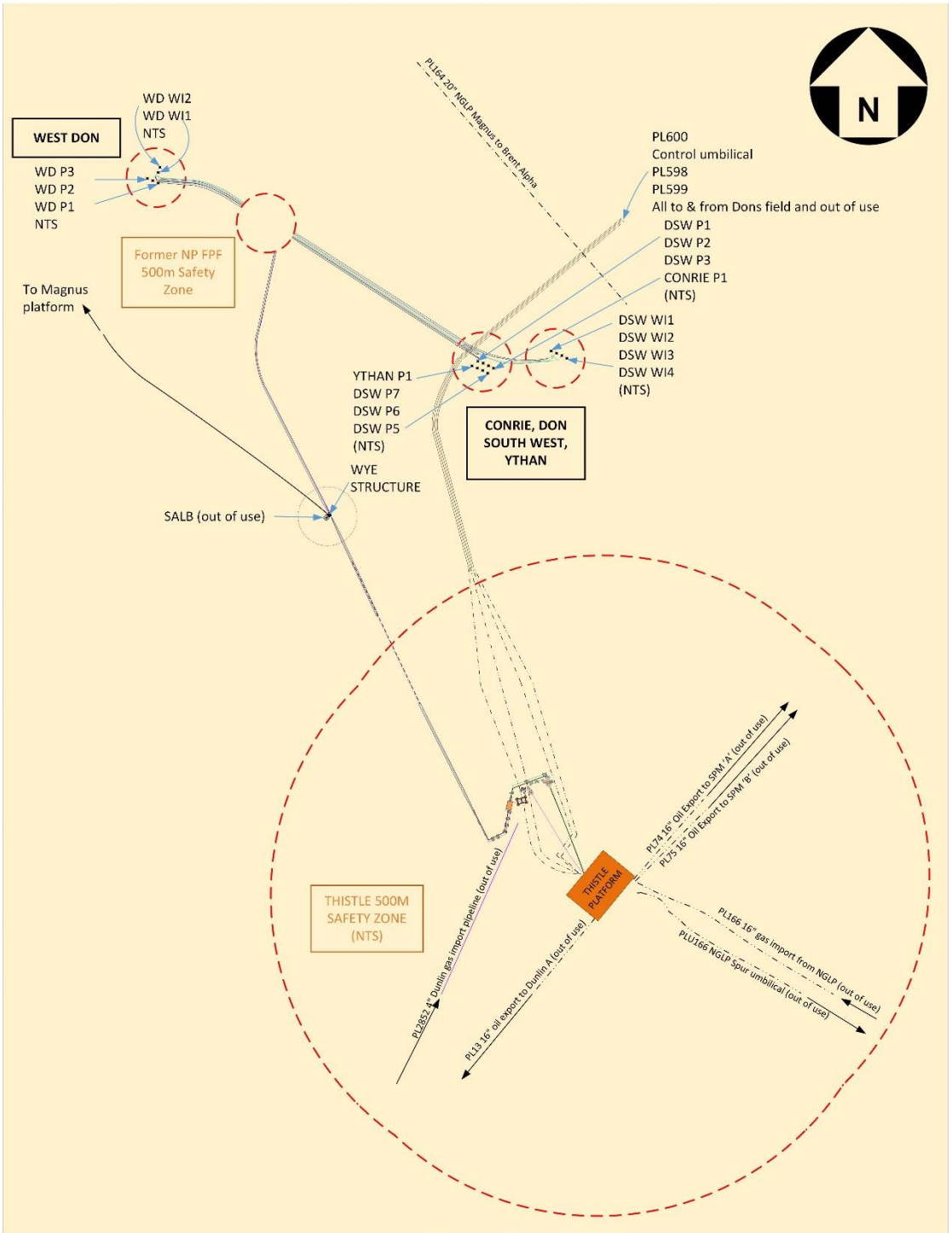
Don South West and West Don Pipeline Decommissioning Comparative Assessment



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FIGURES AND TABLES

ABBREVIATION	EXPLANATION
~	Approximately
3LPP	3-Layer Polypropylene, coating used for carbon steel pipelines and pipework
ALARP	As Low As Reasonably Practicable
Approach	Initial or final stretch of pipeline (or umbilical) as it leaves its point of origin or reaches its destination
CSV	Construction Support Vessel
Cut and lift	The 'cut and lift' method of removing trenched and buried pipelines would involve excavating the pipelines from within the seabed and thereafter cutting the pipeline into recoverable and transportable lengths. This method of removal can be very time-consuming for long pipelines and, would be problematic for concrete coated pipelines. The method is usually only viable for short pipelines
DOL	Depth of Lowering (bottom of pipe in trench)
DP	Decommissioning Programme(s)
DSW	Don South West
DUTU	Dynamic Umbilical Termination Unit
EA	Environmental Appraisal
EnQuest	EnQuest Heather Limited
ESDV	Emergency Shutdown Valve
Exposure	An exposure occurs when the 'crown' of a pipeline or umbilical can be seen. This does not generally mean it is a hazard
FishSAFE	The FishSAFE database contains a host of oil & gas structures, pipelines, and potential fishing hazards. This includes information and changes as the data are reported for pipelines and cables, suspended wellheads pipeline spans, surface & subsurface structures, safety zones & pipeline gates (www.fishsafe.eu)
FPF	(Northern Producer) Floating Production Facility
HSEQ	Health, Safety, Environment, Quality
ID	Identity (as in tabulated feature)
", in	Inch; 25.4 millimetres
J-Lay	Method used for installing pipelines whereby pipe stalks with a length up to 6 joints are upended and welded to the seagoing pipe in a near vertical ramp. The ramp angle is chosen in such a way that it is in line with the catenary of the pipe to the seabed
km	Kilometre
LAT	Lowest Astronomical Tide
m	Metre(s)
MSB	Mean Seabed
N,S,E,W	North, South, East, West
n/a	Not Applicable
N/A	(Data) Not Available
NFFO	National Federation of Fishermen's Organisations
NIFPO	Northern Ireland Fish Producers Organisation Ltd
NOF	Northern Offshore Limited
NORM	Naturally Occurring Radioactive Material
NP	Northern Producer
OD	Outside Diameter (of pipe)
OGUK	Oil & Gas UK
OPRED	Offshore Petroleum Regulator for Environment and Decommissioning
Order of Magnitude	Size difference by factor of 10: one (10^1) means 10-times, two (10^2) means 100-times difference
Piggybacked	Clamped or connected to another pipeline along its length
Pipeline	Pipeline or umbilical
P1, P2, WI1	Production (P) or Water Injection (WI) Tree Identifier
PL, PLU	Pipeline, Umbilical Identification numbers (UK)
Post-trenching	Post-trenching involves cutting, ploughing or jetting a trench underneath the pipeline, such that it is lowered into the seabed.
PWA	Pipeline Works Authorisation

ABBREVIATION	EXPLANATION
Q1, Q2, Q3, Q4	Quarter 1, Quarter 2, Quarter 3, or Quarter 4 of any given year
Qualitative	Result determined using judgement and use of risk and impact matrices
Quantitative	Result determined using numerical data and by calculation
RBS	Riser Base Structure
Remediation	For the purposes of this document remediation can mean one of, or a combination of the following: post-trenching, removal of exposures and spans, deposition of additional rock
Reportable span	A reportable span is a significant span which meets set criteria (FishSAFE criteria) of height above the seabed and span length
Reel lay	Using the reel-lay method a flexible pipeline or small diameter rigid pipeline is installed from a large reel mounted on a pipelay barge. A pipe is spooled from a drum (reel) straightened with tension applied and laid over a ramp to the seabed
ROV	Remotely Operated Vehicle
ROVSV	Remotely Operated Vehicle Support Vessel
S-lay	A pipelay method whereby sections of pipe are welded together on a horizontal deck, their transition down to seabed taking the form of an elongated “S”
SAC	Special Area of Conservation
SDU	Subsea Distribution Unit
SFF	Scottish Fishermen’s Federation
Span	Similar to an exposure except that the whole of the section of pipeline is visible above the seabed rather than just part of it. Once the height and length dimensions meet or exceed certain criteria the spam becomes a reportable span
SSIV	Subsea Isolation Valve
SUTU	Subsea Umbilical Termination Unit
TOP	Top of Pipe
UK	United Kingdom
UKCS	United Kingdom Continental Shelf
Umbilical	Flexible pipeline manufactured of various materials including steel and plastics typically used to send electrical power, communication signals, chemicals and hydraulic fluid to a manifold or wellhead. An umbilical will include cables and tubes that are covered with an outer sheath to protect them from damage
UNO	Unless Notified Otherwise
WD	West Don
WGS84	World Geodetic System 1984
WI	Water Injection
WS	Wye Structure
x	Number of (e.g. 16x = 16 in Number)

ASSESSMENT	DESCRIPTION
Broadly Acceptable / Low & least preferred[1]	Risks broadly acceptable but controls shall be subject to continuous improvement through the implementation of the HSEQ Management System and considering changes such as technology improvements; performance in other 'broadly acceptable' options marginally better.
Broadly Acceptable / Low & in-between least & most preferred[1]	As above, but performance of this option is marginally better or marginally worse than others.
Broadly Acceptable / Low & most preferred[1]	As above but performance in other 'broadly acceptable' options marginally worse.
Tolerable / Medium Non-preferred[1]	Risks are tolerable and managed to ALARP. Controls and measures to reduce risks to ALARP require identification, documentation, and approval by responsible leader.
Intolerable / High[1] not acceptable	Impacts are intolerable. Controls and measures to reduce impact to ALARP (at least to Medium) and require identification, documentation, implementation, and approval.
	Recommended decommissioning option as indicated in the Executive Summary.
	Decommissioning option considered but not recommended as indicated in the Executive Summary.

[1] The colour of this highlighted cell is used in the assessment tables – please refer Appendix C and Appendix D.

1. EXECUTIVE SUMMARY

A Comparative Assessment of the pipelines is a key consideration within the Decommissioning Programmes submitted to the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED). This report has been written on the assumption that the Northern Produced has departed the field.

The West Don, Don South West, Conrie and Ythan Fields are situated within Blocks 211/13b, 211/18a and 211/18e of the Northern North Sea sector of the United Kingdom Continental Shelf. They used to be tied back to the Northern Producer Floating Production Facility (FPF). The FPF used to be moored ~2.5km from West Don and ~4.5km from Don South West.

A Rise Base Manifold Structure (RBS) used to be installed on the seabed with rigid pipe spools connecting the inter-field pipelines to the RBS.

Produced crude oil from the Fields was initially exported to the Northern Producer Floating Production Facility (FPF) and onwards via PL2578, an 8in export pipeline to a submerged single anchor loading buoy to facilitate shuttle tanker loading. Latterly, crude oil was exported via the same pipeline (PL2578) to a Wye connection commingling oil exported from the Northern Producer with oil exported from Thistle Alpha for export to the Magnus platform using PL4556.

Processed gas used to be imported from Thistle Alpha using a 3in pipeline (PL2579) routed between the RBS and Thistle Alpha.

Don South West, Conrie and Ythan

Don South West comprises two drill centres. Six production wells P1, P2, P3, P5, P6 and P7 and four water injection wells, WI1, WI2, WI3 and WI4. The Conrie and Ythan production wells are connected to the Don South West infrastructure and use the same export routes as DSW.

Produced fluids from DSW were routed via PL2572, an 8in oil production pipeline, piggybacked by PL2573, a 3in gas lift pipeline both using individual pipespools at each Xmas tree. The Northern Producer provided water injection to the DSW water injection wells using PL2581, an 8in pipeline, before integrity issues rendered this pipeline redundant. It was replaced by PL4262, an 8in pipeline with individual pipespools branching off to each tree.

Chemicals and hydraulic power were provided to the DSW production wells using PLU2576, an umbilical while hydraulic power was provided to the water injection wellheads using PLU2577. Both umbilicals were routed to the local distribution unit before being connected to each tree using individual jumpers.

Conrie and Ythan effectively comprise part of the DSW infrastructure but are connected using their own dedicated pipelines and umbilical jumpers. They are not material to this comparative assessment as they are surface laid and will be fully recovered.

For the majority of their lengths,PLU2577 and PL2581 are trenched and buried in the seabed while PL2572 & PL2573, PLU2576, PL2583 & PL2584 and PL4262 are mostly buried under deposited rock. All the pipelines cross over the disused Don field pipelines PL598, PL599, PL600 and the control umbilical.

West Don

West Don comprises one drill centre with three production wells P1, P2, P3 and two water injection wells, WI1 and WI2. Gas used to be exported from West Don to the Northern Producer via the RBS using an 8in gas pipeline, PL2583. This pipeline is piggybacked by a 3in gas lift pipeline, PL2584. The Northern Producer used to provide water injection to the WD water injection wells using an 8in pipeline PL2582 before integrity issues necessitated its replacement. It was replaced by PL4261, an 8in pipeline with individual pipespools branching off to each tree.

Chemicals and hydraulic power were provided to the WD production wells using PLU2585 with the same umbilical providing just hydraulic power to the water injection wells. PLU2585 was routed to the

local distribution unit before being provided to each tree using individual jumpers.

For the majority of their lengths PL2582 and PLU2585 are trenched and buried in the seabed while PL2583, PL2584 and PL4261 are mostly buried under deposited rock.

Pipeline Burial Status

This document summarises a comparative assessment of the most feasible options for decommissioning the following pipelines:

- Combined Don South West and West Don pipelines PL2578, PL2579;
- Don South West pipelines PL2572 (part, excluding Conrie pipespools), PL2573, PL2581, PLU2576, PLU2577, and PL4262;
- West Don pipelines PL2582, PL2583, PL2584, PLU2585 and PL4261.

Three decommissioning options are considered for the pipelines:

- **Complete removal** – This involves the complete removal of the pipelines by whatever means would be most practicable and acceptable from a technical perspective;
- **Partial removal** – This will involve removing exposed or potentially unstable sections of pipelines. Necessary remedial work would be carried out to make the remaining pipeline safe for leaving the remainder *in situ*;
- **Leave *in situ*** – This involves leaving the pipeline(s) *in situ* with no remedial works, but possibly needing to verify their status via future surveys.

The method for decommissioning of surface laid sections of pipelines and pipeline approaches is the same irrespective of which option is pursued. Therefore, decommissioning of these parts of the pipelines are not included in the assessment. All options include removal of features such as pipespools, surface laid pipelines, jumpers, concrete mattresses, and grout bags in accordance with mandatory requirements.

Comparative assessment

The options were assessed using the OPRED Decommissioning guidance notes. During the assessment process, evaluations were made principally on a qualitative basis using the EnQuest established corporate risk assessment tables. The following components were assessed from a short-term (project) and longer-term (legacy) perspective:

- Technical;
- Safety;
- Environmental;
- Societal;
- Cost.

For the purposes of the assessment the pipelines were assessed in one of three groups that reflect the type and burial status of the pipelines.

Pipeline decommissioning assessment

The results of the assessment concluded that the technical risks associated with complete removal and partial removal were non-preferred compared to the leave *in situ*. This is primarily due to there being limited experience in removing trenched and buried pipelines, especially if they are piggybacked.

From an environmental perspective, lower risks and impacts would be incurred for the leave in situ option than for either the complete removal or partial removal options.

From a safety perspective the risk to offshore and onshore personnel will increase with the amount of materials being handled and transported. Therefore, complete removal would present more of a risk to offshore and onshore project personnel, although there would probably be little to differentiate

partial removal and complete removal due to the piece-meal nature of the partial removal activities.

For other users of the sea, complete removal would be preferred as no potential residual snagging hazards would remain. Where considered, partial removal would be the least preferred as there would be more pipeline ends to contend with. Exposures and short spans would be preferable to the potential for pipeline ends being exposed even if they had been remediated, and so on this basis the partial removal option would be non-preferred. It is also noted that the level of commercial fishing activity in the area is currently low. Therefore, unless the pipelines are completely removed the leave *in situ* would be the preferred option.

Should removal operations be non –preferred, there remains the possibility of depositing rock over existing exposures or spans. While this operation is technically feasible and could be carried out without incident, this approach would have the disadvantage of requiring new material, and of introducing additional hard strata onto the seabed, although the additional area of seabed impacted be expected to be small, as most of the additional rock would be deposited in areas where rock was used to bury the pipelines when they were originally installed. If we assume a 10m corridor of additional rock, the total area of seabed affected in this way would measure up to ~0.081km2.for the combined lengths of PLU2576, PLU2577 & PL2581 and PLU2585 & PL2582.

The societal assessments showed that complete removal would be marginally beneficial because of the continuation of employment due extension of vessel use and onshore waste management activities, although in the short-term fishing activities might proportionally be disrupted as decommissioning activities increase. Conversely, fishing activities could be affected by legacy pipeline surveys that would be required for both the partial removal and leave *in situ* options.

The final differentiator is cost which is implemented should there be little to differentiate the options. Cost is related to the amount of material being recovered and dealt with both offshore and onshore. The leave *in situ* option would cost the least to implement in the short-term, while over the longer term both the partial removal (where applicable) and leave *in situ* options would probably require at least two pipeline surveys to be carried out.

In most instances the cost of removal can be expected to be an order of magnitude (i.e. 10x) greater than leave *in situ*.

PLU2576 & PLU2577 were laid in the same trench as PL2581, and PLU2585 was laid in the same trench as PL2582. This could mean that removal of one or the other – either the umbilical or the adjacent pipeline, would likely result in a disruption to the other lying nearby. This means that the complete removal option would need to apply to none or all of the pipelines and umbilicals in any one trench. The situation would be similar for the removal of just part of a pipeline or umbilical; another lying nearby in the same trench would also likely be disrupted. Should only one or other pipeline or umbilical be removed from a trench it can be expected that remedial work such as deposition of additional rock, would need to follow.

Due to the disruption that would be caused by removing just one of the adjacent pipelines and umbilicals in a trench, the by difference costs were combined for all of the pipelines and umbilicals in this group. For this situation, the complete removal option cost by difference would be an order of magnitude greater than leave *in situ*. Partial removal would also be an order of magnitude greater than leave *in situ*. Although not calculated, by inspection it can be expected that the deposition of rock would cost significantly less than partial removal.

Summary of decommissioning proposals

The results of the comparative assessment are such that it is proposed that all trenched and buried pipelines will be left *in situ* along with those concrete mattresses buried under deposited rock. On the approaches at each end of burial the buried pipelines will be cut either within the trench in the case of seabed burial or where the pipelines exit or enter deposited rock and only the exposed sections will be removed. The intention is that all exposed mattresses and grout bags will also be removed.

