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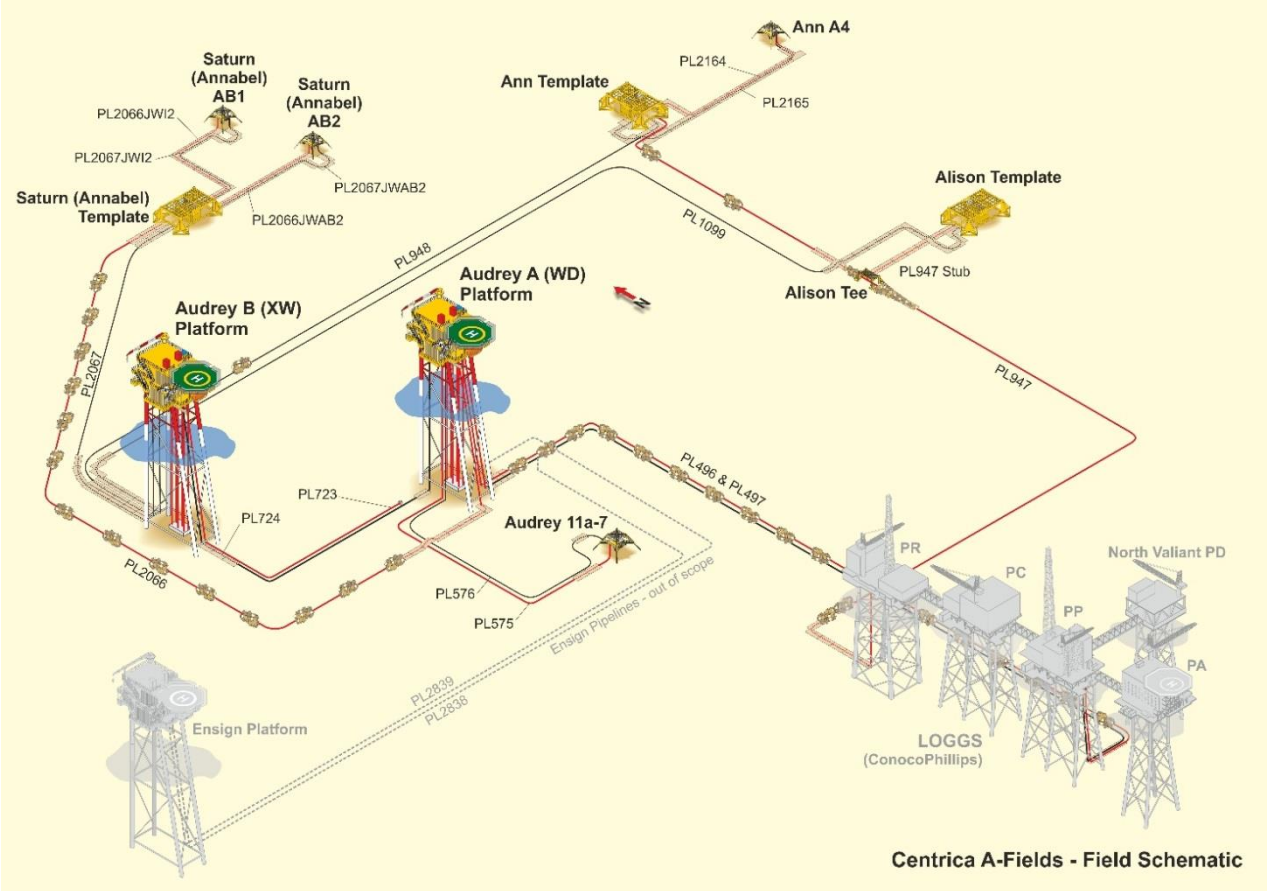
Ann & Alison Decommissioning Comparative Assessment



DOCUMENT CONTROL

Document ID:		CEU-DCM-SNS0096-REP-0007	
Document Classification:		PUBLIC	
Document Ownership:		Capital Projects	
Date of Document	29/11/16	Signature	Date
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REVISION RECORD

Revision No.	Date of Revision	Reason
A1	17/03/17	Issued for internal review and comment
A2	07/04/17	Issued to BEIS for comment
A3	26/06/17	Issued for Statutory Consultation

1. EXECUTIVE SUMMARY

A Comparative Assessment of pipeline decommissioning options is a key consideration within Decommissioning Programmes submitted to the Department of Business, Energy and Industrial Strategy (BEIS). We also consider the options available for fronded mattresses that are buried.

Collectively the A Fields series of developments lie approximately 110km north-north-east of the English coastal town of Great Yarmouth, in the southern sector of the North Sea. 'A-Fields' is a collective term used to describe the Audrey, Ann, Alison and Annabel Fields.

Ann and Alison pipelines

The primary export route for Ann and Alison is **PL947**. This 12" pipeline is routed to LOGGS and is 41.8km long. Both Ann and Alison derive their power and controls via two separate umbilical lines **PL948** and **PL1099**. These are routed from Audrey B (XW) and are 17.6km and 15.1km long respectively. Ann A4 exports gas to Ann manifold via **PL2164**. The 6" surface laid pipespools are 124m long. Ann A4 derives power, controls and chemicals from the Ann manifold via a short umbilical line **PL2165**, 129m long.

Pipeline decommissioning options

This document summarises a comparative assessment of the most feasible options for decommissioning the Ann and Alison pipelines **PL947**, **PL948**, **PL1099**, **PL2164** and **PL2165**.

In general terms three options are considered for decommissioning the pipelines:

- **Complete removal** – This involves the complete removal of the pipelines by whatever means would be most practicable and acceptable from a technical perspective;
- **Partial removal or remediation** – This will involve remediating or removing part(s) of the pipeline to make it safe for leaving the remainder *in situ*;
- **Leave *in situ*** – This involves leaving the pipeline *in situ* with no remedial works but verifying the stability of the pipeline via future surveys on an as-required basis

Since the decommissioning of the pipeline (and umbilical) approaches is the same irrespective of which option is pursued, decommissioning of these is not included in the assessment. All options include removal of features such as spool pieces, mattresses and grout bags in accordance with mandatory requirements. Any pipelines buried in rock on the approaches will be left *in situ* although any exposed sections will be recovered to shore.

Fronded mattress decommissioning options

Two decommissioning options were considered for the fronded mattresses:

- Complete removal;
- Leave *in situ*

The options were assessed using the BEIS Decommissioning Guidance Notes and Centrica Comparative Assessment guidelines for the A Fields decommissioning project. During the assessment process, evaluations were made principally on a qualitative basis using Centrica's established corporate risk assessment tables. The following components were assessed from a short-term (project) and longer-term (legacy) perspective:

- Safety
- Environmental
- Technical
- Societal
- Cost

Pipeline decommissioning assessment

The results of the assessment showed the risks and impacts of all pipeline decommissioning options to be broadly acceptable, although the technical and safety risks associated with complete removal of the 12" pipeline (**PL947**) would be 'tolerable' rather than 'broadly acceptable'. This is primarily due to there being limited experience in removing trenched and buried pipelines [11]. From an environmental perspective, lower risks and impacts would be incurred for the leave *in situ* option than for any of the other decommissioning options.

For all buried pipelines in the short-term the complete removal option would result in the Special Area of Conservation objectives being impacted and this was classed as 'tolerable' rather than 'broadly acceptable'. In the case of the first-half of **PL1099** the assessment concluded that if complete removal wasn't implemented in the short-term the objectives of the SAC could still be affected in the longer-term due to the potential need to remedial work in future.

The societal assessment showed that short-term decommissioning activities taking longer to complete would be marginally beneficial because of continuation of employment due to extension of vessel use and onshore waste management activities. Conversely, fishing activities might proportionately be disrupted as decommissioning activities, and area of seabed affected, increase.

Finally for all pipelines and associated decommissioning options the partial removal (where applicable) and leave *in situ* options would cost less to adopt than the complete removal options. However, in the case of **PL1099**, we believe that the uncertainties associated with legacy elements are such that the cost of addressing future legacy elements could offset any short-term financial savings associated with removing the exposed elements rather than completely removing the first half of the pipeline.

Summary of decommissioning proposals

As **PL947** exits Ann manifold it is buried in rock and apart from the short-exposed sections at the pipeline ends at Ann and LOGGS RP that would be removed, the pipeline would be decommissioned by leaving *in situ*. The short-exposed lengths of the pipeline at KP3.4 and KP4.7 as well as potentially exposed area near a sand bank between KP31.0 and KP33.5 will be left *in situ*. Sections of **PL947** protected by deposited rock on the approach to LOGGS RP will be left *in situ* but short exposed sections in this area will be recovered.

Although the pipeline crosses over several pipelines, no pipelines at the pipeline crossings would be disturbed during removal of **PL947** providing **PL1099** is decommissioned first.

For the most part **PL948** appears to be buried and stable and we would propose to leave this line *in situ*. On the Audrey B (XW) and Ann approaches the umbilical is surface laid and protected and stabilised using concrete mattresses; we would propose to fully remove these parts of the umbilical.

PL1099 is a pipeline umbilical of two parts. We propose to completely remove the umbilical between Audrey B (XW) and KP8.0 and leave the remainder of the umbilical *in situ*. As we consider this to be part of the Alison approach, we would propose to fully remove the surface laid section of **PL1099** at the **PL947** pipeline crossing up to the Alison manifold.

The surface laid pipelines **PL2164**, **PL2165** and **PL947** stub (pipespools 46m long between the Alison manifold and Alison tee) will be fully removed. Excepting deposited rock and frond mattresses the Alison tee will be fully removed. After flushing and being left full of seawater, **PL947, PL948** and the second half of **PL1099** will be left *in situ* with no disruption for most of their lengths. We propose to fully remove the first 8km of **PL1099**.

Where the pipelines are buried and not covered in rock they will be cut below the seabed at trench depth and the pipespools, pipelines on the seabed, and the transition sections to a burial depth of 600mm will be removed. The intention is that all the pipeline protection materials such as concrete mattresses and grout bags will be fully removed to gain access to the pipelines.

Decommissioning of the different pipeline components are summarised below.

PL947, 41.8km long	**Leave *in situ***	**Partial removal**	**Complete Removal**
Ann approaches & transition zone		●	
Pipeline between Ann and Alison tee	●		
Alison tee spool pieces			●
Pipeline between Alison tee and LOGGS	●		
LOGGS PR approaches & transition zone		●	
PL947 Stub, 46m long	**Leave *in situ***	**Partial Removal**	**Complete Removal**
Alison manifold to Alison tee, surface laid			●

PL948, 17.6km long	**Leave *in situ***	**Partial Removal**	**Complete Removal**
Audrey B (XW) approaches & transition zone			●
Umbilical between Audrey B (XW) and Ann	●		
Ann approaches & transition zone			●
PL1099, 15.1km long	**Leave *in situ***	**Partial Removal**	**Complete Removal**
Audrey B (XW) approaches & transition zone			●
Umbilical (first 8km, approx.)			●
Umbilical (second 8km, approx.)	●		
Alison approaches, crossing & transition zone			●

PL2164, 124m long	**Leave *in situ***	**Partial Removal**	**Complete Removal**
Ann A4 to Ann manifold, surface laid			●
PL2165, 129m long	**Leave *in situ***	**Partial Removal**	**Complete Removal**
Ann manifold to Ann A4, surface laid			●

The Comparative Assessment also recommends that the fronded mattresses will be left buried *in situ*.

Post-decommissioning overtrawl

Finally, although we can expect the seabed to recover following the overtrawl activities, to minimise the short-term impact in the seabed and thus the conservation objectives of the SAC,

excepting the first 8km or so of **PL1099**, we would propose to carry out over trawl activities only within the 500m safety zones.

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TERMS AND ABBREVIATIONS

ABBREVIATION	DESCRIPTION	ABBREVIATION	DESCRIPTION
ALARP	As Low As Reasonably Practicable	LOGGS	Lincolnshire Offshore Gas Gathering System
Approach	Initial or final stretch of pipeline (or umbilical) as it leaves its point of origin or reaches its destination	MBES	Multi-Beam Echo Sounder. A type of sonar that can be used to map the seabed
BEIS	Department of Business, Energy and Industrial Strategy	MM	Million
Centrica, CNSL	Centrica North Sea Limited	N/A	(Data) Not Available
CO_2	Carbon Dioxide	NB	Nominal Bore
CSV	Construction Support Vessel	NORM	Naturally Occurring Radioactive Material
°	Degree	OGUK	Oil & Gas UK
DOB	Depth of burial. The depth between the blue line (DOC) and maroon line (DOL) on the burial profiles	Pipeline(s)	Pipeline or umbilical as defined by BEIS. Includes PL947, PL948, PL1099, PL2164, PL2165
DOC	The blue line on the burial profiles shows the profile of cover. The area between the blue line (DOB) and maroon line (DOL) shows the backfill	Pipespool(s)	Short sections of pipe that is typically flanged and bolted together.
DOL	Pipeline trench profile; depth of lowering (to tom of pipe)	Qualitative	Result determined using judgement and use of risk and impact matrices
DSV	Dive Support Vessel	Quantitative	Result determined using numerical data and by calculation
Exposure	A pipeline can be seen on the surface of the seabed but is not free-spanning	ROV (SV)	Remotely Operated Vehicle (Support Vessel)
FishSAFE	The FishSAFE database contains a host of oil & gas structures, pipelines and potential fishing hazards. This includes information and changes as the data are reported for: pipelines and cables, suspended wellheads, pipeline spans, surface & subsurface structures, safety zones & pipeline gates (www.fishsafe.eu)	RP	LOGGS Riser Platform, final destination for PL947
Free span	A pipeline is called to be at free span when a pipe segment is not supported by the seabed.	Scour	Local erosion of a sedimentary seabed, usually cumulative
HAZID	Hazard Identification Workshop	S-lay	This involves welding sections of pipe together on the deck of the vessel, then lowering the pipeline to the seabed as a continuous string of pipe, as the vessel moves forward, It is used for larger diameter pipelines
HSE	Health, Safety, Environment	pSAC	possible Special Area of Conservation
in (“)	Inch (25.4mm); used to describe nominal bore of pipe, or approx. outside diameter of umbilical	Spoolpieces	Short sections of pipe that are typically flanged and bolted together (aka pipe spools).
infield	Portion of pipeline outside 500m safety zone and therefore potentially already exposed to fishing activity	Te	Tonne(s)
km, m	Kilometre(s), Metre(s)	Template	Structure protecting wellheads, Christmas trees and piping manifold inside
KP	Kilometre Post, measured from place of origin	UK	United Kingdom
LAT	Lowest Astronomical Tide	UKCS	United Kingdom Continental Shelf

ABBREVIATION	DESCRIPTION	ABBREVIATION	DESCRIPTION

Broadly Acceptable / Low[1] & least preferred	Risks broadly acceptable but controls shall be subject to continuous improvement through the implementation of the HSEQ Management System and considering changes such as technology improvements; performance in other 'broadly acceptable' options marginally better	Tolerable / Medium[1]	Risks are tolerable and managed to ALARP. Controls and measures to reduce risks to ALARP require identification, documentation and approval by responsible leader
Broadly Acceptable / Low[1] & in-between least & most preferred	As above, but performance of this option is marginally better or marginally worse than others	Intolerable / High[1]	Impacts are intolerable. Controls and measures to reduce impact to ALARP (at least to Medium) and require identification, documentation, implementation and approval.
Broadly Acceptable / Low[1] & most preferred	As above but performance in other 'broadly acceptable' options marginally worse		

[1] The colour of this highlighted cell is used in the assessment tables

2. INTRODUCTION

2.1 Overview

The A Fields is an arrangement of sub-sea tiebacks and platforms tied-into third party infrastructure: Ann, Alison, Annabel, and Audrey. These are all tied in some degree to the ConocoPhillips' Lincolnshire Offshore Gas Gathering System (LOGGS) platform complex. Until the wells were shut in 01 May 2016 the A Fields had been in production since 1988.

The Ann and Alison gas fields were developed as subsea tie-backs, achieving first production in 1993 and 1995 respectively. The Ann template incorporates a piping arrangement that allowed the commingling of gas (and lesser quantities of other produced fluids) from Ann AN2 and Ann AN3, with those from Ann AN4. Gas was exported from Ann A4 to the Ann manifold pipework via a series of 6" nominal bore surface laid pipeline spool pieces totalling 124m long. Gas was exported from the Ann manifold via a trenched and buried 12" nominal bore pipeline approximately 41.8km long (PL947) tied into LOGGS RP. Alison is connected to PL947 at the Alison tee via a small 8" surface laid pipeline (PL947 stub) approximately 48m long.

Both the Ann and Alison piping manifolds and Xmas trees derived their power, controls and chemicals from Audrey B (XW) via trenched and buried umbilical lines PL948 and PL1099 approximately 17.6km and 15.1km long respectively. Ann A4 derives its power, controls and chemicals from a surface laid umbilical jumper (PL2165) approximately 129m long via the Ann manifold. The infrastructure components of Ann and Alison are:

Pipeline ID	Description, Size & Quantity
PL947	12" gas export pipeline, 41.8km long
PL947 Stub	8" gas export pipeline, 48m long
PL948	Power, control and chemical umbilical pipeline, 17.6km long
PL1099	Power, control and chemical umbilical pipeline, 15.1km long
PL2164	6" gas export line comprising pipespools, total 128m long
PL2165	Umbilical jumper, approx. 4in diameter bundle, 165m long
Stabilisation feature	Concrete Mattresses, various sizes, 140
Stabilisation feature	Fronded mattresses, various sizes, 26
Stabilisation feature	Grout bags[2] 2738 x 25kg & 53 x 1000kg
Stabilisation feature	Deposited rock[3], 853 m, 17,438 tonnes

Table 2.1: Ann & Alison pipeline components[4]

There are two primary interfaces with other facilities and infrastructure:

- Audrey B (XW) – source of umbilical lines PL948 & PL1099;
- LOGGS RP - destination of PL947.

Refer Figure 2.1 for an illustration of A Fields infrastructure and components.

[2] The number of grout bags has been estimated using available data including sketches, as-built drawings; and video footage. There is a degree of uncertainty associated with the exact numbers quoted
[3] The quantity of deposited rock has been estimate from available data including historical 'as-built' reports and PWA applications
[4] Refer Appendix A.1 for more details of stabilisation features

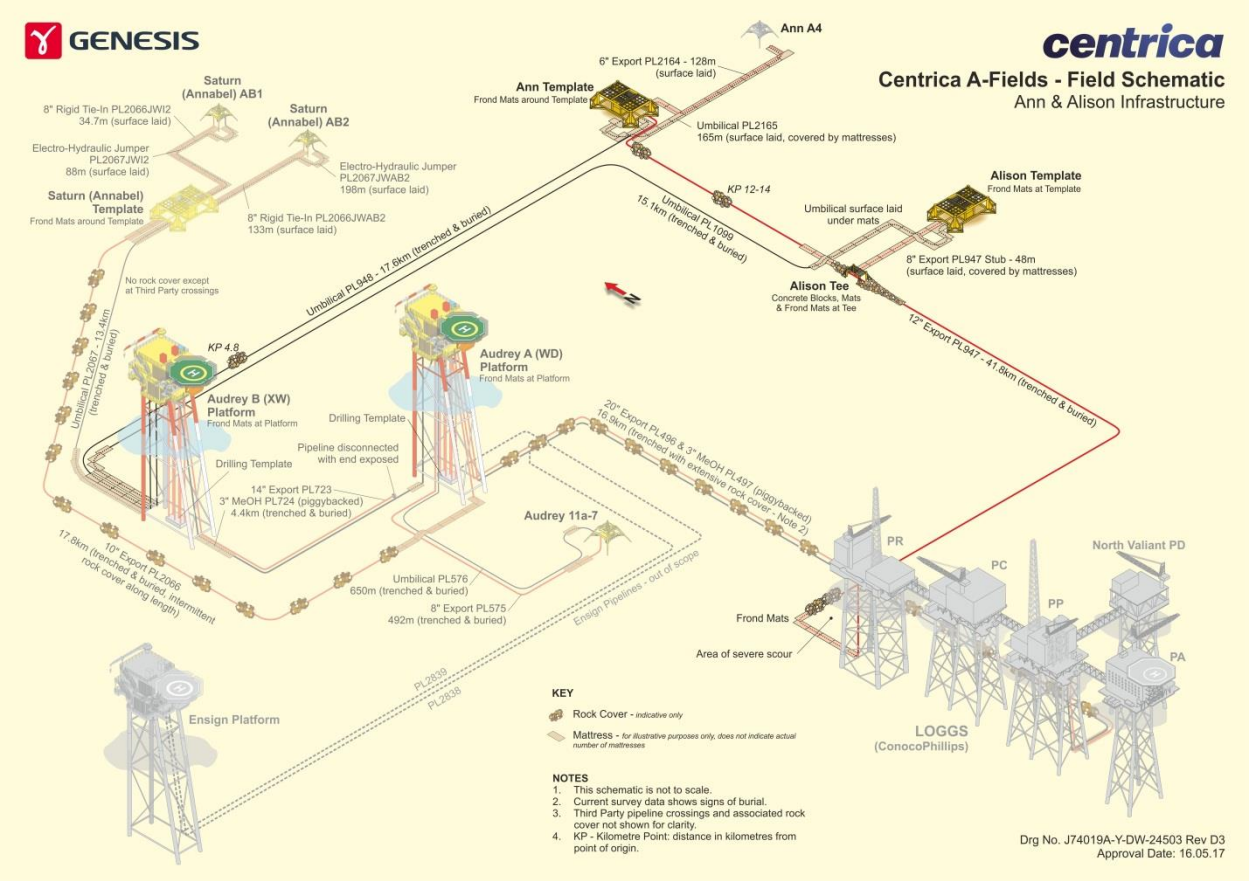

Figure 2.1: Ann & Alison Infrastructure and Components

2.2 Purpose

The purpose of this document is to present a comparative assessment in support of the Ann and Alison Decommissioning Programmes [5]. The comparative assessment describes the options considered for decommissioning the pipelines and fronded mattresses, and uses the Centrica guidance notes for the project [3].

As per the BEIS Guidance Notes [1] pipeline decommissioning options require to be comparatively assessed. Further, the guidance notes state that if the condition of the mattresses or grout bags precludes their safe or efficient removal, then any proposal to leave them in place must be supported by an appropriate comparative assessment of the options. The findings have been determined using Centrica's comparative assessment guidance prepared for the project [3].

There are no drill cuttings near either Ann or Alison installations, so no screening is required.

Following public, stakeholder and regulatory consultation the Ann & Alison combined Decommissioning Programmes will be submitted in the UK in full compliance with the BEIS Guidance Notes [1]. The Ann & Alison Decommissioning Programmes [5] explain the principles of the removal activities and are supported by an environmental impact assessment [4] and this comparative assessment.

2.3 Environmental Setting

The pipelines are located in a European Protected Site within the North Norfolk Sandbanks and cross the edge of the Indefatigable Banks and Swarfe Bank and the southern North Sea Harbour Porpoise pSAC. Details of the North Norfolk Sandbanks, pSAC and all other relevant environmental baseline data related to the area are provided in the environmental impact

assessment [4].

The North Norfolk Sandbanks are the best example of linear sandbanks in UK waters. The banks are important not only as geological features but they also support a variety of fish, seabirds and important communities of invertebrates like crabs, starfish and worms.

The A Fields are also a feeding ground for birds that depend on the marine environment for their survival. The seabirds are vulnerable to the effects of hydrocarbon spills all year round, but especially in March, May, July, October and November.

The A Fields are right on the edge of an area protected for harbour porpoise. Two other protected species - common and grey seals can also be found here.

This location is also an important spawning and nursery ground for several different fish species. These include mackerel, herring, cod, lemon sole and the Norwegian lobster. The spawning periods will vary by species throughout the year, but all year round this location is a nursery for important fish stocks. Fish stocks can be affected by disturbance to the seabed and discharges of chemicals or hydrocarbons.

2.3.1 Sand waves and sand banks

It is worth explaining what sand banks and sand waves are as this will provide context for some of the uncertainties we attempt to address in this comparative assessment.

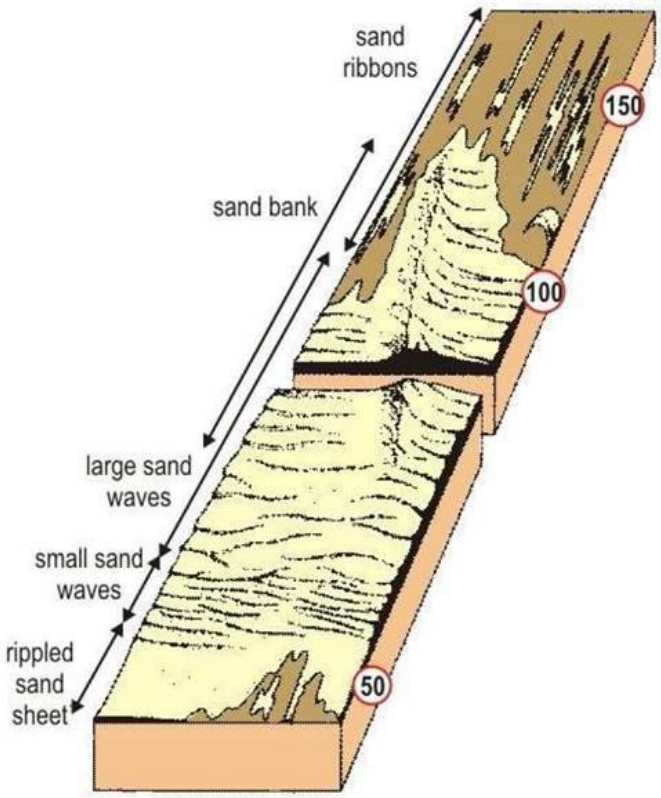

Figure 2.2: Sand waves and sand banks [2] [5]

Sand waves: Sand waves are a periodic bottom waviness generated by tidal currents in shallow tidal seas. Typical wavelengths range from 100 to 800m and they can be up to between 1 and 5m high. The crests are almost orthogonal to the direction of tide propagation. They are

[5] The numbers in red circles are mean spring near surface currents in cm/sec. i.e. divide by 100 to give speed in m/sec

not static bed forms and migration speeds can be up to tens of metres per year.

When local tidal flows interact with a bottom waviness it generates a steady streaming in the form of recirculating cells. When the steady velocity drags the sediment from the troughs towards the crests of the waviness, sand waves tend to appear. They can be complex to model, and subtle changes to the environment can change the dynamics of the local interaction between the tidal flows and the seabed.

Sand banks: The sand banks in the North Norfolk area of the southern North Sea are large-scale mobile seabed forms in dynamic equilibrium with the environment. They can have a wavelength between 1 and 10km, and they can achieve a height of several tens of metres [12]. Sand banks are found widely on shallow continental shelves where there is an abundance of sand and where currents exceed a certain speed [9]. This speed is much more than is needed to move seabed sediment and sand banks arise from an inherent instability of a seabed subject to tidal flow and mass transport. They can go from being active to a dying state, stranded in weak currents as the sea level rises.

2.3.2 The seabed in relation to the pipelines

PL947 departs from Ann Template across a relatively smooth seabed with water depths ranging between 27-29m LAT. Large mega-ripples or small sand waves are restricted to occasional examples at around KP6.0. At KP9.0 PL947 ascends a gentle slope on to a gently undulating plateau lying at approximately 24m LAT. The plateau is broken by occasional sand waves between KP24.0 and KP27.0 Even between extreme bathymetric features in this part of the route, gradients are low reaching 1°. The plateau surface continues to KP28.0 from where PL947 descends into a broad dip with its axis at about 35m at KP31. The southern side of the dip is formed by a ridge with water depths of 11.8m with PL947 ascending a 1.1° slope. The ridge's south face gently falls reaching a depth of 32m around KP35.0. From this point PL947 crosses an undulating mega-rippled seabed with occasional sand waves (with examples standing up to 4m above local seabed level at KP39.3) shelving to the south. At the southern limit of bathymetry coverage at approximately KP40.0 the seabed lies at a depth of approximately 24.0m LAT.

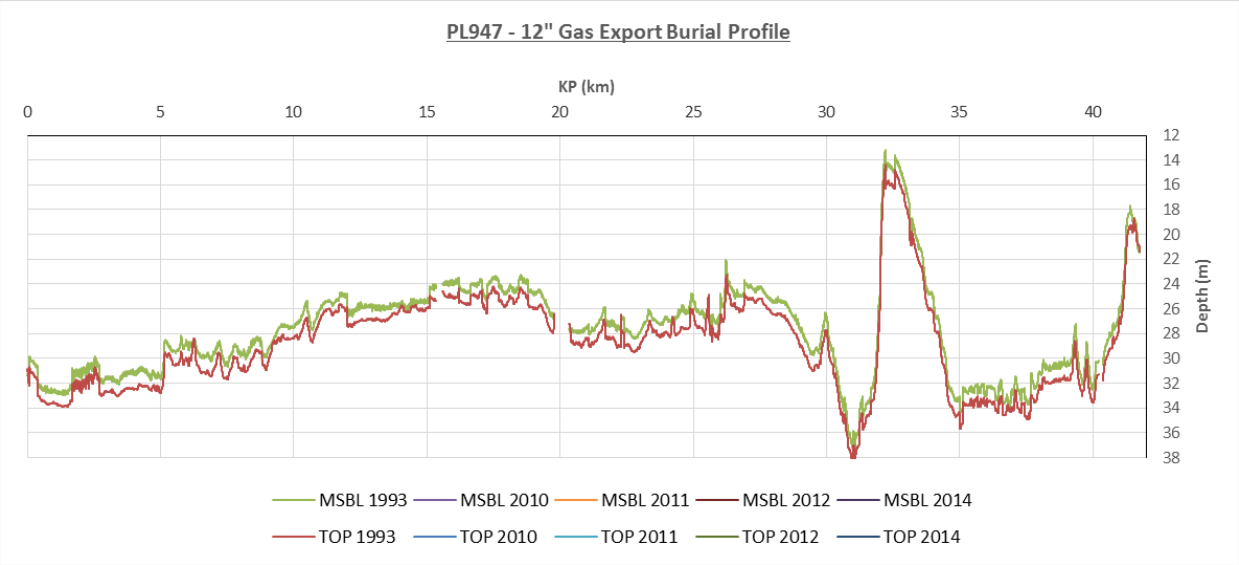

Figure 2.3: Seabed profile for PL947

PL948 departs Audrey B (XW) heading NNE towards Ann initially crossing a seabed lying at between 24 and 25m LAT upon which are located sand waves up to 3.5m high and at about 250m intervals. Beyond KP2.5 the seabed becomes smoother and descends at a consistent gradient of about 1° to reach the maximum depth encountered along the route of 42m at KP3.5. PL948 then ascends a very gentle slope reaching a depth of 30m at KP7.0. From this point to

the Ann Template at KP 17.4, PL948 crosses a very gently undulating plateau with water depths in the range of 28-30m with occasional sand waves standing 2m to 4m above the local terrain. The largest sand wave seen is 4m high at KP15.2. At Ann, the water depth is approximately 29m.

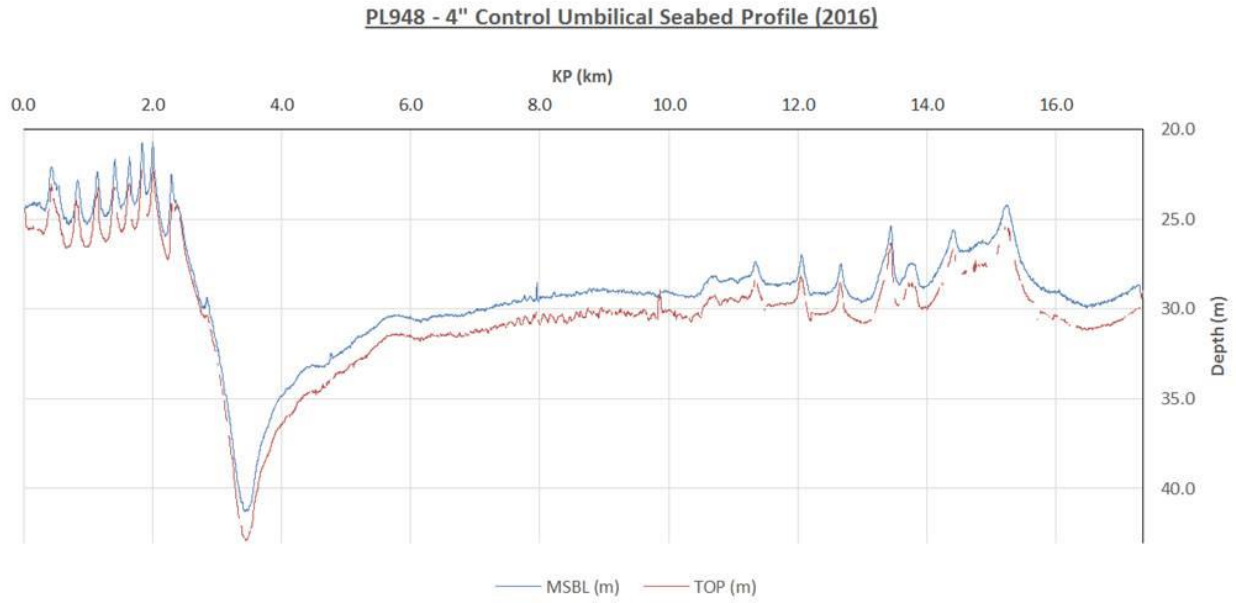

Figure 2.4: Seabed profile for PL948

PL1099 departs Audrey B (XW) and crosses an area of smooth sandy seabed. From KP0.138 to KP8.5 the seabed along the umbilical comprises an area of mega-ripples and sand waves up to 3.5m high. Mega-ripples replace sand-waves as the largest bedform from KP8.5 to KP10.0. From KP8.5 to KP10.7, PL1099 crosses a major depression (16m deep) reaching a maximum depth of 48.0m LAT at KP9.6. From KP10.0 (with the depression's eastern break of slope at KP10.7) to KP11.4 the umbilical crosses a particularly smooth seabed with occasional mega-ripples developing between KP11.4 and KP11.9. From KP11.9, other than encountering a lone sand wave at KP13.9 the umbilical crosses smooth gravelly sand, which continues to the proximity of the Alison Manifold. PL1099 crosses the PL947 12" Ann to LOGGS pipeline at KP 14.925.

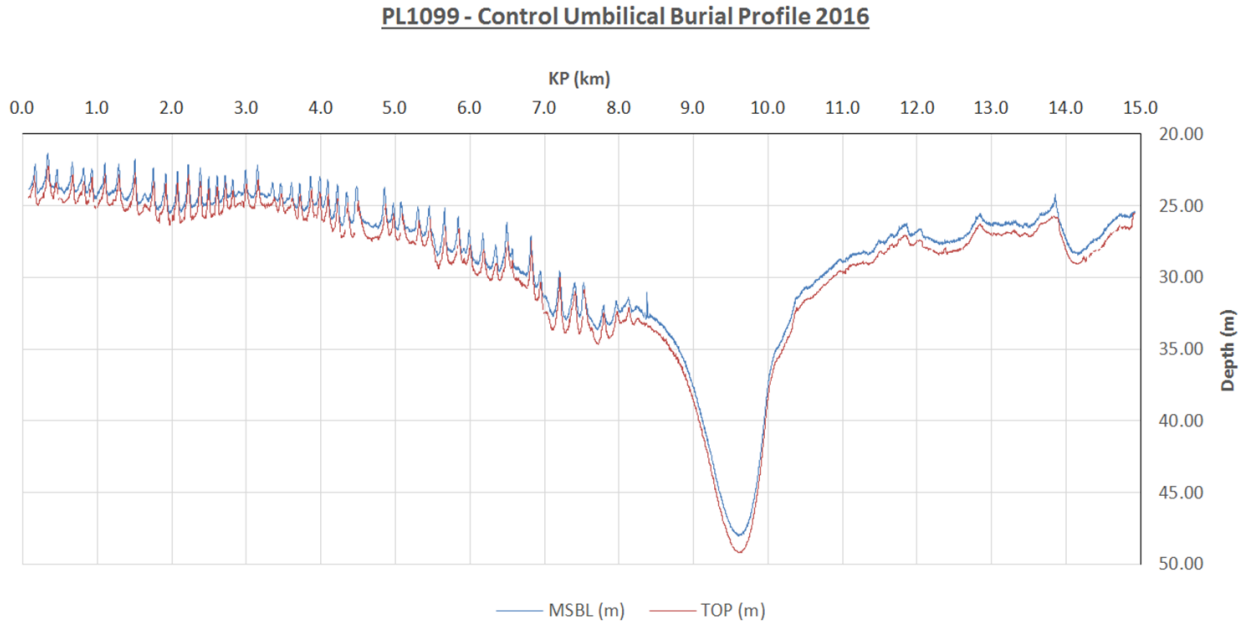

Figure 2.5: Seabed profile for PL1099

2.3.3 Deposited rock

While it is considered physically possible to remove the deposited rock, the decommissioning philosophy in this document is consistent with the Guidance Notes [1], hence all placed rock will be left *in situ*.

Material left in place will preserve the marine habitat that will have established over duration – over 20 years in the case of Ann and Alison - it has been on the seabed. In this case its presence – given the relatively small footprint – with regard to impact on the conservation aims of the proposed conservation areas in the vicinity or impact on the safety and other uses of the sea was assessed as low.

Methods that could be used to remove the rock include:

- dredging the scour protection and disposing of the material at an approved offshore location;
- dredging the scour protection and transporting the material to shore to be disposed of in an approved manner;
- lifting the rock using a grab vessel, depositing in a hopper barge and transporting it to a shore for appropriate disposal.

These proposed methods would impact on the seabed and associated communities, create sediment plumes, and require additional vessel use with the associated environmental impacts, safety risks, impacts on other users of the sea and additional costs. These outweigh the benefits of removing the rock

2.4 Assumptions, Limitations and Gaps in Knowledge

The assumptions, limitations and knowledge gaps relating to the comparative assessment are listed below. In addition, it should be noted that the presentation of the different categories of risks for comparison has required a degree of engineering judgement.

