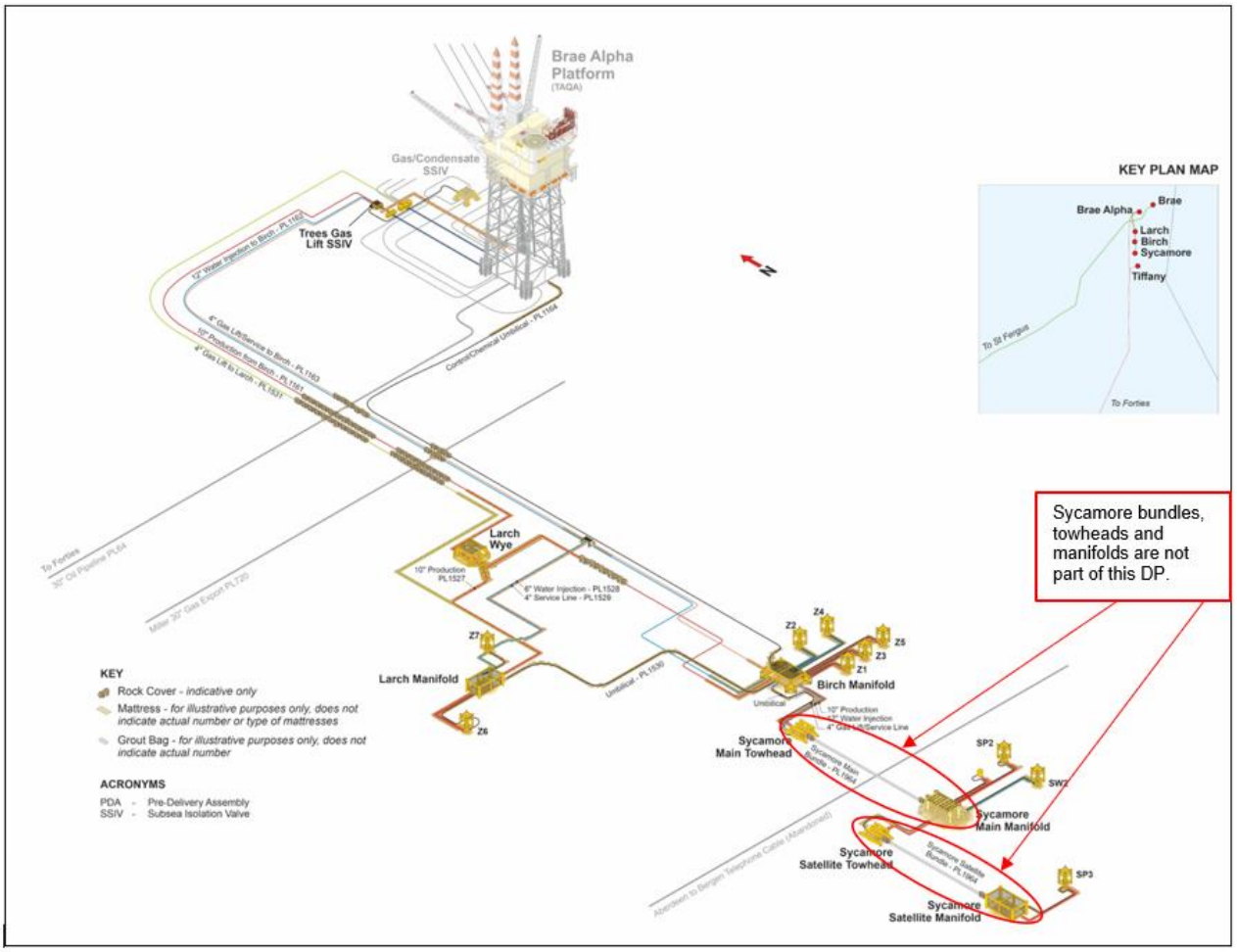
Trees Pipelines Decommissioning Comparative Assessment (Birch, Larch and Sycamore)



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Prepared by:	S. Kiltie (PDi)	S. Kiltie	06/09/2024
Reviewed by:	J Mitchell	DocuSigned by: John Mitchell CD37CCBF80CC45F...	06/09/2024
Approved by:	C. Wheaton	DocuSigned by: Ceri Wheaton F3364F01C41E4A8...	06/09/2024

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C1	18/11/21	Issued for use
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C3	22/07/22	Re-issued for Use
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C5	11/05/2023	Updated following OPRED comments
C6	23/10/2023	Re-issued for Use
C7	10/05/2024	Re-issued for use. Sycamore bundles and associated structures will be addressed under a separate CA.
C8	25/07/2024	Updated following OPRED comments.
C9	06/09/2024	Issued for Statutory Consultation.

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TABLE OF CONTENTS

FIGURES AND TABLES

ABBREVIATIONS

Abbreviation	Explanation
BEIS	Department for Business, Energy & Industrial Strategy (now DESNZ)
CA	Comparative Assessment (Report)
CNS	Central North Sea
c/w	Complete with
DESNZ	Department for Energy Security and Net Zero
DOL	Depth of Lowering (mean seabed level to top of pipe)
DP	Decommissioning Programme(s)
DSV	Dive Support Vessel
EA	Environmental Appraisal
EIA	Environmental Impact Assessment
EMOBF	Enhanced Mineral Oil-Based Fluid
GL	Gas Lift
GMG	Global Marine Group
ICES	International Council for the Exploration of the Seas
INTOG	Innovation and Targeted Oil and Gas
IRM	Inspection, Repair, Maintenance
JNCC	Joint Nature Conservation Committee
km	kilometre
KP	Kilometre Point
LTOBF	Low Toxicity Oil-Based Fluid
m	metres
MPA	Marine Protected Area
MTO	Material Take-Off
NFFO	National Federation of Fishermen's Organisations
NIFPO	Northern Ireland Fish Producers' Organisation
NORM	Naturally Occurring Radioactive Material
NSTA	North Sea Transition Authority
OD	Outside diameter
OPF	Organic Phase Fluid
OPRED	Offshore Petroleum Regulator for Environment and Decommissioning
OSPAR	Oslo Paris Convention
PAO	Polyalphaolefin Based Fluid
PDI	Project Development International Limited
PL, PLU	Pipeline (or umbilical) identification numbers
PMF	Priority Marine Feature
PWA	Pipeline Works Authorisation
SBF	Synthetic Based Fluids
SIMOPS	Simultaneous Operations e.g. multiple vessels/activities at the same location
SMM	Sycamore Main Manifold
Spirit Energy	Spirit Energy North Sea Oil Limited
SSM	Sycamore Satellite Manifold
TAQA	TAQA Bratani Limited
Te	Tonne(s)
TOC	Top of Cover i.e. backfill (seabed sediment) on top of the pipe within the trench
UK	United Kingdom
UKBAP	United Kingdom Biodiversity Action Plan
WI	Water Injection

HOLDS LIST

Number	Description

1 EXECUTIVE SUMMARY

1.1 Overview

The Trees development consists of the Birch, Larch and Sycamore fields operated by Spirit Energy North Sea Oil Ltd (Spirit Energy). Birch, Larch and Sycamore Central are subsea developments with a total of 11 wells (7 production, 4 water injection) tied back to the TAQA Bratani Limited (TAQA) operated Brae Alpha Platform which provides for the processing of all Trees reservoirs fluids through the B separation train, dedicated for Trees Field fluids. These fields are located in Block 16/12a in the Central North Sea (CNS).

A comparative assessment (CA) of the pipelines and umbilicals is a key consideration within the Decommissioning Programmes (DP) submitted to the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED).

Note that the 2 x bundles in the Trees fields, namely the Sycamore Main bundle and Sycamore Satellite bundle, together with their associated towheads and manifolds, will be covered in a separate CA and DP.

1.2 Comparative Assessment

1.2.1 Pipelines and Umbilicals

Following a pre-screening workshop, three options were taken forward to the CA for pipeline decommissioning.

- **Option 3** - Complete removal.
- **Option 5** - Partial removal (cut trenched pipelines & exposed ends and recover to vessel, rock covered sections remain *in-situ*).
- **Option 6** - Partial removal (cut and recover exposed ends to trench transition, trenched and rock covered sections remain *in-situ*).

The assessment considered six criteria for both the short-term decommissioning activities and the longer-term for 'legacy' related activities. The criteria were: safety risks, environmental risks, technical challenges, societal impacts, legacy aspects and economic impact.

The pipelines have been installed in open trenches, lowered to a depth expected to be between 1.0m and 2.0m below the mean adjacent seabed level and left to naturally backfill.

Three pipelines have been protected by rock at various locations along their routes to provide stabilisation and upheaval buckling mitigation. Rock berms have also been installed where pipelines cross the 30" Miller (PL720) and 30" Forties (PL64) pipelines.

Natural backfill has occurred to an extent within the open trenches but this is generally limited to a depth of cover of ~0.3m with numerous exposures noted along most pipelines. Given that the pipelines are trenched to a depth of >0.6m below seabed level and do not currently pose a snagging hazard to fishing gear, the trench depth is considered a suitable mitigation against snagging hazards.

PL1527 has an area between approximately KP 0.238 and KP 0.275 where the pipeline is exposed at a depth <0.6m below seabed level, within the Larch well 16/12a-24z(Z7) 500m safety zone. This section of pipeline will need to be remediated should the pipeline be decommissioned *in-situ.* Remediation will be performed by dredging using a mass flow excavator or similar. In the event that remedial trenching is unsuccessful, rock placement shall be used. The other remediation option of cut and recovery, with remaining pipeline ends protected using nominal quantities of rock may be considered but is not a preferred solution.

Of the three options considered, **Option 6** (partial removal - cut and recover exposed ends to

trench transitions - trenched and rock covered sections remain *in-situ*) produced the lowest average score overall and is therefore considered the most appropriate decommissioning option for the pipelines. Concrete mattresses that are located within the pipeline trenches or under rock deposits will be decommissioned *in-situ* along with the pipelines. The ends of the cut pipelines will be further protected by a nominal quantity of rock to ensure they are not a snagging hazard. This option minimises safety risk to offshore and onshore personnel, minimises vessel emissions and seabed disturbance. The methodology is a common approach in North Sea pipeline decommissioning and with the pipelines being flushed and cleaned to an acceptable cleanliness level, their decommissioning *in-situ* is not expected to have any significant impact to the marine environment. Finally, the cost impact of Option 6 is an order of magnitude lower than that of the other options.

Option 5 was considered the least preferable option which, whilst technically feasible, leaves a large number of cut pipeline ends on the seabed, thus increasing the risk of future snagging hazards developing. It also requires significant deck handling of cut pipelines and associated onshore disposal therefore increasing the safety risk to both offshore and onshore personnel.

Option 3 is similar to Option 5 but the sections of pipeline under the rock berms are also removed. However, as with Option 5, the excavation activities will cause significant seabed disturbance along the pipeline length. While this option does provide the benefit of a clear seabed the increased safety risk, seabed disturbance and highest cost impact meant that this option was considered less appropriate than Option 6.

1.2.2 Sycamore Bundles

The Sycamore bundles and associated towheads and manifolds are not included within this CA and will be addressed under a separate CA, EA and DP. The tie-in spools and jumpers between the bundle manifolds, towheads and wells are included within this CA as their removal has no impact on any future decommissioning options for the bundles, manifolds and towheads.

1.2.3 Spools and Jumpers

All surface laid tie-in spools and jumpers will be fully recovered.

1.2.4 Mattresses & grout bags

Mattresses and grout bags that are surface laid will be fully recovered unless any are found to be unsafe for recovery.

Mattresses and grout bags which are located under rock e.g. at crossings will be left *in-situ*.

Mattresses and grout bags which are below natural seabed level within the trench and are not considered to be a potential snagging hazard will be left *in-situ*. Should the mattresses or grout bags be considered to be a potential snagging hazard then they will be recovered. The pipelines underneath will then be assessed and potentially remediated should they be less than 0.6m below natural seabed level or be a reportable freespan. Remediation will be by dredging/trenching (preferred method where feasible) or by cut & recover, and/or spot rock placement, subject to consultation with OPRED.

Mattresses which are partially buried under rock will be left *in-situ* and remediated should they be considered a snagging hazard. Should any remedial work be required to provide additional protection in such areas e.g. remedial dredging, or spot rock placement, then OPRED will be consulted.

1.2.5 Deposited rock

Deposited rock has been used to protect and stabilise sections of PL1161, PL1527 and PL1531 at various locations along the pipeline length within their respective trenches. Deposited rock is also

installed at the Miller and Forties pipeline crossings. In total, 38,168 Te of rock has been deposited on the pipelines. In line with current guidelines, it has been assumed that deposited rock shall remain *in-situ*.

Additional rock is proposed to provide robust protection of the remaining pipeline ends and to remediate any sections of the pipelines which are insufficiently trenched.

1.3 Proposed Decommissioning Option

Infrastructure	Selected Option	Description
Trees (Birch and Larch) trenched pipelines and umbilicals.	**6. Partial removal** - recover exposed ends	- Cut and recover exposed pipeline ends to trench transition (0.6m burial depth). Protect pipeline ends using nominal quantities of rock. Trenched pipeline is decommissioned *in-situ*. - Remedial work to be carried out on the 37m section of PL1527 which is in a shallow (<0.6m) trench. Remedial work will be by dredging / trenching (the preferred option) or placement of additional rock should dredging be unsuccessful. Cut and recovery with rock remediation of cut ends is also an option.

Table 1-1: Trees Decommissioning Summary

Following completion of decommissioning activities, a post-decommissioning pipeline survey will be carried out. This will be compared with the existing historical survey data and the results will typically be risk assessed with a recommendation for future legacy surveys included in the decommissioning close out report.

2 INTRODUCTION

2.1 Overview

The Trees field is located in UK Central North Sea in water depths of around 125m and comprises of Birch, Larch, Sycamore Central and Sycamore South.

The Birch installation is served by a solitary subsea manifold structure with three production wells and two water injection wells. Birch is tied back to the TAQA operated Brae Alpha platform via a 13.5km 10” production pipeline, 12” water injection pipeline, 4” gas lift/service line and control umbilical.

The 10” production pipeline between Birch and Brae Alpha has a Wye piece connection 2.39km downstream of the Birch Manifold which allows the Larch Installation to direct production fluids back to Brae Alpha. The Birch 12” water injection and 4” gas lift/services pipelines also have T-piece connections that allow for Larch installation connection. Rigid spools connect the pipelines and wells to the manifold and Brae Alpha Platform. Production from Birch commenced in 1995.

The Larch field has been developed with single production and water injection wells. The production well is tied-back via a 2.39km 10” production pipeline to the Larch Wye structure into the Wye connection on the Birch pipeline system whilst the 6” injection water & 4” service pipelines to the injection well are tied-back to Brae Alpha via T-pieces in the Birch Lines close to the Larch Wye location. Gas lift is provided to the production well from Brae Alpha by a separate 12.1km 4” pipeline connected to a T-piece in West Brae Gas Lift line and routed through the Larch Manifold near the wells. Controls and chemicals are supplied by the Larch umbilical via the Larch Manifold connected to the Birch manifold. Rigid spools connect the pipelines and wells to the Larch and Birch manifolds and the Wye. Production from Larch commenced in 1998.

The Sycamore subsea facilities consist of two pipeline bundles – Sycamore Main Bundle 4.4km long and Sycamore Satellite Bundle 800m long – with a manifold at one end and a towhead at the other end of each bundle. The bundles were installed, and production commenced in 2003.

Note that the Sycamore bundles and their associated towheads and manifolds will be addressed within a separate CA and the general description included herein if completeness only. There are no facilities within the Sycamore field that form part of this CA, however some facilities e.g. tie-in spools, jumpers and associated protection & stabilisation are included within the DP and EA.

2.2 Trees Area Layout

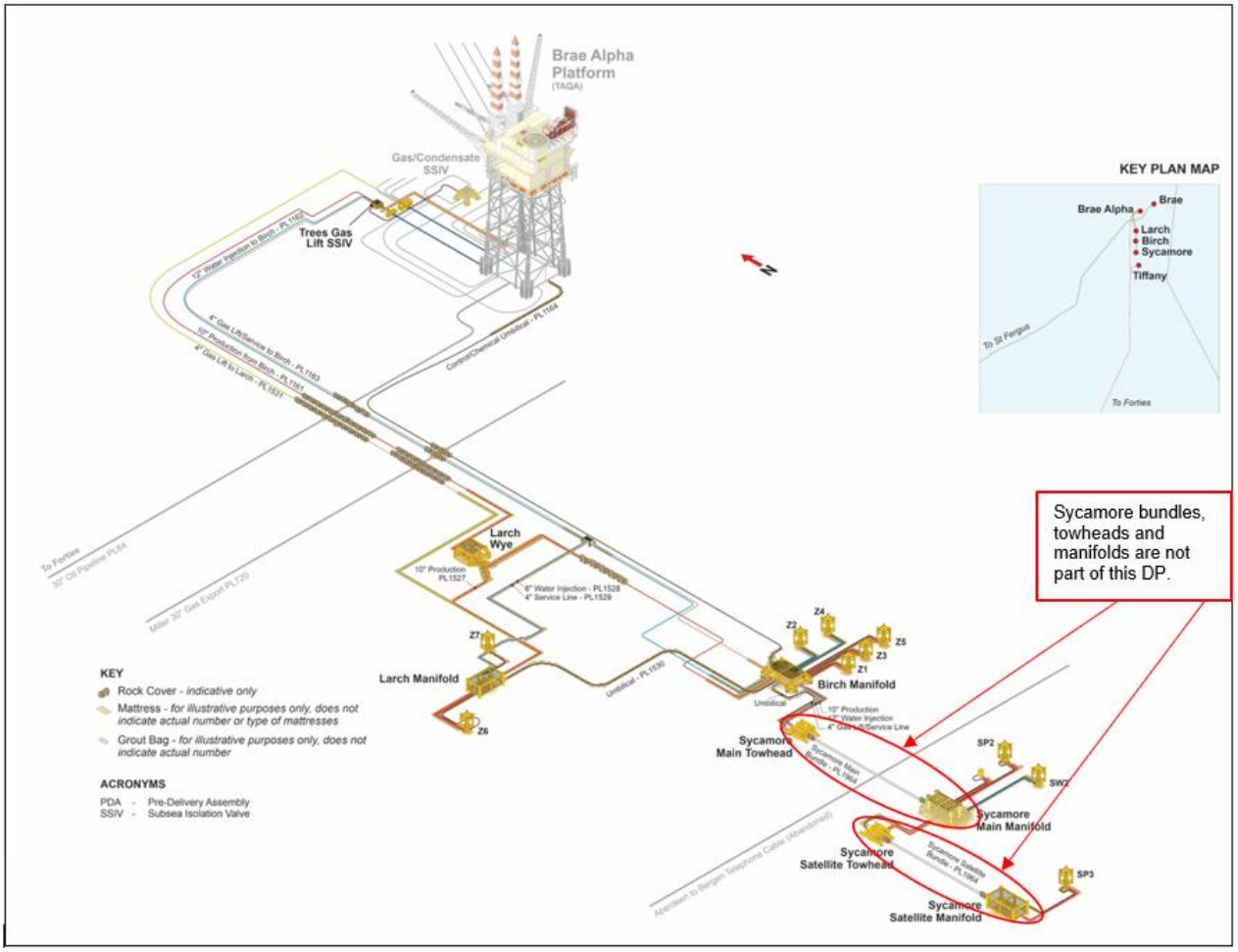

Figure 2-1: Trees Field Schematic

A summary of the pipelines and umbilicals which form part of the CA is presented in Table 2-1.