The pipeline crossings over the Don pipelines that are out of use will be left undisturbed. Decommissioning of the various pipeline components is summarised below:

Combined Don South West and West Don pipelines

Decommissioning of the PL2578 and PL2579 pipeline components is summarised below:

PL2578 8in oil export pipeline, ~5.5km long piggybacked by PL2579 3in gas import pipeline ~15.7km long	Leave *in situ*	Partial removal	Complete removal
PL2578 composite flexible riser and associated expansion spools, ~451m long overall & PL2579 dynamic flexible riser and associated expansion spools on approach to & including RBS, ~453m long overall. Complete removal as part of Phase 1.	n/a	n/a	
PL2578 piggybacked by PL2579, 5,086m long carbon steel flowlines, leave *in situ* except for surface laid ends outside of trench and not buried – these will be removed.		n/a	
PL2579. Surface laid pipespool sections by passing the Wye Structure, ~45m long. Complete removal.		n/a	
PL2578 terminates at the Wye Structure and continues as PL4555 to Thistle Alpha. PL2579 (piggybacked to PL4555 which is outside scope), 10,160m long, leave *in situ* except for surface laid ends outside or trench and not buried – these will be removed.		n/a	
PL2579 Expansion spools near SSIVs and flexible riser at Thistle Alpha, ~337m long		n/a	

Don South West pipelines

Decommissioning of the PL2572, PL2573, PL2581, PL4262, PLU2576 and PLU2577 pipeline components is summarised below:

PL2572 (excl. Conrie pipespools) 8in oil production pipeline piggybacked by PL2573 3in gas injection pipeline, ~4.9km long	Leave *in situ*	Partial removal	Complete removal
PL2572 composite flexible riser and associated expansion spools, ~463m long overall & PL2573 dynamic flexible riser and associated expansion spools on approach to & including RBS, ~473m long overall. Complete removal as part of Phase 1.		n/a	
PL2572 piggybacked by PL2573, 4,027m long carbon steel flowlines between pipespools at the ends, leave *in situ* except for surface laid ends outside of trench and not buried – these will be removed.		n/a	
PL2572 surface laid duplex and carbon steel expansion spools and gate valves, ~314m long on approach to DSW production wellheads, PL2573 surface laid carbon steel expansion spools & gate valves ~350m long on approach to DSW production wellheads. Complete removal.		n/a	

PL2581 8in water injection pipeline, ~5.3km long	Leave *in situ*	Partial removal	Complete removal
PL2581 5,237m long carbon steel pipeline, between expansion spools at pipeline ends, leave *in situ* except for surface laid ends outside of trench and not buried – these will be removed.			
PL2581 surface laid expansion spools, ~27m long on approach to Xmas trees will be completely removed. Additional wet stored end pipespools will be completely removed.		n/a	

PL4262 8in water injection pipeline, ~5.7km long	Leave *in situ*	Partial removal	Complete removal
PL4262 carbon steel pipespools, ~9m long within RBS. Complete removal as part of Phase 1.		n/a	
PL4262 5,550m long flexible pipeline between RBS and DSW WI1, leave *in situ* except for surface laid ends outside of trench and not buried – these will be removed.		n/a	
PL4262 surface laid expansion spools, ~109m long on approach to WI wellheads will be completely removed.		n/a	

PLU2576 chemical and hydraulic fluid umbilical c/w umbilical jumpers at ends, ~4.2km long	Leave *in situ*	Partial removal	Complete removal
PLU2576 8x static umbilical jumpers between DUTU and SUTU at RBS, ~10m long. Complete removal as part of Phase 1.		n/a	
PLU2576, static umbilical between SUTU at RBS and SUTU at DSW SDU, ~4,162m long, leave *in situ* except for surface laid ends outside of trench and not buried - these will be removed. Monitor exposures and non-reportable spans.		n/a	
PLU2576 8x static umbilical jumpers between SUTU at DSU at DSW DSU, ~10m long. Completely removed along with DSU at DSW.		n/a	

PLU2577 Hydraulic fluid umbilical, ~1.3km long	Leave *in situ*	Partial removal	Complete removal
PLU2577, static umbilical between DSW SDU and DSW WI1 wellhead, ~1,312m long, leave *in situ* except for relatively short surface laid ends outside of trench and not buried - these will be removed. Remove the umbilical up to KP0.070 to include the anomaly at KP0.055. Monitor exposures.		Remove up to ~KP0.070	

West Don pipelines

Decommissioning of the PL2582, PL2583, PL2584, PL4261, and PLU2585 pipeline components is summarised below:

PL2582 8in water injection pipeline, ~2.4km long	Leave *in situ*	Partial removal	Complete removal
PL2582 carbon steel pipespools, ~61m long. Complete removal as part of Phase 1.		n/a	
PL2582 2,274m long carbon steel pipeline between RBS and WD WI pipeline flange, leave *in situ* except for relatively short surface laid ends outside of trench and not buried – these will be removed. Monitor exposures and non-reportable spans.			
PL2582 surface laid expansion spools, ~27m long on approach to WD production Xmas trees will be completely removed. Additional wet stored end pipespools will be completely removed.		n/a	

PL2583 8in oil production pipeline piggybacked by PL2584 3in gas injection pipeline, ~2.9km long	Leave *in situ*	Partial removal	Complete removal
PL2583 composite flexible riser and associated expansion spools, ~445m long overall & PL2584 dynamic flexible riser and associated expansion spools on approach to & including RBS, ~444m long overall. Complete removal as part of Phase 1.		n/a	
PL2583 piggybacked by PL2584, 2,300m long carbon steel flowlines between pipespools at the ends, leave *in situ* except for surface laid ends outside of trench and not buried – these will be removed.		n/a	
PL2583 surface laid duplex and carbon steel expansion spools and gate valves, ~141m long on approach to WD production P3 wellhead, PL2584 surface laid carbon steel expansion spools & gate valves ~145m long between production P1 and P3 wellheads. Complete removal.		n/a	

PL4261 8in water injection pipeline, ~2.9km long	Leave *in situ*	Partial removal	Complete removal
PL4261 carbon steel pipespools, ~8m long within RBS. Complete removal as part of Phase 1.		n/a	
PL4261 2,842m long flexible pipeline between RBS and WD WI2, leave *in situ* except for surface laid ends outside of trench and not buried – these will be removed.		n/a	
PL4261 surface laid expansion spools, ~81m long on approach to WI wellheads will be completely removed.		n/a	

PLU2585 chemical and hydraulic fluid umbilical, ~2.6km long	Leave *in situ*	Partial removal	Complete removal
PLU2585 8x static umbilical jumpers between DUTU and SUTU at RBS, ~10m long. Complete removal as part of Phase 1.		n/a	
PLU2585, static umbilical between SUTU at RBS and SUTU at WD SDU, ~2,600m long, leave *in situ* except for surface laid ends outside of trench and not buried - these will be removed. Monitor exposures and non-reportable spans.			
PLU2585 8x static umbilical jumpers between SUTU at DSU at WD DSU, ~10m long. Completely removed along with DSU at WD.		n/a	

2. INTRODUCTION

2.1 Overview

Please note that this report has been written on the assumption that the Northern Producer has departed the field.

The Don South West, Conrie Ythan and West Don fields are situated within Blocks 211/13b, 211/18a, and 211/18e of the Northern North Sea sector of the United Kingdom Continental Shelf and operated by EnQuest Heather Limited. These fields are located approximately 527km north-north-east of Aberdeen in water depths between ~172m and ~178m. The export route for these fields used to be via the Northern Producer Floating Production Facility, but this has now departed. The associated risers and pipelines in and around the 500m safety zone have been disconnected and removed.

The Don South West development comprises:

- Six subsea production wells;
- Four water injection wells;
- The Don South West Subsea Distribution Unit (SDU);
- Flexible flowlines (production, gas lift, and water injection pipelines, and chemical and hydraulic control umbilicals)

The Conrie development comprises:

- One production well, daisy-chained to the Don South West infrastructure;
- Production, gas lift, water injection tie-in pipespools, chemical and electrical control umbilical jumpers.

The Ythan development comprises:

- One production well, daisy-chained to the Don South West infrastructure;
- Production, gas lift, water injection tie-in pipespools, chemical and electrical control umbilical jumpers.

The West Don development comprises:

- Three subsea production wells;
- Two water injection wells;
- The West Don Subsea Distribution Unit (SDU);
- Flexible flowlines (production, gas lift, and water injection pipelines, and chemical and hydraulic control umbilicals).

2.1.1 Don South West and West Don Pipelines

Produced crude oil from the Fields was initially exported to the Northern Producer Floating Production Facility (FPF) and onwards via PL2578, an 8in export pipeline to a submerged single anchor loading buoy to facilitate shuttle tanker loading. Latterly crude oil was exported via the same pipeline (PL2578) to a Wye connection commingling oil exported from the Northern Producer with oil exported from Thistle Alpha for export to the Magnus platform using PL4556.

Processed gas used to be imported from Thistle Alpha using a 3in pipeline (PL2579) routed between the RBS and Thistle Alpha.

Pipeline ID	Phase 1 Removed	Original Description, Size & Quantity
PL2578	~5m	8in production flowline, 5,086m long, excluding pipespools
PL2579	~5m	3in gas export pipeline, 15,220m long including 45m bypass pipespool at Wye structure

NOTES
1. During Phase 1 the 500m zone was cleared - parts of the pipelines were removed;
2. For details of pipeline stabilisation features please refer Decommissioning Programmes.

Table 2.1.1: Combined DSW & WD Pipeline Description

2.1.2 Don South West Pipelines

Produced fluids from DSW was routed via PL2572, an 8in oil production pipeline, piggybacked by PL2573, a 3in gas lift pipeline both using individual pipespools at each Xmas tree. The Northern Producer provided water injection to the DSW water injection wells using PL2581, an 8in pipeline, before integrity issues rendered this pipeline redundant. It was replaced by PL4262, an 8in flexible flowline with individual pipespools branching off to each tree.

Chemicals and hydraulic power were provided to the DSW production wells using PLU2576, an umbilical while hydraulic power was provided to the water injection wellheads using PLU2577. Both umbilicals were routed to the local distribution unit before being connected to each tree using individual jumpers.

Conrie and Ythan effectively comprise part of the DSW infrastructure but are connected using their own dedicated pipelines and umbilical jumpers. They are not material to this comparative assessment.

For the majority of their lengths,PLU2577 and PL2581 are trenched and buried in the seabed while PL2572 & PL2573, PLU2576, PL2583 & PL2584 and PL4262 are mostly buried under deposited rock. All the pipelines and umbilicals except PLU2577 cross over the disused Don field pipelines PL598, PL599, PL600 and the control umbilical.

Pipeline ID	Phase 1 Removed	Original Description, Size & Quantity
PL2572	~5m	8in oil production pipeline, 4,027m long excl. pipespools at ends
PL2573	~5m	3in gas lift pipeline, 4,027m long, excl. pipespools
PLU2576	~300m	114.5mm OD static umbilical, 4,127m long, excl. umbilical jumpers
PLU2577	n/a	114.5mm OD static umbilical, 1,312m long, excl. umbilical jumpers
PL2581	~50m	8in water injection pipeline, 5,237m long, excl. pipespools
PL4262	~120m	8in replacement water injection flexible flowline, 5,550m long excl. pipespools

NOTES
1. During Phase 1 the 500m zone was cleared - parts of the pipelines were removed;
2. For details of pipeline stabilisation features please refer Decommissioning Programmes.

Table 2.1.2: Don South West Pipeline Description

2.1.3 West Don Pipelines

Produced fluids used to be exported from West Don to the Northern Producer via the RBS using an 8in pipeline, PL2583. This pipeline is piggybacked by a 3in gas lift pipeline, PL2584. The Northern Producer used to provide water injection to the WD water injection wells using an 8in pipeline PL2582 before integrity issues necessitated its replacement. It was replaced by PL4261, an 8in flexible flowline with individual pipespools branching off to each tree.

Chemicals and hydraulic power were provided to the WD production wells using PLU2585 with the same umbilical providing just hydraulic power to the water injection wells. PLU2585 was routed to the local distribution unit before being connected to each tree using individual jumpers.

For the majority of their lengths PL2582 and PLU2585 are trenched and buried in the seabed while

PL2583, PL2584 and PL4261 are mostly buried under deposited rock.

Pipeline ID	Phase 1 Removed	Original Description, Size & Quantity
PL2582	~51m	8in water injection pipeline, 2,274m long, excl. pipespools
PL2583	~50m	8in oil production pipeline, 2,300m long, excl. pipespools
PL2584	~50m	3in gas lift pipeline, 2,300m long, excl. pipespools
PLU2585	~330m	114.5mm OD static umbilical, 2,842m long, excl. umbilical jumpers
PL4261	~470m	8in replacement water injection flexible flowline, 5,550m long excl. pipespools
NOTES 1. During Phase 1 the 500m zone was cleared - parts of the pipelines were removed; 2. For details of pipeline stabilisation features please refer Decommissioning Programmes.		

Table 2.1.3: West Don Pipeline Description

2.2 Purpose

As per the OPRED guidance notes [5] pipeline decommissioning options require to be comparatively assessed. Further, if the condition of the mattresses or grout bags precludes their safe or efficient removal, then any proposal to leave them in place must be supported by an appropriate comparative assessment of the options.

Following public, stakeholder and regulatory consultation, the Conrie, Don South Wet, West Don and Ythan Decommissioning Programmes will be submitted in full compliance with the OPRED guidance notes [5]. The Decommissioning Programmes [1], [3] explain the principles of the removal activities and are supported by an Environmental Appraisal [4] and this Comparative Assessment.

2.3 Environmental Setting

2.3.1 Overview

The environmental characteristics and sensitivities are such that the seabed area is stable with relatively homogenous community. It is typical of sandy sediments, generally diverse and evenly distributed community with low taxonomic dominance.

Generally uniform and background hydrocarbon and metal concentrations typical of the northern North Sea, concentrations of hydrocarbons and metals were below recognised toxicity thresholds and were not found to have exerted any notable influence on the macrofaunal community structure.

The closest SAC or Annex 1 feature is the Pobie Bank Reef that is ~109km south-west of NP.

Impact from operations from the NP are not significant as there are no discharges from drilling, and seabed impacts from anchors can be considered minimal.

The types of fishing in the area is predominantly trawler activity, 99% of the activity targeting demersal fish and to a lesser extent shellfish. Historically, the area has seen pelagic trawler fishing, but currently this type of fishing is not prevalent, Vessel Monitoring System (VMS) data from 2009-2013 indicates that fishing intensity within Block 211/18 is low for demersal and shellfish species, and medium for pelagic species (mackerel). Fishing activity is moderate for demersal fish in comparison to the adjacent ICES Rectangles located west and south [4].

2.3.2 Deposited rock

While it is considered physically possible to remove deposited rock, the decommissioning philosophy in this document is consistent with the OPRED guidance notes [5], hence all deposited rock will be left *in situ*.

Material left in place will preserve the marine habitat that will have established over the time it has been on the seabed, and in this case its presence will not have a negative impact on the environment, nor impact on the safety of other users of the sea.

Methods that could be used to remove the rock include:

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

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

2.3.3 Concrete mattresses

There are 511 concrete mattresses remaining within the Don South West, Conrie, Ythan and West Don fields, all of similar design and construction, either the same type (6m x 3m x 0.15m or 6m x 2m x 0.15m, manufactured by Subsea Protection Systems, SPS). The locations and condition of each of the concrete mattresses and proposals for decommissioning are detailed in the Decommissioning Programmes [3]. Please also refer to the schematics in Figure B.1.1, Figure B.2.1, and Figure B.3.1.

2.3.4 Grout bags

The number of grout bags noted in the Decommissioning Programmes has been estimated using engineering judgement based on drawings and design sketches.

The intention will be to remove all the grout bags when decommissioning the pipelines. However, although several different methods could theoretically be used to remove the grout bags, from a practical perspective it is not known whether the bag material has remained intact.

2.4 Assumptions, Limitations, & gaps in Knowledge

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

- Complete removal of the umbilicals would be achievable should the overlying deposited rock be displaced to allow the umbilicals to be pulled from the trench;
- It is possible that the pipelines could be removed using reverse reel assuming that the overlying rock could be displaced to allow the pipelines to be pulled from the trench;
- Technically, removal of the pipelines could be achieved using the ‘cut and lift’ method of removal, assuming that the overlying rock could be excavated or displaced to allow access;
- EnQuest is not aware of any fishing gear snagging reports. To the companies’ knowledge no exposures have been of such a magnitude that they have warranted being recorded as a snagging hazard via Kingfisher Information Services on FishSAFE (www.fishsafe.eu).

The following legacy assumptions have also been made:

- An environmental survey would be required on completion of decommissioning activities;
- Any pipeline being left *in situ* would be subject to at least three legacy burial surveys owing to relatively poor depth of cover for some of the pipelines;
- The seabed sediment type is such that any spoil heaps created during any decommissioning operations would not present significant snagging hazards;
- In the long term, deposited rock would not present snagging hazards;
- The impact of the procurement of any new materials such as fabricated items or mining of new rock is ignored;

- Impact on commercial activities is inversely proportional to vessel activity;
- Societal benefits and vessel associated environmental impacts and risks are assumed to be proportional to vessel duration;
- Only a high-level comparison of what differentiates the costs is used.

3. THE PIPELINES, AND UMBILICALS

3.1 Overview

The pipelines are all laid in trenches, some of which were allowed to backfill naturally, others were covered with deposited rock. Piggybacked pipelines and sometimes other pipelines were laid in the same trench.

Asset	Pipeline ID	Type of Burial	Length of Rock
DSW & WD	PL2578 & PL2579	Deposited Rock	5.045km, 10.050km
DSW	PL2572 & PL2573	Deposited Rock	3.951km
DSW	PLU2576	Seabed, ~3.951km long	0.320km (pipeline crossing only)
DSW	PLU2577	Seabed, ~1.2km long	n/a
DSW	PL2581	Seabed, ~5.1km long	0.320km (pipeline crossing only)
DSW	PL4262	Deposited Rock	5.145km
WD	PL2582 & PLU2585	Seabed, ~2.1km long	Local protection at NP, 0.480km
WD	PL2583 & PL2584	Deposited Rock	2.250km
WD	PL4261	Deposited Rock	1.881km

NOTE

1. The 'DSW' pipelines all cross over the disused Don field pipelines, PL598, PL599, PL600 and control umbilical and are buried under deposited at the crossing.

Table 3.1.1: Overview of types of pipeline burial

The burial profiles presented herein are determined from 2019 survey data. Previous surveys were carried out in 2016 and the indications are that there has a been very little change to the burial profiles in the intervening period.

3.2 Combined Don South West & West Don Pipelines

3.2.1 PL2578 8in oil export piggybacked by PL2579 3in gas import pipeline

PL2578 is an 8in carbon steel pipeline ~5.1km long coated using 3LPP. It is piggybacked by PL2579, a 3in carbon steel pipeline also coated using 3LPP. The pipelines used to be routed via the Riser Base Structure (RBS) near the Northern Producer inside the 500m safety zone, but the RBS and the surface laid sections of the pipelines have been removed while the remainder of the pipelines remain intact. Most of the pipeline lies in a trench overlain with deposited rock. On approach to the Wye Structure, both pipelines are protected and stabilised by concrete mattresses. PL2578 terminates at the Wye Structure while PL2579 proceeds towards the Thistle Alpha Subsea Isolation Valve, where on approach it is protected and stabilised by concrete mattresses. Figure 3.2.1, Figure 3.2.2, Figure 3.2.3 and Figure 3.2.4 all show that the pipelines have a reasonable depth of cover inside the trench. The pipelines experience no exposures or spans other than at the ends.