- A purely qualitative approach has been taken. This has necessarily required a degree of judgement, but since most impacts are related to area impacted, duration of works and vessel time we felt this was appropriate;
- The Ann and Alison assets were installed at a time when digital data was in the early stages of development. Retrieval of data – much of it hardcopy - from archives has required a degree of interpretation and judgement. We have interpreted what data are available in good faith, but its accuracy cannot be confirmed;
- Complete removal of the pipelines would be achieved by reverse reeling but could also be achieved by reverse S-lay or by cutting and retrieving the pipeline in sections, but in any event would be achieved without divers. However, we recognise that there is limited experience of reverse reeling trenched and buried pipelines or by removing such a long pipeline using ‘cut and lift’ from the seabed [11], so estimations of the safety risks, technical challenges and cost implications carry some uncertainty;
- The ‘complete removal’ option assumes that pipelines underneath any pipeline crossing would be cut on either side of the pipeline crossing;
- There are known exposures on the pipelines outside of the Audrey B (XW), Ann and Alison 500m safety zones, Centrica is not aware of any fishing gear snagging reports. To our knowledge no exposures have been of such a magnitude that they have not warranted being recorded as a snagging hazard via Kingfisher Information Services in FishSAFE (www.fishsafe.eu);
- An environmental survey would be required on completion of decommissioning activities;
- Any pipeline (or umbilical) being left *in situ* would be subject to legacy burial surveys;
- The seabed sediment type is such that mounds created during any decommissioning operations would not present snagging hazards;

- Deposited rock would not present snagging hazards;
- Demersal fishing is the most prominent type of fishing the pipeline area. NFFO advise that as well as 'rockhoppers', beam trawling is also used in the area. This type of fishing involves holding the mouth of a fishing net open with a 9-12m long beam[6] that slides over and disturbs the seabed;
- Impacts on SAC are assumed to be proportional to the amount of work done on the seabed;
- The impact of the procurement of any new materials such as fabricated items or mining of new rock is ignored;
- The potential impact and potential for interaction with commercial activities will increase with the number of vessels and the length of time that they are in the field carrying out decommissioning related activities;
- Societal benefits and vessel associated environmental impacts and risks are assumed to be proportional to vessel duration;
- Only a high-level comparison of what differentiates the costs is used.

[6] Typically, this is constructed from a heavy steel tube

3. THE PIPELINES

The following sections detail the current status of the pipelines.

3.1 PL947 Ann 12" gas export pipeline to LOGGS

PL947 is the Ann gas export pipeline that is approximately 41.8km long and routed from the Ann Manifold inside the Ann template through to LOGGS RP. When installed in 1993 the pipeline was trenched. On the approach to the Ann manifold the pipeline was trenched and protected with deposited rock. Approximately half-way along is the Alison Tee which has 48m long spool pieces branching from PL947 and connecting the Alison manifold to the main Ann gas export pipeline. We refer to this as the PL947 stub. The Alison tee and enclosed pipeline arrangement is protected and stabilised by steelwork, several large concrete blocks, concrete mattresses, grout bags and deposited rock. As PL947 approaches and exits the Alison tee it is protected and stabilised using rock. The short pipeline stub is laid on the surface and protected by concrete mattresses.

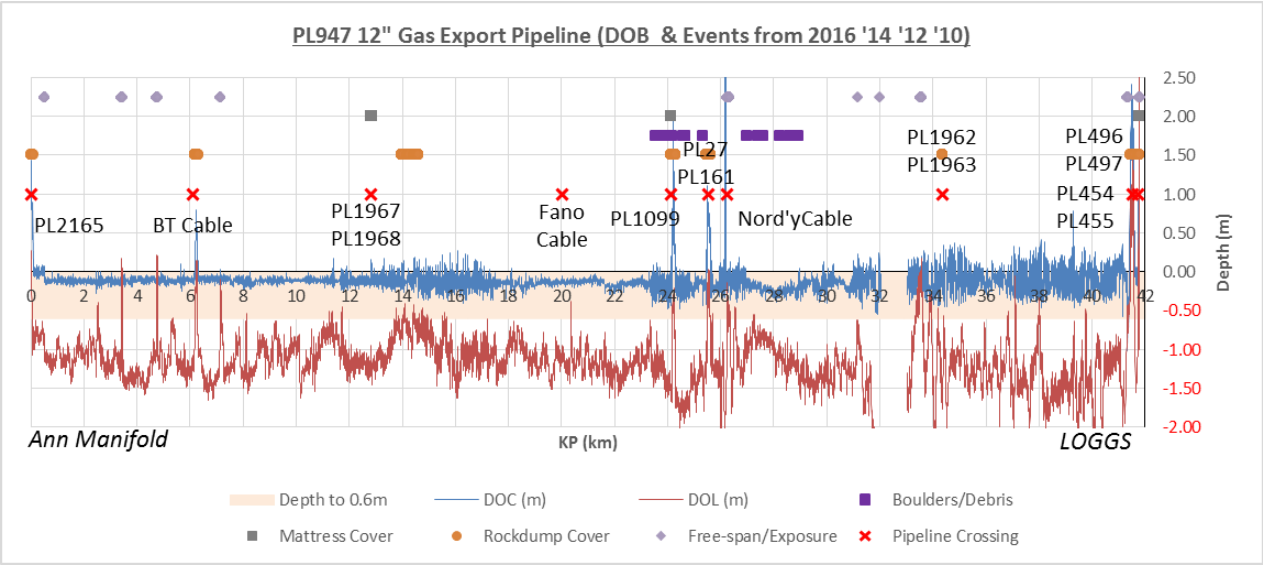

Figure 3.1: Overall burial of PL947 (12" gas export line Ann to LOGGS)

A number of pipeline[7] and cable crossings have been identified and are shown in Figure 3.1 and listed in Table 3.1.

Pipeline or Cable Description	KP	Protection
PL2165 4" umbilical jumper from Ann manifold to Ann A4	0.01	PL947 trenched & buried, PL2164 on seabed overlain with mattresses
BT Telecoms cable from Weybourne to ACMI MASTER (under)	6.1	4 mattresses laid under PL947, overlain with rock
PL1967 36" gas export pipeline from Carrack South to Clipper PR	12.84	Overlain with mattresses
PL1968 4" methylene glycol pipeline from Clipper PR to Carrack QA		
Cable from Weybourne to Fano (Dead) N/A	20.04	No physical crossing[8]
PL1099 4" Umbilical from Audrey (B) XW to Alison Manifold	24.13	PL947 buried, overlain with 3 mattresses and PL1099 with further mattresses on top
PL27 28" gas export line from Viking AR to Mablethorpe	25.55	PL27/PL161 trenched & buried, mattresses under
PL161 3" methanol piggy back line from Viking AR to Mablethorpe		

[7] A higher pipeline number crosses over the top of a pipeline with a lower identification number, so for example, PL1099 crosses **over** PL947

[8] The 'Weybourne to Fano' cable was cut during installation; there is no physical crossing present

Pipeline or Cable Description	KP	Protection
		PL947 and overlain with rock
PL1962 12” gas export line from Viscount VO to Vampire OD	34.36	PL947 trenched & buried, overlain with 7 mattresses under PL1962 with rock covering of PL1962
PL1963 3” methanol line from Mablethorpe to Vampire VR		
PL496 20” gas export line from Audrey A (WD) to LOGGS PP	41.54	PL496/497 trenched & buried, rock & 6 mattresses under PL947 and overlain with rock
PL497 3” methanol line from LOGGS PP to Audrey A (WD)		
PL454 36” gas export line LOGGS to Mablethorpe	41.72	PL454/455 trenched & buried, 4 mattresses under PL947 and overlain with rock
PL455 4” methanol line from Mablethorpe to LOGGS		

Table 3.1: PL947 Pipeline & Cable crossings

PL496 and PL497 are owned by Centrica, PL27, PL161, PL454, PL455, PL1962 & PL1963 are owned by ConocoPhillips and PL1967 & PL1968 are owned by Shell.

PL947 was trenched and has naturally backfilled along its length. As can be seen in the burial profile (Figure 3.1) there are two short exposures 24m and 22m long respectively at KP3.4 and KP4.7, and some intermittent exposures for a length of 109m at KP6.1. Further exposures occur at KP26 (19m & 24m). Survey data obtained periodically since installation would suggest that the pipeline has remained relatively stable throughout its entire length.

Historically, however, on the LOGGS approach the seabed has experienced significant scour. However, the pipeline is stabilised and protected with rock in this area except for the pipe spools between the end of the deposited rock and the LOGGS Riser Platform.

There are no data for the pipeline where it passes through a sandbank in relatively shallow water (approximately 11m LAT) between approximately KP31 and KP33.5. However, recent (2016) MBES data suggest that there are intermittent exposures over a 186m length from KP33.5. In general terms, the length of the pipeline with greatest uncertainty is where the pipeline approaches LOGGS RP between KP41.3 and KP41.8. Our experience would suggest that this area experiences scour, with the profile of the local seabed constantly changing.

The BEIS Guidance Notes [1] state that in most cases burial or trenching to a minimum depth of 0.6m above the top of the pipeline is necessary for pipelines decommissioned *in situ*. Most the pipeline is buried to a depth greater than 0.6m below mean seabed.

The presence of the pipeline crossings over PL947 has not unduly influenced the comparative assessment for pipeline PL947, although clearly such influences need to be accounted for.

Proposals for decommissioning this pipeline are examined in this comparative assessment.

3.2 PL948 Ann umbilical line from Audrey B (XW) to Ann manifold

The Ann manifold valves and wellhead are supplied with chemicals and hydraulic controls from Audrey B (XW) via pipeline PL948. This is an umbilical. The umbilical is approximately 17.6km long and when installed it was trenched. In the transition and surface laid sections at both Audrey B (XW) and the Ann manifold the pipeline is protected and stabilised using concrete mattresses.

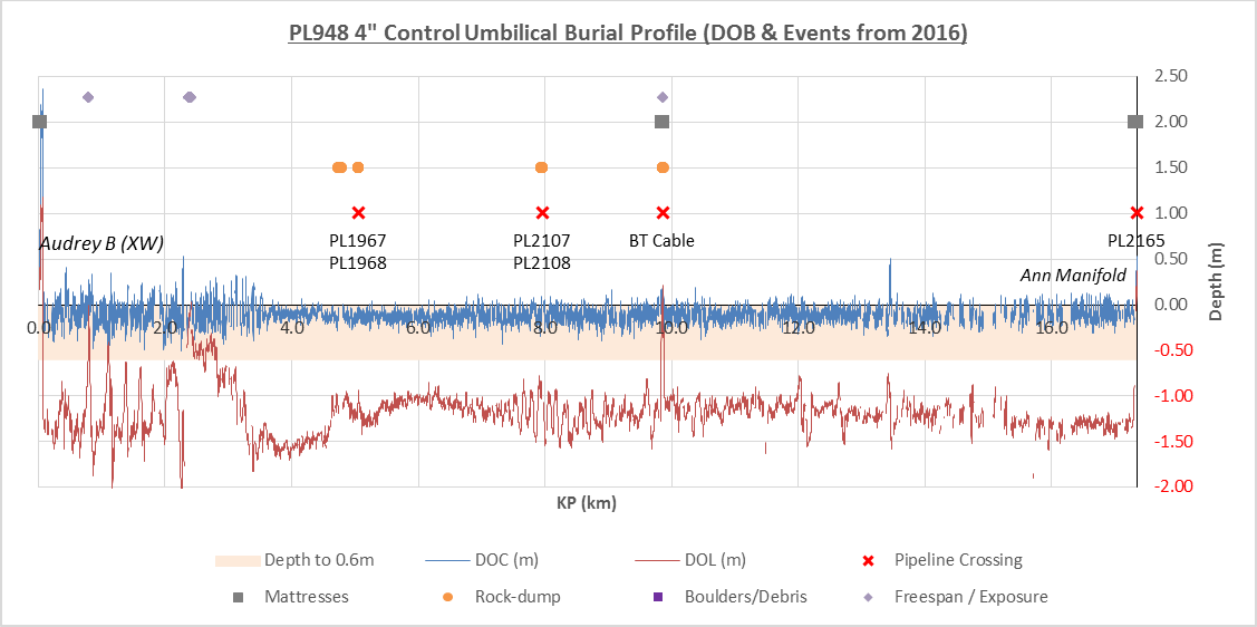

Figure 3.2: Overall burial of PL948 (Umbilical Audrey B (XW) to Ann)

Six crossings[7] have been identified and are shown in Figure 3.2 and listed in Table 3.2:

Pipeline or Cable Description	Crossing KP	Protection
PL1967 36" gas export pipeline from Carrack South to Clipper	KP5.1	Latest survey data suggests that rock is deposited at this crossing with PL948 suitably buried underneath
PL1968 4" methylene glycol pipeline from Clipper PR to Carrack QA		
PL2107 14" gas export pipeline from Saturn ND to LOGGS RP	KP8.0	The pipeline crossing is protected with rock
PL2108 3" methanol line from LOGGS RP		
BT Telecoms Cable from Weybourne to ACMI MASTER (under)	KP9.87	Cable trenched & buried, mattress protection under PL948, overlain with rock
PL2165 4" umbilical jumper from Ann manifold to Ann A4	KP13.0	PL948 on seabed overlain with mattresses, PL2165 and additional mattresses to protect PL2165

Table 3.2: PL948 Pipeline & Cable crossings

PL1967 & PL1968 are owned by Shell, PL2107 & PL2108 are owned by ConocoPhillips and PL2165 is owned by Centrica and is discussed elsewhere in this report.

The umbilical was trenched and allowed to naturally backfill along its length. As can be seen in the burial profile (Figure 3.2), PL948 experiences an irregular burial profile between KP0.5 and KP2.8 although few actual exposures have been recorded. This can be attributed to the presence of large sand waves near Audrey B (XW). Two exposures were recorded in 2013, one short length adjacent to the Audrey B (XW) platform and one near KP2.4 about 11 metres long, and more recent survey data obtained in 2016 suggests that the exposure at KP2.4 had extended intermittently to a length of 39m. However, we believe these exposures to be slight, so despite their occurrence we believe the umbilical remains comparatively stable.

The BEIS Guidance Notes [1] state that in most cases burial or trenching to a minimum depth of 0.6m above the top of the pipeline is necessary for pipelines decommissioned *in situ*. Most of the umbilical is buried to a depth greater than 0.6m below mean seabed.

The presence of the pipeline crossings over PL948 has not unduly influenced the comparative assessment for pipeline PL948, although clearly such influences need to be accounted for.

Proposals for decommissioning this pipeline are examined in this comparative assessment.

3.3 PL1099 Alison umbilical line from Audrey B (XW) to Alison manifold

The Alison manifold valves and wellhead derive chemicals and hydraulic controls from Audrey B (XW) via pipeline PL1099. This is an umbilical pipeline. As can be seen in Figure 3.3, PL1099 is a 15.1km long umbilical line of two halves, each having a distinct trench profile. Between KP0 (i.e. 'Start') and KP8.0 the depth of cover for the umbilical line fluctuates throughout. Historically, since the umbilical was originally installed, there has been an increase in the number and length of exposures over the first 8km. We believe that this is due to the presence of large mobile sand waves near the Audrey B (XW) platform.

From KP8.0 to KP15.1 (i.e. 'End') the burial and depth of cover has remained relatively stable since it was first installed, with no exposures occurring along the remainder of its length to the Alison manifold.

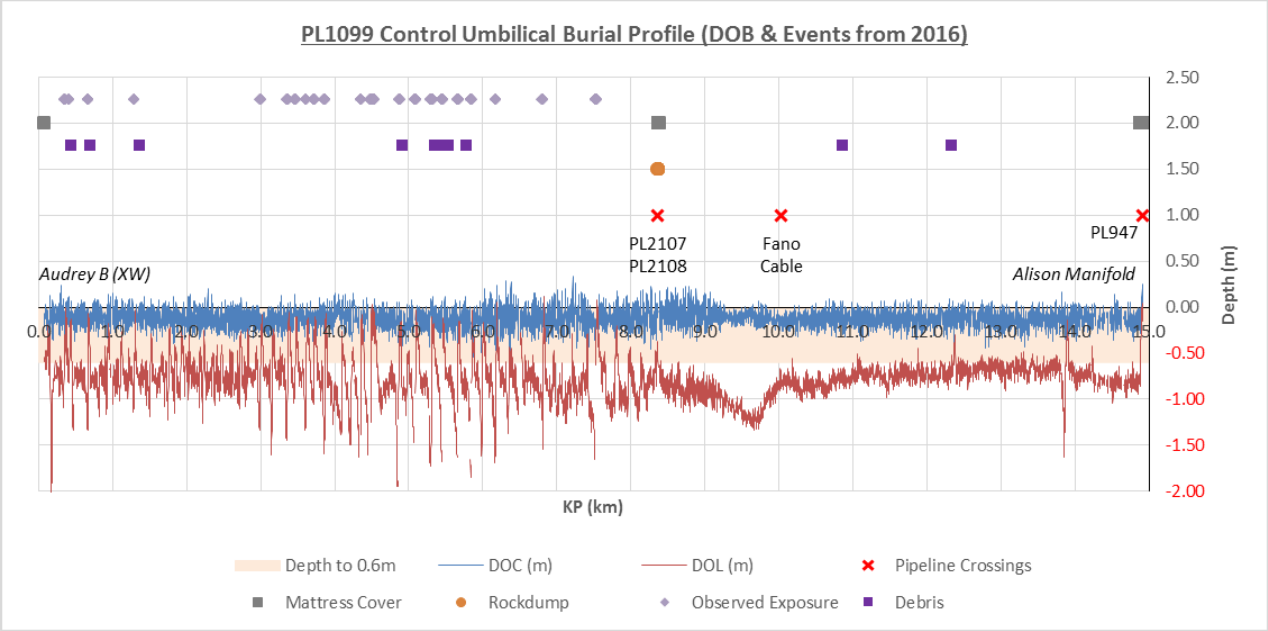

Figure 3.3: Overall burial of PL1099 (Umbilical Audrey B (XW) to Alison)

Three pipeline and cable crossings[7] have been identified and are shown in Figure 3.3 and listed in Table 3.3.

Pipeline or Cable Description	Crossing KP	Protection
PL2107 14" gas export pipeline from Saturn ND to LOGGS RP	KP8.38	PL1099 protected with concrete mattresses and overlain with rock
PL2108 3" methanol line from LOGGS RP		
BT Telecoms Cable from Weybourne to Fano (Dead) (under PL1099)	KP9.87	PL1099 trenched and buried. Not protected and no longer used
PL947 12" gas export line pipeline from Ann manifold to LOGGS RP	KP14.93	PL947 trenched & buried, mattresses under PL1099 and mattresses on top

Table 3.3: PL1099 Pipeline & Cable crossings

PL947 is owned by Centrica and is being addressed as part of this comparative assessment report. PL2107 & PL2108 are owned by ConocoPhillips.

The umbilical was trenched and allowed to naturally backfill along its length. The BEIS Guidance Notes state that in most cases burial or trenching to a minimum depth of 0.6m above the top of the pipeline is necessary for pipelines decommissioned *in situ*. In this instance, the burial profile of the first half of the pipeline between 'Start' and KP8.0 suggests that the pipeline

is prone to an increasing number and lengths of exposures. Although individually these are short in length they appear to be increasing with time. The second half of the pipeline between KP 8.0 and 'End'.1 has remained buried to depths usually around 0.6m below the level of adjacent seabed but are fewer sand waves in the area and so we believe that the pipeline will remain stable.

The BEIS Guidance Notes [1] state that in most cases burial or trenching to a minimum depth of 0.6m above the top of the pipeline is necessary for pipelines decommissioned *in situ*. On balance most the umbilical is buried to a depth greater than 0.6m below mean seabed.

The presence of the pipeline crossings over PL1099 has not unduly influenced the comparative assessment for pipeline PL1099 although clearly such influences need to be accounted for.

Proposals for decommissioning this pipeline are examined in this comparative assessment.

3.4 PL2164 Ann A4 6" production spool pieces to Ann manifold

PL2164 is a short pipeline 128m long routed from Ann A4 to the Ann manifold. It comprises a number of surface laid pipespools. The pipeline is protected and stabilised using concrete mattresses. As it is surface laid we propose to fully remove this pipeline and associated protection and stabilisation features.

As this pipeline is surface laid, from a comparative assessment perspective we believe that the benefits of removal would outweigh those for leaving the pipeline *in situ*. Therefore, as this approach is in full compliance of para 10.8 of the BEIS Guidance Notes [1], we propose not to subject this pipeline to comparative assessment.

3.5 PL2165 Ann A4 pipeline from Ann manifold to Ann A4

PL2165 is a short control and chemical injection jumper 165m long routed from the Ann manifold to Ann A4 wellhead. It is described as an electro-hydraulic composite control and chemical injection jumper. The pipeline is protected and stabilised using the same concrete mattresses used for PL2165[9]. As it is surface laid we propose to fully remove this pipeline and associated protection and stabilisation features.

As this pipeline is surface laid, from a comparative assessment perspective we believe that the benefits of removal would outweigh those for leaving the pipeline *in situ*. Therefore, as this approach is in full compliance of para 10.8 of the BEIS Guidance Notes [1], we propose not to subject this pipeline to comparative assessment.

3.6 Pipeline crossings

The pipelines considered in this comparative assessment either cross over cables and pipelines installed previously or are crossed by newer pipelines as illustrated in Figure 3.4. This can be determined by the pipeline number. A higher pipeline number crosses over the top of a pipeline with a lower identification number, so for example, PL1099 crosses over PL947.

[9] The Ann Pre-Decommissioning Survey Report [7] section 2.5.1 refers to three mattresses on PL947. We have associated these mattresses with PL2164/PL2165 rather than PL947

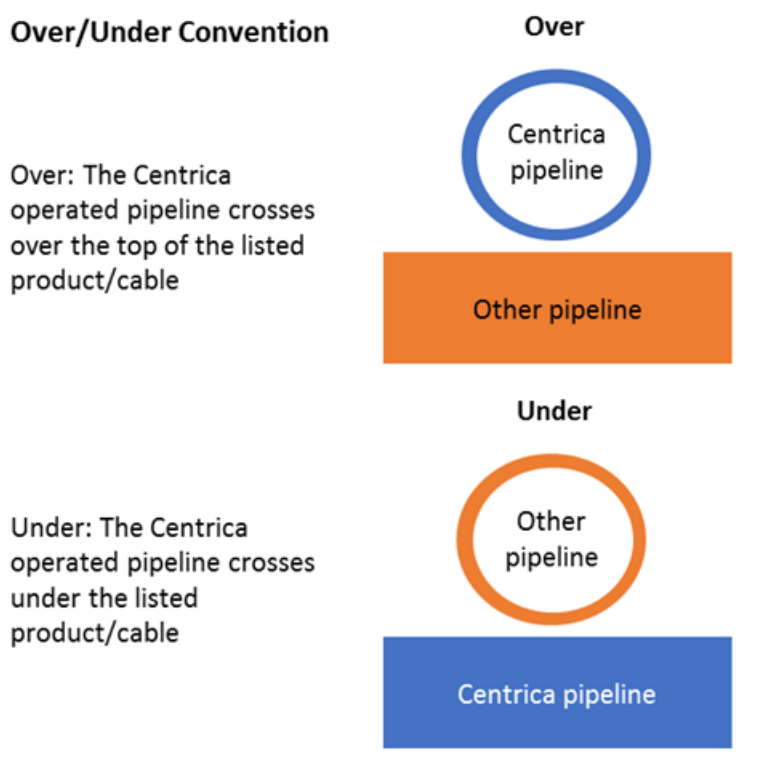

Figure 3.4: Over/under convention for pipeline crossings

4. DECOMMISSIONING OPTIONS

4.1 Decommissioning the pipelines

The options detailed in this section are those that have been included in the comparative assessment process. The pipelines are separate and are therefore considered individually. Therefore, the options for decommissioning these pipelines are independent.

There is an implicit assumption that options for re-use of the pipelines have been exhausted by Centrica prior to the facilities moving into the decommissioning phase and associated comparative assessment; therefore, this option has been excluded.

In general terms three options are considered for decommissioning the pipelines, although depending on the pipeline being assessed the number of options may reduce to two, because there is little to differentiate at least two of the three options:

- **Complete removal** – This involves the complete removal of the pipelines by whatever means would be most practicable and acceptable from a technical perspective. In the event a pipeline is crossed over by a third-party pipeline, the pipeline would be cut either side of the third-party crossing;
- **Partial removal or remediation** – This will either involve removing poorly buried or potentially unstable sections of pipelines or doing what other remedial work we believe would be necessary to make the pipeline safe for leaving the remainder *in situ*;
- **Leave *in situ*** – This involves leaving the pipeline *in situ* with no remedial works but possibly verifying the stability of the pipeline via future surveys

By implication, all options would involve removing short ends exposed on the seabed as well as the pipelines in the trench transition areas not covered with rock, so these elements are not considered as differentiators in this comparative assessment process. All options include removal of features such as spool pieces, mattresses and grout bags in accordance with mandatory requirements unless explicitly stated otherwise.

The short ends associated with the pipeline approaches and exposed on the seabed are illustrated in Figure 4.1 as follows:

PL947: Items 6, 11, 16

PL948: Items 17, 18

PL1099: Items 13, 14, 19, 20

Further details of the pipeline decommissioning options are described in sections 4.1.1, 4.1.2 and 4.1.3. The activities detailed in these sections are expected to be undertaken using different vessel types. Vessel types might include a construction support vessel (CSV), a dive support vessel (DSV), or a pipelay vessel or a mixture of all three, depending on the activities being undertaken.

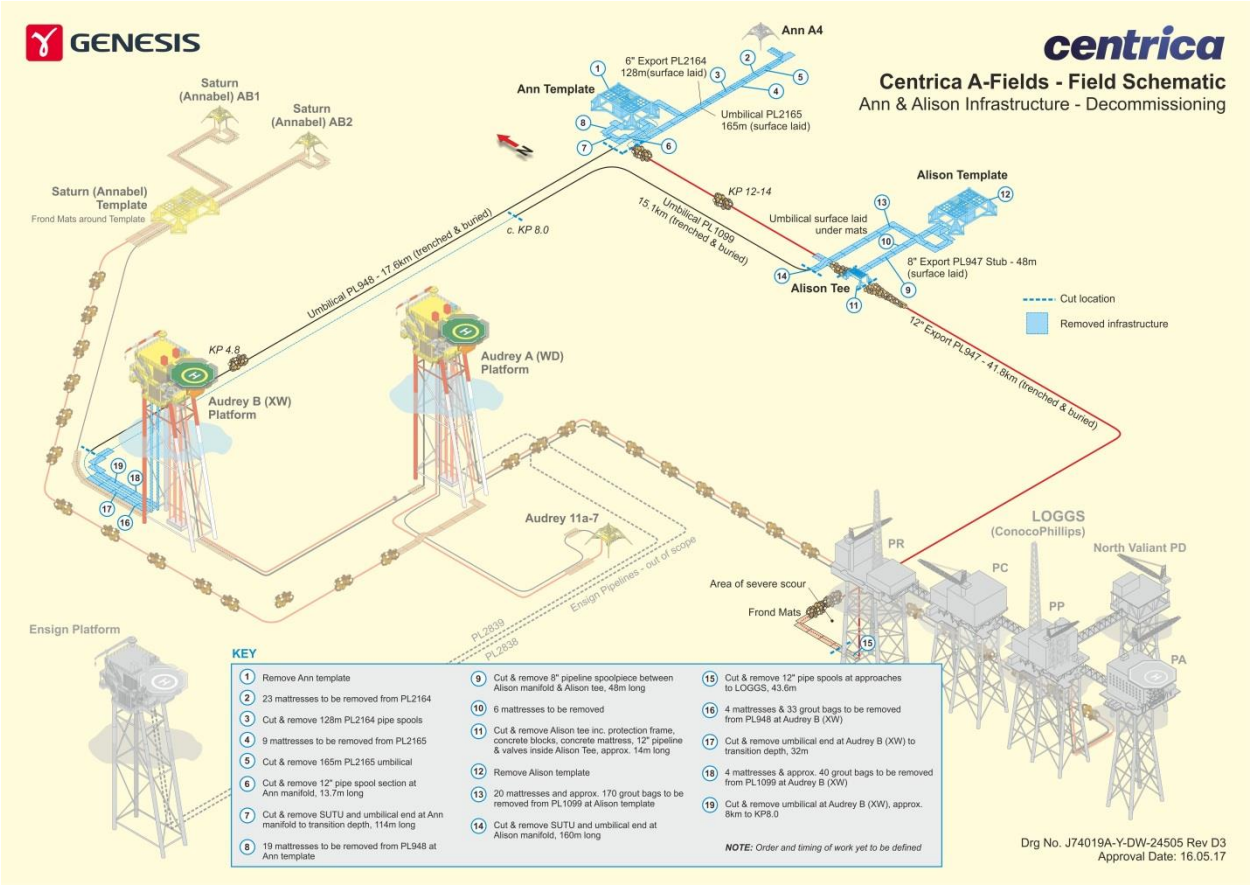

Figure 4.1: Proposed decommissioning solution

4.1.1 Options and methods for decommissioning PL947

ID[10]	Item	Option 1 Complete Removal	Option 2 Partial Removal	Option 3 Leave *in situ*
1	12" pipe spools exiting Ann manifold, 13.7m long	Remove. *Cut pipe on approach into rock using remotely operated cutting equipment and lift pipe to CSV. Return pipe to shore for processing*	Remove*. As option 1*	Remove*. As option 1*
2	12" pipeline	Remove. *Uncover the buried pipeline ahead of removal operations using mass flow excavator; recover pipelines by spooling onto to a suitable vessel such as a pipelay vessel. The vessel used would be dependent on cost, but essentially recovery works would be supported by ROVSV. A typical vessel might be able hold 15km of pipe at one go so would need three trips to port to offload to pipeline. Return pipe to shore for cutting into transportable lengths and processing*	Remove poorly buried or potentially unstable sections at KP3.4 (24m), KP4.7 (22m), KP6.1 (109m), crown exposures KP26.2 (9m), KP26.3 (24m), and intermittent exposures from KP33.5 (186m)and leave acceptably buried or acceptable stable sections *in situ*. Leave potentially poorly buried 12" pipeline in sandbank area in vicinity of between KP31.0 to KP33.0 *in situ* *Method for individual lengths of pipe would be to locally excavate, cut and lift*	Leave entire pipeline *in situ* with no remedial works to rectify any exposed sections of pipeline
3	8" pipeline spool pieces between Alison manifold and Alison tee, 46m long	Remove. *Pipespools disconnected or cut and recovered to CSV. Return pipe to shore for processing*	Remove*. As option 1*	Remove*. As option 1*
4	Alison Tee including protection frame, concrete blocks, concrete mattresses, 12" pipeline and valves inside Alison Tee, approx. 14m long	Remove. *Cut pipeline either side of Alison Tee where it enters the rock cover and recover to DSV. Return pipe to shore for processing* Remove. *Protection frame, concrete blocks and concrete mattresses and grout bags all completely removed, Existing rock cover left in situ but re-profiled. Recover frond mattresses if possible*	Remove*. As option 1*	Remove*. As option 1*
5	12" pipeline approaches at LOGGS, 43.6m	Remove. *Cut pipe and recover pipe between end of rock and LOGGS RP to CSV. Return pipe to shore for processing*	Remove exposed pipeline at LOGGS. *At LOGGS this would involve removing the final lengths of pipe between the rock and the LOGGS RP riser.* *Return pipe to shore for processing*	Leave exposed pipeline at LOGGS. *At LOGGS this would involve removing the final lengths of pipe between the rock and the LOGGS RP riser. Return pipe to shore for processing*

Table 4.1: Options for decommissioning PL947

[10] Items 1 & 5 are included for completeness, although the approach will be the same for all decommissioning options being considered

4.1.2 Options and methods for decommissioning PL948

ID[11]	Item	Option 1 Complete Removal	Option 2 Partial Removal or Remedial Work	Option 3 Leave *it situ*
1	Umbilical end adjacent to Audrey B (XW) to transition depth, 32m long on seabed	Remove. *Remove concrete mattresses and grout bags to expose umbilical. Disconnect from TUTU on platform topsides and connect rigging to subsea end excavated at transition depth. This may also involve local excavation. Pull section out from bottom of J-tube to deck of Dive or Construction Support Vessel using winch[12]. Cut into manageable lengths using remotely operated cutting equipment supported by CSV. Return to shore for processing*	*Complete removal, as option 1*	*Complete removal, as option 1*
2	Buried umbilical from transition depth at Audrey B (XW) to start of transition on approach to Ann manifold	Remove. *Pull umbilical out through covered trench and onto a reel mounted on a vessel, probably a DSV or CSV. Return to shore for cutting into manageable lengths and processing*	Leave *in situ*. As option 3	Leave *in situ.* No work
3	Exposure at KP0.8, approx. 8m long, and intermittent exposure at KP2.4, 39m long	Removed as part of overall umbilical removal activity	Remove. *Locate poorly buried sections, expose end extremities by local water jetting, cut using remotely operated cutting equipment, and connect to winch for recovering to deck of vessel. Recover to deck of DSV and return to shore for processing*	Leave *in situ.* No work
4	SUTU and umbilical end at Ann manifold, 114m long	Continue to remove as part of overall umbilical removal activity	*Remove concrete mattresses and grout bags to expose the surface laid umbilical and excavate to transition depth. This may involve local excavation. Cut into manageable lengths using remotely operated cutting equipment. Return to shore for processing*	*Complete removal, as option 1*

Table 4.2: Options for decommissioning PL948

[11] Items 1 & 4 are included for completeness, although the approach will be the same for all decommissioning options being considered
[12] An alternative approach would be to cut the umbilical at the bottom of the J-tube and recover to topsides; best method to be determined during detailed design

4.1.3 Options for decommissioning PL1099

ID[13]	Item	Option 1 Complete Removal	Option 2 Partial Removal or Remedial Work	Option 3 Leave *it situ*
1	Umbilical end at Audrey B (XW), 138m long on seabed	Remove. *Disconnect from TUTU on topsides, connect rigging to subsea end excavated at transition depth and pull section out from bottom of J-tube to deck of DSV using winch. Cut into manageable lengths using remotely operated cutting equipment. Return to shore for processing*	Remove*. As option 1*	Remove*. As option 1*
2	Buried umbilical (first half); Start to KP8.0	Remove. *Pull umbilical out through covered trench and onto a reel mounted on a vessel, probably a DSV. Return to shore for cutting into transportable lengths or weights and processing*	Remove several individually exposed sections[14]	Leave *in situ.* No work
3	Buried umbilical (second half); KP8.0 to end at Alison manifold	Remove. *Continue recovery operations from first half of umbilical*	Leave *in situ*, as option 3. No work.	Leave *in situ.* No work
4	SUTU and umbilical end at Alison manifold, 160m long; this includes the section of umbilical that crosses over PL947	Remove. *Remove concrete mattresses to expose the surface laid umbilical and excavate to transition depth. Cut into umbilical pipeline manageable lengths using remotely operated cutting equipment and recover to DSV. Return to shore for processing*	Remove. *As option 1*	Remove*. As option 1*

Table 4.3: Options for decommissioning PL1099

[13] Items 1 & 4 are included for completeness, although the approach will be the same for all decommissioning options being considered

[14] Up to 30 individual exposures totalling 149m in length (Alison Pre-Decommissioning Report [6] section 2.4.1 refers to 30 exposures totalling 157m with the longest being 130m; the apparent discrepancy is due to different interpretations of the available data) have been identified within the first 8km of umbilical. Should sections of exposed umbilical be cut and removed it's possible that the ends would present a greater long-term threat to interactions with fishing activities in the area. Furthermore, the cover of the exposures and any cut ends could present an increased risk to the mariners. However, we are not aware of any physical snagging having occurred, and no exposed lengths of umbilical have warranted reporting to FishSAFE

4.2 Dealing with pipeline crossings

The various pipeline and cable crossings will impact or be impacted by the decommissioning options described in section 4.1. The potential impacts are summarised in Table 4.4 and illustrated in Figure 4.2, although we have not considered this level of detail in the comparative assessments.

Decommissioning Option	Newer Pipeline on Top	Older Pipeline or Cable Underneath[15]
Full removal	Cut Centrica pipeline either side of third-party pipeline crossing	No impact on option
Partial removal or remedial work	No impact on option as none of the partial removal options involve removing pipelines from underneath; leave CENTRICA pipeline i*n situ*	No impact on option
Leave *in situ*	No impact on option as none of the3 leave in situ options would involve removing a pipeline from underneath another pipeline; leave CENTRICA pipeline *in situ*	No impact on option

Table 4.4: Impact of pipeline crossings on pipeline decommissioning options

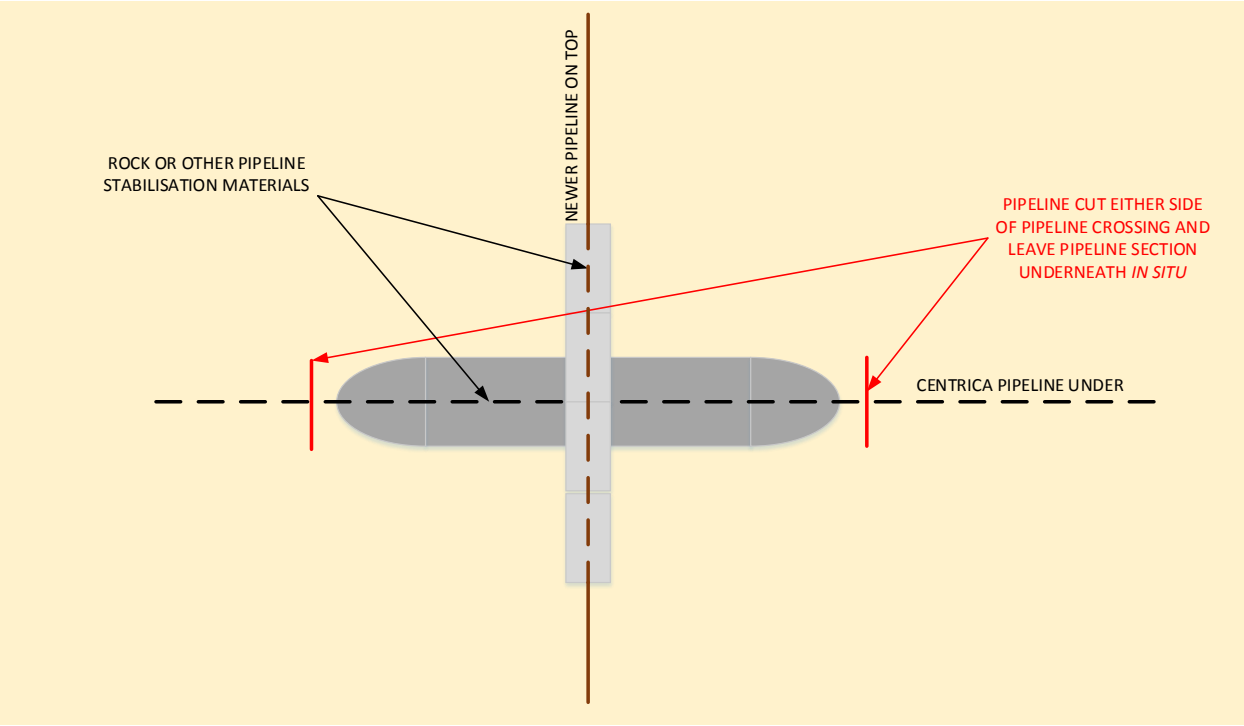

Figure 4.2: Pipeline underneath being removed

Unless stated otherwise herein – for example, when dealing with bitumen mattresses, we would propose to leave the pipeline crossings undisturbed, so any concrete mattresses overlain with deposited rock will remain *in situ*.