Pipeline No.	From	To	Size	Description	Approx. Length (km)
PL1161	Birch Manifold	Brae Alpha	254mm ID x 14.1mm WT	10” Production Pipeline, trenched and spot rock covered with concrete mattresses at manifold, wye and platform approaches.	14.3
PL1162	Brae Alpha	Birch Manifold	323.9mm ID x 23.8mm WT	12" WI Pipeline, trenched with concrete mattresses at manifold and platform approach c/w PL1163 piggybacked pipeline.	13.9
PL1163	Brae Alpha	Birch Manifold	114.3mm ID x 17.12mm WT	4" Gas Lift Pipeline, trenched with concrete mattresses at manifold and platform approach. Piggybacked to PL1162.	13.9
PL1164.1 to PL1164.10	Brae Alpha	Birch Manifold	Various	Control Umbilical containing scale inhibitor, wax inhibitor, methanol & demulsifier. Trenched with concrete mattresses at manifold and platform approach.	13.9
PL1527	Larch Manifold	Larch Wye	282mm OD x 14.1mm WT	10” Production Trenched with concrete mattresses at manifold and wye approach c/w piggybacked PL1531. Trenched with spot rock cover.	2.4

Pipeline No.	From	To	Size	Description	Approx. Length (km)
PL1528	Larch Manifold	Larch Tee	168mm OD x 14.3mm WT	6" water injection pipeline c/w piggyback PL1529. Trenched with concrete mattresses at manifold and tee approach.	2.2
PL1529	Larch Manifold	Larch Tee	114mm OD x 11.1mm WT	4" Service Line piggybacked to PL1528. Trenched with concrete mattresses at manifold and tee approach.	2.4
PL1530.1 to PL1530.5	Birch Manifold	Larch Manifold	Various	Umbilical containing methanol, wax inhibitor, scale inhibitor and demulsifier. Trenched with concrete mattresses at manifold approaches.	1.8
PL1531	Larch Manifold	West Brae Gas Lift Pipeline Tee Assembly at Brae Alpha	114mm OD x 11.1mm WT	4" gas lift piggybacked to PL1527 for ~2.3km. Trenched with spot rock cover. Concrete mattresses at manifold, wye and platform approaches.	12.1

Table 2-1: Pipeline & Umbilical summary

2.3 Purpose

The purpose of this document is to present a comparative assessment in support of the decommissioning of the pipelines in the Trees Decommissioning Programme, covering the Birch, Larch and Sycamore fields, as per the Guidance Notes [1]. The comparative assessment describes the decommissioning options considered for the pipelines and umbilicals.

2.4 Supporting Studies

The following supporting studies have been prepared to inform the CA, EA and the DP.

2.4.1 Material Take-Off (MTO) and Data Book [4]

This workbook records and summarises all the data required, e.g. permits & consents (PWA, S29), inventories, etc for each field.

2.4.2 Trees Pipeline Burial Profiles [3]

This document collates and summarises the burial status of the pipelines and identifies any exposures, anomalies or trends that require to be considered. The data from the report has been replicated herein where applicable.

2.4.3 Trees Pipeline Decommissioning Options [2]

This document identifies the possible decommissioning options for the Trees Fields pipelines, highlighting their respective advantages and disadvantages against the standard criteria of Safety, Environmental, Technical, Cost/Schedule and Ongoing Liability.

2.5 Environmental setting

The CA was performed prior to the EA [6] being available and was based on general data for the area together with a well intervention EIA for Birch [5].

Following completion of the EA, which included a pre-decommissioning environmental survey, the CA has been reviewed and it is confirmed that no changes are required to the assessment or findings from the CA.

The data provided below is summarised from the EA [6].

2.5.1 Overview

The Trees fields are located in UKCS blocks 16/12a and 16/7 of the central North Sea (CNS), ca. 209km from Peterhead and in 125m water depth. The fields are located to the south of the Brae A platform, to which they are tied back, and positioned linearly along an approximate north south bearing. The description of the environment within which the Trees fields are located, draws information from a number of different sources, including site specific surveys, and regional surveys, and e.g. fisheries (International Council for the Exploration of the Seas (ICES) rectangle) data (spawning / nursery), bird and marine mammal distribution data.

Spirit Energy conducted a pre-decommissioning environmental survey in March 2022 for the Trees fields at the Birch, Larch, Sycamore and the Brae A locations. This survey is supported by results from two previous surveys of the Trees area. The pre-decommissioning survey comprised a geophysical survey using side-scan sonar and multibeam echosounder, video and still photos taken using drop down camera and benthic grab samples using a dual Van Veen grab. Survey stations were positioned in a cruciform pattern around each field manifold location, with the main axis aligned with the residual current direction.

2.5.2 Historic Drill Cuttings

The Birch, Larch and Sycamore fields were developed between 1985 and 1997 and in the absence of drilling records it is assumed that oil-based muds and organic phase fluids (OPF) were used in some hole sections with cuttings discharged at all wells drilled prior to the ban on such discharges coming into place. Samples from the drill cuttings piles indicate the presence of low toxicity oil-based fluid (LTOBF), synthetic based fluids (SBF), Polyalphaolefin based fluid (PAO) and enhanced mineral oil-based fluid (EMOBF) in the cuttings. An assessment has been performed and the accumulations found to be below the OSPAR 2006/5 thresholds [8].

2.5.3 Sensitive Habitats and Species

The pre-decommissioning survey (Fugro 2022a) recorded sea pens and burrows in sufficient density to indicate the presence of the OSPAR listed threatened and/or declining habitat, sea pens and burrowing megafauna communities. There was no clear pattern of spatial distribution of the two sea pen taxa across the survey areas and burrow types showed a consistently high occurrence throughout all stations in the Trees fields survey (Fugro 2022a).

The PMF broad habitats Burrowed mud and Offshore deep-sea muds, as well as the UKBAP Priority Habitat (JNCC 2019) Mud habitats in deepwater are also likely to be present within the survey area.

These habitats are widely distributed in the CNS and are represented within the UK Marine Protected Area (MPA) network, including the Norwegian Boundary Sediment Plain MPA and Central Fladen MPA, located more than 45km from the Trees fields.

One live adult ocean quahog (*Arctica islandica*) specimen was recovered within a grab sample at the Larch Wye survey area, with possible *Arctica islandica* siphons identified during seabed video and photography analysis at two Larch Wye stations. However, no further specimens were recovered and there was no further video or photographic evidence of adults or aggregations in the survey area.

No other Annex I habitats, OSPAR threatened and/or declining species and habitats, or Scottish biodiversity list species and habitats (OSPAR 2008; JNCC 2019; NatureScot 2020) were observed within the survey areas.

2.5.4 Commercial Fisheries

The Trees fields infrastructure are located within ICES rectangle 46F1 and the landings (quantity and value) for this rectangle over the period 2020 to 2022 are shown in Table 2-2 (the Trees fields

infrastructure are located close to the border of rectangle 45F1 and, the information relevant to that rectangle is also included). It should be noted, that the data presented includes the period of the COVID-19 pandemic, and catches may have been affected by related restrictions. For ICES rectangle 46F1, for all three years, landings (weight) were dominated by demersal species, with shellfish dominating in terms of value in 2021 and 2022. In contrast, shellfish was the dominant catch (weight and value) in 45F1, for the whole period. In both rectangles, and throughout this period, pelagic catches have been consistently low.

Nephrops is the dominant shellfish species landed, with haddock, cod, monks/anglers, whiting and saithe accounting for the majority of the landings, although over a dozen other species are also landed.

Both rectangles account for less than 1% of the total UK landings indicating the area is of relatively low importance compared to other areas fished around the UK.

	2020		2021		2022	
Species Type	**Liveweight (Te)**	**Value (£)**	**Liveweight (Te)**	**Value (£)**	**Liveweight (Te)**	**Value (£)**
ICES Rectangle 46-F1						
Demersal	874	1,345,455	506	878,093	466	715,191
Pelagic	0	60	-	-	0	75
Shellfish	191	459,090	365	1,185,511	384	1,968,250
Total	**1,065**	**1,804,605**	**871**	**2,063,604**	**851**	**2,683,516**
UK Total	**525,685**	**642,630,058**	**538,343**	**685,441,244**	**431,398**	**684,497,956**
% of UK total	**0.2**	**0.3**	**0.2**	**0.3**	**0.2**	**0.4**
ICES Rectangle 45-F1						
Demersal	364	511,061	671	1,142,680	714	1,094,748
Pelagic	1	674	0	3	0	135
Shellfish	367	904,715	948	3,065,264	844	4,009,086
Total	**732**	**1,416,415**	**1619**	**4,207,947**	**1,558**	**5,103,969**
UK Total	**525,685**	**642,630,058**	**538,343**	**685,441,244**	**481,398**	**684,497,956**
% of UK total	**0.1**	**0.2**	**0.3**	**0.6**	**0.3**	**0.7**

Notes: Landing by UK vessels into the UK ports and abroad and foreign vessels into UK. Total from summing all landings and all values from all relevant rectangles in that year and using annual total tab from official statistics spreadsheet. Source: Marine Scotland Data website.

Table 2-2 Landings (quantity and value) by species type in ICES rectangle 46F1 and 47F1 2021

2.5.5 Other Commercial Activity

Shipping density data shows block 16/12a as having moderate, and block 16/07 having low levels of shipping. Typical vessels in the area are likely to be oil and gas supply and support vessels, the routes of the majority of which are expected to originate from service ports in Peterhead and Aberdeen.

There are no operational, under construction and consented wind farm developers/demonstrators in and around the Trees fields and wider area, the closest of these being the Cerulean Winds Innovation and Targeted Oil and Gas (INTOG) leasing area, 59km away; the Trees area (Larch wye) is close to (2km), and sections of the pipelines traverse through, the INTOG area of search and exclusion NE-d, however, none of the 13 projects offered exclusivity agreements are located within NE-d and it is unknown when, or if this area is to be offered again. The Trees fields are relatively close (ca. 3km) to CS012, an area awarded in the recent North Sea Transition Authority (NSTA) carbon storage licensing round.

2.6 Protection and Stabilisation

2.6.1 Mattresses

There are a total of around 900 concrete mattresses used for protection and stabilisation of the transitions and tie-ins of the Trees pipelines and umbilicals. Various sizes of concrete mattress have been used, ranging from e.g. 5m x 2.4m x 0.15m to 10m x 2.4m x 0.15. A full list can be found in the materials inventory [4].

For the purposes of the Comparative Assessment, it is assumed that all surface laid concrete mattresses will be fully removed. Mattresses which are buried under rock will remain *in-situ*. Mattresses installed within pipeline trenches (below natural seabed level), are considered as part of the comparative assessment for the associated pipeline.

2.6.2 Grout bags

The number of grout bags noted in the materials inventory [4] has been estimated using engineering judgement based on available data such as as-built drawings, design sketches and deposit consents where available.

For the purposes of the Comparative Assessment, it is assumed that all exposed grout bags will be fully removed. Those which are buried under rock will remain *in-situ*. Grout bags installed within pipeline trenches (below natural seabed level), are considered as part of the comparative assessment for the associated pipeline.

2.6.3 Deposited Rock

Rock was used to protect and stabilise sections of PL1161 at various locations along its length within its trench and was also used to mitigate pipeline buckles in four locations. Deposited rock was also used to provide stabilisation and upheaval buckle mitigation on the Larch production pipeline PL1527 and piggybacked PL1531 service line. The locations can be seen in Section 3 or in the pipeline burial profiles report [3]. In total, 38,167.98 Te of rock has been deposited on the pipelines.

The decommissioning philosophy in this document is consistent with the DESNZ guidance notes [1] and the deposited rock will be left *in-situ*.

2.7 Exclusions & Assumptions

2.7.1 Exclusions

The following infrastructure have not been considered in the CA as they will be fully removed in accordance with DESNZ guidelines:

- Spools/Jumpers – All spools and jumpers, including electrical/chemical/hydraulic jumpers will be completely recovered for future reuse, recycling or disposal.
- Subsea Structures – All structures will be completely removed from the seabed for either future reuse, recycling or disposal. Any piles holding the structures in place will be cut to a target depth of 3m below the natural seabed level and at such a depth to ensure that any remains are unlikely to become uncovered over time.
- Subsea Trees – All subsea trees shall be completely removed from the seabed for either future reuse, recycling or disposal.

- Rock Cover – It is recognised by DESNZ that the removal of rock cover is unlikely to be practicable therefore it is proposed that all rock cover will remain in place. All unburied pipelines and mattresses that have rock cover are to be inspected and proposed to be *left in-situ* (pending a survey of the rock cover resulting in no areas of exposure or defective/deteriorated rock cover).
- Concrete mattresses and grout bags – All exposed concrete mattresses and grout bags are to be recovered for future reuse, recycling or disposal. Concrete mattresses and grout bags that are buried under rock berms shall remain in situ, as per the rock cover bullet above. Partially buried items will be subject to CA.
- Well decommissioning. Note that Xmas trees and their associated protection structures have been covered under a separate, approved DP [9].

2.7.2 Assumptions

For the purposes of the CA, the following assumptions have been made:

- The pipelines and umbilicals shall be flushed and cleaned (as appropriate) to a cleanliness level agreed with the regulators prior to any pipeline decommissioning operations.
- Minimising the number of cut pipeline or umbilical ends is preferred from a legacy and environmental perspective.
- Any pipeline(s) being left *in-situ* would be subject to at least two legacy burial surveys although given the depth of lowering it is possible that this requirement could be re-assessed following the post-decommissioning surveys.
- Pipelines lowered to a depth of greater than 0.6m below mean seabed level are not considered to pose a snagging hazard to fishing vessels, regardless of exposures as long as the lines do not include reportable freespans. Periodic monitoring will however be required, at a frequency to be agreed with the Regulator, with remediation carried out if required.
- In the long-term, assuming the size and profile or the resulting rock berm is suitable, deposited rock remaining *in-situ* would not present snagging hazards.
- Vessel associated environmental impacts and risks are assumed to be proportional to vessel durations.
- Only a high-level comparison of what differentiates the costs is considered.

3 PIPELINE BURIAL PROFILES

3.1 Overview

The Trees pipelines have been installed in open trenches and left to naturally backfill. The trenched pipelines have been lowered to a depth of between 1.0m and 2.0m below the mean adjacent seabed level.

PL1161, PL1527 and PL1531 have been rock covered at various locations along their routes to provide stabilisation and upheaval buckling mitigation. Rock cover has also been installed where pipelines cross the 30" Miller (PL720) and 30" Forties (PL64) pipelines.

PL1527 / PL1531 have concrete mattresses installed on top of the pipelines both within the trench and under rock cover spread across various locations along the pipe route.

Natural backfill has occurred to an extent within the open trenches which is generally limited to a depth of cover of ~0.3m with numerous exposures noted along most pipelines. Given that the pipelines are trenched to a depth of >0.6m below seabed level and do not currently pose a snagging hazard to fishing gear, the trench depth is considered a suitable mitigation against snagging hazards.

PL1527 has an area between approximately KP 0.238 and KP 0.275 where the pipeline is exposed at a depth <0.6m below seabed level. This section of pipeline may need to be remediated should the pipeline be decommissioned *in-situ*.

A summary of the data used for the burial profiles and confirmation of the status of the subsea pipelines is shown in the table below.

Survey Date	Pipeline Nos.	Comments
2010	PL1161, PL1162, PL1163 & PL1164.	Partial details available – no relevant anomalies recorded.
2014	PL1527, PL1528 & PL1531.	Full burial profiles available.
2018	PL1161, PL1162, PL1163, PL1164, PL1527, PL1528 & PL1531.	Full burial profiles available.