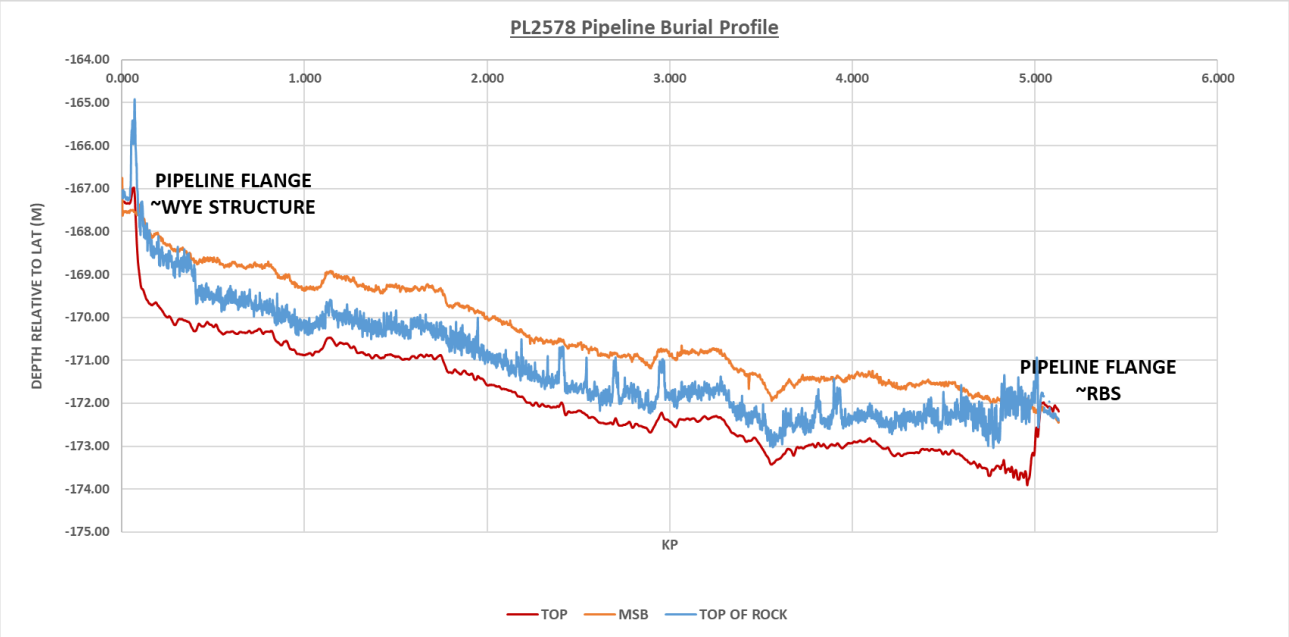

Figure 3.2.1: PL2578 seabed & burial profile

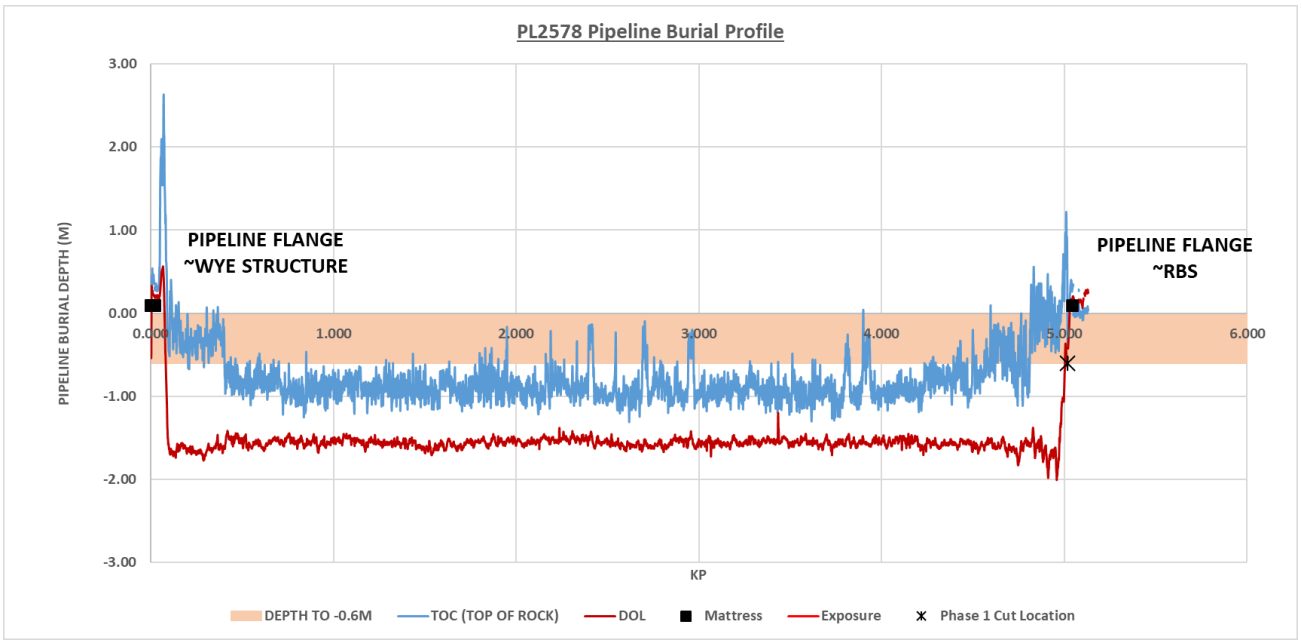

Figure 3.2.2: PL2578 depth of burial profile

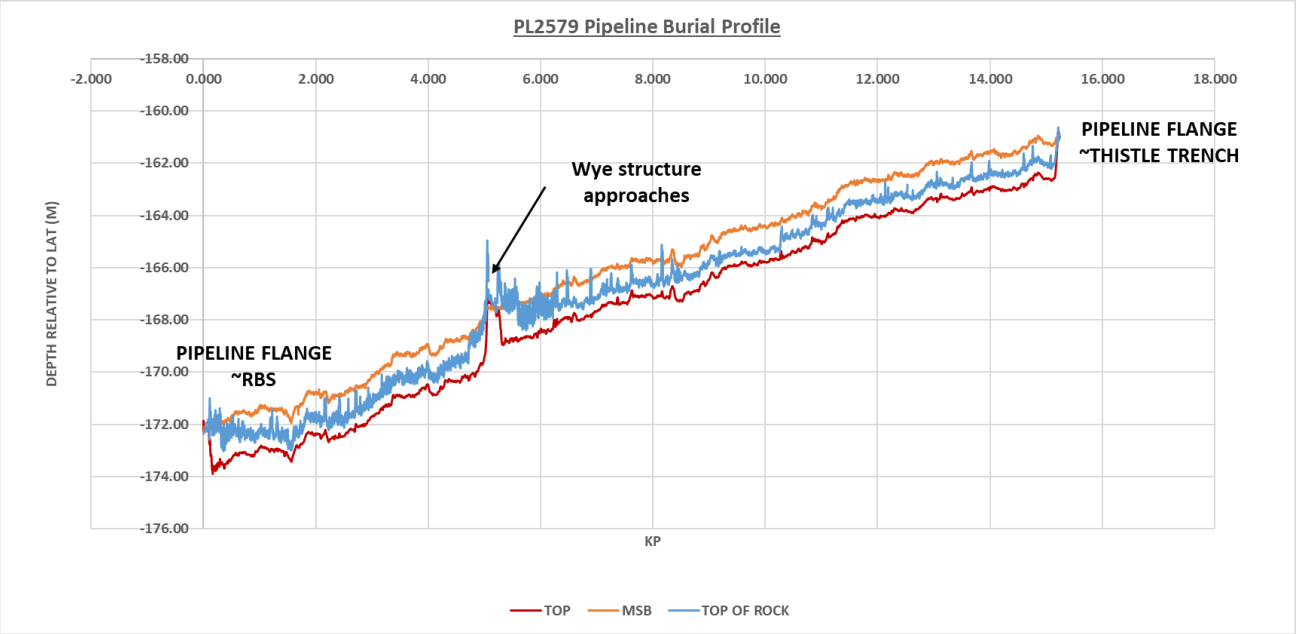

Figure 3.2.3: PL2579 seabed & burial profile

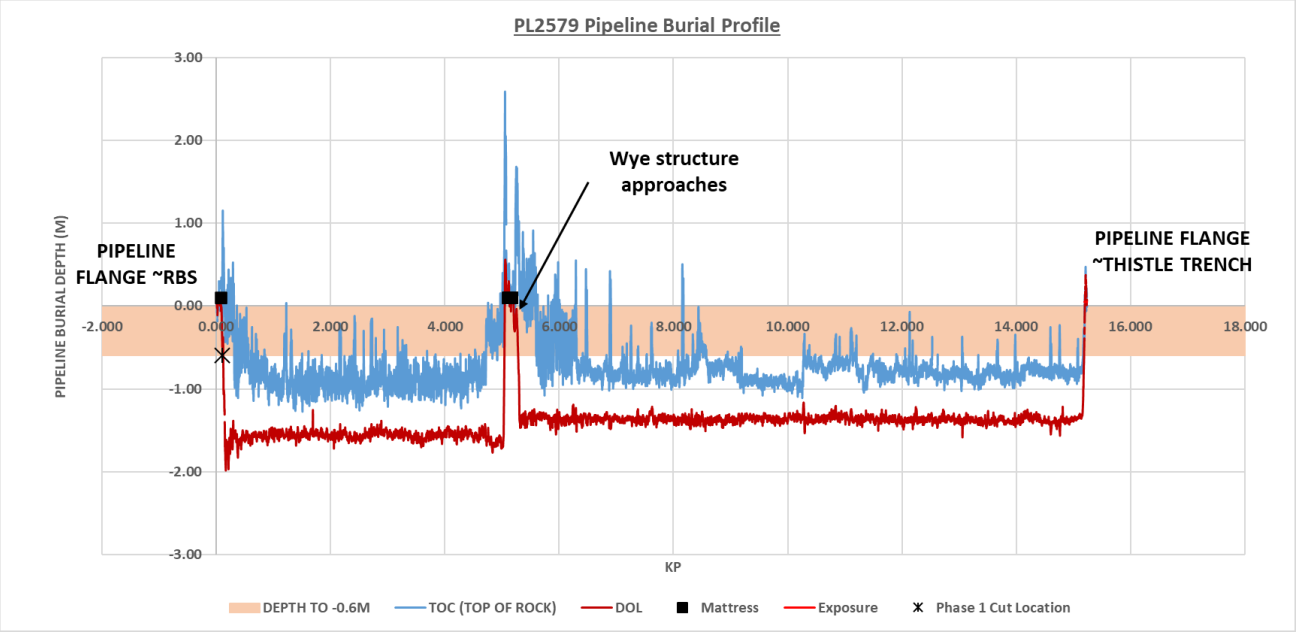

Figure 3.2.4: PL2579 depth of burial profile

3.3 Don South West

3.3.1 PL2572 8in oil production pipeline piggybacked by PL2573 3in gas injection pipeline

PL2572 is an 8in carbon steel pipeline ~4.3km long coated using 3LPP. It is piggybacked by PL2573, a 3in carbon steel pipeline also coated using 3LPP. The pipelines used to be connected to the Riser Base Structure (RBS) near the Northern Producer inside the 500m safety zone, but the RBS and the surface laid sections of the pipelines have been removed while the remainder of the pipelines to Don South West remain intact. On approach to the DSW production wells the pipeline spools are protected and stabilised by concrete mattresses. Most of the pipeline lies in a trench overlain with deposited rock. Figure 3.3.1, Figure 3.3.2, Figure 3.3.3, and Figure 3.3.4 show that the pipelines have a good depth of cover inside the trench. The pipelines experience no exposures or spans other than at the ends.

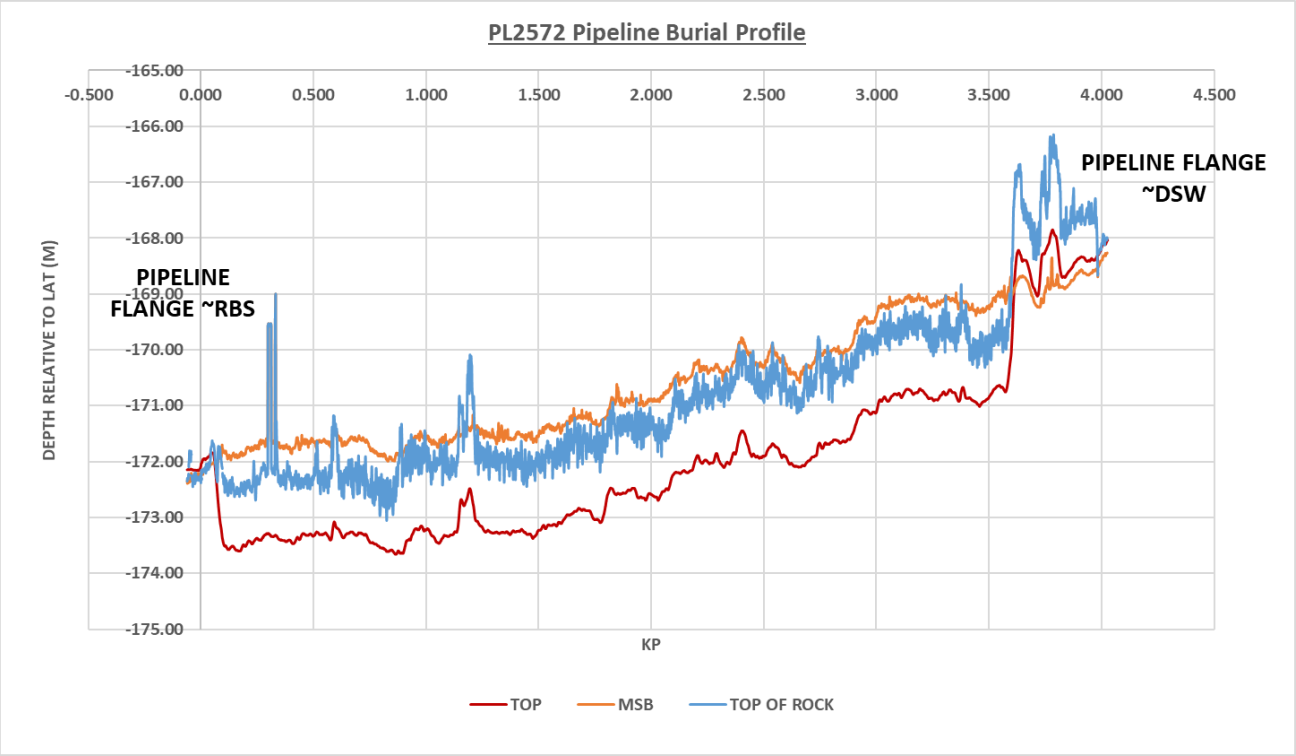

Figure 3.3.1: PL2572 seabed & burial profile

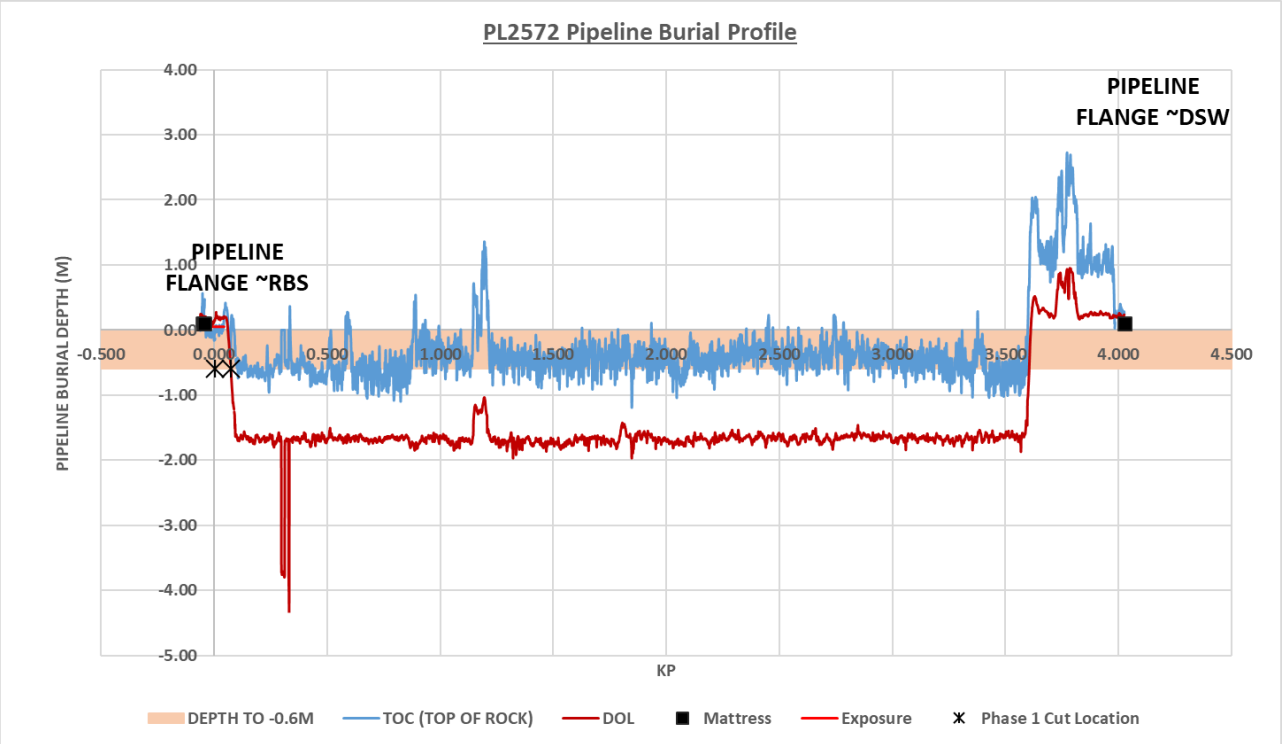

Figure 3.3.2: PL2572 depth of burial profile

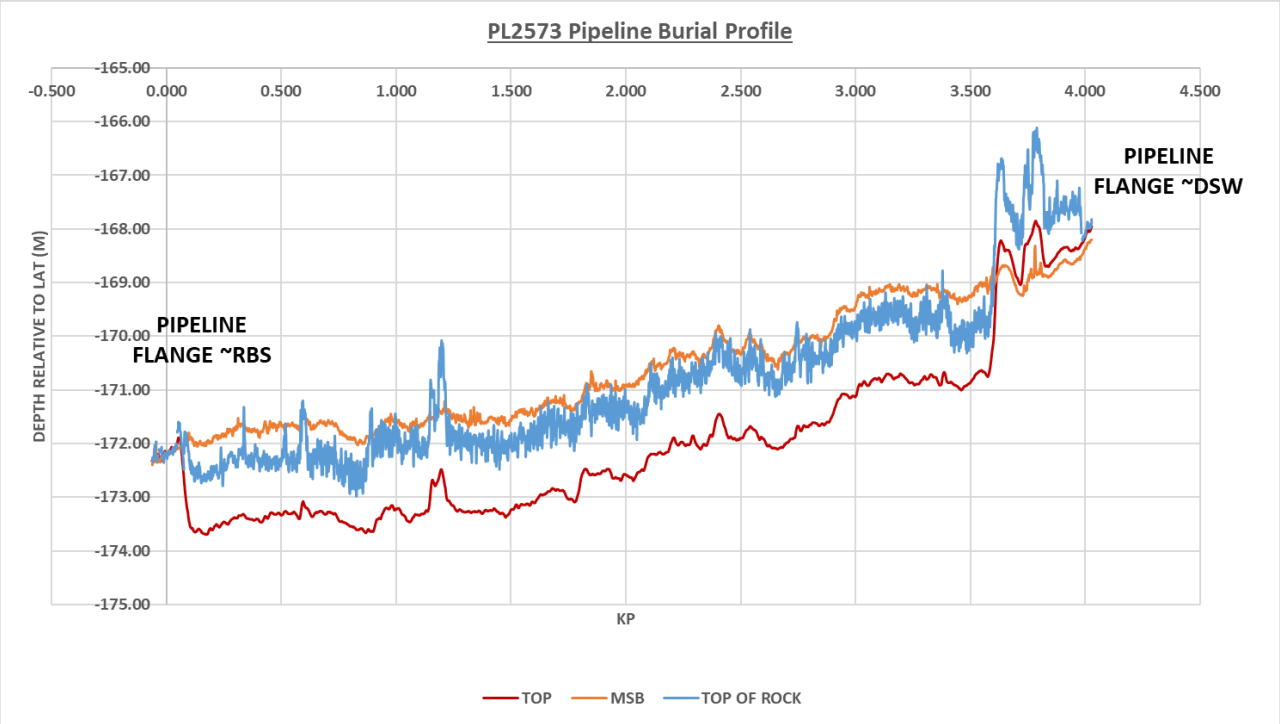

Figure 3.3.3: PL2573 seabed & burial profile

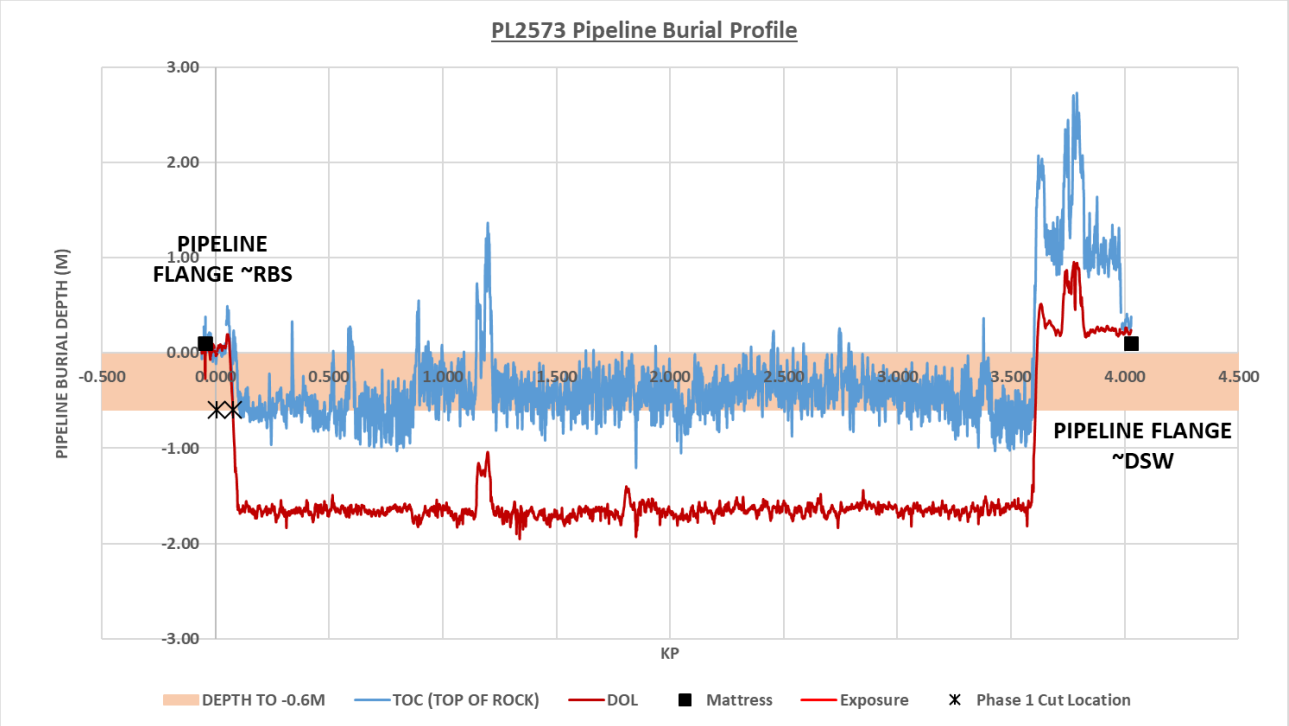

Figure 3.3.4: PL2573 depth of burial profile

3.3.2 PLU2576, PLU2577 static umbilicals & PL2581 8in water injection pipeline

PLU2576 is a 114.5mm OD umbilical ~3.9km long manufactured using a variety of materials including steel and plastics. It is laid in the same trench as PL2581 but left to naturally backfill. The umbilical used to connect to the RBS near the Northern Producer inside the 500m safety zone, but the RBS and the surface laid sections of the umbilical have been removed up to the start of the deposited rock, while the remainder of the umbilical to DSW Subsea Distribution Unit (SDU) remains intact. On approach to the DSW SDU it is protected and stabilised by concrete mattresses. Figure 3.3.5 and

Figure 3.3.6 show that the umbilical has poor depth of cover inside the trench with numerous exposures. In the 2019 pipeline survey, five anomalous spans totalling ~25m were noted for PLU2576, but none exceeded the dimensions reportable to FishSAFE. Refer Table 3.3.1. The spans reported during the survey occur near the start of the pipeline (up to ~KP0.220) are being removed during phase 1 of the decommissioning works.

