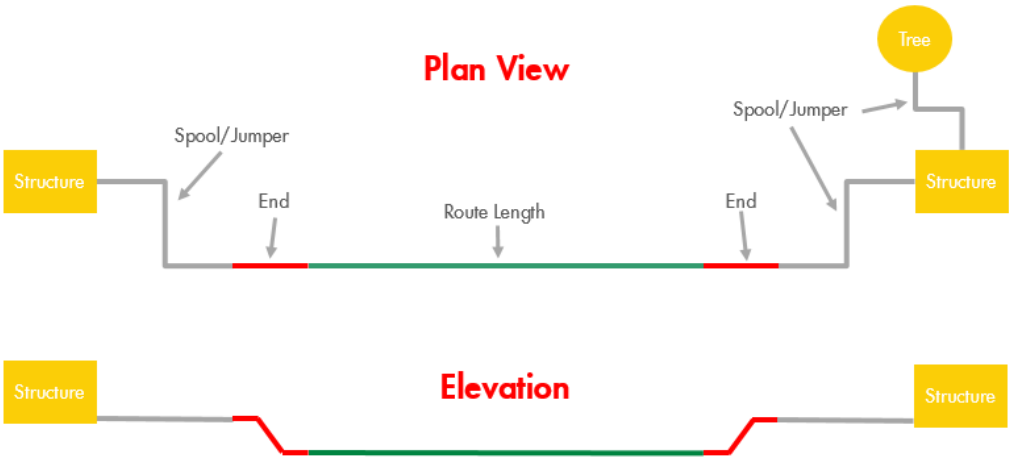
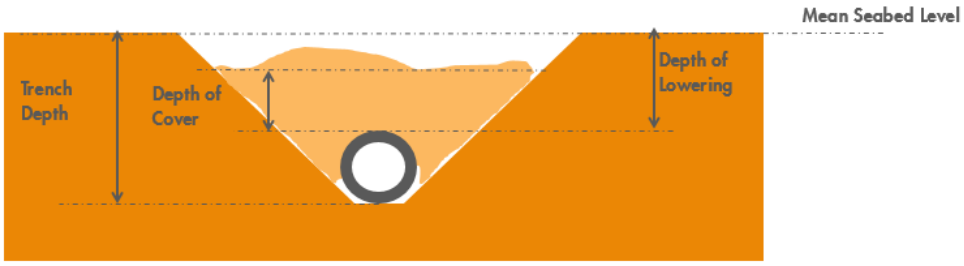
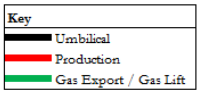
Wording	Definition for the purposes of this assessment
	
Burial Depth Definitions	Different definitions will be used for different burial depths. The following diagram illustrates the different burial depth definitions: 
Key for lines on diagrams	
Exposure	When an exposure is described this is essentially when the crown of the pipe or umbilical can be seen. This does not generally mean a hazard.
Reportable Span	A reportable span is a significant span which meets a set criteria (fish safe criteria) of height above the seabed and span length.
Liquefaction	Liquefaction is the process of fluidising the seabed to the point where the soil has no inherent strength and hence the pipe or similar will simply fall to the bottom of the trench.

Table 2-2 – General Definitions

2.5. Abbreviations

The following table presents the abbreviations presented within this document:

BAT	Best Available Technology	OSPAR	Oslo Paris
BEIS	Department of Business, Energy and Industrial Strategy	QRA	Quantitative Risk Assessment
CA	Comparative Assessment	ROV	Remotely Operated Vehicle
DECC	Department of Energy and Climate Change	SAC	Special Area of Conservation
DG	Deep Gas	SCI	Site of Community Importance
FEED	Front End Engineering Design	SDU	Subsea Distribution Unit
FPSO	Floating, Production, Storage and Offloading	SE	South East
FSM	Field Signature Monitoring	SFF	Scottish Fisheries Federation
ICES	International Council for the exploration of the sea	SSIV	Subsea Isolation Valve
JNCC	Joint Nature Conservation Committee	UK	United Kingdom
MDAC	Methane Derived Authigenic Carbonate	UKCS	United Kingdom Continental Shelf
MWA	Mid Water Arch	UTA	Umbilical Termination Unit
OGUK	Oil and Gas UK		

Table 2-3 – Table of Abbreviations

2.6. Field Overview

2.6.1. General

The Curlew field is located in Block 29/7 of the United Kingdom Continental Shelf (UKCS) in the central North Sea. It is situated 197 km SE of Aberdeen in a water depth of approximately 90 m (Figure 2-1). The Curlew FPSO receives production fluids from 3 reservoirs, Curlew B, Curlew C and Curlew D. The Curlew FPSO is a Floating Production, Storage and Offloading vessel (FPSO) located over the Curlew reservoir. The FPSO has equipment for oil and gas processing, storage and offloading, gas processing and export and treatment of produced water. Oil from the Curlew FPSO is exported onshore via shuttle tanker, while gas is exported from the Curlew FPSO to the St. Fergus Terminal, via the Fulmar Gas Pipeline.

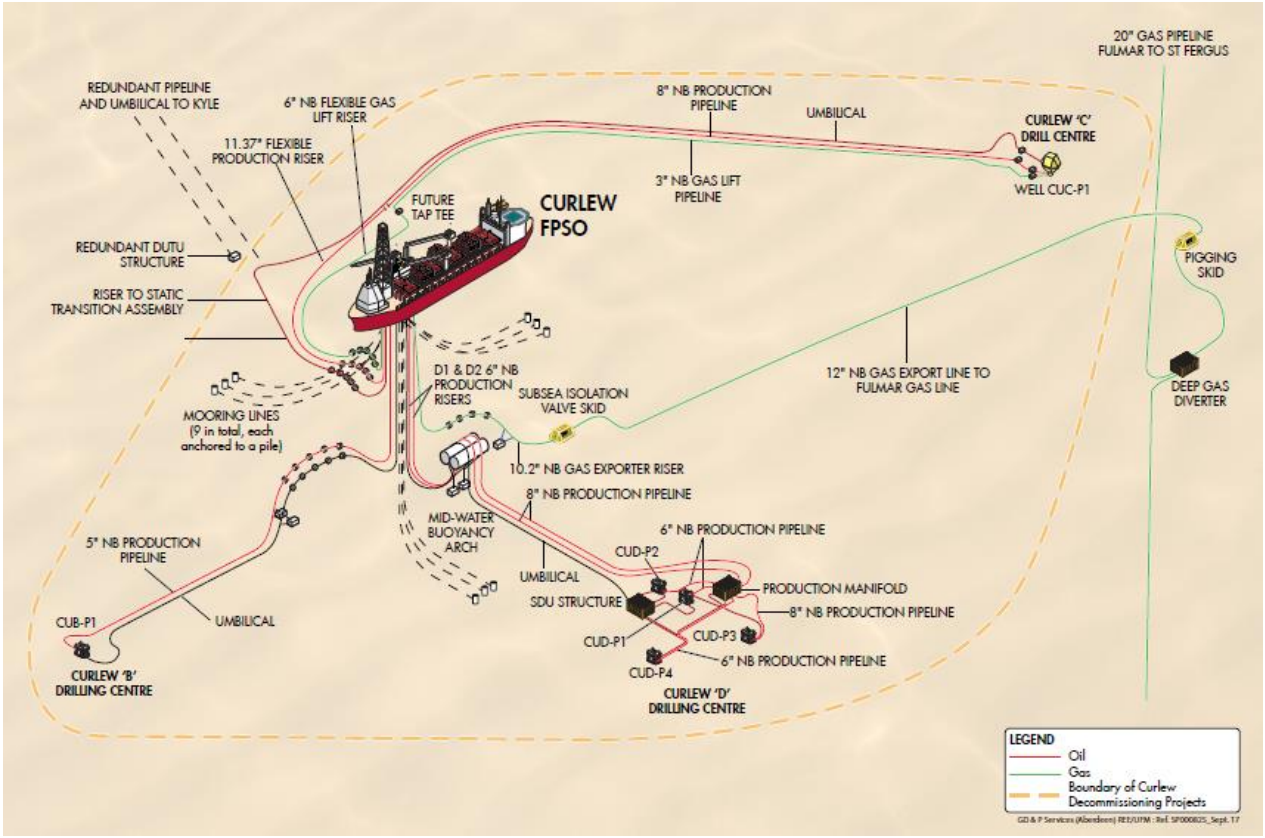


Figure 2-1 – Curlew Field Layout Schematic

Shell UK Ltd requested Cessation of Production (CoP) on the Curlew fields including Floating Production Storage and Offloading (FPSO) facility in January 2016. The Curlew fields are expected to reach their economic limit in Q1 2019 and there are no further developments or third-party tieback opportunities that could extend the field's life. Approval from the Oil & Gas Authority (OGA) for cessation of production has been granted from 2016, should the Curlew FPSO become uneconomic (e.g. if a significant event such as well or equipment failure occurs from which economic recovery is not possible). Planning for decommissioning of the field has started and this report will focus on the decommissioning requirements for the Curlew pipelines, mooring system and any protection materials (e.g. concrete mattresses).

2.6.2. Environmental Summary of Curlew Field

Pre-decommissioning environmental survey of the Curlew area was undertaken in summer 2016 by Fugro Ltd. on request of Shell UK Ltd.

The seabed sediment around the Curlew area is relatively uniform and can be classed as very fine sand. There is little variation in habitat across the site, and megafaunal burrows and/or seapens were observed throughout the area during the pre-decommissioning survey. Upon further examination and consultation with JNCC, the area was confirmed to represent OSPAR threatened / declining "Seapen and Burrowing Megafauna Communities" habitat. No live adult ocean quahog (*Arctica islandica*) or siphons were visible at the sediment surface, however juveniles were observed at all grab samples except for one. Methane Derived Authigenic Carbonate (MDAC) were not observed during the 2016 survey. The Curlew cluster is not located within or close to a designated protected site. The nearest designated areas are located approximately 150 km away, i.e. Scanner Pockmark SAC (to the northeast) and Dogger Bank SCI (to the south).

The most abundant taxa are similar across the Curlew area, with the polychaete *Paramphinome jeffreysii* dominant at all stations. Other dominant taxa included the polychaetes *Galathowenia oculata*, Spiophanes *kroyeri*, Spiophanes bombyx and the bivalves *Axinulus croulinensis* and *Adontorhina similis*. The species composition has not changed largely since the development of the field.

Small quantities of drilling cuttings deposits are limited to about 200 m from the Curlew drill centres. Changes in the sediment composition when compared with historical results indicate that a considerable amount of environmental weathering has occurred since drilling was completed in the late 1990s and there is no evidence of a layer of anoxic subsurface conditions in sediment.

The Curlew cluster lies within spawning grounds for cod (*Gadus morhua*; January to April), lemon sole (*Microstomus kitt*; April to September), mackerel (*Scomber scombrus*; May to August), sandeels (*Ammodytidae spp.*; November to January) and Norway pout (*Trisopterus esmarkii*; January to April). The area is also used as nursery grounds for anglerfish (*Lophius piscatorius*), blue whiting (*Micromesistius poutassou*), cod, European hake (*Merluccius merluccius*), haddock (*Melanogrammus aeglefinus*), herring (*Clupea harengus*), Norway pout, ling (*Molva molva*), mackerel, plaice (*Pleuronectes platessa*), sandeels, spurdog (*Squalus acanthias*) and whiting (*Merlangius merlangus*).

The Curlew cluster is in the ICES rectangle 42F1, where fishing effort (days) is generally higher than in the neighbouring rectangles, however it is still relatively low in comparison to other ICES rectangles within the UKCS. The 5-years average effort is 202 days per year, while fish landing is estimated at average of £668k and 133 tonnes. The area is of low to moderate shipping traffic, with no designated or dangerous wrecks in the vicinity of the field.

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2.6.3. Curlew B Field Infrastructure

2.6.3.1. General Description

The Curlew B field produces from a single well CUB-P1 (Figure 2-2) back to the Curlew FPSO via a 5.5" flexible production pipeline and through a dynamic flexible riser to the FPSO. The pipeline is laid in a pre-cut trench then backfilled for protection. A controls umbilical is also laid within a separate trench adjacent to the production pipeline. As there is only 1 production well and the pipeline is a flexible there are no spools at Curlew B.

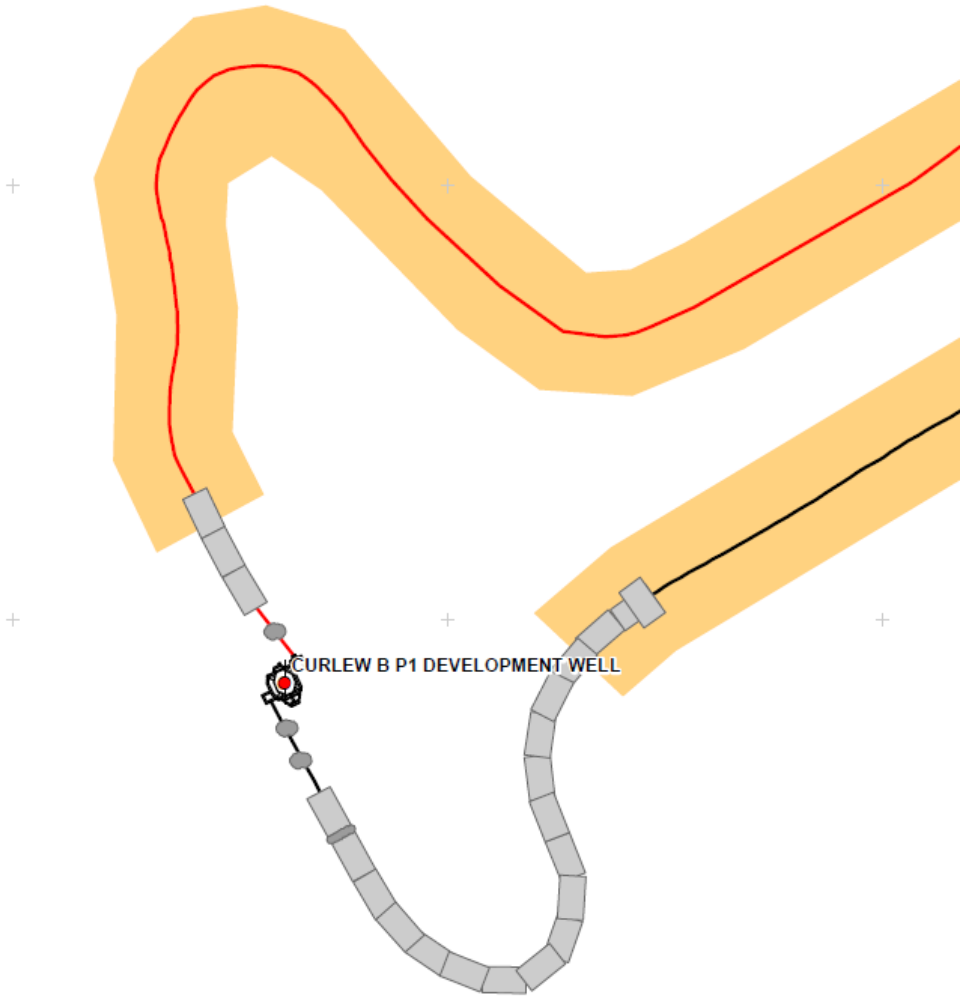

Figure 2-2 – Curlew B Field Schematic

2.6.3.2. Physical Limits

For the purposes of this comparative assessment only the pipeline and umbilical from the base of the riser to the tree will be considered. The riser and tree will be recovered as part of the decommissioning programme. The limits are clearly identified in the inventory in section 7.3, the sections highlighted in yellow are not included in this CA. As the pipeline and umbilical are one continuous section the end points will be treated as a pipeline / umbilical end.

2.6.3.3. Inventory

At a high level the inventory associated with the Curlew B subsea infrastructure includes the following:

- Dynamic production riser, including buoyancy modules, end fittings, bend stiffeners and clump weights;
- Flexible production pipeline (protected by seabed backfill and mats in some areas);
- Dynamic umbilical, including buoyancy modules, end fittings, bend stiffeners and clump weights;
- Static umbilical (protected by seabed backfill and mats in some areas);
- Production tree.

The detailed inventory for the Curlew B subsea infrastructure is presented in section 7.3 and the limits of the comparative assessment clearly highlighted in yellow (not included in CA).

2.6.4. Curlew C Field Infrastructure

2.6.4.1. General Description

The Curlew C field produces from a single well CUC-P1 (Figure 2-3) back to the Curlew FPSO via an 8" production pipeline and re-uses the original 11.75" Kyle dynamic flexible riser. The pipeline is laid in a pre-cut trench then blanket rock covered for protection and up-heaval buckling prevention. A 3" gas lift pipeline is piggybacked to the production pipeline. A controls umbilical is also laid within the same trench as the production and gas lift pipelines.

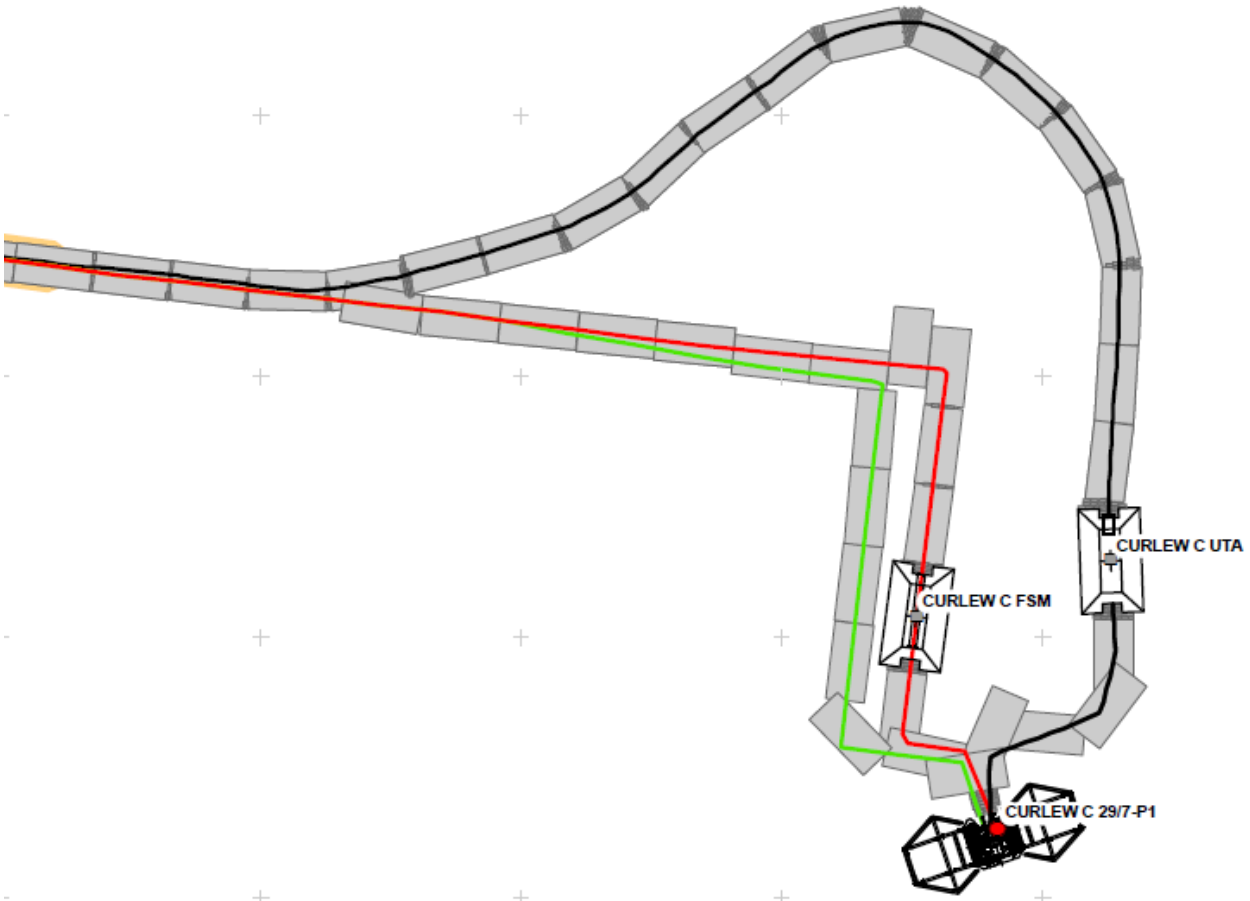

Figure 2-3 – Curlew C Field Schematic

2.6.4.2. Physical Limits

For the purposes of this comparative assessment only the pipelines, spools and umbilical from the base of the riser to the tree will be considered. The riser, tree and FSM (corrosion spool)/UTA (Umbilical Termination Unit) protection structures will be recovered as part of the decommissioning programme. The limits are clearly identified in the inventory in section 7.4 (highlighted in yellow) (not included in CA).

2.6.4.3. Inventory

At a high level the inventory associated with Curlew C subsea infrastructure includes the following:

- Production riser, including buoyancy modules, end fittings, bend stiffeners and clump weights;
- Production spools from riser base to pipeline (protected by mats);
- Production pipeline (protected by blanket rock cover and mats in some areas);
- Production spools from pipeline to tree (protected by mats);
- Gas lift riser, including buoyancy modules, end fittings, bend stiffeners and clump weights;
- Gas lift spools from riser base to pipeline (protected by mats);
- Gas lift pipeline piggybacked to production pipeline (protected by blanket cover and mats in some areas);
- Gas lift spools from pipeline to tree (protected by mats);
- Dynamic umbilical, including buoyancy modules, end fittings, bend stiffeners and clump weights;
- Static umbilical (protected by blanket rock cover and mats in some areas);
- Production tree.

The detailed inventory for the Curlew C infrastructure is presented in section 7.4 and the limits of the comparative assessment clearly highlighted in yellow (not included in CA).

2.6.5. Curlew D Field Infrastructure

2.6.5.1. General Description

The Curlew D field produces from 4 wells (Figure 2-4) back to the Curlew FPSO via two 8" production pipelines and through dynamic flexible risers over a mid-water arch to the FPSO. The pipelines are laid in separate trenches and backfilled for protection. A controls umbilical is also laid within a separate trench and buried adjacent to the production pipelines. The pipelines are then connected into the Curlew D manifold structure, where production from each of the 4 production wells is comingled via spools. The umbilical terminates in the SDU structure and then distributes controls, hydraulics, power and signal to each of the trees.

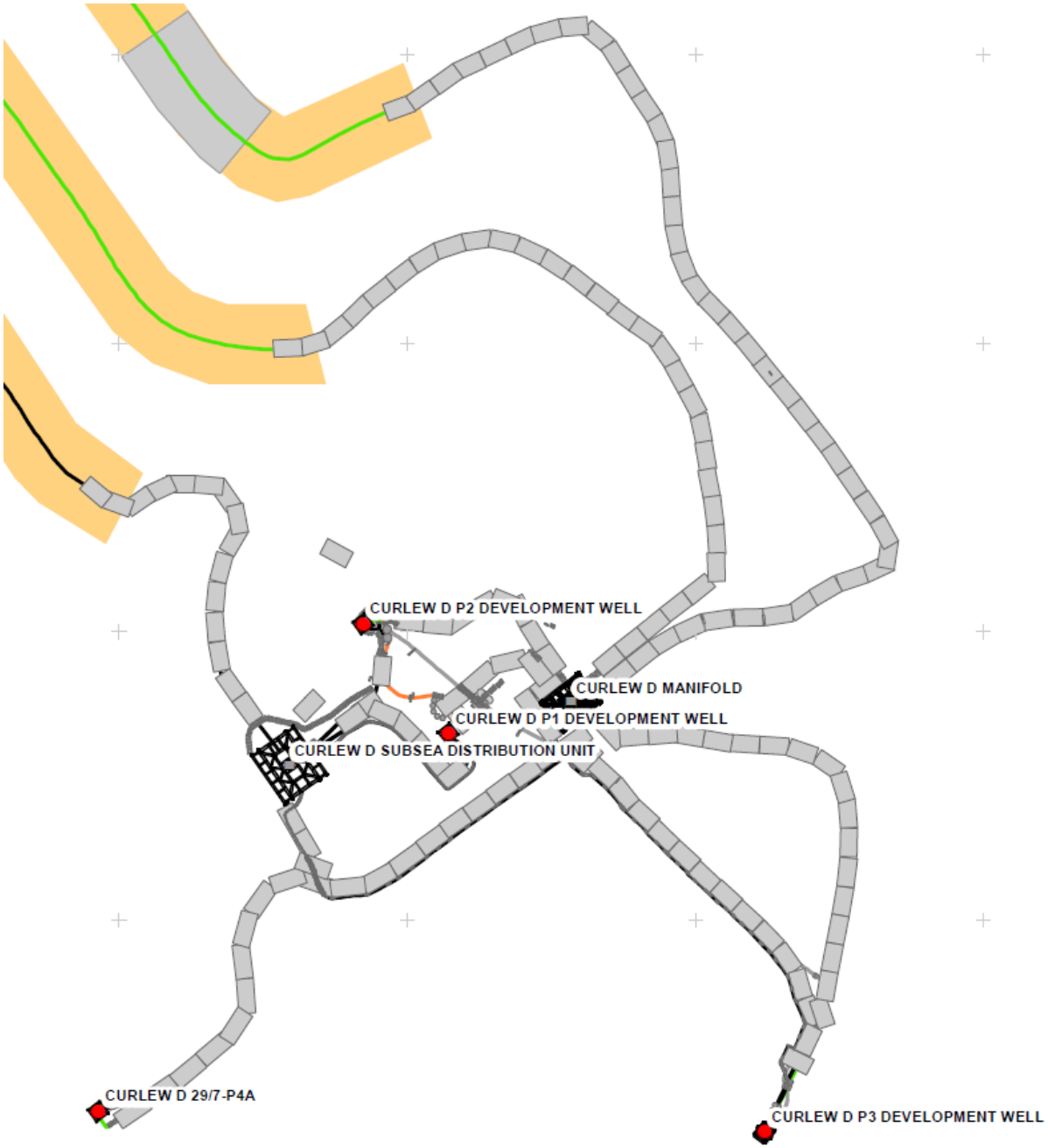

Figure 2-4 – Curlew D Field Schematic

2.6.5.2. Physical Limits

For the purposes of this comparative assessment only the pipelines, umbilicals, spools and jumpers from the base of the riser to the tree will be considered. The riser, manifold, SDU structure and trees will be recovered as part of the decommissioning programme. The limits are clearly identified in the inventory in section 7.5 (highlighted in yellow) (not included in CA).

2.6.5.3. Inventory

At a high level the inventory associated with the Curlew D subsea infrastructure includes the following:

- Dynamic production riser 1, end fittings and bend stiffeners;
- Dynamic production riser 2, end fittings and bend stiffeners;
- Dynamic umbilical, end fittings and bend stiffeners;
- Mid water arch with hold down system;
- Flexible production pipeline 1 (protected by seabed backfill and mats in some areas);
- Flexible production pipeline 2 (protected by seabed backfill and mats in some areas);
- Static umbilical (protected by seabed backfill and mats in some areas);
- Curlew D production manifold;
- Curlew D subsea distribution unit structure;
- Curlew D manifold to production tree production spools (protected by mats);
- Curlew D SDU to production tree umbilical jumpers (protected by mats);
- P1, P2, P3 and P4 production trees;

The detailed inventory for the Curlew D subsea infrastructure is presented in section 7.5 and the limits of the comparative assessment clearly highlighted in yellow (not included in CA).

2.6.6. Curlew Gas Export Field Infrastructure

2.6.6.1. General Description

The Curlew gas export pipeline consists of a single 12" gas export dynamic flexible riser from the FPSO turret to the SSIV structure at the riser base. A rigid 12" pipeline then transports gas from the SSIV to the pigging skid structure, which is situated approximately 25.7km to the east of the Curlew FPSO. A rigid spool then ties in the Curlew gas export pipeline into the Fulmar Gas Pipeline via the Curlew Deep Gas Diverter structure. The figure below shows a schematic of the Curlew gas export pipeline system.

In 2015 the tie-in spool from the SSIV structure to the gas export pipeline was replaced due to an incident.