Table 3-1 – Survey Dates

3.2 PL 1161 – 10” Production Pipeline

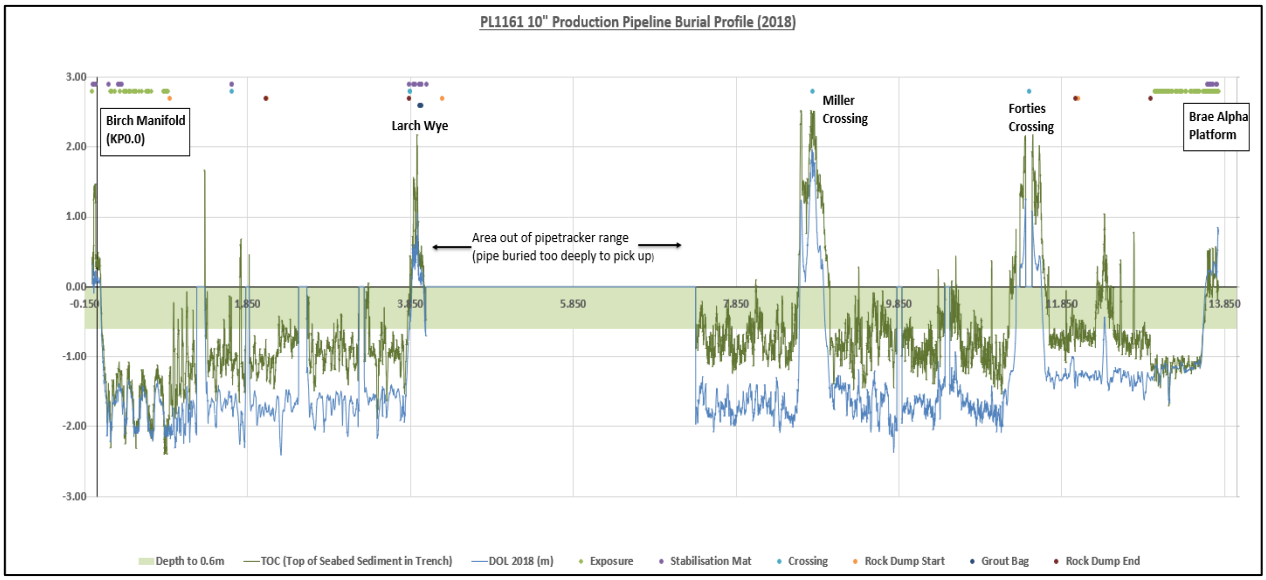

Figure 3-1: PL1161 10" Production Pipeline Burial Profile (2018)

Figure 3-1 shows the burial profile of the PL1161 10” production pipeline from the Birch manifold (KP 0.0) to the Brae Alpha platform. The pipeline enters the trench at approximately KP 0.056 (circa 100m from the Birch manifold) and remains at a trench depth of between 1m and 2m below the adjacent seabed level until it reaches the Larch Wye at approximately KP 3.834. Within the trench, the pipeline is rock covered from KP 0.890 along its length to the tie-in spools to the Larch Wye. The trenched section of pipeline between KP 0.0 and the start of rock cover at KP 0.890 has minimal backfill with numerous exposures within the trench. Survey listings also show concrete mattresses within the trench at KP 0.259 (estimated 3-off) and KP 0.290 (estimated 3-off).

Prior to 2018, PL1161 was surveyed in 2010 but full listings (which could be included in the graphs) are unavailable, however no relevant anomalies/issues were noted during the survey. With the 2018 data showing significant lowering below the seabed, in excess of the minimum recommended of 0.6m, there is nothing to indicate that this will deteriorate over time.

North of the Larch Wye, the pipeline re-enters burial (approximately KP 4.030). The pipeline is rock covered within the trench from KP 4.236 to KP 12.017, followed by a further approx. 900m of rock cover between KP 12.044 and KP 12.940. There is a gap in the survey data between KP 4.039 and KP 7.353 where the pipeline was out of range of the pipe tracker. When the pipeline comes back into range it is trenched to a depth of between 1m and 2m. Given the pipeline was out of range of the pipe tracker and no exposures have been noted, it is assumed the pipeline is trenched and rock covered to a suitable depth along this section.

Pipeline crossings are noted at ~KP 8.792 (30” Miller pipeline PL720) and ~KP 11.451 (30” Forties pipeline PL64). Pipeline separation has been achieved via concrete mattresses and concrete blocks, followed by rock cover to provide stabilisation and overtrawl protection.

Along the final ~800m of pipeline on approach to Brae Alpha, the pipeline remains trenched to a depth of >1m, with intermittent natural backfill.

3.3 PL1162 12” WI Pipeline c/w Piggybacked PL1163 4” GL Pipeline

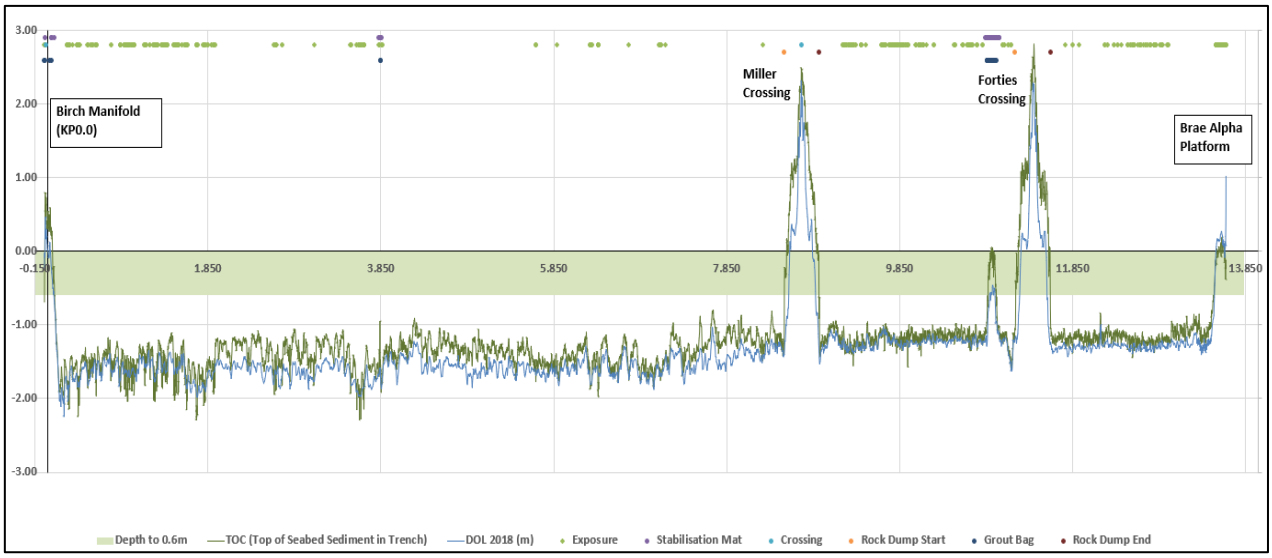

Figure 3-2: PL1162 12” WI Pipeline c/w Piggybacked PL1163 4” GL Pipeline Burial Profile (2018)

PL1162 is a 12” water injection pipeline that runs between the Birch manifold and Brae Alpha. PL1163 is a 4” gas lift pipeline that is piggybacked to PL1162 along its length. KP 0.0 is referenced from the Birch manifold end. Burial profiles for the pipelines are shown in Figure 3-2. Prior to 2018, PL1162 and PL1163 were surveyed in 2010 but full listings (suitable for inclusion in the graphs) are unavailable, however no relevant anomalies/issues were noted during the survey. With the 2018 data showing significant lowering below the seabed, in excess of the minimum recommended of 0.6m, there is nothing to indicate that this will deteriorate over time.

The pipelines enter trench transition at approximately KP 0.040 and transition down to a depth of approximately 1.5m around KP 0.113. The pipelines remain trenched at a depth approximately between 1m and 2m along their entire length with the exception of the 30” Miller and 30” Forties pipeline crossings. At the crossing locations, pipeline separation is achieved by concrete mattresses and concrete blocks, and rock cover has been installed over the crossings to provide stabilisation and overtrawl protection.

Between KP 10.839 and KP 11.001 there are a number of concrete mattresses and grout bags installed on the pipelines shortly before the approach to the 30” Forties crossing, where there is a section of pipeline with depth of lowering <0.6m below seabed level. These will be reviewed in detail during the decommissioning operations to ensure that the remaining facilities are left in a safe condition for other users of the sea, with any remediation activities being subject to consultation with OPRED.

The pipelines have been installed in an open trench which has been left to backfill naturally. The pipelines have maintained their trenched depth but limited backfill has occurred (typically <0.3m coverage) with numerous exposures noted along the entire length of the pipelines.

PL1530 umbilical between the Birch and Larch manifolds also shares a trench with PL1162 & PL1163.

There are some items of debris (fishing nets etc.) noted along the pipeline. From the survey videos these items appear to be lost or discarded items that have ended up near the pipelines. There is no evidence of snagging from the screengrabs (example below):

Figure 3-3: Example of fishing debris.

3.4 PL1164 Control / Chemical Umbilical

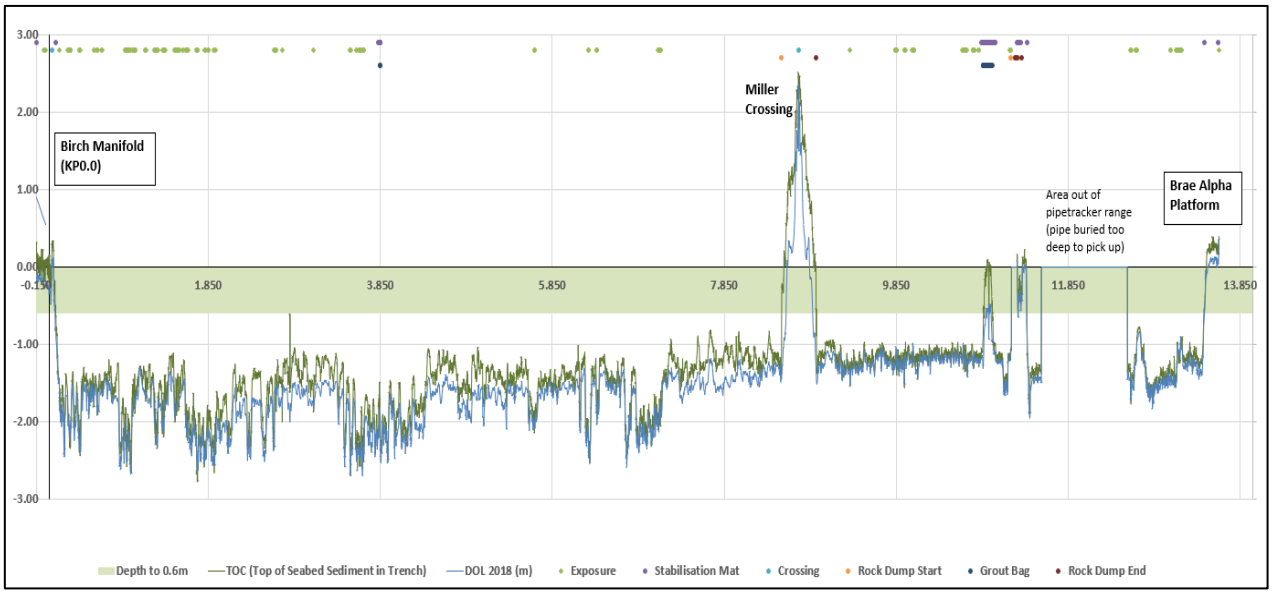

Figure 3-4: PL1164 Control / Chemical Umbilical Burial Profile (2018)

PL1164 is a control / chemical umbilical that runs between the Birch manifold and Brae Alpha. KP 0.0 is referenced from the Birch manifold end. The burial profile for the pipeline is shown in Figure 3-4. Prior to 2018, PL1164 was surveyed in 2010 but full listings are unavailable, however, no issues were noted during the survey. With the 2018 data showing significant lowering below the seabed, in excess of the minimum recommended of 0.6m, there is nothing to indicate that this will deteriorate over time.

The umbilical shares a trench with PL1162 & PL1163 from the Birch manifold until just South of the 30" Forties pipeline crossing (PL64), where the umbilical is routed North East and runs parallel with PL64 to Brae Alpha.

As per PL1162 & PL1163, PL1164 is trenched along its entire lay route to a depth of between 1m and 2m, except at the Miller crossing location, where pipeline separation has been achieved with concrete mattresses and is under the same protective rock berm as PL1162 & PL1163. The umbilical has maintained its trenched depth with limited backfill taking place (typically < 0.3m coverage) with numerous exposures noted along the entire length of the umbilical.

On approach to the Forties crossing, at approximately KP 11.303, the umbilical breaks from the trench it shares with PL 1162 & PL1163 and runs parallel with PL64. There are several concrete mattresses installed on the umbilical at this trench transition area and where it runs inside the trench until it reaches the platform. These will be reviewed in detail during the decommissioning operations to ensure that the remaining facilities are left in a safe condition for other users of the sea, with any remediation activities being subject to consultation with OPRED.

There is a gap in the survey data where the umbilical was out of range of the Pipetracker unit between KP 11.189 – KP 11.255 and KP 11.537 – 12.538. This was due to the burial depth being greater than could be identified by the equipment.

3.5 PL1527 10" Production Pipeline c/w Piggybacked PL1531 4" GL Pipeline

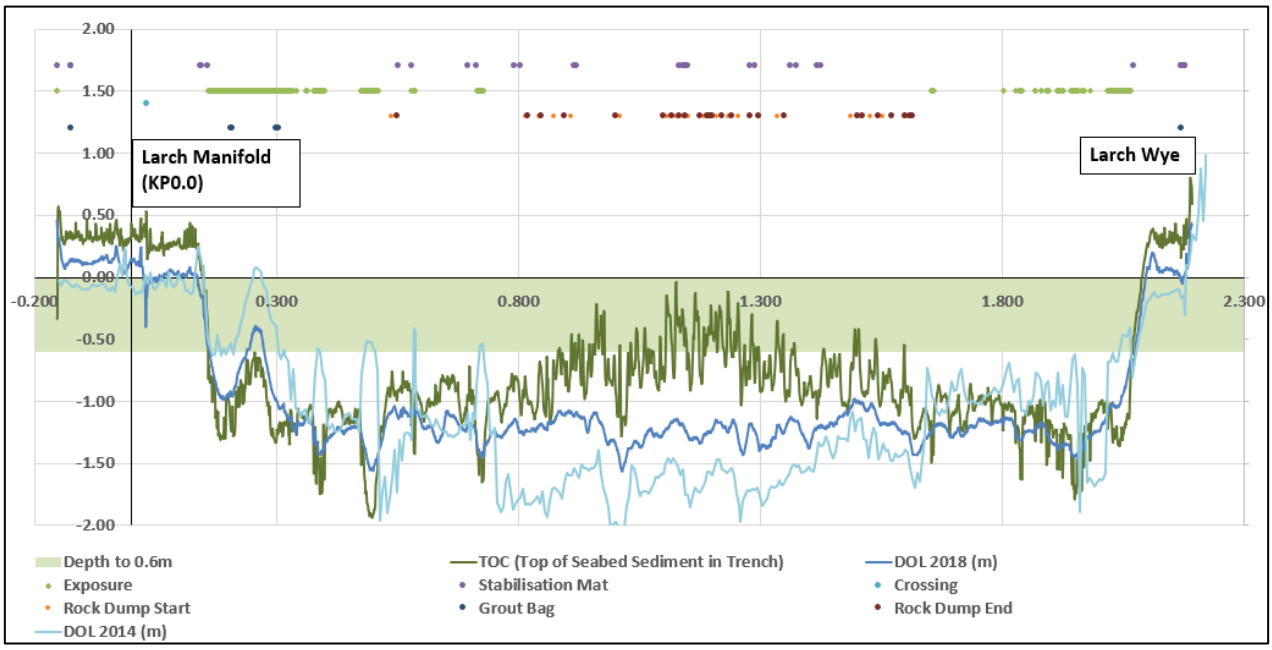

Figure 3-5: PL1527 10" Production Pipeline Burial Profile (2014 & 2018)

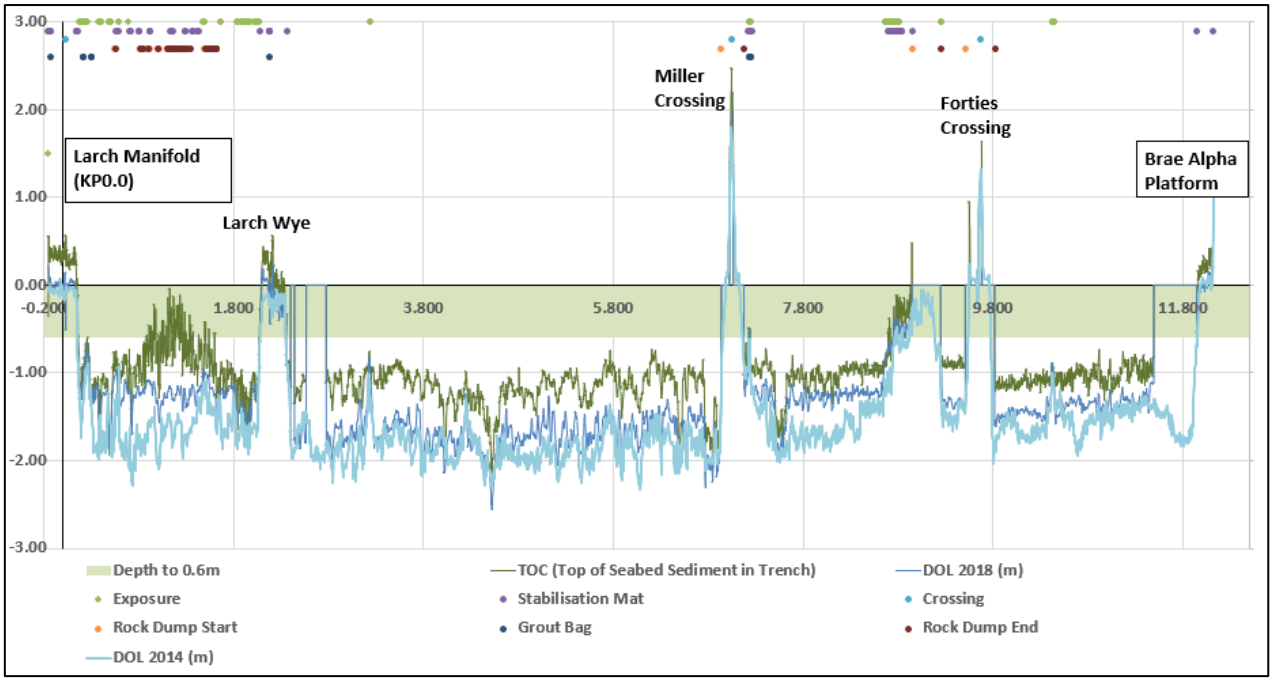

Figure 3-6: PL1531 4" GL Pipeline Burial Profile (2014 & 2018)

PL1527 is a 10” production pipeline that runs from the Larch manifold to the Larch wye, approximately 2.3km in length. PL1531 is piggybacked to PL1527 between the Larch manifold and wye, beyond which it continues north to the Brae Alpha platform. The burial profiles for the pipelines are shown in Figure 3-5 and Figure 3-6. KP 0.0 is referenced from the Larch manifold end.