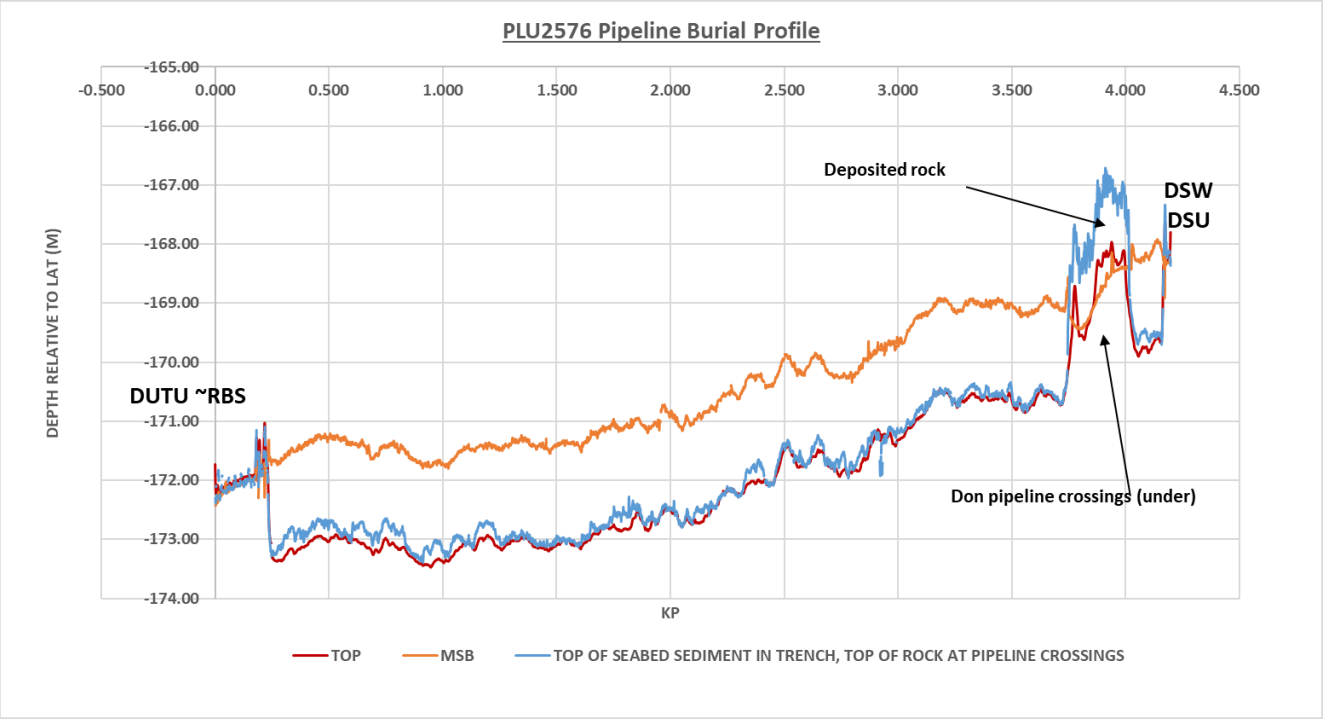

Figure 3.3.5: PLU2576 seabed & burial profile

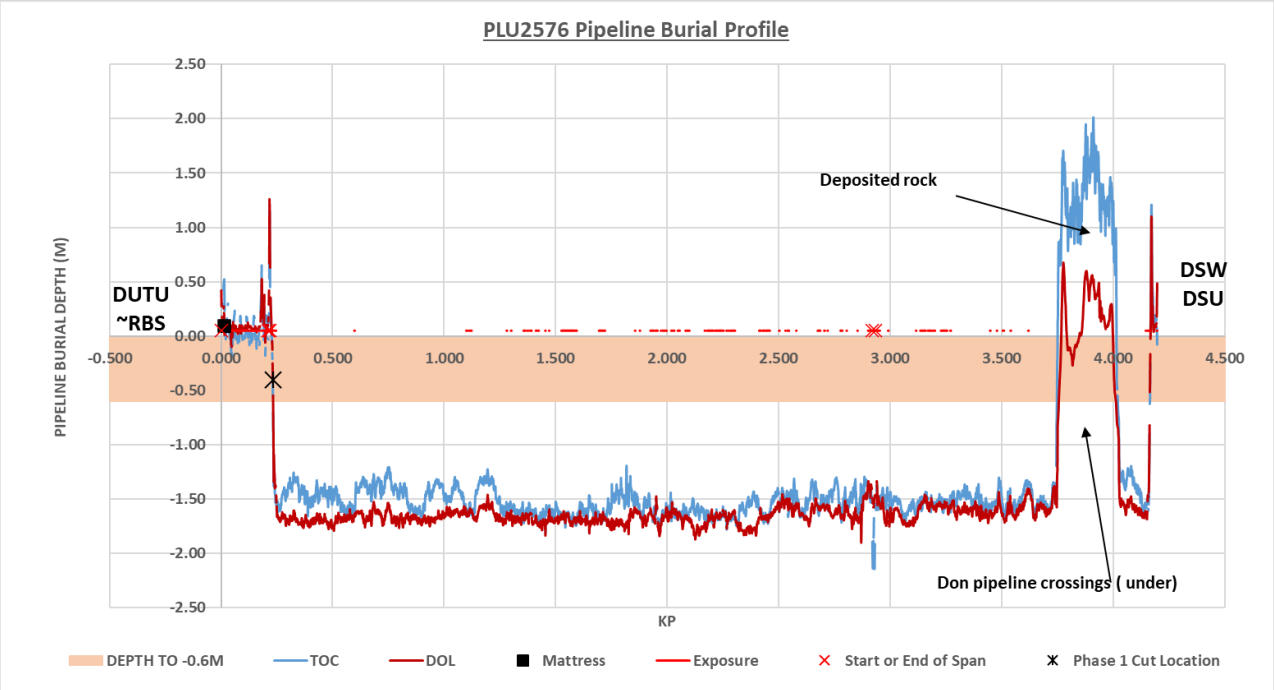

Figure 3.3.6: PLU2576 depth of burial profile

Pipeline ID (Survey)	KP	KP	Description	Length (m)	Height (m)	Comment
PLU2576-NP	0.199	0.201	Anomalous span	1.40	0.05	Removed in Phase 1
PLU2576-NP	0.210	0.218	Anomalous span	7.53	0.20	Removed in Phase 1
PLU2576-NP	0.220	0.221	Anomalous span	1.31	0.15	Removed in Phase 1
PLU2576-1	2.918	2.933	Anomalous span	14.81	0.50	Non-reportable
PLU2576-1	2.937	2.939	Anomalous span	1.89	0.01	Non-reportable
PLU2576			**SUB-TOTAL**	**25.08**		

Table 3.3.1: PLU2576 - pipeline span survey data

PLU2577 is a 114.5mm OD umbilical ~1.3km long manufactured using a variety of materials, including steel and plastics. It is routed from the DSW Subsea Distribution Unit (SDU) to the DSW water injection wells, and after being installed the trench was left to backfill naturally. PLU2577 was unaffected by the Phase 1 of the decommissioning works. Figure 3.3.7 and Figure 3.3.8 show that the umbilical has poor depth of cover inside the trench with numerous exposures. In the 2019 pipeline survey, a total 45 exposures were found for PLU2577 with a total length of ~208m and one anomalous observation 11m long was noted for PLU2577, but as it remains inside the trench it is not regarded as a span and is not reportable to FishSAFE. Refer Table 3.3.4.

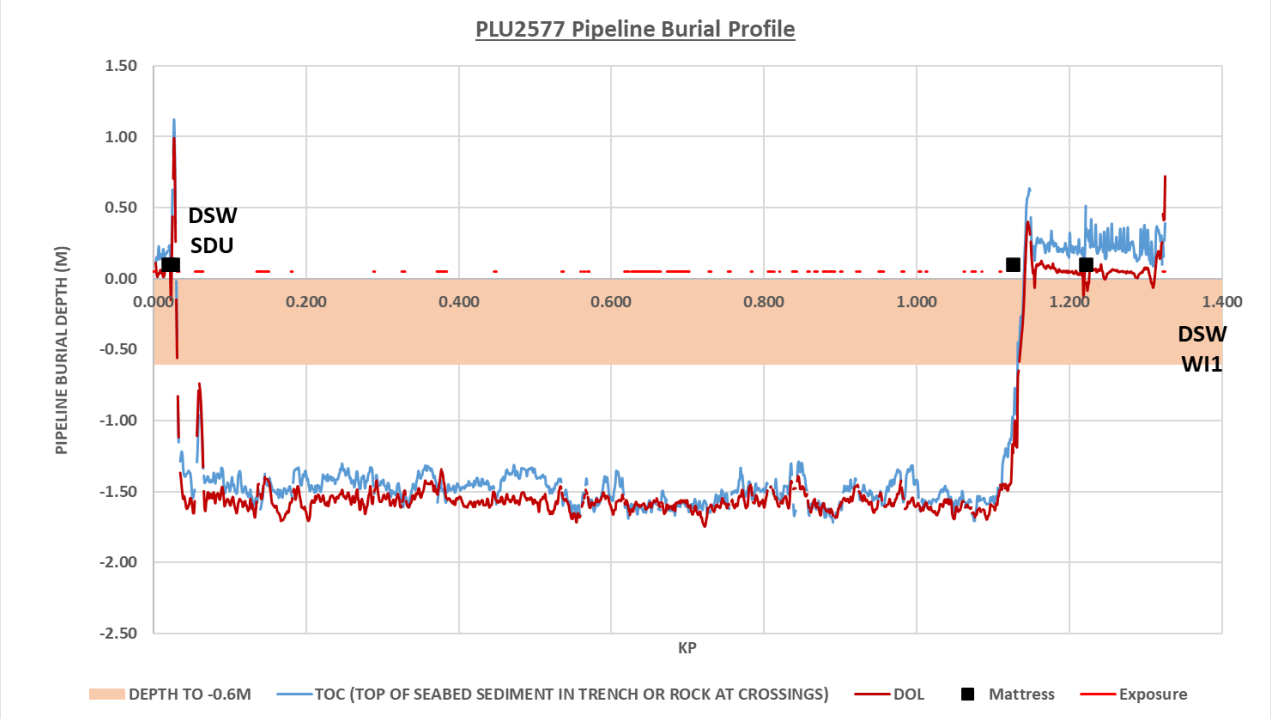

Figure 3.3.7: PLU2577 seabed & burial profile

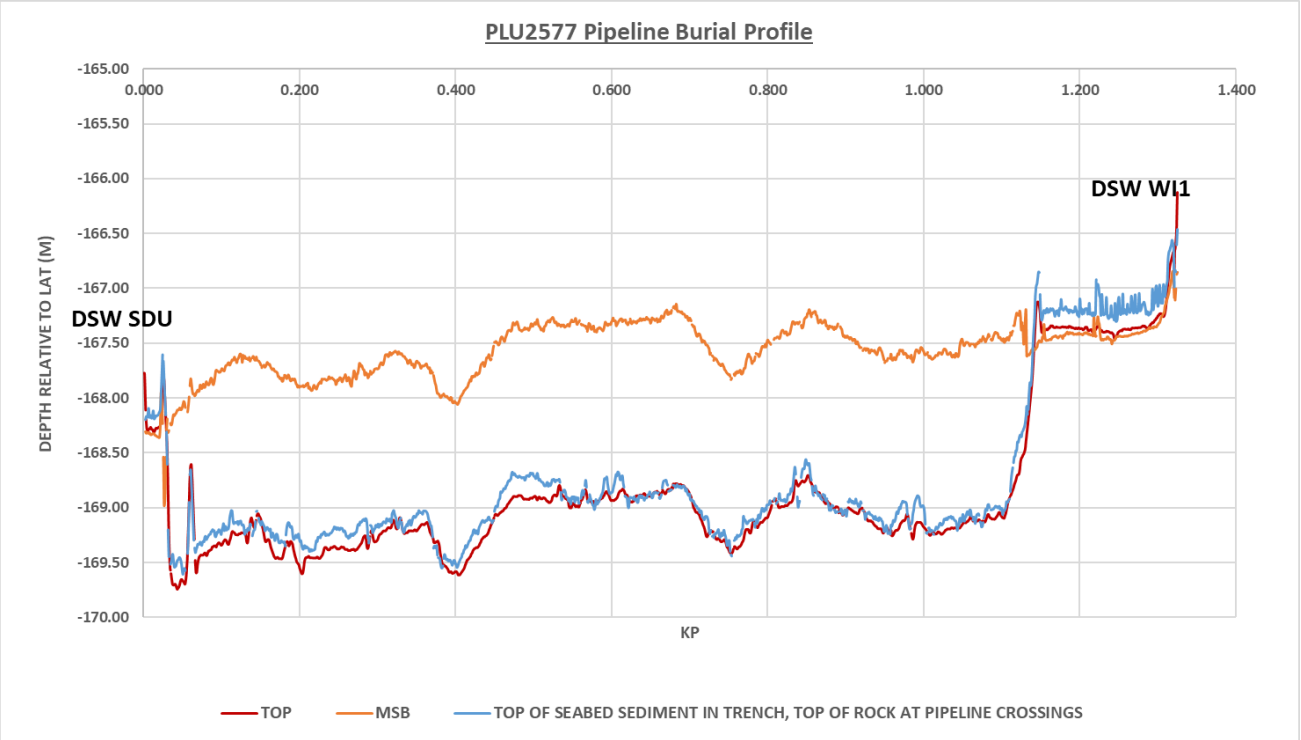

Figure 3.3.8: PLU2577 depth of burial profile

Pipeline ID	KP	KP	Description	Length (m)	Height (m)	Comment
PLU2577	0.055	0.066	Pipeline movement – lateral movement within trench	11.00	n/a	Max. displacement 1.5m to the North and 0.9m up the wall of the trench; no exposure indicated in survey records
			SUB-TOTAL	**11.00**		

Table 3.3.2: PL2577 - pipeline span survey data

PL2581 is an 8in carbon steel pipeline ~5.2km long coated using 3LPP. It is partly laid in the same trench as PLU2577. Both PL2581 and PLU2577 emerge out of the trench to cross over the disused Don pipelines (PL598, PL599, PL600 and control umbilical) where they are protected using concrete mattresses and buried deposited rock. PL2581 used to connect to the RBS near the Northern Producer inside the 500m safety zone, but the RBS and the surface laid sections of the pipeline have been removed while the remainder of the pipeline up to the Don South West water injection trees remain largely intact. The end pipespools, however, have been disconnected and laid aside as the pipeline suffered integrity problems and is no longer used. On approach to the DSW water injection wells the remaining pipeline spools are protected and stabilised by concrete mattresses. Figure 3.3.9 and Figure 3.3.10 show that the pipeline has poor depth of cover inside the trench with numerous exposures. In the 2019 pipeline survey, a total 155 exposures were found for PL2581 with a total length of 3.257km and four anomalous spans totalling ~25m were noted. The longest exposure was 381.5m long. This means ~62.6% of the pipeline is exposed. None of the spans exceeded the dimensions reportable to FishSAFE. Refer Table 3.3.4. The spans reported during the survey occur near the start of the pipeline (up to ~KP0.069) are being removed during phase 1 of the decommissioning works.

Pipeline ID (Survey)	Start KP	End KP	Length (m)	Comment
PL2581	0.895	1.003	107.28	Up to 50% exposure
PL2581	1.120	1.502	381.48	Up to 90% exposure
PL2581	2.073	2.213	139.65	Up to 50% exposure
PL2581	2.792	2.914	122.1	Up to 100% exposure
PL2581	2.997	3.156	159.03	Up to 100% exposure

Table 3.3.3: PL2581 - pipeline survey data, exposures >100m

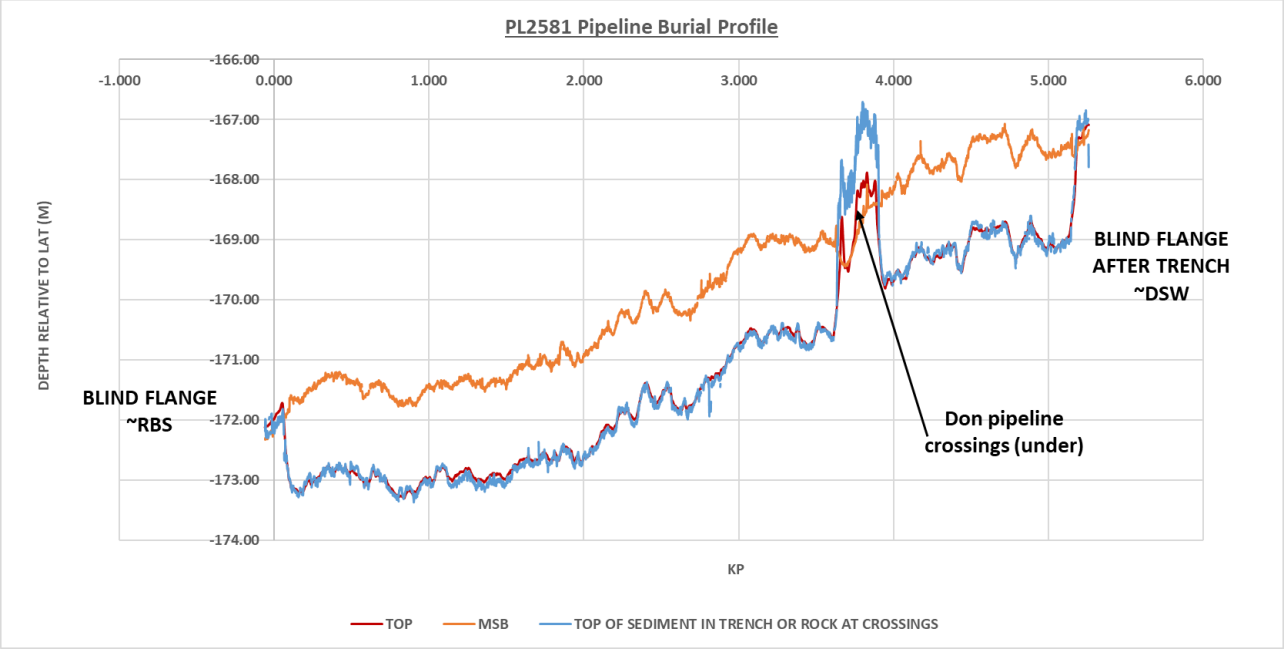

Figure 3.3.9: PL2581 seabed & burial profile

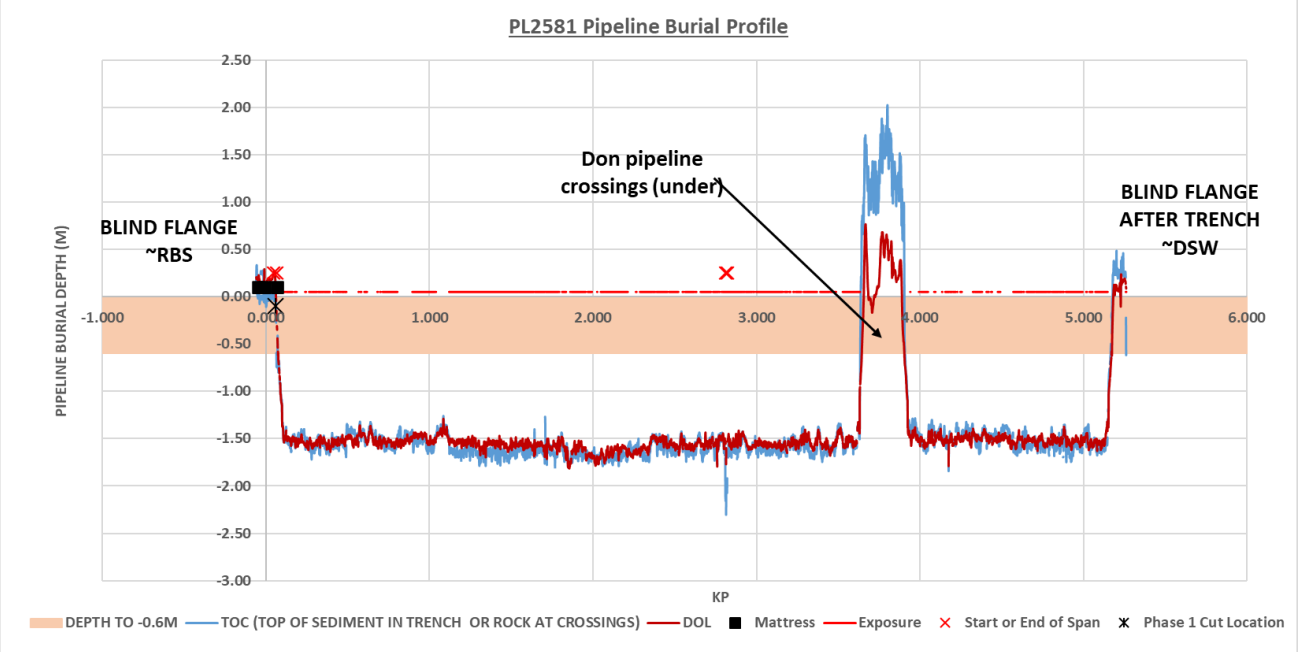

Figure 3.3.10: PL2581 depth of burial profile

Pipeline ID (Survey)	KP	KP	Description	Length (m)	Height (m)	Comment
PL2581	0.044	0.050	Anomalous span	6.04	0.05	Removed in Phase 1
PL2581	0.062	0.069	Anomalous span	6.75	0.30	Removed in Phase 1
PL2581	2.809	2.816	Anomalous span	7.11	0.50	Non-reportable
PL2581	2.818	2.823	Anomalous span	5.19	0.5	Non-reportable
			SUB-TOTAL	**25.08**		

Table 3.3.4: PL2581 - pipeline span survey data

3.3.3 PL4262 8in water injection flexible flowline

PL4262 is a flexible flowline ~5.6km long that was installed as a replacement for PL2581. It is laid on the seabed and buried under rock throughout between KP0.12 and KP5.265), crossing over the disused Don pipelines (PL598, PL599, PL600 and control umbilical). The flexible flowline used to be connected to the RBS near the Northern Producer inside the 500m safety zone, but the RBS and the surface laid sections of the flowline have been removed. The remainder of the flowline up to the Don South West water injection trees remains intact. On approach to the DSW water injection wells the pipe spools are protected and stabilised by concrete mattresses. Figure 3.3.11 and Figure 3.3.12 show that the flowline has good depth of cover inside the trench. In the 2019 pipeline survey, two anomalous spans totalling ~16m were noted for PL4262, but none exceeded the dimensions reportable to FishSAFE. Refer Table 3.3.5. The spans reported during the survey occur near the start of the flowline (up to ~KP0.087) are being removed during the decommissioning works that are addressed by the Phase 1 Decommissioning Programmes [2].