4.3 Decommissioning of the concrete mattresses

The quantity of mattresses that need to be removed is detailed in Appendix A. An interrogation of recent survey data (May 2016) would suggest that the concrete mattresses are of the 'flexible' concrete mattress type, articulated to flexible along and across pipeline being

[15] Although it is noted here that there would be discernible impact on the decommissioning option, permission would need to be granted from the owner of the older pipeline to carry out any works in the vicinity

protected, rather than the 'log'-type which is only flexible in one direction. These are available from several different manufacturers, including Subsea Protection Systems Ltd (1990s), Pipeshield (1999), etc.

Typically, mattresses are provided in a standard size 6m x 3m or 6m x 2m and can be supplied with blocks that are 150mm, 300mm and (less frequently) 450mm thick. Typically, the concrete blocks are held together with polypropylene rope, and this is also looped around the edges to allow the mats to be lifted and moved into positon.

The concrete material of manufacture can be customised in a range of densities from standard (1850kg/m^3) to high (4850kg/m^3). The availability of the different dimensions and type depend on manufacturer.

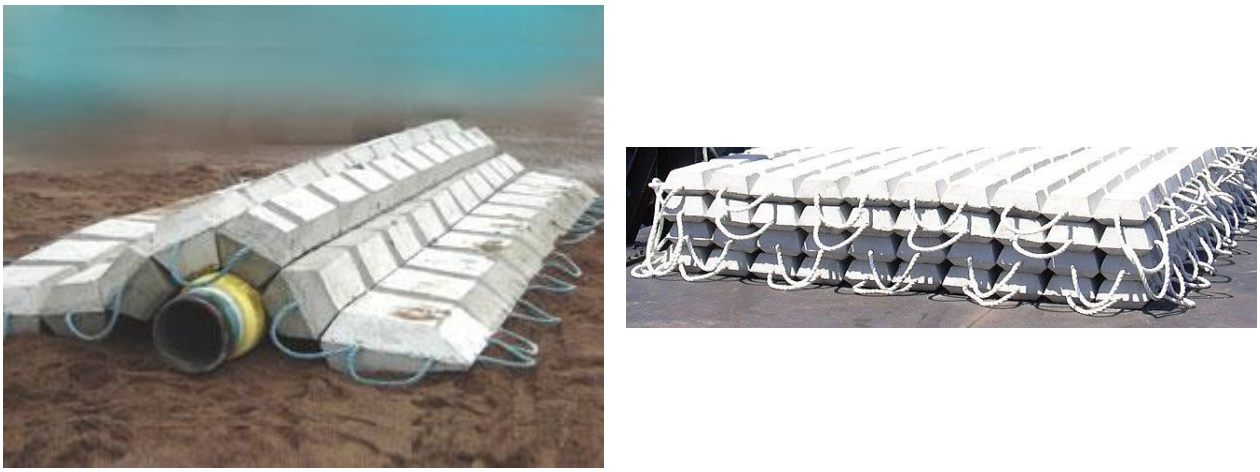

Figure 4.3: Typical Concrete Mattresses[16]

Older concrete mattresses were manufactured using steel rope, although this material is less durable. If the mattresses have been in location for a long-time its condition usually precludes using the loops for lifting and often results in the concrete mattress disintegrating as attempts at recovery are made.

The intention is to remove all the accessible[17] concrete mattresses. The recoverability of a mattress is heavily influenced by its condition. Mattresses that have become degraded are more difficult and dangerous to recover and have less scope for re-use once recovered. In this case, however, as we have test lifted one of the concrete mattresses at Ann template in January 2016, and as the mattresses are of a similar vintage as those at Alison we believe that the condition of the concrete mattresses at both Ann and Alison is such that they can be fully recovered. Should we encounter any difficulties during recovery operations we shall discuss possible solutions with BEIS.

4.4 Decommissioning of the bitumen concrete mattresses

Bitumen mattresses provide stabilisation and protection to pipelines in the same way as concrete mattresses, although they are used in circumstances where concrete is considered too abrasive. They support and protect pipelines and cables with a cushioned interface to reduce the threat of damage from sharp edges. They are manufactured from a blend of mastic and concrete. They are not extensively used in A Fields. As per Table 9.1, three bitumen mattresses measuring approximately 4m x 2.5m x 1500m thick are used to protect PL1099 at the PL947 pipeline crossing north-west of the Alison Tee (Figure 4.4). Although we have not found any

[16] Picture courtesy of Subsea Protection Systems Limited and Pipeshield Limited
[17] That is, not those buried under rock or under crossings

specific design details we believe the mattresses have a nominal mass in air of 3,700kg.

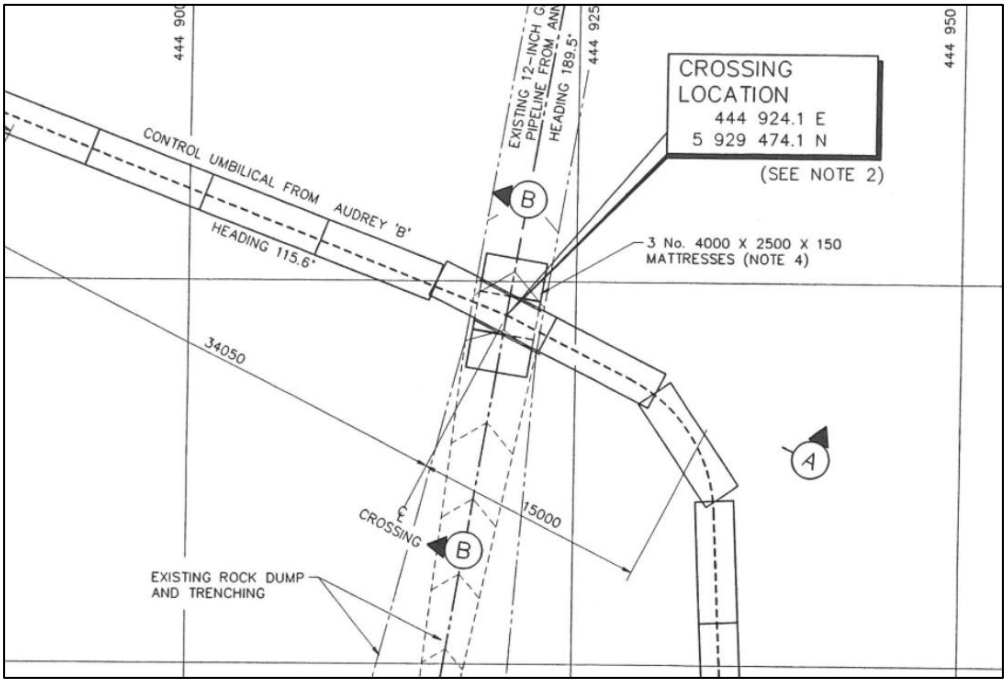

Figure 4.4: Bitumen mattresses at PL1099 over PL947 pipeline crossing[18]

The recoverability of a bitumen mattress is heavily influenced by its condition. Mattresses that have become degraded are more difficult and dangerous to recover and have less scope for re-use once recovered. At the time of writing we have not been able to establish whether the bitumen mattresses could be physically recovered without incident, although we will know more if the overlying concrete mattresses that protect PL1099 can be removed. Any removal method will need to take account of the proximity of any underlying pipeline PL947. Any removal method will need to take account of the proximity of the rock on the approach to the Alison tee. Our decommissioning proposals would involve leaving any rock in the area otherwise undisturbed to provide ongoing protection.

4.5 Decommissioning of the fronded mattresses

When a pipeline or structure is placed into an area with a loose sedimentary material, under certain conditions the flow of water can cause erosion of the seabed, and this is called scour. Scour around a structure or pipeline will undermine its stability, and so is undesirable.

Fronded mattresses are put in place to provide protection against scour, and when they do their job the fronds act like natural seaweed, and silt and sediment that is carried in the water column builds up within the fronds. Eventually they become buried. Given the right conditions they can be very effective.

In general terms, there are two basic types of frond mattresses: the anchor retained type and the gravity-based type, but they both perform the same basic function. The anchor retained type are typically rolled out as a sheet and pegged into the seabed, whereas gravity-based types might use concrete or some other medium to hold them in place while they become buried.

[18] Note 4: 'Seamat' Bitumen Mattress or equivalent

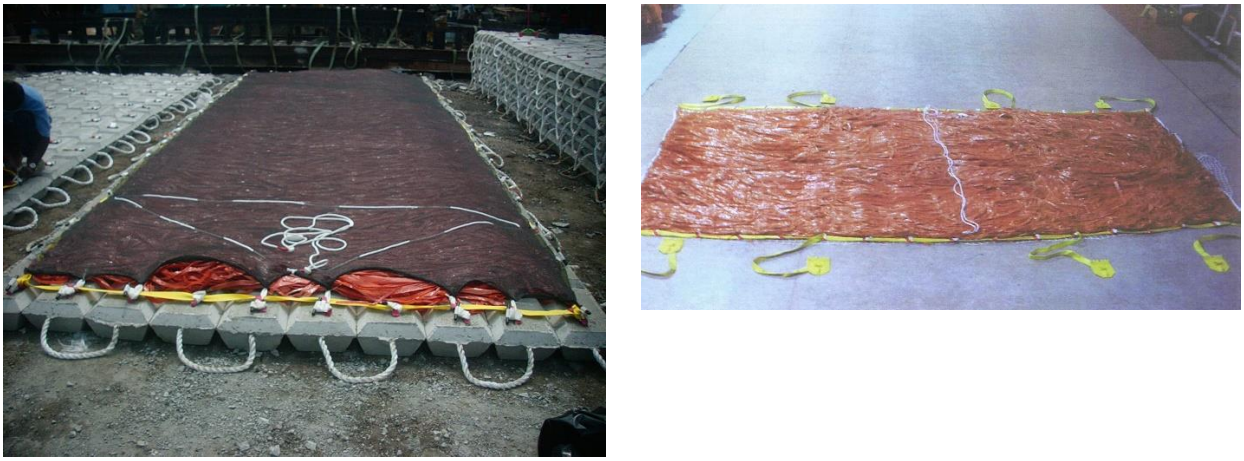

Figure 4.5: Typical Fronded Mattress Types (gravity based & anchored)[19]

Frond mattresses are used to a lesser extent than concrete mattresses in the south North Sea [10]. The quantity of frond mattresses that need to be removed is detailed in Appendix A. We have identified that several frond mattresses were installed to protect the Ann and Alison template structures as well as the Alison tee and PL947 at LOGGS although we have not been able to determine the design details or how they were designed to stay in place with absolute certainty. The indications are that they have performed their function and are now indistinguishable from the surrounding seabed.

- 10 frond mattresses 5m x 5m x 2.5m high around the Ann template
- 4 frond mattresses 5m x 5m x 1m high at the Alison Tee
- 10 frond mattresses 5m x 2.5m x 500mm high on the LOGGS approach
- 2 frond mattresses 5m x 5m x 1m high at Alison template

Much of their thickness is manufactured from flexible material designed to accumulate seabed sediment and as such we don't believe that they would present a snagging hazard. Therefore, we would propose to decommission the frond mattresses by leaving them *in situ*.

4.6 Decommissioning of the 'grout bags'

The number of grout bags has been estimated using engineering judgement based on available data such as as-built drawings, design sketches and Pipeline Works Authorisations.

The intention will be to remove all the grout bags when decommissioning the pipelines. However, although several different methods could theoretically be used to remove the grout bags, from a practical perspective we don't know whether the bag material has remained intact.

[19] Photos courtesy of http://www.sscsystems.com/

5. COMPARATIVE ASSESSMENT FOR PIPELINES

5.1 Method

Much of the comparative assessment is qualitative, carried out at a level sufficient to differentiate between the options. However, in some cases, such as cost, it is necessary to examine the differences in more detail and quantitatively to provide clarity. The comparative assessment considers the following generic evaluation criteria and specific sub-criteria in line with BEIS and Centrica Guidance [1] and [3]. These elements are considered for short-term work as the assets are decommissioned as well as over the longer-term as 'legacy' impacts and risks.

- Technical:
  - Risk of major project failure
- Health & Safety:
  - Risk to offshore project personnel
  - Risk to other users of the sea
  - Risk to onshore project personnel
- Environment:
  - Emissions to atmosphere
  - Effect on seabed
  - Impact on Special Area of Conservation
  - Effect on water column
  - Waste
- Societal:
  - Effect on commercial activities
  - Employment
  - Communities or impact on amenities
- Cost

No scores have been determined but risk matrices have been used to determine if the planned impacts and unplanned impacts would be for example broadly acceptable, possibly acceptable unlikely to be acceptable or not acceptable. Cells coloured red indicate high risk or high impact and less desirable outcomes. Green coloured cells indicate less risk, less impact and more desirable outcomes. Cells coloured orange sit in-between red and green and may or may not be less, or more, desirable. High costs also attract a 'less desirable outcome' but cost differences are compared relative to each other. A relatively high cost therefore would be coloured red whereas a relatively low cost would be coloured green. It should be noted that societal score looked at beneficial outcomes as well as detrimental outcomes.

To simplify the assessments PL947 and PL1099 were split into segments to reflect the varying bathymetry along the pipelines or to acknowledge that one single decommissioning option might not necessarily apply to the whole pipeline. PL948 was not segmented but is included in Table 5.1 for completeness.

We describe an 'approach' as the first part of a pipeline as it leaves its point of origin or the final part of the pipeline as it reaches its destination. On leaving its point of origin, a pipeline 'approach' might typically entail a stretch of pipeline that is surface laid and protected by concrete mattresses, grout bags or rock, or combinations thereof, as it leaves and progresses along a transition until it reaches the design trench depth or the reverse as the pipeline reaches its destination.

As described earlier we propose to decommission the approaches for each pipeline in the same way irrespective of the decommissioning option chosen for the pipeline segments, so the approaches are not included in this assessment. However, for completeness they are included

in Table 4.1, Table 4.2, Table 4.3 and Table 5.1

PL947 Segments	PL948 'Segments'	PL1099 Segments
Ann approach	Audrey B (XW) approach	Audrey B (XW) approach
Ann manifold to edge of sandbank area (KP31.0) incl. Alison tee	Audrey B (XW) to Ann manifold	'Start' (i.e. end of approach) to KP8.0
Sandbank area between KP31.0 and KP33.5	Ann approach	KP8.0 to 'End' (i.e. start of final approach)
Edge of Sandbank area (KP33.5) to LOGGS		Alison approach (extending as far back as the PL947 crossing)
LOGGS approach		

Table 5.1: Segmentation of PL947, PL948 & PL1099

5.1.1 Technical Assessment

The technical aspect of the assessment is concerned with the technical feasibility of the decommissioning options. Technical feasibility confirms whether the approach being assessed is physically possible given the technical issues to be addressed, and the risk of failure that is presented.

The technical evaluation is simply the application of a measure to express the complexity of a job, which can be expected to proceed without major consequence, or failure, if it is adequately planned and executed.

5.1.2 Safety Assessment

Definition: An assessment of the potential health and safety risk to people directly or indirectly involved in the programme of work offshore and onshore, or who may be exposed to risk as the work is carried out. Health and safety risk is assessed using three specific sub-criteria.

Sub-criteria:

1. The health and safety risk for project personnel who would be engaged in carrying out decommissioning activities offshore are presented in Table 5.2:

Example Description of Hazard	Who is at risk?
Loss of dynamic positioning leading to uncontrolled movement of vessel and pipeline(s), hydrocarbon release, dropped objects	Diving personnel underwater; platform if operations are being carried out inside platform 500m safety zone
Limited experience surrounding the process for recovering trenched and buried pipelines [7]. Pipeline parting or buckling during reverse reeling operations; uncontrolled movement of pipelines and associated reeling and recovery equipment	Vessel based personnel and very expensive assets
Sudden movements during pipeline recovery works leading to dropped objects or swinging loads	Diving personnel, vessel based personnel, vessel based assets (e.g. Remotely Operated Vehicles)
Collision between vessels and offshore structures due to mix of shipping lane traffic, product transport vessels, supply and maintenance barges and boats, drifting boats	Offshore personnel and assets
Residual hazardous materials such as methanol, chemicals from umbilical cores, wax deposits, hydrocarbons or NORM from within pipelines released to the local marine environment	Divers and vessel based personnel

Table 5.2: Description of offshore hazards

2. The residual risks to marine users on successful completion of the assessed decommissioning option are presented in Table 5.3:

Example Description of Hazard	Who is at risk?
Exposed pipeline or umbilical sections leading to snagging risk	Other users of the sea, predominantly fishing vessels

Table 5.3: Description of residual hazards to mariners

3. The safety risks for project personnel who would be engaged in carrying out decommissioning activities onshore are presented in Table 5.4:

Example Description of Hazard	Who is at risk?
Residual hazardous materials such as methanol, chemicals from umbilical cores, wax deposits, hydrocarbons or NORM from within pipelines released to the local onshore environment	Hazardous or toxic substances affecting onshore personnel
Onshore cutting – sharp edges and repetitive operations when dismantling pipelines	Onshore personnel
Unplanned sudden movements during pipeline dismantling works leading to dropped objects or swinging loads	Onshore personnel

Table 5.4: Description of onshore hazards

Assessment of sub-criteria:

The difference in potential safety risks between the options is sufficiently large that a HAZID was not deemed to be required at this stage. A Hazard Identification (HAZID) workshop will be carried out when the selected option is developed in more detail. For the purposes of the comparative assessment in lieu of a HAZID a high-level review of the differences was undertaken and correlated to the duration of activities that would be required.

Only those hazards giving rise to difference between the options were assessed. Examples of this are:

- Where a hazard exists for one option but not the other (e.g. risks relating to pipeline failure during reverse reel lay recovery)
- Where the hazard exists for both options but is different in magnitude (e.g. risks relating to dropped objects if whole pipeline is recovered to shore (to be cut into transportable pieces)

From this a discussion of the key contributors to the differences between options - the differentiators, is presented below.

5.1.3 Environmental Assessment

The comparative assessment uses two sub-criteria for the assessment of environmental impacts. These are described below.

Definition: An assessment of the significance of the risks/impacts to the environmental receptors because of activities or the legacy, separated into the following specific sub-criteria.

Sub-criteria:

1. Short-term environmental impacts of operational activities;
    - Emissions to atmosphere
    - Effect on seabed
    - Impact on Special Area of Conservation
    - Effect on water column
    - Waste
2. Legacy environmental impacts due to what would be left behind
    - Emissions to atmosphere
    - Effect on seabed
    - Impact on Special Area of Conservation
    - Effect on water column
    - Waste

Assessment of sub-criteria:

The environmental assessment considers the impacts of the decommissioning options.

Environmental impacts include consideration of such impacts on the atmosphere (energy and emissions), seabed (area impacted and material mobilised into water column), Special Area of Conservation (area impacted as a percentage of the overall SAC), the water column (vessel discharges and effect of material lifted in the water column) and waste (fate and quantity of material) in the short-term due to project related activities and over the longer–term due to legacy activities offshore.

Only the *differentiators* between decommissioning options were included in the overall assessment.

The sub-criteria are qualitative and assessed per the Centrica Environmental Impact Assessment matrix [3]. Based on experience we can conclude that energy use and the associated emissions to air are unlikely to significantly contribute to greenhouse gas emissions or global warming impacts: total direct carbon dioxide (CO_2) emissions generated by the proposed decommissioning are 6,448Te. In relation to the total CO_2 produced from domestic shipping the direct CO_2 emissions from the decommissioning of the Ann and Alison facilities is c. 0.07%. The numbers and the effect on the overall environmental scoring are trivial.

A full assessment of the environmental impacts of the selected decommissioning option can be found in the Environmental Impact Assessment [4].

Sub-criteria definitions:

Note that the emissions to air and energy requirements are *representative,* although not the same, of the fuel and energy input data used for waste handling activities.

The environmental assessment was developed by identifying the interactions with the environment for the activities required for each of the options. Activities that were not differentiators were not considered. Those remaining activities with associated interactions with the environment were assessed for consequence and duration to ascertain the potential level of significance of the environmental impact.

Environmental impact of operational activities

The environmental impact of operational activities undertaken to decommission considered:

- Durations of vessels used in the field for the decommissioning activities and legacy surveys. The interactions with the environment (activity which has the potential to impact the environment) which differed between options were:
  - liquid discharges from vessels
  - noise in water from vessels
  - emissions to air and energy requirements
- Amount of cutting, lifting and disposal required. The interactions with the environment which differed between options were:
  - liquid discharges to sea
  - liquid discharges to surface water
  - noise in water
  - seabed disturbance
  - resource use – landfill space

Environmental Assessment of impact on SAC

The environmental impact on the SAC considered the area of the seabed that could be directly affected by decommissioning activities, and how long it would take the area affected to recover.

Environmental impact of legacy activities

The environmental impact of legacy activities undertaken are considered in the same way as impact of operational activities.

5.1.4 Societal Assessment

Definition: An assessment of the significance of the impacts on societal activities, including offshore and onshore activities associated with the complete programme of work for each option and the associated legacy impact. If carrying out as quantitative assessment this would include an estimate of all the "direct" societal effects (e.g. employment on vessels undertaking the work) as well as "indirect" societal effects (e.g. employment associated with services in the locality to onshore work scope, accommodation, etc.). However, our assessment is qualitative.

Sub-criteria:

1. Effects on commercial activities
2. Employment
3. Communities or impact on amenities

Assessment of sub-criteria:

A qualitative assessment has been undertaken to differentiate between options from a societal perspective. This was undertaken through review of relevant data, discussion and textual descriptions. Generally, the qualitative approach assumes that an increase in offshore activities, vessel time and amount of material being recovered would lead to an incremental increase in employment.

5.1.5 Cost Assessment

Only the incremental costs of the main offshore decommissioning activities are compared, with owners' costs such as engineering, management, insurance, procurement and logistical costs contributing to the difference as a percentage (12.5%) of the offshore work. To simplify the assessment, we have concentrated on the different vessel types that would be required for a specific activity and how long the vessel would be required for. Although different for different activities, common elements such as mobilisation costs and decommissioning of pipeline ends are not included on the assumption that they would be decommissioned in much the same way irrespective of which option was being pursued.

For this assessment complete removal represents the full scope and other options are compared to this.

We compare the difference in cost for like-for-like activities in the short-term as well as for legacy related activities in the longer-term. From a legacy perspective, all decommissioning options would involve carrying out an environmental survey at the end of offshore works, so this would not differentiate the costs over the longer-term. Legacy survey costs will be different depending on the option. For example, no legacy surveys would be required for the complete removal option.

This shows the difference in incremental cost as being comparable to the other evaluation criteria (i.e. safety, environmental, technical and societal) and it allows an understanding of the *significance* of the difference.

In the assessment tables that follow we indicate the acceptability or otherwise of the costs. We do, however, recognise that the cost of an option would only be *acceptable* if the other aspects of the comparative assessment show that this would be preferred.

If the incremental difference in cost for one option is assessed to be an order to magnitude greater than the other options being considered it is assessed as being 'Tolerable & non-preferred'.

5.2 PL947 Comparative Assessment

The detailed assessment involved examining PL947 as three distinct sections:

- Ann to Sandbank area @ KP31
- Sandbank area (KP31 to KP33.5)
- Sandbank to LOGGS RP

For the purposes of this report, Table 5.6 summarises the assessment over the whole length of the pipeline. The colour coding - green being best - indicates whether the risks are broadly acceptable or tolerable. It should be noted that these risks are for the *differences* between options only. There is little to distinguish partial removal from leave *in situ* because there is only a small section of pipeline that would need to be dealt with under partial removal.

5.2.1 Technical Assessment

Please note that dealing with the pipeline approaches will be common for all decommissioning options and so is not used to differentiate the options.

We believe that all decommissioning options for PL947 are technically feasible, although if the pipeline was installed using the s-lay technique the pipeline would not be a candidate for reverse reeling.

There is limited experience in reverse reeling trenched & buried pipelines in the UKCS [7], and as such the technical uncertainty was deemed likely to have an adverse impact on technical risk. Two alternatives are that it would need to be recovered in sections using ‘cut and lift’ or recovered using reverse S-lay. We believe although somewhat repetitive, the ‘cut and lift’ method would be the most feasible but would take a significant amount of time to carry out. This is the preferred method for short or discrete lengths of pipe, when it is impractical or prohibitively expensive to mobilise major removal equipment.

In contrast, operations that involve removal of relatively short lengths of pipe in discrete areas are well-established activities with little technical uncertainty. This option has been widely used for removing a short pipeline in its entirety, or for removing discrete lengths. It is usually the recommended removal option for short sections of pipe when it is impractical or prohibitively expensive to mobilise major equipment for removal.

For the pipeline to be removed either in its entirety or for removal of discrete lengths, apart from the short-exposed sections at each end, the pipeline would need to be removed from the backfill and from inside rock at the Alison tee. Subject to integrity checks theoretically this could be achieved by reverse reeling, either pulling it through the seabed material or more likely by removing the material first using specialist equipment such as mass flow excavation tools. Excavation using water jetting to remove the cover has been widely used for short lengths of pipeline, although this would be more time consuming and costly for the entire pipeline.

Sub-Criterion	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
Technical feasibility	**Short-term:** There is limited experience of reverse reeling of trenched & buried pipelines in the North Sea [7]. Further there is limited experience of using the 'cut and lift' method for removing pipelines of this scale. Some sections are covered with rock.	**Short-term:** Buried pipe has been uncovered and 'cut and lift' method can and has been used for removing relatively short sections of pipe so we know this is achievable	**Short-term:** Stable and buried pipelines have been left *in situ* before and we know this is achievable
	Legacy: No pipeline burial surveys would be required	**Legacy:** Depth of burial pipeline surveys have been undertaken by Centrica in the past, and from a technical perspective this is achievable with no complications	**Legacy:** Depth of burial pipeline surveys have been undertaken by Centrica in the past, and from a technical perspective this is achievable with no complications
Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.5: PL947 Technical Assessment

Summary of technical assessment

Three options were considered for PL947, and theoretically, given the right conditions - for example, no integrity issues can be foreseen - all three options can be considered technically feasible.

However, to achieve complete removal the pipeline would need to fully excavated to be exposed and then either reverse reeled onto a pipelay vessel or removed in sections using the cut and lift method. The reverse reel method has not been used before in the North Sea and although the 'cut and lift' method has been used for relatively short lengths of pipeline this approach has not been undertaken for pipelines 41.8km long. Therefore, complete removal has been classed as 'tolerable' but non-preferred.

As noted, the medium / tolerable rating is driven by uncertainties in the probability of success of either reverse reeling or the 'cut and lift' method, which although feasible is a non-preferred way of removing long pipelines, is considered to present risks to the delivery of the project.

As mentioned already, the cut and lift method has been used for recovery of short pipelines and so this option and leave *in situ* can both be regarded as technically feasible and would be preferred to complete removal using either of the methods described.

5.2.2 Safety Assessment

Safety Risk to Offshore Project Personnel

All hazards were assessed as broadly acceptable except for the risk associated with the heavy object on or near the vessel during reverse reeling. This was assessed as tolerable but non-preferred for complete removal. Similarly, although technically feasible - albeit repetitive - we would want to avoid the 'cut and lift' method of removal due to the length of pipeline being recovered. Key differences between the options are as follows.

The key differences between the decommissioning options are as follows.

- Risk to personnel on the vessel from hydrocarbon or hazardous substance releases from recovered pipelines will be greater for complete removal than for partial removal or leave *in situ* due to the larger volume of material that would be recovered;
- For the reverse reeling method, the risk associated with a heavy object – the pipeline and reel, on or near the vessel during reverse reeling but eliminated for partial removal or leave *in situ*. The risk to personnel and assets are greater for complete removal option compared to partial removal option or leave *in situ* where only a small part of the overall pipeline would

be removed;

- For the reverse reeling method, any risks to personnel from pipe buckling (and any associated corrective work) on or near the deck of the vessel or subsea would be eliminated for partial removal or leave *in situ*;
- Risk associated with the complete removal due to the uncertainties in performing reverse reeling method and in particular the integrity of the pipeline during recovery;
- Exposure to potentially NORM contaminated materials increases with the volume of material being recovered;
- Increased risk to all activities due to adverse weather is greater for complete removal than for partial removal or leave *in situ* as the time the vessel would be in the field is greater, irrespective of the removal method adopted;
- Risk associated with legacy survey activities that is, the risks associated with vessels being used is greater for partial removal than for complete removal. We've assumed that at least two legacy surveys would be required to confirm the condition of any pipelines or sections thereof left *in situ*;

There is little experience recovering a trenched and buried pipeline 41.8km long, but we believe that although associated risks would be higher for complete than for either partial removal or leave *in situ*, they would still be tolerable should sufficient mitigation and control measures be adopted.

Using the 'cut and lift' method, since the activities and techniques associated with pipeline removal are used in the North Sea, albeit not at this scale for complete removal, it is presumed that the risks from all hazards would be broadly acceptable providing sufficient mitigations are put in place for such repetitive work. This risk only really relates to the complete removal option since such activities would be more tolerable for partial removal or leave *in situ*.

Operational Safety Risk to Fishermen and Other Marine Users

There remains the possibility of interaction with other mariners while decommissioning works are being carried out in the field and this potentially would increase with the number of vessels, the location of the work and the frequency of marine traffic. Decommissioning activities involve vessels working in the field, and over the longer term will be related to the amount of surveys and any pipeline remedial works that may be required in future. By way of example, for PL947 vessel durations associated with the complete removal option will be greater than for the partial removal and leave *in situ*.

The greatest risk relating to marine users is likely to be concerned with snagging of fishing gear.

The type of fishing in the area is predominantly demersal trawling for flatfish. Therefore, there is a potential for snagging on equipment and spoil mounds left on the seabed. Data relating to pipeline burial status are shown in Figure 3.1. The data shows that excepting two short exposures 24m and 22m long respectively at KP3.4 and KP4.7, and some intermittent exposures for a length of 109m at KP6.1 for the most part the pipeline is trenched and buried consistently to a depth of greater than 0.6m. There are no data for the pipeline where it passes through a sandbank in relatively shallow water (approximately 11m LAT) between approximately KP31 and KP33.5. However, recent (2016) MBES data suggest that there are no exposures in this area. Survey data obtained periodically since would suggest that most of the pipeline has remained relatively stable throughout its entire length albeit with short exposures.

From this it can be reasoned that decommissioning activities that minimise the disturbance to the seabed will reduce the likelihood of creating new snag hazards and avoid leaving an open trench. Decommissioning activities that leave the seabed free of equipment will minimise the impact on local fishing activities; this will be no different from the current situation. Both complete removal and partial removal will leave the seabed free of equipment, while leave *in situ* will present risks that will remain as they are now. Although the complete removal option has the potential to leave open trenches that could present snagging hazards, it is possible that

with extra effort these could be filled, or they would disappear over time as occurred following installation.

The risk of snagging fishing gear and the risk of snagging equipment were assessed as broadly acceptable. The key differences between the options are:

- There would be a risk of snagging fishing gear on the pipeline in future for partial removal or leave *in situ* should the burial status change but this would be eliminated for complete removal;
- As the partial removal and leave *in situ* options leave a significant portion of the pipeline *in situ*, legacy surveys are required for these options. These legacy surveys have risks associated with the use of vessels that are not required for the complete removal option, and their work can be considered to be routine. Legacy related survey vessels would also be in the field for significantly less time than vessels involved in the complete removal and partial removal activities

Safety Risk to Onshore Project Personnel

All hazards associated with the handling of a large number of pipe lengths or associated with a heavy object (pipeline) on or near the vessel during reverse reeling were assessed as 'tolerable and non-preferred' for the complete removal option. The key differences between the options are as follows:

- Risks associated with cutting the pipeline and exposure of any residues, resulting in injury are greater for complete removal due to the higher quantity of material returned to shore compared with the partial removal and leave *in situ* options;
- Risks associated with lifting and handling pipeline sections are also greater for complete removal, due to larger quantity of material being returned to shore.
- Exposure to potentially NORM contaminated materials increases with the volume of material recovered;

Sub-Criterion	Option 1 Complete Removal	Option 2 Partial Removal	Option 3 Leave *in situ*
Health & safety risk offshore project personnel	**Short-term:** More offshore work and more onshore handling than partial removal. Little experience in the North Sea of either reverse reeling or 'cut and lift' of trenched and buried pipelines. Both reverse reeling and 'cut and lift' activities are assessed as tolerable for the 41.8km pipeline	**Short-term:** Less offshore work than complete removal. Experience in the North Sea of removal of pipeline sections	**Short-term:** Less offshore work than complete removal. Experience in the North Sea of removal of pipeline sections
	Legacy: No depth of burial surveys or remediation related activities	**Legacy:** Assume up to three depth of burial related surveys	**Legacy:** Assume up to four depth of burial related surveys
Health & safety risk to mariners	**Short-term:** Duration of vessels in the field would be longer than for partial removal or leave *in situ*. The risk to mariners would be aligned with the duration the activities are undertaken in the field	**Short-term:** Duration of vessels in the field would be shorter than for complete removal and marginally longer than for leave *in situ*	**Short-term:** As option 2. There is little to differentiate option 2 and 3

Sub-Criterion	Option 1 Complete Removal	Option 2 Partial Removal	Option 3 Leave *in situ*
	Legacy: Infrastructure completely removed so no residual snag hazards remain	**Legacy:** Degradation of the remaining pipeline will occur over a long period within seabed sediment. Post decommissioning surveys and existing data would provide evidence that exposures and the associated potential snagging risks remain limited	**Legacy:** As option 2. There is little to differentiate option 2 and 3
Safety risk onshore project personnel	**Short-term:** Significantly more onshore cutting, lifting and handling associated with disposal of the pipelines presents an increased safety risk to personnel	**Short-term:** Safety risk is directly associated with the duration and repetitive nature of the work. Less onshore cutting, lifting and handling so less safety risk to onshore personnel	**Short-term:** As option 2. There is little to differentiate option 2 and 3
Colour Key:			
Medium / Tolerable & non - preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.6: PL947 Safety Assessment

Summary of safety assessment

Many of the hazards described above are common to all decommissioning options. Based on the differences, in the short-term the partial removal and leave *in situ* options give rise to lower risks to project personnel for the following three reasons:

- Less offshore work;
- Less onshore handling;
- Little experience in the removal of trenched and buried pipelines in the North Sea [7], resulting in an increase in perceived risk.

By completely removing the pipelines the risk of snagging is removed in perpetuity. Therefore, the complete removal option results in lower residual risks to mariners and other users of the sea.

There is likely to be no increased snagging risk associated with the partial removal or leave *in situ* options due to the burial status of the pipeline (Figure 3.1). However, although status surveys will need to be done in future to verify that the risk of snagging remains low for the foreseeable future.

5.2.3 Environmental impact of operational activities

In all cases the duration vessels would be required in the field for complete removal was longer than either the partial removal and leave *in situ* options. The leave *in situ* option would result in least duration of vessels working in the field. The impact of this on liquid discharges to sea, noise, emissions to air and energy requirements, water column, seabed, waste, etc. are summarised in Table 5.7.

Operational Environmental factors impacted	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
Atmosphere (energy & emissions)	Emissions and use of energy greatest for this option but no offset would be generated because of the energy and emissions needed to create new material to replace any that may be left *in situ*	Emissions and energy use for this option fall in-between complete removal and leave *in situ*	Least amount of energy used and least emissions generated in the short-term, although this is counteracted by the energy and emissions required to create new material
Seabed disturbance; area affected	The amount of seabed disturbed is directly related to the length of pipeline (or umbilical) being removed. The area affected would be largest for this option	This area of seabed disturbed would fall in-between the complete removal and leave *in situ* options	The least area of seabed would be disturbed with this option
Water column disturbance: • liquid discharges to sea • liquid discharges to surface water • noise	Discharges and releases to the water column are related to the duration of activities being undertaken and will therefore be greatest for the complete removal	Discharges and release would be less than generated for complete removal but slightly more than leave *in situ*	Discharges and releases would be least for this option, particularly in the short-term
Waste creation and use of resources such as landfill. Recycling and replacement of materials	This option would result in the largest mass of material being returned to shore. No material would be lost as no material would be left *in situ*	This option sits in-between option 1 and option 3	No material would be returned to shore for recycling and so the material would be lost and new material would be needed to replace the loss
Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.7: PL947 & PL948 Operational Environmental Impacts

We can expect emissions to air and energy requirements to demonstrate that there are differences between the options, but since this would be related to the duration that vessels would be in the field we have not calculated the difference but have examined this qualitatively. Based on our experience with previous assessments we can say that the gap in emissions to air and energy requirements between complete removal, partial removal and leave *in situ* narrow when indirect emissions and energy requirements – such as that required to manufacture new material to replace the material left *in situ* – are taken into account.

From Table 5.7, while there will be different impacts for each of the options, the overall impact of the 'complete removal' option will be higher on the atmosphere, seabed disturbance, and water column and lowest in terms of material being left *in situ* and needing to be replaced. The reality, however, is that there is little to differentiate the three options, especially between partial removal and leave *in situ* options.

Conversely, the legacy survey requirements for leave *in situ* are greater than for partial or complete removal and these will mostly affect the atmosphere and water column. However, in real terms there will be little to distinguish between the options.

In Table 5.7 the boxes coloured darker green would be the most favourable option for each individual pipeline while lighter green boxes would the least favourable. However, we believe that there is little to differentiate the options.

5.2.4 Environmental impact of legacy activities

On completion of decommissioning activities, a final environmental survey would be carried out, and this would be common for all options and is not a differentiator. For longer-term legacy related activities, a differentiator between options would be the number of pipeline burial

surveys that would be required as well as any possible remedial works.