It can be seen from Figure 3-5 and Figure 3-6 that the 2014 and 2018 survey profiles match well indicating no movement of the pipelines during the interim period. Minor deviations in the overall baseline can be attributed to survey calibrations.

Between the Larch manifold and Wye, the pipelines are trenched from approximately KP 0.160 along the route until they transition out of the trench at the Wye at approximately KP 2.075. Generally, the pipelines are within the trench at a depth of >1.0m below seabed level, with the exception of a section of the line between KP 0.238 and KP 0.275 where the pipelines are exposed and the depth of lowering is <0.6m below seabed level.

There are numerous exposures within the trench (at a depth >0.6m below seabed level) along the route between the Larch manifold and Wye and also numerous sections of spot rock cover and concrete mattresses installed to stabilise the pipeline. Some of the mattresses are buried under the rock berms, while some are laid within the trench.

From the Larch wye, PL1531 re-enters an open trench at approximately KP 2.345 where it continues at a lowered depth generally >1.0m along its entire route, with the exception of the Miller and Forties 30” pipeline crossings. At the crossings, pipeline separation has been achieved with concrete mattresses and covered with rock to provide stabilisation and overtrawl protection.

3.6 PL1528 6” WI Pipeline c/w Piggybacked PL1529 4” Service Pipeline

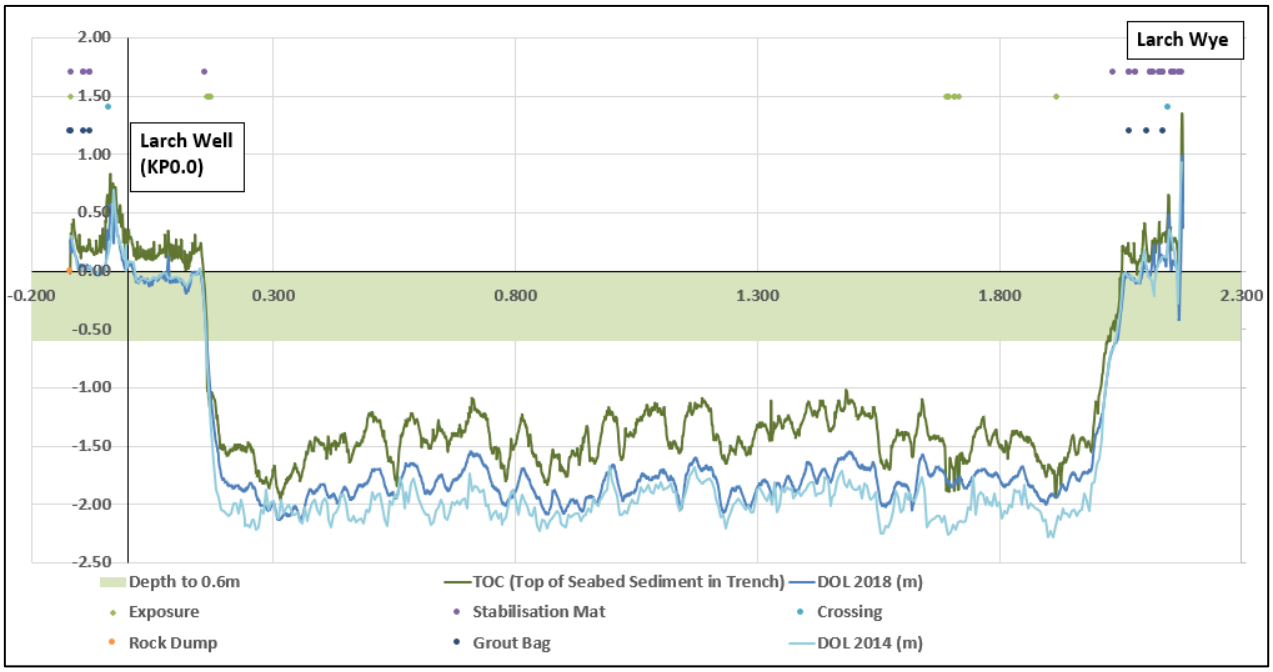

Figure 3-7: PL1528 6” WI Pipeline c/w Piggybacked PL1529 4” Service Pipeline Burial Profile (2014 & 2018)

PL1528 and PL1529 are water injection and gas lift / service pipelines that branch off from PL1162 and PL1163 respectively at the Larch wye, onwards to Larch well 16/12a-24(Z7), located near the Larch manifold. Both pipelines share the same trench and KP 0.0 is referenced from the Larch well end.

It can be seen from Figure 3-7 that the 2014 and 2018 survey profiles match well indicating no movement of the pipelines during the interim period. Minor deviations in the overall baseline can be attributed to survey calibrations.

The pipelines enter burial at approximately KP 0.162 the pipelines transition to a burial depth of 1.5m by KP 0.183 and maintain a trenched depth of 1.5m – 2.2m along their entire length, until they transition out of burial at KP 2.042 for tie-in to PL 1163 and PL1164. Natural backfill has occurred to some extent within the trenches, generally burying the pipelines to 0.3m – 0.5m with relatively few exposures noted along the route.

3.7 Pipeline exposures and spans

The Trees pipelines have been installed in open pre-cut trenches and lowered to a depth of between 1m and 2m. Natural backfill has occurred to a limited extent within the trenches, however, a large number of pipeline exposures are noted along the majority of pipeline routes. Given that the exposures are within the trenches and the historical survey data indicates that the pipelines are stable, the pipeline exposures are not considered to be a snagging hazard for fishing interaction.

No freespans have been noted in the survey of the pipelines. Upheaval buckling has occurred at four locations on PL1161 which have been addressed with spot rock berms installed over the pipeline. No further upheaval buckling will occur since the pipelines are no longer operational.

A 37m long section of PL1527 is noted to be exposed and at a shallow trench depth (< 0.6m) between KP 0.238 and KP 0.275. This section of pipeline will require to be remediated. The preferred method for the remediation is by dredging using a mass flow excavator or similar, however should this be unsuccessful, then alternative solutions such as cut and recovery, or rock placement shall be used, subject to consultation with OPRED.

3.8 Pipeline crossings

PL1531, PL1161, PL1162 and PL1163 cross the 30” Forties oil export pipeline PL64. Pipeline separation has been achieved using concrete mattresses and rock berms installed over the crossing locations. PL1164 has mattresses on approach to this crossing and is contained within the rock berm where it shares the trench with PL1162 and PL1163 but does not physically cross PL64.

PL1531, PL1161, PL1162, PL1163 and PL1164 cross the Miller 30” gas export pipeline PL720. Pipeline separation has been achieved using concrete mattresses and rock berms installed over the crossing locations.

Crossing details are included in Appendix A

4 DECOMMISSIONING OPTIONS

4.1 Options Pre-Screening / Scoping

A pipeline decommissioning options pre-screening workshop was held on 22nd September 2021 via Teams call with Technical and Project representatives from Spirit Energy and PDi as follows:

John Mitchell	Spirit Energy	Project Manager
Craig Stenhouse	Spirit Energy	Project Engineer
Andy Thomson	PDi Ltd	Project Manager
James Miller	PDi Ltd	Lead Project Engineer
Mike McHardy	PDi Ltd	Senior Project Engineer

The purpose of the pre-screening workshop was to identify all potential options for the decommissioning of the Trees pipelines and bundles and filter out those identified to be unfeasible or unrealistic.

Prior to the session, high level execution methodologies were developed for each option identified and shown in Table 4-1.

Option	Description
1	Reuse
2a	Complete removal – reverse reeling / S-Lay through seabed
2b	Complete removal – reverse reeling / S-Lay through cleared trench
3	Complete removal – recover in sections
4a	Partial removal (trenched sections) - reverse reeling / S-lay through seabed
4b	Partial removal (trenched sections) - reverse reeling / S-Lay through cleared trench
5	Partial removal (trenched sections) – Recover in Sections
6	Partial removal – recover exposed ends
7	Leave *in-situ*

Table 4-1: Pipeline Decommissioning Options

At the workshop itself, the methodologies were presented, discussed and evaluated using a traffic light system, against the criteria of Safety, Environmental, Technical, Cost/Schedule and Ongoing Liability.

A summary of the discounted decommissioning options for the pipelines is shown in Table 4-2. Full details of the pipeline decommissioning options, and pre-screening results are included in [2].

Option		Description	Reason for Removal
1.	Reuse	Reuse pipelines for other subsea developments.	Previously assessed within Spirit Energy and no further economic opportunities are available for the Trees pipelines.
2a.	Complete removal – reverse reeling / S-lay through seabed.	1. DSV to install pipeline recovery clamp (first end) and hold back anchor (2nd end) 2. S-lay / Reel lay vessel to connect A&R wire to clamp and recover via reverse installation. 3. NB buried pipe is pulled directly through seabed / rock berm.	Technical risk considered too great. Unproven operation and unknown pipeline integrity. Recovery of piggybacked pipelines via methodology considered unfeasible. Pipelines / umbilicals share a trench which may impact recovery operations. Pipe likely to buckle due to soil and rock berm loads.

Option		Description	Reason for Removal
2b.	Complete removal – reverse reeling / S-lay through cleared trench	As per Option 2a but a mass flow excavator is use to expose pipeline prior to commencing recovery operations.	As per Option 2a with exception of soil / rock berm loads.
4a.	Partial removal (trenched sections) - reverse reeling / S-lay through seabed.	Recover trenched sections of pipelines. Rock covered sections i.e. crossings to remain *in-situ*. Recovery methodology as per Option 2a.	As per Option 2a. with exception of rock berm loads. Large number of pipeline cut ends remain *in-situ* due to spot rock cover poses an increased snagging risk.
4b.	Partial removal (trenched sections) - reverse reeling / S-lay through cleared trench	Recover trenched sections of pipelines. Rock covered sections i.e. crossings to remain *in-situ*. Recovery methodology as per Option 2b.	As per Option 2b. Large number of pipeline cut ends remain *in-situ* due to spot rock cover poses an increased snagging risk.
7.	Leave *in-situ*	Leave pipelines *in-situ* with no intervention	Not in accordance with Regulations. Not considered a responsible option due to residual snagging risk to trawlers.

Table 4-2: Discounted Pipeline Decommissioning Options

4.2 Pipeline Decommissioning Options

The pipeline decommissioning options carried forward for comparative assessment are summarised in Table 4-3.

Option		Description
3.	Complete removal – recover in sections	1. Use mass flow excavator to dredge seabed / rock berm and expose pipeline. 2. Cut pipeline into ~20m sections and recover to deck of construction vessel.
5.	Partial removal (trenched sections) – recover in sections	Recover trenched sections of pipelines. Rock covered sections i.e., crossings to remain *in-situ*. Recovery methodology as per Option 3.
6.	Partial removal - recover exposed ends	1. Cut and recover pipeline ends to trench transition (0.6m burial depth). Buried pipeline is decommissioned *in-situ*. 2. Remedial work (dredging using mass flow excavator, cut & recovery, or spot rock placement) carried out on sections of shallow burial along the lay route to mitigate snagging hazards.

Table 4-3: Pipeline Decommissioning Options for Comparative Assessment

5 COMPARATIVE ASSESSMENT METHODOLOGY

5.1 General

The purpose of the session is to assess and compare the options for the decommissioning of certain items of subsea infrastructure associated with the Trees fields. In order to compare the options, each was scored against a set of assessment criteria in the following categories:

- Safety
- Environmental
- Technical
- Societal
- Legacy
- Economic

5.2 Comparative Assessment Session

The comparative assessment session was held on 1st October 2021 via Microsoft Teams call and in accordance with Terms of Reference Document [7]. The following representatives from PDi and Spirit Energy participated in the session.

John Mitchell	Spirit Energy	Project Manager
Craig Stenhouse	Spirit Energy	Project Engineer
Andy Thomson	PDi Ltd	Project Manager
James Miller	PDi Ltd	Lead Project Engineer
Mike McHardy	PDi Ltd	Senior Project Engineer
Carmine Cappuccio	PDi Ltd	Senior Structural Engineer

The session followed a similar format to the Pre-screening/scoping session and commenced with a presentation of each option followed by the discussion and scoring by the session attendees. Where applicable, comments were added to the scoring sheets to record any particular reasons for the scoring or follow-up actions required.

5.3 Comparative Assessment Tools

PDi's comparative assessment programme "PDi Compare" has been developed for use as part of PDi's Decommissioning toolkit which consists of a suite of complimentary software. The assessment criteria used in PDi Compare is based on the example comparative assessment given in the DESNZ guidance notes [1].

In the guidance notes a matrix is presented as a tool for assessing options that require derogation from the OSPAR Decision 98/3 i.e. derogation from complete removal. While it is recognised that subsea infrastructure such as pipeline systems do not fall under the auspices of OSPAR and as such no derogation is sought, the application of the matrix is still considered a solid foundation for comparing the relative advantages and disadvantages of the identified options.

5.3.1 Comparative Assessment Matrix

The comparative assessment matrix combines the consequence of each of the decommissioning options being considered with the confidence in this consequence rating. This gives an overall comparative assessment rating for the item of Very Low, Low, Medium, High or Very High.

The Comparative Assessment Matrix utilised during the session can be found in Appendix C [7].

5.3.1.1 Consequence

In order to accurately categorise the consequences of each decommissioning options the assessment criteria have been quantified at 5 levels of consequence; Slight, Minor, Moderate, Major and Massive as per the example in Figure 5-1 (Appendix C).

	Consequence				
	1	2	3	4	5
ASSESSMENT CRITERIA	Slight	Minor	Moderate	Major	Massive
SAFETY					
Project Risk to Personnel - Offshore	Slight injury or health effect i.e. (No major treatment required or first aid case). No preparatory activity to be completed prior to start of removal activity. No underdeck / overside working. No materials handling on deck or barge during removal. No diving activity.	Lost workday injury. Medium term health effect. Minimal preparatory activity to be completed prior to start of removal activity. Minimal underdeck / overside working. Minimal materials handling on deck or barge during removal. Minimal diving activities	Major injury or health effect i.e. (Lost workday case or restricted workday case, injury resulting in permanent partial disability or occupational illness with irreversible health effects resulting in permanent partial disability). Some preparatory activity to be completed prior to start of removal activity - but straight forward. Limited underdeck / overside working. Some materials handling activity on deck or barge during removal. Increased diving activity for short intervals	Single fatality or multiple major injuries with long term effects. Complex / non-standard preparatory activities prior to start of removal activity Significant underdeck / overside working. Significant materials handling on deck during removal. Diving activities required for extended durations at various intervals.	Potential for multiple fatalities due to injury or occupational illness, injury which results in permanent total disability or occupational illness (including cancer) with irreversible health effects resulting in permanent disability. Extensive high level of preparatory activity to be completed prior to start of removal activity. Extensive underdeck / overside working. Extensive multiple materials handling activity on deck or barge during removal. Extended diving activity throughout entire project phase.

Figure 5-1: Extract from consequence matrix

The complete Consequence Matrix which quantifies all the assessment criteria is included in Appendix C [7]. The consequence matrix includes a set of guide criteria which may not all be met for a particular activity; in this instance an assessment is made based on which consequence level is most appropriate.

5.3.1.2 Likelihood / Uncertainty

Once the consequence of the item has been rated, the likelihood or uncertainty in the assigned rating was categorised. The level of confidence was scored from 1 to 5 as per the table below which is extracted from the comparative assessment matrix.

Rating		Likelihood	Uncertainty
1	Very Low	Has never occurred in the industry.	Detailed definition and understanding of methodology, hazards and equipment. Very low level of uncertainty.
2	Low	Has previously occurred in the industry.	High level definition and understanding of methodology, hazards or equipment. Low level of uncertainty.
3	Medium	Has occurred in the organisation or might occur in life of site and/or more than once per year in the industry.	General definition and understanding of methodology, hazards or equipment. Moderate level of uncertainty.
4	High	Might occur several times in life of site.	Basic definition and understanding of methodology, hazards or equipment. High level of uncertainty.
5	Very High	Might happen once a year on site.	Limited definition and understanding of methodology, hazards or equipment. Very high level of uncertainty.