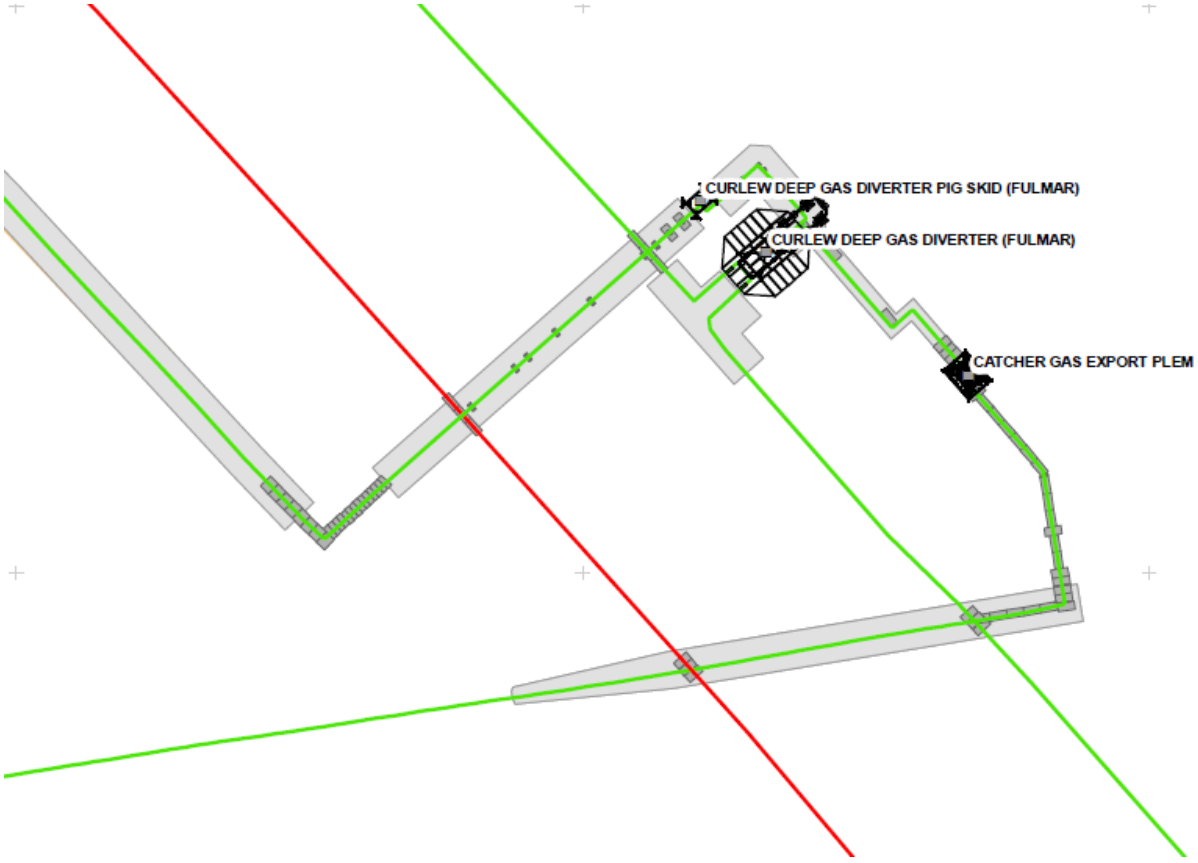

Figure 2-5 – Curlew Gas Export Pipeline Schematic

2.6.6.2. Physical Limits

For the purposes of this comparative assessment only the pipeline and spools from the SSIV structure to the pigging skid assembly will be considered. The riser and SSIV structure will be recovered as part of the decommissioning programme. The pigging skid assembly will be left in-situ for the potential re-use of future developments requiring a tie-in into the Fulmar gas pipeline. The limits are clearly identified in the inventory in section 7.2 (highlighted in yellow) (not included in CA).

2.6.6.3. Inventory

At a high level the inventory associated with the gas export pipeline includes the following:

- Gas export riser, including buoyancy modules, end fittings, bend stiffeners and clump weights;

- Gas export SSIV skid;
- Gas export spools from SSIV skid to pipeline (protected by mats);
- Gas export pipeline (protected by spot rock cover and mats in some areas);
- Gas export spools from pipeline to pigging skid assembly (protected by mats);
- Gas export pigging skid assembly;
- Gas export spools from pigging skid assembly to Deep gas diverter structure (protected by mats).

The detailed inventory for the gas export pipeline is presented in section 7.2 and the limits of the comparative assessment clearly highlighted in yellow (not included in CA).

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2.6.7. Curlew Mooring System

2.6.7.1. General Description

The Curlew FPSO mooring system is a 3 x 3 spread mooring system. Each line is approximately 1.4 km long and consists of a top chain, wire rope for the majority of the length and then bottom chain. The touchdown zone of each mooring line is approximately 150m from the FPSO and in some locations a trench of up to 4m deep has been created. Each mooring line is anchored by a suction anchor and the chain connection into the anchor is approximately 5m to 7m below the seabed. The figure below shows the mooring system general arrangement.

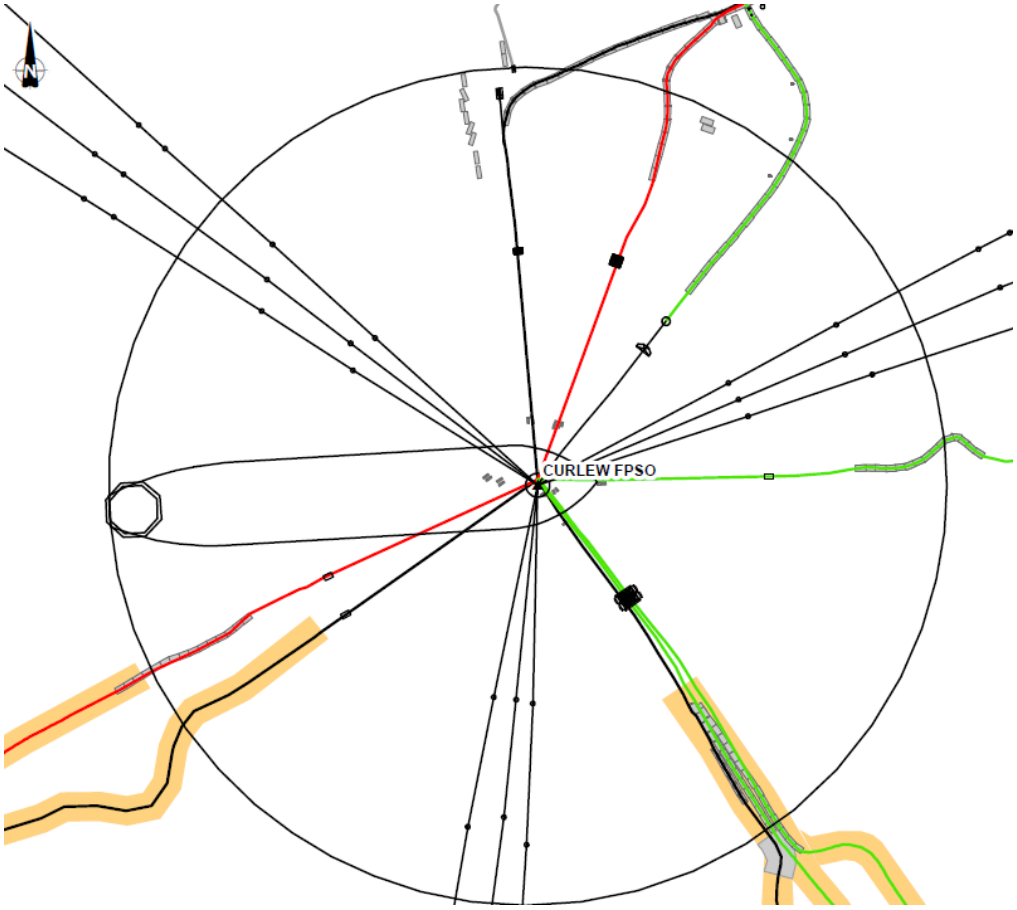

Figure 2-6 – Curlew Mooring System Arrangement

2.6.7.2. Physical Limits

The mooring lines will be recovered from the FPSO to the section of mooring line laying on the seabed at the anchor pile as a minimum. The anchor pile and section of chain buried with the anchor will be subject to the comparative assessment process, as well as the trenches in the thrashing zone as a result of the movements of the mooring line in the touchdown region. The areas subject to comparative assessment are highlighted in the red boxes in Figure 2-7.

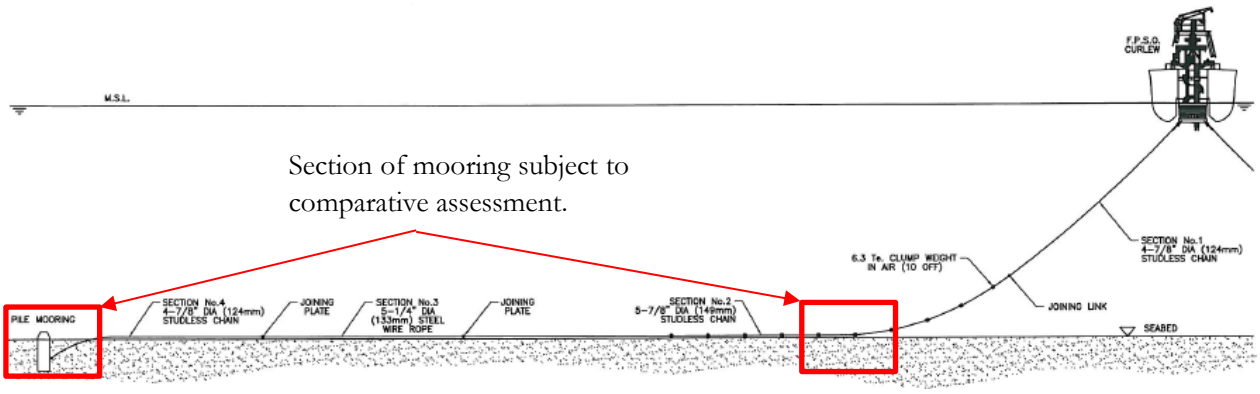

Figure 2-7 – Curlew Mooring Line Schematic

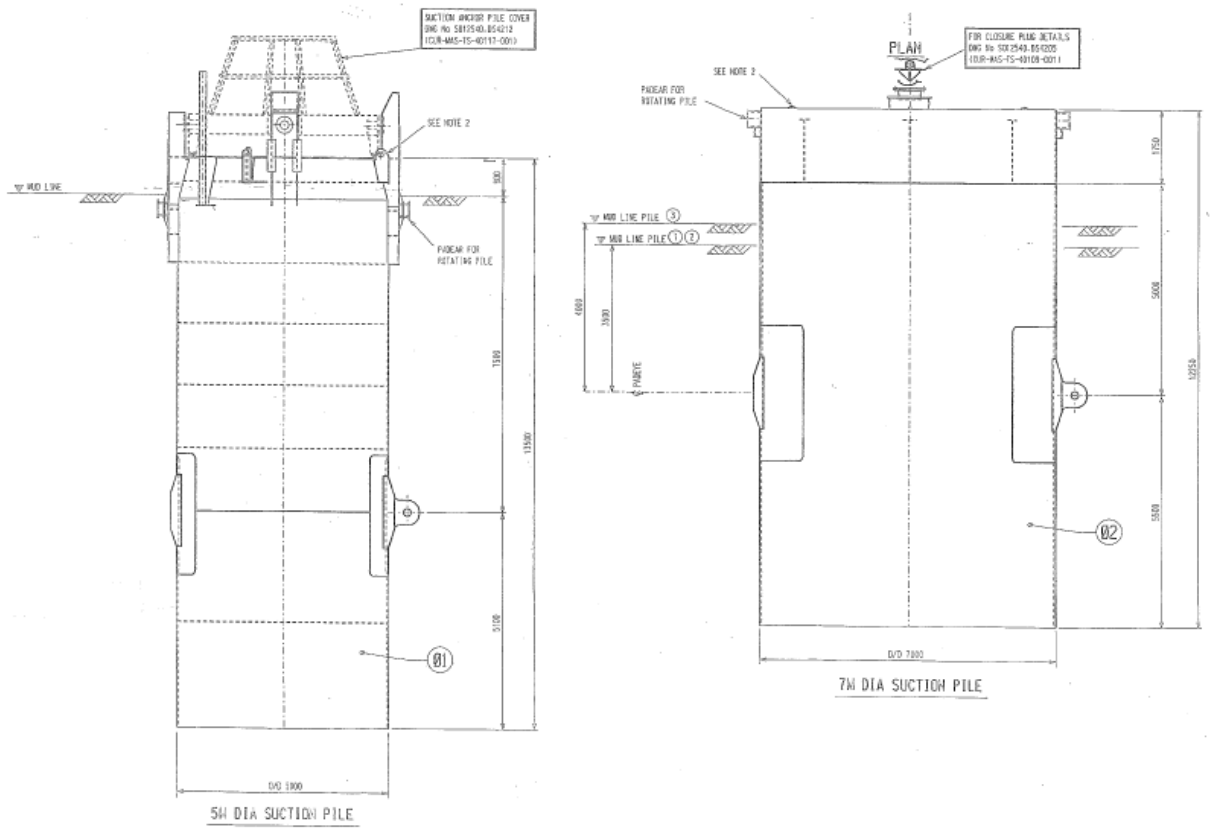

Figure 2-8 **– Curlew Mooring Suction Anchor Pile Schematic**

2.6.7.3. Inventory

The Curlew mooring lines consist of wire rope, chain and other ancillary equipment, such as joining plates and shackles. A summary of the materials associated with the mooring system is summarised in the below table:

Mooring Components	Mooring Chains and Wires	Anchor Piles
Weight (Te)	2415 (total of all chains and wires)	108 Tonnes (Anchors 1 - 3) 54 Tonnes (Anchors 4 – 9)

Table 2-4 – Mooring System Inventory

A typical arrangement of each mooring line is shown in the below figure:

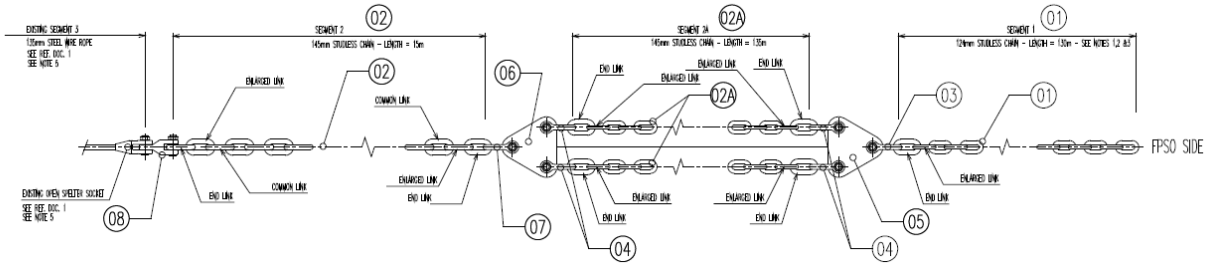

Figure 2-9 – Curlew Mooring Line Arrangement

3. Comparative Assessment Process

3.1. General Process Description

The comparative assessment process was performed in accordance with the BEIS (formerly DECC) decommissioning guidance notes [1] and guidance was used from the OGUK pipeline comparative assessment guidance notes [2].

The following sections present the comparative assessment methodology used for each of the Curlew pipelines, umbilicals, and mooring piles, however a summary of the process is used as follows:

- Scoping of subsea infrastructure to be decommissioned and inventory mapping;
- Decommissioning assessment criteria and sub-criteria;
- Decommissioning options to be considered;
- Screening workshop to initially agree the decommissioning options to take further and any grouping to be considered.
- Selection of groups for narrative conclusion;
- Traffic light assessment, if required;
- Scoring assessment, if required.

Stakeholder engagement and multi-disciplinary reviews have formed an important part of the comparative assessment process and stakeholder.

3.2. Scoping and Inventory Mapping

The initial phase of the comparative assessment process was to identify the scope to be decommissioned and map the inventory which requires decommissioning. This is summarised in sections 2.6 and 7.

3.3. Criteria and Sub-Criteria

The next step in the comparative assessment process is to agree the criteria and sub-criteria to be used. The following table presents the selected criteria and sub-criteria, which was used to assess each option for decommissioning during the comparative assessment process. The criteria is in line with the criteria recommended in the OGUK comparative assessment guidelines [2], except for the impact of operations and legacy impact sub-criteria which have been adapted as shown in the table below.

Criteria	Sub-Criteria	Applicable to	Applicable When	Factors	Potential Sources of data
Safety	**Project risk to personnel – Offshore**	Project team offshore, project vessels crew, diving teams, supply boat crew, heli-ops, survey vessels crew	During execution phase of the project including any subsequent monitoring surveys	Type of activity Number of personnel involved & project duration. Number of crew changes (helicopter transfers) Number of vessels involved & SIMOP activity Numbers, durations and depth that divers are anticipated to work. Any unique or unusual handling or access activities required of personnel.	Decommissioning methodology for each option; vessel study; diving study; etc Coarse QRA data based on POB / exposure, durations and activity Fatal Accident Rate (FAR). Industry data will be used to derive the probability of loss of life.
	Project risk to other users of the sea	Navigational safety of all other users of the sea, fishing vessels, commercial transport vessels, military vessels	During execution phase of the project including any subsequent monitoring surveys	Likelihood of incursion into project exclusion zone by other users of the sea Number and type of transits by project vessels to and from the project work site	Fishing study on anticipated activity in area of activity Other vessels movements review, stakeholder engagement
	Operational risk to personnel – Onshore	Onshore dismantling and disposal sites personnel; extent of materials transfers/ handling on land	During execution phase of the project, through to final disposal of recovered materials	Extent of dismantling required & hazardous material handling anticipated. Numbers of road transfers from dismantling yard to final disposal site.	Decommissioning methodology for each option, considering volume and type of material to be returned to shore Coarse QRA data based on POB / exposure, durations and activity Fatal Accident Rate (FAR)
	Potential for a high consequence event	Project team offshore and onshore; project vessels; diving teams; supply boat crew; heli-ops; survey vessels; onshore dismantling and disposal sites personnel	During execution phase of the project including any subsequent monitoring surveys	Decommissioning philosophy; potential for dropped object over a live pipeline; degree of difficulty anticipated in onshore dismantling	Decommissioning methodology for each option; vessel study; diving study; etc
	Residual risk to other users of the sea	Fishing vessels, fishermen, supply boat crews, military vessel crews, commercial vessel crew and passengers, other users of the sea	Following completion of the Decommissioning project and residual / ongoing impact in perpetuity	Extent of facility / equipment / pipeline left in situ on completion of the project and its likelihood to form a future hazard; likelihood for further deterioration; predicted future fishing activity; proximity of retained facilities to main transport routes	Decommissioning methodology for each option, focussing on volume and type of infrastructure to be left in situ; fishing navigational safety study on anticipated activity in area(s) where infrastructure is decommissioned in situ; assessment(s) of degradation for infrastructure left in situ; stakeholder engagement

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Criteria	Sub-Criteria	Applicable to	Applicable When	Factors	Potential Sources of data
Environmental	**Impact of operations**	Environmental impact to the marine environment, nearshore areas and onshore caused by project activities	During execution phase of the project from mobilisation of vessels to the end of project activities at the waste processing / disposal site (does not include landfill and long-term storage impacts) For rock placement, trenching and dredging any seabed disturbance is included here, depending on area of impact – changes to habitat and species are covered in Legacy Impact.	Associated planned discharges; marine noise; seabed disturbance, including seabed footprint (area), sediment suspension and contaminated sediment including drill cuttings; protected habitat and species in nearshore, marine and onshore areas – conservation objectives, their presence, impacts, distance from activities; waste processing Note - the use of chemicals for cleaning and removal of operations chemicals in umbilicals or pipelines is not a factor to be assessed in CA.	Asset knowledge, decommissioning methodologies, Environmental Baseline Survey, Habitat Survey, Waste Inventory, Environmental Impact Assessment Report, project schedule, collision assessment, predicted discharges to sea, historic events
	Energy and emissions and resource consumption	Project activities from vessel mobilisation to the final destination of waste, including the energy and emissions penalty for leaving recyclable material in field. Includes vessel mobilisation, demobilisation, waiting on weather, post-decommissioning monitoring surveys.	During execution phase of the project from mobilisation of vessels to the end of project activities at the waste processing / disposal site (does not include landfill and long-term storage impacts) Not recovering and recycling the installations material will require that raw material and energy will be consumed to replace the materials which would have been recycled if the structure had been brought onshore	Number and type of vessels; duration of vessel activities; tasks vessels are fulfilling; vessel station keeping approach Energy and emissions required to replace recyclable materials not recovered for recycle of re-use Helicopter trips are not to be included as impact is marginal.	Energy and emissions assessment, undertaken per Institute of Petroleum: Guidelines for the Calculation of Estimates of Energy Use and Gaseous Emissions in the Decommissioning of Offshore Structures
	Legacy Impact	Ongoing long term environmental impact and benefit caused by materials left in place or long-term waste storage / landfill	Following completion of the Decommissioning project and residual / ongoing impact For rock placement, trenching and dredging any changes to habitat and species are included here - seabed disturbance is included in Impact of Operations, depending on area of impact.	Waste disposal including onshore landfill and long-term waste storage; habitat alteration and long-term changes in species composition; physical and chemical degradation of products left on the seabed (make and content of material like wax, chemicals, plastic and concrete, steel, debris). CA will be conducted with assumption that reasonable endeavours are used to ensure infrastructure is cleaned using best available techniques (BAT).	Decommissioning methodology for each option, focussing on volume and type of infrastructure to be left in situ; Environmental Baseline Survey; Habitat Survey; Waste Inventory

Criteria	Sub-Criteria	Applicable to	Applicable When	Factors	Potential Sources of data
Technical	**Risk of major project failure** Cost and Schedule overruns. Ease of recovery from excursion.	Overall Project	From project select phase through to completion, including monitoring surveys and ultimate disposal of materials returned to shore.	Maturity of scope definition, confidence level that project will proceed as foreseen; ability to recover from unplanned events which could impact completion of the project as planned; extent of potential re-engineering that may be required and its impact if strategy goes wrong	Decommissioning methodology for each option, concept / pre-FEED study, lessons learned from industry
	Technology demands, Availability / Track Record	Overall Project	From project select phase through to completion, including monitoring surveys and ultimate disposal of materials returned to shore.	Extent of new or emerging technology proposed by the option; extent of application of existing technology to different uses; extent that the approach has been completed before	Decommissioning methodology for each option, concept / pre-FEED study, lessons learned from industry
Societal	**Commercial impact to fisheries**	Impacts from both the decommissioning operations and the end-points on the present commercial fisheries in and around the field	During and following completion of the Decommissioning project and residual / ongoing impact	Residual impact on fishing areas: • If exclusion zones are to be retained where equipment or materials are left in-situ • If fishing habitats are inhibited as a result of the decommissioning methods adopted	Fishing study on anticipated activity in area of activity; decommissioning methodology for each option focussing on volume and type of infrastructure to be left in situ; vessel study; publicly available data; stakeholder engagement
	Socio-economic impact on communities and amenities	The impact from any near shore and onshore operations and end-points (dismantling, transporting, treating, recycling, land filling) on the health, well-being, standard of living, structure or coherence of communities or amenities. E.g. business or jobs creation, job loss, increase in noise, dust or odour pollution during the process which has a negative impact on communities, increased traffic disruption due to extra-large transport loads.	During and following completion of the Decommissioning project and residual / on-going impact	May be positive or negative; jobs created; establishment of track record; improvements to roads and quaysides; use of limited landfill resource	Decommissioning methodology for each option; publicly available data; stakeholder engagement
Economic	**Cost**	Overall Project	Full decommissioning project cost including future monitoring surveys and proposed remediation, if required	Actual cost estimates are not to be included in the CA report but a normalised scale can be produced to indicate the comparison between each option	Cost and schedule estimates
	Cost Risk / Uncertainty	Overall Project	Project execution phase and ongoing cost liability (surveys and potential remedial action)	Uncertainty in estimates prepared, potential for / risk of growth through the project, risk will be greater with a larger number of unknowns and where activities are weather sensitive	Risk and opportunity register

Table 3-1 – Comparative Assessment Criteria and Sub-Criteria

3.4. Decommissioning Options and Initial Screening Workshop

3.4.1. Decommissioning Options

The options available for decommissioning have been considered and were assessed as part of the initial screening process to assess each options feasibility. The options for decommissioning being assessed are shown in section 4.

3.4.2. Initial Screening Workshop

An initial screening workshop was held where internal Company experts (pipelines, subsea, environmental, HSSE) were consulted to assess the technical feasibility and practicality of each of the decommissioning options relating to each scope. The initial screening workshop also identified the grouping of pipelines, umbilicals, ends and spools.

Where a particular piece of scope was in-line with the BEIS (formerly DECC) guidance notes [1], such as a blanket rock covered pipeline, the decommissioning option was preliminary selected at the initial screening workshop. During the CA workshop the proposed methods were presented to and discussed with the key external stakeholders to confirm their acceptance of the proposed decommissioning method. The scope that could not be selected during the initial screening workshop was taken into the comparative assessment workshop for traffic light screening.

3.5. Traffic-light assessment

A comparative assessment workshop was organised with the relevant stakeholders to assess each decommissioning option that was not selected during the initial screening workshop. Table 5-1 shows a summary of the groups assessed during the traffic light screening stage.

During the workshop each scope or group was assessed individually, whereby each option was qualitatively assessed against each of the sub-criteria detailed in Section 3.3, using a simple traffic light system. An example of the traffic lighting is shown in the table below.

		Option Category	Leave In-Situ	Remediate	Remove
		Include Option for Screening?	☑ Option 1	☑ Option 2	☑ Option 5
Criteria	**Ref**	**Sub Criteria**	**Option 1: Leave In-Situ (Do Nothing)**	**Option 2: Leave In-situ (Remediate with Rock Cover Above Seabed)**	**Option 5: Full Removal**
Safety	1	Project risk to personnel - Offshore			
	2	Project risk to other users of the sea			
	3	Project risk to personnel - Onshore			
	4	Potential of a high consequence even			
	5	Residual risk to other users of the sea			

Table 3-2 – Example Traffic Lighting

The traffic lighting assessment was conducted using the qualitative scoring guidance provided in section 9, developed from Appendix A of the Oil and Gas UK Guidelines for Comparative Assessment in Decommissioning Programmes [2] with two adaptations for the sub-criteria "impact of operations" and "legacy impact".

The preferred option will be one which scores better in the traffic light scoring than all other available options. The assessment of what quantifies "better" was made on a case-by-case basis by the project team, however the following guidance is provided:

- It is not necessary for the preferred option to score all, or even a majority, of "green" results;
- A "red" result does not necessarily mean that an option is unacceptable or has been ruled out, it merely indicates that it is not favourable for the associated sub-criteria;
- The relative importance of each sub-criteria should be considered, e.g. safety risk to project personnel is a more important factor than cost risk;
- Quality of the discussion between the stakeholders is important when considering the better options;
- Cost can only be a deciding factor where all other criteria are equal.

For scopes where it was not possible to reach a clear conclusion from the traffic lighting assessment, the workshop considered three possible options:

1. When scoring was similar and no parties had a strong preference for one or the other, then the project could either:
    a. select the option which best fits within a "campaign approach", i.e. offers synergies with other scopes, and/or provides the optimum cost solution. No further CA would be required. NB - cost can only be deciding factor when all other criteria are equal; or
    b. projects may wish to retain two options which offer the same end outcome but utilising different methods, e.g. total removal by cut-and-lift and total removal by reverse-reeling, where this would allow the market to tender for both options and offer competitive opportunities. This is in line with the OGUK Guidelines for Comparative Assessment which state "operators may wish to retain flexibility on the recommendations around the detailed removal or recovery methods to be adopted until the execution phase of the decommissioning project, as this may retain market competition and potential for innovation"; or
2. If there are particularly sensitive stakeholders considerations (e.g. a pipeline through a Marine Protected Area) then the remaining credible options could have been taken to a scoring assessment.

3.6. Scoring Assessment

None of the Curlew decommissioning scopes required a scoring assessment.

4. Decommissioning Options

4.1. Pipeline Decommissioning Options

A brief discussion of the decommissioning options is presented below, which will cover the high level options of pipeline removal, re-use, remediation and leave in-situ as well as the options for the mooring system decommissioning.

4.1.1. Re-use

No opportunities have been identified to re-use any of the Curlew subsea pipelines, spools, umbilicals, jumpers or the mooring system. In addition, the majority of the subsea infrastructure is closely approaching its design life.