The environmental impact of legacy activities associated with future requirements of ensuring that PL947 remain buried and stable are assessed in much the same way as operational activities. The impacts of legacy related activities can be expected to be significantly less than those brought about by operational activities during decommissioning work.

Operational Environmental factors impacted	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
Atmosphere (energy & emissions)	No pipeline burial surveys required	We anticipate that future survey requirements would be about the same for either option 2 or option 3	
Seabed disturbance; area affected	Pipeline burial surveys do not usually involve disturbance to the seabed, and we assume that no remedial activities would be required otherwise, so no impact		
Water column disturbance: • liquid discharges to sea • liquid discharges to surface water • noise	No pipeline burial surveys required	We anticipate that future survey requirements would be about the same for either option 2 or option 3	
Waste creation and use of resources such as landfill. Recycling and replacement of materials	If we assume that no pipeline remedial activities would be required as part of legacy related activities there is nothing to differentiate the options from a waste perspective		
Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.8: PL947 & PL948 Legacy Environmental Impacts

5.2.5 Environmental impact on SAC

Our assessment of the short-term impact of decommissioning PL947 and longer term impact of legacy related activities such as surveys, potential remedial work on the Special Area of Conservation is summarised in Table 5.9.

Sub-Criterion	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
Short-term: Environmental impacts on SAC due to decommissioning activities	Dredging to access the pipeline for complete recovery would open a trench and introduce sediment into the water column. We would expect the area to recover relatively quickly as the survey data doesn't show much evidence of the original trench. Assuming a 4m wide corridor along the pipeline being disturbed, the area affected would be 0.164km^2, 16.4ha equivalent to c. 0.005% of the SAC.	Dredging to access the sections of the pipeline for recovery would open a trench and introduce sediment into the water column We would expect the area to recover relatively quickly as the survey data doesn't show much evidence of the original trench. The area affected would be much less than that affected by complete recovery.	Limited or no impact on the SAC during offshore decommissioning operations
Legacy: Environmental impacts on SAC	No impact. Only environmental survey following completion of decommissioning activities	Environmental survey and pipeline status survey only, assuming no remedial work would be required – as suggested by historical survey data. Survey data suggests that the presence of the buried pipeline in the seabed is not affecting the structure or function of the SAC as no evidence of change to the direction or size of the sand waves (and consequently sandbanks)	Impact on SAC would be the same as option 2 assuming no remedial work would be required over the longer term

Sub-Criterion	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.9: PL947 Environmental Impact on SAC

The significance of the impacts associated with the interactions with the environment was assessed using the Environmental Impact Matrix in the comparative assessment guidance document [3]. This was done to allow an understanding of the significance of the impacts and to aid decision making where conflicts arose between assessment criteria and sub-criteria. These are reflected in the traffic light colour coding.

The orange rating for complete removal in the above table is driven by the absolute area that would be disturbed because of removing the pipeline from its buried position, although the proportion of the SAC affected is very small.

5.2.6 Summary of environmental assessment

The environmental assessment was split into short-term operational impacts, legacy impacts and both short-term and long-term impacts due to legacy related activities on the Special Area of Conservation.

In the short-term, and from operational perspective, leave *in situ* would be the favoured option although in practical terms there is little to differentiate partial removal from leave *in situ*. Conversely complete removal would result in no legacy activities being required, and there would be little to choose between partial removal and leave *in situ* from a legacy perspective, especially as it can be legitimately assumed that no remedial works would be required in future. All impacts for all options were assessed as broadly acceptable.

The complete removal option would result in recovery of all the pipeline material for recycling whereas the leave *in situ* and partial removal options would result in most of the pipeline material being left where it is, and therefore unavailable for recycling. Any raw material not recovered would need to be replaced with newly manufactured material.

In the short-term, the leave *in situ* decommissioning option was considered to cause the least disruption to the SAC and so would be the most preferred. Over the longer-term the leave *in situ* option would be preferred to either the partial removal or the complete removal options, although in practical terms there would be little to differentiate partial removal and leave *in situ*.

In the short-term and due to operational activities, the complete removal option would be least favourable but was nevertheless assessed as ‘tolerable’. However, the area can be expected to fully recover within 20 years after the initial impact of decommissioning works, and so in the longer-term complete removal was assessed to be the marginally preferred option.

5.2.7 Societal Assessment

The assessment of the other criteria (safety, environment, cost and technical) considers the level of detrimental effect whereas the assessment of impacts on employment asses the level of benefit, a positive effect. We use vessel durations as an indicator of magnitude of the *continuation* of employment rather than creating new employment. We can discuss short-term effects due to decommissioning operations – ‘project’ activities - and longer-term impacts due to legacy related activities.

The societal issues around the pipeline are discussed below.

Commercial activities

The main commercial activity in the area is fishing. The potential effects could be loss of fishing

revenue due to exclusion from fishing grounds, disturbance of the seabed or loss or damage of fishing equipment.

While the vessels are present in the field and activities are being undertaken, the area will not be accessible for fishing. Therefore, the magnitude of the impact on commercial activities is related to the vessel duration. In the short-term, irrespective of which pipeline (or umbilical) is being considered, the complete removal activities will incur longer vessel activities. Conversely, the leave *in situ* option would require the least vessel activity. Where available the partial removal option will involve vessel activities with durations that would sit somewhere in-between complete removal and leave *in situ*. We try to differentiate the options using different shades of green in the summary table.

Decommissioning activities that would be common to all decommissioning options such as dealing with the pipeline ends or removing surface laid pipelines or removing the Alison tee, are not considered here as they do not differentiate the options.

Activities which involve removal, reburial will implicitly disturb the seabed. Therefore, since complete removal will require more activities on the seabed it will have a higher short-term impact on commercial fishing compared to partial removal or leave *in situ* options.

Therefore, during decommissioning activities the complete removal option is expected to have a greater impact on fishing activities as it has the longest duration and the greatest amount of activity disturbing the seabed. Partial removal leaves much of the infrastructure *in situ* and, the leave *in situ* option would leave most of the infrastructure in the seabed resulting in less work offshore, so there would be less of an impact on commercial fishing activities.

While all decommissioning options would require an environmental survey to be completed, only the partial removal; and leave *in situ* options would require pipeline burial surveys and stability assessments. The degree to which these will be required will be governed by the results of each survey, and if it can be demonstrated that the pipeline remains stable and pose no snagging risk such surveys may no longer be required. This would be assessed on a case by case basis.

While any such surveys are being undertaken, fishing activity may be disrupted for a short time but the impact can be expected to be minimal. Typically, one post-decommissioning environmental survey would be required, and for each decommissioning option we have assumed the number of pipeline surveys that would be required so that we can compare the impact of the options. The exact magnitude of the impact will be dependent on the type, frequency and duration of the surveys required.

Employment

The complete removal option has greater vessel duration and waste management requirements and therefore impacts more positively on employment than partial removal. The effect on employment will be the continuation of existing jobs, as opposed to the creation of new opportunities; therefore, the significance of the positive impact has been assessed as low.

Communities

Vessels would be in the field for relatively short duration, both within and outside the 500m safety zones. Fishing vessels would be excluded from the area outside the 500m zone but we believe that when compared to the wider area this would have a relatively small effect. There is little to differentiate between the options. Aggregate extraction area is north of the area where decommissioning activities would be undertaken. Shipping will be notified and continue an alternative route. There could be an effect on other users of the ports and there would be a marginally higher impact for complete removal but overall, we believe that there is little to differentiate the options.

The port and the disposal site for recovered materials have yet to be established. However, they will be existing sites which are used for oil and gas activities and hold the required permits for waste management. The communities around the port and the waste disposal sites are

therefore, expected to be adapted to the types of activities required and the decommissioning activities will be an extension of the existing situation. Therefore, the effect on communities is not considered a differentiator between options.

The results of the societal assessments for PL947 are presented in Table 5.10. In the short-term, commercial activities would be affected most by the amount of time the vessels were in the field undertaking partial removal activities. We believe that generally however, there is very little to differentiate the options for each.

Sub-Criterion	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
Short-term: Commercial activities	Impact of decommissioning vessel traffic on local commercial activities such as fishing would greatest for complete removal	Impact of decommissioning traffic on local commercial activities such as fishing would be less than for complete removal and more that for leave *in situ* option	Impact of decommissioning vessel traffic on local commercial activities such as fishing would least for complete removal
Legacy: Commercial activities	An environmental survey would be required but this is the same for all options. No pipeline surveys would be required	Impact of survey vessel traffic on local commercial activities such as fishing would be slightly more than for complete removal and less than for leave *in situ.*	Impact of survey vessel traffic on local commercial activities such as fishing would be slightly more with the leave *in situ* option but there is little to differentiate option 2 and option 3
Short term: Employment	Decommissioning activities would contribute greatest to continuity of employment for complete removal.	Decommissioning activities would contribute to continuity of employment less than for complete removal and more that for leave *in situ* option.	Decommissioning activities would contribute the least to continuity of employment for leave *in situ*
Legacy: Employment	Once the pipeline had been completely removed, the opportunity for continuation of employment would be minimal once the environmental survey had been completed	Once the pipeline had been partially removed the opportunity for continuation of employment would be associated with survey work would be like the leave *in situ* option. Some jobs would be associated with the manufacture of new material to replace that which is left *in situ*	Should the pipeline be left *in situ* surveys would need to be carried out as would be required for option 2 and Some jobs would be associated with the manufacture of new material to replace that which is left *in situ*, otherwise there is little to differentiate options 2 & 3.
Short-term: Communities	Decommissioning activities would contribute greatest to continuity of work in ports and disposal sites for complete removal	Decommissioning activities would contribute to continuity of work in ports and disposal sites less than for complete removal and more that for leave *in situ* option	Decommissioning activities would contribute the least to continuity of work in ports and disposal sites for leave *in situ*
Legacy: Communities	Once the pipeline had been removed there would be few opportunities for continuity of work in ports and disposal sites	Once the pipeline had been partially removed there would be few opportunities for continuity of work in ports and disposal sites other than associated with survey related and possible remedial work	Once the pipeline had been left *in situ* there would be few opportunities for continuity of work in ports and disposal sites other than associated with survey related and possible remedial work. There is little to differentiate options 2 & 3.
Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.10: PL947 Societal Assessment

Summary of societal assessment

We use vessel durations as an indicator of magnitude of the *continuation* of employment rather than creating new employment, and we have considered short-term effects due to decommissioning operations – 'project' activities - and longer-term impacts due to legacy related activities. We have also examined potential disruption to commercial activities resulting from the presence of vessels specifically to carry out the decommissioning work. We have taken a somewhat holistic approach.

Disruption to commercial activities would be least when the decommissioning effort in the field is minimised, and this is the case for leave *in situ*, whereas complete removal could potentially result in the most disruption to commercial activities with partial removal being in-between.

Conversely, legacy related disruption on commercial activities in the area would be greatest for leave *in situ*, since there would be no legacy activities once decommissioning activities associated with complete removal had been completed because there would no infrastructure left to inspect, whereas the leave *in situ* and partial removal options would require legacy activities to be carried out at least for the foreseeable future.

Employment opportunities would be greatest for the complete removal option owing to the larger amount of vessel time and onshore dismantling and recycling works. Such opportunities would be least for the leave *in situ* option but slightly greater for the partial removal option.

Conversely, legacy related employment opportunities would be least for complete removal and greatest for leave *in situ*, with opportunities associated with partial removal being like leave *in situ*. This is because the leave *in situ* and partial removal options would require legacy activities to be carried out, at least for the foreseeable future.

5.2.8 Cost Assessment

The incremental difference in cost between complete removal and partial removal – including the requirement for legacy surveys - on a like-for-like basis would be least £8.7MM, and the incremental difference in cost between partial removal and leave *in situ* would be at least £0.5MM. The incremental difference in cost between complete removal and leave *in situ* would be at least £9.2MM. For this reason, because of the order of magnitude difference involved the short-term costs for complete removal in Table 5.11 are classed as “Medium, or tolerable but non-preferred”. The incremental differences in cost for each option are compared in Appendix E.2.

Sub-Criterion	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
Short-term: Cost	The cost of complete removal would be an order of magnitude higher than for either of the partial removal or the leave *in situ* options	The cost of removing a few short-exposed sections would be less than for complete removal but more than for leave *in situ*	The cost of leave *in situ* would be the least expensive of all options
Legacy: Cost	Once the pipeline had been completely removed no pipeline burial surveys after decommissioning works had been completed or over the longer-term	Future burial surveys will be required. The premise is that if two successive surveys demonstrate that the pipeline remains stable the premise is that no more surveys would be required. There is little to differentiate options 2 and 3 over the longer-term	Future burial surveys will be required. The premise is that if two successive surveys demonstrate that the pipeline remains stable the premise is that no more surveys would be required. There is little to differentiate options 2 and 3 over the longer-term
Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.11: PL947 Cost Assessment

5.2.9 Overall Summary of Assessment

Once the approaches at Ann, Alison tee and Alison manifold and LOGGS have been decommissioned, leave *in situ* is the recommended decommissioning option for PL947.

The results of the assessment are summarised in Table 5.12. To simplify the assessment the pipeline was segmented, but overall this option has been assessed as having the lowest safety risk, lowest environmental impact and risk, lowest technical uncertainty and lowest cost. Waste recovery and societal elements were the only criterion where complete removal was assessed

as being beneficial and this was due to the potential extension of employment opportunities associated with this option.

Despite being the best option over the longer-term, the complete removal option would involve several elements that would be considered 'tolerable' but non-preferred. These elements concern short-term risk to the safety of project personnel during recovery operations and dealing with the pipeline as it is removed from the reel and cut into manageable lengths for transportation. Furthermore, the field work involved with assuring that the integrity of the pipeline is sufficient to endure the stresses and strains of removal without incident would not be insignificant. From an environmental perspective one aspect of the assessment that appears prominently is the effect on the objectives of the SAC, and we have assessed that these would be adversely affected most by activities associated with complete removal. In other words, even though complete removal might be achievable it is non-preferred when considering the objectives of the SAC. Finally, we estimate that the cost of complete removal would be an order of magnitude greater for complete removal than either of the other two options and future surveys to ensure that the pipeline remains buried and stable.

Although we have identified that there are several exposures along the pipeline, none of the historical exposures that have been recorded during pipeline integrity surveys have been significant enough to be reported to the Kingfisher Information Service. In adopting this decommissioning option we will continue to monitor the pipeline for any changes in burial status and monitor whether any exposures are significant enough to be reported to Kingfisher Information Service and require remedial work.

There are sections of the pipeline after the sand bank area between (KP31.0 and KP33.5) where it has not been possible to establish the burial status of the pipeline. For the purposes of this assessment we have assumed that there may be short lengths of exposed pipeline in this area.

As reported previously, in the immediate vicinity of the LOGGS area is subject to continual scour, and the effectiveness of pipeline stability features such as concrete mattresses and grout bags in this area is uncertain. Therefore, we would propose to remove stability features such as concrete mattresses and grout bags where we can see them, but otherwise monitor the situation at least until some of the uncertainty is reduced to a satisfactory level.

The biggest differentiators between the complete removal and partial removal options are safety and technical elements. Examination of the criteria within these categories shows that the issues relate to:

- Uncertainties as to the reliability of recovering a 12" rigid pipeline of unknown condition to a pipeline reel on the deck of the vessel and effect on those working in proximity should the pipeline fail during recovery or cutting;
- The lack of experience in reverse reeling [7] pipelines, leading to higher safety risks and higher probability that the project will significantly over-run in both cost and schedule;
- The large amount of handling and particularly lifting involved in recovering the pipeline to shore, where it will need to be cut and moved in transportable lengths.

It can also be seen that environmental assessment favours leaving the pipeline *in situ*. This is primarily because complete removal would require disturbance to the SAC as the pipeline runs through the area. Also, there would be fewer disturbances to ecosystems from removal activities and less impact associated with emissions to air, discharges to sea, noise, and disposal requirements for vessel. These factors were considered to outweigh the impact of the ongoing surveys needed for the pipeline remaining *in situ* after decommissioning.

Aspect	Sub-criterion	Short-term or legacy?	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
Technical	Technical feasibility	Short-term			
		Legacy			

Safety	Safety risk to offshore project personnel	Short-term			
		Legacy			
	Safety risk to mariners	Short-term			
		Legacy			
	Safety risk to onshore project personnel	Short-term			
	Atmosphere (energy & emissions)	Short-term			
		Legacy			
	Seabed disturbance area affected	Short-term			
		Legacy			
Environmental	Impact on SAC	Short-term			
		Legacy			
	Water column disturbance	Short-term			
		Legacy			
	Waste creation	Short-term			
		Legacy			
Societal	Commercial activities	Short-term			
		Legacy			
	Employment	Short-term			
		Legacy			
	Communities	Short-term			
		Legacy			
Cost (by difference)		Short-term			
		Legacy			

Table 5.12: PL947 Summary of Comparative Assessment

5.3 PL948 Comparative Assessment

5.3.1 Technical Assessment

All the umbilical decommissioning options are technically feasible. Complete removal and partial removal operations – where the length of umbilical justifies the approach, that involve reverse reeling to remove the umbilical from its trench. There is limited experience of reverse reeling *trenched* and *buried* umbilical lines in the UKCS [11] and as such we considered that the technical uncertainty has an adverse impact on technical feasibility and risk. The difficulties are however considered to be of a lesser order than those associated with removing the rigid steel pipeline. The technical difficulties concern securing the umbilical and pulling it up from the seabed and ensuring that it retains its integrity while being recovered. The partial removal option would require removal and in some cases uncovering discrete sections of umbilical that would be relatively easy to handle. This is a routine activity and as such is considered less likely to result in a negative impact on technical safety and risk.

PL948 originates at Audrey B (XW). The presence of sand waves might suggest that it is in these areas where the chances of the umbilical pipeline being exposed over the longer-term are greatest. We also don't fully know what the impact of removing the platforms will have on the local landscape of the seabed in future, for example due to local scouring, but we have tried to account for this in our assessment.

The results of the assessment are presented in Table 5.13.

Sub-Criterion	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
Technical feasibility	**Short-term:** Reverse reeling is a viable option albeit with technical challenges as the umbilical is unburied and pulled from the seabed. Considered more technically difficult than options 2 and 3	**Short-term:** This option only requires cut and lift of discrete sections of the umbilical and this can be considered a relatively routine operation. Minimum number of operations therefore minimum technical risk	**Short-term:** Stable and buried umbilical lines have been left *in situ* before and we know this is achievable. From a technical perspective this would be the least challenging option
	Legacy: No pipeline surveys would be required	**Legacy:** Pipeline surveys have been undertaken in the past and are technically feasible with no complications	**Legacy:** Pipeline surveys have been undertaken in the past and are technically feasible with no complications
Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.13: PL948 Technical Assessment

Summary of technical assessment

Three options were considered for PL948, and theoretically, given the right conditions - for example, no integrity issues can be foreseen - all three options can be considered technically feasible.

However, to achieve complete removal the umbilical would need to be extracted from the seabed and reverse reeled onto any vessel fitted with a carousel or reel. Therefore, complete removal has been classed as 'broadly acceptable' but not as favourable as leave *in situ* or partial removal.

As mentioned already, the 'cut and lift' method has been used for recovery of short pipelines and for the recovery of short umbilical sections already in the southern North Sea so this option and leave *in situ* can both be regarded as technically feasible and would be preferred to complete removal using either of the methods described.

5.3.2 Safety Assessment

Safety Risk to Offshore Project Personnel

All hazards were assessed as broadly acceptable. However, there were some key differences:

- Risk to personnel on vessel from methanol or hazardous substance releases would be greater for complete removal than for partial removal;
- There would be a risk associated with the presence of an object on or near the vessel during reverse reeling for the complete removal option but eliminated for the partial removal and leave *in situ* options;
- There would also be more risk of the umbilical failing during recovery operations associated with complete removal;
- For partial removal, more individual lengths of the umbilical (2-3 cut lengths totalling 39m) would need to be recovered to the deck of the vessel, potentially posing as more individual threats to personnel working on deck;
- The increase in risk to all activities due to adverse weather is greater for complete removal than for either partial removal or leave *in situ;*
- Risks associated with legacy survey activities (risks associated with vessels being used) are greater for partial removal or leave *in situ* than for complete removal

Residual Safety Risk to Fishermen and Other Marine Users

There remains the possibility of interaction with other mariners while decommissioning works are being carried out in the field and this potentially would increase with the number of vessels, the location of the work and the frequency of marine traffic. Decommissioning activities involve vessels working in the field, and over the longer term will be related to the amount of surveys and any pipeline remedial works that may be required in future. By way of example, for PL948 vessel durations associated with the complete removal option will be greater than for the partial removal and leave *in situ*.

The risk of snagging fishing gear was assessed as tolerable and the risk of snagging equipment during offshore construction was assessed as broadly acceptable. The key differences between the options are:

- There would be a risk of snagging fishing gear on the umbilical in the future for partial removal or leave *in situ* but this would be eliminated for complete removal;
- As all the partial removal and leave *in situ* options leave a significant portion of the umbilical *in situ*, legacy surveys are required for these options. These legacy surveys have risks associated with the use of vessels that are not required for the complete removal option.

Safety Risk to Onshore Project Personnel

All hazards were assessed as broadly acceptable. The key difference between the options is as follows.

- Risks associated with cutting and handling sections of the umbilical onshore;
- Risks associated with dealing with any residues within the umbilical

Sub-Criterion	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
Health & safety risk offshore project personnel	**Short-term:** More offshore work than partial removal. Limited experience in the North Sea of reverse reeling trenched and buried umbilical lines	**Short-term:** Less offshore work than complete removal. Experience in the North Sea and the Company of removal of umbilical sections	**Short-term:** No work done offshore other than that which would be undertaken for complete and partial removal
	Legacy: No depth of burial surveys or remediation related activities	**Legacy:** Once section of pipeline had been removed, assume legacy requirements are as per option 3, with no remedial work required	**Legacy:** Assume up to four depth of burial related surveys
Health & safety risk to mariners	**Short-term:** Duration of vessels in the field would be longer than for partial removal or leave *in situ*. The risk to mariners would be aligned with the duration the activities are undertaken in the field	**Short-term:** Duration of vessels in the field would be shorter than for complete removal and marginally longer than for leave *in situ*	**Short-term:** Marginally better than for option 2, although practically there is little to differentiate option 2 and 3
	Legacy: Infrastructure completely removed so no residual snag hazards remain	**Legacy:** Once short exposed sections have been removed, degradation of the remaining umbilical will occur over a long period within seabed sediment and not expected to represent a hazard to other users of the sea, although potential snag hazards would remain. Overall initially assessed as 'tolerable' but mitigated with pipeline status surveys	**Legacy:** As option 2. Since only a small section of the umbilical would be removed under partial removal there is little to differentiate option 2 and 3
Safety risk onshore project personnel	**Short-term:** Significantly more onshore cutting, lifting and handling associated with disposal of the umbilical presents an increased safety risk to personnel but broadly acceptable	**Short-term:** Safety risk is directly associated with the duration and repetitive nature of the work. Less onshore cutting, lifting and handling than complete removal so less safety risk to onshore personnel	**Short-term:** As option 2. Since only a short length of the umbilical would be removed under partial removal there is little to differentiate option 2 and 3
Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least Preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.14: PL948 Safety Assessment

Summary of safety assessment

Table 5.14 summarises the safety assessment for the PL948 decommissioning options. Many of the hazards associated with decommissioning PL948 are common to all three options and are assessed as broadly acceptable. The partial removal and leave *in situ* options give rise to lower risks to personnel for the following reasons:

- The reverse reeling required to remove the umbilical carries more risk than partial removal or leave *in situ*;
- Partial removal or leave *in situ* present lower risks to onshore personnel due to less material needing to be dealt with when cutting, lifting and handling onshore

Complete removal would give rise to lower residual risks to mariners and other users of the sea because there would be no potential snagging hazards occurring in future. Notwithstanding the erratic burial profile between KP0.5 and KP2.8, for the most part the umbilical is trenched and buried to a depth greater than 0.6m (Figure 3.2). The ends of the umbilical would be removed irrespective of which option is pursued.

5.3.3 Environmental impact of operational activities

Please refer section 5.2.3 as we believe that the environmental impacts of operational activities for PL947 and PL948 are broadly similar. Therefore, we propose not to repeat the discussion here.

5.3.4 Environmental impact of legacy activities

Please refer section 5.2.4 as we believe that the environmental impacts of legacy activities for PL947 and PL948 are broadly similar. Therefore, we propose not to repeat the discussion here.

5.3.5 Environmental impact on SAC

Our assessment of the short-term impact of decommissioning PL948 and longer term impact of legacy related activities such as surveys, potential remedial work on the Special Area of Conservation is summarised in Table 5.15.

Sub-Criterion	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
Short-term: Environmental impacts on SAC due to decommissioning activities	Larger area of the SAC impacted due to the disturbance of the seabed as the umbilical is pulled or jetted out of the trench. Assuming 2m wide corridor the area affected would be 0.04km^2, 4ha equivalent to c. 0.001% of the SAC	Smaller area of the SAC impacted due to the disturbance of the seabed as the umbilical is pulled or jetted out of the trench.	Limited or no impact on the SAC during offshore decommissioning operations compared with option 1 or option 2
Legacy: Environmental impacts on SAC	None; all infrastructure would be removed in this option. Consideration was given to the disturbance from removal. The recovery since installation indicates that the area will recover relatively quickly after the disturbance. That is, the survey data shows no evidence of the trenching that occurred during installation - long term e.g. greater than 20 years, the duration the line has been in place	As for option 3, leave *in situ*	The SAC could be impacted if remedial work was required, but we don't believe that remedial activities would be required given that the umbilical is buried and appears to be stable. We don't believe that the long-term presence of the umbilical under the sand waves within the SAC would impact the conservation objectives of the SAC. The local bathymetry has a uniform pattern that hasn't noticeably changed over the years. Refer [4]
Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.15: PL948 Environmental Impact on SAC

Although Table 5.15 suggests that there is a slight difference in legacy environmental impacts on the SAC, we believe that it is unlikely that any remedial activities would be required in future, which means that there is little to differentiate the options.

5.3.6 Summary of environmental assessment

The environmental assessment can be summarised as per PL947 in section 5.2. Therefore, we propose not to repeat the discussion here.

5.3.7 Societal Assessment

The results of the societal assessment for PL948 are the same as assessed for PL947 and

discussed in section 5.2.7. Therefore, we propose not to repeat the discussion here.

5.3.8 Cost Assessment

The incremental difference in cost between complete removal and partial removal – including the requirement for legacy surveys - on a like-for-like basis would be least £7.7MM, and the incremental difference in cost between partial removal and leave *in situ* would be at least £0.2MM. The incremental difference in cost between complete removal and leave *in situ* would be at least £7.9MM. The incremental differences in cost for each option are compared in Appendix E.4.

For this reason, because of the order of magnitude difference involved the short-term costs for complete removal in Table 5.16 are classed as "Medium, or tolerable but non-preferred".

Sub-Criterion	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
Short-term: Cost	The cost of complete removal would be higher than for either of the partial removal or the leave *in situ* options, and an order of magnitude higher	The cost of removing a few short-exposed sections would be less than for complete removal but more than for leave *in situ*	The cost of leave *in situ* would be the least expensive of all options
Legacy: Cost	Once the umbilical had been completely removed no pipeline burial surveys or stability assessments after decommissioning works had been completed or over the longer-term	Future burial surveys and stability assessments will be required. The premise is that if two successive surveys demonstrate that the pipeline remains stable the premise is that no more surveys would be required. There is little to differentiate option 2 and 3 over the longer-term	Future burial surveys and stability assessments will be required. The premise is that if two successive surveys demonstrate that the pipeline remains stable the premise is that no more surveys would be required. There is little to differentiate option 2 and 3 over the longer-term
Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.16: PL948 Cost Assessment

5.3.9 Overall Summary of Assessment

Once the approaches at Audrey B (XW) and Ann manifold have been decommissioned, the recommended decommissioning option for PL948 is leave *in situ.*

The evaluation Table 5.17 shows that there is little difference between the decommissioning options for the umbilical.

On the most recent survey (2016) established that the umbilical is exposed at around KP2.4 for a length of 11m (Figure 3.2). This exposure is not of sufficient concern that it needs to be reported to Kingfisher Information Service. There is only one exposure that would need to be dealt with during partial removal means that there is very little otherwise to differentiate partial removal and leave *in situ*.

Modest differences are found between the environmental assessment (leave *in situ* favoured largely because of lesser ecosystem disturbance from removal activities and less impact associated with vessel use (emissions to air, discharges to sea, noise and disposal requirements) and societal scoring (removal favoured as more resources are required).

From an environmental perspective one aspect of the assessment that appears prominently is the effect on the conservation objectives of the SAC, and we have assessed that these would be adversely affected most by activities associated with complete removal. In other words, even though complete removal might be achievable it is non-preferred when considering the conservation objectives of the SAC.

Small differences are found between the safety assessment with more work required offshore and onshore for the complete removal than partial removal or leave *in situ* and consequently higher safety risk. Conversely there would be lower safety risks to mariners arising from complete removal than for either partial removal or leave *in situ* because the pipeline would no longer be present as a potential snag hazard.

Aspect	Sub-criterion	Short-term or legacy?	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave in situ
Technical	Technical feasibility	Short-term			
		Legacy			
Safety	Safety risk to offshore project personnel	Short-term			
		Legacy			
	Safety risk to mariners	Short-term			
		Legacy			
	Safety risk to onshore project personnel	Short-term			
Environmental	Atmosphere (energy & emissions)	Short-term			
		Legacy			
	Seabed disturbance area affected	Short-term			
		Legacy			
	Impact on SAC	Short-term			
		Legacy			
	Water column disturbance	Short-term			
		Legacy			
	Waste creation	Short-term			
		Legacy			
Societal	Commercial activities	Short-term			
		Legacy			
	Employment	Short-term			
		Legacy			
	Communities	Short-term			
		Legacy			
Cost (by difference)		Short-term			
		Legacy			

Table 5.17: PL948 Summary of Comparative Assessment

5.4 PL1099 Comparative Assessment

For the assessment of PL1099, we have split the umbilical into two parts: '**Start to KP8.0**' and '**K8.0 to End'**. This is to reflect the marked differences in its burial profile status. Note that 'start and end' are somewhat misleading as they do not include the very ends of the umbilical that are being removed – an activity that is common to all decommissioning options, but hopefully the intent is understood. These are approximate locations. The exact location would be determined during detailed engineering should it be required.

For the first part, three decommissioning options were assessed. For the second part, just two options were considered: complete removal and leave *in situ*.

5.4.1 Technical Assessment

All the umbilical decommissioning options are technically feasible. The key issues are:

- The increase in the number and length of exposures in successive surveys;
- The potential that future surveys may not establish that the first half of the umbilical is stable; therefore, ongoing future surveys may be required. The number is difficult to predict and will be based on a number factors such as location (e.g. if outside existing 500m zone, extent and significance of exposures survey on survey);
- That future remediation may be required, involving excavation, cutting and lifting of sections and, or the addition of rock deposits;
- Partial removal may require rock deposits to keep the cut ends from re-emerging;
- In areas of heavy scour, such as near the Audrey B (XW) platform, we don't know what the addition of rock deposits will do to local scour patterns;
- We don't fully understand the impact of removing the platform will have on the stability or burial of the umbilical in close proximity of the platform.

Complete removal and partial removal operations – where the length of umbilical justifies the approach, that involve reverse reeling to remove the umbilical from its trench. There is limited experience of reverse reeling in the UKCS [11] and as such we considered that the technical uncertainty has an adverse impact on technical feasibility and risk. The difficulties are however considered to be of a lesser order than those associated with removing the rigid steel pipeline. The technical difficulties concern securing the umbilical and pulling it up from the seabed and ensuring that it retains its integrity while being recovered. The partial removal options would require removal and in some cases uncovering discrete sections of umbilical that would be relatively easy to handle. This is a routine activity and as such is considered less likely to result in a negative impact on technical safety and risk.

From a technical perspective, potential rock placement activities used for any remedial measures can also be considered routine, involving vessels designed specifically for this task.

The results of the assessment are presented in Table 5.18.

Sub-Criterion	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
Start to KP8.0 Technical feasibility	**Short-term:** Reverse reeling is a viable option albeit with technical challenges as the umbilical is pulled from the seabed. Considered more technically difficult than options 2 and 3	**Short-term:** This option only requires cut and lift of discrete sections of the umbilical and this can be considered a relatively routine operation. Minimum number of operations therefore minimum technical risk	**Short-term:** Stable and buried umbilical lines have been left *in situ* before and we know this is achievable. From a technical perspective this would be the least challenging option
	Legacy: No pipeline surveys would be required	**Legacy:** Pipeline surveys have been undertaken in the past and are technically feasible, although obtaining depth of	**Legacy:** Pipeline surveys have been undertaken in the past and are technically feasible, although obtaining depth of

Sub-Criterion	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
		burial underneath sand waves can be problematic in overall terms from a technical perspective this is achievable with no complications	burial underneath sand waves can be problematic in overall terms from a technical perspective this is achievable with no complications
KP8.0 to end Technical feasibility	**Short-term:** Reverse reeling is a viable option albeit with technical challenges as the umbilical is pulled from the seabed. Considered more technically difficult than options 2 and 3	**Short-term:** We believe that there is nothing that would require partial removal from 'KP8.0 to end'. N/A	**Short-term:** Stable and buried umbilical lines have been left *in situ* before and we know this is achievable. From a technical perspective this would be the least challenging option
	Legacy: No pipeline surveys would be required	**Legacy:** We believe that there is nothing that would require partial removal from 'KP8.0 to end'. N/A	**Legacy:** Pipeline surveys have been undertaken in the past and are technically feasible, although obtaining depth of burial underneath sand waves can be problematic in overall terms from a technical perspective this is achievable with no complications

Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.18: PL1099 Technical Assessment

The umbilical pipeline originates at Audrey B (XW). The presence of sand waves might suggest that it is in these areas where the chances of the umbilical line being exposed over the longer-term are greatest. We also don't fully know what the impact of removing the platforms will have on the local landscape of the seabed in future, for example due to local scouring, but we have tried to account for this in our assessment.

Summary of technical assessment

For the first part of PL1099, theoretically, given the right conditions - for example, no integrity issues can be foreseen - all three options can be considered technically feasible.

However, to achieve complete removal the umbilical would need to be extracted from the seabed and reverse reeled onto any vessel fitted with a carousel or reel. Therefore, complete removal has been classed as 'broadly acceptable' but not as favourable as leave *in situ* or partial removal.

As mentioned already, the 'cut and lift' method has been used for recovery of short pipelines and for the recovery of short umbilical sections already in the southern North Sea so this option and leave *in situ* can both be regarded as technically feasible. However, the number of interventions that would be required to execute the 'cut and lift' method are such that the partial removal method using this technique would be non-preferred.

For the second part of umbilical, we believe that the partial removal option is not required, and as discussed above both complete removal and leave *in situ* could be considered technically feasible notwithstanding potential integrity issues that could emerge. For the second part of the umbilical leave *in situ* would be preferred to complete removal from a technical perspective.

5.4.2 Safety Assessment

Safety Risk to Offshore Project Personnel

All hazards were assessed as broadly acceptable. The key differences between the options are as follows.

- Risk to personnel on the vessel from methanol or hazardous substance releases would be greater for complete removal than for partial removal;
- Risk to personnel on the vessel deck is considered greater for the partial removal option than for complete removal. This is due to the requirement to lift the cut umbilical ends and the increased number of individual sections requiring to be handled on the vessel deck;
- There is a risk associated with the presence of an object such as a partly or fully reverse reeled umbilical pipeline on or near the vessel during reverse reeling and there would also be more risk of the umbilical failure during recovery; The inclusion of reverse reeling in the complete removal option is the largest single differentiator as the risks associated with this activity are eliminated completely for the leave *in situ* option;
- The alternative option for partial removal whereby several individual lengths of umbilical are removed would likely involve increased diving activities and associated risk compared to the reverse reel related activities needed for complete removal. The alternative partial removal and would likely be non-preferred from a safety risk perspective;
- The increase in risk to offshore personnel due to adverse weather is greater for complete removal and partial removal options than for the leave *in situ* options, the risk being proportional to the length of time at sea while the recovery operations are being carried out. This is due to the increase in vessel duration required to complete the reverse reeling process. In comparison, apart from those activities common for all options, there are no offshore activities required for the leave *in situ* option.

Residual Safety Risk to Fishermen and Other Marine Users

The residual safety hazards identified as differences between the options were assessed as broadly acceptable. The key difference between the options and future snagging hazards and are presented as follows:

- Due to the partial removal and leave *in situ* options leaving a portion of the umbilical *in situ*, there is a potential snagging hazard that does not exist for the complete removal option. The presence of slow moving sand waves potentially introduces a degree of uncertainty. However, this is expressed as having only a minimal impact, given the trenched and buried status of the umbilical and the type of fishing activity in the area.
- As the partial removal and leave *in situ* options leave a significant portion of the umbilical *in situ*, legacy surveys are required for these options, and we would expect more for the left *in situ*. These legacy surveys have risks associated with the use of vessels that are not required for the complete removal option.

Post decommissioning surveys and existing data would provide additional information if the number and total length of exposures continue to increase, as the trend currently shows. This would present additional risk to mariners and may require additional remediation or surveys or both. Degradation of the umbilical wouldn't change the risk if it remains buried, but having degraded and exposed the risks of snagging would increase. No remedial work has been required to date, so it is possible that no additional monitoring over and above what might be considered normal would be needed to establish what remedial works would be required in future.

Safety Risk to Onshore Project Personnel

The hazards identified as *differences* between the options were assessed as broadly acceptable. The key differences between the options are:

- Risks associated with onshore cutting of umbilical resulting in injury. These risks are considered greater for complete removal and partial removal ('Start to KP8.0') compared to the leave in situ option due to the increased length of umbilical that would be recovered;
- Risks associated with onshore lifting and handling umbilical sections. These risks are considered greater for complete removal and partial removal ('Start to KP8.0') compared to the leave in situ option due to the increased length of umbilical that would be recovered.