Figure 5-2: Likelihood / Uncertainty Matrix

5.3.2 Comparative Assessment Rating

The consequence and confidence ratings were then combined in the matrix to arrive at an overall comparative assessment rating for the criterion being considered.

Consequence		Increasing Likelihood / Uncertainty				
Value	Rating	1	2	3	4	5
		Very Low	Low	Medium	High	Very High
1	Minimal	1	2	3	4	5
2	Minor	2	4	6	8	10
3	Considerable	3	6	9	12	15
4	Major	4	8	12	16	20
5	Massive	5	10	15	20	25

Figure 5-3: Comparative Assessment Rating Matrix

For example a minor consequence (2) with a medium likelihood/uncertainty (3) will result in an overall rating of Medium (6). The full categorisation of Low, Medium and High can be found in the figure below.

Comparative Assessment Rating	
High	This is the highest rating and reflects either a high-risk activity, an activity that is still subject to a large number of uncertainties, or purely an activity/option that should be scored highest in comparison to the other options.
Medium	A Medium Risk activity reflects a medium risk activity when combining the risk with the likelihood or uncertainty. It may also be an activity that is determined to neither be in the High or Low rating in comparison to the other options.
Low	A Low Risk activity reflects a standard operation or activity that is performed regularly or has a well-defined methodology or low risk of occurrence.

Figure 5-4: Comparative Assessment Rating Categories

5.3.3 Comparative Assessment Record Sheet

The score is then entered into the PDi Compare programme:

ID	Assessment Criteria	Consequence	Confidence	Comparative Assessment Rating	Comments
Option 2b: Leave *In-Situ* - Trench/Bury Exposed Sections					
1.0	**Safety**				
1.1	Risk to offshore personnel - Construction vessels	Moderate	Medium	6	

Figure 5-5: Extract from representative comparative assessment record sheet.

The options were scored against each assessment criteria and the completed record sheets form part of this comparative assessment report.

Record sheets were completed for all options under consideration during the session.

5.4 Assessment Criteria

To allow accurate categorising of the potential decommissioning options the assessment criteria are discussed in more detail in the following sections. For information on how the criteria have been quantified, refer to the consequence matrix in Appendix C [7].

It should be noted that the assessment is largely qualitative and the assessment does not always meet every guide criteria in the consequence matrix. In such circumstances, the most appropriate rating is chosen based on previous project experience.

5.4.1 Safety

When considering these risks, it is assumed that all activities are being undertaken by competent contractors and personnel. Moreover, all tasks will have been fully risk assessed and as such all necessary mitigating measures will already be in place including; approved procedures, certified equipment, personal protective equipment etc.

5.4.1.1 Risk to personnel – offshore / subsea / onshore

This assessment criterion generally covers the risks to personnel during decommissioning operations. Those at risk may include but not be limited to divers, personnel on board construction vessels or onshore personnel receiving and processing any decommissioning and decommissioned equipment.

The level of risk will vary depending on the quantity of equipment being recovered, as well as the duration and complexity of the tasks considered.

5.4.1.2 Residual risk to other users of the sea

Each option reviewed will consider the residual risk following completion of decommissioning activities. The primary risk will be to fishermen however commercial and recreational shipping/boating must also be considered if applicable.

5.4.2 Environmental

The criteria against which environmental consequence will be assessed are:

Impact of decommissioning activities -

- Spills, discharges to sea, disturbance to seabed, underwater noise. Seabed Disturbance;
- Impacts of items left *in-situ* - Legacy impact
- Energy, Emissions, Resource Consumption

5.4.3 Technical

5.4.3.1 Technological Challenge

The technological challenge posed by each decommissioning option will vary depending on the level of unknowns anticipated, the level of industry experience that exists for a particular task and the equipment availability and track record of executed similar scopes.

5.4.3.2 Risk of Major Project Failure

The risk of major project failure assesses the likelihood of being unable to complete the decommissioning scope within the planned timeframe / budget / methodology due to the technical challenges associated with the options.

The weather sensitivity of each option will be considered. In some cases certain tasks will carry high weather sensitivity and these tasks will be on the critical path. Other options may also require specific weather windows for certain tasks but it should be considered if these tasks can be optimised so as not to be schedule critical.

While consideration must be given to existing industry experience and technology it should not discount potential advances in both these areas prior to the decommissioning programme start date. Such a reliance on new or developing technologies will however increase the risk.

5.4.4 Societal

5.4.4.1 Fisheries Impact

The effect on fisheries and fishing activity is of particular importance. This should be assessed with regard to the level of fishing activity in the area, the possible short- and long-term consequences and any mitigation measures that can be put in place.

5.4.4.2 Amenities

The consequence of the decommissioning options on local amenities and communities should be considered. This will most likely be applicable to potential onshore disposal sites, where regional development and employment may be encouraged by one or more of the decommissioning options.

This may also be applicable to the local area where partnerships with local schools etc. may increase the company's profile.

5.4.5 Legacy

The legacy criteria considers the ongoing liability impact of the subsea infrastructure after the decommissioning project work has been completed. This considers the extent of post decommissioning monitoring surveys and associated technology reviews to assess the feasibility of recovery of the assets in future.

5.4.6 Economic

The economics of the decommissioning options will be assessed. Costs will consider offshore construction cost including vessels, equipment and onshore decommissioning cost for any recovered material. In addition, engineering, management and internal Spirit Energy costs will also be considered.

The economic assessment shall be qualitative and based on the experience of the personnel in attendance at the comparative assessment.

6 PIPELINE DECOMMISSIONING COMPARATIVE ASSESSMENT RESULTS

The three options considered for the Trees pipeline and umbilical decommissioning were:

- Option 3 - complete removal
- Option 5 - partial removal (trenched sections and exposed ends, not rock covered areas)
- Option 6 - partial removal (exposed ends only)

As detailed in the sections above, the pipelines are installed in open trenches at a depth of 1m – 2m below seabed level. Natural backfill has occurred to a limited extent, resulting in numerous exposures along the pipeline lengths and historical data indicates the pipelines are stable with no known free spans.

PL1161, PL1527 and PL1531 have spot rock deposits installed along their length. PL1527 has a 37m shallow section where the pipeline is trenched to a depth less than 0.6m and is exposed.

The comparative assessment results for the Trees pipelines and umbilicals are detailed in the following sections.

6.1 Safety Considerations

6.1.1 Project Risk to Personnel – Offshore

The key difference between the options is the risk to vessel personnel in the deck handling of the cut pipeline sections. Options 3 and 5 both require handling of significant volumes of cut pipe sections on deck, while Option 6 minimises the number of offshore lifts and the quantity of pipe handled on deck.

While none of the options are considered unsafe if properly planned, the extended vessel duration and number of offshore lifts required for Options 3 and 5 resulted in these options being less preferable to Option 6.

6.1.2 Project Risk to Other Users of the Sea

The project risk to other users of the sea considered the impact of the project offshore operations to other vessels within the vicinity. It was concluded that no option posed a significant risk to other users of the sea, given there are little / no Simultaneous Operations (SIMOPS) required to execute the work and good communication protocols should be adhered to throughout.

Option 6 is considered lower risk than Options 3 and 5 because all offshore operations shall be conducted inside existing 500m zones. For Options 3 and 5 the majority of the work will be executed out with 500m zones over a significantly longer duration. This will limit access to the working areas for the duration of the specific activities. Notification of activities will be provided via Notices to Mariners, Seafish Kingfisher Bulletin, etc as applicable at the time.

6.1.3 Project Risk to Personnel – Onshore

The project risk to onshore personnel was deemed to be proportional to the volume of infrastructure to be recovered and disposed of. Options 3 and 5 require significant volumes of pipework to be returned for onshore disposal, requiring a greater number of onshore lifts, more onshore handling of cut pipe ends and larger volumes of NORM contaminated materials to dispose of.

Option 6 minimises the volume of material to be handled onshore and was therefore deemed to be the most preferable option in terms of risk to onshore personnel.

6.1.4 Potential of a High Consequence Event

Option 6 is considered a standard operation in North Sea IRM and decommissioning projects, therefore the potential of high consequence even was deemed to be very low for this operation. Options 3 and 5 were deemed to be of a higher risk activity in terms of probability of a high consequence event due to the large number of lifts required, some of which will be non-routine.

6.1.5 Residual Risk to Other Users of the Sea – Legacy Impact

The residual risk to other users of the sea was considered negligible for Option 3, as all infrastructure is removed and was deemed the most preferred option.

Option 5 was considered least preferable due to the high number of cut pipeline ends to rectify along the spot rock covered sections of the pipelines. Although Option 6 leaves more infrastructure *in-situ*, fewer cut ends was deemed to be less of residual risk to other users of the sea than the high number of residual cut ends offered by Option 5.

6.2 Environmental

6.2.1 Impact of Decommissioning Activities – Spills, Discharges to Sea, Disturbance to Seabed & Underwater Noise

The biggest differentiator between the three options was considered to be the seabed disturbance required to expose the pipelines for cutting operations. Option 3 creates the greatest amount of seabed disturbance as the trenched and rock covered sections are required to be excavated for cutting operations, followed closely by Option 5 which requires excavation of the trenched sections only (excluding rock cover). The most preferred option was deemed to be Option 6 due to the relatively low seabed disturbance required to expose the pipelines within the trench transitions.

6.2.2 Impacts of Items Left *In-Situ* – Legacy Impact

Option 3 was considered to be the most preferable option for the environmental impact of items left *in-situ* as all infrastructure is recovered, therefore there is no impact. Option 5 was considered the next preferred option as most items are recovered, however, significant sections of pipelines under rock berms are left *in-situ*. Finally, Option 6 was considered the least preferred option as the majority of the pipelines are left *in-situ*, resulting in the largest quantity of materials which will eventually and gradually degrade into the water column.

No environmental appraisal has been performed on the options at the time of the comparative assessment but, based on previous project experience, the decommissioning of flushed pipelines *in-situ* (Options 5 and 6) is not considered to pose a significant risk to the environment. The pipelines and umbilicals inner lines will be flushed and cleaned (with untreated seawater and gel) back to the Brae Alpha platform. Topsides sampling of the seawater returns from the production pipelines will ensure an acceptable level of cleanliness is achieved (agreed with OPRED prior to any pipeline decommissioning activity) and the lines will be left filled with untreated seawater. If the hydraulic fluid (Oceanic HW443ND) cannot be flushed from the umbilical and remain present in the umbilical hoses/jumpers, there will be an initial discharge to sea upon cutting of the umbilical ends, with full discharge over time. This will be risk assessed as part of the environmental (chemical) permits required.

Discharges will contribute to local water quality changes and associated interactions with water column biota; however, discharges will be small and are expected to be readily diluted and dispersed.

6.2.3 Energy, Emissions & Resource Consumption

The energy, emissions and resource consumption impact were considered to be directly proportional to the number of offshore vessel days required to execute the work and the quantity of infrastructure recovered for onshore transport and disposal. Therefore, Option 3 was deemed to be least preferable, followed by Option 5 and finally Option 6 considered the most preferred option.

6.3 Technical

6.3.1 Risk of Major Project Failure

None of the three options were considered to carry a high risk of major project failure. Option 3 was deemed to hold a higher level of uncertainty than the other options as there is uncertainty as to amount of rectification required on the rock berms should they become snagging hazards post excavation. Option 3 was therefore deemed the least preferred option.

Option 5 was considered slightly higher risk than Option 6 due to the scale of the recovery operations being out with that which is typically performed. Option 6 was the most preferred option as it involves standard operations with minimal risk of major project failure.

6.3.2 Technological Challenge

Option 6 was the deemed to be the most preferred option, as standard equipment is used for standard operations, therefore there is negligible technological challenge for this option. Options 3 and 5 were not considered to carry any significant technological challenges as the same equipment shall be used, however, it does carry a slightly increased risk due to the scale of the operation.

6.4 Societal

6.4.1 Commercial Impact on Fisheries

For all options, upon completion of the decom activities, there will be no remaining 500m zones, so there will be no loss of fishing ground. Any rock berms will be designed and installed to be overtrawlable, so there should be no risk of damage to fishing gear.

Option 3 returns the fishing grounds with no restrictions, providing any rock berms are remediated correctly and was therefore deemed the most preferable option in regard to the commercial impact on fisheries.

Option 5 was considered the least preferred option due to the high number of cut pipeline ends to remain *in-situ*. Options 3 and 5 will have a temporary impact on fishing operations in the area during the offshore execution as most of the work is performed out with existing 500m zones.

Option 6 is not expected to have a significant impact on fishing operations in the area, given the trench depth of the pipelines and umbilicals. Any shallow sections will require remediation and the fishing industry be kept informed of any mitigations put in place. Option 6 was considered less preferable than Option 3 but preferable to Option 5.

6.4.2 Socio-Economic Impact on Communities and Amenities

None of the options were considered to offer any significant positive or negative impact to local communities and amenities. Due to the volume of infrastructure recovered, Options 3 and 5 may provide a slight positive impact if local vessel contractors and waste management contractors are used.

6.5 Legacy

6.5.1 Economic

Only the economic legacy impact was considered in the comparative assessment, as the safety and environmental impacts are captured in the relevant sections above. The primary cost impact on legacy activities is the requirement for ongoing monitoring surveys of items left *in-situ*. On this basis, Option 3 was considered the preferred option as there are no ongoing liabilities. Options 5 and 6 were less preferred as both would require ongoing monitoring surveys to confirm the *in-situ* pipelines are stable and no snagging hazards are developing.

6.6 Economic

6.6.1 Cost

Option 6 was considered the lowest cost operation entailing a relatively short vessel campaign carrying a low risk of significant cost escalation.

Option 3 was considered the highest cost option due to the extensive offshore vessel duration with multiple interim mobilisations required. Uncertainties remain over the NORM contamination within the pipelines and the extent of remediation required on the rock berms after excavation.

Option 5 was considered to be similar to Option 3 but slightly lower cost as less infrastructure is to be disposed of, therefore reducing NORM disposal costs and vessel duration. Option 5 was also considered to carry slightly less uncertainty, when compared with Option 3, as the rock berms will not be excavated.

6.7 Pipeline Decommissioning Summary

A comparison of the results of each option, for the assessed criteria, is shown in Figure 6-1. While the results are qualitative, a score is assigned to each option based on the consequence and likelihood / uncertainty matrices to help differentiate the options. A lower score represents the preferred option in each criterion.

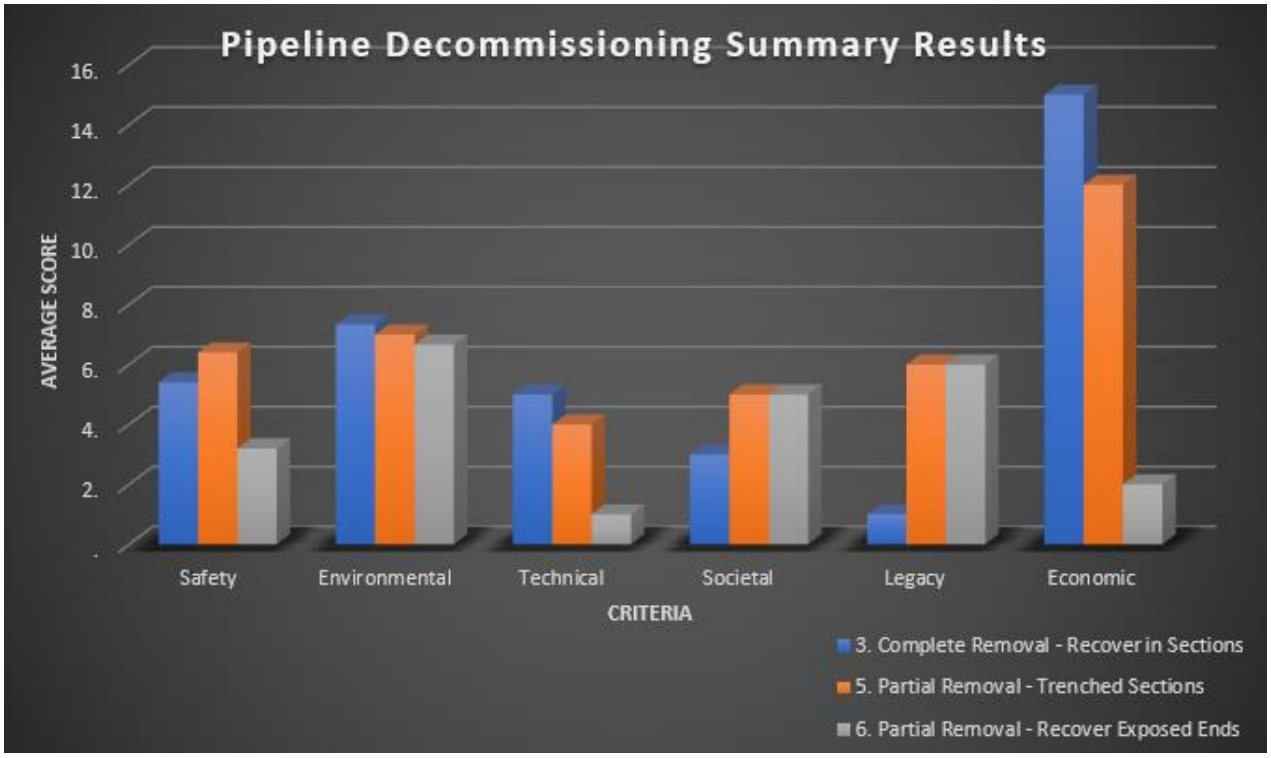

Figure 6-1: Pipeline Decommissioning Summary Results

Option 6 was assessed to be the most preferred option in terms of safety, environmental, technical and economic criteria. Option 3 was considered the most preferred option in societal and legacy criteria, however, was the least preferential option in the environmental, technical and economic assessments.