4.1.2. Removal

4.1.2.1. Cut and lift

The cut and lift method to date has been the most commonly used method to remove pipelines. The method requires the pipeline to be un-trenched and water flooded. The pipeline will then be cut into sections by an ROV using hydraulic shears and then recovered by a vessel using a hydraulic lifting beam ready for transport to shore and disposal. A simplified schematic of the cut and lift process is shown in Figure 4-1. The preferred method of cutting will generally be decided by the contractor performing the work, following risk assessments, however will most likely be hydraulic shears.

The cut and lift method can be used for the entire pipeline removal or localised sections, such as spools or spans.

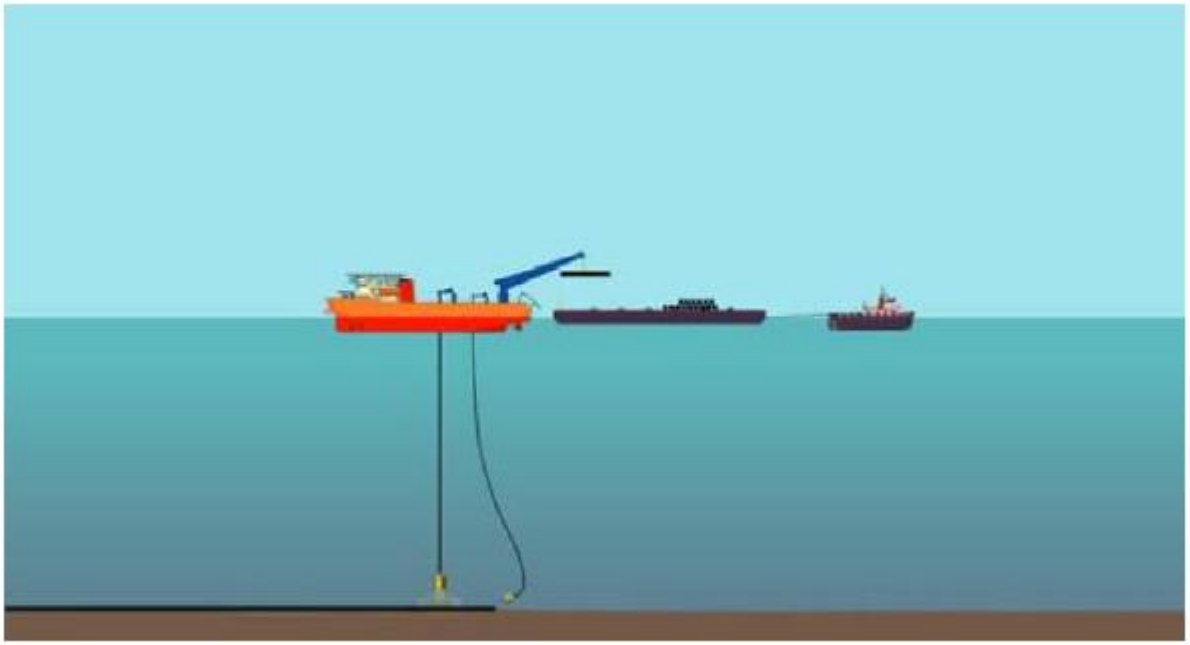

Figure 4-1 – Cut and Lift Pipeline Removal Illustration

4.1.2.2. Reverse Reel

All the pipelines (flexible and rigid) and umbilicals at Curlew have been installed by reeling. To reverse reel the pipelines and umbilicals they would potentially need to be un-trenched and de-watered to reduce the submerged unit weight. The pipeline ends would then need to be cut or disconnected and then the reeling vessel would connect to the pipeline end and then recover the end using the A&R (abandonment and recovery) winch until the tensioner could grip the pipeline and proceed to pull the pipeline on to the vessel. The pipeline or umbilical would then need to be connected to the main reel, so that the vessel could proceed to reel on. The pipeline would then be transported to shore for disposal or recycling.

Reverse reeling has previously been performed on flexible pipelines and umbilicals, however there is very little, if any, experience of the reverse reeling of a complete rigid pipeline. Due to this a significant level of engineering would need to be completed, prior to selecting this option.

4.1.2.3. Reverse S-lay

Reverse S-lay is a potentially feasible option to recover pipelines, however there is very limited experience using this technique and a detailed study and trials would need to be performed prior to committing to this method. Reverse S-lay is the reversal of the common S-lay installation technique, which generally consists of a pipeline lay vessel or barge equipped with a stinger and tensioner and then the line pipe is welded together on the vessel, prior to being laid onto the seabed, which is controlled by the applied tension to the pipeline.

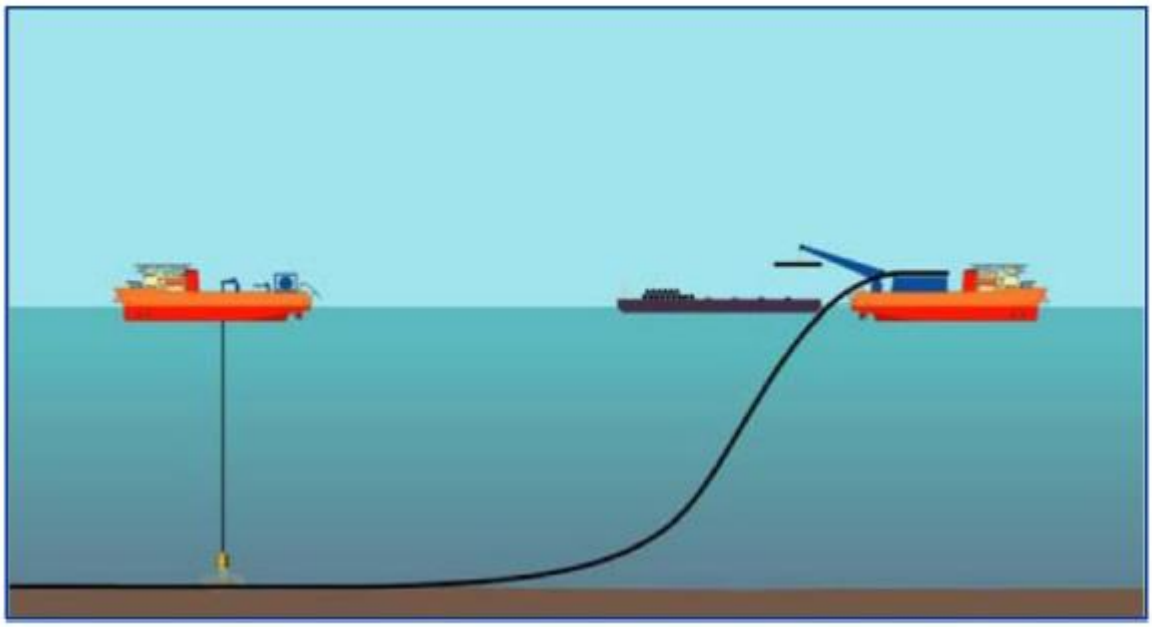

Figure 4-2 – Reverse S-lay Illustration

For the removal process the tensioner would be used to recover the pipeline from the seabed and then it would be cut to manageable lengths on the vessel and transported back to shore.

The pipeline would need to be un-trenched to perform this method of recovery. In addition, it would be prudent to dewater the pipeline (air filled or nitrogen purged) to reduce the equivalent weight of the pipeline and hence reduce the required tension. A summary of the reverse S-lay methodology is summarised in Figure 4-2.

4.1.3. Leave In-situ

4.1.3.1. Pipelines (No remediation)

This option consists of leaving the pipeline or umbilical in-situ with no further remediation, however the pipeline ends maybe cut and buried or cut and rock covered.

4.1.3.2. Pipelines (Re-trench)

Re-trenching the pipelines is an option for pipelines subject to increased risk from snagging or becoming unstable (e.g. buoyant pipelines or free spanning pipelines) due to a reduction in the burial depth or cover. The retrenching of a pipeline can be performed by a jet trencher, plough or mass flow excavator. Re-trenching on areas with remedial rock may need the rock removed prior to trenching, depending on the rock grade.

4.1.3.3. Localised Cut and Lift

For localised exposures or areas of low cover, localised cut and lift operations can be used, which would be executed in a similar manner to that shown in section 4.1.2.1.

4.1.3.4. Pipelines (Remedial Rock Cover)

Remedial rock cover involves either blanket or locally placing rock at specific locations to increase the cover to the pipeline to reduce the risk of snagging or it affecting other users of the sea. Due to the water depth at Curlew (approx. 90m) a fall pipe vessel, shown in Figure 4-3, would be used.

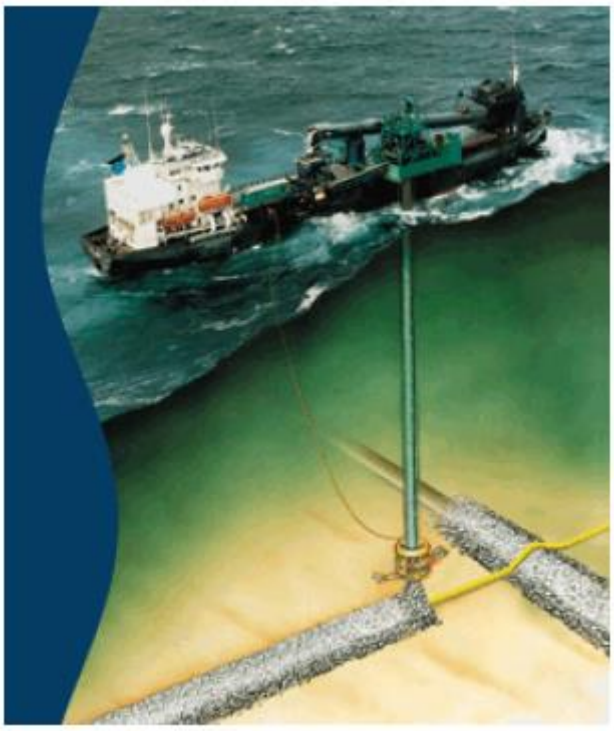

Figure 4-3 – Remedial Rock Cover Installation Illustration

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4.1.4. Spool Decommissioning Options

4.1.4.1. Leave Spools In-situ (Protected by Concrete Mattresses)

Many of the spools and pipeline ends at Curlew are protected by concrete mattresses. One option for the spool decommissioning is to leave the spools in-situ protected by the concrete mattresses. However, the gooseneck connecting the spool to the manifold or tree will be cut and removed to remove any significant snagging issues.

4.1.4.2. Leave Spools In-situ (Remedial Rock Cover)

Similar to the above option, however the concrete mattresses over the spools/jumpers will be protected by additional rock cover. The rock cover operations will be performed in the same manner as that described in section 4.1.3.4.

4.1.4.3. Removal

Removal of the spools will be via cutting the spools/jumpers at the structures and pipeline/umbilical ends or disconnection by breaking the flanged joints. The spools would then be recovered to the back of a vessel and sent on-shore for recycling and/or disposal.

4.2. Mooring System Decommissioning Options

In general the mooring system lines will be removed from the FPSO connection to the area of the mooring chain at the pile that remains on the seabed. The two areas that will be focused on for this comparative assessment are the trenches left by the touchdown location from the mooring chains and the mooring system anchor piles.

4.2.1. Mooring System Trench Decommissioning

4.2.1.1. Leave In-situ (No remediation)

The trenches left behind at the anchor chain touchdown locations in some areas are as deep as 4.0m (see figure below). One option was to leave these trenches in-situ without any further remediation and allow them to backfill naturally.

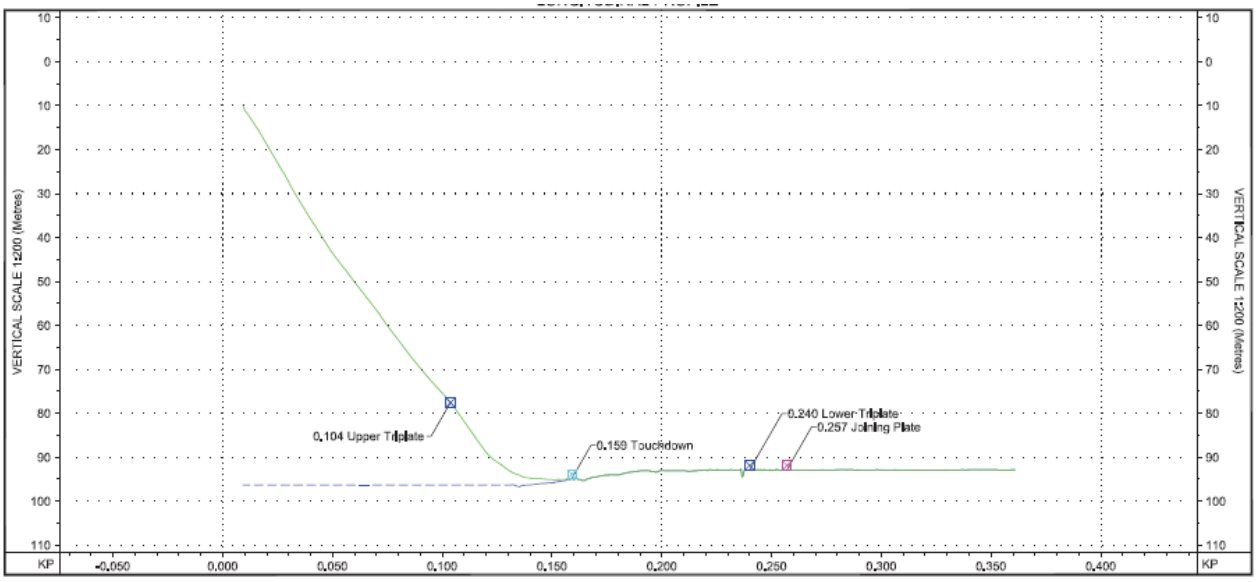

Figure 4-4 – Typical Curlew Mooring Chain Trench

4.2.1.2. Remedial Rock Only

This option considers filling the trenches with remedial rock placement to the mean seabed level. Again, this operation would be similar to that described in section 4.1.3.4.

4.2.1.3. Remedial Rock and Recycled Mattresses

One option was also to consider filling the trenches with concrete mattresses removed from the spools to recycle them, as opposed to returning them to shore. The remedial rock would then be placed to return the trench to the mean seabed level.

4.2.1.4. Remediate with Drag Chains

The option to remediate the mooring trenches with drag chains consists of trawling the mooring trenches with a chain mat to drag loose soil from the seabed into the trench and "smooth" out the seabed.

4.2.1.5. Remediate with Rock up to 0.5m below seabed and allow natural backfill

This option considers filling the trenches with rock up to 0.5m below the seabed and then relying on natural backfill to cover the rock and essentially backfill the remaining trench.

4.2.1.6. Mass Flow Excavator

This option consists of using a mass flow excavator to remove the "berms" and smooth out the trenches. Figure 4-5 shows an illustration of a mass flow excavator.

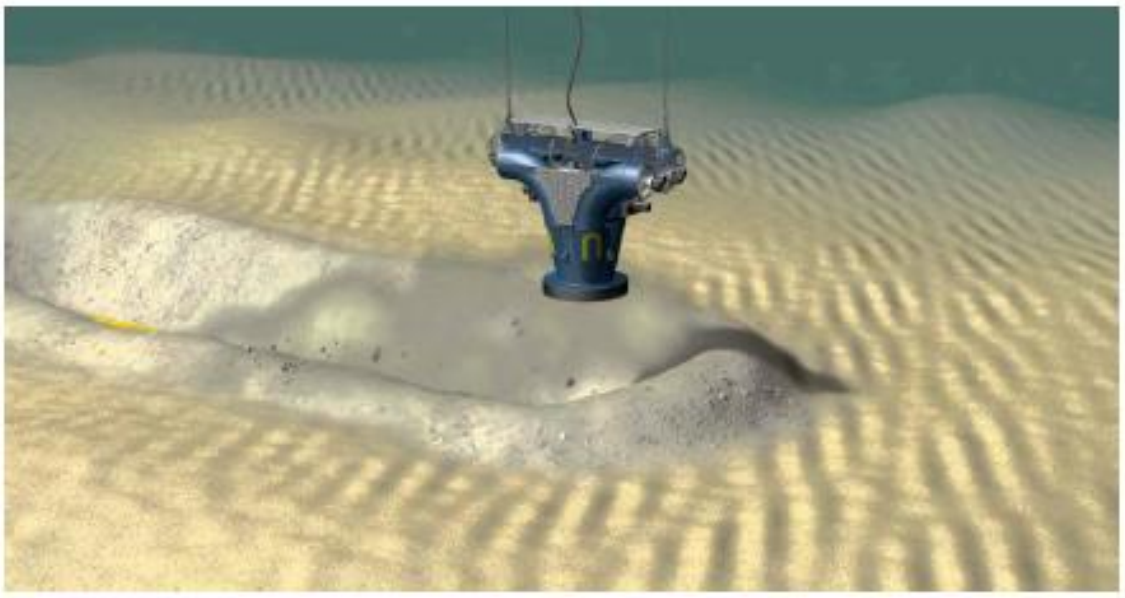

Figure 4-5 – Mass Flow Excavator Illustration

4.2.2. Mooring System Anchor Piles

The base case approach for Curlew is to remove the anchor piles. If there is a scenario where the piles cannot be removed then the following options were considered during the CA workshop so that the project has a remediation option. In all cases, if difficulty is encountered whilst attempting to remove the anchors, BEIS will be consulted to discuss and agree the way forward.

4.2.2.1. Leave In-situ (No remediation)

One option for the mooring anchor piles was to leave them in-situ without any further remediation.

4.2.2.2. Leave In-situ (Cut Piles below mean seabed level)

The leave in-situ option which includes the cutting of the mooring piles to a safe depth below the seabed, which involves either dredging down and cutting the pile from the outside or cutting the pile internally. Once cut the section of pile will be recovered to the vessel and either recycled or disposed of onshore. The depression left in the seabed would then be remediated with rock to provide a safe level of cover to the top of the pile. Additional rock would be required to return the excavation to the mean seabed level.

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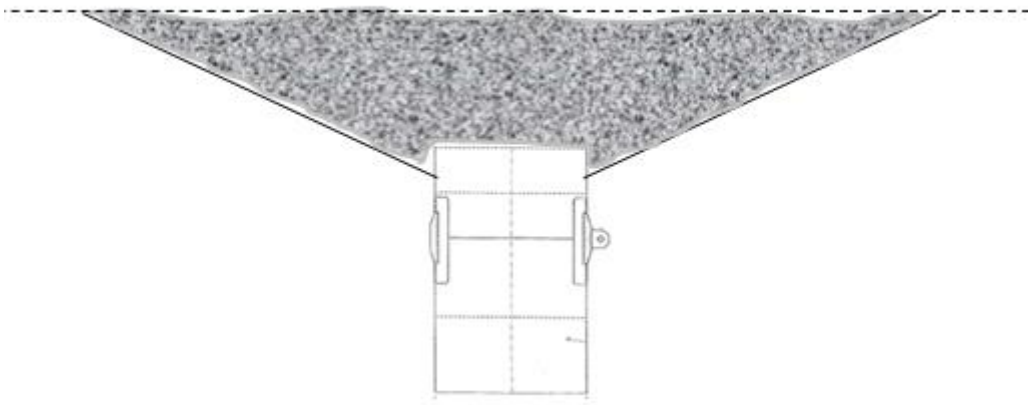

Figure 4-6 – Suction Pile cut to acceptable depth and then rock covered to mean seabed level

4.2.2.3. Leave In-situ (Remedial Rock Cover)

This option would involve leaving the mooring piles in-situ and placing remedial rock cover over the location of the piles to ensure they are not a snagging hazard.

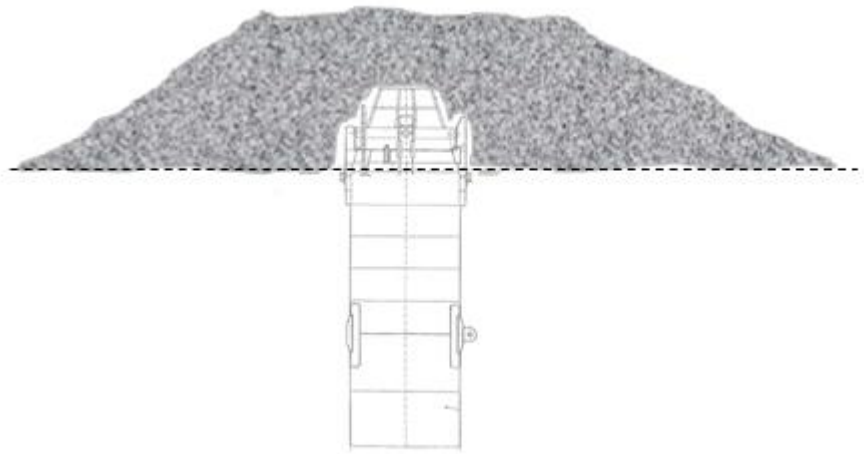

Figure 4-7 – Suction pile left in-situ (proud of the seabed) and then rock covered above (0.5m above top of pile)

4.2.2.4. Leave in-situ (Cut at MSL and Remediate with Rock)

This option requires the pile to be cut at the mean seabed level and then rock cover would be required to cover the top of the pile to prevent any scouring and also to ensure the cut pile would not become a snagging hazard.

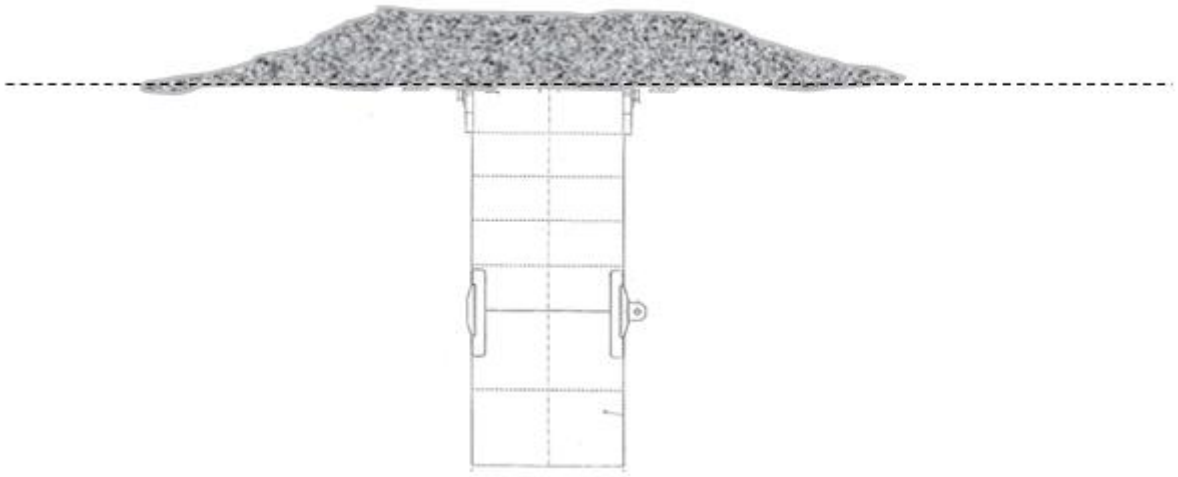

Figure 4-8 – Suction pile left in-situ (cut at mean seabed seabed) and then rock covered above (0.5m above top of pile)

4.2.2.5. Remove

The removal option for the mooring piles involves pulling the moorings piles from the seabed using a vessel. The process of pulling the mooring piles out involves pumping the piles out and applying a tension force, given the piles are suction piles.

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5. Comparative Assessment Results

5.1. Initial Decommissioning Options Screening and Grouping

A number of stakeholder engagements took place during the initial screening phase to further understand and clarify each stakeholder's concerns and views regarding the decommissioning of the Curlew Field.

Three internal workshops to screen the options were held by Shell in Q2 2017 utilising information from historic survey data. The workshops enabled the project team to identify and define feasible options for each scope, whilst highlighting data gaps associated with each option and defining the studies required prior to the comparative assessment workshop.

In July 2016, pre-decommissioning environmental survey was completed by Fugro Ltd. on behalf of Shell UK. The survey included surface sediment grab samples, video footage and digital photographs at stations across the Curlew Fields, and 5 core samples of the Curlew D drill cuttings pile. The survey provided an assessment of the biological and physio-chemical characteristics of the Curlew area and inform the future decommissioning process with regard to the potential disturbance of contaminated sediments and habitats.

During the initial screening workshop the scopes for a narrative conclusion were identified, if they were generally within regulator guidelines for decommissioning, e.g. blanket rock covered. In addition to identifying the narrative conclusions the pipelines / umbilicals were grouped, where applicable, for the purposes of the comparative assessment workshop. A summary of the grouping is shown in Table 5-1.

Table 5-1 – Summary of Decommissioning Options and Grouping

Notes:

1. Options in red with a strikethrough (e.g. ~~Leave in-situ~~) were deselected during initial screening.
2. Pipeline / umbilical ends and spools / jumper decommissioning options also include the treatment of mats.