Sub-Criterion	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
Start to KP8.0 Health & safety risk offshore project personnel	**Short-term:** Less offshore work when reeling the umbilical compared to removal of individual lengths involving vessels and possibly divers and more onshore handling than partial removal. Limited experience in the North Sea of reverse reeling *trenched* and *buried* umbilical lines. Considered broadly acceptable if safety risks are driven to ALARP	**Short-term:** More vessel time and possibly divers when removing individual exposed lengths than needed for complete removal by reverse reel which would be a continuous process	**Short-term:** Least amount of work done offshore other than that undertaken for partial and complete removal
	Legacy: No depth of burial surveys or remediation related activities	**Legacy:** Once sections of pipeline had been removed, assume legacy requirements are as per option 3. It is likely that remedial work will be required sometime in the future	**Legacy:** Assume up to four depth of burial related surveys. It is likely that remedial work will be required sometime in the future
KP8.0 to end Health & safety risk offshore project personnel	**Short-term:** See KP0 to 8.0. More offshore work involving vessels and possibly divers and more onshore handling than partial removal. Considered broadly acceptable if safety risks are driven to ALARP	**Short-term:** No exposures, therefore no partial removal so no option 2. As Option 3, leave *in situ*	**Short-term:** Least amount of work done offshore than that undertaken for complete removal
	Legacy: No depth of burial surveys or remediation related activities	**Legacy:** No exposures, therefore no partial removal so no option 2. As Option 3, leave *in situ*	**Legacy:** Assume up to four depth of burial related surveys
Start to KP8.0 Health & safety risk to mariners	**Short-term:** Duration of vessels in the field would be longer than for partial removal or leave *in situ*. The risk to mariners would be aligned with the duration the activities are undertaken in the field	**Short-term: Start to KP8.0:** Duration of vessels in the field would be shorter than for complete removal and longer than for leave *in situ*	**Short-term:** Vessels would spend the least amount of time in the field for this option, therefore the potential for interaction with other mariners and any associated risk would be minimised
	Legacy: Infrastructure completely removed so no residual snag hazards remain	**Legacy:** Twenty-nine (29) exposures identified in the first half of the umbilical. If sections of exposed umbilical are cut and removed the ends could present a greater long-term threat to fishing interaction. In addition, the cover of the exposures / cut ends could present an increased risk to the mariners. However, we have received no reports snagging in the exposed areas	**Legacy:** Post decommissioning surveys data combined with what is already known will provide additional information if the number and total length of exposures continue to increase, as the trend currently shows. This would present additional risk to mariners and may require additional remediation / surveys. An increase in degradation along with exposures could increase the possibility of snagging

Sub-Criterion	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
KP8.0 to end Health & safety risk to mariners	**Short-term:** Duration of vessels in the field would be longer than for leave *in situ*. The risk to mariners would be aligned with the duration the activities are undertaken in the field	**Short-term:** No exposures, therefore no partial removal activities. Therefore, threat to mariners would be as per option 3, leave *in situ*	**Short-term:** Vessels would spend more time in the field for this option than for complete removal, therefore the potential for interaction with other mariners and any associated risk would be lower
	Legacy: Please refer to the description for 'start to KP8.0' for option 1, as the longer-term threats to mariners will be similar	**Legacy:** No exposures, therefore no partial removal activities. Therefore, threat to mariners would be as option 3, leave *in situ*	**Legacy:** Unlike option 1, depth of burial related surveys will be required, but that no intervention work would be needed
Start to KP8.0 Safety risk onshore project personnel	**Short-term:** Significantly more onshore cutting, lifting and handling associated with disposal of the umbilical presents an increased safety risk to personnel but still broadly acceptable	**Short-term:** Safety risk is directly associated with the duration and repetitive nature of the work. Less onshore cutting, lifting and handling so less safety risk to onshore personnel	**Short-term:** Leave in situ would involve removing the least amount of material from the field. There would be less onshore cutting, lifting and handling for this option
KP8.0 to end Safety risk onshore project personnel	**Short-term:** Significantly more onshore cutting, lifting and handling associated with disposal of the umbilical presents an increased but broadly acceptable safety risk to personnel	**Short-term:** No exposures, therefore no partial removal activities. Therefore, safety risk to onshore project personnel would be as per option 3, leave *in situ*	**Short-term:** This option presents less of a safety risk to onshore project personnel as this option would involve the least material being returned to shore for processing
Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.19: PL1099 Safety Assessment

Summary of safety assessment

Table 5.19 summarises the safety assessment for the PL1099 decommissioning options. Many of the hazards associated with decommissioning PL1099 are common to all three options and are assessed as broadly acceptable. The partial removal and leave *in situ* options give rise to lower risks to personnel for the following reasons:

- Although partial removal for the first half of PL1099 would require more individual lengths of the umbilical to be handled, we believe that the reverse reeling required to remove the umbilical carries more risk than partial removal or leave *in situ*;
- Partial removal or leave *in situ* present lower risks to onshore personnel due to less material needing to be dealt with when cutting, lifting and handling onshore

The complete removal and partial removal options[20] would give rise to lower residual risks to mariners and other users of the sea because there would be no potential snagging hazards occurring in future, with residual risks reducing as more of the umbilical is removed. Removing the first 8km of umbilical at the time of decommissioning and that we believe that the remainder of the umbilical would remain stable. This would be the optimal solution from a legacy perspective. We would have reduced the uncertainty associated with the need for remedial activities in future, and we would have eliminated the potential snagging hazards for the most unstable section of the umbilical. We would use future legacy surveys to monitor the situation for the remainder of the umbilical.

[20] Remembering that for the assessment PL1099 was split into two segments, partial removal involved removing a number (up to 30) of individual sections for the first half of the umbilical totalling up to 157m

Therefore, we would propose to remove the first 8km of the umbilical using reverse reeling and monitor the remainder of the umbilical line being left *in situ* for the foreseeable future to ensure that the umbilical remains buried and that the residual snagging risks remain low.

5.4.3 Environmental impact of operational activities

The environmental impact of operational activities undertaken to decommission PL1099 resulted in marginally different impacts on the environment, depending on which half of the umbilical being assessed, as indicated in Table 5.20. For the first half of the umbilical, the impact on the atmosphere would be greater because vessel time associated with the partial removal option is greater because of the number of individual sections that would need to be located, excavated at each ends, cut and removed.

Operational Environmental factors impacted	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
Start to KP8.0: Atmosphere (energy & emissions)	**Short-term:** Emissions and use of energy greatest for this option but no offset would be generated because of the energy and emissions needed to create new material to replace any that may be left *in situ*	**Short-term:** Emissions and energy use for this option would be greater than for either complete removal or leave *in situ* owing to the longer time the vessel is in the field	**Short-term:** Least amount of energy used and least emissions generated in the short-term, although this is slightly counteracted by the energy and emissions required to create new material
KP8.0 to end: Atmosphere (energy & emissions)	**Short-term:** Emissions and energy use for this option are greater than for leave *in situ*	**Short-term:** No partial removal activities required	**Short-term:** Same as for 'Start to KP8.0'
Start to KP8.0: Seabed disturbance; area affected	**Short-term:** The amount of seabed disturbed is directly related to the length of pipeline (or umbilical) being removed. The area affected would be largest for this option	**Short-term:** For the **first half** of the umbilical, the area of seabed disturbed would fall in-between the complete removal and leave *in situ* options	**Short-term:** The least area of seabed would be disturbed with this option
KP8.0 to end: Seabed disturbance; area affected	**Short-term:** Same as for 'Start to KP8.0'	**Short-term:** No partial removal activities required	**Short-term:** Same as for 'Start to KP8.0'
Start to KP8.0: Water column disturbance: • liquid discharges to sea • liquid discharges to surface water • noise	**Short-term:** Discharges and release would be less than generated for partial removal but less than leave *in situ*	**Short-term:** Discharges and releases to the water column are related to the duration of activities being undertaken and will therefore be greatest for partial removal	**Short-term:** Discharges and releases would be least for this option, particularly in the short-term
KP8.0 to end: Water column disturbance: • liquid discharges to sea • liquid discharges to surface water • noise	**Short-term:** Same as for 'Start to KP8.0'	**Short-term:** No partial removal activities required	**Short-term:** Same as for 'Start to KP8.0'
Start to KP8.0: Waste creation and use of resources such as landfill. Recycling and replacement of materials	**Short-term:** This option would result in the largest mass of material being returned to shore. No material would be lost as no material would be left *in situ*	**Short-term:** This option sits in-between option 1 and option 3	**Short-term:** No material would be returned to shore for recycling and so the material would be lost and new manufactured material would be needed to replace the loss

Operational Environmental factors impacted	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
KP8.0 to end: Waste creation and use of resources such as landfill. Recycling and replacement of materials	**Short-term:** Same as for 'Start to KP8.0'	**Short-term:** No partial removal activities required	**Short-term:** Same as for 'Start to KP8.0'
Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.20: PL1099 Operational Environmental Impacts

5.4.4 Environmental impact of legacy activities

The environmental impact of legacy activities associated with future requirements of ensuring that PL1099 remains buried and stable are assessed in much the same way as operational activities. The impacts of legacy related activities can be expected to be significantly less than those brought about by operational activities during decommissioning work. PL1099 was assessed in two parts: '**Start to KP8.0**' and '**KP8.0 to end**'.

Legacy Environmental factors impacted	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
Start to KP8.0: Atmosphere (energy & emissions)	No pipeline burial surveys required	We assume that future survey requirements for partial removal would be like those required for leave *in situ*	We assume that future survey requirements for leave *in situ* would be like those required for partial removal
KP8.0 to end: Atmosphere (energy & emissions)	No pipeline burial surveys required	There is no partial removal considered for the first part of the pipeline so legacy requirements would be the same as for leave *in situ*	Pipeline burial surveys will likely be required, at least in the near term.
Start to KP8.0: Seabed disturbance; area affected	No pipeline burial surveys or remedial work would be required	Pipeline burial surveys do not usually involve disturbance to the seabed, and we assume that no remedial activities would be required otherwise, so no impact	
KP8.0 to end: Seabed disturbance; area affected	No pipeline burial surveys or remedial work would be required	There is no partial removal considered for the first part of the pipeline so legacy requirements would be the same as for leave *in situ*	Pipeline burial surveys do not usually involve disturbance to the seabed, and we assume that no remedial activities would be required otherwise, so no impact
Start to KP8.0: Water column disturbance: • liquid discharges to sea • liquid discharges to surface water • noise	No pipeline burial surveys required	We assume that future survey requirements for partial removal would be like those required for leave *in situ*	Arguably if we leave exposed sections *in situ* in the short-term and monitored the situation there might come a time when remedial activities would be required. For the leave *in situ* option disturbance to the water column would be significantly less than for either complete or partial removal

Legacy Environmental factors impacted	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
KP8.0 to end: Water column disturbance: • liquid discharges to sea • liquid discharges to surface water • noise	No pipeline burial surveys required	There is no partial removal considered for the first part of the pipeline so legacy requirements would be the same as for leave *in situ*	Pipeline burial surveys will likely be required, at least in the near term
Start to KP8.0: Waste creation and use of resources such as landfill. Recycling and replacement of materials	No material would need to be recovered over the longer-term	Arguably if we leave exposed sections in situ in the short-term and monitored the situation there might come a time when remedial activities would be required. For the leave in situ case the amount of material recovered would be marginally less than for leave *in situ*	Arguably if we leave exposed sections *in situ* in the short-term and monitored the situation there might come a time when remedial activities would be required. For the leave *in situ* option the amount of material recovered would be marginally more than that for partial removal
KP8.0 to end: Waste creation and use of resources such as landfill. Recycling and replacement of materials	No material would need to be recovered over the longer-term	There is no partial removal considered for the first part of the pipeline so legacy requirements would be the same as for leave *in situ*	We anticipate that no material would need to be recovered over the longer-term whereas complete removal would leave no material to be recovered in future
Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.21: PL1099 Legacy Environmental Impacts

5.4.5 Environmental impact on SAC

Our assessment of the short-term impact of decommissioning PL1099 and longer term impact of legacy related activities such as surveys, potential remedial work on the Special Area of Conservation is summarised in Table 5.22.

For the complete removal option we believe that the impact would be relatively short-term and that the sand wave structure would recover within 20 years. This is based on the extent of recovery since installation. The complete removal option would result in the largest area of seabed being disturbed, but the area impacted would be relatively small compared to the original trenching operations. Therefore, we would expect recovery of the seabed to be relatively quick and sediment will settle back into the trench at the time the umbilical was being removed.

The partial removal option is really only considered a potential requirement for the first half of the umbilical. For this option there would be local disturbances where either the short sections of umbilical are removed, or as an alternative, to deposit rock on the exposed sections. Although this would have a similar impact to those associated with full removal, deposited rock is a different type of habitat for the local fauna and would take longer to recover, if at all. Furthermore, it's possible that rock introduced to the area could result in changes to local current and scour patterns as we have seen evidence of scour at the installations. There would also be the possibility that further remedial work would be required over the longer-term due to changes in scour patterns.

Recent survey data suggests that areas where rock has been placed are still distinct from the surrounding area and act as a different habitat type, albeit a small area.

For the leave *in situ* option there would be little disturbance to the local seabed. As for partial

removal, continued monitoring in the foreseeable future does carry the risk of additional remedial work being required. In this option there would be no change from the way the conservation objectives are affected now.

In the longer-term there would be no long term legacy issues or impacts associated with complete removal.

For partial removal, areas where items have been removed will result in no long-term legacy issues or impacts, and this is the same as per complete removal. Should rock be placed to remediate exposed lengths, the local habitat would be changed, and this would take longer to recover, if at all, given the scour and the subsequent effects on the surrounding areas and the associated sand waves. There may also be a requirement for additional remedial work with the associated additional changes to habitat and scour patterns.

We have evidence that the number and length of exposures has been increasing over the years and we believe that surveys would be required until we can demonstrate that the umbilical is stable. On the evidence we have seen, we believe that it is unlikely that legacy surveys over the short and longer-term would be able to demonstrate that the first half of the umbilical remains buried and stable. In our view continued monitoring will likely identify a requirement for additional remedial works, resulting in additional and ongoing subsequent impacts on the seabed and SAC in line with those for the execution impacts for complete removal.

Sub-Criterion	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
Short-term: Environmental impacts on SAC due to decommissioning activities	**Start to KP8.0:** Compared to the other options, a large area of seabed would be disturbed, although compared to the North Norfolk Sandbank the area affected would be relatively small and the impact would be relatively short-term. Assuming a 2m wide corridor, the area affected would be 0.016km^2, 1.6ha equivalent to c. 0.0004% of the SAC	**Start to KP8.0:** In this option there would be local disturbances where short sections of umbilical are removed and the remediation method used could have a different effect on the ecology of the local seabed. Assuming 2m wide corridor affected the area affected would be negligible	The leave *in situ* option would have the least effect compared to the other options, as there no change to the current environment
	KP8.0 to end: Larger area of the SAC impacted due to the disturbance of the seabed as the umbilical is pulled or jetted out of the trench. Assuming 2m wide corridor affected the area affected would be 0.015km^2, 1.5ha equivalent to c. 0.0004% of the SAC	**KP8.0 to end:** In this instance, partial removal is not considered. Refer leave *in situ*, option 3.	Limited or no impact on the SAC during offshore decommissioning operations compared with option 1
Legacy: Environmental impacts on SAC due to decommissioning activities	**Start to KP8.0:** No long-term legacy issues or impacts	**Start to KP8.0:** Areas where items have been removed will result in no long-term legacy issues or impacts as per complete removal. We believe that remedial work would likely be required in future, resulting in additional and ongoing subsequent impacts on the seabed and SAC in line with those for the short-term impacts for complete removal	**Start to KP8.0:** Based on the evidence so far, additional remedial work could be required over the longer term. This would result in impacts on the seabed and SAC and such impacts would be in line with those associated with partial removal
	KP8.0 to end: None, as the entire infrastructure will have been removed. We would expect the area will recover relatively quickly after the disturbance. Survey data to date shows little or no evidence of the trenching that occurred during installation over the period of over 20	**KP8.0 to end:** In this instance partial removal is not considered. Refer leave in situ, option 3.	**KP8.0 to end:** We believe no remedial works will be required as this section of the umbilical is buried and appears to be stable. The local bathymetry has a uniform pattern that hasn't really changed over the

Sub-Criterion	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
	years since the umbilical was originally installed		years, and the umbilical is buried and stable. Refer [4]

Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.22: PL1099 Environmental Impact on SAC

There has been no requirement for remedial measures for the last 20 years, even though the number and length of exposures has been increasing in each survey. As per partial removal (for the first half of the umbilical) we believe that it is unlikely that future surveys would demonstrate that the umbilical remains stable and buried. Continued monitoring will be likely to identify the need for additional remedial work over the longer term. This would result in impacts on the seabed and SAC and such impacts would be in line with those associated with partial removal.

5.4.6 Summary of environmental assessment

The environmental assessment was split into short-term operational impacts, legacy impacts and both short-term and long-term impacts due to legacy related activities on the Special Area of Conservation. The umbilical was also segmented into two parts, 'Start to KP8.0' and KP8.0 to End'.

'Start to KP8.0'

In the short-term, and from operational perspective, leave *in situ* would be the favoured option, and vessel time associated with the partial removal option would be greater than either the complete removal and leave in situ options. Conversely complete removal would result in no legacy activities being required, while both partial removal and leave *in situ* can expect legacy activities such as surveys and remedial works to be required in future.

There would be little to choose between partial removal and leave *in situ* from a legacy perspective.

The complete removal option would result in recovery of all the umbilical material for recycling whereas the leave *in situ* and partial removal options would result in most of the umbilical material being left where it is, and therefore unavailable for recycling. Any raw material not recovered would need to be replaced with newly manufactured material.

In the short-term, the leave *in situ* decommissioning option was considered to cause the least disruption to the SAC and so would be preferred. However, over the longer term both the leave *in situ* and partial removal options would result in more significant disruption to the seabed and SAC due to the anticipated remedial works required in future. This will remain an area of uncertainty and risk. In practical terms, however, there would be little to differentiate these options over the longer-term.

In the short-term and due to operational activities, the complete removal option would be least favourable but was nevertheless assessed as 'tolerable'. Over the longer-term the leave *in situ* and partial removal options would be least favourable. However, after the initial shock of disruption from complete removal activities the SAC can be expected to fully recover within 20 years after the initial impact of decommissioning works, and so in the longer-term complete removal was assessed to be the most preferred option. This is because the SAC is expected to experience continued disruption due to remedial works until it can be demonstrated that the umbilical remain stables.

'KP8.0 to End'

The environmental assessment was split into short-term operational impacts, legacy impacts and both short-term and long-term impacts due to legacy related activities on the Special Area of Conservation.

Remembering that only two decommissioning options were considered appropriate for this section of the umbilical, in the short-term, and from operational perspective, leave *in situ* would be the favoured option, and conversely complete removal would result in no legacy activities

being required, and so this option would be favoured over the longer-term. However, as it can be legitimately assumed that no remedial works would be required in future, there would be little to choose between the complete removal and leave *in situ* options over the longer term. All impacts for both options were assessed as broadly acceptable.

The complete removal option would result in recovery of all the pipeline material for recycling whereas the leave *in situ* option would result in most of the pipeline material being left where it is, and therefore unavailable for recycling. Any raw material not recovered would need to be replaced with newly manufactured material.

In the short-term, the leave *in situ* decommissioning option was considered to cause the least disruption to the SAC and so would be the most preferred. Over the longer-term the leave *in situ* option would be preferred to the complete removal option, but in practical terms there would be little to differentiate the two.

In the short-term and due to operational activities, the complete removable option would be least favourable but was nevertheless assessed as 'tolerable'. However, the area can be expected to fully recover within 20 years after the initial impact of decommissioning works, and so in the longer-term complete removal was assessed to be the marginally preferred option.

5.4.7 Societal Assessment

The assessment of the other criteria (safety, environment, cost and technical) considers the level of detrimental effect whereas the assessment of impacts on employment asses the level of benefit, a positive effect. We use vessel durations as an indicator of magnitude of the *continuation* of employment rather than creating new employment. We can discuss short-term effects due to decommissioning operations – 'project' activities - and longer-term impacts due to legacy related activities.

The societal issues around the pipeline are discussed below.

Commercial activities

The main commercial activity in the area is fishing. The potential effects could be loss of fishing revenue due to exclusion from fishing grounds, disturbance of the seabed or loss or damage of fishing equipment.

While the vessels are present in the field and activities are being undertaken, the area will not be accessible for fishing. Therefore, the magnitude of the impact on commercial activities is related to the vessel duration. In the short-term, irrespective of which pipeline (or umbilical) is being considered, the complete removal activities will incur longer vessel activities. Conversely, the leave in situ option would require the least vessel activity. Where available the partial removal option will involve vessel activities with durations that would sit somewhere in-between complete removal and leave *in situ*. We try to differentiate the options using different shades of green in the summary table.

Decommissioning activities that would be common to all decommissioning options such as dealing with the pipeline ends or removing surface laid pipelines are not considered here as they do not differentiate the options.

Activities which involve removal, reburial will implicitly disturb the seabed. Therefore, since complete removal will require more activities on the seabed it will have a higher short-term impact on commercial fishing compared to partial removal or leave *in situ* options.

Therefore, during decommissioning activities the complete removal option is expected to have a greater impact on fishing activities as it has the longest duration and the greatest amount of activity disturbing the seabed. Partial removal leaves much of the infrastructure *in situ* and, the leave *in situ* option would leave most of the infrastructure in the seabed resulting in less work offshore, so there would be less of an impact on commercial fishing activities.

While all decommissioning options would require an environmental survey to be completed, only

the partial removal; and leave *in situ* options would require pipeline burial surveys. The degree to which these will be required will be governed by the results of each survey, and if it can be demonstrated that the pipeline remains stable and pose no snagging risk such surveys may no longer be required.

While any such surveys are being undertaken, fishing activity may be disrupted for a short time but the impact can be expected to be minimal. Typically, one post-decommissioning environmental survey would be required, and for each decommissioning option we have assumed the number of pipeline surveys that would be required so that we can compare the impact of the options. The exact magnitude of the impact will be dependent on the type, frequency and duration of the surveys required. We might expect more future surveys for the first half of PL1099 than for other pipelines and umbilical lines being left *in situ* where the seabed is less mobile.

Employment

The complete removal option has greater vessel duration and waste management requirements and therefore impacts more positively on employment than partial removal. The effect on employment will be the continuation of existing jobs, as opposed to the creation of new opportunities; therefore, the significance of the positive impact has been assessed as low.

Communities

Vessels would be in the field for relatively short duration, both within and outside the 500m safety zones. Fishing vessels would be excluded from the area outside the 500m zone but we believe that when compared to the wider area this would have a relatively small effect. There is little to differentiate between the options. Aggregate extraction area is north of the area where decommissioning activities would be undertaken. Shipping will be notified and continue an alternative route. There could be an effect on other users of the ports and there would be a marginally higher impact for complete removal but overall, we believe that there is little to differentiate the options.

The port and the disposal site for recovered materials have yet to be established. However, they will be existing sites which are used for oil and gas activities and hold the required permits for waste management. The communities around the port and the waste disposal sites are therefore, expected to be adapted to the types of activities required and the decommissioning activities will be an extension of the existing situation. Therefore, the effect on communities is not considered a differentiator between options

The results of the societal assessments for both segments of PL1099 ('**Start to KP8.0**' and '**KP8.0 to end**') are presented in Table 5.23 and Table 5.24. There is very little to differentiate the options for each. Note that for PL1099 there is no 'partial removal option for 'KP8.0 to end'. In other words, the assessment for PL1099 and partial removal should be taken to be the same as determined for 'leave *in situ*', but otherwise the data presented in Table 5.23 remain valid.

Sub-Criterion	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
Short-term: Commercial activities	Impact of decommissioning vessel traffic on local commercial activities such as fishing would greatest for complete removal	Impact of decommissioning traffic on local commercial activities such as fishing would be less than for complete removal but greater than for leave *in situ* option	Impact of decommissioning vessel traffic on local commercial activities such as fishing would least for complete removal
Legacy: Commercial activities	Impact of environmental survey vessel traffic on local commercial activities such as fishing would be less once the pipeline had been completely removed	Impact of survey vessel traffic on local commercial activities such as fishing could be slightly more than for complete removal but less than for leave *in situ*	Impact of survey vessel traffic on local commercial activities such as fishing could be slightly more with the leave *in situ* option but there is little to differentiate option 2 and option 3
Short term: Employment	Decommissioning activities would contribute greatest to	Decommissioning activities would contribute to continuity	Decommissioning activities would contribute the least to

Sub-Criterion	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
	continuity of employment for complete removal	of employment less than for complete removal and more that for leave *in situ* option	continuity of employment for leave *in situ*
Legacy: Employment	Once the pipeline had been completely removed, the opportunity for continuation of employment would be minimal once the environmental survey had been completed	Once the pipeline had been partially removed the opportunity for continuation of employment would be associated with survey work would be similar to the leave *in situ* option	Should the pipeline be left *in situ* surveys would need to be carried out as would be required for option 2, otherwise there is little to differentiate options 2 & 3
Short-term: Communities	Decommissioning activities would contribute greatest to continuity of work in ports and disposal sites for complete removal	Decommissioning activities would contribute to continuity of work in ports and disposal sites less than for complete removal and more that for leave *in situ* option	Decommissioning activities would contribute the least to continuity of work in ports and disposal sites for leave *in situ*
Legacy: Communities	Once the pipeline had been removed there would be few opportunities for continuity of work in ports and disposal sites	Once the pipeline had been partially removed there would be few opportunities for continuity of work in ports and disposal sites other than associated with survey related and possible remedial work	Once the pipeline had been left *in situ* there would be few opportunities for continuity of work in ports and disposal sites other than associated with survey related and possible remedial work. There is little to differentiate options 2 & 3
Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.23: PL1099 ('Start to KP8.0') Societal Assessment

Sub-Criterion	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
Short-term: Commercial activities	Impact of decommissioning traffic on local commercial activities such as fishing would be more than for leave *in situ* option	N/A	Impact of decommissioning vessel traffic on local commercial activities such as fishing would be less than for complete removal
Legacy: Commercial activities	Impact of environmental survey vessel traffic on local commercial activities such as fishing would be least once the pipeline had been completely removed	N/A	Impact of survey vessel traffic on local commercial activities such as fishing would be slightly more with the leave *in situ* option
Short term: Employment	Decommissioning activities would contribute most to continuity of employment for complete removal on the basis of vessel use durations and onshore activities associated with complete removal	N/A	Decommissioning activities would contribute the least to continuity of employment for leave *in situ*
Legacy: Employment	Once the pipeline had been completely removed, the opportunity for continuation of employment would be minimal once the environmental survey had been completed	N/A	Opportunities for continuation of employment would be greater than for the leave *in situ* option
Short-term: Communities	Decommissioning activities would contribute greatest to continuity of work in ports and disposal sites for complete removal	N/A	Decommissioning activities would contribute the least to continuity of work in ports and disposal sites for leave *in situ*
Legacy:	Once the pipeline had been	N/A	Once the pipeline had been

Sub-Criterion	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
Communities	removed there would be few opportunities for continuity of work in ports and disposal sites		left *in situ* there would be few opportunities for continuity of work in ports and disposal sites other than for surveys and possible remedial work
Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.24: PL1099 ('KP8.0 to end') Societal Assessment

Summary of societal assessment

We use vessel durations as an indicator of magnitude of the *continuation* of employment rather than creating new employment, and we have considered short-term effects due to decommissioning operations – 'project' activities - and longer-term impacts due to legacy related activities. We have also examined potential disruption to commercial activities resulting from the presence of vessels specifically to carry out the decommissioning work. We have taken a somewhat holistic approach.

'Start to KP8.0'

Disruption to commercial activities would be least when the decommissioning effort in the field is minimised, and this is the case for leave *in situ*, whereas because of the inefficiencies involved partial removal could potentially result in the most disruption to commercial activities with complete removal slightly less than for partial removal but greater than for leave *in situ*.

Conversely, legacy related disruption on commercial activities in the area would be greatest for leave *in situ*, since there would be no legacy activities once decommissioning activities associated with complete removal had been completed because there would be no infrastructure left to inspect, whereas the leave *in situ* and partial removal options would require legacy activities to be carried out at least for the foreseeable future.

Employment opportunities would be greatest for the partial removal option owing to the larger amount of vessel time although opportunities for onshore employment would be less, as less material would be recovered for dismantling and recycling works. In any event, employment opportunities would be least for the leave *in situ* option.

Conversely, legacy related employment opportunities would be least for complete removal and greatest for leave *in situ*, with opportunities associated with partial removal being like leave *in situ*. This is because the leave *in situ* and partial removal options would both require legacy activities to be carried out, at least for the foreseeable future.

'KP8.0 to End'

Disruption to commercial activities would be least when the decommissioning effort in the field is minimised, and this is the case for leave *in situ*, whereas complete removal could potentially result in the most disruption to commercial activities.

Conversely, legacy related disruption on commercial activities in the area would be greatest for leave *in situ*, since there would be no legacy activities once decommissioning activities associated with complete removal had been completed because there would be no infrastructure left to inspect, whereas the leave *in situ* options would require legacy activities to be carried out at least for the foreseeable future.

Employment opportunities would be greatest for the complete removal option owing to the larger amount of vessel time and onshore dismantling and recycling works. Such opportunities would be least for the leave *in situ* option.

Conversely, legacy related employment opportunities would be least for complete removal and greatest for leave *in situ*. This is because the leave *in situ* option would require legacy activities

to be carried out, at least for the foreseeable future.

5.4.8 Cost Assessment

Recall that for simplicity PL1099 has been assessed as an umbilical in two halves. For the first half of the umbilical (**Start to KP8.0**) the complete removal would be more efficient to achieve than the removal of circa 29 individual exposed sections of umbilical line, totalling an equivalent of circa 149m in length. Each exposed length would take time to locate and be dealt with, whereas removal by reeling would be executed as a continuous operation. The incremental differences in cost for each option are compared in Appendix E.6.

For the **first half** of the umbilical, the incremental difference in cost between complete removal and partial removal – including the requirement for legacy surveys - on a like-for-like basis would be least £1.5MM, and the incremental difference in cost between partial removal and leave *in situ* would be at least £1.3MM. The incremental difference in cost between complete removal and leave *in situ* would be at least £2.8MM. This assessment does not take account of future remedial works to remove future potential snagging hazards, but if the partial removal costs can be considered an indicator of future costs, the incremental difference between complete removal and partial removal could easily become comparable should future remedial works be required.

For the **first half** of the pipeline the difference in incremental cost between complete removal and partial removal and leave *in situ* options is less marked, particularly if further exposures need to be removed as part of legacy related activities. Note that future legacy related remedial works have not been accounted for in the incremental cost by difference assessment, but an indication of the potential costs may be comparable to the short-term costs associated with partial removal. The difference the short-term costs for complete removal compared with partial removal cannot be classed as an order of magnitude greater, so the cost has been classed as "Low / Broadly Acceptable & least preferred" in Table 5.25.

Survey data suggest that the second half (**KP8.0 to end**) of the umbilical is relatively stable with no exposures so the partial removal option doesn't apply. The incremental difference in cost between complete removal and leave *in situ* would be at least £2.6MM.

For this pipeline, we believe that legacy related survey costs would become more of an issue because the number of exposures seems to be increasing year-on-year, so there is no guarantee that the progress of these would stop once the partial removal option had been implemented. Indeed, the evidence to date would seem to suggest that future surveys could well identify additional exposures in future, and that these would need to be remediated in some way. This may mean that additional exposures would need to be cut out or possibly covered in rock in future, posing an additional burden on legacy costs.

For the **second half** of the umbilical, because there is an order of magnitude difference in the costs for complete removal compared with leave *in situ* the difference in cost has been classed as "Medium / Tolerable & non-preferred" in Table 5.25.

Sub-Criterion	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
Start to KP8.0 **Short-term:** Cost	The cost of complete removal would be higher than for either of the partial removal or the leave *in situ* options, but not an order of magnitude higher	Because of the inefficiencies involved, the cost of removing several short-exposed sections is estimated to be 50% of the cost of complete removal on a like-for-like basis	The cost of leave *in situ* would be the least expensive of all options
Start to KP8.0 **Legacy:** Cost	Once the pipeline had been completely removed no pipeline burial surveys or stability assessments after decommissioning works had	Future burial surveys and stability assessments will be required. The premise is that if two successive surveys demonstrate that the pipeline	Future burial surveys and stability assessments will be required. If two successive surveys demonstrate that the pipeline remains stable the

Sub-Criterion	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave *in situ*
	been completed or over the longer-term	remains stable the premise is that no more surveys would be required. Although arguably for partial removal there are more potential snag hazards to manage, there is little to differentiate option 2 and 3 over the longer-term	premise is that no more surveys would be required. Outcome less certain than for complete removal. There is little to differentiate option 2 and 3 over the longer-term
KP8.0 to end **Short-term:** Cost	The cost of complete removal would be an order of magnitude higher than for the leave *in situ* option	Partial removal not applicable since there are no lengths of umbilical that would need to be removed. As option 3	The cost of leave *in situ* would be less expensive than complete removal
KP8.0 to end **Legacy:** Cost	Once the pipeline had been completely removed no pipeline burial surveys or stability assessments after decommissioning works had been completed or over the longer-term	Partial removal not applicable. As option 3, leave *in situ*	Future burial surveys and stability assessments will be required. If two successive surveys demonstrate that the pipeline remains stable no more surveys would be required. We believe that this is realistically achievable
Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 5.25: PL1099 Cost Assessment

5.4.9 Overall Summary of Assessment

PL1099 is approximately 15.1km long and was assessed as two parts, '**Start to KP8.0**' and '**KP8.0 to end**'. The partial removal option is only considered for the first half of the umbilical as there are no recorded exposures to be dealt with in the second half of the line. Our assessment concludes that the most efficient approach that removes uncertainty concerning the burial status and stability of the umbilical would be that the first 8km of umbilical should be removed. The second half of the umbilical should be left *in situ* as it appears buried and stable.

The first part of the umbilical passes through large sand waves near Audrey B (XW) and examination of historical records suggest that although they are not significant enough to need reporting to the Kingfisher Information Service, the number of exposures (29, totalling 149m length) is increasing in number and total length year on year, and we believe that it is only a matter of time before these exposures would need to be remedied. Our assessment indicates that it would be more efficient to remove the first 8km of the umbilical by reverse reeling rather than attempt to locate and remove each individual span, and this is reflected in Table 5.26.

Complete removal of the first 8km is the best option over the longer-term in that it removes future uncertainty of the burial status and stability of the umbilical. In the short-term the conservation objectives of the SAC would be compromised but evidence from the original installation suggests that over the longer term the seabed affected by removal operations will fully recover.

Removal operations would need to be managed to ensure that the risk to project personnel both offshore and onshore would be ALARP for recovery operations for the pipeline as it is reeled onto the umbilical reel on the pipe lay vessel as well as when it is dealt with onshore. Furthermore, although we have assumed that the umbilical could be recovered onto a reel by pulling it directly from the seabed engineering analysis would need to be completed to confirm that this could be done. Our view, however, is that the removal of the umbilical would have a much greater chance of success compared to removal of a buried 12" pipeline such as PL947.

From an environmental perspective one prominent element is the effect on the conservation objectives of the SAC, and we have assessed that the SAC will be affected at some time, whether in the short-term due to removal operations or sometime in future when remedial

activities are required to rectify any exposed spans. Another complication for the first half of the umbilical is that we think that it is unlikely that we would be able to demonstrate that the umbilical remains stable in two consecutive surveys in the near term, meaning that future ongoing surveys would probably be required over a longer period.

Small differences are found between the safety assessment with more work required offshore and onshore for the complete removal than partial removal and consequently higher safety risk. Conversely there is lower safety risk to mariners from complete removal than for partial removal and leave *in situ* due to the complete removal of the pipeline as a potential snag hazard.

The approach we have used for the impact assessment suggests that 'complete removal' in the short-term is assessed 'medium, tolerable and non-preferred' with the cell coloured orange. This is the same for the legacy elements of 'partial removal' and leave '*in situ*' for the first half of the umbilical. Note that in practical terms the area of SAC affected would still be negligible. The assessment merely illustrates that the area of SAC affected by complete removal would be an order of magnitude higher than for either partial removal or leave *in situ*. We don't believe any of the impacts would affect the long-term aims and conservation objectives of the SAC.

Finally, for the first 8km of the umbilical we estimate that in the short-term, complete removal would be more expensive to achieve than partial removal. In the longer-term however, it's possible that for leave *in situ* there will be a continual requirement to monitor and possibly remediate the different parts of the umbilical, and that costs could exceed those associated with complete removal over the longer term. We have not fully quantified this as it remains an area of uncertainty.

Aspect	Sub-criterion	Short-term or legacy?	Option 1 Complete removal		Option 2 Partial removal	Option 3 Leave *in situ*	
			First half	Second half	First half	First half	Second half
Technical	Technical feasibility	Short-term					
		Legacy					
Safety	Safety risk to offshore project personnel	Short-term					
		Legacy					
	Safety risk to mariners	Short-term					
		Legacy					
	Safety risk to onshore project personnel	Short-term					
Environmental	Atmosphere (energy & emissions)	Short-term					
		Legacy					
	Seabed disturbance area affected	Short-term					
		Legacy					
	Impact on SAC	Short-term					
		Legacy					
	Water column disturbance	Short-term					
		Legacy					
	Waste creation	Short-term					
		Legacy					
Societal	Commercial activities	Short-term					
		Legacy					

Aspect	Sub-criterion	Short-term or legacy?	Option 1 Complete removal		Option 2 Partial removal	Option 3 Leave *in situ*	
	Employment	Short-term					
		Legacy					
	Communities	Short-term					
		Legacy					
Cost (by difference)		Short-term					
		Legacy					

Table 5.26: PL1099 Summary of Comparative Assessment

For the second half of the umbilical we believe that the assessment for PL948 largely holds true for PL1099, and this is reflected in Table 5.26. That is, there is very little otherwise to differentiate complete removal and leave *in situ*.

Modest differences are found between the environmental assessment scoring (leave in place favoured largely because of lesser ecosystem disturbance from removal activities and less impact associated with vessel use (emissions to air, discharges to sea, noise and disposal requirements)) and societal scoring (removal favoured as more resources are required).

From an environmental perspective one aspect of the assessment that appears prominently is the effect on the objectives of the SAC, and we have assessed that these would be adversely affected most by activities associated with complete removal. Complete removal is non-preferred when considering the conservation objectives of the SAC and in this instance there are no advantage with complete removal since the umbilical appears buried and stable.

More significant differences are found between the safety assessment with more work required offshore and onshore for the complete removal – where significant offshore and onshore work would be required - than leave *in situ* where in the short-term there would be no offshore work required apart from burial status surveys following on from decommissioning the umbilical ends and pipeline crossing over PL947. Conversely there is lower safety risk to mariners from complete removal than for leave *in situ* due to the complete removal of the pipeline as a potential snag hazard.