Figure 6-2 shows the overall combined results of the three options.

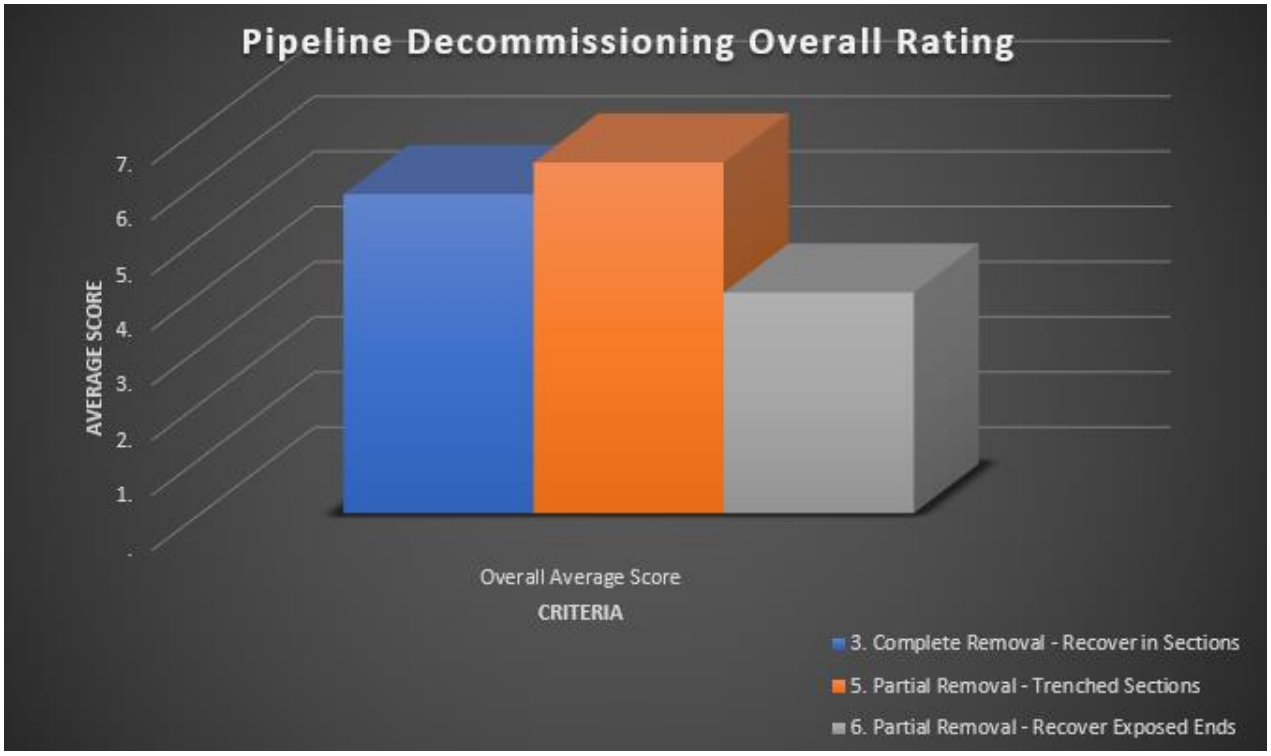

Figure 6-2: Pipeline Decommissioning Overall Rating

The comparative assessment concluded Option 6 to be the preferred option for decommissioning of the pipelines, with an average score of 4.0 across all criteria. Option 3 was the second lowest scoring option at 5.79 while Option 5 was the highest scoring and least preferred option with an average score of 6.36.

On conclusion of the comparative assessment for the Trees pipelines, Option 6 shall therefore be included in the Decommissioning Programme for the field. The full comparative assessment scoring sheets for the pipelines can be found in Appendix B.

7 CONCLUSIONS

7.1 Pipeline Decommissioning

The comparative assessment was undertaken with a focus on the decommissioning options for the Trees subsea pipelines. After a pre-screening workshop, three decommissioning options were considered in the comparative assessment. The recommended decommissioning method was concluded to be Option 6:

- Option 3 - complete pipeline removal (cut into sections)
- Option 5 - partial removal (recover trenched sections and exposed ends. Rock covered sections are decommissioned *in-situ*)
- **Option 6 - partial removal (recover exposed ends only. Trenched & rock covered sections are decommissioned *in-situ*)**

The assessment considered six criteria for both the short-term decommissioning activities and the longer-term for 'legacy' related activities. The criteria were: safety risks, environmental risks, technical challenges, societal impacts, legacy aspects and economic impact.

The assessment did not consider the decommissioning of surface laid jumpers and tie-in spools as these shall be fully recovered for onshore disposal.

The Trees pipelines have been installed in open trenches and left to naturally backfill. The trenched pipelines have been lowered to a depth of between 1.0m and 2.0m below the mean adjacent seabed level.

Three pipelines have been rock covered at various locations along their routes to provide stabilisation and upheaval buckling mitigation. Rock berms have also been installed where pipelines cross the 30" Miller (PL720) and 30" Forties (PL64) pipelines.

Natural backfill has occurred to an extent within the open trenches but this is generally limited to a depth of cover of ~0.3m with numerous exposures noted along most pipelines. Given that the pipelines are trenched to a depth of >0.6m below seabed level and do not currently pose a snagging hazard to fishing gear, the trench depth is considered a suitable mitigation against snagging hazards.

PL1527 has an area between approximately KP 0.238 and KP 0.275, where the pipeline is exposed at a depth <0.6m below seabed level. This section of pipeline will need to be remediated should the pipeline be decommissioned *in-situ*. Remediation method is still to be determined; however, dredging/trenching is the preferred method at this stage. Should this method be unsuccessful or shown to be unfeasible then spot rock placement will be performed. Cut and recovery remains a viable, though non-preferred option as it results in additional cut ends along the pipeline routes.

Of the three options considered, the recovery of the exposed ends only while decommissioning the trenched sections *in-situ* (Option 6) produced the lowest average score overall and is therefore considered the most appropriate decommissioning option for the pipelines. Concrete mattresses that are installed within the pipeline trenches or under rock deposits will be decommissioned *in-situ* along with the pipelines. This option minimises safety risk to offshore and onshore personnel, minimises vessel emissions and minimises seabed disturbance. The methodology is a common approach in North Sea pipeline decommissioning and providing the pipelines are flushed and cleaned to an acceptable cleanliness level, their decommissioning *in-situ* is not expected to have any significant impact to the marine environment. Finally, the cost impact of Option 6 is an order of magnitude lower than that of the other options.

Option 5 was considered the least preferable option, while technically feasible, due to the high number of cut pipeline ends left on the seabed, increasing the likelihood of future snagging hazards developing, while also requiring significant deck handling of cut pipelines and associated onshore disposal therefore increasing the safety risk to both onshore and offshore personnel.

Option 3 is similar to Option 5 but the sections of pipeline under the rock berms are also removed. However, as with Option 5, the excavation activities will cause significant seabed disturbance along the pipeline length. While this option does provide the benefit of a clear seabed the increased safety risk, seabed disturbance and cost impact were considered to outweigh this benefit.

8 SUPPORTING DOCUMENTS

[1] Guidance Notes – Decommissioning of Offshore Oil and Gas Installation and Pipelines, BEIS, November 2018

[2] 2715-PDI-PE-REP-001 Rev. C1, Trees Pipeline Decommissioning Options, PDi Ltd.

[3] 2715-PDI-PE-TN-002 Rev. C1, Trees Pipeline Burial Profiles, PDi Ltd.

[4] TREEDC-SPT-Z-0000-MTO-0001, Trees Decommissioning MTO and Data Book for Decommissioning Programmes, Spirit Energy.

[5] A-301305-S67-PERM-001-002, Birch 16/12a-21 (Z5) Well Intervention EIA Justification, Xodus, September 2019

[6] TREEDC-PDI-S-0000-REP-0001, Trees Decommissioning Environmental Appraisal (Birch, Larch and Sycamore)

[7] 2715-PDi-PE-TOR-003 Rev. C1, Trees Comparative Assessment Terms of Reference, PDi Ltd.

[8] Trees Fields Decommissioning – Drill Cuttings Screening Assessment. Hartley Anderson Limited Report No.: J-PDI-492, April 2023

[9] TREEDC-SPT-F-0000-PRG-0002, Rev C1. Trees Protection Cages Decommissioning Programmes (Birch, Larch and Sycamore).