Pipeline / Asset	Sub Category	Decommissioning Options	Comparative Assessment Method	Applicable Grouping
Curlew B	Production Pipeline	~~1. Reverse Reel Lay;~~ 2. ~~Cut and lift~~; 3. ~~Reverse S-lay~~; 4. Leave in-situ (Do nothing); 5. Leave in-situ (remediate with spot rock cover); ~~6. Leave in-situ (remediate with partial cut and lift);~~ ~~7. Leave in-situ (Remediate by Re-trenching);~~ ~~8. Leave in-situ (remediate by backfilling existing trench).~~	Narrative	1
	Production Pipeline End	See pipeline / umbilical end		6
	Umbilical Route Length	~~1. Reverse Reel Lay;~~ 2. ~~Cut and lift~~; 3. ~~Reverse S-lay~~; 4. Leave in-situ (Do nothing); 5. Leave in-situ (remediate with spot rock cover); ~~6. Leave in-situ (remediate with partial cut and lift);~~ ~~7. Leave in-situ (Remediate by Re-trenching);~~ ~~8. Leave in-situ (remediate by backfilling existing trench).~~	Narrative	1
	Umbilical End	See pipeline / umbilical end group 6.		6
Curlew C	Production Pipeline Route Length	1. ~~Reverse Reel Lay~~; 2. ~~Cut and lift~~; 3. ~~Reverse S-lay~~; 4. Leave in-situ (Do nothing); 5. ~~Leave in-situ (remediate with spot rock cover)~~; ~~6. Leave in-situ (remediate with partial cut and lift);~~ ~~7. Leave in-situ (remediate with blanket rock cover);~~	Narrative	2
	Production Pipeline Ends	See pipeline / umbilical ends group 5.		5
	Production Pipeline Spools	See spools / jumpers group 7.		7
	Gas Lift Pipeline Route Length	Pipeline is piggybacked (Strapped) to production pipeline.	Narrative	2
	Gas Lift Pipeline Ends	See pipeline / umbilical ends group 5.		5
	Gas Lift Pipeline Spools	See spools / jumpers group 7.		7
	Umbilical	1. ~~Reverse Reel Lay~~; 2. ~~Cut and lift~~; 3. ~~Reverse S-lay~~; 4. Leave in-situ (Do nothing); 5. ~~Leave in-situ (remediate with spot rock cover)~~; ~~6. Leave in-situ (remediate with partial cut and lift);~~ ~~7. Leave in-situ (remediate with blanket rock cover);~~	Narrative	2
	Umbilical Ends	See pipeline / umbilical end group 5.		5

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Pipeline / Asset	Sub Category	Decommissioning Options	Comparative Assessment Method	Applicable Grouping
Curlew D	Production Pipeline 1 Route Length	1. Reverse Reel Lay; 2. ~~Cut and lift~~; 3. ~~Reverse S-lay~~; 4. Leave in-situ (Do nothing); 5. Leave in-situ (remediate with spot rock cover); 6. Leave in-situ (remediate with partial cut and lift); ~~7. Leave in-situ (Remediate by Re-trenching);~~ ~~8. Leave in-situ (remediate by backfilling existing trench).~~	Traffic Light Assessment	3
	Production Pipeline 1 Ends	See pipeline / umbilical ends group 6.		6
	Production Pipeline 1 Spools	See spools / jumpers group 8.		8
	Production Pipeline 2 Route Length	See Curlew D production pipeline 1 route length.	Traffic Light Assessment	3
	Production Pipeline 2 Ends	See pipeline / umbilical ends group 6.		6
	Production Pipeline 2 Spools	See spools / jumpers group 8.		8
	Production spools at Curlew D manifold	See spools / jumpers group 8.		8
	Umbilical Route Length	See Curlew D production pipeline 1 route length.	Traffic Light Assessment	3
	Umbilical Ends	See pipeline / umbilical end group 6.		6
	Umbilical Jumpers at Curlew D manifold	See spools / jumpers group 8		8
Curlew Gas Export	0 (FPSO End) – 10km Pipeline Route Length	~~1. Reverse Reel Lay;~~ 2. ~~Cut and lift~~; 3. ~~Reverse S-lay~~; 4. Leave in-situ (Do nothing); 5. Leave in-situ (remediate with spot rock cover); ~~6. Leave in-situ (remediate with partial cut and lift);~~ ~~7. Leave in-situ (remediate with blanket rock cover);~~ ~~8. Leave in-situ (Remediate by Re-trenching);~~ ~~9. Leave in-situ (Remediate by Collapsing trench wall);~~ 10. ~~Leave in-situ (remediate by backfilling existing trench).~~	Narrative	4a
	10km – 25km Pipeline Route Length	1. Reverse Reel Lay; 2. ~~Cut and lift~~; 3. ~~Reverse S-lay~~; 4. Leave in-situ (Do nothing); 5. Leave in-situ (remediate with spot rock cover); ~~6. Leave in-situ (remediate with partial cut and lift);~~ 7. Leave in-situ (remediate with blanket rock cover); ~~8. Leave in-situ (Remediate by Re-trenching);~~ 9. ~~Leave in-situ (Remediate by Collapsing trench wall)~~; 10. Leave in-situ (remediate by backfilling existing trench).	Traffic Light Assessment	4b

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Pipeline / Asset	Sub Category	Decommissioning Options	Comparative Assessment Method	Applicable Grouping
Curlew Gas Export	Pipeline End	See pipeline / umbilical ends group 5 & 6		5&6
	Pipeline Spools	See spools / jumpers group 7 & 8		7&8
Pipeline/Umbilical Ends	Pipeline/Umbilical ends in close proximity to rock cover or covered by rock	1. Remove (cut to acceptable depth and lift) and bury with rock to mean seabed level; 2. Remove (cut at mean seabed level and lift) then cover with rock; 3. Leave in-situ Dredge and buried to acceptable depth by liquifaction; 4. ~~Cut at seabed level then dredge remaining pipeline end~~; 5. Leave in-situ Rock cover (Above mean seabed level); 6. Leave in-situ;	Traffic Light Assessment	5
	Pipeline/Umbilical ends NOT in close proximity to rock cover or covered by rock	1. Remove (cut to acceptable depth and lift) and bury with rock to mean seabed level; 2. Remove (cut at mean seabed level and lift) then cover with rock; 3. Leave in-situ Dredge and buried to acceptable depth by liquifaction; 4. ~~Cut at seabed level then dredge remaining pipeline end~~; 5. Leave in-situ Rock cover (Above mean seabed level); 6. Leave in-situ;	Traffic Light Assessment	6
Spools / Jumpers	Spools / Jumpers in close proximity to rock cover or covered by rock	~~1. Leave in-situ, remove mattresses, dredge and buried to acceptable depth by liquefaction;~~ 2. Leave in-situ and Rock cover (Above mean seabed level); 3. Leave in-situ (do nothing); 4. Full Removal;	Traffic Light Assessment	7
	Spools / Jumpers NOT in close proximity to rock cover or covered by rock	~~1. Leave in-situ, remove mattresses, dredge and buried to acceptable depth by liquefaction;~~ 2. Leave in-situ and Rock cover (Above mean seabed level); 3. Leave in-situ (do nothing); 4. Full Removal;	Traffic Light Assessment	8

Pipeline / Asset	Sub Category	Decommissioning Options	Comparative Assessment Method	Applicable Grouping
Mooring System	Mooring Touchdown Trenches	1. Leave in-situ – Chain mat over trawl; 2. Rock fill trenches; 3. Fill trenches with mattresses and top with rock; 4. Mass flow excavation to smooth out trenches; ~~5. Plough seabed.~~	Traffic Light Assessment	9
	Anchor Piles	1. Full Removal (Base case option, below options are for contingency planning); 2. ~~Leave in-situ (Do nothing)~~; 3. Leave in-situ and rock cover; 4. Partial Removal (cut pile down to safe depth) and excavate chain end to acceptable depth, cut remaining chain end, then bury using rock fill. 5. Partial Removal (cut pile down to safe depth) and cut chain end at mean seabed level then leave in-situ. 6. Partial Removal (cut pile down to safe depth) and cut chain end at mean seabed level then rock cover. 7. Partial Removal (cut pile down to safe depth) and cut chain end at mean seabed level then dredge below mean seabed level.	Traffic Light Assessment	10

5.2. Curlew B Pipelines and Umbilicals Route Length (Group 1)

The Curlew B pipeline and umbilical route length decommissioning option was provisionally selected during the initial screening workshop as the pipeline is trenched and buried and is generally in line with regulatory guidance for achieving a minimum of 0.6m cover to the top of pipe or umbilical.

The pipeline is generally buried to a depth of 0.6m along the whole length, however 2 exposures along the umbilical length have been identified from surveys. As can be seen in the burial depth summary in section 8.3, which also show the level of natural cover is gradually increasing.

In-line with section 5.1 the initial feasible options for decommissioning were:

- Reverse Reel Lay;
- Cut and lift;
- Reverse S-lay;
- Leave in-situ (do nothing);
- Leave in-situ (remediate with spot rock cover);
- Leave in-situ (remediate with partial cut and lift);
- Leave in-situ (remediate by Re-trenching);
- Leave in-situ (remediate by backfilling existing trench).

Given the pipeline and umbilical were installed by reeling, reeling was selected as the most practical removal option and so the other removal options were de-selected.

Due to the degree of burial on the Curlew B pipeline umbilical leave in-situ and do nothing was considered a feasible option.

In terms of remediation options, remediate by spot rock cover was selected as there is already presence of rock cover in the area and only very localised sections would require remediation.

Partial cut and lift was considered, however this would leave behind additional pipeline ends, which are considered more of a hazard to the SFF, hence this option was de-selected.

Remediation by re-trenching was also considered, however localised re-trenching was not considered practical as a long length of the pipeline would require re-trenching to ensure the localised snagging hazard area is lowered further below the mean seabed. This option was de-selected.

Remediation by backfilling the existing trench was considered, however as the pipeline and umbilical has been installed for approximately 20 years the likelihood of having sufficient natural fill material to increase the depth of cover along the whole length is low and hence there would be potential for additional spot rock cover to be installed. This is illustrated by Figure 5-1, as can be seen the seabed above the pipe is generally flat, hence there is no "mound" of soil to backfill into the trench to increase cover. This option was de-selected due to the risk that additional spot rock cover would be required, therefore remediating by spot rock cover was considered to be a more practical option.

Figure 5-1 – Typical photo of survey footage of Curlew B pipeline

The proposed decommissioning option is to leave the pipeline and umbilical in-situ and provide spot rock cover in areas of low cover or where the overtrawl trials identify a snagging hazard. An as-left post decommissioning survey would then be performed to further verify the burial depth of the pipeline and umbilical. The overtrawl trial would be performed by the SFF to verify there are no snagging hazards along the pipeline or umbilical length and it is left in a safe condition for other users of the sea. This option was selected as the pipeline and umbilical burial depth is generally within regulatory guidance for a leave in-situ candidate.

During the comparative assessment workshop the proposed decommissioning option was presented to the stakeholders in the room. All the stakeholders agreed with the proposed decommissioning option, however the SFF proposed the following slight amendments which will be implemented by the project:

- Curlew B Pipeline: Perform overtrawl trial and only remediate areas that present a snagging hazard;
- Curlew B Umbilical: Provide spot rock cover at locations of exposures, then perform overtrawl survey to verify the pipeline does not present a snagging hazard.

5.3. Curlew C Pipelines and Umbilicals (Group 2)

The Curlew C pipelines (production and gas lift) and umbilical route length decommissioning option was provisionally selected during the initial screening workshop as the pipelines are trenched and blanket rock covered and is in full compliance with regulatory guidance for achieving a minimum of 0.6m cover to the top of pipe or umbilical.

The pipelines and umbilicals are laid in the same trench and there is at least 0.6m of blanket rock cover above the top of pipe. As can be seen in the burial depth summary in section 8.4, which also show the level of natural cover is gradually increasing.

In-line with section 5.1 the initial feasible options for decommissioning were:

- Reverse Reel Lay;
- Cut and lift;
- Reverse S-lay;
- Leave in-situ (Do nothing);
- Leave in-situ (remediate with spot rock cover);
- Leave in-situ (remediate with partial cut and lift);
- Leave in-situ (remediate with blanket rock cover);

Given the pipelines and umbilical were installed by reeling, reeling was selected as the most practical removal option and so the other removal options were de-selected.

In terms of remediation options, remediate by spot rock cover was selected as the pipeline and umbilical is blanket rock covered and so the other options were not considered to add any benefit above spot rock cover.

The proposed decommissioning option is to leave the pipelines and umbilical in-situ without any remediation. An as-left post decommissioning survey will be performed to further verify the burial depth of the pipeline and umbilical. The overtrawl trial will be performed by the SFF to verify there are no snagging hazards along the pipeline or umbilical length and it is left in a safe condition for other users of the sea. This option was selected as the pipelines and umbilical burial depth is in full compliance with regulatory guidance for a leave in-situ candidate.

During the comparative assessment workshop the proposed decommissioning option was presented to the stakeholders in the room. All the stakeholders agreed with the proposed decommissioning option.

5.4. Curlew D Pipelines and Umbilicals (Group 3)

The Curlew D production pipelines and umbilical route length decommissioning options were considered during the initial screening workshop. The current condition of the pipelines and umbilical is close to meeting the criteria in the regulatory guidance to leave in-situ, however from survey data it was identified that there were some areas of exposure and low cover along the pipeline and umbilical route, which also included areas of spot rock cover. For this reason the project team decided to assess this option at the comparative assessment process with the stakeholders in the room to ensure that any concerns were considered during the decommissioning option selection. The burial depth summaries are provided in section 8.5, which also show the level of natural cover is gradually increasing.

In-line with section 5.1 the initial feasible options for decommissioning were:

- Reverse Reel Lay;
- Cut and lift;
- Reverse S-lay;

- Leave in-situ (Do nothing);
- Leave in-situ (remediate with spot rock cover);
- Leave in-situ (remediate with partial cut and lift);
- Leave in-situ (Remediate by Re-trenching);
- Leave in-situ (remediate by backfilling existing trench).

Given the pipeline and umbilical were installed by reeling, reeling was selected as the most practical removal option and so the other removal options were de-selected.

As the pipelines and umbilicals are laid within the trench and not protruding above the mean seabed level the leave in-situ with no remediation was considered a potentially feasible option that should be assessed during the CA workshop.

As can be seen in the burial summary in section 8.5 the pipelines and umbilical have spot rock cover installed. Therefore remediation by spot rockcover was considered a feasible option for the comparative assessment workshop.

Partial cut and lift was then considered as another remediation option some of the exposures have little cover and so would make the localised cut and lift option simpler, as can be seen in Figure 5-2.

Figure 5-2 – Curlew D Pipeline Exposure Example

Remediation by re-trenching was also considered, however retrenching was deselected as the pipeline was initially installed with trenching being the main form of protection and given the exposures, shown above and poor burial profile, re-trenching was considered to have a low likelihood of success.

A traffic light screening assessment was performed (see Figure 5-3) to assess the different decommissioning options, whilst considering the stakeholders concerns. From the traffic light screening assessment the proposed

decommissioning option is to leave the pipeline and umbilical in-situ and provide spot rock cover in areas of low cover/exposures or where the overtrawl trials identify a snagging hazard.

During the comparative assessment workshop, the Scottish Fisherman's Federation (SFF) advised that, for safety reasons, it would be advisable to create a "link" between rock berms which are in series along the same pipeline where rock berms were close to one another (approx. 50 m).

Following remediation operations a post decom activity survey will be performed to verify the depth of cover and overtrawl trials will be performed by the SFF to ensure that the pipeline is not a potential risk to other users of the sea.

During the CA workshop it was asked why a narrative conclusion was not made to leave in-situ and remediate with spot rock cover as the pipelines and umbilical already had areas protected by rock. Although the project team during the initial screening workshop were close to selecting a narrative conclusion for leave in-situ with remedial rock cover they wanted to consult the stakeholders to ensure that all concerns were being considered.

		Option Category	Leave In-Situ	Remediate		Remove
		Include Option for Screening?	☑ Option 1	☑ Option 2	☑ Option 3	☑ Option 5
Criteria	**Ref**	**Sub Criteria**	**Option 1: Leave In-Situ (Do Nothing)**	**Option 2: Leave In-situ (Remediate with Spot Rock Cover)**	**Option 3: Leave In-situ (Remediate with Partial Cut and Lift)**	**Option 5: Removal by Reel Lay**
Safety	1	Project risk to personnel - Offshore				
	2	Project risk to other users of the sea				
	3	Project risk to personnel - Onshore				
	4	Potential of a high consequence even				
	5	Residual risk to other users of the sea				
Environment	6	Marine impact of operations				
	7	Energy, emissions, resource consumption				
	8	Impact of marine end points (legacy impact)				
Technical	9	Risk of major project failure				
	10	Technology demands / track record				
Societal	11	Commercial impact on fisheries				
	12	Socio-economic impact on communities and amenities				
Economic	13	Cost				
	14	Cost risk and uncertainty				
		Option Screened for Comparative Assessment Inclusion?	☑ Option 1	☑ Option 2	☑ Option 3	☑ Option 5

Figure 5-3 – Curlew D Traffic Light Screening Assessment Output

Note:

The two reds in Figure 5-3 were recorded for options 2 and 3 for impact to marine end points (sub-criteria 8). However, option 2 (smaller volume of rock would be required) has less environmental impact than option 3 in terms of localised change of habitat.

The red recorded for marine impact of operations (sub criteria 6) for option 5 is because the area of disturbance will be greater than during installation and operations.

5.5. Curlew Gas Export Pipeline (Group 4)

5.5.1. 0km (FPSO End) – 10km Section (Group 4a)

The Curlew Gas Export pipeline section from the KP 0.0 (FPSO) – KP 10.0 route length decommissioning option was provisionally selected during the initial screening workshop as this section of the pipeline is trenched and rock covered with a significant amount of rock. The pipeline is laid in a 1.8m deep trench and is generally covered by rock for the entire 10 km. As can be seen in the summary in section 8.6.

From the survey data 2 exposures were identified as shown in Figure 5-4.

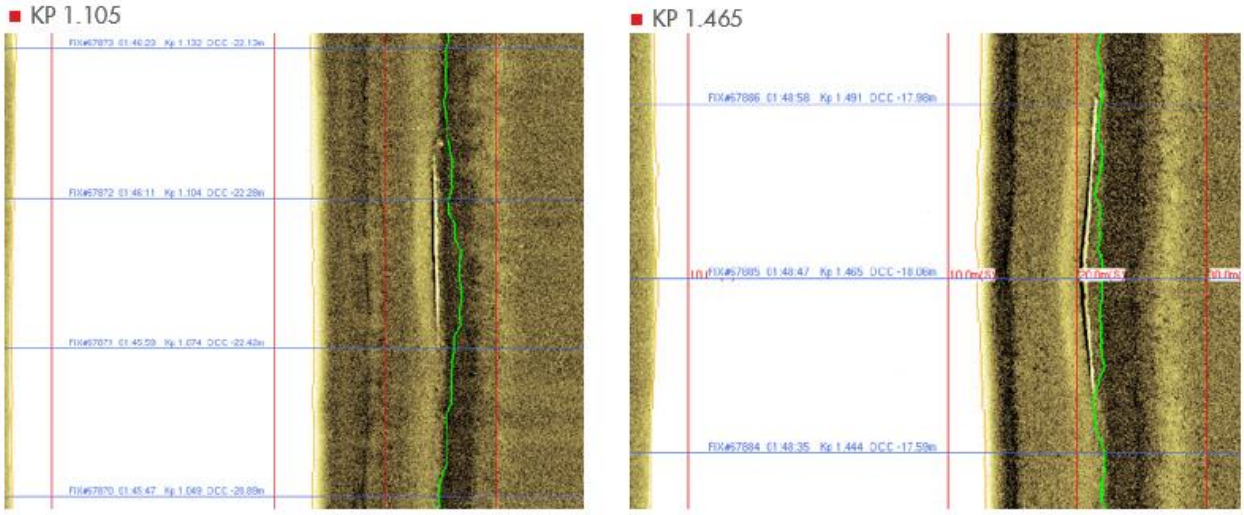


Figure 5-4 – Gas Export Pipeline Exposures close to FPSO

In-line with section 5.1 the initial feasible options for decommissioning were:

- Reverse Reel Lay;
- Cut and lift;
- Reverse S-lay;
- Leave in-situ (Do nothing);
- Leave in-situ (remediate with spot rock cover);
- Leave in-situ (remediate with partial cut and lift);
- Leave in-situ (remediate with blanket rock cover);
- Leave in-situ (Remediate by Re-trenching);
- Leave in-situ (Remediate by Collapsing trench wall);
- Leave in-situ (remediate by backfilling existing trench).

Given the pipeline was installed by reeling, reeling was selected as the most practical removal option and so the other removal options were de-selected.

In terms of remediation options, remediate by spot rock cover was selected as this section of the pipeline has a significant volume of rock cover so the other options were not considered to add any benefit above spot rock cover.

The proposed decommissioning option agreed at the CA was to leave the pipeline section in-situ with spot rock cover over the 2 identified exposures. A post decommissioning survey will be performed to further verify the burial depth of the pipeline. The overtrawl trial would be performed by the SFF to verify there are no snagging hazards along the pipeline section and it is left in a safe condition for other users of the sea.

During the comparative assessment workshop the proposed decommissioning option was presented to the stakeholders in the room. All the stakeholders agreed with the proposed decommissioning option.

5.5.2. 10km – 25.6km Section (Group 4b)

The Curlew Gas Export pipeline section from the KP 10.0 – KP 25.6 route length decommissioning options were considered during the initial screening workshop. The pipeline is laid in a 1.8m deep trench and is left to naturally backfill. As can be seen in the summary in section 8.6. Although the pipeline is greater than 0.6m below the mean seabed level, based upon the available survey data the pipeline, between KP10 and KP26, is covered and there are no exposure areas, however, the depth of cover is unknown and the fishermen are concerned that a deep trench without cover to mean seabed level could pose a hazard.

In-line with section 5.1 the initial feasible options for decommissioning were:

- Reverse Reel Lay;
- Cut and lift;
- Reverse S-lay;
- Leave in-situ (Do nothing);
- Leave in-situ (remediate with spot rock cover);
- Leave in-situ (remediate with partial cut and lift);
- Leave in-situ (remediate with blanket rock cover);
- Leave in-situ (Remediate by Re-trenching);
- Leave in-situ (Remediate by Collapsing trench wall);
- Leave in-situ (remediate by backfilling existing trench).

Given the pipeline was installed by reeling, reeling was selected as the most practical removal option and so the other removal options were de-selected.

As the pipelines is not protruding above the mean seabed level the leave in-situ with no remediation was considered a potentially feasible option that should be assessed during the CA workshop.

As can be seen in the burial summary in section 8.6 the pipeline has rock cover installed between the FPSO and KP 10.0, in addition spot rock cover is also installed at various locations between KP 10.0 and KP 25.6. Therefore remediation by spot rockcover was considered a feasible option for the comparative assessment workshop. In addition to spot rock cover, blanket rock cover was also considered a potential remediation option as the section between KP 0.0 and KP 10.0 is essentially blanket rock covered.

Partial cut and lift was then considered as another remediation option, however the partial cut and lift option was deselected as given the length of the pipeline and natural backfill design this option could create numerous

end points that could increase the snagging risk or would require significant volumes of rock cover to protect the ends.

Remediation by re-trenching was also considered, however retrenching was deselected as the current trench depth of 1.8m will prevent the trenching equipment getting access to further deepen the trench.

Remediation by backfilling the existing trench was considered, however the probability of success for this remediation option is low as the pipeline has been installed for 20 years and there is no guarantee that sufficient fill material will be available from the original soil berms created by the initial trenching process, as can be seen from the as-built records shown in Figure 5-5.

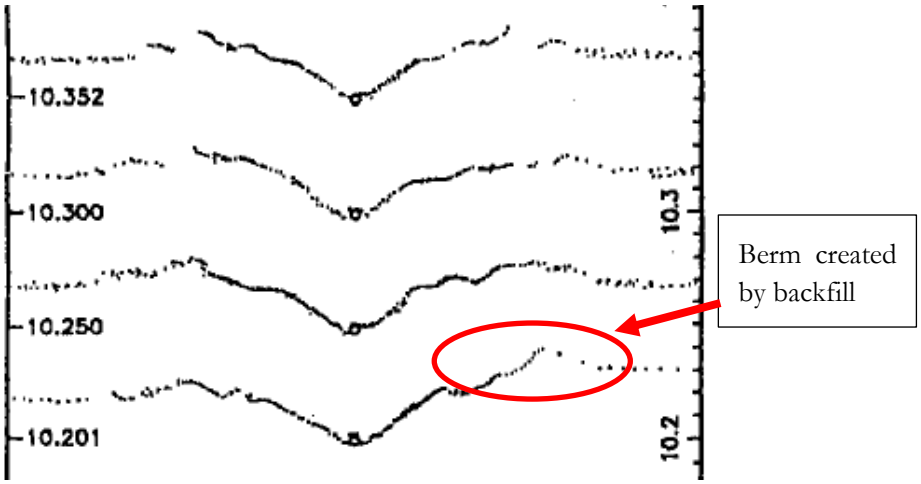


Figure 5-5 – Gas Export Pipeline As-Built Trench Profile

Another remediation option considered was to use a water lance or jet to collapse the existing trench and provide natural cover above the pipe, however this was deselected as the trench gradient is too shallow.

During the CA workshop the SFF presented a remediation option using gateways, which were included in the assessment. Gateways are created by the SFF by continuously trawling the pipeline, which "smoothes" out the seabed and distributes any natural fill over the pipeline. These gateways would be created at locations across the pipeline and create notified safe crossing zones for other users of the sea.

A traffic light screening assessment was performed (see Figure 5-6) to assess the different decommissioning options, whilst considering the stakeholders concerns. From the traffic light screening assessment the proposed decommissioning option is to leave the pipeline in-situ, however following flushing operations an as-left survey will be performed and then overtrawl trials will take place to verify that the pipeline is not a snagging hazard. If issues arise "gateways" will be created. One of the main reasons that gateway remediation by over trawling scored highly, was that it achieved safe passage for fishing trawlers at specific locations, by accelerating the design intent which was to let the seabed naturally in-fill the trench and return it to its natural state. Furthermore, it was understood that by use, over-time the width of these gates would naturally increase, expanding the locations of safe passage until ultimately the entire length would be identified as safe to cross.

In the event that the overtrawl trial fails Shell would agree the number and location of gateways with the SFF to provide a safe crossing zone over the pipeline.

Option Category			Leave In-Situ	Remediate		Remove	Other
Include Option for Screening?			☑ Option 1	☑ Option 2	☑ Option 3	☑ Option 5	☑ Option 8
Criteria	Ref	Sub Criteria	Option 1: Leave In-Situ (Do Nothing)	Option 2: Leave In-situ (Gateway)	Option 3: Leave In-situ (Remediate by Backfilling)	Option 5: Removal by Reel Lay	Option 8: Blanket rock dump (to 0.6 above TOP)* (with opportunity to remediate to BEIS in future)
Safety	1	Project risk to personnel - Offshore					
	2	Project risk to other users of the sea					
	3	Project risk to personnel - Onshore					
	4	Potential of a high consequence even					
	5	Residual risk to other users of the sea					
Environment	6	Marine impact of operations					
	7	Energy, emissions, resource consumption					
	8	Impact of marine end points (legacy impact)					
Technical	9	Risk of major project failure					
	10	Technology demands / track record					
Societal	11	Commercial impact on fisheries					
	12	Socio-economic impact on communities and amenities					
Economic	13	Cost					
	14	Cost risk and uncertainty					
Option Screened for Comparative Assessment Inclusion?			☑ Option 1	☑ Option 2	☑ Option 3	☑ Option 5	☐ Option 8

Figure 5-6 – Curlew Gas Export (10km – 25.6km) Traffic Light Screening Assessment Output

Note:

During the workshop the SFF indicated that their preference will always be for pipelines to be trenched and the seabed levelled and that trenching and backfilling is their preferred remediation option. The SFF also stated it's view that the majority of snagging incidents go unreported.

5.6. Pipeline and Umbilical Ends (NOT Protected by or in close proximity to rock) (Group 6)

The pipeline ends not protected by or in close proximity to rock was considered similar to the ends protected by rock, however as the rock is not present liquefying the seabed near to the adjacent pipe was considered to be a feasible option, in addition to the options raised in group 5, which would not require additional rock.

The traffic light screening assessment, shown in Figure 5-7, concluded that either option 2 (remediate with rock above mean seabed level) or option 5 (Lower pipeline end below seabed and cover with rock to mean seabed level were acceptable). The SFF raised a concern that option 2 could leave a number of rock berms protruding above the seabed, which could present potential snagging concerns. In addition, the SFF raised a concern that for option 3 the seabed could scour away and cause a snagging hazard, therefore this option was considered the least preferred option. To consider the snagging concerns from the SFF the stakeholders and project team agreed that option 5 would be selected.

The project team and the stakeholders agreed that the method of lowering the pipe below the seabed is a project decision, however the end should then be covered with rock to mean seabed level.

In all the above cases the ends will be subject to an overtrawl trial to ensure they are not a snagging hazard.

Option Category			Remediate		Remove
Include Option for Screening?			☑ Option 2	☑ Option 3	☑ Option 5
Criteria	**Ref**	**Sub Criteria**	**Option 2: Leave In-situ (Remediate with Rock Cover Above Seabed)**	**Option 3: Leave In-situ (Remediate by Dredging and Burial to acceptable depth)**	**Option 5: Remove: Cut at acceptable depth and lift, fill with rock to mean seabed level**
Safety	1	Project risk to personnel - Offshore			
	2	Project risk to other users of the sea			
	3	Project risk to personnel - Onshore			
	4	Potential of a high consequence even			
	5	Residual risk to other users of the sea			
Environment	6	Marine impact of operations			
	7	Energy, emissions, resource consumption			
	8	Impact of marine end points (legacy impact)			
Technical	9	Risk of major project failure			
	10	Technology demands / track record			
Societal	11	Commercial impact on fisheries			
	12	Socio-economic impact on communities and amenities			
Economic	13	Cost			
	14	Cost risk and uncertainty			
Option Screened for Comparative Assessment Inclusion?			☑ Option 2	☑ Option 3	☑ Option 5

Figure 5-7 – Pipeline/Umbilical End (NOT Protected by or in close proximity to rock) Traffic Light Screening Assessment Output

5.7. Pipeline and Umbilical Ends (Protected by or in close proximity to rock) (Group 5)

The Curlew pipeline end sections (protected by or in close proximity to rock) decommissioning options were considered during the initial screening workshop. From the workshop the following decommissioning options were identified to be assessed further during the CA:

- Remove (cut to acceptable depth and lift) and bury with rock to mean seabed level;
- Remove (cut at mean seabed level and lift) then cover with rock;
- Leave in-situ Dredge and buried to acceptable depth by liquifaction;
- Cut at seabed level then dredge remaining pipeline end;
- Leave in-situ Rock cover (Above mean seabed level);
- Leave in-situ;

During the workshop the project team and the stakeholders assessed the options and agreed that the leave in-situ with no remediation was not acceptable and so this option was removed from the assessment. The reason for removing the do-nothing option was that the SFF considered it to be a significant snagging risk and the SFF commented that mattresses also cause a snagging hazard.

To reduce the number of options, shown above, the options were simplified to the following:

- Leave in-situ Rock cover (Above mean seabed level);
- Cut and lift at acceptable depth below seabed and fill with rock to mean seabed level.

The traffic light screening assessment, shown in Figure 5-8, concluded that either option was acceptable. The SFF raised a concern that option 2 could leave a number of rock berms protruding above the seabed, which could present potential snagging concerns. In order to address the snagging risk raised by the SFF the stakeholders and project team agreed that option 5 would be selected with the following exceptions:

- Curlew C production pipeline will be disconnected and capped as agreed with BEIS due to potential wax deposits present in the pipeline. For this option it was agreed that the pipeline ends would be lowered below the seabed by a suitable means selected by the project team and then rock covered to mean seabed level.
- Curlew Gas export pipeline end at the FPSO is laid on the seabed, however the end is protected by rock. Therefore the pipeline will be cut and then the existing rock berm will be extended over the pipeline.