6. COMPARATIVE ASSESSMENT FOR FRONDED MATTRESSES

The following section presents the results from the comparative assessment of frond mattresses.

The same method used for pipeline was applied to the frond mattresses. The options considered are shown in Table 6.1.

Item	Option 1 Complete Removal	Option 2 Leave *in situ*	Option 3 Leave *in situ* and remediate
Frond mattresses	Remove. Mattresses excavated, if required, lifted using a grappling tool and recovered to a suitable vessel. If condition is found to be poor, lifted into baskets using remotely operated tools and recovered to a suitable vessel. *Return mattress to shore for processing*	Leave mattresses *in situ* with no remedial works	Option not assessed as mattresses are currently buried

Table 6.1: Fronded Mattress Decommissioning Options

6.1.1 Technical Assessment

We believe that the two options, complete removal and leave *in situ*, are both technically feasible, although excavating around the buried mattress to allow for removal in the sandy sediment will prove more difficult than leave *in situ*.

The options for recovery of the frond mattresses includes using ROVs to excavate the mattresses, grappling tools to lift the mattress whole directly to the vessel or, if in poor condition, in pieces into baskets prior to being lifted to the vessel for recovery to shore. Both methods have been used in the North Sea before, and as such the technical uncertainty was deemed unlikely to have an adverse impact on technical risk. Excavation using water jetting to remove the cover has been widely used although this would be more time consuming and costly. Likewise, using a grappling tool to lift mattress pieces would take a significant amount of time to carry out.

Providing the mattresses remain buried in the long term leaving the mattress in place would be equally acceptable. The mattresses are designed to capture sediment and remain buried therefore the likelihood of them becoming unburied is considered to be low, although conceivable. Monitoring of the mattresses locations would be undertaken to establish their burial status.

Leave *in situ* would be preferred in the short term. In the long term there is little to differentiate between the options, however complete removal is marginally preferable.

The results of the assessment are presented in Table 6.2.

Sub-Criterion	Aspect	Option 1 Complete Removal	Option 2 Leave *in situ* (no intervention)
Technical feasibility	Short-term	Technically feasible. Would require excavation to remove c.1m depth of sediment. There is a possibility that the removal of the installations would require the area to be excavated making removal easier. A grab could be used.	Technically feasible.
	Legacy	No legacy activities required.	Surveys have been undertaken in the past and are feasible. Assumed to remain buried, as designed but surveys would be required to establish if this assumption is correct.

Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 6.2: Fronded Mattresses Technical Assessment

6.1.2 Safety Assessment

Safety Risk to Offshore Project Personnel

All hazards were assessed as broadly acceptable. Key differences between the options are:

- Lifting and handling of the mattresses on the deck and during demobilisation; the risk to personnel on the vessel from handing will be greater for complete removal than for leave *in situ* due to the material that would be recovered;
- Survey requirements for the leave *in situ* options. There are no survey requirements for the complete removal options;
- Future remedial requirements. No future remedial work is required for complete removal. There is a low, but possible requirement for remedial works for leave *in situ*.

Centrica have not recovered fully buried mattresses previously, although we believe that it has been undertaken in the North Sea. Therefore we believe that although the risks would be higher for complete than for leave *in situ*, they would still be broadly acceptable. Sufficient mitigation and control measures would be adopted.

Short Term and Legacy Safety Risk to Fishermen and Other Marine Users

There remains the possibility of interaction with other mariners while decommissioning works are being carried out in the field, and this would increase with the number and duration of vessels in the field, the location of the work and the frequency of marine traffic. Decommissioning activities involve vessels working in the field, and over the longer term will be related to the amount of surveys required in future.

Vessel durations associated with the complete removal option will be greater than for leave *in situ.* The reverse is true for legacy issues, where there will be surveys required for the leave *in situ* options, but none for the complete removal option.

The greatest risk relating to marine users is likely to be concerned with snagging of fishing gear. The risk of snagging fishing gear and the risk of snagging equipment during offshore construction and legacy were assessed as broadly acceptable.

The type of fishing in the area is predominantly demersal trawling for flatfish. Therefore, there is a potential for snagging any exposed frond mattresses. Currently the mattresses are within 500m zones, which will be relinquished following the completion of the decommissioning activities. Survey data has shown that the frond mattresses are buried therefore the removal of the 500m zone is not expected to change the risk.

Safety Risk to Onshore Project Personnel

The key difference between the options is the risks associated with lifting and handling of frond mattresses onshore. The risks are greater for complete removal due to larger quantity of material being returned to shore.

The results of the assessment are presented in Table 6.3.

Sub-Criterion	Option 1 Complete Removal	Option 2 Leave *in situ* (no intervention)
Short-term: Health & safety risk offshore project personnel	Associated with vessel duration. All undertaken as diverless activities. Feasible although if the fronds are not buried they can be a hazard to the ROV.	None - no activity.
Legacy: Health & safety risk offshore project personnel	No legacy activities required.	Associated with undertaking surveys
Short-term: Health & safety risk to mariners	Associated with vessel activity, all of which would be undertaken within 500m zone.	None - no activity.
Legacy: Health & safety risk to mariners	No legacy activities required.	Mattresses could present a potential snagging risk. Unlikely as surveys will establish if they remain buried. The nature of the construction means that the risk of unburied frond mattresses would be low. Little to differentiate between complete removal and minimal removal.
Short-term: Safety risk onshore project personnel	Activities associated with disposal of recovered fronded mattresses.	None - no activity.
Legacy: Safety risk onshore project personnel	None.	None.

Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 6.3: Fronded Mattresses Safety Assessment

Summary of safety assessment

Based on the differences, in the short-term the leave *in situ* option gives rises to lower risks to project personnel, other users of the sea and onshore project personnel as there is no offshore work and no onshore handling.

By completely removing the mattresses the risk of snagging is removed in perpetuity. Therefore, the complete removal option results in lower residual risks to mariners and other users of the sea, however the survey data has shown that the frond mattresses are buried and, due to their design, are likely to remain buried, therefore there is little to differentiate between the two options.

6.1.3 Environmental impact of operational activities

Vessels would be required for complete removal whereas no activity would be required for the leave *in situ*. The vessel duration is proportional to the impacts from liquid discharges to sea, noise, emissions to air and energy requirements, water column, seabed, waste as they are associated with the marine activities.

Emissions to air and energy requirements are also associated with recycling of material returned to shore.

While there will be different impacts for each of the options, the overall impact of the 'complete removal' option will be higher on the atmosphere, seabed disturbance, and water column.

Conversely, the legacy survey requirements for leave *in situ* are greater than for complete removal and these will mostly affect the atmosphere and water column.

We believe that leave *in situ* is preferable for short-term environmental impacts.

The results of the assessment are presented in Table 6.4.

Sub-Criterion	Option 1 Complete Removal	Option 2 Leave *in situ* (no intervention)
Atmosphere (Energy & Emissions)	Associated with vessel duration.	None – no activity.
Seabed disturbance, area affected	The area affected will depend on the area of excavation or grab.	None – no activity.
Water column disturbance: • liquid discharges to sea • liquid discharges to surface water • noise	Associated with vessel duration.	None – no activity.
Waste creation and use of resources such as landfill. Recycling and replacement of materials	We expect that the material returned to shore could be recycled, although we don't know for certain the original material of manufacture.	None – no activity.
Colour Key:		

Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 6.4: Fronded Mattress Operational Environmental Impacts

6.1.4 Environmental impact of legacy activities

On completion of decommissioning activities, a final environmental survey would be carried out, and this would be common for all options and is not a differentiator. For longer-term legacy related activities, a differentiator between options would be the number of monitoring condition status and environmental surveys that would be required as well as any possible remedial works.

The environmental impact of legacy activities is associated with future requirements of ensuring that the mattresses remain buried and don't present an unacceptable risk to the marine environment or other users of the sea.

The impacts of each survey can be expected to be similar, but on a smaller scale to those brought about by operational activities during decommissioning work.

The results of the assessment are presented in Table 6.5.

Sub-Criterion	Option 1 Complete Removal	Option 2 Leave *in situ* (no intervention)
Atmosphere (Energy & Emissions)	No legacy activities required.	Associated with survey vessel activity
Seabed disturbance, area affected	No legacy activities required.	None unless removal is required in which case the area impacted will be the same as for complete removal.
Water column disturbance: • liquid discharges to sea • liquid discharges to surface water • noise	No legacy activities required.	None – unless removal is required, in which case this would be the same as for complete removal – short-term.
Waste creation and use of resources such as landfill. Recycling and replacement of materials	None.	None – unless removal is required, in which case this would be the same as for complete removal – short-term

Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 6.5: Fronded Mattresses Legacy Environmental Impacts

6.1.5 Environmental impact on SAC

The area impacted in the short term is greatest for complete removal than for leave *in situ* due to requirement to excavate the buried mattresses (estimated to be between 1m deep and a width of 4m).

We don't expect there to be an impact on the SAC for either option in the longer-term. It is unlikely but possible that should the frond mattresses become exposed resulting in some remedial action being required. Therefore complete removal is preferred in the long term, but there is little to differentiate between the options.

When considering both short term and legacy impacts on the SAC leave in situ is preferred given the low likelihood of the mattresses becoming exposed.

Sub-Criterion	Option 1 Complete Removal	Option 2 Leave *in situ* (no intervention)
Short-term: Environmental impacts on SAC due to decommissioning activities	The area affected will depend on the area of excavation or grab.	None – no activity.
Legacy: Environmental impacts on SAC due to decommissioning activities	No legacy activities required.	None – unless removal is required, in which case this would be the same as for complete removal – short-term.

Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 6.6: Summary of Environmental Impact on SAC

6.1.6 Summary of environmental assessment

The environmental assessment was split into short-term operational impacts, legacy impacts and impacts on the Special Area of Conservation.

In the short-term, and from operational perspective, leave in situ would be the favoured option. Conversely complete removal would result in no legacy activities being required. All impacts for all options were assessed as broadly acceptable.

In the short-term, the leave in situ decommissioning option was considered to cause the least disruption to the SAC and so would be the most preferred. Over the longer-term the complete removal option would be preferred, although there is little to differentiate between the options.

Overall on balance of the short term and long term impacts leave in situ would be preferred.

6.1.7 Societal Assessment

We use vessel durations as an indicator of magnitude of the *continuation* of employment rather than creating new employment. Short-term effects are due to decommissioning operations – 'project' activities - and longer-term impacts are due to legacy related activities.

Due to the relatively small number of frond mattresses and the relatively short duration for works, societal effects are not considered to be a differentiator. Any effects would be in line with durations of vessel use and mass of material recovered for disposal, but the difference is considered not to be material.

Sub-Criterion	Option 1 Complete Removal	Option 2 Leave *in situ* (no intervention)
Short-term: Commercial activities	Not considered a differentiator due to the relatively small number of fronded mattresses	
Legacy: Commercial activities		
Short-term: Employment		
Legacy: Employment		
Short-term: Communities		
Legacy: Communities		

Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 6.7: Fronded Mattress Societal Assessment

6.1.8 Cost Assessment

The incremental difference in cost between complete removal and leave *in situ* on a like-for-like basis would be least £0.3MM taking account of the need for survey to confirm burial status in future. Therefore leave *in situ* is the preferred option.

A high-level breakdown of the costs can be found in Appendix F.2.

Sub-Criterion	Aspect	Option 1 Complete Removal	Option 2 Leave *in situ* (no intervention)
Cost (by difference)	Short-term		
	Legacy		

Colour Key:			
Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Table 6.8: Fronded Mattress Cost Assessment

6.1.9 Overall Summary of Assessment

Overall complete removal was assessed as having the lowest legacy safety risk, lowest environmental impact and risk and lowest cost. Given that the design of the frond mattresses is that they remain buried there is little to differentiate between the two options over the long term. It was assessed that societal impacts were not materially different between options.

Leave *in situ* was assessed having the lowest short term safety risk, environmental impact and risk, technical uncertainty and cost.

On balance given the little difference in long term impacts and risks of the two options and that over the short term leave *in situ* was assessed having lower risks and impacts leave *in situ* is the preferred option.

A summary of the results are shown in Table 6.9 and discussed in the section below. The colour coding - green being best - indicates whether the risks are broadly acceptable or tolerable. It should be noted that these risks are for the *differences* between options only. For safety, leave *in situ* is preferred when considering the combined short-term and legacy risks.

Aspect	Criteria	Aspect	Option 1 Complete Removal	Option 2 Leave *in situ* (no intervention)
Technical	Technical feasibility	Short-term		
		Legacy		
Safety	Health & safety risk offshore project personnel	Short-term		
		Legacy		
	Health & safety risk to mariners	Short-term		
		Legacy		
	Safety risk onshore project personnel	Short-term		
		Legacy		
Environmental	Atmosphere (energy & emissions)	Short-term		
		Legacy		
	Seabed disturbance area affected	Short-term		
		Legacy		
	Impact on SAC	Short-term		
		Legacy		
	Water column disturbance	Short-term		
		Legacy		
	Waste creation	Short-term		
		Legacy		
Societal	Commercial activities	Short-term		
		Legacy		
	Employment	Short-term		
		Legacy		
	Communities	Short-term		
		Legacy		
Cost (by difference)		Short-term		
		Legacy		

Table 6.9: Fronded Mattress Summary Comparative Assessment

7. OVERTRAWL AND VERIFICATION OF CLEAN SEABED

Upon completion of each decommissioning operation, appropriate surveys should be taken to identify and recover any debris located on the seabed which has arisen from the decommissioning operation or from past development and production activity. The area to be covered will depend on the circumstances of each case, but the minimum required will be a radius of 500 metres from the location of an installation [1].

Debris surveying and removal may be required up to 100 metres either side of a decommissioned pipeline over its whole length, and following this independent verification of seabed clearance will be required [1].

The advisability of post-decommissioning over-trawl to confirm that the area is clear of debris will be considered on a case-by-case basis and will be dependent upon the extent of relevant circumstances [1].

In the southern North Sea, the verification of a clean seabed might typically involve using 'rock hopper' fishing gear with scraper chains to determine if there remain any snagging hazards. Assuming the area is free of snagging hazards, a Clean Seabed Certificate is issued. These over trawl surveys are carried out to make sure the seabed is safe for normal fishing.

In our assessment of complete removal of the longer pipelines (e.g. PL947, PL948 and PL1099) we considered that the impact on the SAC would be 'medium; tolerable & non-preferred'. This was due to the scale of the impact that decommissioning works would have on the seabed, and by implication, the conservation objectives of the SAC.

Our assessment was based on a corridor on the seabed between 2m and 5m wide depending on the nature of the pipeline or umbilical, along the full length of the pipeline being affected compared with a 200m wide corridor affected by an overtrawl. A comparison of the area of seabed affected outside of the 500m zones reveals that the area affected by complete removal would be 0.23km^2 compared to 13.7km^2, the area impacted by an overtrawl[21]. For details refer Table 9.11 in Appendix G.

The in-field lengths of pipelines outside of the 500m safety zones will already have been subject to fishing activity. Except for the first 8km or so of PL1099, all our pipeline decommissioning activities will be undertaken within the existing Ann, Alison, Audrey B (XW) and LOGGS 500m safety zones. Therefore, although we can expect the seabed to recover following the overtrawl activities, to minimise the short-term impact in the seabed and thus the conservation objectives of the SAC we would propose to carry out overtrawl activities only within the 500m safety zones.

[21] Note that this assessment is slightly conservative in that the overtrawl at Audrey B (XW) would be done as part of decommissioning Audrey B (XW) rather than as part of decommissioning Ann and Alison.

8. CONCLUSIONS

The comparative assessment was undertaken with a focus on the decommissioning options for PL947, PL948, PL1099 and fronded mattresses.

The assessments considered five criteria in both the short-term for decommissioning activities and the longer term for any 'legacy' related activities. The criteria were: safety related risks (three sub-criteria), environment (two sub-criteria), technical feasibility, societal effects (three sub-criteria), and cost.

Since the decommissioning of the pipeline (and umbilical) approaches is the same irrespective of which option is pursued, decommissioning of these is not included in the assessment. Therefore, any differences are incremental to the activities associated with dealing with the pipeline approaches.

8.1 Conclusion of PL947 Comparative Assessment

Pipeline PL947 is trenched and buried and the evidence would suggest that although there are exposures throughout the pipeline there are relatively small and there has been no requirement to report the exposures to the Kingfisher Information Service.

Three decommissioning options were compared for this pipeline – complete removal, partial removal and leave *in situ*. Partial removal would involve removing at least five individual and exposed lengths of pipeline and an intermittent length of exposed pipeline 186m long, giving a total of approximately 384m of pipeline being removed. The leave *in situ* solution could involve leaving the pipeline 'as is' and monitor its burial over the foreseeable future.

Removal of the pipeline and associated stability features at the Alison tee will prove challenging but we believe that it is feasible. Any rock used to stabilise the Alison tee will be disturbed to enable access to the concrete blocks, concrete mattress and grout bags, but will be left *in situ* and profiled to ensure no residual hazards remain after decommissioning operations have been completed.

Complete removal would involve exposing the pipeline using a mass flow excavator and then re-reeling the pipeline back onto a suitable vessel or cutting into manageable sections and lifting. Depending on the capacity of the pipeline reel, recovery of the pipeline may involve a few trips back to shore to offload the recovered pipe. Once onshore, approximately 41.8km of pipe would need to be retrieved from the pipe reel, cut into manageable lengths and recycled.

Complete removal option would incur higher cost, unplanned impacts and greater short-term impacts on the environment. Offshore there would be an increased risk to safety of personnel and planned environmental impacts associated with transferring and disposing of any recovered material onshore.

By completely removing the pipeline the risk of snagging is removed in perpetuity and therefore the complete removal option results in lower residual risks to mariners and other users of the sea. However, residual snagging hazards for the partial removal and leave *in situ* options can also be considered low on the basis that the pipelines are buried and stable and the Alison tee and exposed ends - including the 46m long surface laid PL947 stub from Alison - will be removed.

Although the pipeline has exposed sections of pipe along its length, the assessment found that there was little to differentiate the partial removal and leave *in situ* options, but both were found to be preferable to complete removal. Both options were found to be materially better for safety, environment, technical and cost considerations.

Residual snagging risks associated with the partial removal and leave *in situ* options are likely to remain low, but legacy surveys will be required in order to verify this.

Finally there is an order of magnitude in the incremental difference in cost for complete removal

versus partial removal or leave *in situ*.

In conclusion, based on the comparative assessment 'leave *in situ*' is the recommended option for decommissioning the pipeline. On this basis, the pipeline will be left *in situ* underneath existing burial cover, but future inspections will be planned to ensure that pipeline does not pose a risk to other users of the sea.

8.2 Conclusion of PL948 Comparative Assessment

Pipeline PL948 is approximately 17.6km long and trenched and buried. The most recent survey data indicate that the umbilical is only exposed for a short length of circa 11m at a single location (circa KP2.4). This exposure is small when taking account of the length of the umbilical and to date there has been no requirement to report any exposures to the Kingfisher Information Service.

Otherwise the assessment found the risks and impacts associated with the decommissioning options to be broadly acceptable for most impacts except that in the complete removal option the short-term impact of decommissioning operations on SAC rises to 'tolerable' and non-preferred compared to other options.

Small differences are found between the safety assessment with more work required offshore and onshore for the complete removal than leave *in situ* and consequently higher safety risk. Conversely there would be lower safety risks to mariners arising from complete removal than for either partial removal or leave *in situ* because the pipeline would no longer be present as a potential snag hazard. However, our assessment concluded that even with the umbilical pipeline remaining *in situ* the snagging risk posed to fishermen and other users of the sea would remain low on the basis that the umbilical would remain buried.

Finally there is an order of magnitude in the incremental difference in cost for complete removal versus partial removal or leave *in situ*.

In conclusion, based on the comparative assessment 'leave *in situ*' is the recommended option for decommissioning the pipeline. On this basis, the majority of the umbilical pipeline will be left *in situ* underneath existing burial cover, but future inspections will be planned ensure that that pipeline does not pose a risk to other users of the sea.

8.3 Conclusion of PL1099 Comparative Assessment

PL1099 is approximately 15.1km long and was assessed as two parts, Start to KP8.0 and KP8.0 to end. For the first half of the umbilical up to KP8.0 the decommissioning options considered were: complete removal, partial removal and leave in situ. For the second half of the umbilical between KP8.0 and the end there was nothing to distinguish between 'partial removal' and 'leave *in situ*', so the partial removal option was discounted.

Our assessment concludes that the most efficient approach that removes uncertainty concerning the burial status and stability of the umbilical would be that the first 8km of pipeline should be removed. The second half of the umbilical should be left *in situ* as it appears buried and stable.

Complete removal of the first 8km is the best option over the longer-term in that it removes future uncertainty of the burial status and stability of the umbilical. In the short-term the objectives of the SAC would be compromised but evidence suggests that over the longer term the seabed and surrounding area affected by removal operations will fully recover. For the second half of the umbilical the proposed solution would be to leave this section of umbilical *in situ* and monitor its burial, at least over the foreseeable future although we believe that it is likely to remain stable.

Partial removal of the first half of the umbilical did not find favour. Primarily this was because of the effort that would be involved in finding and excavating the ends of the exposed umbilical and

the ensuing uncertainty of what might happen to the severed parts of the umbilical that would be left and the increased snagging risk they might impose on commercial users. The assessment concludes that it could be better to leave the umbilical intact *in-situ*, but better still remove the first half entirely. This would remove the associated snagging risks in perpetuity.

Finally, there is an incremental difference – but not an order of magnitude difference - in incremental cost for complete removal versus partial removal or leave *in situ*. For the first half of the pipeline the difference is even less marked, particularly should further exposures need to be removed as part of legacy related activities.

8.4 Conclusion of Fronded Mattress Comparative Assessment

The fronded mattresses are used at the Ann and Alison infrastructure primarily associated with installations to prevent scouring around their bases. Surveys have shown that the frond mattresses are buried, which aligns with the purpose and design of the mattresses. These mattresses are within the 500m safety zones which will be removed once decommissioning has been completed.

Two options have been considered for decommissioning the frond mattresses; complete removal and leave *in situ*. The two options were assessed against 5 criteria (technical, safety, environmental, societal and cost) for both short term and long term risks and impacts.

The results of the assessment are summarised in Table 6.9. Due to the frond mattresses being buried and their design meaning that they should remain buried, there was little to differentiate the options using the five criteria used for the assessment over the long term.

Technically both options are possible.

The short term and long term safety risks of both of the options were assessed as broadly acceptable providing control measures are adopted to ensure that risks are ALARP.

All environmental impacts and risks were assessed as broadly acceptable, providing that control and mitigation measures are adopted to ensure the impacts and risk are as low as reasonably practicable.

Little difference of impact on commercial activities, employment and communities was found between the options, with the differences being related to duration of vessel use and material returned to shore.

Leave *in situ* was assessed having the lowest short term safety risk, environmental impact and risk, technical uncertainty and cost.

Overall complete removal was assessed as having the lowest legacy safety risk, lowest environmental impact and risk, lowest technical uncertainty and lowest cost. However, given that the design of the fronded mattresses is such they should self-bury there is little to differentiate between the two options over the longer term.

Over the short term leave *in situ* was assessed having lower risks and impacts while over the longer term there is little to choose between the impacts and risks over the longer term. Therefore, on balance we conclude that leave *in situ* is the preferred option.

8.5 Conclusion of Overtrawl and Impact on SAC

A comparison of the area of seabed (and thus SAC) affected outside of the 500m zones reveals that complete removal of all the pipelines would impact just 0.23km^2 (0.006% of the SAC) of the seabed compared to 13.7km^2 (0.38% of the SAC) the area affected by an over trawl sweep outside of the 500m safety zones.

9. REFERENCES

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APPENDIX A STABILISATION FEATURES

Appendix A.1 Summary of stabilisation features

Pipeline	No. of concrete mattresses and locations	No. of grout bags and locations[22]	Number of Frond Mattresses and location
PL947	4 on PL454 & PL455 pipeline crossing 8 on PL496 & PL497 pipeline crossing 4 over BT cable crossing 0 on Mundesley & Nordenley cable 1 on Weybourne to Fano cable crossing 6 on PL27 & PL161 crossing 19 on LOGGS approach[23]	33 on PL454 & PL455 pipeline crossing 67 on PL496 & PL497 pipeline crossing 4 over BT cable crossing 0 on Mundesley & Nordenley cable 8 on Weybourne to Fano cable crossing 50 on PL27 & PL161 crossing 1482 (25kg) on LOGGS approach 53 (1000kg) on LOGGS approach	10 at LOGGS approach, classified as 'anti-scour' mattresses but their size is inconsistent with typical fronded mattresses
PL947 stub	6 between Alison template and Alison tee	60 between Alison template and Alison tee	None
PL948	12 on BT Cable crossing 4 at Audrey B (XW) 19 on Ann approaches	33 at Audrey B (XW) 190 at Ann template	None
PL1099	3 over PL947 crossing (bitumen) 4 at Audrey B (XW)[24] 18+2 at Alison template	40 at Audrey B (XW) 170 at Alison template	None
PL2164	23 along PL2164	None	None
PL2165	9 additional along PL2165	None	None
Ann	None	None	10 around Ann template 4 at Alison tee
Alison	1 on Alison tee 6 x concrete blocks	634 over Alison tee protection frame	2 at Alison template
SUB-TOTAL	**Crossings:** 38 + 3 x bitumen **Approaches:** 102	**Crossings:** 162 x 25kg **Approaches:** 2576 x 25kg, 53 x 1000kg	**Installations:** 26

Table 9.1: Summary of Protection & Stabilisation Features

[22] Although the number of grout bags appears precise, the number is based on engineering judgement and an interpretation of the data available; the exact number is used for traceability across the various documents

[23] There is uncertainty regarding whether these concrete mattresses had been installed, and whether the pipe spools at the LOGGS approach to the Riser Platform are protected at all

[24] The Audrey Pre-Decommissioning Survey Report [8] section 2.12.2 refers to five mattresses on the approach from Audrey B (XW) whereas we have estimated four; this apparent discrepancy is due to interpretation of the data

Pipeline	Quantity of rock, Te	Location
PL947	1540	KP-0.006 to KP0.080 (Ann approach)
	790	KP-0.096 to KP-0.053 (Ann approach)
	1300	KP13.980 to KP14.022
	(incl. in 1300)	KP14.195 to KP14.252
	(incl. in 1300)	KP14.421 to KP14.498
	(incl. in 1300)	KP14.540 to KP14.594
	2060	KP24.120 to KP24.130 (BT cable crossing)
	1950	KP24.215 to KP24.220 (Alison tee assembly)
	(incl. in 1950)	KP24.235 to KP24.230 (Alison tee assembly)
	(incl. in 1950)	KP24.320 to KP24.225 (BT cable crossing remedial work)
	2010	KP25.454 to KP25.624 (Viking pipeline & BT cable crossing)
	600	KP36.769 to KP36.915
	985	KP41.480 to KP41.539 (PL496/7 crossing, LOGGS approach)
	(incl. in 985)	KP41.536 to KP41.560 (Remedial work)
	3602	KP41.560 to KP41.756 (LOGGS approach & crossing)
	1591	LOGGS Approach to LOGGS RP, 22m long
PL947 Stub	None	None
PL948	290	KP9.875 to KP9.825 (BT Cable crossing)
	720	KP4.781 to KP4.729
Sub-total:	**17438Te**	

Table 9.2: Summary of Deposited Rock

APPENDIX B FIELD LAYOUT ILLUSTRATIONS

Appendix B.1 PL947, PL948, PL2164 & PL2165 @Ann

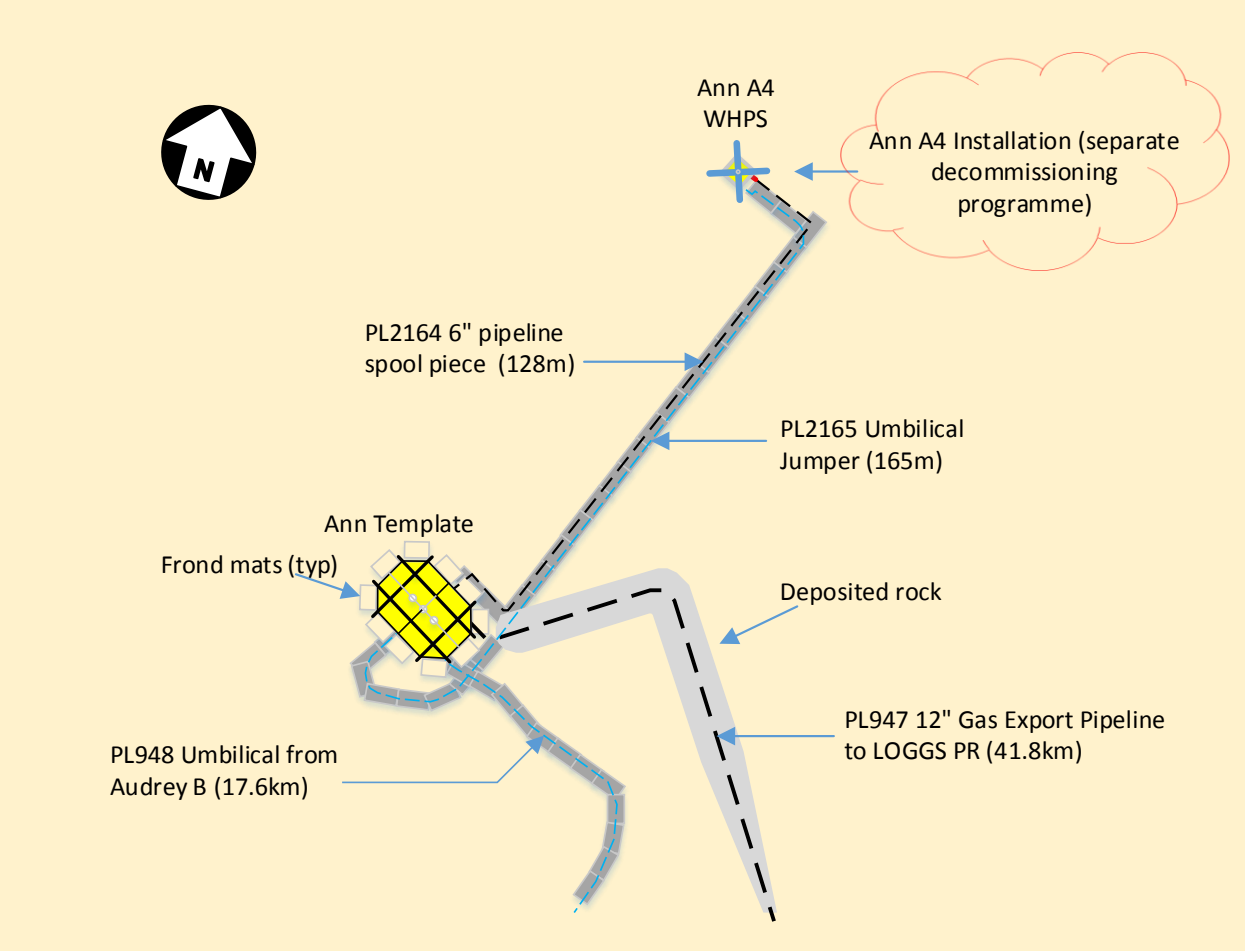


Figure 9.1: PL947, PL948, PL2164 & PL2165 @Ann

Appendix B.2 PL947, PL948 & PL1099 @Alison

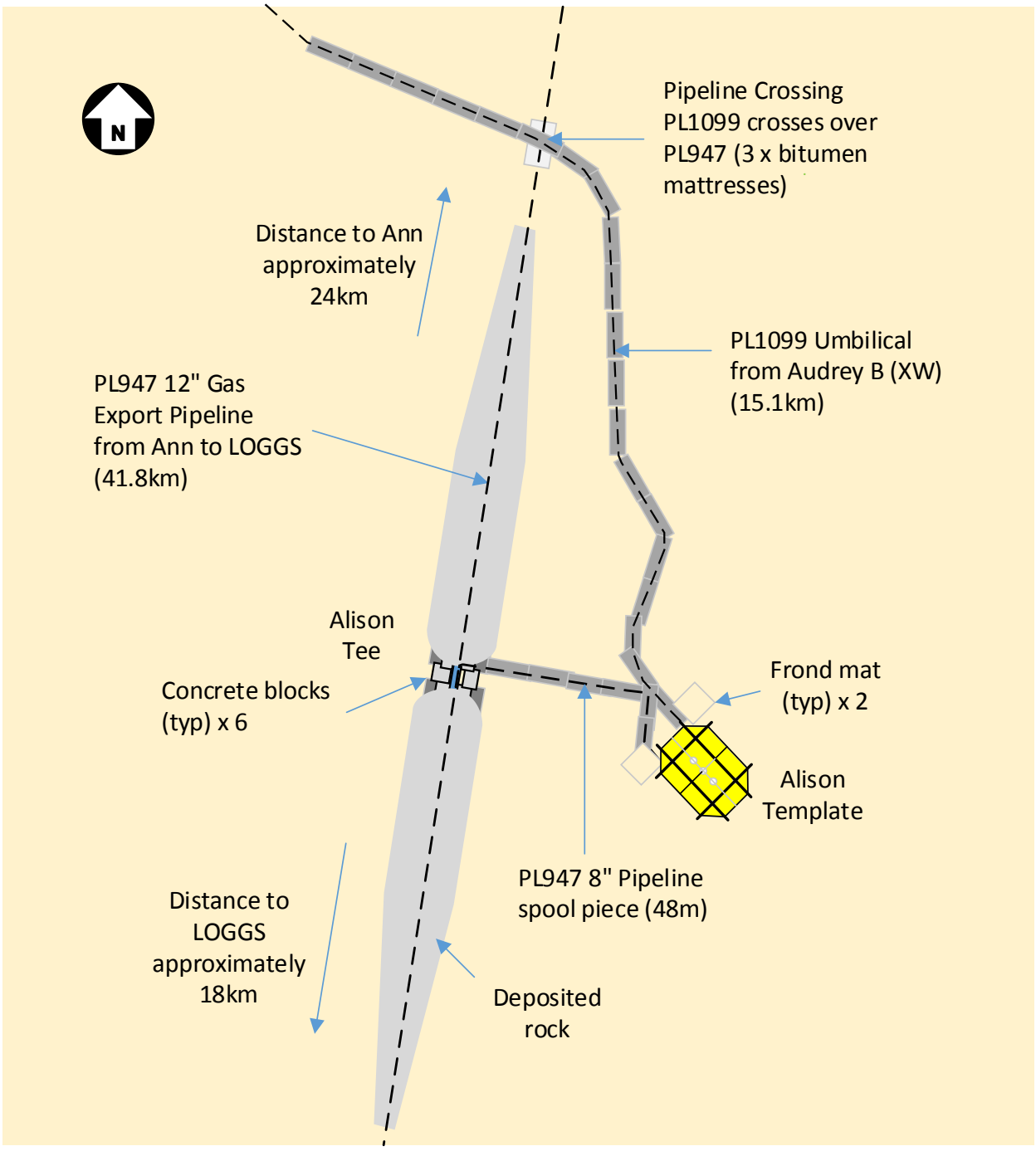


Figure 9.2: PL947, PL948 & PL1099 @Alison

Appendix B.3 Audrey B (XW)

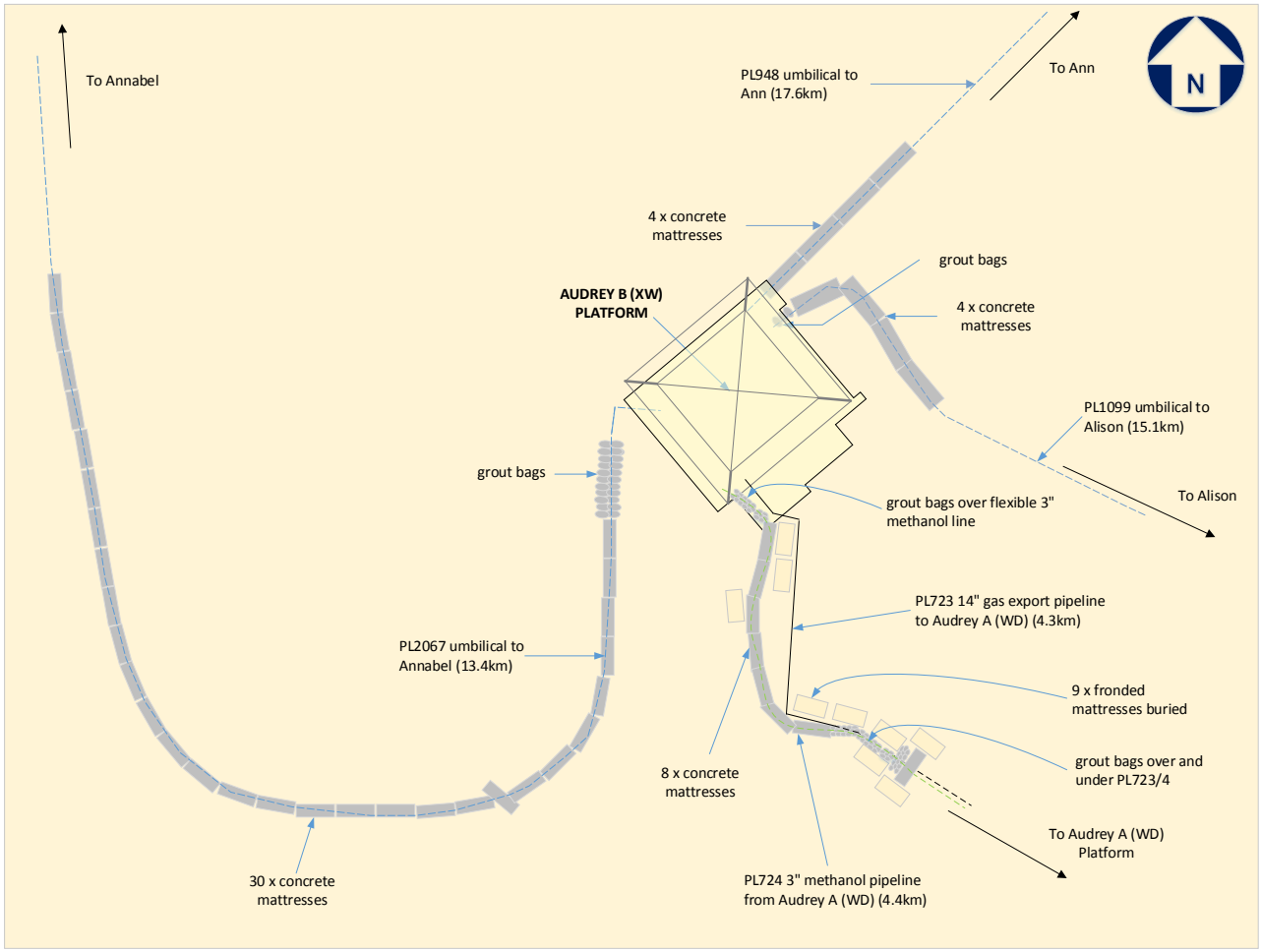


Figure 9.3: PL948 & PL1099 at Audrey B (XW)