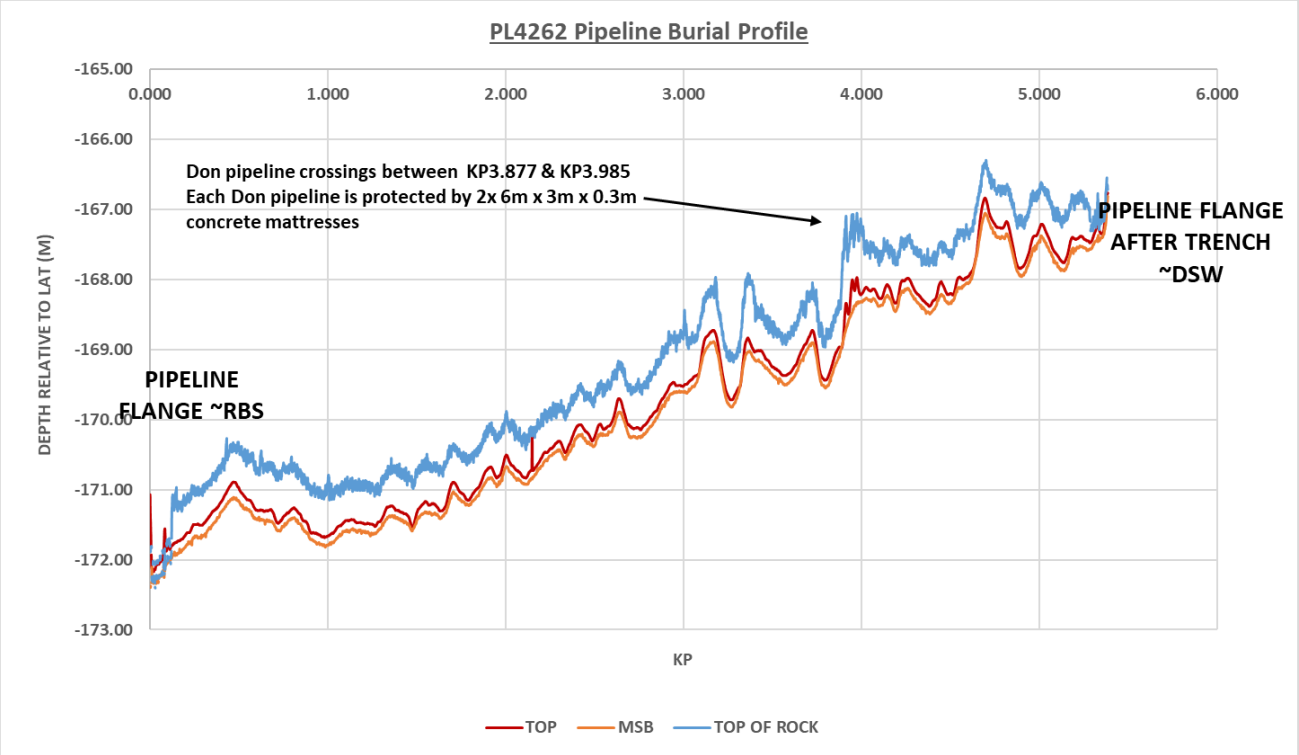

Figure 3.3.11: PL4262 seabed & burial profile

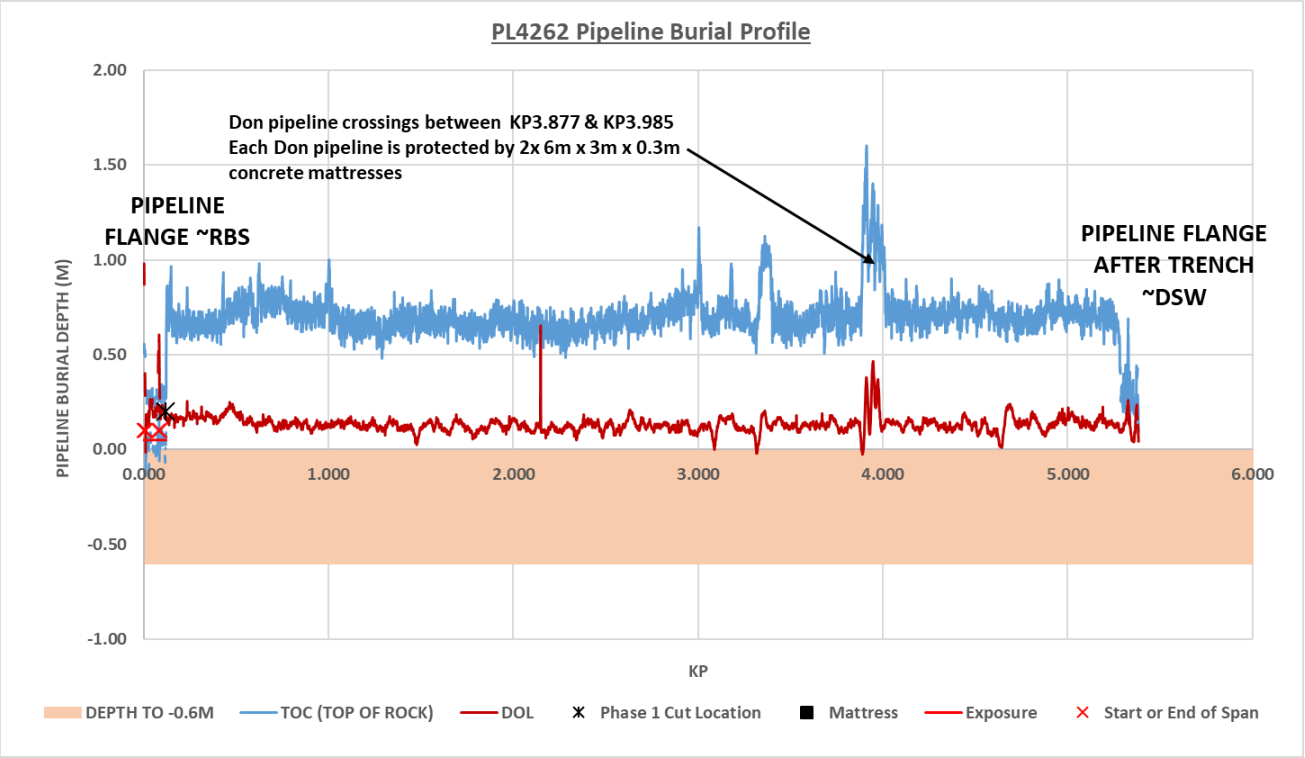

Figure 3.3.12: PL4262 depth of burial profile

Pipeline ID (Survey)	KP	KP	Description	Length (m)	Height (m)	Comment
PL4262	0.000	0.050	Anomalous span	5.97	0.15	Removed in Phase 1
PL4262	0.077	0.087	Anomalous span	10.03	0.20	Removed in Phase 1
PL4262			**SUB-TOTAL**	**16.00**		

Table 3.3.5: PL4262 - pipeline span survey data

3.4 West Don

3.4.1 PL2582 8in water injection pipeline & PLU2585 114.5 mm static umbilical

PL2582 is an 8in carbon steel pipeline ~2.3km long coated using 3LPP. PLU2585 is a static umbilical ~2.6km long that used to be connected to the RBS and provided chemicals and hydraulic fluids to the WD SDU and onto the production wellheads using jumpers. PL2582 and PLU2585 were laid in the same trench and left to backfill naturally in the seabed, except in the former NP 500m safety zone where deposited rock was installed to protect the pipelines from objects. The RBS along with surface laid pipelines and umbilicals has been removed. On approach to the WD water injection wells the remaining pipeline spools are protected and stabilised by concrete mattresses. Figure 3.4.1, Figure 3.4.2, Figure 3.4.3, and Figure 3.4.4 show that both pipelines have poor depth of cover along most of their length with multiple exposures. In the 2019 pipeline survey, a total 97 exposures were found for PL2582 with a total length of 0.914km, and five anomalous spans totalling ~28m were found. This means that None of the spans exceeded the dimensions reportable to FishSAFE. The anomalies near the start of the pipeline up to ~KP0.148 will have been removed during phase 1 [2] of the decommissioning works while the anomalies towards KP2.8 will be removed during phase 2 of the decommissioning works, the scope of which is described in the Phase 2 Decommissioning Programmes [3]. Refer Table 3.4.1. In the 2019 pipeline survey, a total 14 exposures were found for PLU2585 with a total length of ~88m.

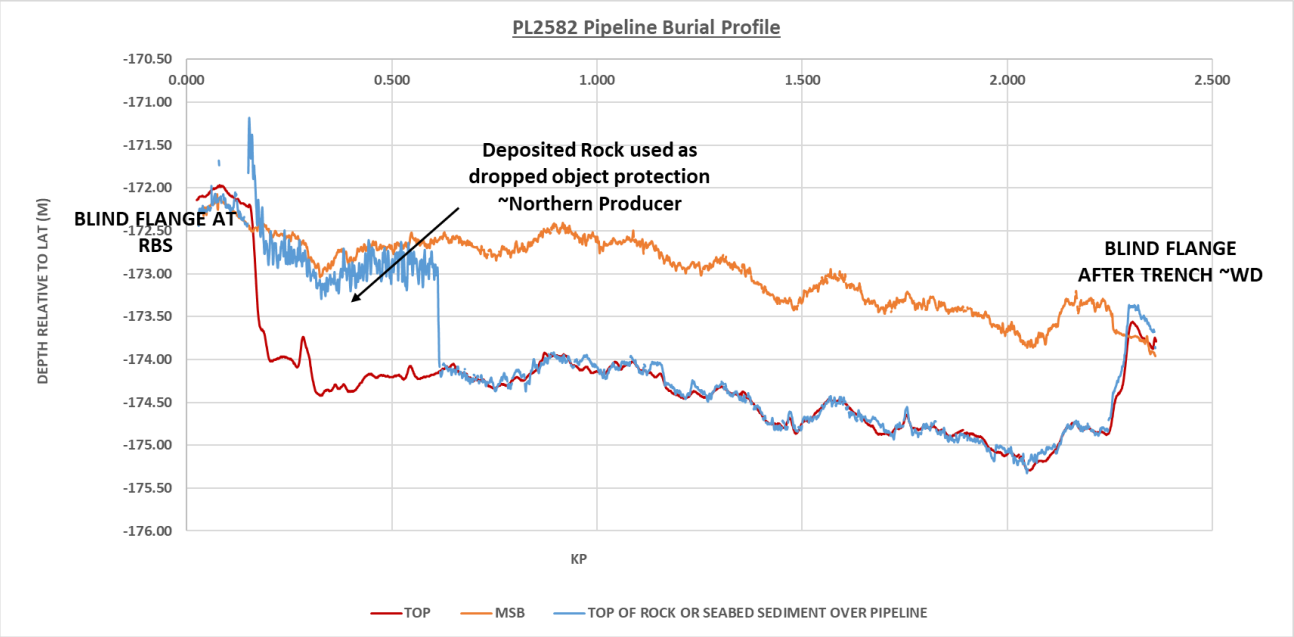

Figure 3.4.1: PL2582 seabed & burial profile

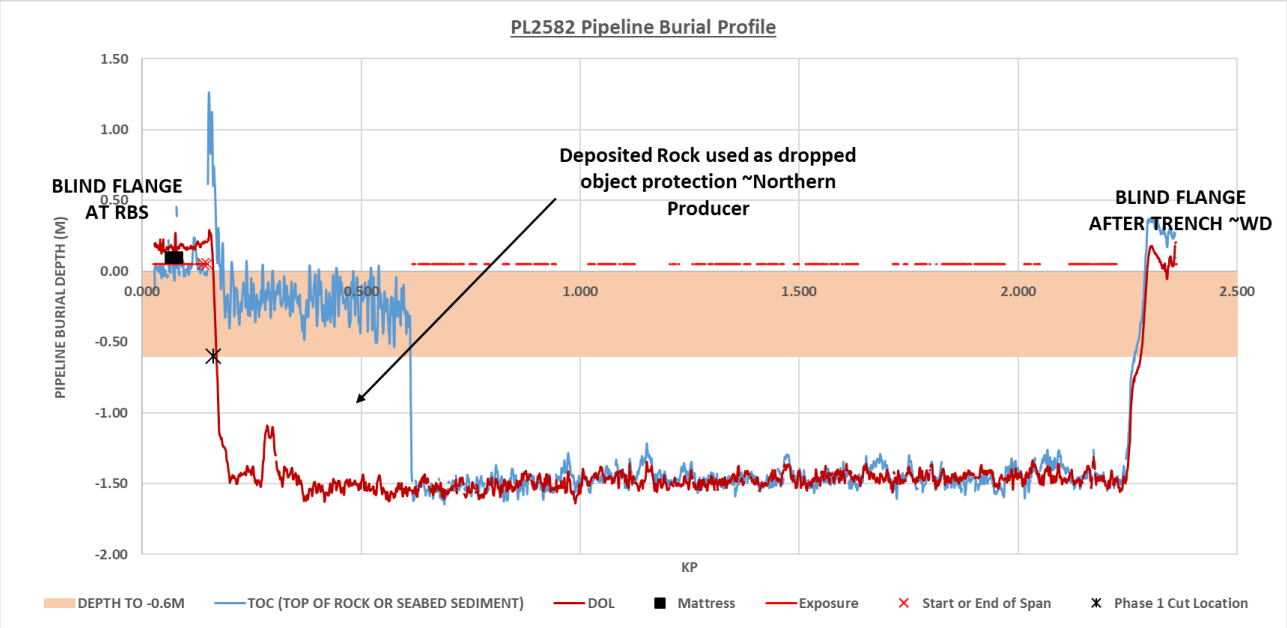

Figure 3.4.2: PL2582 depth of burial profile

Pipeline ID (Survey)	KP	KP	Description	Length (m)	Height (m)	Comment
PL2582	0.062	0.069	Anomalous span	6.75	0.30	Removed in Phase 1
PL2582	0.136	0.138	Anomalous span	1.61	0.05	Removed in Phase 1
PL2582	0.141	0.148	Anomalous span	7.42	0.05	Removed in Phase 1
PL2582	2.809	2.816	Anomalous span	7.11	0.50	Non reportable
PL2582	2.818	2.823	Anomalous span	5.19	0.50	Non reportable
PL2582			**SUB-TOTAL**	**28.08**		

Table 3.4.1: PL2582 - pipeline span survey data

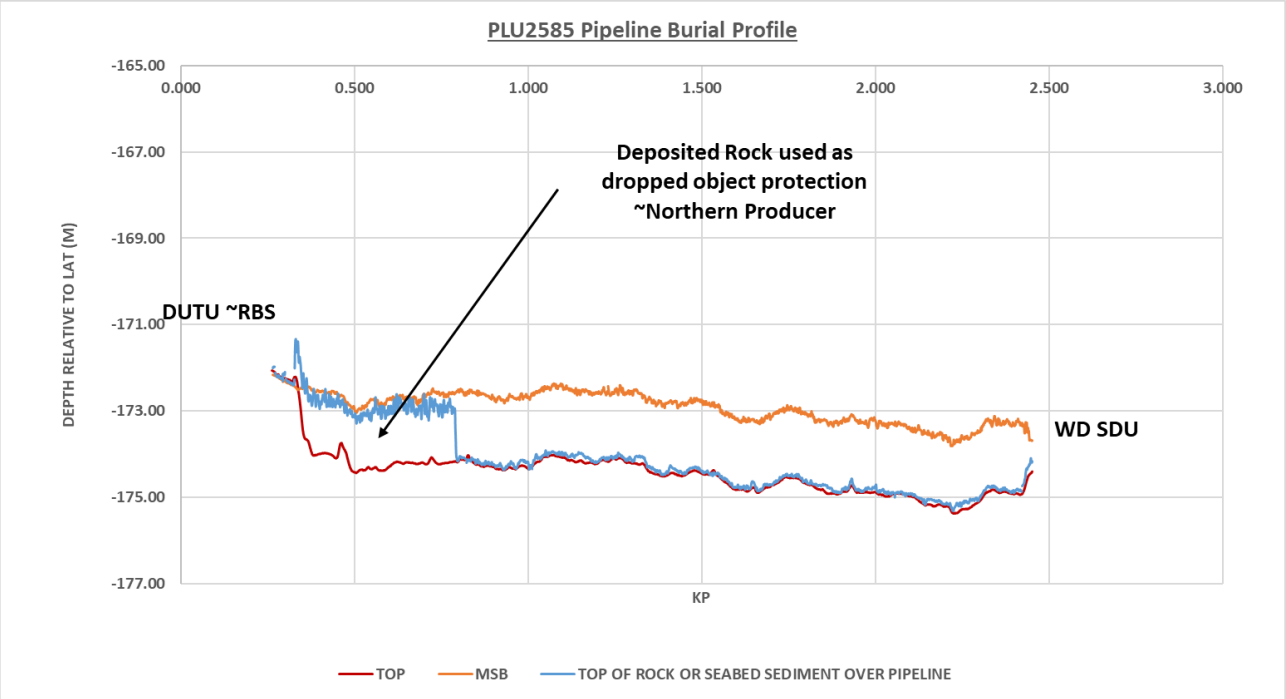

Figure 3.4.3: PLU2585 seabed & burial profile

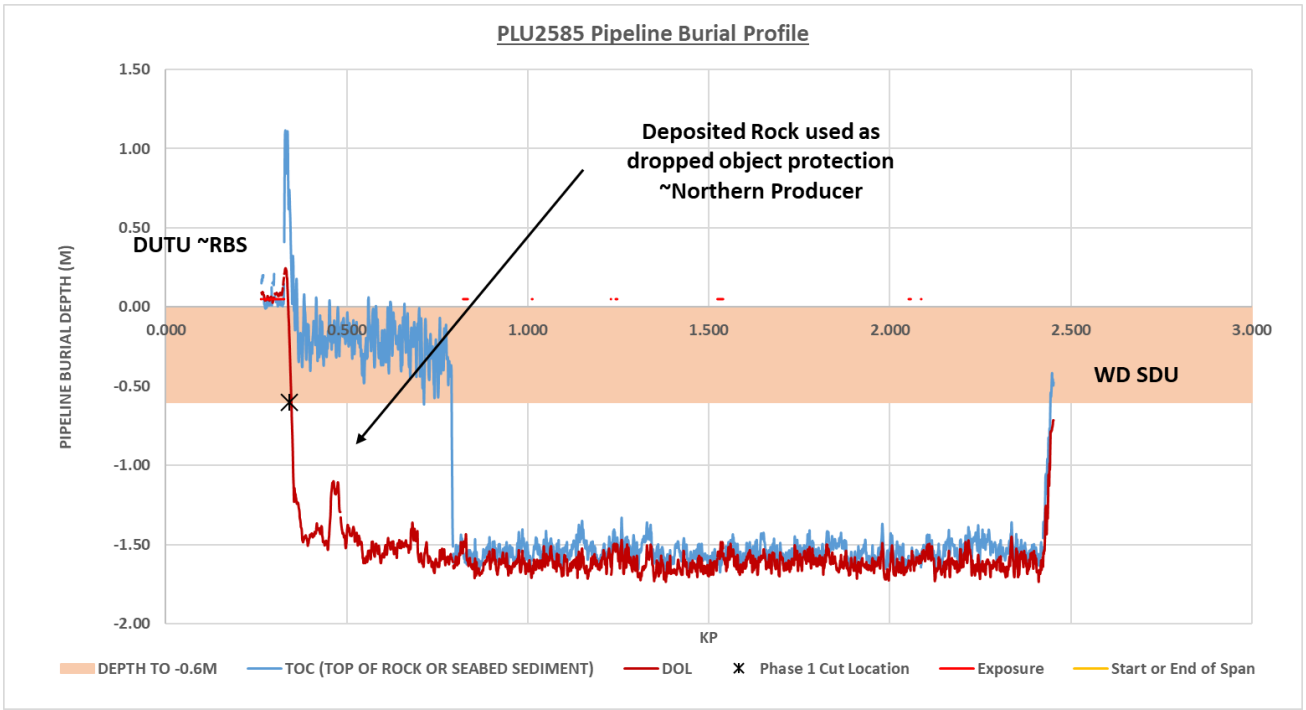

Figure 3.4.4: PLU2585 depth of burial profile

3.4.2 PL2583 8in oil production pipeline piggybacked by PL2584 3in gas injection pipeline

PL2583 is an 8in carbon steel pipeline ~2.3km long coated using 3LPP. It is piggybacked by PL2584, a 3in carbon steel pipeline also coated using 3LPP. The approach from the former Northern Producer end has been removed while the remainder of the pipelines to WD remain intact. On approach to the WD production wells the pipeline spools are protected and stabilised by concrete mattresses. Most of the pipeline lies in a trench overlain with deposited rock. Figure 3.4.5, Figure 3.4.6, Figure 3.4.7 and Figure 3.4.8 show that the pipelines have a good depth of cover inside the trench.