APPENDIX A FIELD LAYOUT SKETCHES

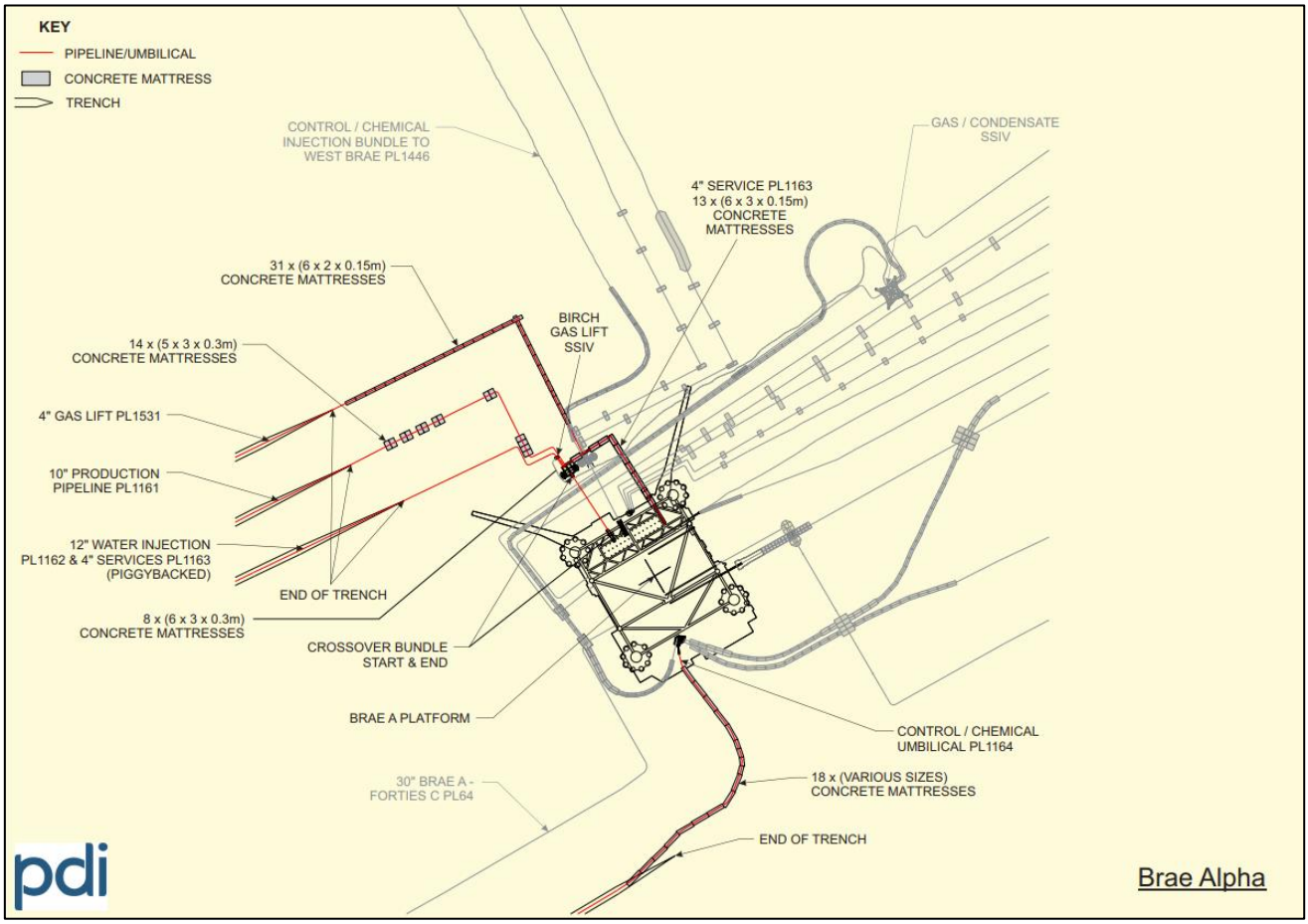

Figure A-1: Brae Alpha Approaches

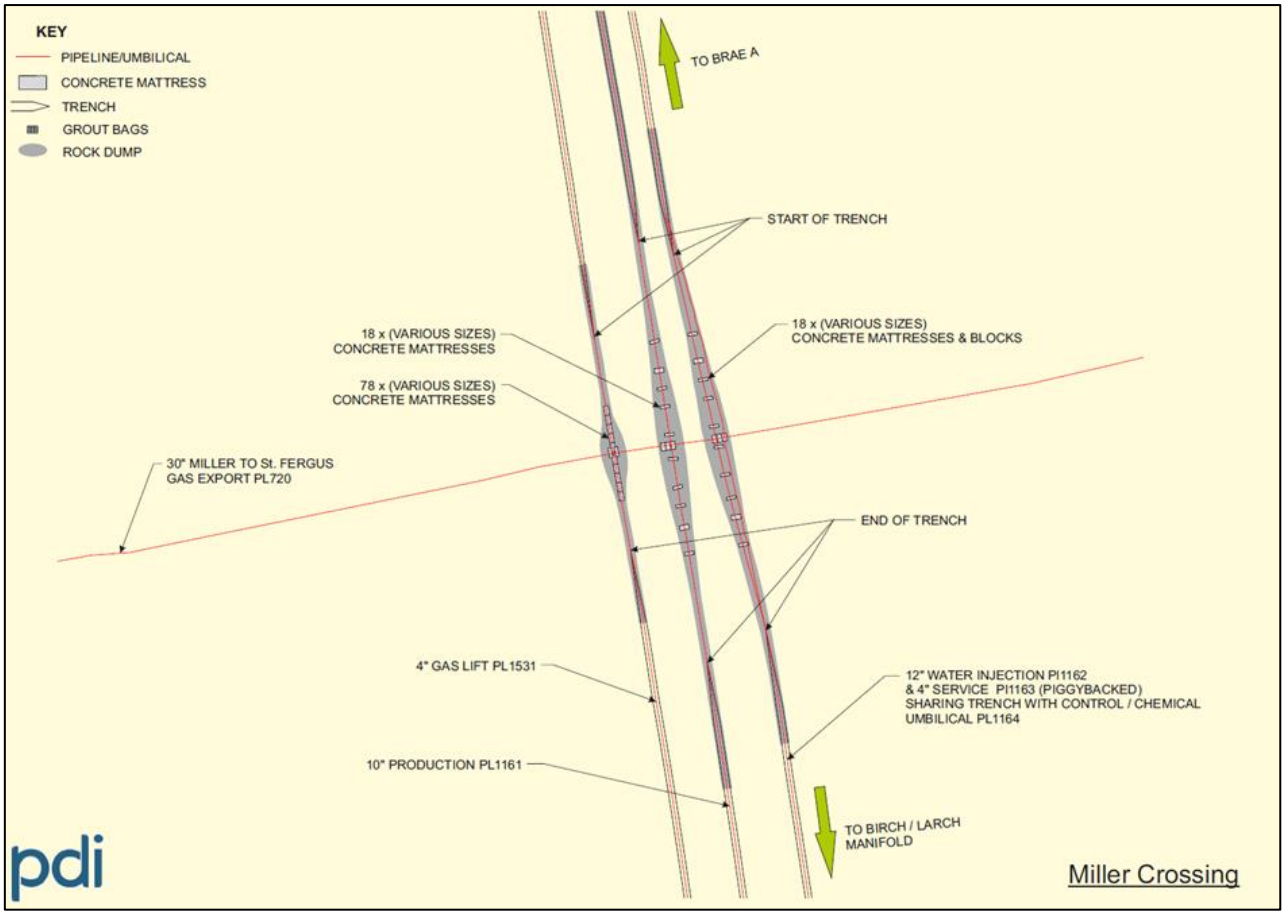

Figure A-1: Miller Crossing

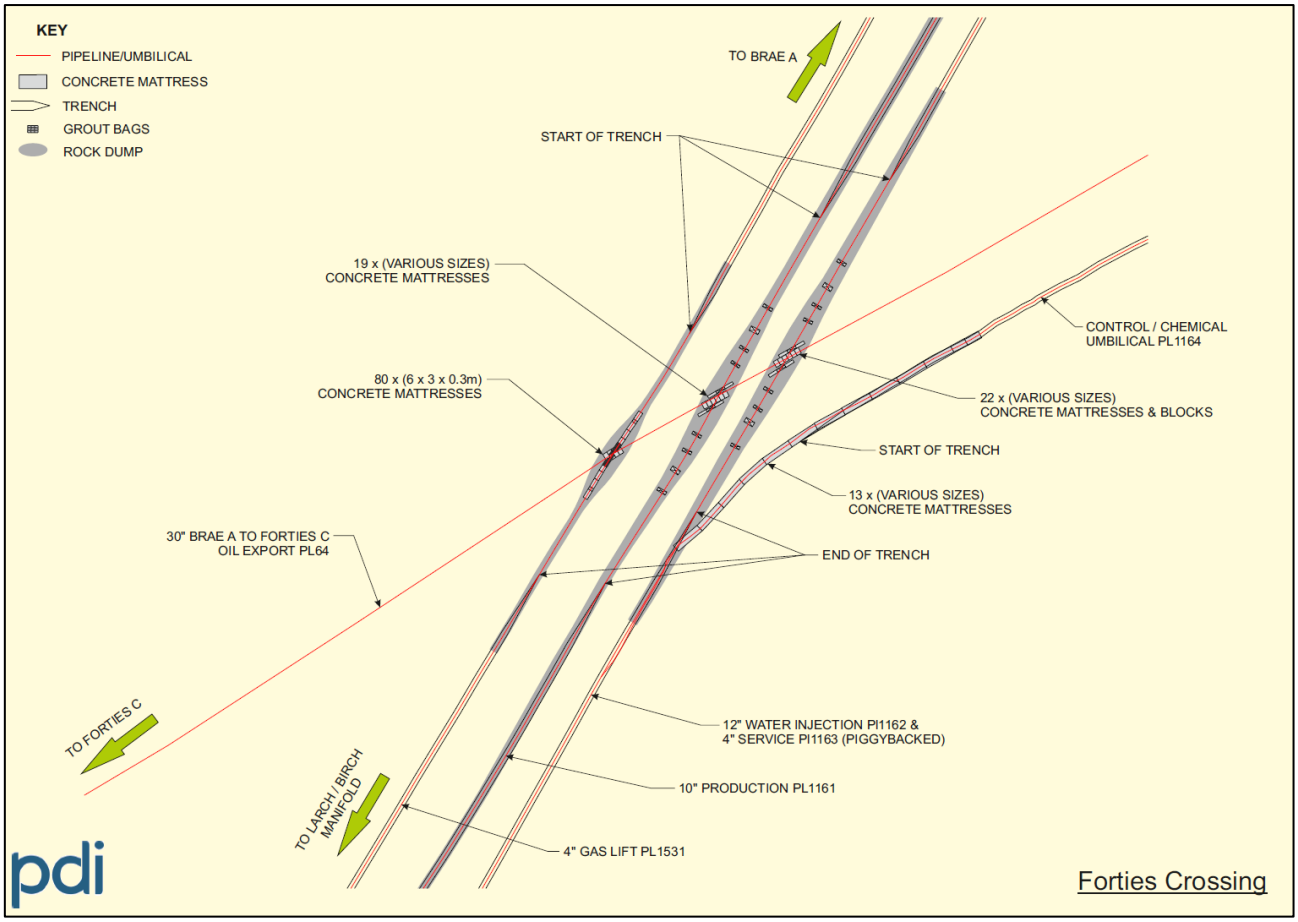

Figure A-2: Forties Crossing

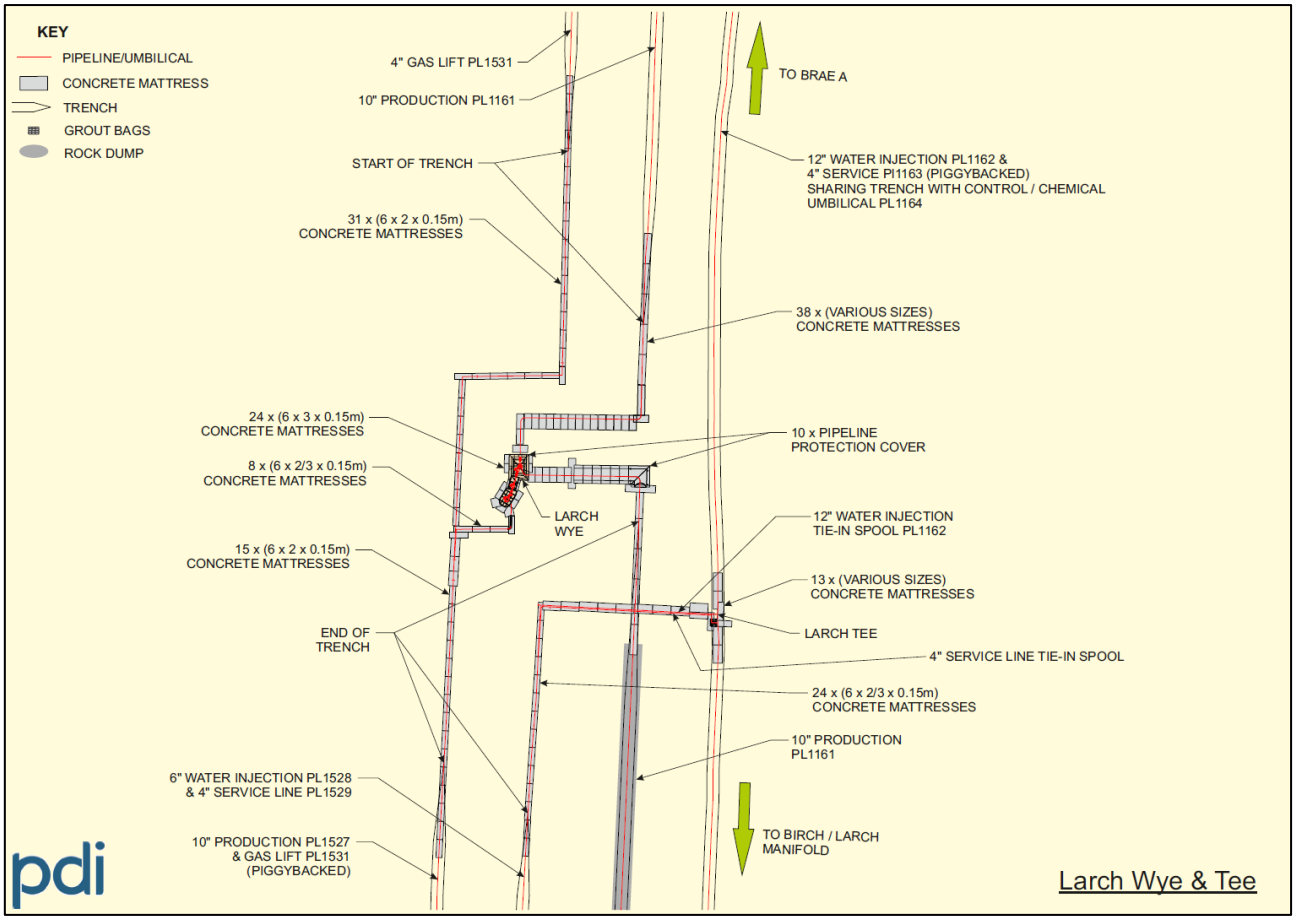

Figure A-3: Larch Wye Approaches

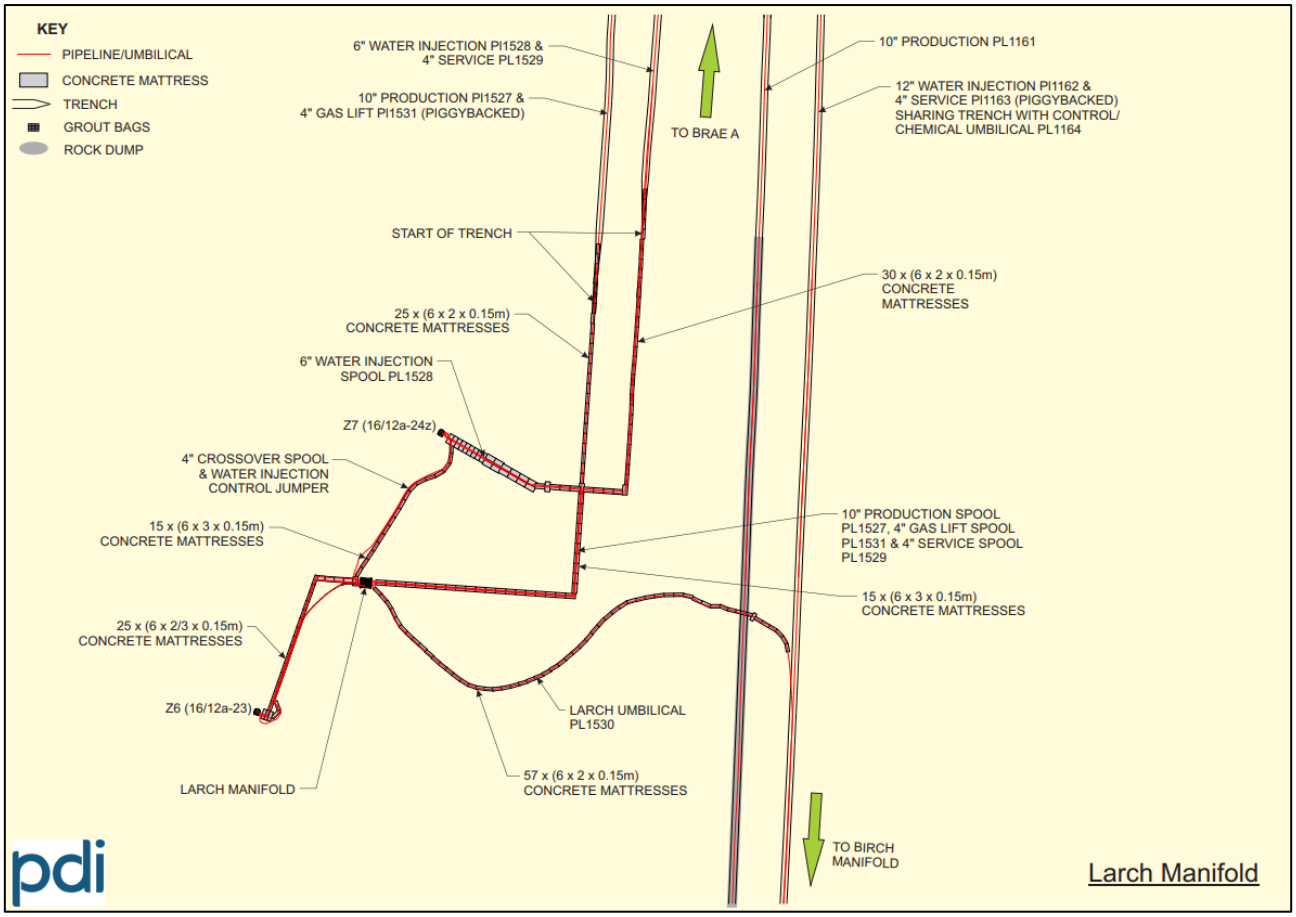

Figure A-4: Larch Gas Lift (& Production) Manifold & Wells

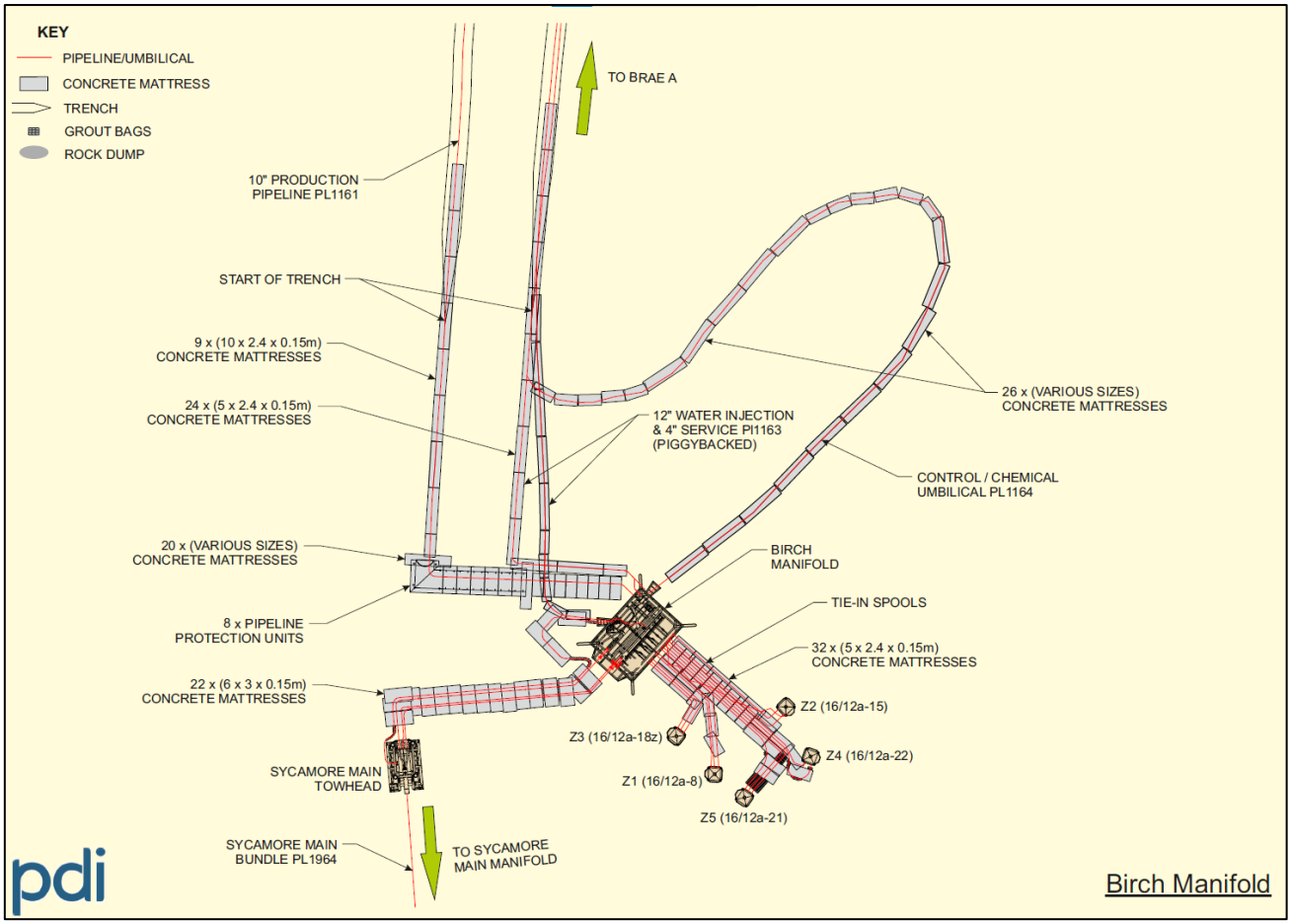

Figure A-5: Birch Manifold and Wells

APPENDIX B PIPELINE COMPARATIVE ASSESSMENT TABLES

Appendix B.1 Option 3 – Complete Removal – Recover in Sections

3. Complete Removal - Recover in Sections - Pipeline Decommissioning					
Id	Assessment Criteria	Severity / Consequence	Likelihood	Comparative Assessment Rating	Comments
1	Safety				
1.1	Project Risk to Personnel - Offshore	4 - Major	2 - Low	8	Extended offshore campaign with significant deck handling.
1.2	Project Risk to Other Users Of The Sea	4 - Major	1 – Very Low	4	Majority of the work carried out outside of 500mz.
1.3	Project Risk to Personnel - Onshore	4 - Major	2 - Low	8	Significant onshore handling of cut pipe sections.
1.4	Potential of a High Consequence Event	3 - Moderate	2 - Low	6	
1.5	Residual Risk to Other Users of the Sea	1 - Slight	1 – Very Low	1	All pipelines removed - no residual risk.
2	Environmental				
2.1	Impact of decommissioning activities - Spills, discharges to sea, disturbance to seabed, underwater noise.	3 - Moderate	3 - Medium	9	Significant seabed dredging activities to expose pipe.
2.2	Impacts of items left in-situ - Legacy impact	1 - Slight	1 – Very Low	1	All materials recovered.
2.3	Energy, Emissions, Resource Consumption	4 - Major	3 - Medium	12	Vessel operating on DP for extended offshore duration.
3	Technical				
3.1	Risk Of Major Project Failure	2 - Minor	3 - Medium	6	Rock berm displacement may be a challenge and a risk to the schedule if it is to be remediated.
3.2	Technological Challenge	2 - Minor	2 - Low	4	Proven concept using existing equipment. Slight increase in uncertainty due to larger scale.
4	Societal				
4.1	Commercial Impact On Fisheries	1 - Slight	2 - Low	2	Return of fishing grounds with no restrictions. Displaced rock berms increase uncertainties.
4.2	Socio-Economic Impact On Communities and Amenities	2 - Minor	2 - Low	4	Slight positive impact if a local waste management contractor is contractor.
5	Legacy				
5.1	Economical	1 - Slight	1 – Very Low	1	
6	Economic				
6.1	Cost	5 - Massive	3 - Medium	15	Extensive offshore vessel duration with multiple interim mobilisations. Uncertainties over NORM quantities and rock displacement / remediatin.
			Overall Rating:	5.79	

Table B-1: Pipeline Decommissioning Option 3 Comparative Assessment Table

Appendix B.2 Option 5 – Partial Removal – Trenched Sections and Exposed Ends

5. Partial Removal (trenched sections) - Recover in Sections - Pipeline Decommissioning					
Id	Assessment Criteria	Severity / Consequence	Likelihood	Comparative Assessment Rating	Comments
1	Safety				
1.1	Project Risk to Personnel - Offshore	4 - Major	2 - Low	8	Extended offshore campaign with signifcant deck handling.
1.2	Project Risk to Other Users Of The Sea	4 - Major	1 – Very Low	4	Majority of work carried out outside of 500mz.
1.3	Project Risk to Personnel - Onshore	4 - Major	2 - Low	8	Significant onshore handling of cut pipe sections.
1.4	Potential of a High Consequence Event	3 - Moderate	2 - Low	6	
1.5	Residual Risk to Other Users of the Sea	2 - Minor	3 - Medium	6	Potential snagging hazard if protection deteriorates or is removed. Increased uncertainty due to large number of cut ends to be remediated.
2	Environmental				
2.1	Impact of decommissioning activities - Spills, discharges to sea, disturbance to seabed, underwater noise.	3 - Moderate	2 - Low	6	Significant seabed excavation work to expose pipe.
2.2	Impacts of items left in-situ - Legacy impact	3 - Moderate	2 - Low	6	Majority of pipeline recovered. Significant lengths remain in-situ.
2.3	Energy, Emissions, Resource Consumption	3 - Moderate	3 - Medium	9	Single vessel operating on DP for extended offshore duration.
3	Technical				
3.1	Risk Of Major Project Failure	2 - Minor	2 - Low	4	Considered a standard operation for smaller scale cutting operations. Slight increase in uncertainty due to scaling up the activities.
3.2	Technological Challenge	2 - Minor	2 - Low	4	Proven concept using existing equipment. Slight increase in uncertainty due to larger scale.
4	Societal				
4.1	Commercial Impact On Fisheries	2 - Minor	3 - Medium	6	Temporary impact during extended offshore campaign to remove pipelines.Potential impact with mitigation required on cut ends.
4.2	Socio-Economic Impact On Communities and Amenities	2 - Minor	2 - Low	4	Slight positive impact if local waste disposal contractor is used.
5	Legacy				
5.1	Economical	3 - Moderate	2 - Low	6	
6	Economic				
6.1	Cost	4 - Major	3 - Medium	12	High cost due to extensive vessel campaigns. Some uncertainties remain around NORM quantities within recovered pipelines.
			Overall Rating:	6.36	