In all the above cases the ends will be subject to an overtrawl trial to ensure they are not a snagging hazard.

		Option Category	**Remediate**	**Remove**
		Include Option for Screening?	☑ Option 2	☑ Option 5
Criteria	**Ref**	**Sub Criteria**	**Option 2: Leave In-situ (Remediate with Rock Cover Above Seabed)**	**Option 5: Remove: Cut at acceptable depth and lift, fill with rock to mean seabed level**
Safety	1	Project risk to personnel - Offshore		
	2	Project risk to other users of the sea		
	3	Project risk to personnel - Onshore		
	4	Potential of a high consequence even		
	5	Residual risk to other users of the sea		
Environment	6	Marine impact of operations		
	7	Energy, emissions, resource consumption		
	8	Impact of marine end points (legacy impact)		
Technical	9	Risk of major project failure		
	10	Technology demands / track record		
Societal	11	Commercial impact on fisheries		
	12	Socio-economic impact on communities and amenities		
Economic	13	Cost		
	14	Cost risk and uncertainty		
		Option Screened for Comparative Assessment Inclusion?	☑ Option 2	☑ Option 5

Figure 5-8 – Pipeline/Umbilical End (Protected by or in close proximity to rock) Traffic Light Screening Assessment Output

5.8. Spools and Jumpers (In close proximity to rock) (Group 7)

Decommissioning options for the spools and jumpers were considered during the initial screening workshop. The decommissioning options identified are shown below:

- Leave in-situ, remove mattresses, dredge and buried to acceptable depth by liquefaction;
- Leave in-situ and Rock cover (Above mean seabed level);
- Leave in-situ (do nothing);
- Full Removal;

Although the base case for the project was to remove all mattresses and pipeline spools the project team wanted to test the requirement to remove concrete mattresses and the spools and jumpers. From the initial screening assessment the dredging option was de-selected as it was considered to be impractical as it would be a diver intensive dredging operation to lower the mattresses and spools below the seabed.

A traffic light screening assessment was performed, shown in Figure 5-9, to assess the different decommissioning options, whilst considering the stakeholders concerns. From the traffic light screening assessment the proposed decommissioning option is option 5, full removal (mattress, jumpers/spools, grout bags).

In all cases, where it is possible and safe to do so, all concrete mattresses will be recovered to shore for recycling or disposal. In the event that the mattresses cannot be recovered due to the integrity or extent of coverage with rock Shell will discuss with BEIS.

		Option Category	Leave In-Situ	Remediate	Remove
		Include Option for Screening?	☑ Option 1	☑ Option 2	☑ Option 5
Criteria	**Ref**	**Sub Criteria**	**Option 1: Leave In-Situ (Do Nothing)**	**Option 2: Leave In-situ (Remediate with Rock Cover Above Seabed)**	**Option 5: Full Removal**
Safety	1	Project risk to personnel - Offshore			
	2	Project risk to other users of the sea			
	3	Project risk to personnel - Onshore			
	4	Potential of a high consequence even			
	5	Residual risk to other users of the sea			
Environment	6	Marine impact of operations			
	7	Energy, emissions, resource consumption			
	8	Impact of marine end points (legacy impact)			
Technical	9	Risk of major project failure			
	10	Technology demands / track record			
Societal	11	Commercial impact on fisheries			
	12	Socio-economic impact on communities and amenities			
Economic	13	Cost			
	14	Cost risk and uncertainty			
		Option Screened for Comparative Assessment Inclusion?	☑ Option 1	☑ Option 2	☑ Option 5

Figure 5-9 – Spools and Jumpers (NOT Protected by or in close proximity to rock) Traffic Light Screening Assessment Output

5.9. Spools and Jumpers (NOT in close proximity to rock) (Group 8)

During the CA workshop the team agreed that this scope was not significantly different to group number 7, and therefore the same decommissioning method was chosen for group number 8, i.e. full removal of mattresses and spools.

5.10. Mooring Touchdown Trenches (Group 9)

The mooring chains and ancillaries (clump weights, chain attachments etc.) will be removed during decommissioning, however there will be significant trenches (approx. 100 m long, 4 m deep and 10 m wide) will be left behind at the touchdown location of each chain, hence there will be 3 sets of 3 trenches. The mooring touchdownn trenches were highlighted by the SFF during initial stakeholder engagements as a concern due to the close proximity of each trench to one another (approx. 25 metres centre to centre). Figure 5-10 and Figure 5-11 show a schematic and photo of the mooring trenches.

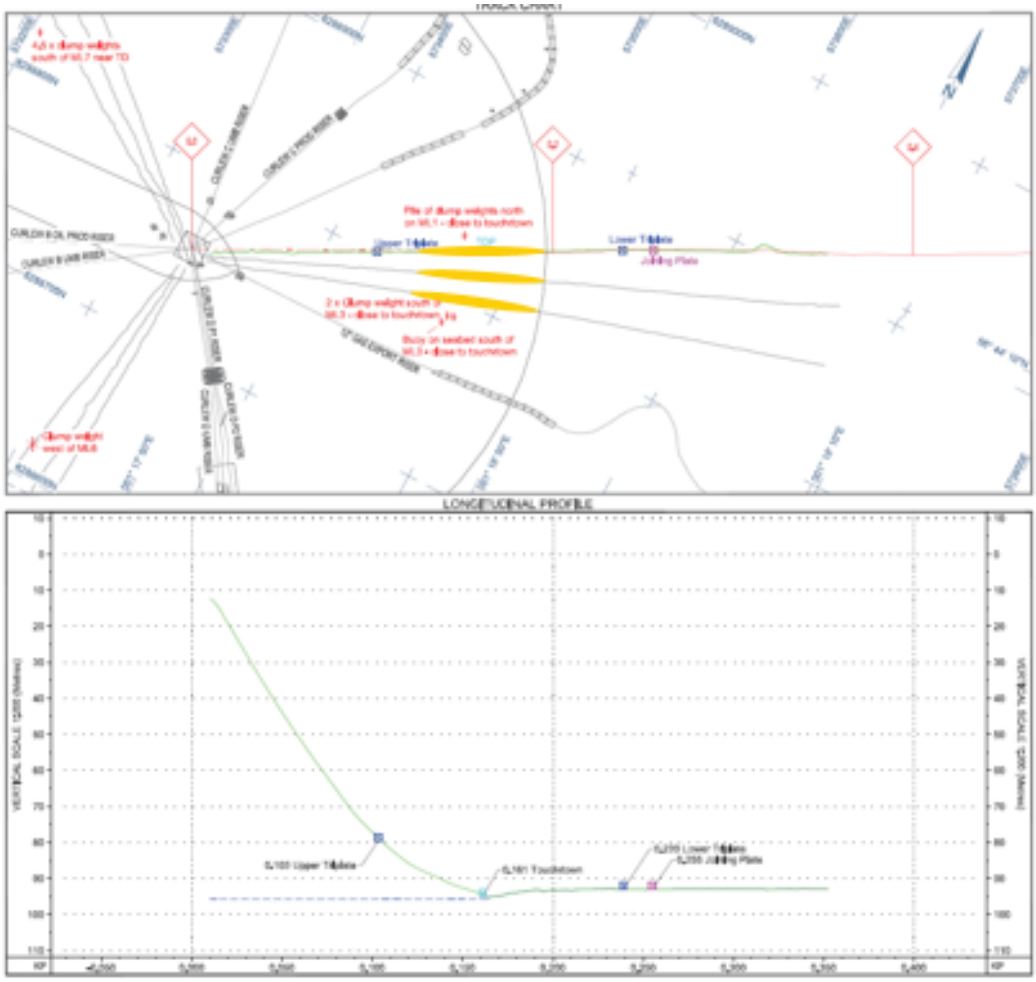


Figure 5-10 – Mooring Trench Schematic

Doc. no. CDP-PT-S-LA-3323-00005

Note: For scale each link is 6" in diameter.

Figure 5-11 – Typical Mooring Trench ROV Photo

The following decommissioning options were identified during the initial screening workshop:

- Leave in-situ – Chain mat over trawl;
- Rock fill trenches;
- Fill trenches with mattresses and top with rock;
- Mass flow excavation to smooth out trenches;
- Plough seabed.

During the initial screening workshop ploughing the seabed to remediate the trenches was de-selected as engagements with the market had raised concerns about the stability of the plough.

During a review of the decommissioning options with the project team and stakeholders at the CA workshop there was concerns raised about the effectiveness of using the chain mat over trawl to remediate the trenches given the depth of the trench. Considering this and in an attempt to reduce the required volume of rock, because of the OSPAR threatened and declining habitats for Sea pen and burrowing megafauna communities, an additional option was added. This option was to fill the trenches with rock in steps, initially to only 0.5m below mean seabed level, and perform the chain mat overtrawl survey until the SFF were satisfied that the trench was remediated to a safe level to prevent snagging. This would then allow the trench to naturally fill with sediment over time and cover the rock.

From the traffic light screening assessment (see Figure 5-12) option 1 (fill trenches with rock to below the mean seabed level and perform overtrawl with a chain mat to verify the trench is safe) was selected as the best performing option. The team in the room at the CA workshop acknowledged that option 1 may transform into option 2 (fill trenches with rock to mean seabed level), however the team felt that it was worth pursuing in attempt to reduce rock volume requirements, which will provide environmental and cost benefits. By not filling the trenches to mean seabed level it may allow the top of the trench, above the rock, to naturally back fill, which would allow soft burrowing muds to return, in time, to its natural state.

Option Category			Leave In-Situ	Remediate		
Include Option for Screening?			☑ Option 1	☑ Option 2	☑ Option 3	☑ Option 4
Criteria	**Ref**	**Sub Criteria**	**Option 1: Remediate by rockfilling trenches to acceptable level below MSL and chain matting**	**Option 2: Remediate by Rockfilling Trenches TO TOP**	**Option 3: Fill Trenches with Mattresses and Top with Rock**	**Option 4: Mass Flow Excavation to Smooth Out Trench**
Safety	1	Project risk to personnel - Offshore				
	2	Project risk to other users of the sea				
	3	Project risk to personnel - Onshore				
	4	Potential of a high consequence even				
	5	Residual risk to other users of the sea				
Environment	6	Marine impact of operations				
	7	Energy, emissions, resource consumption				
	8	Impact of marine end points (legacy impact)				
Technical	9	Risk of major project failure				
	10	Technology demands / track record				
Societal	11	Commercial impact on fisheries				
	12	Socio-economic impact on communities and amenities				
Economic	13	Cost				
	14	Cost risk and uncertainty				
Option Screened for Comparative Assessment Inclusion?			☑ Option 1	☑ Option 2	☑ Option 3	☑ Option 4

Figure 5-12 – Mooring Touchdown Trenches Traffic Light Screening Assessment Output

5.11. Mooring Suction Anchor Piles (Group 10)

The base case for the Curlew Suction anchor piles is to remove them, however experience with other operators has shown that issues can arise during the removal process due to soil conditions or pile integrity. To plan for this possibility, Shell have included remediation options in the comparative assessment where a pile cannot be removed.

From the initial screening workshop the following decommissioning options were identified:

- Full Removal (base case decommissioning option selected, below options are contingencies);
- Leave in-situ (Do nothing);
- Leave in-situ and rock cover;
- Partial Removal (cut pile down to safe depth) and excavate chain end to acceptable depth, cut remaining chain end, then bury using rock fill.
- Partial Removal (cut pile down to safe depth) and cut chain end at mean seabed level then leave in-situ.
- Partial Removal (cut pile down to safe depth) and cut chain end at mean seabed level then rock cover.
- Partial Removal (cut pile down to safe depth) and cut chain end at mean seabed level then dredge below mean seabed level.

As full removal is the base case this has been removed from the assessment. In addition the initial screening workshop concluded that a do-nothing option was not acceptable due to the risk of snagging and the risk to other users of the sea.

During the CA in order to simplify the feasible decommissioning option the team decided to treat the cut chain end in the same manner as a pipeline end, hence some of the options with alternative chain end treatment were removed. In addition a cut at mean seabed level and cover with rock was also considered as a feasible option and was added to the traffic light screening process, due to the significant amount of rock required for some of

the other options. For a full description of the suction anchor pile decommissioning options assessed during the workshop see section 4.2.2.

The traffic light screening assessment concluded that option 3 was the preferred option. The main reason for this is around the volume of rock required to protected the suction anchor cut ends, due to the 1:3 ratio requirement. Sub criteria 6 and 9 all score a red traffic light due to the level of disturbance, presence of threatened/ declining habitat and introduction of rock, however these impacts associated with option 3 were of the smallest magnitude. Option 3 resulted in the least rock required to protect the pile from snagging and hence was considered the preferred option in the event that the pile cannot be removed.

		Option Category	Leave In-Situ	Remediate	
		Include Option for Screening?	☑ Option 1	☑ Option 2	☑ Option 3
Criteria	Ref	Sub Criteria	Option 1: Leave In-Situ and rock dump	Option 2: Leave in-situ, cut to acceptable depth and rock dump to MSL	Option 3: Leave in situ, cut flush to MSL and rock dump
Safety	1	Project risk to personnel - Offshore			
	2	Project risk to other users of the sea			
	3	Project risk to personnel - Onshore			
	4	Potential of a high consequence even			
	5	Residual risk to other users of the sea			
Environment	6	Marine impact of operations			
	7	Energy, emissions, resource consumption			
	8	Impact of marine end points (legacy impact)			
Technical	9	Risk of major project failure			
	10	Technology demands / track record			
Societal	11	Commercial impact on fisheries			
	12	Socio-economic impact on communities and amenities			
Economic	13	Cost			
	14	Cost risk and uncertainty			
		Option Screened for Comparative Assessment Inclusion?	☑ Option 1	☑ Option 2	☑ Option 3

Figure 5-13 – Suction Anchor Piles Traffic Light Screening Assessment Output

Note:

The team concluded that if the pile cannot be removed and the contingency decommissioning option is required then the chain end connected to the pile should be treat in a similar manner to a pipeline end (group 6).

6. References

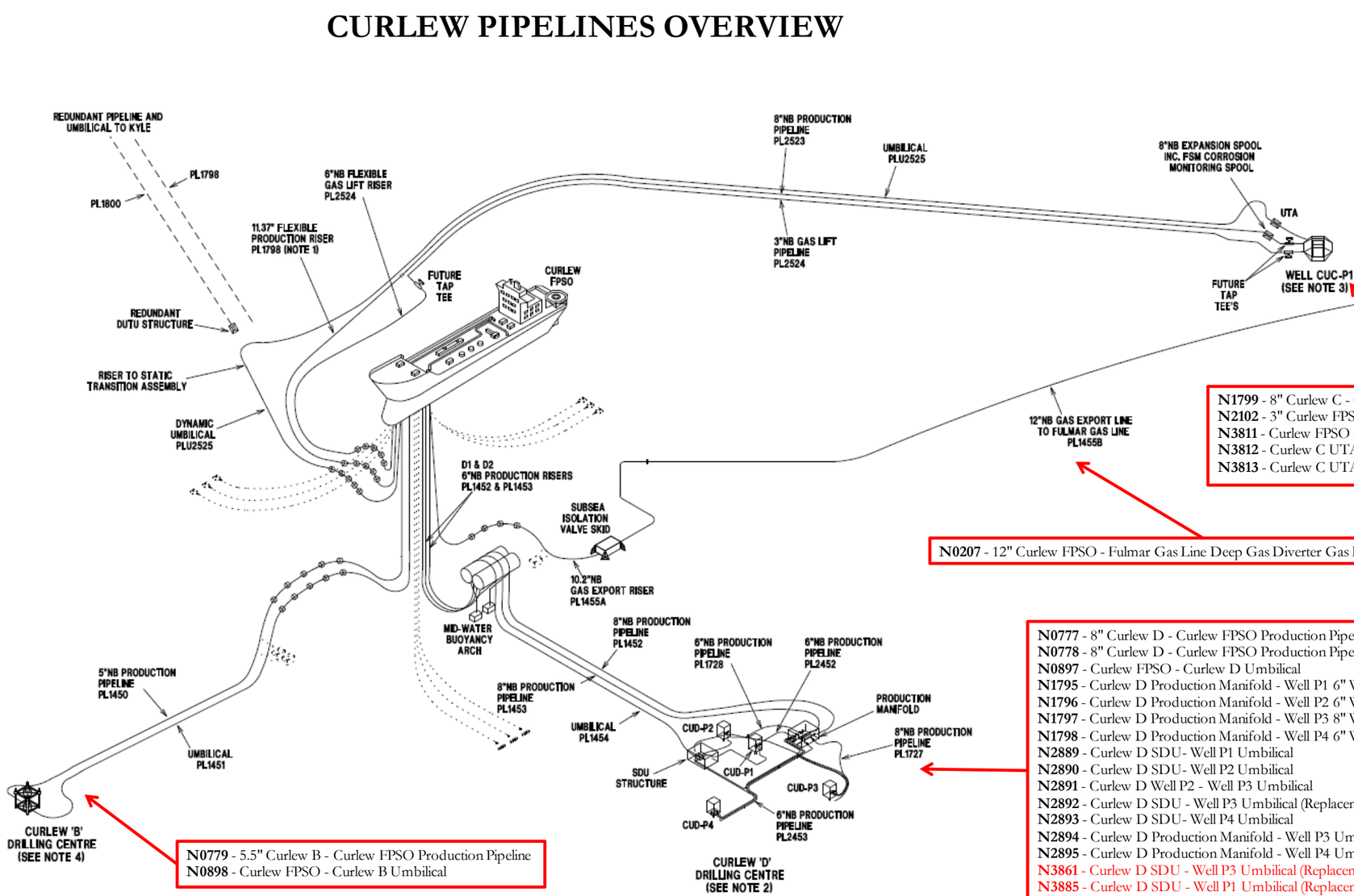
[1] OGUK, "DECC Guidance Notes for Petroleum Act 1998".

[2] Oil and Gas UK, "Guidelines for Comparative Assessment in Decommissioning Programmes," 2015.

7. Appendix A: Inventory Summary

The sections highlighted in yellow are not subject to the comparative assessment process. The sections highlighted in yellow will be removed, apart from the gas export pigging skid, which will be retained for future tie-ins.

7.1. Curlew Subsea Field Summary



7.2. Curlew Gas Export Inventory

PL Number	Name	Nominal Diameter (inch)	External Diameter (mm)	Nom. Wall Thickness (mm)	Internal Diameter (mm)	Length (m)	Size / Weight	Description of component parts	Insulation / Corrosion Coating	Product Conveyed	End Points (From)	End Points (To)	Burial/ Trenching Status	Pipeline contents following cleaning	Decommissioning Status	PWA Reference	Drawing Reference
Main Gas Export Pipeline (Risers, Pipelines, Structures and Spools)																	
PL1455A	Curlew - FGL (DG Diverter) - 12" Gas Export Riser	10	370.7	N/A	259.1	486.75	220kg/m	Flexible riser with end fittings. Bouyancy modules, clump weights, anodes, bend stiffeners etc.	Plastic Sheath	Dense Phase Hydrocarbon Gas	FPSO Turret	Gas Export SSIV Skid Piping	N/A	Seawater	To be decommissioned	Curlew 1997-05-16_-_18-W-97_-_PWA	N/A
PL1455B	Gas Export SSIV Structure	N/A	N/A	N/A	N/A	N/A	44.3 Te (exc. Lid)	Carbon Steel Piping, Flanges, Nuts, Bolts. Isolation Valves, Cathodic Protection (Alluminium) Protection Structure (Carbon Steel)	Painted	Dense Phase Hydrocarbon Gas	N/A	N/A	N/A	N/A	To be decommissioned	Curlew 1997-05-16_-_2-W-97_-_PWA	62697-P-301
PL1455B	Gas Export Pipeline to SSIV Skid 12" Spool 2	12	323.9	15.9	292.1	19.5	5000 kg	Carbon Steel Line Pipe, Flanges, Nuts and Bolts Alluminium Anode (42kg)	Durapol 0.4mm	Dense Phase Hydrocarbon Gas	Gas Export SSIV Skid Piping	12" Gas Export Pipeline	Spools protected by mats	Seawater	To be decommissioned	Curlew 1997-05-16_-_2-W-97_-_PWA with variation 97/V/15	CURE-25-ISL-54713-3001-01
PL1455B	Gas Export Pipeline to SSIV Skid 12" Spool 3	12	323.9	15.9	292.1	26.9	5360 kg	Carbon Steel Line Pipe, Flanges, Nuts and Bolts Alluminium Anode (42kg)	Durapol 0.4mm	Dense Phase Hydrocarbon Gas	Gas Export SSIV Skid Piping	12" Gas Export Pipeline	Spools protected by mats	Seawater	To be decommissioned	Curlew 1997-05-16_-_2-W-97_-_PWA with variation 97/V/16	CURE-25-ISL-54713-3001-01
PL1455B	Gas Export Pipeline to SSIV Skid 12" Spool 4	12	323.9	15.9	292.1	20	5150 kg	Carbon Steel Line Pipe, Flanges, Nuts and Bolts Alluminium Anode (42kg)	Durapol 0.4mm	Dense Phase Hydrocarbon Gas	Gas Export SSIV Skid Piping	12" Gas Export Pipeline	Spools protected by mats	Seawater	To be decommissioned	Curlew 1997-05-16_-_2-W-97_-_PWA with variation 97/V/17	CURE-25-ISL-54713-3001-01
PL1455B	Gas Export Pipeline to SSIV Skid 12" Spool 5	12	323.9	15.9	292.1	20	5150 kg	Carbon Steel Line Pipe, Flanges, Nuts and Bolts Alluminium Anode (42kg)	Durapol 0.4mm	Dense Phase Hydrocarbon Gas	Gas Export SSIV Skid Piping	12" Gas Export Pipeline	Spools protected by mats	Seawater	To be decommissioned	Curlew 1997-05-16_-_2-W-97_-_PWA with variation 97/V/18	CURE-25-ISL-54713-3001-01
PL1455B	Gas Export Pipeline to SSIV Skid 12" Spool 6	12	323.9	15.9	292.1	19.5	5260 kg	Carbon Steel Line Pipe, Flanges, Nuts and Bolts Alluminium Anode (42kg)	Durapol 0.4mm	Dense Phase Hydrocarbon Gas	Gas Export SSIV Skid Piping	12" Gas Export Pipeline	Spools protected by mats	Seawater	To be decommissioned	Curlew 1997-05-16_-_2-W-97_-_PWA with variation 97/V/19	CURE-25-ISL-54713-3001-01
PL1455B	Curlew - FGL (DG Diverter) - 12" Gas Export Pipeline	12	323.9	14.3	295.3	25748.2	Line Pipe: 2811 Te Alluminium Anodes (7.3 Te)	Carbon Steel Line Pipe, Flanges, Nuts and Bolts Alluminium Anode (44kg) every 13 joints.	3-layer polypropylene corrosion coating	Dense Phase Hydrocarbon Gas	Gas Export SSIV Skid Tie-in Spool	Pigging Skid Tie-in Spool	Trenched to a variable depth between 1.1m and 1.8m and covered with remedial rock dump along the majority of the route	Seawater	To be decommissioned	Curlew 1997-05-16_-_2-W-97_-_PWA	CUR-MAS-SU-66100-001
PL1455B	Pigging Skid to Gas Export Pipeline 12" Spool 1	12	323.9	14.3	295.3	30.694	3848 kg	Carbon Steel Line Pipe, Flanges, Nuts and Bolts	3-layer polypropylene corrosion coating	Dense Phase Hydrocarbon Gas	12" Gas Export Pipeline	Pigging Skid Piping	Spools protected by grout bags, mats and rock dump	Seawater	To be decommissioned	Curlew 1997-05-16_-_2-W-97_-_PWA	62697-P-702-001
PL1455B	Pigging Skid to Gas Export Pipeline 12" Spool 2	12	323.9	14.3	295.3	23	3054 kg	Carbon Steel Line Pipe, Flanges, Nuts and Bolts	3-layer polypropylene corrosion coating	Dense Phase Hydrocarbon Gas	12" Gas Export Pipeline	Pigging Skid Piping	Spools protected by grout bags, mats and rock dump	Seawater	To be decommissioned	Curlew 1997-05-16_-_2-W-97_-_PWA	62697-P-702-005
PL1455B	Pigging Skid to Gas Export Pipeline 12" Spool 3	12	323.9	14.3	295.3	50	6084 kg	Carbon Steel Line Pipe, Flanges, Nuts and Bolts Alluminium Anode (44kg)	3-layer polypropylene corrosion coating	Dense Phase Hydrocarbon Gas	12" Gas Export Pipeline	Pigging Skid Piping	Spools protected by grout bags, mats and rock dump	Seawater	To be decommissioned	Curlew 1997-05-16_-_2-W-97_-_PWA	62697-P-702-002
PL1455B	Pigging Skid to Gas Export Pipeline 12" Spool 4	12	323.9	14.3	295.3	50	6002 kg	Carbon Steel Line Pipe, Flanges, Nuts and Bolts	3-layer polypropylene corrosion coating	Dense Phase Hydrocarbon Gas	12" Gas Export Pipeline	Pigging Skid Piping	Spools protected by grout bags, mats and rock dump	Seawater	To be decommissioned	Curlew 1997-05-16_-_2-W-97_-_PWA	62697-P-702-003
PL1455B	Pigging Skid to Gas Export Pipeline 12" Spool 5	12	323.9	14.3	295.3	30	3873 kg	Carbon Steel Line Pipe, Flanges, Nuts and Bolts Alluminium Anode (44kg)	3-layer polypropylene corrosion coating	Dense Phase Hydrocarbon Gas	12" Gas Export Pipeline	Pigging Skid Piping	Spools protected by grout bags, mats and rock dump	Seawater	To be decommissioned	Curlew 1997-05-16_-_2-W-97_-_PWA	62697-P-702-004
PL1455B	Gas Export Pigging Skid Structure	N/A	N/A	N/A	N/A	N/A	8m (L) x 5.5m (W) 35 Te in Air	Carbon Steel Piping, Flanges, Nuts, Bolts. Isolation Valves, Cathodic Protection (Alluminium) Protection Structure (Carbon Steel)	Painted	Dense Phase Hydrocarbon Gas	N/A	N/A	N/A	N/A	Pigging skid to be left in place for future use.	Curlew 1997-05-16_-_2-W-97_-_PWA	62697-P-001
PL1455B	Pigging Skid to Deep Gas Diverter 10" Spool 1	10	273.1	12.7	247.7	30.131	2877 kg	Carbon Steel Line Pipe, Flanges, Nuts and Bolts 1 x Alluminium Bracelet Anode (44kg)	3-layer polypropylene corrosion coating	Dense Phase Hydrocarbon Gas	Pigging Skid Piping	Deep Gas Diverter Piping	Spools protected by grout bags, mats and rock dump	N/A	Spool piece to be left in place for future use of pigging skid.	Curlew 1997-05-16_-_2-W-97_-_PWA	62697-P-701-001
PL1455B	Pigging Skid to Deep Gas Diverter 10" Spool 2	10	273.1	12.7	247.7	25.183	2454 kg	Carbon Steel Line Pipe, Flanges, Nuts and Bolts	3-layer polypropylene corrosion coating	Dense Phase Hydrocarbon Gas	Pigging Skid Piping	Deep Gas Diverter Piping	Spools protected by grout bags, mats and rock dump	N/A	Spool piece to be left in place for future use of pigging skid.	Curlew 1997-05-16_-_2-W-97_-_PWA	62697-P-701-002
PL1455B	Pigging Skid to Deep Gas Diverter 2" Spool 3 (Drain Spool) (connected to Spool 1)	2	60.3	5.5	49.3	1.345	108 kg	Carbon Steel Line Pipe, Flanges, Nuts and Bolts. 2" DBB valve.	3-layer polypropylene corrosion coating	Dense Phase Hydrocarbon Gas	Pigging Skid Spool 1	N/A (Drain point)	Spools protected by grout bags, mats and rock dump	N/A	Spool piece to be left in place for future use of pigging skid.	Curlew 1997-05-16_-_2-W-97_-_PWA	62697-P-701-003
PL1455B	Pigging Skid to Deep Gas Diverter 2" Spool 3 (Drain Spool) (connected to Spool 1)	2	60.3	5.5	49.3	0.995	106 kg	Carbon Steel Line Pipe, Flanges, Nuts and Bolts. 2" DBB valve.	3-layer polypropylene corrosion coating	Dense Phase Hydrocarbon Gas	Pigging Skid Spool 2	N/A (Drain point)	Spools protected by grout bags, mats and rock dump	N/A	Spool piece to be left in place for future use of pigging skid.	Curlew 1997-05-16_-_2-W-97_-_PWA	62697-P-701-004
N/A	Deep Gas Diverter Structure (Limits of Curlew Infrastructure)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