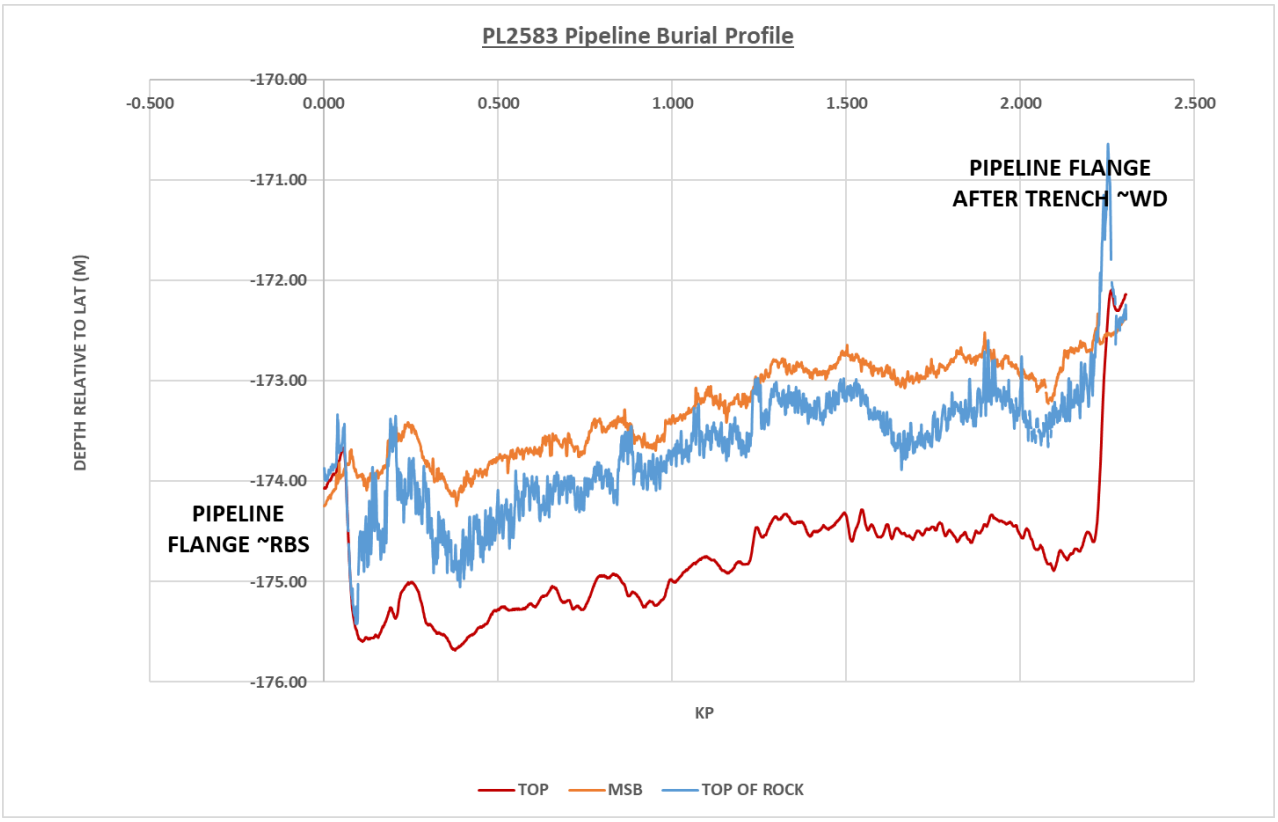

Figure 3.4.5: PL2583 seabed & burial profile

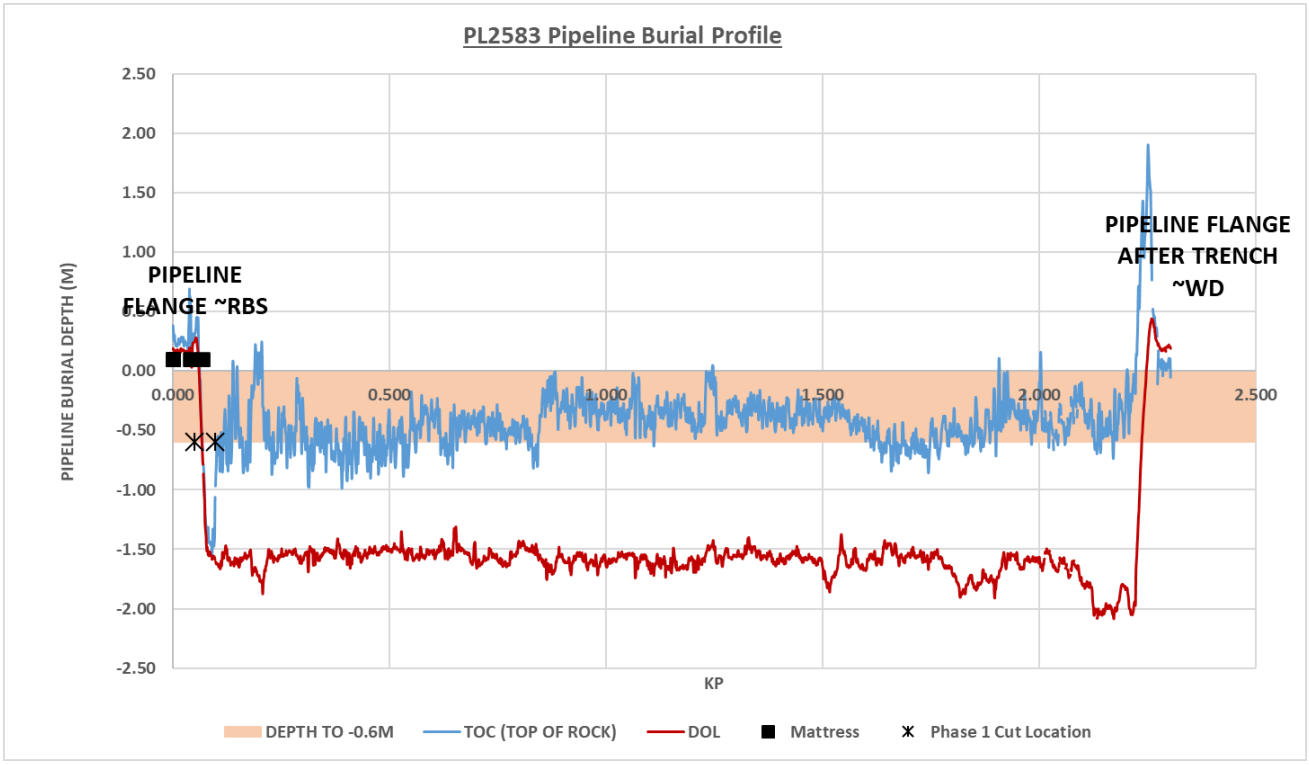

Figure 3.4.6: PL2583 depth of burial profile

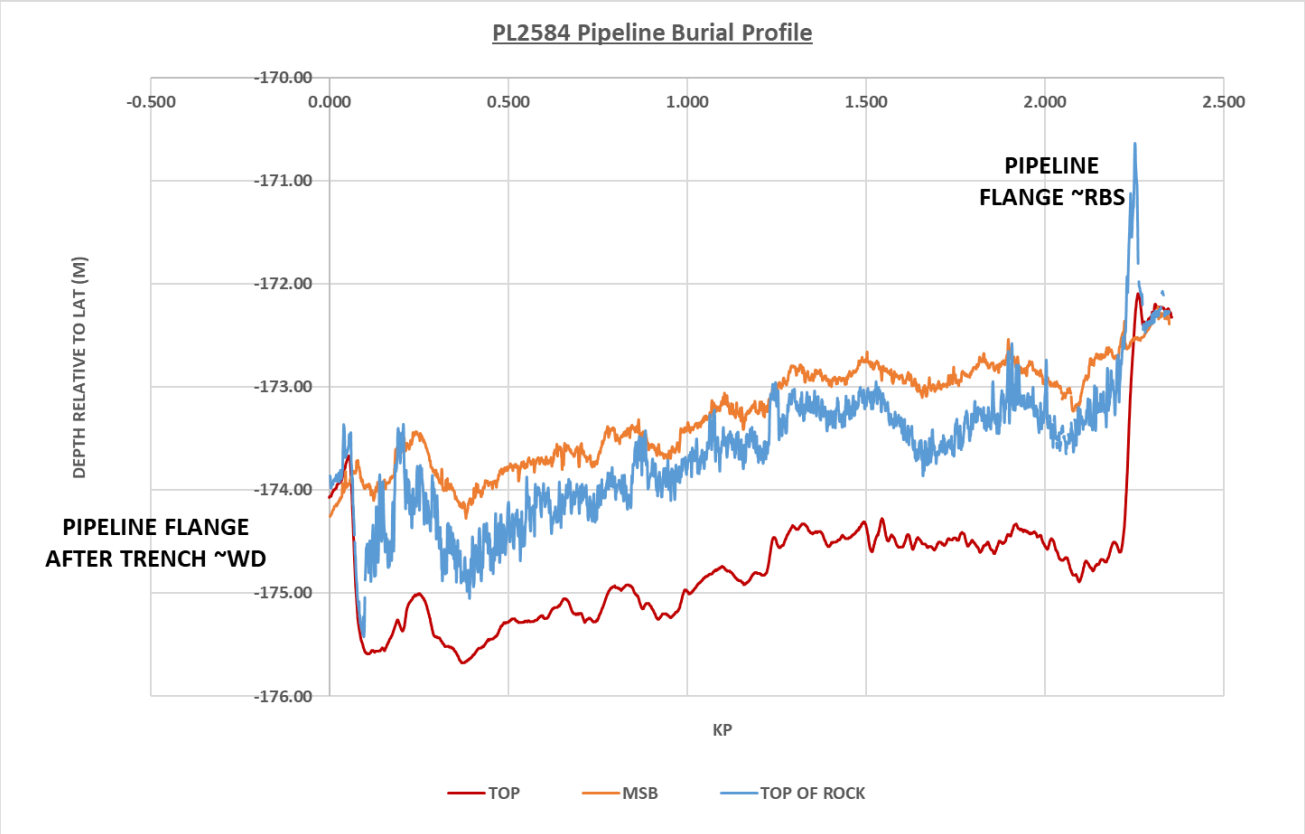

Figure 3.4.7: PL2584 seabed & burial profile

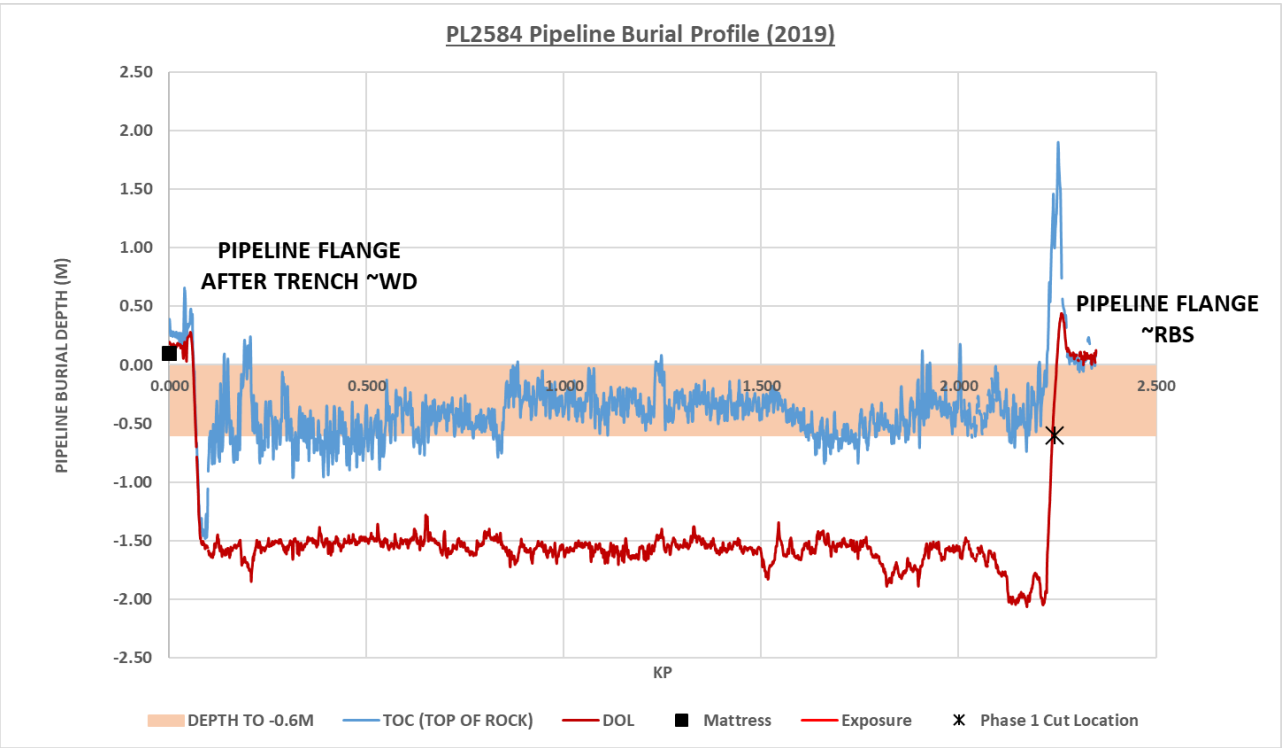

Figure 3.4.8: PL2584 depth of burial profile

3.4.3 PL4261 8in water injection flexible flowline

PL4261 is an 8in flexible flowline ~2.8km long that was installed as a replacement for PL2582. It is laid on the seabed and buried under rock between KP0.467 and KP2.348. The flowline used to be connected to the RBS near the Northern Producer inside the 500m safety zone, but the RBS and the surface laid sections of the pipeline have been removed. The remainder of the flowline up to the WD water injection trees remains intact. On approach to the WD water injection wells the pipe spools are protected and stabilised by concrete mattresses. Figure 3.4.9 and Figure 3.4.10 shows that the pipeline has good depth of cover once inside the trench. Although the 2019 pipeline survey four anomalous spans totalling ~33m were noted for PL4261, this section of the flowline will have been removed during phase 1 of the decommissioning works. Refer Table 3.3.4.

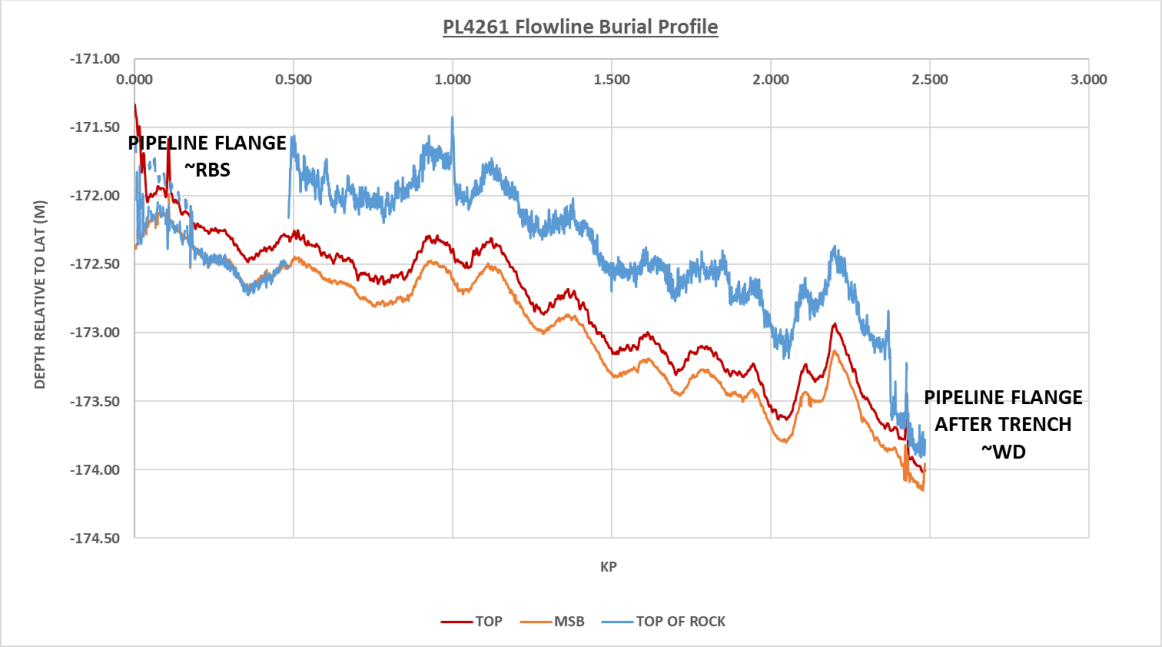

Figure 3.4.9: PL4261 seabed & burial profile

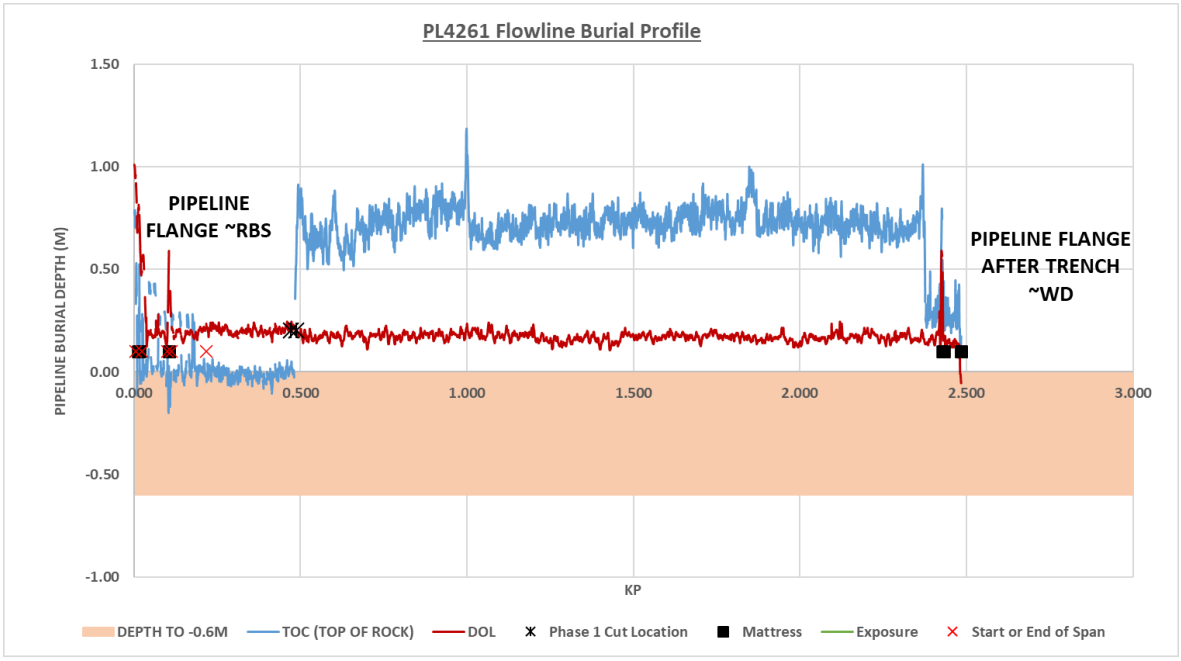

Figure 3.4.10: PL4261: depth of burial profile

Pipeline ID (Survey)	KP	KP	Description	Length (m)	Height (m)	Comment
PL4261	0.005	0.023	Anomalous span	17.42	0.60	Removed in Phase 1
PL4261	0.025	0.030	Anomalous span	5.49	0.50	Removed in Phase 1
PL4261	0.102	0.112	Anomalous span	10.35	0.45	Removed in Phase 1
			SUB-TOTAL	**33.26**		

Table 3.4.2: PL4261 - pipeline span survey data

3.4.4 Summary of Burial Profiles

The pipeline burial profiles are summarised in the following table:

Asset	Pipeline ID	Type of Burial	Burial Quality
DSW & WD	PL2578 & PL2579	Deposited rock	Reasonable depth of cover
DSW	PL2572, PL2573, PLU2576	Deposited rock	Good depth of cover
DSW	PLU2577 & PL2581	Seabed, ~1.2km long Seabed, ~5.1km long	Poor cover, numerous exposures
DSW	PL4262	Deposited rock	Good depth of cover
WD	PL2582 & PLU2585	Seabed, deposited rock	Poor cover, numerous exposures
WD	PL2583 & PL2584	Deposited rock	Good depth of cover
WD	PL4261	Deposited rock	Good depth of cover
NOTE 1. The 'DSW' pipelines all cross over the disused Don field pipelines, PL598, PL599, PL600 and control umbilical and are buried under deposited rock at the crossings.			

Table 3.4.3: Summary of pipeline burial quality

3.5 Pipeline crossings

The DSW pipelines and umbilicals (except PLU2577) considered in this comparative assessment cross over the Don field pipelines and umbilicals as illustrated in Figure B.1.1. These pipelines are out of use.

For oil and gas related infrastructure, this can usually be determined by the pipeline number. The higher pipeline number crosses over the top of a pipeline with a lower identification number, so for example, PL2581 crosses over PL600. This is illustrated in Figure 3.5.1.

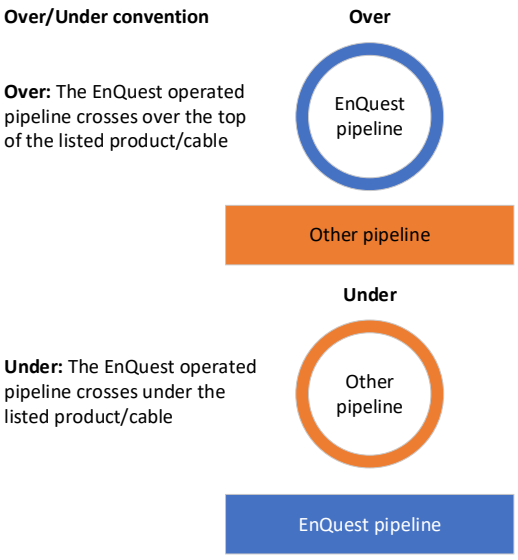

Figure 3.5.1: Over/under convention for pipeline crossings

3.6 Dealing with pipeline crossings

The various pipeline and cable crossings will impact or be impacted by the decommissioning options described in section 4. The potential impacts are summarised in Table 3.6.1 and illustrated in Figure 3.6.1Figure 4.2, although we have not considered this level of detail in the comparative assessments.