Table B-2: Pipeline Decommissioning Option 5 Comparative Assessment Table

Appendix B.3 Option 6 – Partial Removal – Recover Exposed Ends

6. Partial Removal - Recover Exposed Ends - Pipeline Decommissioning					
Id	Assessment Criteria	Severity / Consequence	Likelihood	Comparative Assessment Rating	Comments
1	Safety				
1.1	Project Risk to Personnel - Offshore	2 - Minor	2 - Low	4	Minimal deck handling.
1.2	Project Risk to Other Users Of The Sea	1 - Slight	2 - Low	2	All operations conducted within existing 500mz exclusion zones. Little / no additional vessel transits expected.
1.3	Project Risk to Personnel - Onshore	2 - Minor	2 - Low	4	Low volume of infrastructure returned for onshore disposal.
1.4	Potential of a High Consequence Event	1 - Slight	2 - Low	2	Standard operation. Short vessel campaign with no SIMOPS.
1.5	Residual Risk to Other Users of the Sea	2 - Minor	2 - Low	4	Potential snagging hazard only if protection deteriorates or is removed.
2	Environmental				
2.1	Impact of decommissioning activities - Spills, discharges to sea, disturbance to seabed, underwater noise.	2 - Minor	2 - Low	4	Minor seabed rectification required. Short vessel campaign.
2.2	Impacts of items left in-situ - Legacy impact	4 - Major	3 - Medium	12	Majority of materials left in situ. Robust flushing philosophy should provide assurance the pipelines are clean.
2.3	Energy, Emissions, Resource Consumption	2 - Minor	2 - Low	4	Single vessel operating on DP for relatively short duration.
3	Technical				
3.1	Risk Of Major Project Failure	1 - Slight	1 – Very Low	1	Standard operations considered low risk.
3.2	Technological Challenge	1 - Slight	1 – Very Low	1	Standard operation using existing equipment. Track record on other projects.
4	Societal				
4.1	Commercial Impact On Fisheries	2 - Minor	2 - Low	4	Potential impact with mitigation required. Interface with fishing industry required to ensure that they are well informed and understand mitigated actions. Spirit Energy to confirm type of fishing in area due to exposed sections within open trench.
4.2	Socio-Economic Impact On Communities and Amenities	3 - Moderate	2 - Low	6	Negligible positivie or negative impact.
5	Legacy				
5.1	Economical	3 - Moderate	2 - Low	6	
6	Economic				
6.1	Cost	1 - Slight	2 - Low	2	Short vessel campaign carrying low risk of significant cost escalation
			Overall Rating:	4.0	

Table B-3: Pipeline Decommissioning Option 6 Comparative Assessment Table

APPENDIX C COMPARATIVE ASSESSMENT MATRICES

Comparative Assessment Matrix

Project Name: Trees Decommissioning - Comparative Assessment Workshop

Client: Spirit Energy

Consequence		Increasing Likelihood / Uncertainty				
Value	Rating	1	2	3	4	5
		Very Low	Low	Medium	High	Very High
1	Minimal	1	2	3	4	5
2	Minor	2	4	6	8	10
3	Considerable	3	6	9	12	15
4	Major	4	8	12	16	20
5	Massive	5	10	15	20	25

Comparative Assessment Rating	
High	This is the highest rating and reflects either a high-risk activity, an activity that is still subject to a large number of uncertainties, or purely an activity/option that should be scored highest in comparison to the other options.
Medium	A Medium Risk activity reflects a medium risk activity when combining the risk with the likelihood or uncertainty. It may also be an activity that is determined to neither be in the High or Low rating in comparison to the other options.
Low	A Low Risk activity reflects a standard operation or activity that is performed regularly or has a well-defined methodology or low risk of occurrence.

Rating		Consequence
1	Slight	Refer to consequence matrix
2	Minor	
3	Moderate	
4	Major	
5	Massive	

Rating		Likelihood	Uncertainty
1	Very Low	Has never occurred in the industry.	Detailed definition and understanding of methodology, hazards and equipment. Very low level of uncertainty.
2	Low	Has previously occurred in the industry.	High level definition and understanding of methodology, hazards or equipment. Low level of uncertainty.
3	Medium	Has occurred in the organisation or might occur in life of site and/or more than once per year in the industry.	General definition and understanding of methodology, hazards or equipment. Moderate level of uncertainty.
4	High	Might occur several times in life of site.	Basic definition and understanding of methodology, hazards or equipment. High level of uncertainty.
5	Very High	Might happen once a year on site.	Limited definition and understanding of methodology, hazards or equipment. Very high level of uncertainty.

Consequence Matrix

Project Name: Trees Decommissioning - Comparative Assessment Workshop
Client: Spirit Energy

		Consequence				
		1	2	3	4	5
	ASSESSMENT CRITERIA	Slight	Minor	Moderate	Major	Massive
SAFETY	**1.0 SAFETY**					
	1.1 Project Risk to Personnel - Offshore	Slight injury or health effect i.e. (No major treatment required or first aid case). No preparatory activity to be completed prior to start of removal activity. No underdeck / overside working. No materials handling on deck or barge during removal. No diving activity.	Lost workday injury. Medium term health effect. Minimal preparatory activity to be completed prior to start of removal activity. Minimal underdeck / overside working. Minimal materials handling on deck or barge during removal. Minimal diving activities	Major injury or health effect i.e. (Lost workday case or restricted workday case, injury resulting in permanent partial disability or occupational illness with irreversible health effects resulting in permanent partial disability). Some preparatory activity to be completed prior to start of removal activity - but straight forward. Limited underdeck / overside working. Some materials handling activity on deck or barge during removal. Increased diving activity for short intervals	Single fatality or multiple major injuries with long term effects. Complex / non-standard preparatory activities prior to start of removal activity Significant undereck / overside working. Significant materials handling on deck during removal. Diving activities required for extended durations at various intervals.	Potential for multiple fatalities due to injury or occupational illness, injury which results in permanent total disability or occupational illness (including cancer) with irreversible health effects resulting in permanent disability. Extensive high level of preparatory activity to be completed prior to start of removal activity. Exctensive underdeck / overside working. Extensive multiple materials handling activity on deck or barge during removal . Extended diving activity throughout entire project phase .
	1.2 Project Risk to Other Users Of The Sea	Slight injury or health effect i.e. (No major treatment required or first aid case). All project activity within existing exclusion zone of facility. Little / no additional vessel transits to and from shore.	Lost workday injury. Medium term health effect. Most project activity within existing exclusion zone of facility. Few additional vessel transits to and from shore.	Major injury or health effect i.e. (Lost workday case or restricted workday case, injury resulting in permanent partial disability or occupational illness with irreversible health effects resulting in permanent partial disability). Some project activity outside existing exclusions zones but for short durations. Some additional vessel transits to and from shore of significant sized vessels. No complex transits.	Single fatality or multiple major injuries with long term effects. Some project activity outside existing exclusion zones for extended durations. Multiple transits to and from shore. No complex transits.	Potential for fatality / fatalities due to injury or occupational illness, injury which results in permanent total disability or occupational illness (including cancer) with irreversible health effects resulting in permanent disability. Extensive high level of preparatory activity to be completed prior to start of removal activity. Vast majority of project activity outside existing exclusions zones for most of project duration. Multiple transits to and from the shore - some complex transits to shore.
	1.3 Project Risk to Personnel - Onshore	Slight injury or health effect i.e. (No major treatment required or first aid case). No infrastructure returned as waste - no onshore disposal activities required. No contaminated materials to be returned.	Lost workday injury. Medium term health effect. Low volume of infrastructure returned as waste - cleaning and dismantling required onshore, minimal working at height. Little / no contaminated materials to be returned.	Major injury or health effect i.e. (Lost workday case or restricted workday case, injury resulting in permanent partial disability or occupational illness with irreversible health effects resulting in permanent partial disability.) Moderate volume of infrastructure returned as waste - cleaning and dismantling required with some working at height possible. Some contaminated materials may require processing.	Single fatality or multiple major injuries with long term effects. Significant volume of infrastructure returned as waste - cleaning and dismantling required with some working at height likely but not complex. Contaminated materials require processing.	Potential for fatality / fatalities due to injury or occupational illness, injury which results in permanent total disability or occupational illness (including cancer) with irreversible health effects resulting in permanent disability. Extensive high level of preparatory activity to be completed prior to start of removal activity. Large volume / significant sized or awkward shaped structures returned as waste - significant working at height required, significant and complex dismantling and materials and multiple handling activities required. Significant volumes of contaminated materials requiring processing.
	1.4 Potential of A High Consequence Event	Short vessel campaigns circa 2 weeks . No crew changes to vessels anticipated. No SIMOPS. Minor lifting operations. Very low potential for vessel damage during recovery operations.	Short vessel campaigns < 1 month . Low number of crew changes to vessels anticipated. Low vessel SIMOPS. Minor lifting operations. Low potential for vessel damage during recovery operations. Low quantity of infrastructure recovered to vessel.	Extended vessel campaigns 1 to 2 months. Crew changes possible. Increased vessel SIMOPS . Recovered infrastructure to vessels, moderate in size and number. Moderate potential for vessel damage during recovery operations.	Vessel campaigns 2 to 3 months . Crew changes likely. Vessel SIMOPS (2 - 3 vessels). Majority of infrastructure recovered to vessel. Routine and complex lifts required. Medium to high potential for vessel damage during recovery operations.	Prolonged vessel campaigns > 3 months Multiple crew changes required. High level vessel SIMOPS (more than 3 vessels working together). Major / complex lifting operations for infrastructure recovery to vessel resulting in high potential for vessel damage during recovery operations.
	1.5 Residual Risk to Other Users of the Sea	No additional risk.	Potential snagging hazard if protection deteriorates or is removed. Fishing gear can be freed if snagged.	Potential snagging hazard	Unmitigated snagging hazard - small items of infrastructure left in place. Loss of vessel fishing gear.	Large structures left in place, potential for multiple snagging events - potential fatality or permanent disability injury/illness. Potential loss of fishing vessel.
ENVIRONMENTAL	**2.0 ENVIRONMENTAL**					
	2.1 Impact of decommissioning activities - Spills, discharges to sea, disturbance to seabed, underwater noise.	Negligible effect. No vessel SIMOPS. Very low risk of loss of containment. No incremental discharge to sea anticipated. No significant disturbance to seabed anticipated. Small vessel size and numbers anticipated and activity leading to only minor increase in noise above existing baseline. Simple remediation or rehabilitation. No sensitive areas damaged.	Minor effect. Minor negative impact. Remediation or rehabilitation requiring limited time and local resources. Minor damage to sensitive areas. Change in habitats or species which can be measured but at same scale as natural variability. Minimal transboundary and cumulative effects.	Localised effect. Intermittent SIMOPS. Moderate Increased risk of loss of containment. Some planned discharges from flushing and cleaning activities, moderate risk of spills and discharges. Seabed disturbance resulting from removal operations. Limited number of vessels on DP, some intermittent noise associated with vessels and helicopters for duration of project. Remediation or rehabilitation possible with substantial time and in country resources. Localised and reversible damage to sensitive areas. Change in habitat or species beyond natural variability with recovery likely within 1-2 years following cessation of activities. Impact on status of locally important sites or species.	Major effect. Major negative impact. Remediation or rehabilitation requiring international resources with a limited probability of success. Extensive or persistent damage to sensitive areas. Degradation to the quality of habitats and species likely recovery within 2-10 years following cessation of activities. Transboundary effects expected with moderate contribution to cumulative effects.	Massive effect. Continuous SIMOPS for project duration, increased risk of vessel collisions. Higher increased risk of loss of containment. Potential for unplanned hydrocarbon or contaminated discharges. Increased corridor of seabed disturbance. Increased disturbance from cutting and lifting activities. Continuous noise from vessels (on DP) and helicopter activities. Large vessel size and noise above existing baseline. Remediation or rehabilitation options extremely limited or unavailable. Irreversible or chronic damage to sensitive areas. Potential for mortality or for injury within sensitive areas e.g. on a migration route or in area containing resident population.
	2.2 Impacts of items left in-situ - Legacy impact	All materials are recovered.	Nearly all materials are recovered. Materials remaining are clean and benign. Persistence of materials remaining is short. Nearly all materials are recovered (>90%) and returned to shore for recycling.	Most materials are recovered (>50%) and returned to shore for reuse. Persistence of materials remaining is limited.	Most materials are left in situ Good confidence of cleanliness of materials, although not guaranteeed. Persistence of materials remaining is tens of years	Nearly all materials are left in situ Significant uncertainties in the cleanliness of materials left on seabed. Persistence of materials remaining is tens to hundreds of years
	2.3 Energy, Emissions, Resource Consumption	Lowest CO2 emissions. Single vessel operating on DP for short duration or intermittently during project.	Single vessel operating on DP for duration of project.	Multiple vessels operating on DP for interminent durations.	Multiple vessels operating on DP for duration of the project.	Highest CO2 emissions. Multiple vessels operating on DP for extended duration.
TECHNICAL	**3.0 TECHNICAL**					
	3.1 Risk Of Major Project Failure	High level of confidence that schedule slippage can be accommodated within contingency and float in the plan. High level of confidence that cost increases can be accommodated by contingency/ UAP budget allocation. Slippage to schedule and growth in cost is anticipated is small. Assets and equipment are immediately available to facilitate recovery and stabilise the situation after an incident. Speed of recovery is anticipated to be swift. Methodology has a proven track record of executing the work scope. Limited impact on planned campaign schedule is anticipated, as remaining planned activities can continue in the interim.	Medium to high of confidence that schedule slippage can be accommodated within contingency and float in the plan. Slippage to schedule and growth in cost is anticipated is small. Assets and equipment are identified and available quickly to facilitate recovery and stabilise the situation after an incident. Speed of recovery is anticipated to be swift with few uncertainties work. Methodology has a track track record of successfully executing similar scopes.	Less confidence in cost and schedule, however, moderate level of delay and cost overrun is anticipated as worst case. Assets and equipment are available in a reasonable timeframe from onshore to stabilise the situation after an incident. Speed of recovery is anticipated to be longer due to some re-engineering of activities being required. Considerable impact on the planned campaign schedule is anticipated, as remaining planned activities cannot continue in the interim.	Technical uncertainties may lead to schedule delays and significant overrun of the offshore execution. On the job re-engineering required to mitigate unexpected hazards experienced during the offshore execution. Speed of recovery is relatively slow due to steep learning curve of unproven methodology or equipment.	Significant delays are possible if upsets occur pushing removals phase into a separate season and increased costs overrun possible. Re-engineering required to develop new procedures and identify assets and equipment to stabilise the situation after an incident. Speed of recovery is anticipated to be slow due to re-engineering and procurement of new equipment. Significant impact on the entire project schedule and company reputation. High risk of being unable to execute work via the base case methodology.
	3.2 Technological Challenge	Standard Operations. Existing, proven equipment used for specific task for which it was designed. General operations relying only on ability to launch ROVs / Vessel Crane / station keeping.	Existing, proven equipment used for specific task for which it was designed. General operations relying only on ability to launch ROVs / Vessel Crane / station keeping. Track record of previous work on a smaller scale.	Regular Construction task requiring detailed procedures. Existing proven equipment used for new application. Requires specific weather window for small number of tasks.	Complex Construction task requiring detailed procedures and some bespoke engineering studies / R&D. Existing equipment available but requires significant modification to the task. Some technical uncertainties but considered feasible, subject to engineering challenges.	No (or limited) industry experience of operation. Technology research and development required to perform task. Requires specific weather window for prolonged period. High level of technical uncertainty / feasibility not known.
SOCIETAL	**4.0 SOCIETAL**					
	4.1 Commercial Impact On Fisheries	No impact on the fishing industry. Return of fishing grounds with no restrictions.	Potential impact with mitigation required. Interface with fishing industry required to ensure that they are well informed and understand mitigated actions.	Potential impact on area with low fishing activity. Area to be charted and marked. No effect on employment.	Significant impact on fishing with long term fishing restrictions in place affecting moderate activity fishing area with potential loss of employment.	Major impact on fishing industry with key fishing grounds affected long term and resulting in loss of employment.
	4.2 Socio-Economic Impact On Communities and Amenities	Very Positive. Local infrastructure extensively upgraded.	Positive. Financial contribution to local amenities.	None. No impact on local amenities.	Negative . Disruption to local services / amenities.	Very Negative. Pollution of near shore or beaches.
LEGACY	**5.0 LEGACY**					
	5.1 Ongoing Liabilities	No ongoing liability - all infrastructure removed and seabed returned to original state.	Single survey required after completion of project.	Survey inspection at increasing intervals	Survey inspection at increasing intervals. Annual technology reviews.	Annual surveys and ongoing remedial work. Regular technological reviews and R&D.
ECONOMIC	**6.0 ECONOMIC**					
	6.1 Cost	Lowest cost	Low - medium cost	Medium cost	Medium - high cost	Highest cost