7.3. Curlew B Inventory

PL Number	Name	Nominal Diameter (inch)	External Diameter (mm)	Nom. Wall Thickness (mm)	Internal Diameter (mm)	Length (m)	Size / Weight	Description of component parts	Insulation / Corrosion Coating	Product Conveyed	End Points (From)	End Points (To)	Burial / Trenching Status	Pipeline contents following cleaning	Decommissioning Status	PWA Reference	Drawing Reference
Production Pipeline (Risers, Pipelines, Tree and Spools)																	
PL1450	Curlew B Production Riser	5.5	221.6	N/A	127	303.5	104kg/m (Approx. 32 Te)	Flexible riser with end fittings. Bouyancy modules, clump weights, anodes, bend stiffeners etc.	Plastic Sheath (Rilsan)	Multi-phase Production	FPSO Turret	5.5" Production Pipeline	N/A	Seawater	To be decommissioned	Curlew 1997-05-16_-_18-W-97_-_PWA	CUR-MAS-SU-66993
PL1450	Curlew - Curlew B 5.5" Oil	5.5	195.4	18	139.7	2238	60kg/m (Approx. 135 Te)	Flexible flowline with end fittings.	Plastic Sheath	Multi-phase Production	Curlew B Production Riser	CUB-P1 Well	Trenched to 1.6m and buried to 0.6m/0.8m.	Seawater	To be decommissioned	Curlew 1997-05-16_-_18-W-97_-_PWA	CUR-MAS-SU-66993
N/A	CUB-P1 Well	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Multi-phase Production	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Controls Umbilical (Dynamic Umbilical, Umbilical, Tree, and Jumpers)																	
PLU2525	Curlew B Dynamic Umbilical	N/A	161.52	N/A	N/A	300	69kg/m (Approx. 21 Te)	Dynamic Umbilical with end fittings. Bouyancy modules, clump weights, anodes, bend stiffeners etc.	Plastic Sheath	Chemical, Hydraulics, Electrical Power, Signal	FPSO Turret	Static Controls Umbilical	N/A	Seawater	To be decommissioned	Curlew 1997-05-16_-_18-W-97_-_PWA	CUR-MAS-SU-66993
PLU2525	Curlew - Curlew B Umbilical	N/A	91.3	N/A	N/A	2260	15kg/m (Approx. 34 Te)	Static Umbilical with end fittings	Plastic Sheath	Chemical, Hydraulics, Electrical Power, Signal	Dynamic Umbilical	Curlew B Well (CUB-P1)	Trenched to 0.6m depth.	Seawater	To be decommissioned	Curlew 1997-05-16_-_18-W-97_-_PWA	CUR-MAS-SU-66993
N/A	CUB-P1 Well	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

7.4. Curlew C Inventory

PL Number	Name	Nominal Diameter (inch)	External Diameter (mm)	Nom. Wall Thickness (mm)	Internal Diameter (mm)	Length (m)	Size / Weight	Description of component parts	Insulation / Corrosion Coating	Product Conveyed	End Points (From)	End Points (To)	Burial/ Trenching Status	Pipeline contents following cleaning	Decommissioning Status	PWA Reference	Drawing Reference
Production Pipeline (Risers, Pipelines, Tree and Spools)																	
PL1798B	Curlew C Production Riser (Ex-Kyle)	11.37	405	N/A	288.9	340.6	312kg/m	Flexible riser with end fittings. Bouyancy modules, clump weights, anodes, bend stiffeners etc.	Plastic Sheath (Rilsan)	Multi-phase Production	FPSO Turret	8" Production Pipeline Spool	N/A	Seawater	To be decommissioned	10-V-07 Variation to PWA 15/W/00	WK-UK009111-001
PL2523	Curlew C Production Pipeline to Production Riser Spool	8	219.1	18	201.1	1.496	Approx 0.25 Te	Carbon Steel Line Pipe, Reducer, Flanges, Nuts and Bolts	5 Layer PP Foam Coating (54.3 mm)	Multi-phase Production	Curlew C Production Riser	Curlew C Production Pipeline	Protected by concrete mats	Seawater	To be decommissioned	2008-04-10_-_2-W-08	WK-UK009111-001
PL2523	Curlew - Curlew C 8" Oil	8	219.1	18	201.1	5670.08	Line Pipe: 265 Te Alluminium Anodes (708 kg)	Carbon Steel Line Pipe, Flanges, Nuts and Bolts Alluminium Anode (44kg) every 13 joints.	5 Layer PP Foam Coating (54.3 mm)	Multi-phase Production	FPSO Pipeline Tie-in Spool	CUC-P1 Well Tie-in Spool 1	Trenched to a target of 1.8m and Blanket Rockdumped (Cover 0.6m - 0.7m) Spot Rockdumped to 1.1m in places	Seawater	To be decommissioned	2008-04-10_-_2-W-08	WK-UK009111-001
PL2523	8" Well Spool 1 (from Pipeline Tie-in to Corrosion Monitoring Spool)	8	219.1	18	201.1	26.43	Approx 2 Te	Carbon Steel Line Pipe, Flanges, Nuts and Bolts	Syntactic PU (41mm)	Multi-phase Production	Production Pipeline End	Corrosion Monitoring Spool	Protected by concrete mats	Seawater	To be decommissioned	2008-04-10_-_2-W-08	WK-UK009111-1340
PL2523	Corrosion Monitoring Spool	8	219.1	N/A	183.1	5.5	Approx 1 Te	Carbon Steel FSM Spool	Durapol	Multi-phase Production	8" Well Spool 1	8" Well Spool 3	Protected by concrete mats	Seawater	To be decommissioned	2008-04-10_-_2-W-08	WK-UK009111-1340
PL2523	8" Well Spool 3 (from Corrosion Monitoring Spool to Tree)	8	219.1	27	165.1	16.45	Approx 3 Te	Super Duplex Line Pipe, Flanges, Nuts and Bolts	Syntactic PU (41mm)	Multi-phase Production	Corrosion Monitoring Spool	CUC-P1 Well	Protected by concrete mats	Seawater	To be decommissioned	2008-04-10_-_2-W-08	WK-UK009111-1340
N/A	CUC-P1 Well	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Multi-phase Production	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Gas Lift Pipeline (Risers, Pipelines, Tree and Spools)																	
PL2524	Curlew C Gas Lift Riser	6	245.8	N/A	152.4	388.7	61kg/m	Flexible riser with end fittings. Bouyancy modules, clump weights, anodes, bend stiffeners etc.	Plastic Sheath (PA11)	Dense Phase Hydrocarbon Gas	FPSO Turret	3" Gas Lift Pipeline Spool	N/A	Seawater	To be decommissioned	2008-04-10_-_2-W-08	WK-UK009111-001
PL2524	Curlew C Gas Lift Pipeline to Gas Lift Riser Spool	3	88.9	7.1	74.7	7.99	Approx 0.1 Te	Carbon Steel Line Pipe, Reducer, Flanges, Nuts and Bolts	3-layer polypropylene corrosion coating	Dense Phase Hydrocarbon Gas	Curlew C Gas Lift Riser	Curlew C Gas Lift Pipeline	Protected by concrete mats	Seawater	To be decommissioned	2008-04-10_-_2-W-08	WK-UK009111-001
PL2524	Curlew - Curlew C 3" Gas Lift Pipeline	3	88.9	7.1	74.7	5927.05	Line Pipe: 85 Te	Carbon Steel Line Pipe, Flanges, Nuts and Bolts	3-layer polypropylene corrosion coating	Dense Phase Hydrocarbon Gas	FPSO Pipeline Gas Lift Tie-in Spool	CUC-P1 Well Gas Lift Tie-in Spool 1	Trenched to a target of 1.8m and Blanket Rockdumped (Cover 0.6m - 0.7m) Spot Rockdumped to 1.1m in places (Piggybacked to production pipeline)	Seawater	To be decommissioned	2008-04-10_-_2-W-08	WK-UK009111-001
PL2524	3" Gas Lift Well Spool 1 (from Pipeline Tie-in to Gas lift tie-in on well)	3	88.9	7.1	74.7	26.664	Approx 0.5 Te	Carbon Steel Line Pipe, Flanges, Nuts and Bolts	3-layer polypropylene corrosion coating	Dense Phase Hydrocarbon Gas	Gas lift pipeline end	CUC-P1 Well Gas Lift Tie-in Spool 2	Protected by concrete mats	Seawater	To be decommissioned	2008-04-10_-_2-W-08	WK-UK009111-1340
PL2524	3" Gas Lift Well Spool 2 (from Pipeline Tie-in to Gas lift tie-in on well)	3	88.9	7.1	74.7	23.693	Approx 0.5 Te	Carbon Steel Line Pipe, Flanges, Nuts and Bolts	3-layer polypropylene corrosion coating	Dense Phase Hydrocarbon Gas	CUC-P1 Well Gas Lift Tie-in Spool 1	CUC-P1 Well	Protected by concrete mats	Seawater	To be decommissioned	2008-04-10_-_2-W-08	WK-UK009111-1340
N/A	CUC-P1 Well (Gas Lift)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Dense Phase Hydrocarbon Gas	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Controls Umbilical (Dynamic Umbilical, Umbilical, Tree, and Jumpers)																	
PLU2525	Curlew C Dynamic Umbilical	N/A	190.2	N/A	N/A	290	77kg/m	Dynamic Umbilical with end fittings. Bouyancy modules, clump weights, anodes, bend stiffeners etc.	Plastic Sheath	Chemical, Hydraulics, Electrical Power, Signal	FPSO Turret	Static Controls Umbilical	N/A	Seawater	To be decommissioned	2008-04-10_-_2-W-08	WK-UK009111-001
PLU2525	Curlew - Curlew C UTA Umbilical	N/A	154.8	N/A	N/A	5862	30kg/m	Static Umbilical with end fittings	Plastic Sheath	Chemical, Hydraulics, Electrical Power, Signal	Dynamic Umbilical	Curlew C Umbilical UTA	Trenched to a target of 1.8m and Blanket Rockdumped (Cover 0.6m - 0.7m) Spot Rockdumped to 1.1m in places (In same trench as production pipeline)	Seawater	To be decommissioned	2008-04-10_-_2-W-08	WK-UK009111-001
PLU2525	Curlew C Well Controls Jumper	N/A	N/A	N/A	N/A	50	30kg/m	Static Jumper with end fittings	Plastic Sheath	Chemical, Hydraulics, Electrical Power, Signal	Curlew C Umbilical UTA	CUC-P1 Well	Protected by concrete mats	Seawater	To be decommissioned	2008-04-10_-_2-W-08	WK-UK009111-1340
N/A	CUC-P1 Well	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

7.5. Curlew D Inventory

PL Number	Name	Nominal Diameter (inch)	External Diameter (mm)	Nom. Wall Thickness (mm)	Internal Diameter (mm)	Length (m)	Size / Weight	Description of component parts	Insulation / Corrosion Coating	Product Conveyed	End Points (From)	End Points (To)	Burial/ Trenching Status	Pipeline contents following cleaning	Decommissioning Status	PWA Reference	Drawing Reference
Production Pipeline 1 (Risers, Pipelines, Tree and Spools)																	
PL1452	Curlew D Production Riser 1	6	245.8	N/A	152.4	309.1	105.6kg/m	Flexible riser with end fittings. Bouyancy modules, clump weights, anodes, bend stiffeners etc.	Plastic Sheath (PA11)	Multi-phase Production	FPSO Turret	8" Production Pipeline	N/A	Seawater	To be decommissioned	Curlew 1997-05-16_-_18-W-97_-_PWA	CURD-SH-0009
PL1452	Curlew D 8" Oil Production Pipeline 1	8	297.2	N/A	209.6	2 x 813	150.3kg/m (Approx. 489 Te)	Flexible flowline with end fittings.	Plastic Sheath	Multi-phase Production	Curlew D Production Riser 1	Curlew D Manifold East Prod. Header	Trenched to 1.6m/1.8m and buried to 0.6m/0.8m.	Seawater	To be decommissioned	Curlew 1997-05-16_-_18-W-97_-_PWA	CURD-SH-0009
N/A	Curlew D Manifold	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Multi-phase Production	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Production Pipeline 2 (Risers, Pipelines, Tree and Spools)																	
PL1453	Curlew D Production Riser 2	6	245.8	N/A	152.4	276.1	105.6kg/m (Approx. 30 Te)	Flexible riser with end fittings. (Installed over MWA), clump weights, anodes, bend stiffeners etc.	Plastic Sheath (PA11)	Multi-phase Production	FPSO Turret	8" Production Pipeline	N/A	Seawater	To be decommissioned	Curlew 1997-05-16_-_18-W-97_-_PWA	CURD-SH-0009
PL1453	Curlew D 8" Oil Production Pipeline 2	8	297.2	N/A	209.6	2 x 813	150.3kg/m (Approx. 489 Te)	Flexible flowline with end fittings.	Plastic Sheath	Multi-phase Production	Curlew D Production Riser 2	Curlew D Manifold West Prod. Header	Trenched to 1.6m/1.8m and buried to 0.6m/0.8m.	Seawater	To be decommissioned	Curlew 1997-05-16_-_18-W-97_-_PWA	CURD-SH-0009
N/A	Curlew D Manifold	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Multi-phase Production	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Controls Umbilical (Dynamic Umbilical, Umbilical, Tree, and Jumpers)																	
PL1454	Curlew D Dynamic Umbilical	N/A	161.52	N/A	N/A	300	69kg/m	Dynamic Umbilical with end fittings. (Installed over MWA), clump weights, anodes, bend stiffeners etc.	Plastic Sheath	Chemical, Hydraulics, Electrical Power, Signal	FPSO Turret	Static Controls Umbilical	N/A	Seawater	To be decommissioned	Curlew 1997-05-16_-_18-W-97_-_PWA	CURD-SH-0009
PL1454	Curlew - Curlew D Umbilical	N/A	91.3	N/A	N/A	1650	20.4kg/m (Approx. 34 Te)	Static Umbilical with end fittings	Plastic Sheath	Chemical, Hydraulics, Electrical Power, Signal	Static Umbilical	Curlew D SDU	Trenched to 1.6m/1.8m and buried to 0.6m/0.8m.	Seawater	To be decommissioned	Curlew 1997-05-16_-_18-W-97_-_PWA	CURD-SH-0009
N/A	CUB-P1 Well	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

PL Number	Name	Nominal Diameter (inch)	External Diameter (mm)	Nom. Wall Thickness (mm)	Internal Diameter (mm)	Length (m)	Size / Weight	Description of component parts	Insulation / Corrosion Coating	Product Conveyed	End Points (From)	End Points (To)	Burial / Trenching Status	Pipeline contents following cleaning	Decommissioning Status	PWA Reference	Drawing Reference
Tie-in Spools / Jumpers																	
PL2452	Curlew D Production Manifold - Well P1 6" Wet Gas - Drop Down Spool	6	168.3	14.3	139.7	8	Approx 0.5 Te	Duplex Line Pipe, Flanges, Nuts and Bolts	SPU	Multi-phase Production	CUD Well P1 Tree	Flexible Jumper	Protected by concrete mats	Seawater	To be decommissioned	2007-05-09-33-V-07 Variation to PWA 2/W/00	CURD-25-SH-0001
PL2452	Curlew D Production Manifold - Well P1 6" Wet Gas - Flexible Jumper	6	240.6	N/A	152.4	25	126.6 kg/m (Approx 3.2 Te)	Flexible jumper with end fittings	MDPE	Multi-phase Production	CUD Well P1 Drop Down Spool	Curlew D Production Manifold	Protected by concrete mats	Seawater	To be decommissioned	2007-05-09-33-V-07 Variation to PWA 2/W/00	CURD-25-SH-0001
PL1728	Curlew D Production Manifold - Well P2 6" Wet Gas - Drop Down Spool	6	168.3	14.3	139.7	18	Approx 1 Te	Duplex Line Pipe, Flanges, Nuts and Bolts	SPU	Multi-phase Production	CUD Well P2 Tree	Flexible Jumper	Protected by concrete mats	Seawater	To be decommissioned	2007-05-09-33-V-07 Variation to PWA 2/W/00	CURD-25-SH-0001
PL1728	Curlew D Production Manifold - Well P2 6" Wet Gas - Flexible Jumper	6	236.8	N/A	152.4	25	160.4 kg/m (Approx 21 Te)	Flexible jumper with end fittings	Rilsan	Multi-phase Production	CUD Well P2 Drop Down Spool	Curlew D Production Manifold	Protected by concrete mats	Seawater	To be decommissioned	2007-05-09-33-V-07 Variation to PWA 2/W/00	CURD-25-SH-0001
PL1727	Curlew D Production Manifold - Well P3 8" Wet Gas - Flexible Jumper	8	309.2	N/A	203.2	130	160.4 kg/m (Approx 21 Te)	Flexible jumper with end fittings	Rilsan	Multi-phase Production	CUD Well P3 Tree	Curlew D Production Manifold	Protected by concrete mats	Seawater	To be decommissioned	2007-05-09-33-V-07 Variation to PWA 2/W/00	CURD-25-SH-0001
PL2453	Curlew D Production Manifold - Well P4 6" Wet Gas - Drop Down Spool	6	168.3	14.3	139.7	23	Approx 1.5 Te	Duplex Line Pipe, Flanges, Nuts and Bolts	SPU	Multi-phase Production	CUD Well P4 Tree	Flexible Jumper	Protected by concrete mats	Seawater	To be decommissioned	2007-05-09-33-V-07 Variation to PWA 2/W/00	CURD-25-SH-0001
PL2453	Curlew D Production Manifold - Well P4 6" Wet Gas - Flexible Jumper	6	240.6	N/A	152.4	60	126.6 kg/m (Approx 13 Te)	Flexible jumper with end fittings	MDPE	Multi-phase Production	CUD Well P4 Drop Down Spool	Curlew D Production Manifold Drop Down Spool	Protected by concrete mats	Seawater	To be decommissioned	2007-05-09-33-V-07 Variation to PWA 2/W/00	CURD-25-SH-0001
PL2453	Curlew D Production Manifold - Well P4 6" Wet Gas - Drop Down Spool	6	168.3	14.3	139.7	27	Approx 1.5 Te	Duplex Line Pipe, Flanges, Nuts and Bolts	SPU	Multi-phase Production	Flexible Jumper	Curlew D Production Manifold	Protected by concrete mats	Seawater	To be decommissioned	2007-05-09-33-V-07 Variation to PWA 2/W/00	CURD-25-SH-0001
PL1454	Curlew D SDU - Well P1 Umbilical	N/A	N/A	N/A	N/A	30	Approx 1Te	Static Umbilical Jumper with end fittings	Plastic Sheath	Chemical, Hydraulics, Electrical Power, Signal	Curlew D SDU	Curlew D P1 Tree	Protected by concrete mats	Seawater	To be decommissioned	Curlew 1997-05-16_-_18-W-97_-_PWA	CURD-25-SH-0002
PL1454	Curlew D SDU - Well P2 Umbilical	N/A	N/A	N/A	N/A	30	Approx 1Te	Static Umbilical Jumper with end fittings	Plastic Sheath	Chemical, Hydraulics, Electrical Power, Signal	Curlew D SDU	Curlew D P2 Tree	Protected by concrete mats	Seawater	To be decommissioned	Curlew 1997-05-16_-_18-W-97_-_PWA	CURD-25-SH-0002
PL1726	Curlew D Well P2 - Well P3 Umbilical	N/A	132	N/A	N/A	219.3	Approx 6Te	Static Umbilical Jumper with end fittings	Plastic Sheath	Chemical, Hydraulics, Electrical Power, Signal	Curlew D P2 Tree	Curlew D P3 Tree	Protected by concrete mats	Seawater	To be decommissioned	Curlew 2000-03-01_-_2-W-00_-_PWA	CURD-25-SH-0002
PLU2455	Curlew D SDU - Well P3 Umbilical	N/A		N/A	N/A	180	Approx 6Te	Static Umbilical Jumper with end fittings	Plastic Sheath	Chemical, Hydraulics, Electrical Power, Signal	Curlew D SDU	Curlew D P3 Tree	Protected by concrete mats	Seawater	To be decommissioned	2007-05-09-33-V-07 Variation to PWA 2/W/00	CURD-25-SH-0002
PLU2454	Curlew D SDU - Well P4 Umbilical	N/A		N/A	N/A	95	Approx 4Te	Static Umbilical Jumper with end fittings	Plastic Sheath	Chemical, Hydraulics, Electrical Power, Signal	Curlew D SDU	Curlew D P4 Tree	Protected by concrete mats	Seawater	To be decommissioned	2007-05-09-33-V-07 Variation to PWA 2/W/00	CURD-25-SH-0002
PLU2455	Curlew D Production Manifold - Well P3 Umbilical	N/A		N/A	N/A	109	Approx 5Te	Static Umbilical Jumper with end fittings	Plastic Sheath	Chemical, Hydraulics, Electrical Power, Signal	Curlew D Production Manifold	Curlew D P3 Umbilical	Protected by concrete mats	Seawater	To be decommissioned	2007-05-09-33-V-07 Variation to PWA 2/W/00	CURD-25-SH-0002
PLU2454	Curlew D Production Manifold - Well P4 Umbilical	N/A		N/A	N/A	95	Approx 4Te	Static Umbilical Jumper with end fittings	Plastic Sheath	Chemical, Hydraulics, Electrical Power, Signal	Curlew D Production Manifold	Curlew D P4 Umbilical	Protected by concrete mats	Seawater	To be decommissioned	2007-05-09-33-V-07 Variation to PWA 2/W/00	CURD-25-SH-0002
PLU2455	Curlew D SDU - Well P3 Umbilical (Replacement 2)	N/A		N/A	N/A	162	Approx 6Te	Static Umbilical Jumper with end fittings	Plastic Sheath	Chemical, Hydraulics, Electrical Power, Signal	Curlew D SDU	Curlew D P3 Umbilical	Protected by concrete mats	Seawater	To be decommissioned	2007-05-09-33-V-07 Variation to PWA 2/W/00	CURD-25-SH-0002
PL1454	Curlew D SDU - Well P1 Umbilical (Replacement)	N/A	N/A	N/A	N/A	30	Approx 1Te	Static Umbilical Jumper with end fittings	Plastic Sheath	Chemical, Hydraulics, Electrical Power, Signal	Curlew D SDU	Curlew D P1 Tree	Protected by concrete mats	Seawater	To be decommissioned	2007-05-09-33-V-07 Variation to PWA 2/W/00	CURD-25-SH-0002
PLU2454	Curlew D SDU - Well P4 Umbilical (Replacement)	N/A		N/A	N/A	116	Approx 5Te	Static Umbilical Jumper with end fittings	Plastic Sheath	Chemical, Hydraulics, Electrical Power, Signal	Curlew D SDU	Curlew D P4 Tree	Protected by concrete mats	Seawater	To be decommissioned	2007-05-09-33-V-07 Variation to PWA 2/W/00	CURD-25-SH-0002

8. Appendix B: Pipeline and Umbilical Burial Depth Summary

8.1. General

The burial depth of the pipelines and umbilicals is important information when considering leaving pipelines or umbilicals in-situ or removal. The as-built data and alignment sheets for the Curlew pipelines and umbilicals has been assessed and the operational survey data has been assessed to determine the pipeline and umbilical burial depth. The following sections present the burial depth for the Curlew pipelines and umbilicals.

8.2. Pipeline Burial Depth Definition

The definitions of burial depth that are being reported, generally there are two definitions for burial depth; depth of lowering and depth of cover, which are both illustrated in the figure below. The depth of cover is the conventional definition of burial depth, which is the depth of backfill or rock on top of the pipeline or umbilical. The depth of lowering is the depth of the top of the pipeline or umbilical below the natural mean seabed level. The natural mean seabed level is ignoring any berms to the sides of the trench.

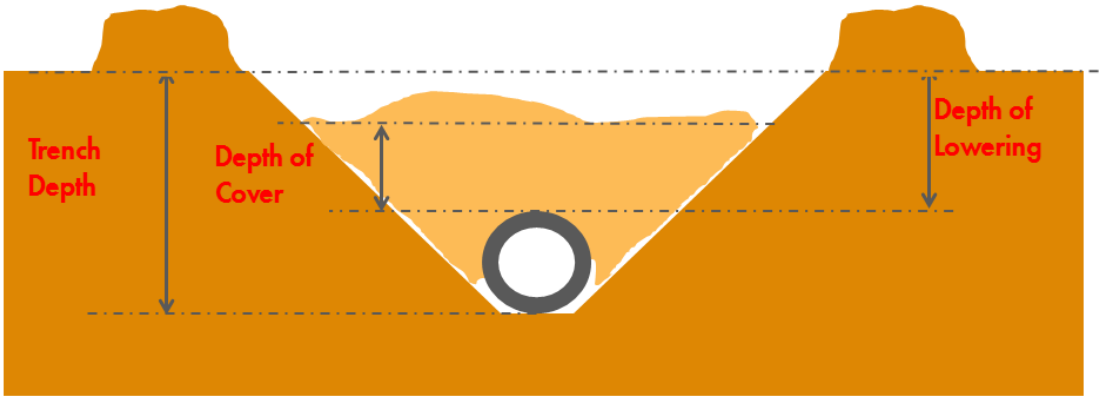


Figure 8-1 – Burial depth definition

8.3. Curlew B Pipelines and Umbilicals

8.3.1. Curlew B 5.5" Oil Production Pipeline (OGA ref: PL1450)

The below figures show the Curlew B production pipeline burial depth from recent survey data. As can be seen the depth of cover is generally greater than 0.6m with only localised sections of pipeline less than 0.6m. The survey data shown is from 2011, 2013 and 2014, as can be seen the cover depth is generally increasing. In addition the depth of lowering shown in Figure 8-3 shows that the depth of lowering (depth below seabed) is much greater then 0.6m for the 2014 survey data. The depth of lowering also shows that all the pipeline is below the mean seabed level (excluding the pipeline ends), with only local sections buried less than 0.6m, up to a depth of 0.4m.