Decommissioning Option	Newer Pipeline on Top	Older Pipeline or Cable underneath[2]
Full removal	Cut EnQuest pipeline either side of third-party pipeline crossing.	No impact on option
Partial removal or remedial work	No impact on option as none of the partial removal options would involve removing pipelines from underneath; leave EnQuest pipeline *in situ*.	No impact on option
Leave *in situ*	No impact on option as none of the leave *in situ* options would involve removing a pipeline from underneath another pipeline; leave EnQuest pipeline *in situ*.	No impact on option

Table 3.6.1: Impact of pipeline crossings on pipeline decommissioning options

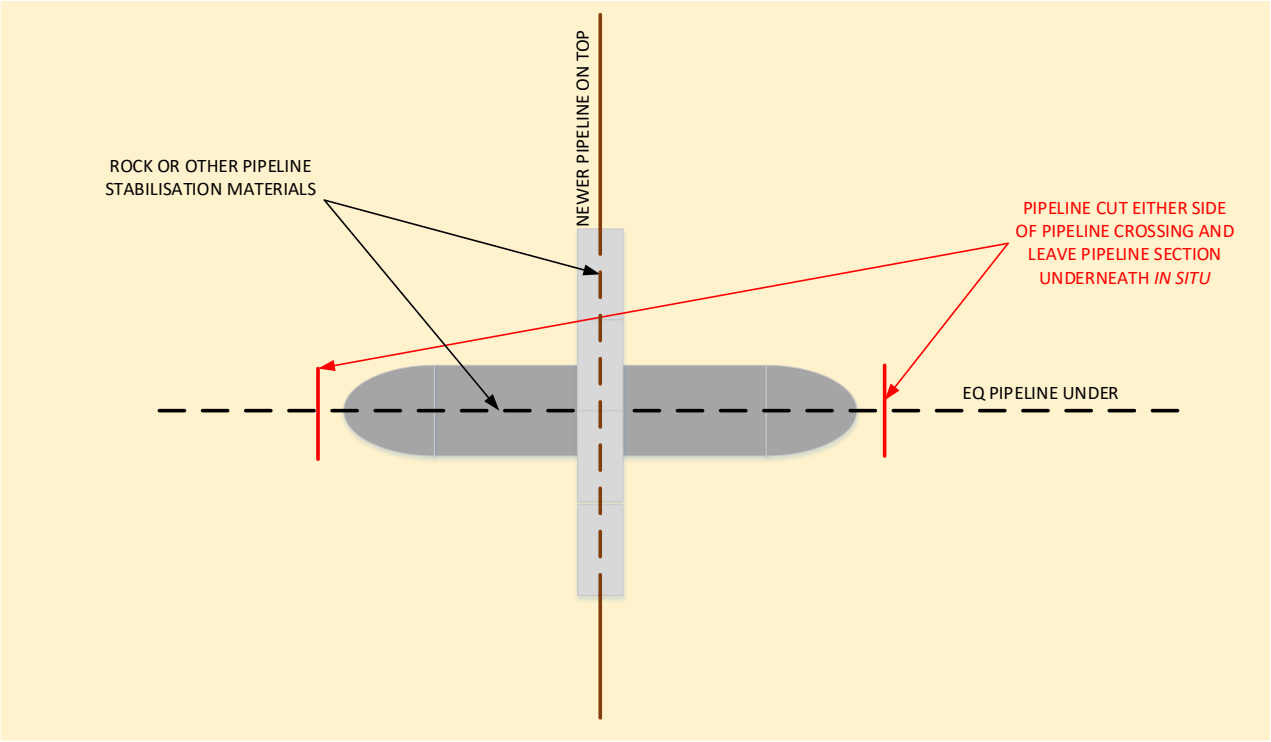

Figure 3.6.1: Pipeline underneath being removed

In this instance the Don South West pipelines and umbilicals (PL2581, PLU2576, PLU2577, PL4262) all cross over the Don pipelines (PL598, PL599, PL600 and 4" control umbilical) and these pipelines and umbilicals are being decommissioned *in situ* [1] and so will not be affected by the decommissioning of the Don South West pipelines. Should the DSW pipelines and umbilicals be removed any operational activities would be carried in liaison with the Don field pipeline owners and would involve crossing agreements for the period that the work is being carried out.

[2] Although it is noted here that there would be no discernible impact on the decommissioning option, permission would need to be granted from the owner of the older pipeline to carry out any works in the vicinity.

4. DECOMMISSIONING OPTIONS

4.1 Pipeline Decommissioning

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

- **Complete removal** – This would involve the complete removal of the pipelines by whatever means would be most practicable and acceptable from a technical perspective;
- **Partial removal or remediation** – This would involve removing exposed or potentially unstable sections of pipelines. Remedial work may need to be carried out to make the remaining pipeline safe for leaving *in situ.* This option is relevant for those pipelines that have known exposures because of poor depth of cover. There will likely be a need to verify their status via future surveys;
- **Leave *in situ*** – This would involve leaving the pipeline(s) *in situ* with no remedial works but possibly verifying their status via future surveys.

The method for decommissioning of the risers or surface laid sections of pipelines and pipeline approaches is the same irrespective of which option is pursued. Therefore, decommissioning of these parts of the pipelines are not included in the assessment. All options include removal of features such as pipespools, surface laid pipelines, jumpers, concrete mattresses, and grout bags in accordance with mandatory guidelines.

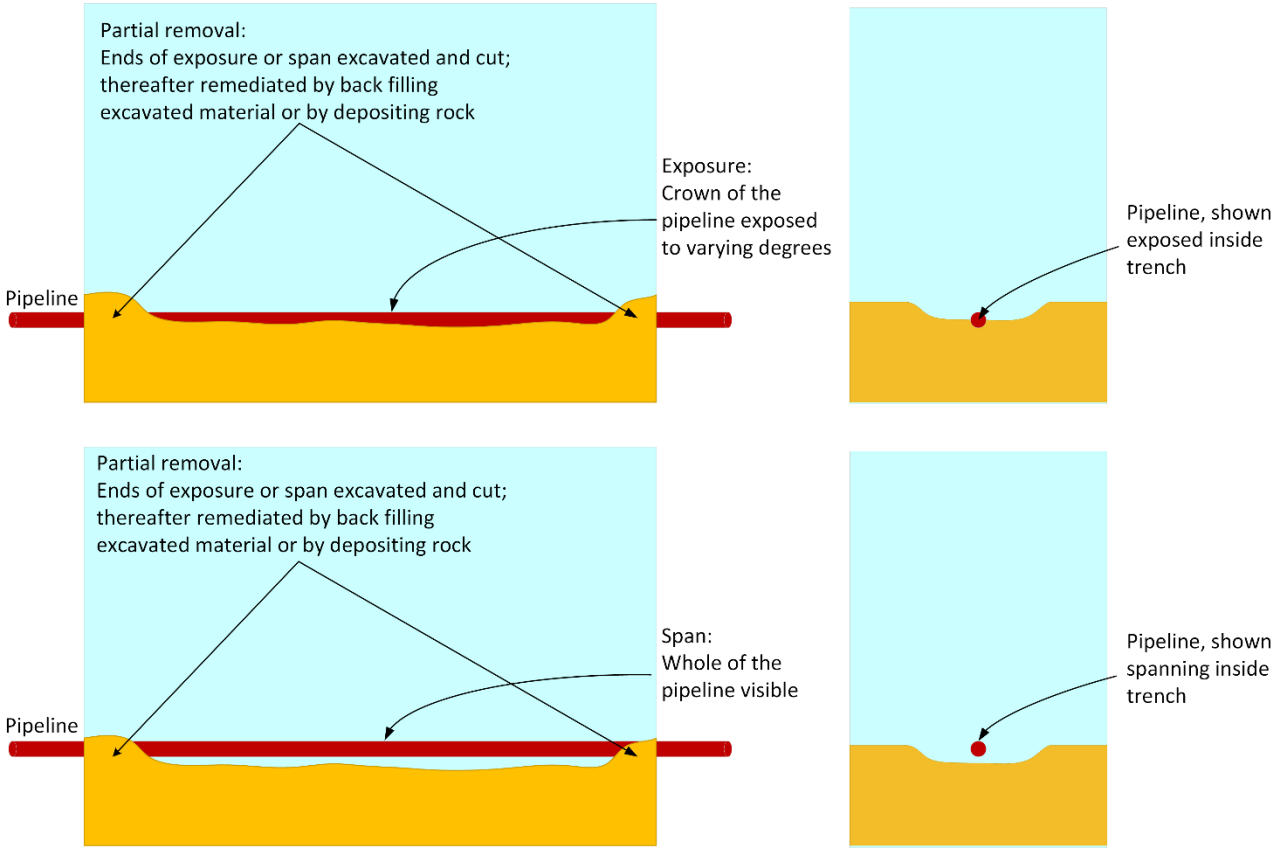

Figure 4.1.1: Exposures, spans & partial removal

Following an assessment of the quality of burial, the decommissioning options considered for the pipelines are summarised as follows:

Asset	Pipeline ID	Complete removal	Partial removal	Leave *in situ*	Group	Comments
DSW & WD	PL2578 & PL2579	X		X	1	Reasonable depth of cover, no exposures
DSW	PL2572 & PL2573	X		X	1	Good depth of cover, no exposures
DSW	PLU2576, PLU2577 & PL2581	X	X	X	3	Poor cover, numerous exposures; partial removal or remedial works to be considered
DSW	PL4262	X		X	2	Good depth of cover, no exposures
WD	PLU2585, PL2582	X	X	X	3	Poor cover, numerous exposures; partial removal or remedial works to be considered
WD	PL2583 & PL2584	X		X	1	Good depth of cover, no exposures
WD	PL4261	X		X	2	Good depth of cover, no exposures

NOTE:

1. PLU2576, PLU2577 and PL2581 were trenched into the seabed and left to backfill naturally, deposited rock used to bury all the other pipelines. Both umbilicals (PLU2576 from RBS up to DSW SDU followed by PLU2577) and the pipeline share the same trench;
2. PLU2585 and PL2582 were trenched in the seabed and left to backfill naturally but they emerge at the Don pipeline crossings where it is buried under deposited rock. Both pipelines share the same trench.

Table 4.1.1: Pipeline decommissioning options and grouping

For efficiency of analysis the options for decommissioning these pipelines will be assessed as three separate groups since many aspects of the assessment are common to all in a group. For example, the pipelines in group 1 are all piggybacked, and the depth of burial is reasonable or good. Any aspect pertinent to an individual pipeline is explained in the narrative.

Group 1: 8in and 3in pipelines laid in the same trench. The 3in pipeline is piggybacked onto the 8in pipeline. No exposures;

Group 2: 8in flexible flowlines laid on the seabed and buried in deposited rock. Good depth of cover, no exposures;

Group 3: 8in pipeline and 114.5mm umbilical laid separately but in the same trench. Poor depth of cover, numerous exposures.

Further details of the decommissioning options for the three pipeline groups are described in sections 0, 4.1.2 and 4.1.3 below. The activities in these sections could be undertaken using a variety of vessel type. Vessel type might include a construction support vessel (CSV), an ROV support vessel (ROVSV) of a pipelay vessel, a rock discharge vessel, or a mixture of all of them, depending on the activities being undertaken.

4.1.1 Decommissioning options and methods for pipelines in group 1

ID	Item Description	Option 1 Complete removal	Option 3 Leave *in situ*
1	Riser & surface laid sections of pipeline ~NP 500m zone	Phase 1 scope. Remove.	Phase 1 scope. Remove.
2	Trenched and buried section of pipeline (PL2578 & PL2579, PL2572 & PL2573, PL2583 & PL2584)	Uncover the pipelines using mass flow excavator. Completely remove pipelines using the 'cut and lift' method.	Leave *in situ*. No remedial work required.
3	Surface laid section of pipeline protected and stabilised with concrete mattresses on approach to, WD (PL2583 & PL2584) production wellheads, and DSW (PL2572 & PL2573) production wellheads, and the near Wye Structure (applicable to PL2578 & PL2579 only)	Remove all surface laid pipespools and associated concrete mattresses and grout bags.	Remove. As option 1.
4	Trenched and buried section of pipeline (PL2579 only although this is piggybacked on Thistle oil export pipeline PL4555[1])	Uncover the pipelines using mass flow excavator. Completely remove pipelines using 'cut and lift' method.	Leave *in situ*. No remedial work required.
5	Surface laid section of pipeline protected and stabilised with concrete mattresses Thistle SSIV and RBS (PL2579 only)	Remove all surface laid pipespools and associated concrete mattresses and grout bags.	Remove. As option 1.

NOTES:

1. The section of PL2578 between the SALB (subsequently replaced by the Wye structure) was renumbered PL4555 and is now owned by the Thistle pipeline owners (refer Figure B.4.1 and Figure B.5.1).

Table 4.1.2: Options for decommissioning pipelines in group 1

4.1.2 Decommissioning options and methods for pipelines in group 2

ID	Item Description	Option 1 Complete removal	Option 3 Leave *in situ*
1	Riser & surface laid sections of pipeline ~NP 500m zone	Phase 1 scope. Remove.	Phase 1 scope. Remove.
2	Surface laid section of flowline buried under rock (PL4261 & PL4262)	Uncover the pipeline from rock using mass flow excavator. Completely remove flowlines using the reverse reel method.	Leave *in situ*. No remedial work required.
3	Surface laid section of pipeline protected and stabilised with concrete mattresses on approach to WD water injection wellheads (PL4261) and DSW water injection wellheads (PL4262)	Remove all surface laid pipespools and associated concrete mattresses and grout bags	Remove. As option 1.

Table 4.1.3: Options for decommissioning pipelines in group 2

4.1.3 Decommissioning options and methods for pipelines in group 3

ID	Item Description	Option 1 Complete removal	Option 2 Partial removal	Option 3 Leave in situ
1	Riser & surface laid sections of pipeline ~NP 500m zone	Phase 1 scope. Remove.	Phase 1 scope. Remove	Phase 1 scope. Remove.
2	Trenched and buried section of umbilical or pipeline (PLU2576, PLU2577 & PL2581, PL2582 & PLU2585)	Uncover the pipeline(s) using mass flow excavator. Completely remove rigid pipelines either using reverse reel or the 'cut and lift' method. Complete remove umbilical(s) using reverse reel method.	Either remove exposed sections of pipelines and remediate the remaining pipeline ends or cover exposed sections by post-trenching or depositing additional rock.	Leave *in situ*. No remedial work required.
3	Surface laid section of pipe spools and umbilical jumpers protected and stabilised with concrete mattresses on approach to WD (PL2582, PLU2585) and DSW (PLU2576, PLU2577 & PL2581)	Remove. Remove all surface laid pipespools and jumpers and associated concrete mattresses and grout bags	Remove. As option 1.	Remove. As option 1.

NOTES

1. Both umbilicals (PLU2576 from RBS up to DSW SDU followed by PLU2577) and the pipeline PL2581 to DSW share the same trench and emerge from the trench over the Don pipeline crossings before continuing inside the trench;
2. PL2582 and PLU2585 to WD share the same trench and are buried under deposited rock near NP. The rock was installed as dropped object protection.

Table 4.1.4: Options for decommissioning pipelines in group 3

5. COMPARATIVE ASSESSMENT

5.1 Method

The comparative assessment is largely qualitative, carried out at a level that is sufficient to differentiate between the options. However, in some cases, for example such as cost, it can be necessary to examine the differences in more detail and quantitatively to provide clarity. The comparative assessment considers the following generic evaluation criteria and specific sub-criteria in line with OPRED guidance notes [5]. These elements are considered for short-term work as the assets are decommissioned as well as over the longer-term as 'legacy' impacts and risks. Please refer Table 5.1.1.

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

It is proposed to decommission the approaches and surface laid sections for each pipeline in the same way irrespective of the decommissioning option chosen. Therefore, the approaches are not included in this assessment.

CRITERIA	DEFINITION	SUB-CRITERIA (Short-term & Legacy, UNO)	COMMENTS
Technical	A technical evaluation of the complexity of a job that can be expected to proceed without major consequence or failure if it is adequately planned and executed.	Risk of project failure. Technological challenge. Technical challenge (legacy).	Technically, complete removal of the pipelines would most likely be achievable, but significant complications could arise because the pipelines are buried, and several are piggybacked. The 'cut and lift' method of removal is tried and tested for relatively short pipelines but would be avoided for longer pipelines several km long. Reverse reeling of pipelines has been achieved for small diameter pipelines and surface laid umbilicals but not for pipelines with significant depth of cover. Reverse reeling has not been used for recovery of piggybacked pipelines and would be technically challenging with no guarantee of success. Technical aspects of post-trenching and the deposition of additional rock (Group 3 only).
Safety	An assessment of the potential health and safety risk to people directly or indirectly involved in the programme of work offshore and onshore, or who may be exposed to risk as the work is carried out.	Health and safety risks for project personnel carrying out decommissioning activities offshore. Residual risks to marine users on successful completion of decommissioning. Safety risks for project personnel engaged in carrying out decommissioning activities onshore.	Typical offshore hazards might include loss of dynamic positioning, sudden movements during pipeline recovery works, dropped objects, collision between vessels, dealing with residual quantities of hazardous materials. Typical diving hazards might include, loss of heat or air supply, trapped cables and hoses, trapped limbs. After decommissioning has been completed typical hazards could relate to exposed pipelines or sections of umbilicals leading to possibility of fishing net snagging. Typical onshore hazards might include dealing with residual hazardous materials, onshore cutting, sudden movements or dropped objects.

CRITERIA	DEFINITION	SUB-CRITERIA (Short-term & Legacy, UNO)	COMMENTS
Environmental	An assessment of the significance of the risks / impacts to the environmental receptors because of operational activities or the legacy aspects.	Energy and emissions to atmosphere.	The assets are located outside of environmentally sensitive areas, so the dominant environmental criteria would likely be the effect on the seabed, the amount and type of waste recovered, or replacement materials needing to be manufactured to compensate for materials left *in situ*.
		Effect on seabed: Seabed disturbance and area affected.	
		Disturbance to protected areas.	
		Effect on water column: • Liquid discharges to sea; • Liquid discharges to surface water; • Noise.	
		Waste creation and use of resources such as landfill. Recycling and replacement of materials.	
Socio-economic	An assessment of the significance of the impacts on societal activities, including offshore and onshore activities associated with the complete programme of work for each option and the associated legacy impact. This includes all the "direct" societal effects (e.g. employment on vessels undertaking the work) as well as "indirect" societal effects (e.g. employment associated with services in the locality to onshore work scope, accommodation, etc.).	Effects on commercial activities e.g. fishing	Decommissioning of pipelines on individual projects involves work that is generally temporary work. On its own this type of work might typically lead to an extension of employment rather than new employment. Any impact on commercial fishing offshore is temporary and of relatively short duration.
		Employment.	
		Communities or impact on amenities.	
Economics or Cost	Difference in cost.	Difference in cost compared for like-for-like activities; pipeline ends included in the comparison on the basis that they would incur mobilisation and demobilisation activities. This means that activities such as partial removal and complete removal, would incur incremental cost increases should the same vessels be used. Normalised to demonstrate a sense of scale.	In the short-term it is cheaper to do nothing, but this needs to be compared with the need for future surveys and potential remedial work.

Table 5.1.1: Comparative Assessment Method – Criteria & Sub-criteria

5.2 Comparative Assessment for pipelines in groups 1 and 2

The 'complete removal' and 'leave *in situ*' decommissioning options are compared for pipelines in Group 1 and Group 2. The pipelines considered here are the piggybacked pipelines and single pipelines with poor to good cover and no exposures.

5.2.1 Technical considerations

Both options are technically feasible. There is limited experience in reverse reeling individual trenched and buried pipelines in the UKCS, and as such the technical uncertainty was deemed likely to have an adverse effect on technical feasibility.

For Group 1 pipelines, technical feasibility and practicality is further tempered by the 8in rigid pipelines being piggybacked by the 3in pipeline and would complicate the recovery process. The pipelines could be recovered in sections using the 'cut and lift' method. This would involve dispersal of the existing deposited rock followed by 'cut and lift' operations. Although the method has been used for relatively short-lengths of pipeline, the length of pipeline(s) probably renders the 'cut and lift' approach impractical.

For Group 2 pipelines, technology is currently available to excavate and reverse reel flexible flowlines PL4261 and PL4262. This would involve excavation or dispersal of the existing deposited rock followed by the recovery operations. While the technology is available it could still prove problematic to achieve.

From a technical perspective the leave *in situ* decommissioning option is also feasible.

5.2.2 Safety considerations

The difference in potential safety risk between the options is sufficiently large that a HAZID was not considered necessary at this stage. A HAZID would ordinarily be carried out as part of the preparatory activities.

Safety Risk to Offshore Project Personnel

The key differences between the options are as follows.

- Risk to divers and personnel on the vessel from hydrocarbon or hazardous substance releases from recovered pipelines will be greater for complete removal than for leave *in situ* due to the larger volume of material that would be recovered;
- Risk associated with 'cut and lift' operations. Assuming the pipelines could successfully be excavated from a technical perspective the operation should be relatively straightforward. However, to ensure road transportable lengths, the 'cut and lift'; operations would require between ~80 to ~100 sections or pipe to be removed *per km* of pipeline. Arguably, from a safety perspective this would likely be manageable, but the associated risks would increase with the number of operations needing to be performed, and the amount of material needing to be transferred and handled on the vessel; No such risks would be incurred for the leave *in situ* decommissioning option;
- Risk associated with reverse reeling operations, with 8in rigid pipelines and the 3in piggybacked pipelines needing to be separated as they arrive at the recovery vessel and with the vessel being attached to the pipelines. The risk to personnel and assets would therefore be greater for complete removal option than for leave *in situ*;
- Risk associated with reverse reeling operations for complete removal, with the flexible flowlines PL4261 & PL4262) needing to be spooled onto a reel on a subsea support vessel being attached to the flowlines. The risk to personnel and assets would therefore be greater for complete removal option than for leave *in situ*;
- Increased risk to all activities due to adverse weather is greater for complete removal than for leave *in situ* as the vessels would be in the field for longer;

- Risk associated with legacy survey activities that is, the risks associated with vessels being used are greater for the leave *in situ* option than for complete removal. Typically, in the UK a minimum of three legacy surveys would be required to confirm the condition of subsea pipelines left *in situ*.