Appendix B.4 PL947 @LOGGS

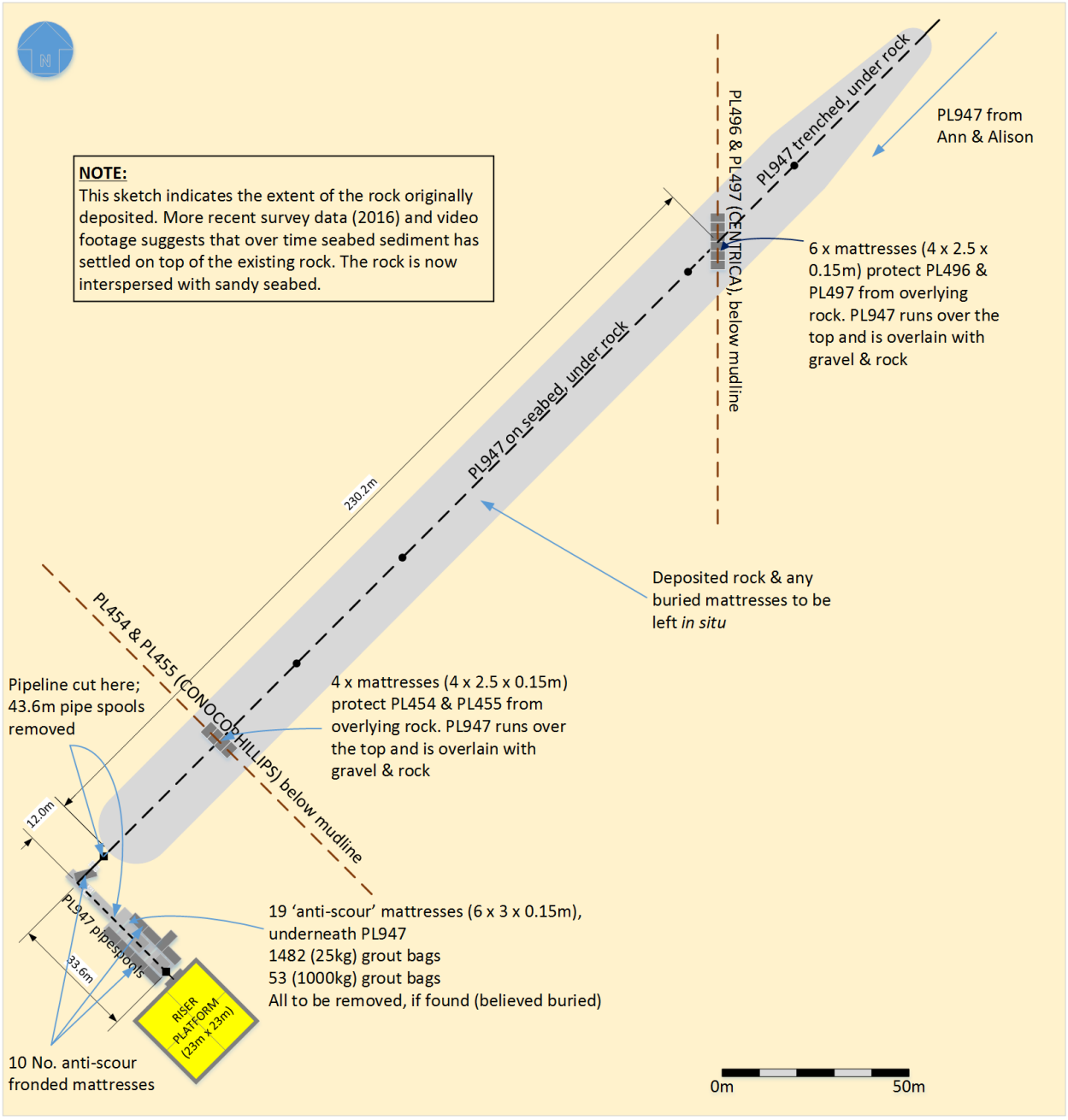
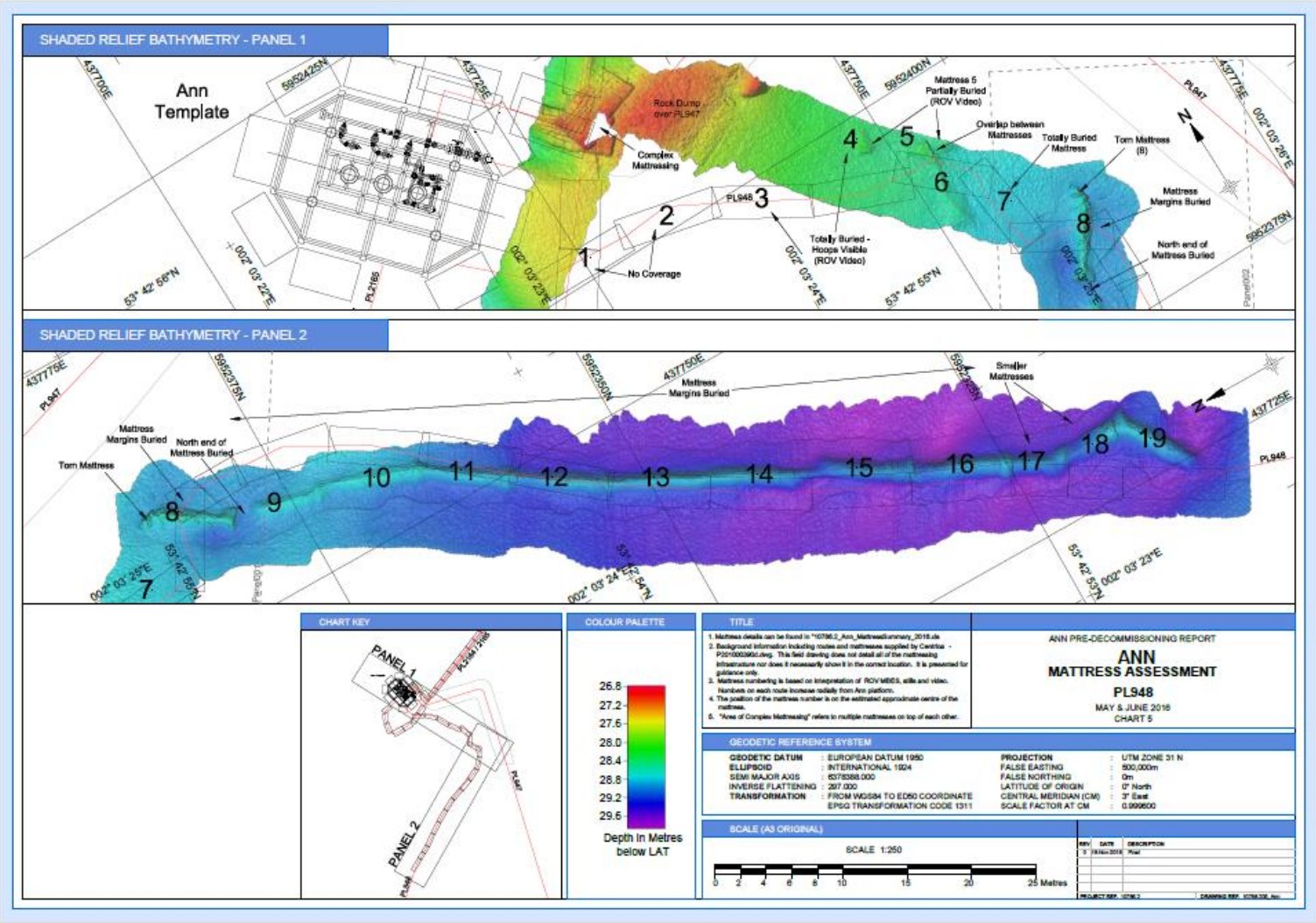
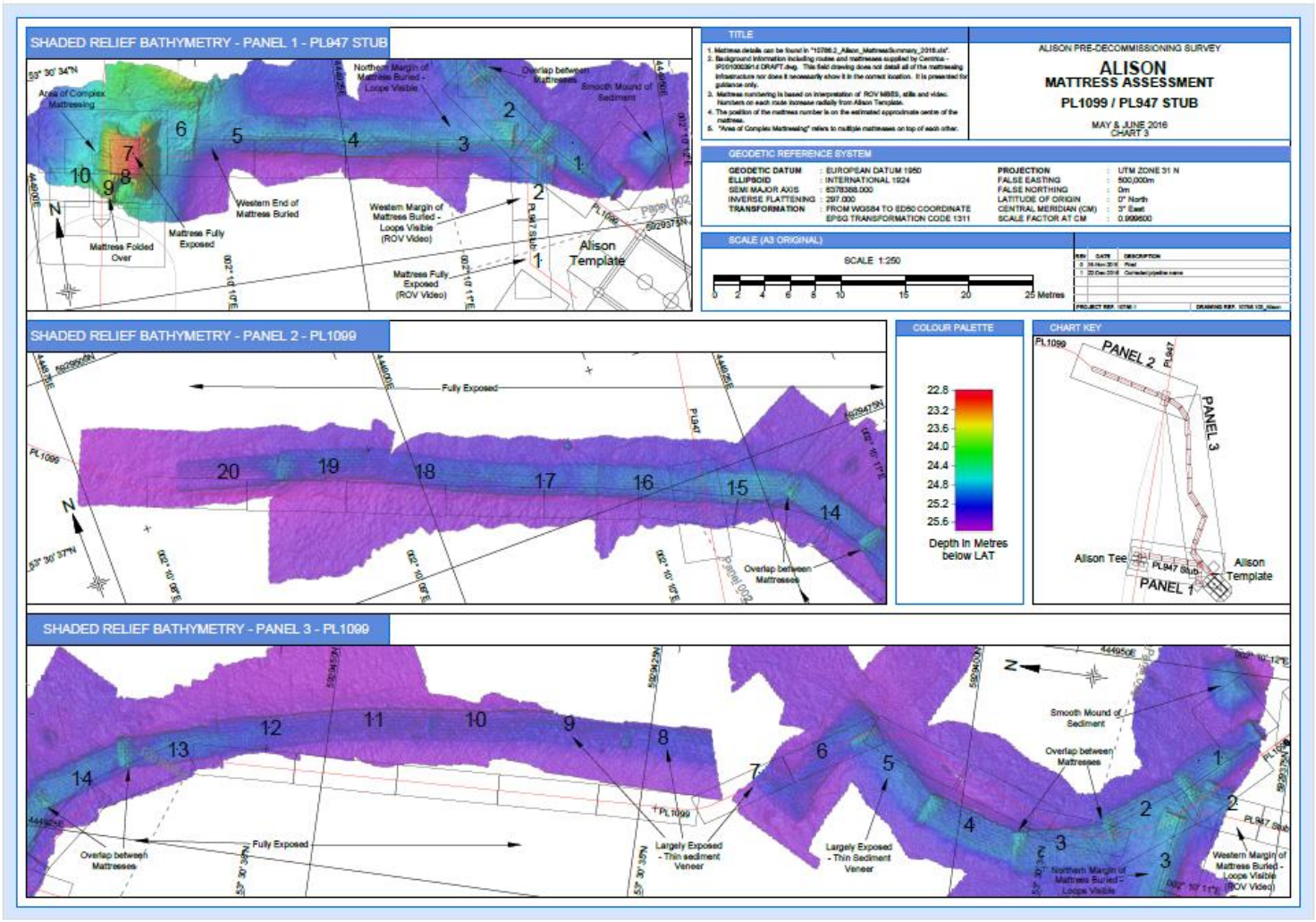


Figure 9.4: PL947 at LOGGS

APPENDIX C BATHYMETRY @ ANN



APPENDIX D BATHYMETRY @ ALISON



APPENDIX E COMPARATIVE ASSESSMENT TABLES

The following section details the qualitative comparative assessment made to distinguish the decommissioning options.

The assessment was carried out in accordance with the Centrica Comparative Assessment Guidance [3]. Safety criteria were assessed with the HSE Risk Matrix, environmental and societal criteria were assessed with the Environmental Impact Matrix and the technical criteria were assessed with the Project Risk Assessment Matrix.

The colour coding is as follows:

Medium / Tolerable & non-preferred	Low / Broadly Acceptable & least preferred	Low / Broadly Acceptable (In-between)	Low / Broadly Acceptable & most preferred

Appendix E.1 PL947 Comparative Assessment Tables

Ann to Sandbank area including Alison tee and between 'LOGGS and Sandbank'			
Criteria	**Option 1- Complete Removal**	**Option 2 - Partial Removal**	**Option 3 - Leave *in-situ***
Technical Short-term:	There is limited experience of reverse reeling of trenched & buried pipelines in the North Sea. Further there is limited experience of using the 'cut and lift' method for removing pipelines of this scale. Some sections are covered with rock.	Buried pipe has been uncovered and 'cut and lift' method can and has been used for removing relatively short sections of pipe so we know this is achievable	Stable and buried pipelines have been left in situ before and we know this is achievable
Technical Legacy:	Environmental surveys have been undertaken by Centrica in the past, and from a technical perspective this is achievable with no complications	Depth of burial and environmental surveys have been undertaken by Centrica in the past, and from a technical perspective this is achievable with no complications	Depth of burial and Environmental surveys have been undertaken by Centrica in the A-fields Trivial
Safety Short-term: Health & safety risk offshore project personnel	More offshore work and more onshore handling than partial removal. Little experience in the North Sea of either reverse reeling or 'cut and lift' of trenched and buried pipelines. Both reverse reeling and 'cut and lift' activities are assessed as tolerable for the 41.8km pipeline	Less offshore work than complete removal. Experience in the North Sea of removal of pipeline sections	Less offshore work than complete removal. Experience in the North Sea of removal of pipeline sections. Significantly shorter than for complete removal. Shorter duration than for partial removal
Safety Short-term: Health & safety risk to mariners	Duration of vessels in the field is longer than for leave *in-situ.* The risk to mariners is aligned with the duration the activities are undertaken in the field.	Duration of vessels in the field would be shorter than for complete removal and marginally longer than for leave *in situ*	Duration of vessels in the field would be shorter than for complete removal and marginally shorter than for leave *in situ*
Safety Short-term: Safety risk onshore project personnel	Safety risk is linked to the mass of material returned to shore. Therefore, there would be significantly more onshore cutting, lifting and handling for complete removal than for partial removal or *leave in-situ.*	Safety risk is directly associated with the duration and repetitive nature of the work. Less onshore cutting, lifting and handling so less safety risk to onshore personnel	Safety risk is directly associated with the duration and repetitive nature of the work. Less onshore cutting, lifting and handling so less safety risk to onshore personnel
Safety Legacy: Health & safety risk offshore project personnel	One environmental survey. No depth of burial surveys or remediation related activities	One environmental survey. Assume up to three depth of burial related surveys	One environmental survey. Assume up to four depth of burial related surveys
Safety Legacy: Health & safety risk to mariners	No infrastructure left therefore no residual snag hazards. Lower risk as potential snag hazards completely removed.	Degradation of the remaining pipeline will occur over a long period within seabed sediment. Post decommissioning surveys and existing data would provide evidence that exposures and the associated potential snagging risks remain limited	Post decommissioning surveys and existing data will provide evidence that exposures are limited, if at all, and therefore the risk to mariners from snagging is low. Degradation of the pipeline if it remains buried, doesn't change the risk. If exposures occur the degradation could change the risk, however the data indicates that exposures will be limited.
Safety Legacy: Safety risk onshore project personnel	Not applicable as no remedial activities planned	Not applicable as no remedial activities planned	Not applicable as no remedial activities planned

Ann to Sandbank area including Alison tee and between 'LOGGS and Sandbank'			
Criteria	**Option 1- Complete Removal**	**Option 2 - Partial Removal**	**Option 3 - Leave *in-situ***
Environmental Short-term: Atmosphere	Emissions to air are aligned with the duration the activities are undertaken in the field. Duration of vessels in the field is longer than for partial or leave *in-situ.* Emissions and use of energy greatest for this option but no offset would be generated because of the energy and emissions needed to create new material to replace any that may be left *in situ*	Emissions and energy use for this option fall in-between complete removal and leave in situ	Emissions to air are aligned with the duration the activities are undertaken in the field. Duration of vessels in the field is shorter than for complete removal or partial removal. Least amount of energy used and least emissions generated in the short-term, although this is counteracted by the energy and emissions required to create new material
Environmental Short-term: Water column	Area of the seabed impacted and material mobilised into the water column is aligned with the length of pipeline removed and the amount of remedial activity required. Area impacted is greater for complete removal than for leave *in-situ* or partial removal.	This area of seabed disturbed would fall in-between the complete removal and leave in situ options	Area of the seabed impacted and material mobilised into the water column is aligned with the length of pipeline removed and the amount of remedial activity required. Area impacted is less than for partial removal and complete removal.
Environmental Short-term: SAC	Dredging to access the pipeline to completely recover would open a trench and introduce sediment into the water column. The area is anticipated to recover relatively quickly as the survey data doesn't show much evidence of the original trench. Assuming 4m wide corridor affected the area affected would be 0.164km2, 16.4ha equivalent to c. 0.005% of the SAC	Dredging to access the sections of the pipeline for recovery would open a trench and introduce sediment into the water column We would expect the area to recover relatively quickly as the survey data doesn't show much evidence of the original trench. The area affected would be much less than that affected by complete recovery	Limited or no impact on the SAC during offshore decommissioning operations
Environmental Short-term: Seabed	Discharges and releases to the water column are aligned with the duration the activities undertaken in the field. Duration of vessels in the field is longer than for partial removal or leave *in-situ.*	Discharges and release would be less than generated for complete removal but slightly more than leave in situ	Discharges and releases to the water column are aligned with the duration the activities undertaken in the field. Duration of vessels in the field is shorter than for complete removal or partial removal
Environmental Short-term: Waste	This option would result in the largest mass of material being returned to shore. No material would be lost as no material would be left *in situ*	This waste would fall in-between the complete removal and leave in situ options	No material would be returned to shore for recycling and so the material would be lost and new manufactured material would be needed to replace the loss
Environmental Legacy: Atmosphere	Emissions to air are aligned survey requirements. Only one environmental survey is planned therefore is less than for leave *in-situ* or partial removal	Emissions to air are aligned with the duration the activities are undertaken in the field. We anticipate that future survey requirements would be about the same for either complete removal and partial removal	Emissions to air are aligned with the duration the activities are undertaken in the field. We anticipate that future survey requirements would be about the same for either complete removal and partial removal
Environmental Legacy: Seabed	Pipeline burial surveys do not usually involve disturbance to the seabed, and we assume that no remedial activities would be required otherwise, so no impact	Pipeline burial surveys do not usually involve disturbance to the seabed, and we assume that no remedial activities would be required otherwise, so no impact	Pipeline burial surveys do not usually involve disturbance to the seabed, and we assume that no remedial activities would be required otherwise, so no impact
Environmental Legacy: SAC	No impact. Only environmental survey following completion of decommissioning activities	Environmental survey and pipeline status survey only, assuming no remedial work would be required – as suggested by historical survey data. Survey data suggests that the presence of the buried pipeline in the seabed is not affecting the structure or function of the SAC as no evidence of change to the direction or size of the sand waves (and consequently sandbanks)	Environmental survey and pipeline status survey only, assuming no remedial work would be required – as suggested by historical survey data. Survey data suggests that the presence of the buried pipeline in the seabed is not affecting the structure or function of the SAC as no evidence of change to the direction or size of the sand waves (and consequently sandbanks)

Ann to Sandbank area including Alison tee and between 'LOGGS and Sandbank'			
Criteria	**Option 1- Complete Removal**	**Option 2 - Partial Removal**	**Option 3 - Leave *in-situ***
Environmental Legacy: Water column	Discharges and releases to the water column are aligned survey requirements. No pipeline burial surveys required	We anticipate that future survey requirements would be about the same for either complete removal and partial removal	We anticipate that future survey requirements would be about the same for either complete removal and partial removal
Environmental Legacy: Waste	If we assume that no pipeline remedial activities would be required as part of legacy related activities there is nothing to differentiate the options from a waste perspective	If we assume that no pipeline remedial activities would be required as part of legacy related activities there is nothing to differentiate the options from a waste perspective	If we assume that no pipeline remedial activities would be required as part of legacy related activities there is nothing to differentiate the options from a waste perspective
Societal Short-term: Commercial activities	Impact of decommissioning vessel traffic on local commercial activities such as fishing would greatest for complete removal	Impact of decommissioning traffic on local commercial activities such as fishing would be less than for complete removal and more that for leave *in situ* option	Impact of decommissioning vessel traffic on local commercial activities such as fishing would least for complete removal
Societal Short-term: Employment	Decommissioning activities would contribute greatest to continuity of employment for complete removal	Decommissioning activities would contribute to continuity of employment less than for complete removal and more that for leave *in situ* option.	Decommissioning activities would contribute the least to continuity of employment for leave *in situ*
Societal Short-term: Communities	Decommissioning activities would contribute greatest to continuity of work in ports and disposal sites for complete removal	Decommissioning activities would contribute to continuity of work in ports and disposal sites less than for complete removal and more that for leave *in situ* option	Decommissioning activities would contribute the least to continuity of work in ports and disposal sites for leave *in situ*
Societal Legacy: Commercial activities	An environmental survey would be required but this is the same for all options. No pipeline surveys would be required	Impact of survey vessel traffic on local commercial activities such as fishing would be slightly more than for complete removal and less than for leave *in situ.*	Impact of survey vessel traffic on local commercial activities such as fishing would be slightly more with the leave *in situ* option but there is little to differentiate partial removal and leave *in situ*
Societal Legacy: Employment	Once the pipeline had been completely removed, the opportunity for continuation of employment would be minimal once the environmental survey had been completed	Once the pipeline had been partially removed the opportunity for continuation of employment would be associated with survey work would be like the leave *in situ* option. Some jobs would be associated with the manufacture of new material to replace that which is left *in situ*	Should the pipeline be left *in situ* surveys would need to be carried out as would be required for partial removal. Some jobs would be associated with the manufacture of new material to replace that which is left *in situ*, otherwise there is little to differentiate partial removal and leave *in situ*
Societal Legacy: Communities	Once the pipeline had been removed there would be few opportunities for continuity of work in ports and disposal sites	Once the pipeline had been partially removed there would be few opportunities for continuity of work in ports and disposal sites other than associated with survey related and possible remedial work	Once the pipeline had been left *in situ* there would be few opportunities for continuity of work in ports and disposal sites other than associated with survey related and possible remedial work. There is little to differentiate partial removal and leave *in situ*
Cost Short-term:	The cost of complete removal would be an order of magnitude higher than for either of the partial removal or the leave *in situ* options	The cost of removing a few short-exposed sections would be less than for complete removal but more than for leave *in situ*	The cost of leave *in situ* would be the least expensive of all options
Cost Legacy:	Once the pipeline had been completely removed no pipeline burial surveys after decommissioning works had been completed or over the longer-term	Future burial surveys will be required. The premise is that if two successive surveys demonstrate that the pipeline remains stable the premise is that no more surveys would be required. There is little to differentiate partial removal and leave in situ over the longer-term	Future burial surveys will be required. The premise is that if two successive surveys demonstrate that the pipeline remains stable the premise is that no more surveys would be required. There is little to differentiate partial removal and leave *in situ* over the longer-term

Sandbank Area (c. kp30 +/- 1km) (no option 2)		
Criteria	**Option 1 - Complete Removal**	**Option 3 - Leave *in situ***
Technical **Short-term:**	Removal of 12" pipeline from a burial within a trench in shallow water (around 11m). Would need to be de-buried and cut and lifted. Buried pipe has been uncovered and 'cut and lift' method can and has been used for removing relatively short sections of pipe so we know this is achievable	Stable and buried pipelines have been left in situ before and we know this is achievable
Technical **Legacy:**	Environmental surveys have been undertaken before in the A-fields. Need to consider which vessel is used due to draught requirements	Depth of burial and environmental surveys have been undertaken by Centrica in the past, and from a technical perspective this is achievable with no complications. Need to consider which vessel is used due to draught requirements.
Safety **Short-term:** Health & safety risk offshore project personnel	More offshore work and more onshore handling than leave *in situ*. Little experience in the North Sea of 'cut and lift' of trenched and buried pipeline, although short sections are normal. The risk associated with the use of vessels and divers, if required, is considered broadly acceptable if driven to ALARP. The duration of vessels in the field is longer than for leave *in-situ*	No requirement for vessels in the field
Safety **Short-term:** Health & safety risk to mariners	Duration of vessels in the field is longer than for leave *in-situ.* The risk to mariners is aligned with the duration the activities are undertaken in the field.	No requirement for vessels in the field
Safety **Short-term:** Safety risk onshore project personnel	Safety risk is linked to the mass of material returned to shore. Therefore, there would be more onshore cutting, lifting and handling for complete removal than for *leave in-situ*	No requirement for handling of material
Safety **Legacy:** Health & safety risk offshore project personnel	One environmental survey. No depth of burial surveys or remediation related activities	One environmental survey, four additional surveys, no planned remediation
Safety **Legacy:** Health & safety risk to mariners	Infrastructure completely removed so no residual snag hazards completely removed	Degradation of the remaining pipeline will occur over a long period within seabed sediment. Post decommissioning surveys and existing data would provide evidence that exposures and the associated potential snagging risks remain limited
Safety **Legacy:** Safety risk onshore project personnel	Not applicable as no remedial activities planned	Not applicable as no remedial activities planned
Environmental **Short-term:** Atmosphere	Emissions and use of energy greatest for this option but no offset would be generated because of the energy and emissions needed to create new material to replace any that may be left *in situ*	Least amount of energy used and least emissions generated in the short-term, although this is counteracted by the energy and emissions required to create new material
Environmental **Short-term:** Water column	Area of the seabed impacted and material mobilised into the water column is aligned with the length of pipeline removed and the amount of remedial activity required. Area impacted is greater for complete removal than for leave *in-situ*	Area of the seabed impacted and material mobilised into the water column is aligned with the length of pipeline removed and the amount of remedial activity required. Area impacted is less than for complete removal
Environmental **Short-term:** SAC	Dredging to access the pipeline to completely recover would open a trench and introduce sediment into the water column. The area is anticipated to recover relatively quickly as the survey data doesn't show much evidence of the original trench	Limited or no impact on the SAC during the execute phase.

Sandbank Area (c. kp30 +/- 1km) (no option 2)		
Criteria	**Option 1 - Complete Removal**	**Option 3 - Leave *in situ***
Environmental **Short-term:** Seabed	Discharges and releases to the water column are related to the duration of activities being undertaken and will therefore be greatest for the complete removal	Discharges and releases to the water column are aligned with the duration the activities are undertaken in the field. Duration of vessels in the field is shorter than for complete removal
Environmental **Short-term:** Waste	This option would result in the largest mass of material being returned to shore. No material would be lost as no material would be left *in situ*	No material would be returned to shore for recycling and so the material would be lost and new manufactured material would be needed to replace the loss
Environmental **Legacy:** Atmosphere	Emissions to air are aligned survey requirements. No pipeline burial surveys required	Emissions to air are aligned with the duration the activities are undertaken in the field. One environmental survey and four depth of burial surveys are planned. Greater than for complete removal.
Environmental **Legacy:** Seabed	No remedial activities planned therefore no impact	No remedial activities planned therefore no impact
Environmental **Legacy:** SAC	Only environmental survey.	Environmental survey and pipeline status survey. No remedial work planned. Limited data to assess the impact of the pipeline within the sandbank and the associated effects on the sandbank. Assumed to be no effect based on the survey data for the other areas of the pipeline and that the pipeline in this area is buried, according to the 2016 SSS data
Environmental **Legacy:** Water column	Discharges and releases to the water column are aligned survey requirements. Only one environmental survey is planned therefore is less than for leave *in-situ*	Discharges and releases to the water column are aligned with the duration the activities are undertaken in the field. One environmental survey and four depth of burial surveys are planned. Greater than for complete removal
Environmental **Legacy:** Waste	If we assume that no pipeline remedial activities would be required as part of legacy related activities there is nothing to differentiate the options from a waste perspective	If we assume that no pipeline remedial activities would be required as part of legacy related activities there is nothing to differentiate the options from a waste perspective
Societal **Short-term:** Commercial activities	Impact of decommissioning vessel traffic on local commercial activities such as fishing would greatest for complete removal. Although given the water depth it is believed that there are limited commercial activities undertaken in the area	Impact of decommissioning vessel traffic on local commercial activities such as fishing would least for complete removal. Although given the water depth it is believed that there are limited commercial activities undertaken in the area
Societal **Short-term:** Employment	Decommissioning activities would contribute greatest to continuity of employment for complete removal	Decommissioning activities would contribute the least to continuity of employment for leave *in situ*
Societal **Short-term:** Communities	Decommissioning activities would contribute greatest to continuity of work in ports and disposal sites for complete removal	Decommissioning activities would contribute the least to continuity of work in ports and disposal sites for leave *in situ*
Societal **Legacy:** Commercial activities	An environmental survey would be required but this is the same for all options. No pipeline surveys would be required	Impact of survey vessel traffic on local commercial activities such as fishing would be slightly more with the leave *in situ* option
Societal **Legacy:** Employment	Once the pipeline had been completely removed, the opportunity for continuation of employment would be minimal once the environmental survey had been completed	Should the pipeline be left *in situ* surveys would need to be carried out as would be required for complete removal. Some jobs would be associated with the manufacture of new material to replace that which is left *in situ*
Societal **Legacy:** Communities	Once the pipeline had been removed there would be few opportunities for continuity of work in ports and disposal sites	Once the pipeline had been left *in situ* there would be few opportunities for continuity of work in ports and disposal sites other than associated with survey related and possible remedial work

Sandbank Area (c. kp30 +/- 1km) (no option 2)		
Criteria	**Option 1 - Complete Removal**	**Option 3 - Leave *in situ***
Cost Short-term:	The cost of complete removal would be an order of magnitude higher than for either of the partial removal or the leave *in situ* options	The cost of leave *in situ* would be the less expensive than complete removal
Cost Legacy:	Once the pipeline had been completely removed no pipeline burial surveys after decommissioning works had been completed or over the longer-term	Future burial surveys will be required. The premise is that if two successive surveys demonstrate that the pipeline remains stable the premise is that no more surveys would be required

LOGGS Area			
Criteria	**Option 1 - Complete Removal**	**Option 2 - Partial Removal**	**Option 3 - Leave *in-situ***
Technical Short-term:	Involves moving the rock to expose the pipeline that would then be cut and lifted up to the trench depth. There is experience of these activities in the North Sea.	Either cutting and removal of exposed sections, rock dump, trenching. Both options are technically feasible.	No work
Technical Legacy:	Environmental surveys have been undertaken by Centrica in the past, and from a technical perspective this is achievable with no complications	Depth of burial and environmental surveys have been undertaken around LOGGS before. There may be a requirement for remedial work given the uncertainty of the cause for current exposures.	Depth of burial and environmental surveys have been undertaken before. There may be a requirement for remedial work given the uncertainty of the cause for current exposures. Trivial
Safety Short-term: Health & safety risk offshore project personnel	More offshore work and more onshore handling than partial removal or leave *in situ*. The risk associated with the use of vessels and divers, if required, is considered broadly acceptable if driven to ALARP	The risk associated with the use of vessels and divers, if required, is considered broadly acceptable if driven to ALARP. The duration of vessels in the field is longer than for leave *in-situ* and shorter than for complete removal.	No work required
Safety Short-term: Health & safety risk to mariners	Duration of vessels in the field is longer than for leave *in-situ* or partial removal. The risk to mariners is aligned with the duration the activities are undertaken in the field	Duration of vessels in the field is longer than for leave *in-situ* and less than for complete removal. The risk to mariners is aligned with the duration the activities are undertaken in the field.	No work required
Safety Short-term: Safety risk onshore project personnel	Safety risk is linked to the mass of material returned to shore. Therefore, there would be more onshore cutting, lifting and handling for complete removal than for *leave in-situ* or partial removal	Safety risk is directly associated with the duration and repetitive nature of the work. Less onshore cutting, lifting and handling so less safety risk to onshore personnel	No work required
Safety Legacy: Health & safety risk offshore project personnel	Only one planned environmental survey. No depth of burial or remediation planned	One environmental survey, three additional surveys, no planned remediation.	One environmental survey, four additional surveys, no planned remediation
Safety Legacy: Health & safety risk to mariners	No infrastructure left therefore no residual snag hazards. Lower risk as potential snag hazards completely removed	Post decommissioning surveys and existing data will provide evidence of exposures and therefore the risk to mariners from snagging. The cause of the exposures along the rock dumped section of the pipeline is currently unknown. Degradation of the pipeline, if it remains buried, doesn't change the risk. If exposures occur the degradation could increase the risk	No remedial activities on spans or exposures. Therefore, there could be snagging. Within the 500m zone, so, to date, fishing has not been undertaken over the area and it is unknown if these exposures or spans present a snagging hazard

LOGGS Area			
Criteria	**Option 1 - Complete Removal**	**Option 2 - Partial Removal**	**Option 3 - Leave *in-situ***
Safety Legacy: Safety risk onshore project personnel	Not applicable as no remedial activities planned	Not applicable as no remedial activities planned	Not applicable as no remedial activities planned
Environmental Short-term: Atmosphere	Emissions and use of energy greatest for this option but no offset would be generated because of the energy and emissions needed to create new material to replace any that may be left *in situ*	Emissions and energy use for this option fall in-between complete removal and leave *in situ*	Least amount of energy used and least emissions generated in the short-term, although this is counteracted by the energy and emissions required to create new material
Environmental Short-term: Water column	Area of the seabed impacted and material mobilised into the water column is aligned with the length of pipeline removed and the amount of remedial activity required. Area impacted is greater for complete removal than for leave *in-situ* or partial removal.	Area of the seabed impacted and material mobilised into the water column is aligned with the length of pipeline removed and the amount of remedial activity required. Area impacted is greater for leave *in-situ* and less than for complete removal, assuming that rock deposits aren't used for remedial measures when the area of the rock berm may have a larger impact than complete removal.	Area of the seabed impacted and material mobilised into the water column is aligned with the length of pipeline removed and the amount of remedial activity required. Area impacted is less than for partial removal and complete removal
Environmental Short-term: SAC	Aligned with the area disturbed by the activities. The area is anticipated to recover relatively quickly	Aligned with the area disturbed by the activities. The area is anticipated to recover relatively quickly	Aligned with the area disturbed by the activities. The area is anticipated to recover relatively quickly
Environmental Short-term: Seabed	Discharges and releases to the water column are aligned with the duration the activities undertaken in the field. Duration of vessels in the field is longer than for partial removal or leave *in-situ*	Discharges and releases to the water column are aligned with the duration the activities undertaken in the field. Duration of vessels in the field is shorter than for complete removal, longer than for leave *in-situ*.	Discharges and releases to the water column are aligned with the duration the activities undertaken in the field. Duration of vessels in the field is shorter than for complete removal or partial removal
Environmental Short-term: Waste	Largest mass of material returned to shore for recycling. No material lost as no material left in place	Small mass of material returned to shore for recycling. Majority of material loss as left *in-situ*	No material returned to shore for recycling. The majority of material loss as left *in-situ*
Environmental Legacy: Atmosphere	Emissions to air are aligned with survey requirements. No pipeline burial surveys required	Emissions to air are aligned with the duration the activities are undertaken in the field. One environmental survey and three depth of burial surveys are planned. Remedial activities may be required.	Emissions to air are aligned with the duration the activities are undertaken in the field. One environmental survey and four depth of burial surveys are planned. Higher likelihood that remedial action will be required than for partial removal. Greater than for complete removal or partial removal
Environmental Legacy: Seabed	No remedial activities planned therefore no impact	Remedial activities may be required.	Remedial activities may be required.
Environmental Legacy: SAC	No activity so no impact	Environmental survey and pipeline status survey. No remedial work planned. Post decommissioning surveys and existing data will provide evidence of exposures and therefore the risk or needing to undertake additional remedial measures. The cause of the exposures along the rock dumped is unknown	Environmental survey and pipeline status survey. No remedial work planned. No remedial activities on spans or exposures. Therefore there could be snagging. Within the 500m zone, so, to date, fishing has not been undertaken over the area and it is unknown if these exposures or spans present a snagging hazard
Environmental Legacy: Water	No activity so no impact	Discharges and releases to the water column are aligned with the duration the activities are undertaken in the field. Greater than for	Discharges and releases to the water column are aligned with the duration the activities are undertaken in