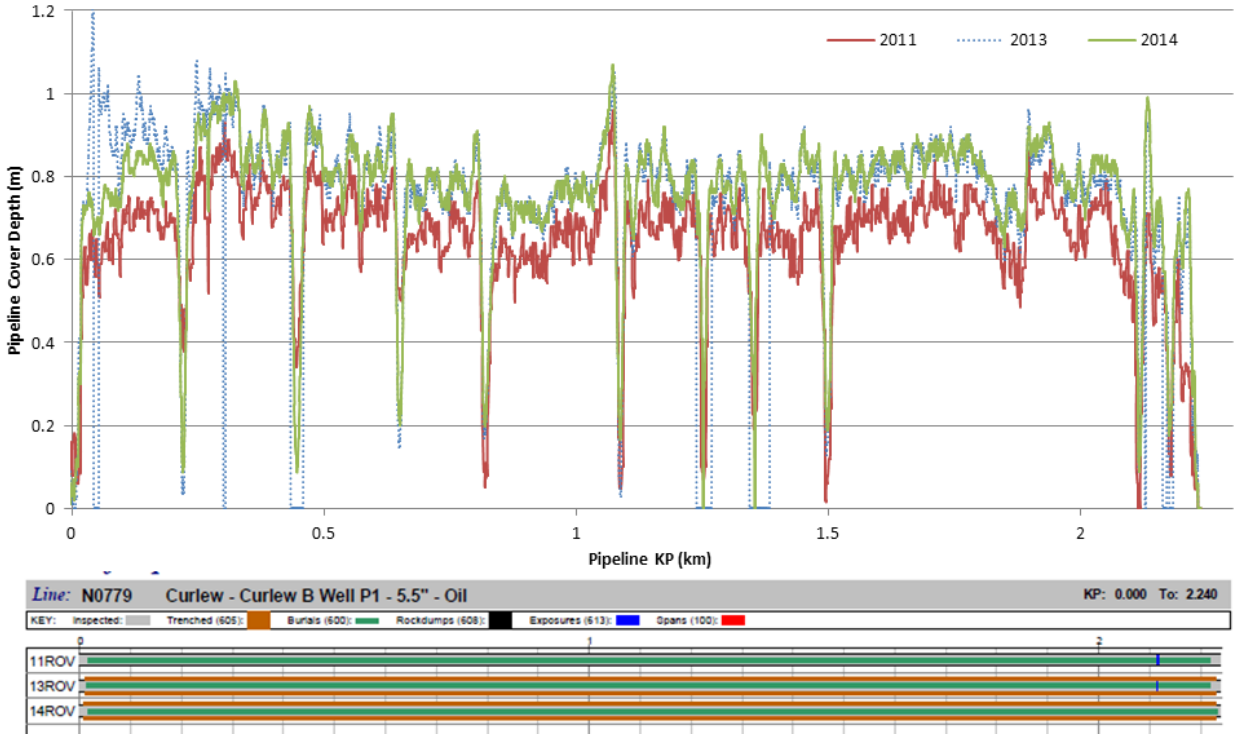


Figure 8-2 – Curlew B Production Pipeline Cover Depth Survey Data

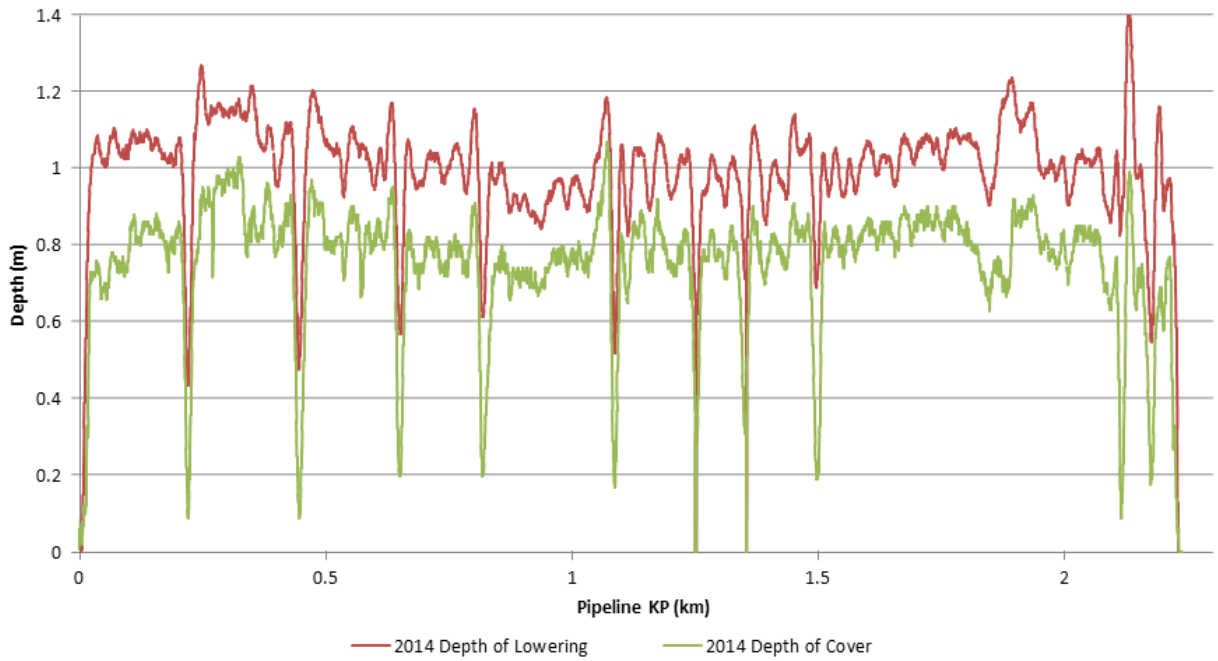


Figure 8-3 – Curlew B Production Pipeline Cover Depth vs. Depth of Lowering

8.3.2. Curlew B Umbilical (OGA ref: PL1451)

The below figures show the Curlew B umbilical burial depth from recent survey data. As can be seen the depth of cover is generally between 0.4m and 0.6m with only localised sections of umbilical less than 0.4m. The survey data shown is from 2011, 2013 and 2014, as can be seen the cover depth is generally increasing. There is little difference between the depth of lowering and the cover depth, which can most likely be attributed to the umbilical being jet trenched and not placed in a trenched and backfilled.

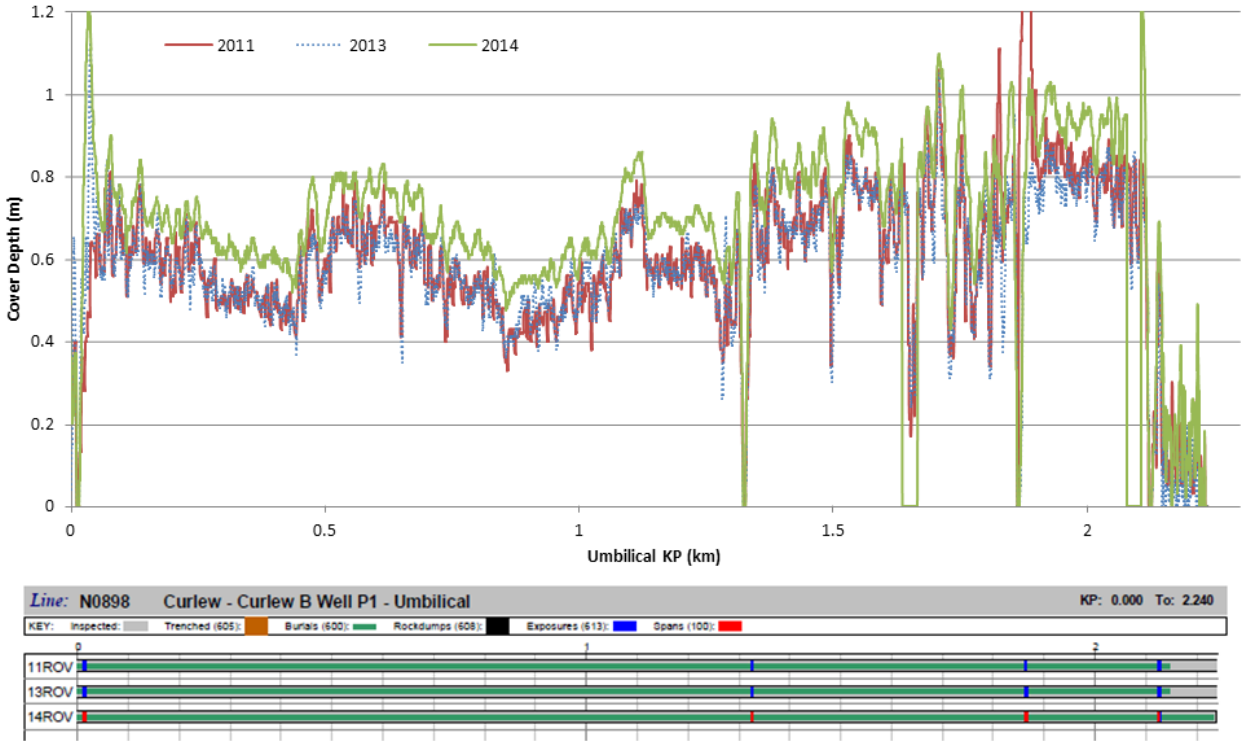


Figure 8-4 – Curlew B Umbilical Cover Depth Survey Data

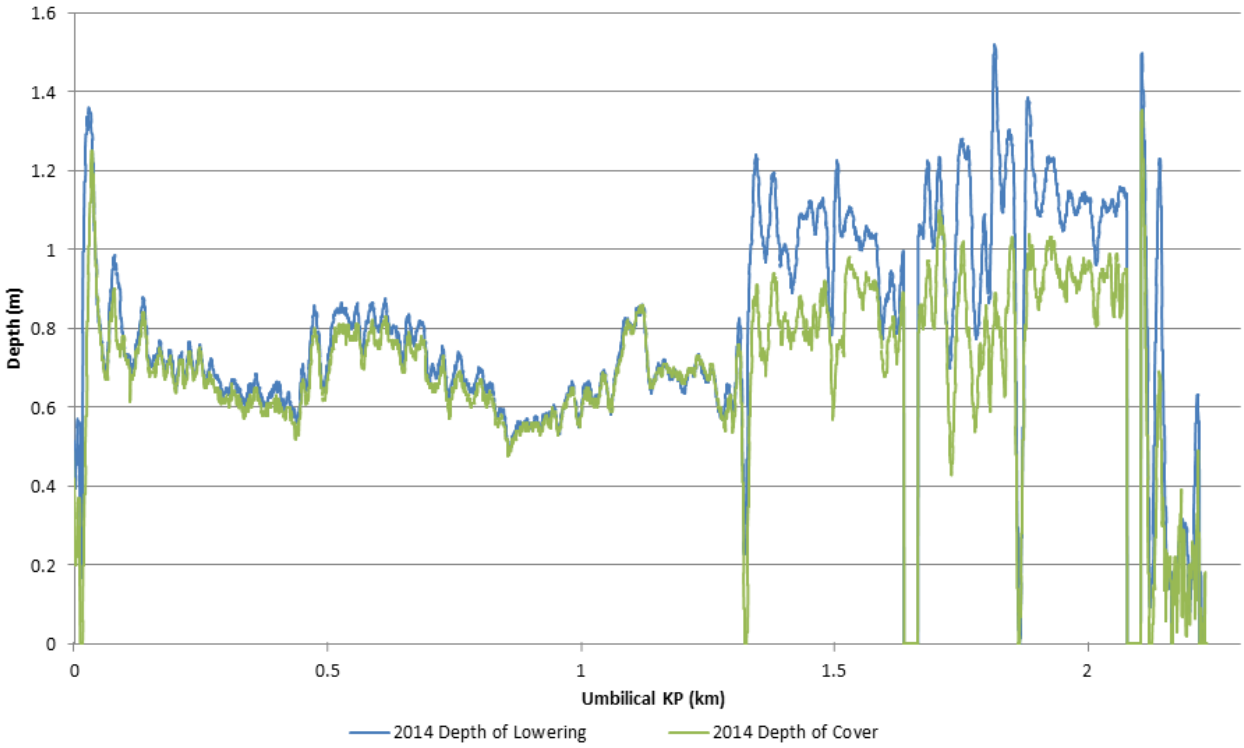


Figure 8-5 – Curlew B Umbilical Cover Depth vs. Depth of Lowering

8.4. Curlew C Pipelines (OGA ref: PL2523 & PL2524) and Umbilical (OGA ref: PLU2525)

The Curlew C pipelines and umbilicals are all installed in the same trench with the gas lift pipeline piggybacked to the production pipeline. The Curlew C pipelines and umbilicals were installed in a 1.8m trench and then a minimum of 0.6m of blanket rock cover was installed to top of pipe. As can be seen in the figure below the majority of the pipeline is covered by at least 0.6m. In addition Figure 8-7 shows that the depth of lowering is much greater than 0.6m. The spike at KP 3.75 is considered to be an anomaly as the SONAR images (see Figure 8-8) shows that the pipelines or umbilical are not exposed.

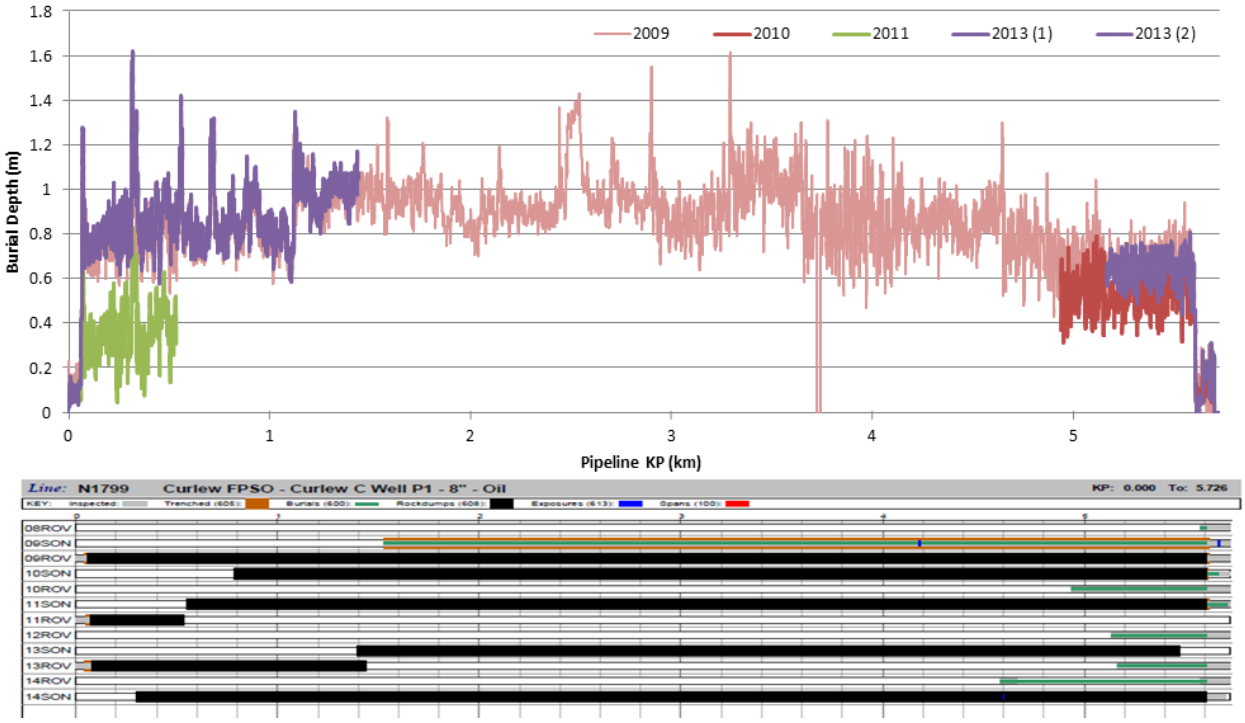


Figure 8-6 – Curlew C Production Pipeline Cover Depth Survey Data (includes gas lift and umbilical)

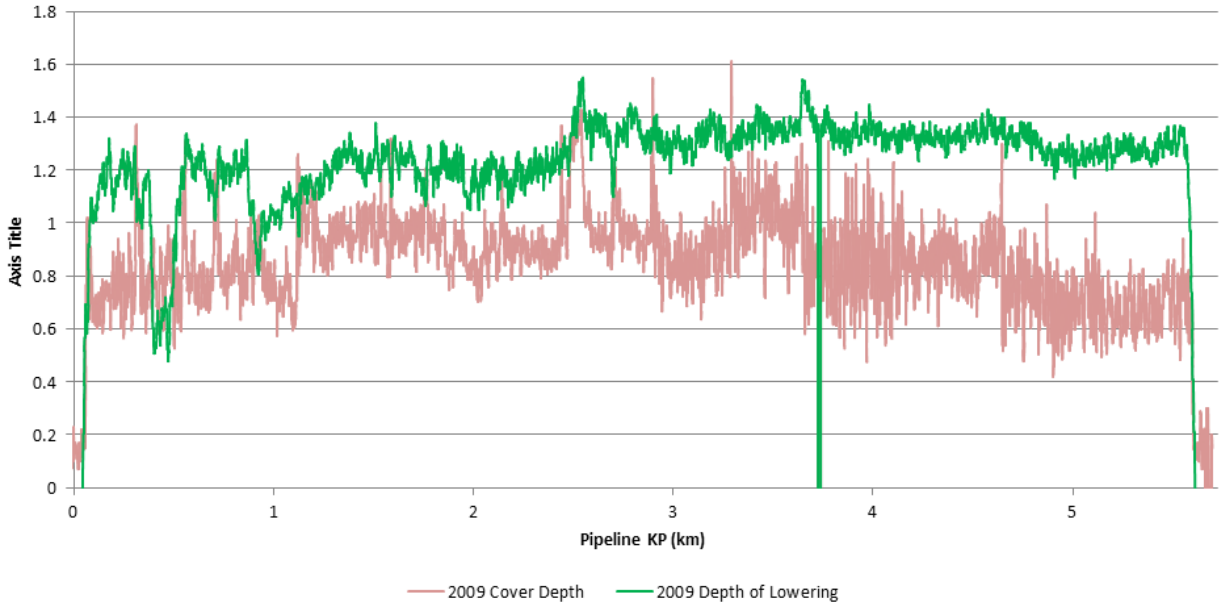


Figure 8-7 – Curlew C Production Pipeline Cover Depth vs. Depth of Lowering (includes gas lift and umbilical)

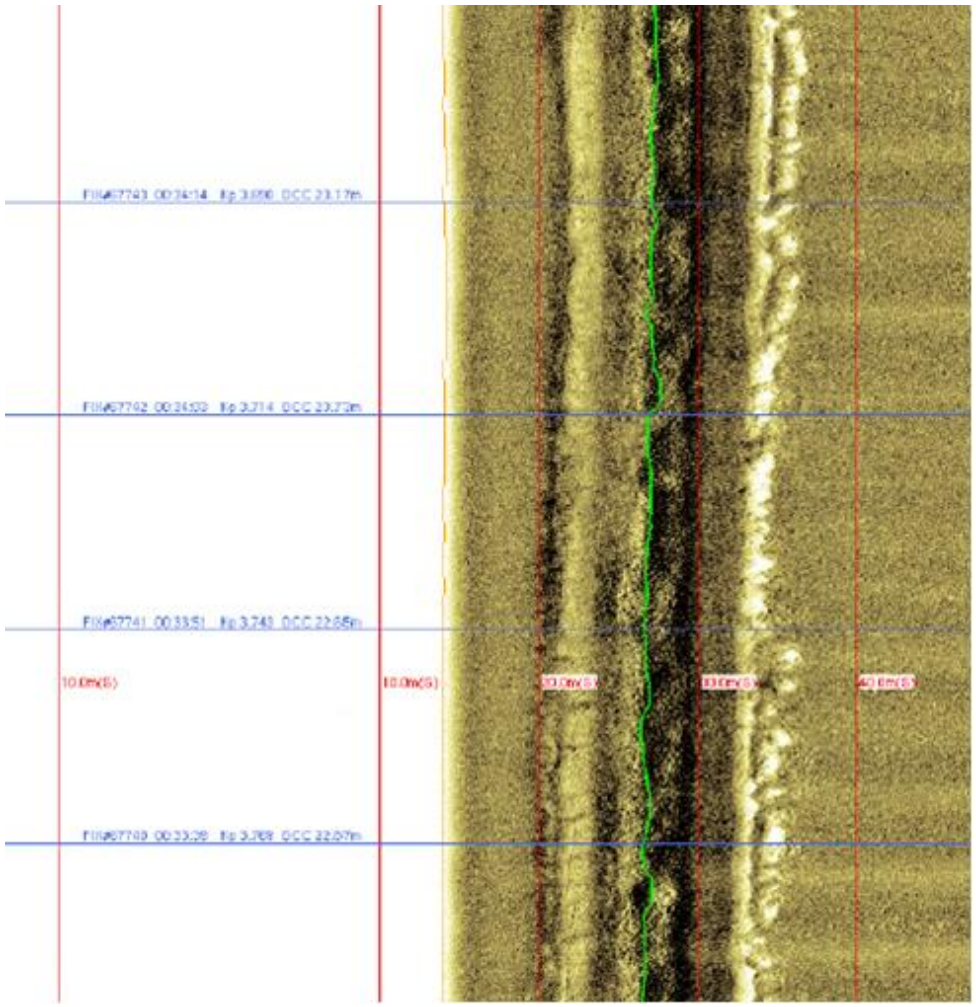


Figure 8-8 – SONAR image of anomaly at KP 3.75

8.5. Curlew D Pipelines and Umbilicals

8.5.1. Curlew D Wet Gas Production Pipeline (OGA ref: PL1452)

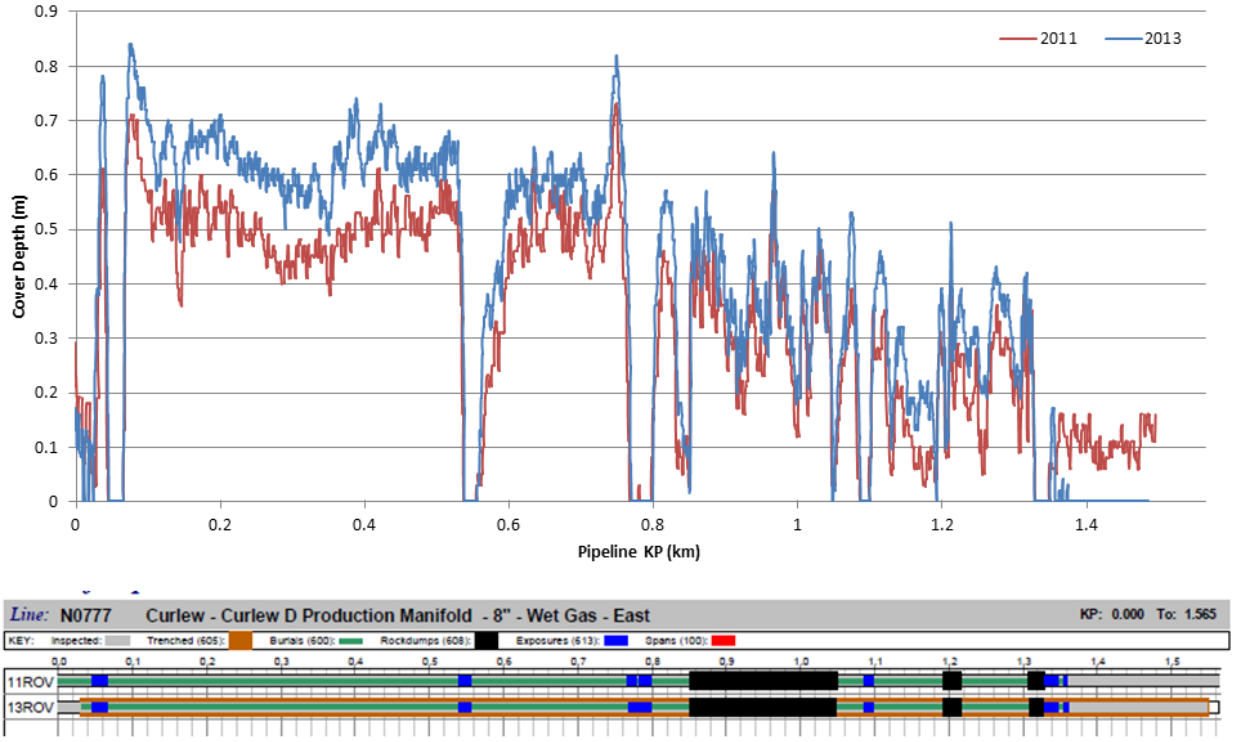


Figure 8-9 – Curlew D Wet Gas Production Pipeline Cover Depth Survey Data (OGA ref: PL1452)

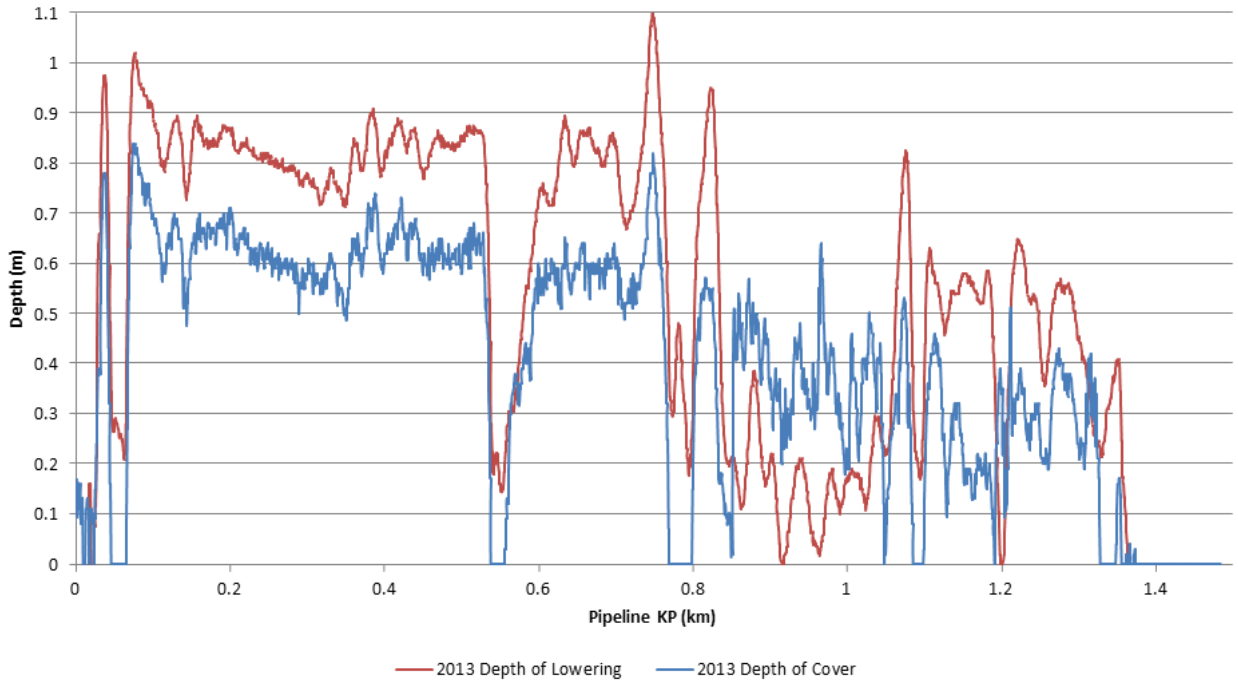


Figure 8-10 – Curlew D Wet Gas Production Pipeline Cover Depth vs Depth of Lowering (OGA ref: PL1452)

8.5.2. Curlew D Wet Gas Production Pipeline (OGA ref: PL1453)

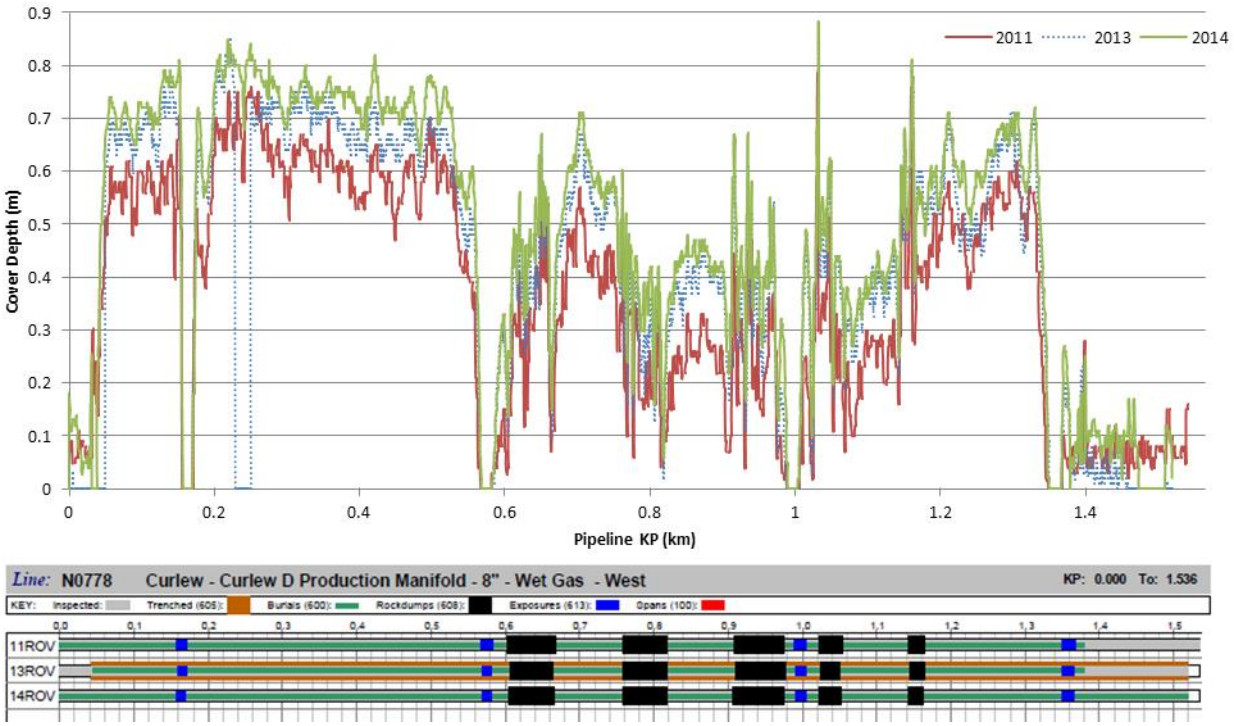


Figure 8-11 – Curlew D Wet Gas Production Pipeline Cover Depth Survey Data (OGA ref: PL1453)