LOGGS Area			
Criteria	**Option 1 - Complete Removal**	**Option 2 - Partial Removal**	**Option 3 - Leave *in-situ***
column		complete removal. Required duration of any remedial activities is unknown.	the field. Greater than for complete removal. Required duration of any remedial activities is unknown
Environmental Legacy: Waste	No remedial activities planned therefore no impact	Remedial activities with associated waste may be required	Remedial activities with associated waste may be required
Societal Short-term: Commercial activities	Impact of decommissioning vessel traffic on local commercial activities such as fishing would greatest for complete removal	Impact of decommissioning traffic on local commercial activities such as fishing would be less than for complete removal and more that for leave *in situ* option	Impact of decommissioning vessel traffic on local commercial activities such as fishing would be least for complete removal
Societal Short-term: Employment	Decommissioning activities would contribute greatest to continuity of employment for complete removal	Decommissioning activities would contribute to continuity of employment less than for complete removal and more that for leave *in situ* option.	Decommissioning activities would contribute the least to continuity of employment for leave *in situ*
Societal Short-term: Communities	Decommissioning activities would contribute greatest to continuity of work in ports and disposal sites for complete removal	Decommissioning activities would contribute to continuity of work in ports and disposal sites less than for complete removal and more that for leave *in situ* option	Decommissioning activities would contribute the least to continuity of work in ports and disposal sites for leave *in situ*
Societal Legacy: Commercial activities	An environmental survey would be required but this is the same for all options. No pipeline surveys would be required	Impact of survey vessel traffic on local commercial activities such as fishing would be slightly more than for complete removal and less than for leave *in situ.*	Impact of survey vessel traffic on local commercial activities such as fishing would be slightly more with the leave *in situ* option. *Uncertainty if a clear seabed certificate would be obtained so this option may exclude commercial activities*
Societal Legacy: Employment	Once the pipeline had been completely removed, the opportunity for continuation of employment would be minimal once the environmental survey had been completed	Once the pipeline had been partially removed the opportunity for continuation of employment would be associated with survey work would be like the leave *in situ* option. Some jobs would be associated with the manufacture of new material to replace that which is left *in situ*	Should the pipeline be left *in situ* surveys would need to be carried out as would be required for partial removal. Some jobs would be associated with the manufacture of new material to replace that which is left *in situ*
Societal Legacy: Communities	Once the pipeline had been removed there would be few opportunities for continuity of work in ports and disposal sites	Once the pipeline had been partially removed there would be few opportunities for continuity of work in ports and disposal sites other than associated with survey related and possible remedial work	Once the pipeline had been left *in situ* there would be few opportunities for continuity of work in ports and disposal sites other than associated with survey related and possible remedial work
Cost Short-term:	The cost of complete removal would be an order of magnitude higher than for either of the partial removal or the leave *in situ* options	The cost of removing a few short-exposed sections would be less than for complete removal but more than for leave *in situ*	The cost of leave *in situ* would be the least expensive of all options
Cost Legacy:	Once the pipeline had been completely removed no pipeline burial surveys after decommissioning works had been completed or over the longer-term	Future burial surveys will be required. The premise is that if two successive surveys demonstrate that the pipeline remains stable the premise is that no more surveys would be required. There is little to differentiate partial removal and leave in situ over the longer-term	Future burial surveys will be required. The premise is that if two successive surveys demonstrate that the pipeline remains stable the premise is that no more surveys would be required. There is little to differentiate partial removal and leave *in situ* over the longer-term

Table 9.3: PL947 Comparison Table

Appendix E.2 PL947 High-Level cost comparison by difference

PL947	Complete Removal (£M)	Partial Removal (£M)	Leave *in situ* (£M)
Cost	£9.41	£0.72	£0.24
Sub-total Normalised	**5**	**0.4**	**0.1**

Table 9.4: PL947 Decommissioning options cost by difference[25]

[25] Cost by difference is considered an order of magnitude higher if the cost difference is at least 10 times higher for one option versus another

Appendix E.3 PL948 Comparative Assessment Tables

	Option 1 - Complete Removal	Option 2 - Partial Removal	Option 3 - Leave *in-situ*
Technical Short-term:	Activities have been undertaken in the southern North Sea by another operator. Reverse reeling is a viable option albeit with technical challenges as the umbilical is unburied and pulled from the seabed. Considered more technically difficult than partial removal or leave *in situ*	Activities have been done in the southern North Sea by another operator. This option only requires cut and lift of discrete sections of the umbilical and this can be considered a relatively routine operation. Minimum number of operations therefore minimum technical risk	Activities have been done in the southern North Sea by Centrica. Stable and buried umbilical lines have been left in situ before and we know this is achievable. From a technical perspective this would be the least challenging option
Technical Legacy:	Environmental surveys have been undertaken by Centrica in the past, and from a technical perspective this is achievable with no complications	Depth of burial and environmental surveys have been undertaken by Centrica in the past, and although obtaining depth of burial underneath sand waves can be problematic in overall terms from a technical perspective this is achievable with no complications	Depth of burial and environmental surveys have been undertaken by Centrica in the past, and although obtaining depth of burial underneath sand waves can be problematic in overall terms from a technical perspective this is achievable with no complications
Safety Short-term: Health & safety risk offshore project personnel	More offshore work and more onshore handling than partial removal. Limited experience in the North Sea of reverse reeling trenched and buried umbilical lines. Use of vessels and divers, if required, risk is broadly acceptable if driven to ALARP. Longer duration than leave *in-situ.*	Less offshore work and more onshore handling than complete removal. Experience in the North Sea and the Company of removal of umbilical sections	No work done offshore other than that which would be undertaken for complete and partial removal
Safety Short-term: Health & safety risk to mariners	Duration of vessels in the field would be longer than for partial removal or leave in situ. The risk to mariners would be aligned with the duration the activities are undertaken in the field	Duration of vessels in the field would be shorter than for complete removal and marginally longer than for leave *in situ*	Marginally better than for partial removal, although in proactive there is little to differentiate partial removal and leave *in situ*
Safety Short-term: Safety risk onshore project personnel	Significantly more onshore cutting, lifting and handling associated with disposal of the umbilical presents an increased safety risk to personnel but not intolerable	Safety risk is directly associated with the duration and repetitive nature of the work. Less onshore cutting, lifting and handling so less safety risk to onshore personnel	As for partial removal. Since only a short length of the umbilical would be removed under partial removal there is little to differentiate partial removal and complete removal
Safety Legacy: Health & safety risk offshore project personnel	Only one planned environmental survey. No depth of burial or remediation planned. All types of survey undertaken frequently within the industry	Once the section of pipeline had been removed, assume legacy requirements are as per option 3, with no remedial work required	One environmental survey and assume up to four depth of burial related survey with planned remediation. All types of survey undertaken frequently within the industry
Safety Legacy: Health & safety risk to mariners	Infrastructure completely removed so no residual snag hazards completely removed	Once the short-exposed sections have been removed, degradation of the remaining umbilical will occur over a long period within seabed sediment and not expected to represent a hazard to other users of the sea, although potential snag hazards would remain. Overall initially assessed as 'tolerable' but mitigated with pipeline status surveys	As for partial removal. Since only a small section of the umbilical would be removed under partial removal there is little to differentiate partial removal and leave *in situ*
Safety Legacy: Safety risk onshore project personnel	Not applicable as no remedial activities planned	Not applicable as no remedial activities planned	Not applicable as no remedial activities planned

	Option 1 - Complete Removal	Option 2 - Partial Removal	Option 3 - Leave *in-situ*
Environmental Short-term: Atmosphere	Emissions and use of energy greatest for this option but no offset would be generated because of the energy and emissions needed to create new material to replace any that may be left *in situ*	Emissions and energy use for this option fall in-between complete removal and leave *in situ*	Least amount of energy used and least emissions generated in the short-term, although this is counteracted by the energy and emissions required to create new material
Environmental Short-term: Water column	Discharges and releases to the water column are related to the duration of activities being undertaken and will therefore be greatest for the complete removal. They are also related to discharges from infrastructure lifted through column. Therefore, higher for complete removal than for partial or leave *in-situ*. Instantaneous discharge for hydraulic fluid for complete removal, diffuse discharge for partial and leave *in-situ*	Discharges from vessel and discharges from infrastructure lifted through column. Therefore, higher for complete removal than for partial or leave *in-situ*. Instantaneous discharge for hydraulic fluid for complete removal, diffuse discharge for partial and leave *in-situ.*	Discharges from vessel and discharges from infrastructure lifted through column. Therefore, higher for complete removal than for partial or leave *in-situ*. Instantaneous discharge for hydraulic fluid for complete removal, diffuse discharge for partial and leave *in-situ.*
Environmental Short-term: SAC	Larger area of the SAC impacted due to the disturbance of the seabed as the umbilical is pulled or jetted out of the trench. Assuming 2m wide corridor affected the area affected would be 0.04km^2, 4ha equivalent to c. 0.001% of the SAC	Smaller area of the SAC impacted due to the disturbance of the seabed as the umbilical is pulled or jetted out of the trench.	Limited or no impact on the SAC during offshore decommissioning operations compared with complete removal or partial removal
Environmental Short-term: Seabed	The amount of seabed disturbed is directly related to the length of pipeline (or umbilical) being removed and the amount of remedial activity required. The area affected would be largest for this option. Area impacted is greater for complete removal than for leave *in-situ* or partial removal	The area affected would be between complete removal and leave *in-situ*	Area of the seabed impacted and material mobilised into the water column is aligned with the length of pipeline removed and the amount of remedial activity required. Area impacted is less than for complete removal.
Environmental Short-term: Waste	This option would result in the largest mass of material being returned to shore. No material would be lost as no material would be left *in situ*	This option sits in-between option 1 and option 3.	No material would be returned to shore for recycling and so the material would be lost and new manufactured material would be needed to replace the loss
Environmental Legacy: Atmosphere	In line with survey vessel duration. No surveys required for complete removal	We anticipate that future survey requirements would be about the same for either partial removal or leave *in situ*	We anticipate that future survey requirements would be about the same for either partial removal or leave *in situ*
Environmental Legacy: Seabed	Pipeline burial surveys do not usually involve disturbance to the seabed, and we assume that no remedial activities would be required otherwise, so no impact	Pipeline burial surveys do not usually involve disturbance to the seabed, and we assume that no remedial activities would be required otherwise, so no impact	Pipeline burial surveys do not usually involve disturbance to the seabed, and we assume that no remedial activities would be required otherwise, so no impact
Environmental Legacy: SAC	None; all infrastructure would be removed in this option. Consideration was given to the disturbance from removal. The recovery since installation indicates that the area will recover relatively quickly after the disturbance. That is, the survey data shows no evidence of the trenching that occurred during installation - long term e.g. greater than 20 years, the duration the line has been in place	As for leave *in situ*	The SAC could be impacted if remedial work was required, but we don't believe that remedial activities would be required given that the umbilical is buried and appears to be stable. We don't believe that the long-term presence of the umbilical under the sand waves within the SAC would impact the conservation objectives of the SAC. The local bathymetry has a uniform pattern that hasn't noticeably changed over the years
Environmental Legacy: Water column	In line with survey vessel duration. No surveys required for complete removal	We anticipate that future survey requirements would be about the same for either partial removal or leave *in situ*.	We anticipate that future survey requirements would be about the same for either partial removal or leave *in situ*

	Option 1 - Complete Removal	Option 2 - Partial Removal	Option 3 - Leave *in-situ*
Environmental Legacy: Waste	If we assume that no pipeline remedial activities would be required as part of legacy related activities there is nothing to differentiate the options from a waste perspective	If we assume that no pipeline remedial activities would be required as part of legacy related activities there is nothing to differentiate the options from a waste perspective	If we assume that no pipeline remedial activities would be required as part of legacy related activities there is nothing to differentiate the options from a waste perspective
Societal Short-term: Commercial activities	Impact of decommissioning vessel traffic on local commercial activities such as fishing would greatest for complete removal	Impact of decommissioning traffic on local commercial activities such as fishing would be less than for complete removal and more that for leave *in situ* option	Impact of decommissioning vessel traffic on local commercial activities such as fishing would least for complete removal
Societal Short-term: Employment	Decommissioning activities would contribute greatest to continuity of employment for complete removal.	Decommissioning activities would contribute to continuity of employment less than for complete removal and more that for leave *in situ* option.	Decommissioning activities would contribute the least to continuity of employment for leave *in situ*
Societal Short-term: Communities	Decommissioning activities would contribute greatest to continuity of work in ports and disposal sites for complete removal	Decommissioning activities would contribute to continuity of work in ports and disposal sites less than for complete removal and more that for leave *in situ* option	Decommissioning activities would contribute the least to continuity of work in ports and disposal sites for leave *in situ*
Societal Legacy: Commercial activities	An environmental survey would be required but this is the same for all options. No pipeline surveys would be required	Impact of survey vessel traffic on local commercial activities such as fishing would be slightly more than for complete removal and less than for leave *in situ*	Impact of survey vessel traffic on local commercial activities such as fishing would be slightly more with the leave *in situ* option but there is little to differentiate partial removal and leave in situ
Societal Legacy: Employment	Once the pipeline had been completely removed, the opportunity for continuation of employment would be minimal once the environmental survey had been completed	Once the pipeline had been partially removed the opportunity for continuation of employment would be associated with survey work would be like the leave *in situ* option. Some jobs would be associated with the manufacture of new material to replace that which is left *in situ*	Should the pipeline be left *in situ* surveys would need to be carried out as would be required for partial removal and leave *in situ*. Some jobs would be associated with the manufacture of new material to replace that which is left *in situ*, otherwise there is little to differentiate partial removal and leave *in situ*
Societal Legacy: Communities	Once the pipeline had been removed there would be few opportunities for continuity of work in ports and disposal sites	Once the pipeline had been partially removed there would be few opportunities for continuity of work in ports and disposal sites other than associated with survey related and possible remedial work	Once the pipeline had been left *in situ* there would be few opportunities for continuity of work in ports and disposal sites other than associated with survey related and possible remedial work. There is little to differentiate partial removal and leave *in situ*
Cost Short-term:	The cost of complete removal would be higher than for either of the partial removal or the leave *in situ* options, but not an order of magnitude higher	The cost of removing a few short-exposed sections would be less than for complete removal but more than for leave *in situ*	The cost of leave *in situ* would be the least expensive of all options
Cost Legacy:	Once the pipeline had been completely removed no pipeline burial surveys or stability assessments after decommissioning works had been completed or over the longer-term	Future burial surveys and stability assessments will be required. The premise is that if two successive surveys demonstrate that the pipeline remains stable the premise is that no more surveys would be required. There is little to differentiate partial removal and leave *in situ* over the longer-term	Future burial surveys and stability assessments will be required. The premise is that if two successive surveys demonstrate that the pipeline remains stable the premise is that no more surveys would be required. There is little to differentiate partial removal and leave *in situ* over the longer-term

Table 9.5: PL948 Comparison Table

Appendix E.4 PL948 High-Level cost comparison by difference

PL948	Complete Removal (£M)	Partial Removal (£M)	Leave *in situ* (£M)
Cost	£8.00	£0.27	£0.12
Sub-total Normalised	**5**	**0.2**	**0.1**

Table 9.6: PL948 Decommissioning options costs by difference[26]

[26] Cost by difference is considered an order of magnitude higher if the cost difference is at least 10 times higher for one option versus another

Appendix E.5 PL1099 Comparative Assessment Tables

Approximately Audrey B (XW) to KP8.0			
Aspect	**Option 1 - Complete Removal**	**Option 2 - Partial Removal**	**Option 3 - Leave *in-situ***
Technical Short-term:	Activities have been done in the southern North Sea by another operator. Reverse reeling is a viable option albeit with technical challenges as the umbilical is pulled from the seabed. Considered more technically difficult than partial removal and leave *in situ*	This option only requires cut and lift of discrete sections of the umbilical and this can be considered a relatively routine operation. Minimum number of operations therefore minimum technical risk	Activities have been done in the southern north sea by Centrica. Stable and buried umbilical lines have been left in situ before and we know this is achievable. From a technical perspective this would be the least challenging option
Technical Legacy:	Environmental surveys have been undertaken by Centrica in the past, and from a technical perspective this is achievable with no complications	Depth of burial and environmental surveys have been undertaken by Centrica in the past, and although obtaining depth of burial underneath sand waves can be problematic in overall terms from a technical perspective this is achievable with no complications	Depth of burial and environmental surveys have been undertaken by Centrica in the past, and although obtaining depth of burial underneath sand waves can be problematic in overall terms from a technical perspective this is achievable with no complications
Safety Short-term: Health & safety risk offshore project personnel	Less offshore work when reeling the umbilical compared to removal of individual lengths involving vessels and possibly divers and more onshore handling than partial removal. Limited experience in the North Sea of reverse reeling trenched and buried umbilical lines. Considered broadly acceptable if safety risks are driven to ALARP	More vessel time and possibly divers when removing individual exposed lengths than needed for complete removal by reverse reel which would be a continuous process	Least amount of work done offshore other than that undertaken for partial and complete removal
Safety Short-term: Health & safety risk to mariners	Duration of vessels in the field would be longer than for partial removal or leave in situ. The risk to mariners would be aligned with the duration the activities are undertaken in the field	Duration of vessels in the field would be shorter than for complete removal and longer than for leave *in situ*	Vessels would spend the least amount of time in the field for this option, therefore the potential for interaction with other mariners and any associated risk would be minimised
Safety Short-term: Safety risk onshore project personnel	Safety risk is linked to the mass of material returned to shore. Significantly more onshore cutting, lifting and handling associated with disposal of the umbilical presents an increased safety risk to personnel but still broadly acceptable	Safety risk is directly associated with the duration and repetitive nature of the work. Less onshore cutting, lifting and handling so less safety risk to onshore personnel	Leave in situ would involve removing the least amount of material from the field. There would be less onshore cutting, lifting and handling for this option
Safety Legacy: Health & safety risk offshore project personnel	No depth of burial surveys or remediation related activities	Once sections of pipeline had been removed, assume legacy requirements are as per option 3. It is likely that remedial work will be required sometime in the future	One environmental survey, four additional surveys, no planned remediation. All types of survey undertaken frequently within the industry
Safety Legacy: Health & safety risk to mariners	No depth of burial surveys or remediation related activities. Assumed that the sediment type will mean that there are no 'mounds' and the seabed or trench areas will stabilise naturally, not presenting snag hazard to fishing gear	Twenty-nine (29) exposures identified in the first half of the umbilical. If sections of exposed umbilical are cut and removed the ends could present a greater long-term threat to fishing interaction. In addition, the cover of the exposures / cut ends could present an increased risk to the mariners. However, we have received no reports snagging in the exposed areas	Post decommissioning surveys data combined with what is already known will provide additional information if the number and total length of exposures continue to increase, as the trend currently shows. This would present additional risk to mariners and may require additional remediation / surveys. An increase in degradation along with exposures could increase the possibility of snagging
Safety Legacy: Safety risk onshore project	Not applicable as no remedial activities planned	Not applicable as no remedial activities planned	Not applicable as no remedial activities planned

Approximately Audrey B (XW) to KP8.0			
Aspect	**Option 1 - Complete Removal**	**Option 2 - Partial Removal**	**Option 3 - Leave *in-situ***
personnel			
Environmental Short-term: Atmosphere	In line with vessel duration, therefore greater for complete removal than for *leave in-situ*. Emissions and use of energy greatest for this option but no offset would be generated because of the energy and emissions needed to create new material to replace any that may be left *in situ*	Emissions and energy use for this option would be greater than for either complete removal or leave *in situ* owing to the longer time the vessel is in the field	Least amount of energy used and least emissions generated in the short-term, although this is slightly counteracted by the energy and emissions required to create new material
Environmental Short-term: Water column	Discharges from vessel and discharges from infrastructure lifted through column. Discharges and release would be less than generated for partial removal but less than leave in. Instantaneous discharge for hydraulic fluid for complete removal, diffuse discharge for partial and leave *in-situ.*	Discharges and releases to the water column are related to the duration of activities being undertaken and will therefore be greatest for partial removal	Discharges from vessel and discharges from infrastructure lifted through column. Therefore higher for partial removal and complete removal than for leave *in-situ*. Diffuse discharge for leave *in-situ*
Environmental Short-term: SAC	Compared to the other options, a large area of seabed would be disturbed, although compared to the North Norfolk Sandbank the area affected would be relatively small and the impact would be relatively short-term. Assuming a 2m wide corridor, the area affected would be 0.016km^2, 1.6ha equivalent to c. 0.0004% of the SAC	In this option there would be local disturbances where short sections of umbilical are removed and the remediation method used could have a different effect on the ecology of the local seabed. Assuming 2m wide corridor affected the area affected would be 0.0016km2, 0.16ha equivalent to c. 0.00004% of the SAC	The leave in situ option would have the least effect compared to the other options, as there no change to the current environment
Environmental Short-term: Seabed	Area of the seabed impacted and material mobilised into the water column is aligned with the length of pipeline removed and the amount of remedial activity required. Area impacted is greater for complete removal than for partial removal or leave *in-situ.*	For the first half of the umbilical, the area of seabed disturbed would fall in-between the complete removal and leave *in situ* options	Area of the seabed impacted and material mobilised into the water column is aligned with the length of pipeline removed and the amount of remedial activity required. Area impacted is less than for complete removal or partial removal.
Environmental Short-term: Waste	This option would result in the largest mass of material being returned to shore. No material would be lost as no material would be left *in situ*	This option sits in-between complete removal and leave *in situ*	No material would be returned to shore for recycling and so the material would be lost and new manufactured material would be needed to replace the loss
Environmental Legacy: Atmosphere	In line with survey vessel duration. No pipeline burial surveys required for complete removal. Therefore less for complete removal than for *leave in-situ*	We assume that future survey requirements for partial removal would be like those required for leave in situ	In line with survey vessel duration, therefore less for complete removal than for *leave in-situ* (fewer surveys).
Environmental Legacy: Seabed	No pipeline burial surveys or remedial work would be required	Pipeline burial surveys do not usually involve disturbance to the seabed, and we assume that no remedial activities would be required otherwise, so no impact	Pipeline burial surveys do not usually involve disturbance to the seabed, and we assume that no remedial activities would be required otherwise, so no impact
Environmental Legacy: SAC	No long-term legacy issues or impacts. Consideration was given to the disturbance from removal. The recovery since installation indicates that the area will recover relatively quickly after the disturbance. I.e. the survey data shows no evidence of the trenching that	Areas where items have been removed will result in no long-term legacy issues or impacts as per complete removal. We believe that remedial would likely be required in future, resulting in additional and on-going subsequent impacts on the seabed and SAC in line with	Based on the evidence so far, additional remedial work could be required over the longer term. This would result in impacts on the seabed and SAC and such impacts would be in line with those associated with partial removal

Approximately Audrey B (XW) to KP8.0			
Aspect	**Option 1 - Complete Removal**	**Option 2 - Partial Removal**	**Option 3 - Leave *in-situ***
	occurred during installation - long term e.g. greater than 20 years, the duration the line has been in place.	those for the short-term impacts for complete removal	
Environmental Legacy: Water column	No pipeline burial surveys required	We assume that future survey requirements for partial removal would be like those required for leave *in situ*	Arguably if we leave exposed sections in situ in the short-term and monitored the situation there might come a time when remedial activities would be required. For the leave *in situ* option disturbance to the water column would be significantly less than for either complete or partial removal
Environmental Legacy: Waste	No material would need to be recovered over the longer-term	Arguably if we leave exposed sections in situ in the short-term and monitored the situation there might come a time when remedial activities would be required. For the leave in situ case the amount of material recovered would be marginally less than for leave in situ	Arguably if we leave exposed sections in situ in the short-term and monitored the situation there might come a time when remedial activities would be required. For the leave in situ option the amount of material recovered would be marginally more than that for partial removal
Societal Short-term: Commercial activities	Impact of decommissioning vessel traffic on local commercial activities such as fishing would greatest for complete removal	Impact of decommissioning traffic on local commercial activities such as fishing would be greater than for complete removal and less than for leave *in situ* option	Impact of decommissioning vessel traffic on local commercial activities such as fishing would least for complete removal
Societal Short-term: Employment	Decommissioning activities would contribute greatest to continuity of employment for complete removal	Decommissioning activities would contribute to continuity of employment less than for complete removal and more that for leave *in situ* option	Decommissioning activities would contribute the least to continuity of employment for leave *in situ*
Societal Short-term: Communities	Decommissioning activities would contribute greatest to continuity of work in ports and disposal sites for complete removal	Decommissioning activities would contribute to continuity of work in ports and disposal sites less than for complete removal and more that for leave *in situ* option	Decommissioning activities would contribute the least to continuity of work in ports and disposal sites for leave *in situ*
Societal Legacy: Commercial activities	Impact of environmental survey vessel traffic on local commercial activities such as fishing would least once the pipeline had been completely removed	Impact of survey vessel traffic on local commercial activities such as fishing would be slightly more than for complete removal and less than for leave *in situ*	Impact of survey vessel traffic on local commercial activities such as fishing would be slightly more with the leave *in situ* option but there is little to differentiate partial removal and leave *in situ.*
Societal Legacy: Employment	Once the pipeline had been completely removed, the opportunity for continuation of employment would be minimal once the environmental survey had been completed	Once the pipeline had been partially removed the opportunity for continuation of employment would be associated with survey work would be similar to the leave *in situ* option	Should the pipeline be left *in situ* surveys would need to be carried out as would be required for partial removal, otherwise there is little to differentiate partial removal and leave in situ.
Societal Legacy: Communities	Once the pipeline had been removed there would be few opportunities for continuity of work in ports and disposal sites	Once the pipeline had been partially removed there would be few opportunities for continuity of work in ports and disposal sites other than associated with survey related and possible remedial work	Once the pipeline had been left *in situ* there would be few opportunities for continuity of work in ports and disposal sites other than associated with survey related and possible remedial work. There is little to differentiate partial removal and leave *in situ*
Cost Short-term:	The cost of complete removal would be higher than for either of the partial removal or the leave *in situ* options, but not an order of magnitude higher	Because of the inefficiencies involved, the cost of removing several short-exposed sections could be comparable if not greater than of complete removal	The cost of leave *in situ* would be the least expensive of all options
Cost Legacy:	Once the pipeline had been completely removed no pipeline burial surveys or stability assessments after	Future burial surveys and stability assessments will be required. The premise is that if two successive surveys	Future burial surveys and stability assessments will be required. If two successive surveys demonstrate that the

Approximately Audrey B (XW) to KP8.0			
Aspect	**Option 1 - Complete Removal**	**Option 2 - Partial Removal**	**Option 3 - Leave *in-situ***
	decommissioning works had been completed or over the longer-term	demonstrate that the pipeline remains stable the premise is that no more surveys would be required. Although arguably for partial removal there are more potential snag hazards to manage, there is little to differentiate partial removal and complete removal over the longer-term	pipeline remains stable the premise is that no more surveys would be required. Outcome less certain that for complete removal. There is little to differentiate partial removal and complete removal over the longer-term

Approximately KP8 to Alison Template (no option 2)		
Aspect	**Option 1 - Complete Removal**	**Option 3 - Leave *in-situ***
Technical Short-term:	Activities have been done in the southern north sea by another operator. Reverse reeling is a viable option albeit with technical challenges as the umbilical is pulled from the seabed. Considered more technically difficult than partial removal and leave *in situ*	Activities have been done in the southern north sea by Centrica. Stable and buried umbilical lines have been left in situ before and we know this is achievable. Rom a technical perspective this would be the least challenging option
Technical Legacy:	Environmental surveys have been undertaken by Centrica in the past, and from a technical perspective this is achievable with no complications	Depth of burial and environmental surveys have been undertaken by Centrica in the past, and although obtaining depth of burial underneath sand waves can be problematic in overall terms from a technical perspective this is achievable with no complications
Safety Short-term: Health & safety risk offshore project personnel	Limited experience in the North Sea of reverse reeling trenched and buried umbilical lines. Considered broadly acceptable if safety risks are driven to ALARP.	Least amount of work done offshore than that undertaken for complete removal
Safety Short-term: Health & safety risk to mariners	Duration of vessels in the field would be longer than for leave in situ. The risk to mariners would be aligned with the duration the activities are undertaken in the field	Vessels would spend more time in the field for this option than for complete removal, therefore the potential for interaction with other mariners and any associated risk would be lower
Safety Short-term: Safety risk onshore project personnel	Significantly more onshore cutting, lifting and handling associated with disposal of the umbilical presents an increased but broadly acceptable safety risk to personnel	This option presents less of a safety risk to onshore project personnel as this option would involve the least material being returned to shore for processing
Safety Legacy: Health & safety risk offshore project personnel	No depth of burial surveys or remediation related activities	One environmental survey, four additional surveys, no planned remediation. All types of survey undertaken frequently within the industry
Safety Legacy: Health & safety risk to mariners	Infrastructure completely removed so no residual snag hazards completely removed. Assumed that the sediment type will mean that there are no 'mounds' and the seabed or trench areas will stabilise naturally, not presenting snag hazard to fishing gear.	Unlike complete removal depth of burial related surveys will be required but that no intervention work would be needed
Safety Legacy: Safety risk onshore project personnel	Not applicable as no remedial activities planned	Not applicable as no remedial activities planned
Environmental Short-term: Atmosphere	In line with vessel duration, therefore greater for complete removal than for *leave in-situ*. Emissions and use of energy greatest for this option but no offset would be generated because of the energy and emissions needed to create new material to replace any that may be left in situ	Least amount of energy used and least emissions generated in the short-term, although this is slightly counteracted by the energy and emissions required to create new material

Approximately KP8 to Alison Template (no option 2)		
Aspect	**Option 1 - Complete Removal**	**Option 3 - Leave *in-situ***
Environmental Short-term: Water column	Discharges from vessel and discharges from infrastructure lifted through column. Discharges and release would be more than for leave in. Instantaneous discharge for hydraulic fluid for complete removal, diffuse discharge for partial and leave *in-situ.*	Discharges from vessel and discharges from infrastructure lifted through column. Therefore higher for complete removal than for leave *in-situ*. Diffuse discharge for leave *in-situ*
Environmental Short-term: SAC	Larger area of the SAC impacted due to the disturbance of the seabed as the umbilical is pulled or jetted out of the trench. Assuming 2m wide corridor affected the area affected would be 0.015km^2, 1.5ha equivalent to c. 0.0004% of the SAC	Limited or no impact on the SAC during offshore decommissioning operations compared with complete removal
Environmental Short-term: Seabed	Area of the seabed impacted and material mobilised into the water column is aligned with the length of pipeline removed and the amount of remedial activity required. Area impacted is greater for complete removal than for leave *in-situ*	Area of the seabed impacted and material mobilised into the water column is aligned with the length of pipeline removed and the amount of remedial activity required. Area impacted is less than for complete removal
Environmental Short-term: Waste	This option would result in the largest mass of material being returned to shore. No material would be lost as no material would be left in situ	No material would be returned to shore for recycling and so the material would be lost and new manufactured material would be needed to replace the loss
Environmental Legacy: Atmosphere	In line with survey vessel duration. No pipeline burial surveys required for complete removal. Therefore less for complete removal than for *leave in-situ*	Pipeline burial surveys will likely be required, at least in the near term. In line with survey vessel duration, therefore less for complete removal than for *leave in-situ*
Environmental Legacy: Seabed	Pipeline burial surveys do not usually involve disturbance to the seabed, and we assume that no remedial activities would be required otherwise, so no impact	Pipeline burial surveys do not usually involve disturbance to the seabed, and we assume that no remedial activities would be required otherwise, so no impact
Environmental Legacy: SAC	None, as the entire infrastructure will have been removed. We would expect the area will recover relatively quickly after the disturbance. Survey data to date shows little or no evidence of the trenching that occurred during installation over the period of over 20 years since the umbilical was originally installed	We believe no remedial works will be required as this section of the umbilical is buried and appears to be stable. The local bathymetry has a uniform pattern that hasn't really changed over the years, and the umbilical is buried and stable
Environmental Legacy: Water column	No pipeline burial surveys required	Pipeline burial surveys will likely be required, at least in the near term. In line with survey vessel duration, therefore less for complete removal than for leave *in-situ*
Environmental Legacy: Waste	No material would need to be recovered over the longer-term	We believe no remedial works will be required as this section of the umbilical is buried and appears to be stable. The local bathymetry has a uniform pattern that hasn't really changed over the years, and the umbilical is buried and stable
Societal Short-term: Commercial activities	Impact of decommissioning traffic on local commercial activities such as fishing would be less than for partial removal and more that for leave *in situ* option	Impact of decommissioning vessel traffic on local commercial activities such as fishing would least for complete removal
Societal Short-term: Employment	Decommissioning activities would contribute most to continuity of employment for complete removal on the basis that although vessel might be longer in the field for partial removal activities there would be more onshore work associated with complete removal	Decommissioning activities would contribute the least to continuity of employment for leave *in situ*
Societal Short-term: Communities	Decommissioning activities would contribute greatest to continuity of work in ports and disposal sites for complete removal	Decommissioning activities would contribute the least to continuity of work in ports and disposal sites for leave *in situ*
Societal Legacy: Commercial activities	Impact of environmental survey vessel traffic on local commercial activities such as fishing would least once the pipeline had been completely removed	Impact of survey vessel traffic on local commercial activities such as fishing would be slightly more with the leave *in situ* option
Societal Legacy: Employment	Once the pipeline had been completely removed, the opportunity for continuation of employment would be minimal once the environmental survey had been completed	Opportunities for continuation of employment would be greater than for the leave *in situ* option

Approximately KP8 to Alison Template (no option 2)		
Aspect	**Option 1 - Complete Removal**	**Option 3 - Leave *in-situ***
Societal **Legacy:** Communities	Once the pipeline had been removed there would be few opportunities for continuity of work in ports and disposal sites	Once the pipeline had been left *in situ* there would be few opportunities for continuity of work in ports and disposal sites other than for surveys and possible remedial work
Cost **Short-term**	The cost of complete removal would be higher than for the leave *in situ* option, but not an order of magnitude higher	The cost of leave *in situ* would be less expensive than complete removal
Cost **Legacy**	Once the pipeline had been completely removed no pipeline burial surveys or stability assessments after decommissioning works had been completed or over the longer-term	Future burial surveys and stability assessments will be required. If two successive surveys demonstrate that the pipeline remains stable no more surveys would be required

Table 9.7: PL1099 Comparison Table

Appendix E.6 PL1099 High-Level cost comparison by difference

PL1099 'Start to KP8.0'	Complete Removal (£M)	Partial Removal (£M)	Leave *in situ* (£M)
Cost	£2.87	£1.40	£0.12
Sub-total Normalised	**5**	**2.4**	**0.2**

PL1099 'KP8.0 to End'	Complete Removal (£M)	Partial Removal (£M)	Leave *in situ* (£M)
Cost	£2.69	N/A	£0.12
Sub-total Normalised	**5**	**N/A**	**0.2**

Table 9.8: PL1099 Decommissioning options costs by difference[27][28]

[27] PL1099(a) – Start to KP8.0; PL1099(b) – KP8.0 to End
[28] Cost by difference is considered an order of magnitude higher if the cost difference is at least 10 times higher for one option versus another

APPENDIX F FRONDED MATTRESS COMPARATIVE ASSESSMENT TABLES

Appendix F.1 Frond Mattress Comparative Assessment Tables

Aspect	Option 1 - Complete Removal	Option 2 - Leave *in-situ*
Technical **Short-term:**	Technically feasible, but would require quite a lot of excavation to remove c. 1m depth of sediment. The width of the excavation would need to account for sediment movement. There is a possibility that the removal of the installations would require the area to be excavated making removal easier. A grab could be used, but this isn't considered to be an effective method	
Technical **Legacy:**	None	Surveys have been undertaken. Assumed to remain buried, as designed but surveys would be required to establish if this assumption is correct. This would be part of a survey campaign
Safety **Short-term:** Health & safety risk offshore project personnel	Associated with vessel duration. All undertaken diverless. Feasibly if the fronds are not buried they can be a hazard to the ROV	Associated with vessel duration, no activity
Safety **Short-term:** Health & safety risk to mariners	Associated with vessel duration. All within the existing 500m zones	No activity
Safety **Short-term:** Safety risk onshore project personnel	Disposal of recovered mattresses	No activity
Safety **Legacy:** Health & safety risk offshore project personnel	None - no activity	Surveys
Safety **Legacy:** Health & safety risk to mariners	None - no activity	Mattresses could present a potential snagging risk. Unlikely as surveys will establish if they remain buried. The nature of the construction means that the risk of unburied anti scour mattresses would be low. Little to differentiate between complete removal and minimal removal
Safety **Legacy:** Safety risk onshore project personnel	None - no activity	None - no activity
Environmental **Short-term:** Atmosphere	Vessel duration	None - no activity
Environmental **Short-term:** Water column		
Environmental **Short-term:** SAC	Area of excavation or grab	None - no activity
Environmental **Short-term:** Seabed	Vessel duration	None - no activity

Aspect	Option 1 - Complete Removal	Option 2 - Leave *in-situ*
Environmental **Short-term:** Waste	Material returned to shore could be recycled	None - no activity
Environmental **Legacy:** Atmosphere	No activity	Survey vessels
Environmental **Legacy:** Seabed		
Environmental **Legacy:** SAC	No activity	Surveys will establish if they remain buried. The assumption is that they will. However if they become exposed this would require removal - as per offshore execution complete removal
Environmental **Legacy:** Water column	No activity	Survey vessels
Environmental **Legacy:** Waste	None	None - unless removal required - same as offshore execution complete removal
Societal	Not considered a differentiator due to the relatively small number of mattresses	
Cost **Short-term:**	The cost of complete removal would be higher than for the leave *in situ* option, but not an order of magnitude higher	The cost of leave *in situ* would be less expensive than complete removal
Cost **Legacy:**	Once the mattresses have been completely surveys or stability assessments after decommissioning works had been completed.	Future burial surveys will be required. Anticipated to be two undertaken as part of a survey campaign

Table 9.9: Fronded Mattress Comparison Table

Appendix F.2 High-Level cost comparison by difference

Fronded Mattresses	Complete Removal (£M)	Leave *in Situ* (£M)
Cost	£0.5	£0.2
Sub-total Normalised	**5**	**0**

Table 9.10: Decommissioning options costs by difference

APPENDIX G ACTIVITY & AREA OF SEABED (SAC) AFFECTED

PIPELINE	LENGTH KM	WIDTH M	COMPLETE REMOVAL KM^2	% SAC	OVERTRAWL KM^2	% SAC	START 500m ZONE	FINISH 500m ZONE	EXCL. 500m ZONE	NO. OF 500m ZONES	OVERTRAWL (EXCL. 500m ZONES) KM^2
					0.200km				0.200km		
PL947	41.8km	4.0m	0.167km^2	0.005%	8.360km^2	0.232%	Ann	LOGGS	0.199km^2	2	7.963km^2
PL947 Stub	0.0km	0.0m	0.000km^2	0.000%	0.009km^2	0.000%	Alison	Alison	0.099km^2	1	0.000km^2
PL948	17.6km	2.0m	0.035km^2	0.002%	3.520km^2	0.098%	Audrey B (XW)	Ann	0.199km^2	2	3.123km^2
PL1099	15.1km	2.0m	0.030km^2	0.002%	3.020km^2	0.084%	Audrey B (XW)	Alison	0.199km^2	2	2.623km^2
PL2164	0.1km	0.0m	0.000km^2	0.000%	0.025km^2	0.001%	Ann	Ann	0.099km^2	1	0.000km^2
PL2165	0.1km	0.0m	0.000km^2	0.000%	0.026km^2	0.001%	Ann	Ann	0.099km^2	1	0.000km^2
SUB-TOTALS:			**0.233 km^2**	**0.006%**	**14.960 Km^2**	**0.415%**			**0.894km^2**		**13.708km^2**

Table 9.11: Activity & Area of Seabed (SAC) Affected[29]

[29] Complete removal figure includes pipeline approaches and length of pipeline located within500m safety zone