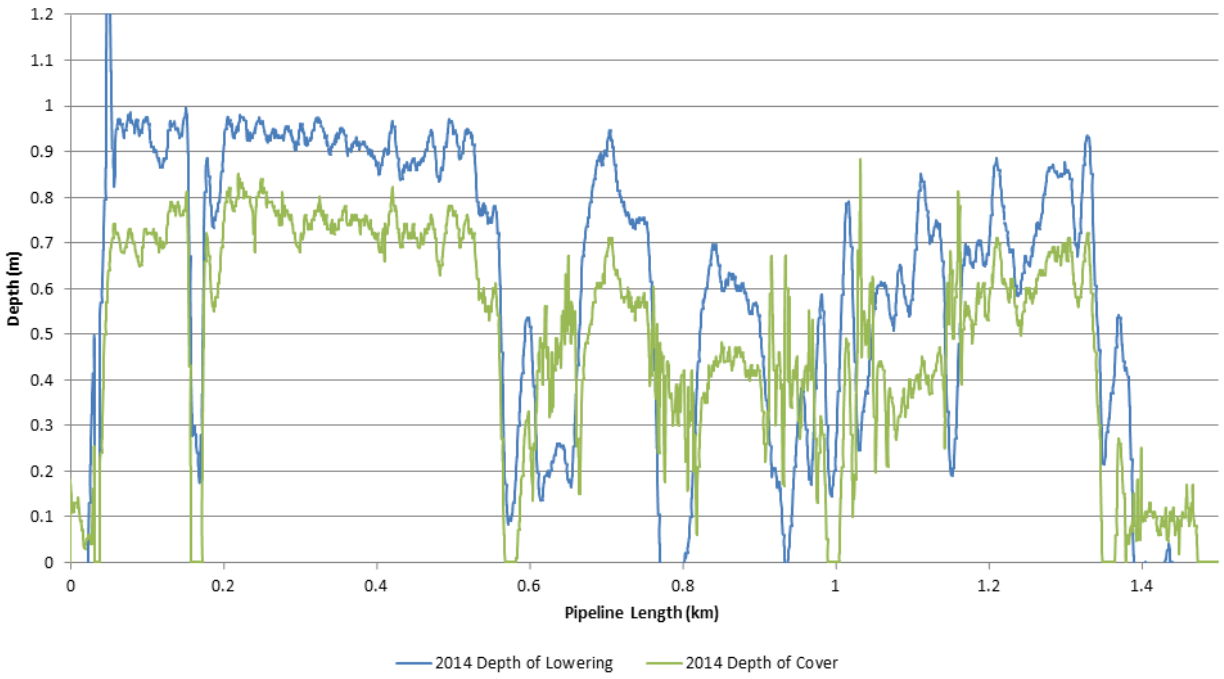


Figure 8-12 – Curlew D Wet Gas Production Pipeline Cover Depth vs Depth of Lowering (OGA ref: PL1453)

8.5.3. Curlew D Umbilical (OGA ref: PL1454)

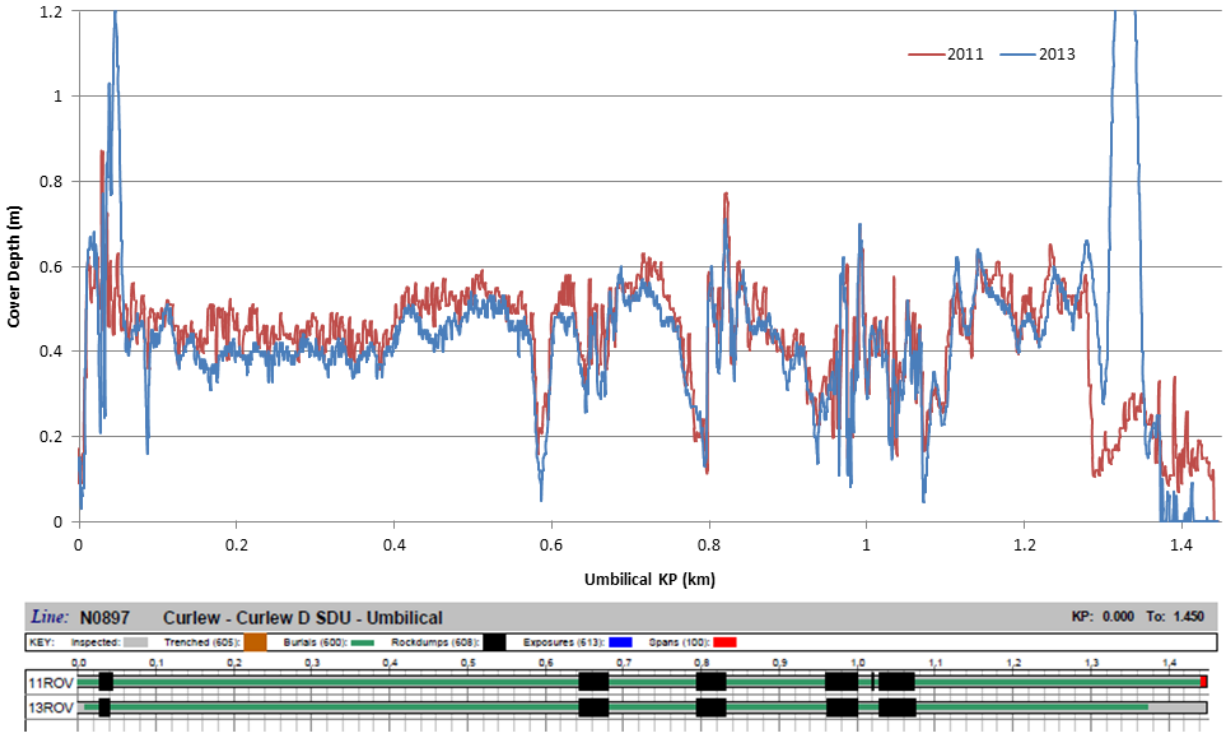


Figure 8-13 – Curlew D Umbilical Cover Depth Survey Data (OGA ref: PL1454)

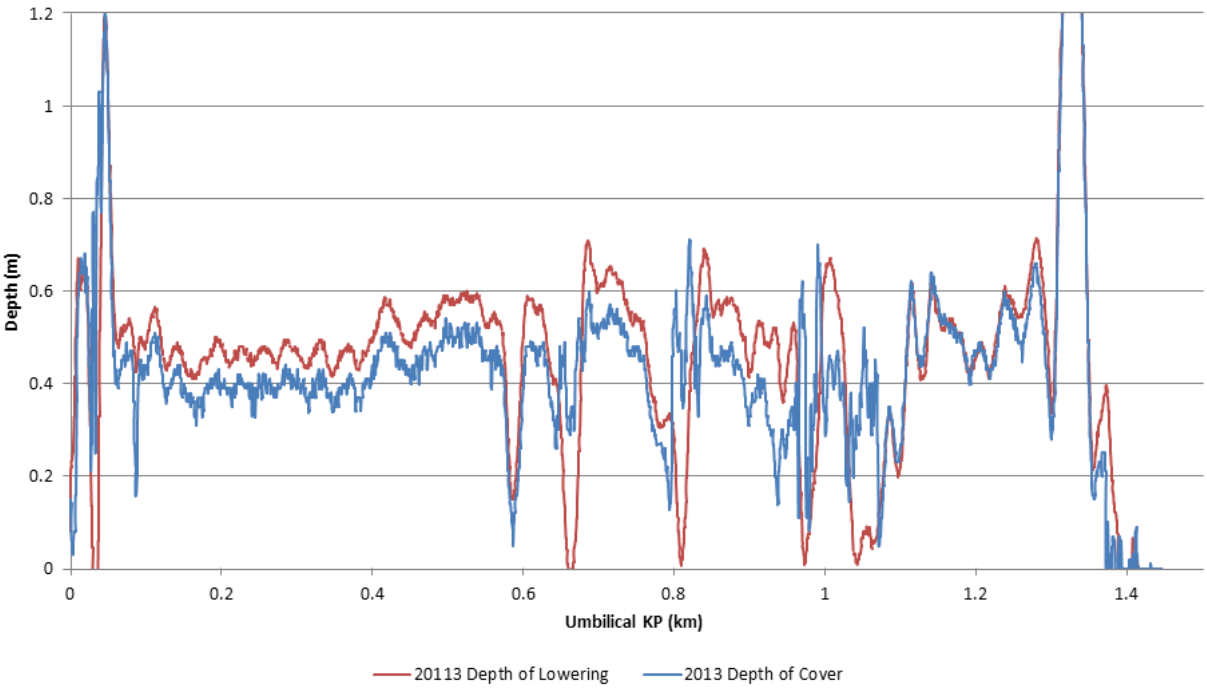


Figure 8-14 – Curlew D Umbilical Cover Depth vs Depth of Lowering (OGA ref: PL1454)

8.6. Gas Export Pipeline (OGA ref: PL1455B)

8.6.1. Gas Export Pipeline Design Basis

The gas export pipeline is a 12" rigid steel pipeline, which was installed in 1998. The design basis was a self burial pipeline. The pipeline was installed in a pre-cut trench which varied in depth between 1.1 and 1.8m, hence the depth of lowering of the pipe is between 0.8m and 1.5m. The majority of the pipeline is rock covered towards the FPSO end, as shown in Figure 8-16. The rock cover requirement is only for upheaval buckling prevention. Full SONAR survey images have been reviewed for the pipeline and they show that the pipeline is within the trench along the route.

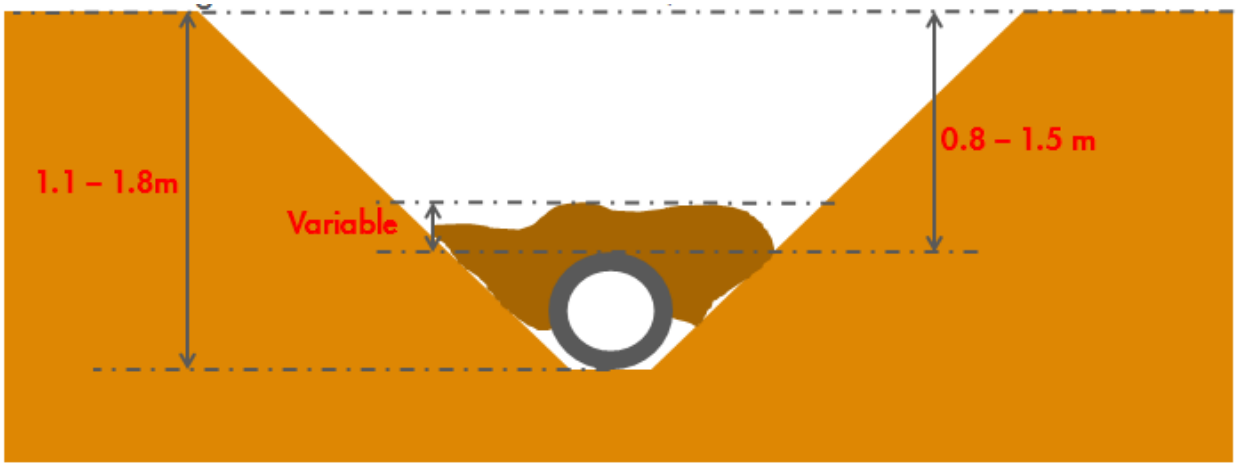


Figure 8-15 – Gas Export Pipeline Design Basis Diagram

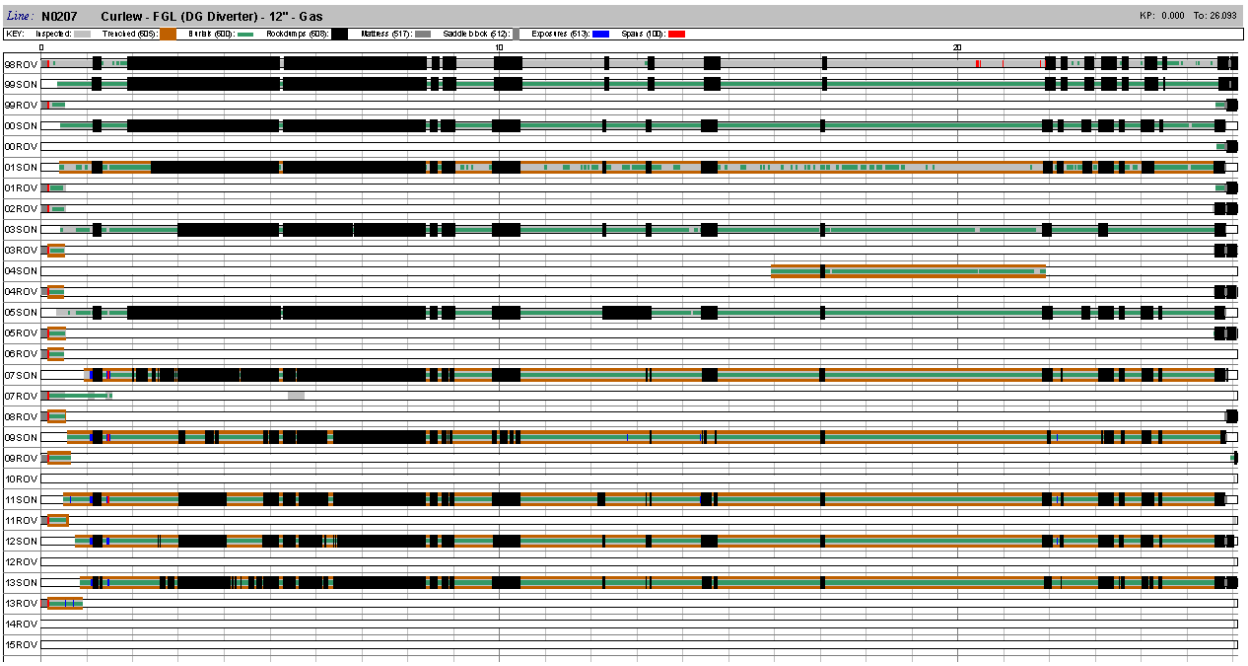


Figure 8-16 – Gas Export Pipeline Survey Coverage (OGA ref: PL1455B)

9. Appendix C: Comparative Assessment Qualitive Scoring Guidance

Criteria	Sub-Criteria	Applicable to	Applicable When	Green / Most Preferred	Amber / Moderate	Red / Least Preferred
Safety	**Project risk to personnel – Offshore**	Project team offshore, project vessels crew, diving teams, supply boat crew, heli-ops, survey vessels crew	During execution phase of the project including any subsequent monitoring surveys	Minimal preparatory activity to be completed prior to start of removal activity. No underdeck / overside working. Minimal materials handling on deck or barge during removal. Minimal diver activity.	Some preparatory activity to be completed prior to start of removal activity – but straight forward. Limited underdeck / overside working. Some materials handling activity on deck or barge during removal – but straight forward. Increased diver activity for short intervals and for less than 25% project duration.	High level of preparatory activity to be completed prior to start of removal activity. Significant underdeck / overside working. Multiple materials handling activity on deck or barge during removal. Extended diver activity throughout entire project phase.
	Project risk to other users of the sea	All other users of the sea, fishing vessels, commercial transport vessels, military vessels	During execution phase of the project including any subsequent monitoring surveys	All project activity within existing exclusion zone of facility. Minimal additional vessels transits to and from shore.	Some project activity outside existing exclusion zones but for short durations. Some additional vessel transits to and from shore of significant sized vessels. No complex transits.	Significant project activity outside existing exclusions zones but for most of project duration. Some complex transits to shore.
	Operational risk to personnel – Onshore	Onshore dismantling and disposal sites personnel; extent of materials transfers/ handling on land	During execution phase of the project, through to final disposal of recovered materials	Medium sized / volume of structures returned as waste - moderate dismantling required onshore, minimal work at height. No contaminated materials to be returned.	Large size / volume of structures returned as waste – more dismantling required onshore, some working at height possible. Some contaminated materials may be returned.	Significant sized or awkward shaped structures returned as waste – significant working at height required, significant and complex dismantling and materials handling activities required. Significant volumes of contaminated materials handling and clean up anticipated.
	Potential for a high consequence event	Project team offshore and onshore; project vessels; diving teams; supply boat crew; heli-ops; survey vessels; onshore dismantling and disposal sites personnel	During execution phase of the project including any subsequent monitoring surveys	Short vessel campaign (summer campaign); low level vessel SIMOPS; no helicopter crew changes anticipated; few lifting operations; all straightforward and not over live plant.	Prolonged vessel campaigns; some vessel SIMOPS; helicopter crew changes possible; some lifting operations; recovered structures lifted onto vessels for backload but not over live plant.	Extensive vessel campaigns; multiple mob / demob; multiple vessel SIMOPS; helicopter crew changes likely; major lifting operations, some very large lifts; possible lifts of structures over live trunk lines.
	Residual risk to other users of the sea	Fishing vessels, fishermen, supply boat crews, military vessel crews, commercial vessel crew and passengers, other users of the sea	Following completion of the Decommissioning project and residual / ongoing impact in perpetuity	None anticipated as clear seabed on completion of project.	Some materials / part structures left in-place but no snagging hazards as mitigating measures carried out. Other mitigations in place (retention of exclusion zones).	Large structures left in place; potential snagging hazards remain; mitigation available is limited to marking on admiralty charts.

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Criteria	Sub-Criteria	Applicable to	Applicable When	Green / Most Preferred	Amber / Moderate	Red / Least Preferred
Environmental	**Impact of operations**	Environmental impact to the marine environment, nearshore areas and onshore caused by project activities	During execution phase of the project from mobilisation of vessels to the end of project activities at the waste processing / disposal site (does not include landfill and long-term storage impacts) For rock placement, trenching and dredging any seabed disturbance is included here, depending on area of impact – changes to habitat and species are covered in Legacy Impact.	No associated discharges*1; No behavioral disturbance to any marine mammals; Area of disturbance equal or less than area disturbed during installation and/or operations; No disturbance to drill cuttings accumulation*2; Extend of the sediment resuspension equal or less than the extent caused during operations and/or installation; No protected species and or habitats affected; No onshore processing required (for instance clean steel for recycling) *4	Non-SUB, GOLD or E/PLONOR chemicals discharges*1; Temporary changes to behavior of any marine mammals i.e. temporary move away from the area; Area of disturbance is up to two times bigger than the area disturbed during installation and / or operation; Less than half the volume of the drill cuttings deposits*2 will be disturbed; Extent of the sediment resuspension is up to two times bigger than during operation and/or installation; Presence of protected species and/or habitats identified and confirmed by a survey*3; Requires non-hazardous waste treatment (for instance clean steel pipeline with concrete coating requires segregation but not special treatment, like for NORM)	Any other chemical discharges*1 (other than in Amber) e.g. SILVER, OCNS A-C or no longer CEFAS registered; Permanent damage / change to behavior of any mammals (i.e. move away permanently and / or permanent damage to hearing); Area of disturbance more than two times bigger than the area disturbed during installation and / or operations; AND Greater than half the volume of the drill cuttings will be disturbed; AND Sediment resuspension is more than twice than during operation and/or installation; Presence of designated protected species and/or habitats*3; Requires hazardous waste treatment processing (for instance NORM treatment; wax deposit cleaning inside the pipeline)
	Energy, emissions and resource consumption	Project activities from vessel mobilisation to the final destination of waste, including the energy and emissions penalty for leaving recyclable material in field. Includes vessel mobilisation, demobilisation, waiting on weather, post-decommissioning monitoring surveys.	During execution phase of the project from mobilisation of vessels to the end of project activities at the waste processing / disposal site (does not include landfill and long-term storage impacts) Not recovering and recycling the installations material will require that raw material and energy will be consumed to replace the materials which would have been recycled if the structure had been brought onshore	Short duration and/or small number of vessels during decommissioning operation and future monitoring; Small volume of material left in situ	Moderate duration and number of vessels during decommissioning operation and future monitoring; Moderate volume of material left in situ	Significant duration and number of vessels required for operations and future monitoring; Significant volume of material left in situ
	Legacy impact	Ongoing long term environmental impact caused by materials left in place or long-term waste storage / landfill	Following completion of the Decommissioning project and residual / ongoing impact For rock placement, trenching and dredging any changes to habitat and species are included here - seabed disturbance is included in Impact of Operations, depending on area of impact.	Majority of recovered material recycled or re-used; No hazardous waste requiring long-term storage; No change to habitat or species composition (introduction of no new materials); No material left on OR in the seabed;	Majority of recovered material reused or recycled; Non-hazardous waste required treatment or disposal (landfill) OR Small amount of hazardous waste requiring treatment and / or long term-storage; Possible / temporary alteration of species composition due to habitat alteration with recovery and recolonization of the area by original species; Inert material left in OR on the seabed (leaving material but not expected to have environmental impact, i.e. BEP)*5	Majority of recovered material destined for landfill; Majority of hazardous waste requires treatment or long-term storage; Permanent habitat alteration with permanent changes in species composition; Material left on OR in seabed with potential environmental impact (hydraulic fluids, plastic, etc.)*6

Criteria	Sub-Criteria	Applicable to	Applicable When	Green / Most Preferred	Amber / Moderate	Red / Least Preferred
Technical	**Risk of major project failure**	Overall Project	From project select phase through to completion, including monitoring surveys and ultimate disposal of materials returned to shore.	High level of confidence that schedule slippage can be accommodated within the contingency and float in the plan; high level of confidence that cost increases can be accommodated by contingency UAP budget allocation; slippage to schedule and growth in cost anticipated is small; assets and equipment are immediately available to facilitate recovery and stabilise the situation after an incident; speed of recovery is anticipated to be swift; limited impact on planned campaign schedule is anticipated as remaining planned activities can continue in the interim.	Less confidence in cost and schedule, however moderate level of delay and cost overrun is anticipated as worst case; assets and equipment are available in a reasonable timeframe from onshore to stabilise the situation after an incident; speed of recovery is anticipated to be longer due to some re-engineering of activities being required; considerable impact on the planned campaign schedule is anticipated, as remaining planned activities cannot continue in the interim.	Significant delays are possible if upsets occur pushing removals phase into a separate season and increased cost overrun possible; re-engineering required to develop procedures and identify assets and equipment to stabilise the situation after an incident; speed of recovery is anticipated to be slow due to re-engineering and procurement of new equipment; significant impact on the entire project schedule and company reputation.
	Technology demands, Availability / Track Record	Overall Project	From project select phase through to completion, including monitoring surveys and ultimate disposal of materials returned to shore.	The proposed concept has been successfully implemented in the past; technological feasibility of the concept is beyond doubt; industry and expert opinion consistently concludes that the proposed solution is technically robust and complies with existing legislation; vessels and most supporting equipment are industry-standard with good track record of successful operation with no new marine asset construction required; some minor supporting equipment may require investment to aid development or proof of use as planned, however it is anticipated that this can be completed successfully ahead of the project schedule; the supply chain is generally readily available in the present market; project schedule is reasonable and equipment availability is within project timetable.	The proposed concept has been seriously considered for several directly comparable assets in the past but has not yet been used; technological feasibility of the concept requires some additional engineering development; expert opinion is united in confidence that the proposed solution is generally technically sound and complies with existing legislation; some vessels require some investment to aid minor development, however there is widespread confidence within the industry that this shall be completed successfully; more supporting equipment requires early investment to aid development, however it is anticipated that this will be completed successfully ahead of the project schedule; the supply chain requires some engagement to meet project requirements; project schedule can be managed to suit equipment availability within the overall project timetable.	The proposed concept is not mature; technological feasibility of the concept requires considerable engineering to prove; there is some doubt within the industry and expert opinion is divided on whether the proposed solution is technically sound and can comply with existing legislation; vessel require investment to aid their development and construction; other supporting equipment requires investment to aid development; there is uncertainty within the industry that this will be completed successfully ahead of the project schedule; the supply chain requires development; project schedule is tight but may be managed to suit equipment availability.

Criteria	Sub-Criteria	Applicable to	Applicable When	Green / Most Preferred	Amber / Moderate	Red / Least Preferred
Societal	**Commercial impact to fisheries**	Impacts from both the decommissioning operations and the end-points on the present commercial fisheries in and around the field	During and following completion of the Decommissioning project and residual / ongoing impact	The status of the area / site post-decommissioning will have no effect on commercial fisheries.	The status of the area / site post-decommissioning results in small areas of fishing ground or water column becoming inaccessible to fishing and is lost to fishing over prolonged period.	The status of the area / site post-decommissioning results in larger areas of fishing ground or water column becoming inaccessible to fishing and is lost to fishing over a prolonged period.
	Socio-economic impact on communities and amenities	The impact from any near shore and onshore operations and end-points (dismantling, transporting, treating, recycling, land filling) on the health, well-being, standard of living, structure or coherence of communities or amenities. E.g. business or jobs creation, increase in noise, dust or odour pollution during the process which has a negative impact on communities, increased traffic disruption due to extra-large transport loads.	During and following completion of the Decommissioning project and residual / on-going impact	No or minor negative impact: short-term (<6 months) impact on local communities causing potential minor nuisance from some aspects of the operations, but would cease and revert to previous condition on completion of specific short term operations. Short-term (<6 months) impact on local amenities for some or all of the operations, but would cease and revert to previous condition on completion of operations, without the need for mitigation. Positive impact: new business or long term employment created, extends beyond duration of the operation by more than 1 year. Permanent road and other infrastructure improvements created.	Some negative impact on local communities, leading some actual deterioration in quality of life, deterioration would exist while actual operations were being carried out but would essentially cease as soon as operations were completed and quickly revert to pre-operation condition; some impact on local amenities, leading to some actual deterioration in amenities; deterioration would exist whilst actual operations were being carried out. Some mitigation / remedial work would be required when operations were completed to restore amenities to pre-operational condition. Short term and local positive impact on communities as localised increased job prospects created for duration of the operation. No permanent positive impact on amenities anticipated.	Significant and long-term (>1 year) negative impact on local communities leading to noticeable deterioration in quality of life during the operations. Anticipated this would persist for a period of 6 months to 1 year after actual operations had ceased. Significant and long-term (>1 year) impact on local amenities, leading to noticeable deterioration during the operations. Mitigation / remedial work would be required when operations were completed to restore amenities to pre-operational condition. No positive impact on communities or amenities. Existing businesses and infrastructure can accommodate operations.
Economic	**Cost**	Overall Project	Full decommissioning project cost including future monitoring surveys and proposed remediation, if required	Lowest cost option	-	Highest cost option
	Cost Risk / Uncertainty	Overall Project	Project execution phase and ongoing cost liability (surveys and potential remedial action)	Scope reasonably defined and understood; estimate developed using recognised and validated estimating tools; validated cost basis industry norms from similar work already carried out.	Some uncertainty / information gaps in parts of the scope and / or equipment used; estimate developed using recognised and validated estimating tools; validated cost basis using industry norms, some information gaps in norms due to costs of new or emerging equipment rates not being available.	Uncertainty in many areas of the scope and in equipment used; OOM estimate only developed; significant information gaps in norms due to costs of new / emerging equipment rates not being available.

Table 9-1 – Comparative Assessment Qualitive Scoring Guidance

Notes relating to the Environmental sub-criteria:

Impact of Operations:

*1 Discharges of pipeline and umbilical contents which have been cleaned to a cleanliness level as agreed with regulator;

*2 Any drill cuttings deposits regardless of OSPAR 2006/05 definition;

*3 must be supported by any survey (ignoring reference station);

*4 this only applies if material is returned onshore for disposal

Associated discharges do not include accidental releases; these are not considered in the environmental evaluation of the options as they are probabilistic events and their inclusion would skew the data as the order of their impact is significantly higher than of the planned activities with build-in mitigations and controls

Legacy Impact:

Waste Disposal to include end-products of any cleaning operations; does not apply if all material is left in situ, i.e. nothing is brought onshore for disposal.

*5 Example: steel pipeline which was cleaned to BAT, but the pipeline is still left in situ

*6 Science immature on plastic content but it is an increasing problem with higher focus from society and environmental science community.