Given that the activities and techniques are frequently used in the North Sea it is assumed that the risks from all hazards relating to 'cut and lift' and reverse reel methods of removal would be broadly acceptable. It is acknowledged that there is relatively little experience of reverse reeling a trenched and buried pipeline and therefore this risk could be higher but still tolerable if sufficient mitigation and control measures are adopted. This risk relates only to the complete removal option.

Short-term Safety Risk to Fishermen and Other Marine Users

The risk to mariners in the short-term is aligned with the duration the activities would be undertaken in the field. While decommissioning operations are underway the duration of vessels in the field would be longer for the complete removal option than for leave *in situ*. Reverse reel and to an extent 'cut and lift' would mean that the vessel is attached to a pipeline(s) and could not move out of the way quickly.

For the leave *in situ* option only the pipeline ends would be dealt with; the duration of the vessels in the field would be much shorter for this option.

Therefore, while decommissioning activities are occurring, the risk to fishermen and other marine users would be least for the leave *in situ* option.

Residual Safety Risk to Fishermen and Other Marine Users

The greatest risk relating to marine users is likely to be concerned with snagging of fishing gear. The types of fishing in the area – albeit several km to the north-east, is predominantly trawler activity, targeting demersal fish and shellfish. Therefore, there is a potential for snagging on equipment left on the seabed, including spoil mounds. In this instance the pipelines being considered remain buried and survey 2019 data indicates that there are no free spans along the pipelines.

From this it can be reasoned that decommissioning activities that minimise the disturbance to the seabed, reduce the likelihood of creating snag hazards / spoil mounds and that leave the seabed free of equipment will minimise the impact on local fishing activities; this will be no different from the current situation. Both complete removal and leave *in situ* options would leave the seabed free of equipment. Although the complete removal option has the potential to leave spoil mounds that present snagging hazards, it is possible that with extra effort these could be dispersed, or they would disappear over time.

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

There is likely to be no increased snagging risk associated with the leave *in situ* option due to the burial status of the pipeline. However, surveys will need to be done in future in order to verify that the risk of snagging would remain low for the foreseeable future. Should pipeline stability and burial surveys notice that exposures or spans occur in future, remedial works may be required.

Health & Safety Risk to Onshore Project Personnel

The key differences between the options are as followed:

- Risks associated with cutting the pipeline(s) resulting in injury would be greater for complete removal due to the higher quantity of material returned to shore compared with the leave *in situ* option;
- Risks associated with lifting and handling pipeline sections are also greater for complete removal due to larger quantity of material being returned to shore.

Many of the hazards described in the foregoing safety assessment are common to both decommissioning options. Based on the differences, the leave *in situ* option gives rise to lower risks to onshore personnel for the following three reasons:

- Less offshore work;
- Less onshore handling;
- Unloading pipespools from a vessel has been done before, but to do this at all for the complete removal option would increase the risk to onshore personnel as compared to the leave *in situ* option;
- Unspooling of pipelines from a reel has been done before, but to have to do this at all increases the risk for onshore personnel compared to the leave *in situ* option.

5.2.3 Environmental considerations

The duration that vessels would be are required in the field for the complete removal option would be longer than required for leave *in situ*. This would be reflected in the discharges to sea, noise, energy requirements and emissions to air. Conversely the legacy survey requirements for leave *in situ* would be greater than for complete removal.

The amount of cutting, lifting and disposal requirements are related to the length of pipeline recovered. Therefore, the discharge to sea, discharges to surface water, noise in water from cutting, seabed disturbance from excavation and lifting, and the potential use of landfill space would all be greater for complete removal than for leave *in situ*.

Energy requirements and emissions to air would be such that there would be a difference between options. However, the gap between complete removal and leave *in situ* narrows when indirect energy requirements and emissions required for replacement of unrecovered material are accounted for.

While the complete removal option would result in no materials left in the seabed, the leave *in situ* option would result in materials being left to degrade naturally. As the pipelines and flowlines are predominantly manufactured from steel this would not be detrimental to the local environment. The flexible flowlines have a higher content of composite materials (~10%) and so would take so would take much longer than steel to decompose. The deposition of the composite materials into the marine environment would likely occur very gradually over hundreds of years, and so would be at little detriment to the local marine environment. Any raw material not recovered would need to be replaced by newly manufactured material.

5.2.4 Societal considerations

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

While the vessels are present in the field and activities are being undertaken the area will not be accessible for fishing. Therefore, the magnitude of the impact on commercial activities is related to the number and duration of vessels.

Activities which involve removal or reburial would implicitly disturb the seabed. Therefore, since complete removal would require more activities on the seabed it will have a higher short-term impact on commercial fishing.

Leave *in situ* would leave infrastructure that presents a potential snag hazard. In this situation there would be a greater chance that fishing gear could be lost or damaged, and this would have an impact on commercial fishing. However, the intensity of fishing activity in the area is low, and in this instance the pipelines are buried; and survey data suggests that there have been no reports of spans or snagging. Therefore, it is unlikely that the leave *in situ* removal option will be detrimental to commercial fishing activities.

For both options seabed clearance and risk assessments will be done to verify that residual snag

hazards will remain low and would be unlikely to occur.

Therefore, during decommissioning activities the complete removal option can be expected to have a greater impact on fishing activities as it would have the longest duration and the greatest amount of activity disturbing the seabed. Leave *in situ* would involve leaving the pipelines and flowlines where they are, and this could result in residual snag hazards. Surveys may need to be undertaken to confirm that the pipelines and flowlines remain buried. While these surveys are being undertaken fishing activity may be disrupted for a short time, but the impact can be expected to be minimal. Typically, at least two post decommissioning surveys would be required; the exact magnitude of the impact will be dependent on the type, frequency and duration of the surveys required.

Employment

The complete removal option would require a longer vessel duration and more waste management requirements. This option would therefore impact more positively on employment than leave *in situ*. However, the effect on employment would likely result in the continuation of existing jobs, rather than lead to the creation of new employment opportunities. The significance of the positive impact has therefore been assessed as low.

Communities

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

5.2.5 Cost considerations

More details of the cost assessment for the pipelines in groups 1 & 2 are presented in Appendix E, Table E.3.1. In all instances the complete removal option would cost more than the leave *in situ* option in the short-term but once completed, no more costs would be incurred for future pipeline surveys. Conversely, pipelines - or parts thereof, that are left *in situ* would likely be subject to future pipeline inspections. Future pipeline surveys can be expected to cost less than the operations associated with complete removal and dealing with the associated waste materials onshore.

For the piggybacked pipelines in Group 1 (PL2572 & PL2573, PL2578 & PL2579 and PL2583 & PL2584) using an incremental difference calculation, the complete removal options - using the ‘cut and lift method and a subsea support vessel, would cost at least an order of magnitude (i.e. more than 10x greater) than the leave *in situ* option. However, please refer assumptions in Appendix E.2.

For the flexible flowlines in Group 2 (PL4261 & PL4262) using an incremental difference calculation, the complete removal option using reverse reel and a subsea support vessel the cost would be less than an order of magnitude greater than leave *in situ*. However, please refer assumptions in Appendix E.2.

The assessment assumes 1x post decommissioning survey would be required irrespective of the decommissioning options, and 3x legacy surveys would be required for any pipelines or flowlines being left i*n situ*.

5.3 Comparative Assessment for pipelines in group 3

The ‘complete removal’, ‘partial removal’ and ‘leave *in situ*’ decommissioning options are compared for Group 3. This group of pipelines includes individual rigid pipelines and umbilicals. The pipelines and umbilicals have poor depth of cover and multiple exposures along their length, and so there could be merit in removing or remediating just those sections of pipelines that are exposed and currently presenting a potential snagging risk, without removing the whole length.

For DSW, PLU2576 (3.9km) and PLU2577 (~1.3km long) were laid in sequence in the same trench as PL2581 (5.2km), separated by a short excursion to the DSW DSU. Refer Figure B.1.1. For WD, PL2582 (~2.3km long) and PLU2585 (~2.6km long) share the same trench in the seabed. Refer Figure B.3.1.

The discussion in section 5.2 comparing the complete removal vs. leave *in situ* also applies here but in this case the comparison addresses the partial removal option as well. The partial removal component considers whether exposed sections of pipelines should be remediated in some way, either by removal of the exposed sections of pipeline and remediating the ends that remain, or by remediating the exposure. This might be achieved either by post-trenching or by the deposition of additional rock.

5.3.1 Technical considerations

All three options would be technically feasible. However, partial removal – that is, removal of the exposed sections of pipeline would not find favour. Primarily this is because of the effort that would be involved in finding and locally excavating the exposed pipelines to reveal the appropriate cut locations. Partial removal activities would likely involve piece-meal excavation and 'cut and lift' activities, with the effort required increasing for an increasing number of exposures or spans being remediated. As a worst case, albeit technically feasible, partial removal using the local excavations and 'cut and lift' method would be expected to take longer than the continuous process associated with complete removal.

Technology is currently available to excavate and reverse reel the two rigid pipelines PL2581 and PL2582 and the three umbilicals PLU2576, PLU2577 and PLU2585 although different types of recovery vessels would likely be used. Technology is also available for the pipelines to be recovered using 'cut and lift' method of recovery. Should it be considered that the integrity of PL2581 and PL2582 would be suitable for reverse reel, their recovery of these rigid pipelines would likely warrant use of a pipelay vessel. A subsea support vessel or anchor handling vessel would likely be suitable for recovering the umbilicals. It is worth noting here that water injection pipelines PL2581 and PL2582 were replaced by PL4262 and PL4261 respectively for integrity reasons[3], so there will remain considerable uncertainties as to the viability of the reverse reel method of recovery for these pipelines. On this basis, the 'cut and lift' method would be preferred for the complete and partial removal options and has been used for this assessment.

From a technical perspective deposition of additional rock would be feasible. For those pipelines or umbilicals already covered in rock, it is unlikely that post-trenching would be considered technically feasible, although post-trenching may be possible for pipelines or umbilicals buried in the seabed. Complications may arise for post-trenching of pipelines or umbilicals sharing the same trench, as it will depend on their spacing; this might affect the suitability of the method. On basis it is assumed that deposition of additional rock would be a more viable alternative to partial removal.

Rigid pipelines and umbilicals have been left *in situ* before so this is technical feasible.

5.3.2 Safety considerations

The difference in potential safety risk between the options is sufficiently large that a HAZID was not considered necessary at this stage. A HAZID would ordinarily be carried out as part of the preparatory activities.

Safety Risk to Offshore Project Personnel

The key differences between the options are as follows.

- Risk to divers and personnel on the vessel from hydrocarbon or hazardous substance releases from recovered pipelines will be greater for complete removal than for leave *in situ* due to the larger volume of material that would be recovered;

[3] Pipeline corrosion issues resulting in significant wall thinning.

- Risk associated with 'cut and lift' operations. Assuming the pipelines could successfully be excavated from a technical perspective the operation should be relatively straightforward. However, to ensure road transportable lengths, the 'cut and lift'; operations would require between ~80 to ~100 sections or pipe to be removed *per km* of pipeline. Arguably, from a safety perspective this would be manageable, but the associated risks would increase with the number of operations needing to be performed and the amount of material needing to be transferred and handled on the vessel; No such risks would be incurred for the leave *in situ* decommissioning option;
- Risk associated with reverse reeling operations for complete removal, with rigid pipelines needing to be spooled onto a reel on a recovery vessel, and risks associated with the vessel being attached to pipelines of unknown integrity, particularly as they would be subject to tension forces as they are pulled from burial. The risk to personnel and assets would therefore be greater for complete removal option than for leave *in situ* but probably less than for the piece-meal 'cut and lift' operations associated with partial removal;
- Risk associated with reverse reeling operations for complete removal, with umbilicals needing to be spooled onto a subsea support vessel being attached to the umbilicals. The risk to personnel and assets would therefore be greater for complete removal option than for leave *in situ*. Arguably the risks associated with partial removal using reverse reel could be greater for partial removal than complete removal because of the piece-meal nature of recovery operations;
- Increased risk to all activities due to adverse weather is greater for complete removal than for leave *in situ* as the vessels would be in the field for longer but for probably less time than for piece meal partial removal operations;
- Risk associated with deposition of rock either along part or all of the pipelines or umbilicals. The operational risks would increase with the amount of material involved but can be expected to be low. To have to carry out the operation at all would present more of a risk than doing nothing at all;
- Risk associated with legacy survey activities that is, the risks associated with vessels being used are greater for the leave *in situ* and partial removal options than for the complete removal option. In this regard, there would be no benefit in pursuing anything other than the complete removal option. Typically, in the UK a minimum of three legacy surveys would be required to confirm the condition of subsea pipelines – or parts thereof, left *in situ*.

Given that the activities and techniques are frequently used in the North Sea it is presumed that the risks from all hazards would be broadly acceptable. It is acknowledged that although the pipelines and umbilicals could be excavated, there is little experience of reverse reeling trenched and buried pipelines and therefore this risk could be higher but still tolerable if sufficient mitigation and control measures are adopted. This risk relates to the complete removal and possibly the partial removal option.

Short-term Safety Risk to Fishermen and Other Marine Users

The risk to mariners in the short-term is aligned with the duration the activities would be undertaken in the field. While decommissioning operations are underway the duration of vessels in the field would be longer for either the complete removal or partial removal options than for leave *in situ*. Reverse reel and to an extent 'cut and lift' would mean that the vessel is attached to a pipeline and could not move out of the way quickly.

For the partial removal option or deposition of additional rock, the duration that the vessels would be in the field would be shorter than for complete removal but longer than for leave *in situ*.

For any post trenching activities, the duration would be related to the length of pipelines or umbilicals being trenched, but it could be expected that the duration would be less than complete removal activities but longer than for leave *in situ*.

For the leave *in situ* option only the pipeline or umbilical ends would be removed and the duration of the vessels in the field would be much shortest for this option.

Therefore, while decommissioning activities are occurring, the risk to fishermen and other marine users would be least for the leave *in situ* option.

Residual Safety Risk to Fishermen and Other Marine Users

The greatest risk relating to marine users is likely to be concerned with snagging of fishing gear and this could be due to snagging on pipelines or snagging on equipment left on the seabed, including spoil mounds.

In the 2019 surveys it was observed that 62.6% of PL2581 was exposed, and 39.7% of PL2582 was exposed. Also, five anomalous spans totalling 25m were observed for PLU2576, 15.9% of PLU2577 was exposed, and 3.4% of PLU2585 was exposed. Two non-reportable spans 14.8m and 1.9m long were observed for PLU2576, and two non-reportable spans 7.1m and 5.2m long were observed for PL2581. All the non-reportable spans occur outside of the 500m safety zones. In PLU2577 there is also a 11m long anomaly to the side and up the side wall of the trench at KP0.055 This means that there is a potential for snagging and snagging risks would generally be higher for spans than for pipelines or umbilicals that are merely exposed.

It can be reasoned that decommissioning activities that minimise the disturbance to the seabed and reduce the likelihood of creating snag hazards or spoil mounds and that leave the seabed free of equipment will minimise the potential impact on local fishing activities.

The complete and partial removal options would leave the seabed free of equipment, although any resulting spoil mounds would likely need to be dispersed.

As mentioned earlier, PLU2576 & PLU2577 were laid in the same trench as PL2581, and PLU2585 was laid in the same trench as PL2582. This could mean that removal of one or the other – either the umbilical or the adjacent pipeline, would likely result in a disruption to the other lying nearby. This means that the complete removal option would need to apply to none or all of the pipelines and umbilicals in any one trench. The situation would be similar for the removal of just part of a pipeline or umbilical; another lying nearby in the same trench would also likely be disrupted. Should only one or other pipeline or umbilical be removed from a trench it can be expected that remedial work such as deposition of additional rock, would need to follow.

The leave *in situ* option would be no different to the current situation although future surveys would need to be done in future to confirm that the pipelines and umbilical remain stable and that risk of snagging would remain low.

Health & Safety Risk to Onshore Project Personnel

The key differences between the options are as followed:

- Should deposition of rock be required, there would be risks associated with the quarrying of rock, its transportation, and transfer to a rock discharge vessel at quayside, although the risks might be expected to be well managed, and so would be low;
- Risks associated with cutting the pipeline(s) or umbilical(s) resulting in injury would be greater for complete removal and partial removal options due to the higher quantity of material returned to shore compared with the leave *in situ* option. More material would be recovered to shore for the complete removal option;
- Risks associated with lifting and handling sections or pipeline or umbilical are also greater for the complete removal and partial removal options due to larger quantity of material being returned to shore.

Many of the hazards described in the foregoing safety assessment are common to both decommissioning options. Based on the differences, the leave *in situ* option gives rise to lower risks to personnel for the following three reasons:

- Less offshore work;
- Less onshore handling;

- Unloading pipespools from a vessel has been done before, but to do this at all for either the complete or partial removal options would increase the risk to onshore personnel compared to the leave *in situ* option;
- Unspooling of pipelines from a reel has been done before, but to have to do this at all increases the risk for onshore personnel compared to the leave *in situ* option.

5.3.3 Environmental considerations

The duration that vessels would be required in the field for the complete removal and partial removal option would be longer than required for leave *in situ* and the piece-meal nature of partial removal activities could take longer than those associated with complete removal. This would be reflected in the discharges to sea, noise, energy requirements and emissions to air. Conversely, the legacy survey requirements for partial removal and leave *in situ* would be greater than for complete removal, and in the case of partial removal the need for remedial works such as post trenching or deposition of rock ion the pipeline ends would increase with the number of cut pipeline ends.

The amount of cutting, lifting and disposal requirements are related to the length of pipeline or umbilical being recovered. Therefore, the discharge to sea, discharges to surface water, noise in water from cutting, seabed disturbance from excavation and lifting, and the potential use of landfill space would all be greater for the complete removal and partial removal options than for leave *in situ*. From this perspective the impact of the partial removal options would be slightly less than for complete removal but much more than for the leave *in situ* option.

Used instead of partial removal, remedial work such as post-trenching and backfill, or the deposition of rock would cause more disruption to the seabed. Post-trenching and backfill would be temporary although the indications are that the seabed in the area is relatively immobile, meaning that any post trenching and backfill would have a more than temporary effect on the seabed. Deposition of rock would involve the permanent addition of a hard substrate to the area. The area of seabed impacted would be similar for both these methods of remediation.

Energy requirements and emissions to air would be such that there would be little difference between the complete and partial removal options for PL2582. This is because of the additional time vessel time needed to find and remediate the cut the pipelines at the end of each exposure. For other pipelines and umbilicals there would be a more discernible difference in energy use and emissions for the complete removal, partial removal and leave *in situ* options. However, the gap between complete removal, partial removal and leave *in situ* narrows when indirect emissions and energy requirements – such as that required for replacement of unrecovered material – are accounted for.

Energy requirements for post-trenching remediation would likely be comparable to partial removal, while the deposition of additional rock might be expected to involve less vessel time than the complete or partial removal operations, and the operation would be relatively straightforward.

While the complete removal option would result in no materials left in the seabed, the partial removal and leave *in situ* options would result in materials being left to degrade naturally. As the rigid pipelines are predominantly manufactured from steel this would not be detrimental to the local environment. Umbilicals are manufactured from a variety of materials including steel and plastics and so would take much longer than steel to decompose. The deposition of composite materials into the marine environment would likely occur very gradually over hundreds of years, and so would be at little detriment to the local marine environment. Any raw material not recovered would need to be replaced by newly manufactured material.

5.3.4 Societal considerations

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

While the vessels are present in the field and activities are being undertaken the area will not be accessible for fishing. Therefore, the magnitude of the impact on commercial activities is related to

the number and duration of vessels.

Activities which involve removal or reburial would implicitly disturb the seabed. Therefore, since complete removal will require more activities on the seabed it will have a higher short-term impact on commercial fishing.

Both the leave *in situ* and partial removal options would involve leaving infrastructure behind, presenting a potential snag hazard. In either situation there would be a greater chance that fishing gear could be lost or damaged, and this would have an impact on commercial fishing. The leave in situ option would present more of a potential snag hazard than partial removal or remedial works, with the potential consequence of lost commercial fishing time and fishing equipment. According to survey records there are no records of any snagged fishing equipment on these pipelines and umbilicals.

The most recent surveys have indicated that no reportable spans are present, and there have been no reports of snagging, so it is unlikely that the leave *in situ* removal option would be detrimental to commercial fishing activities.

For all the decommissioning options seabed clearance and risk assessments would be done to verify that residual snagging hazards remain low and would be unlikely to occur.

Therefore, during decommissioning activities, in the short-term the complete removal and partial options can be expected to have a greater impact on fishing activities as they would have the longest duration and the greatest amount of activity disturbing the seabed. The partial removal and leave *in situ* options would involve leaving most of the pipelines where they are, and this could result in residual snag hazards. Pipeline surveys may need to be undertaken to confirm that the pipelines remain buried. While these surveys are being undertaken fishing activity may be disrupted for a short time, but the impact can be expected to be minimal. Typically, at least two post decommissioning surveys would be required; the exact magnitude of the impact will be dependent on the type, frequency and duration of the surveys required.

Employment

The complete removal and partial removal options would require a longer vessel duration and waste management requirements and therefore impacts more positively on employment than leave *in situ*. The effect on employment would likely result in the continuation of existing jobs, rather than lead to the creation of new employment opportunities. The significance of the positive impact can, however, be assessed as low. The same can probably be said for any remedial works carried out in lieu of partial removal.

Communities

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

5.3.5 Cost considerations

More details of the cost assessment by difference for the pipelines in group 3 are presented in Appendix E, Table E.3.1. In all instances the complete removal option would cost more than the leave *in situ* option in the short-term but once completed, no more costs would be incurred for future pipeline surveys. Conversely, pipelines - or parts thereof, that are left *in situ* would likely be subject to future pipeline inspections. Future pipeline surveys can be expected to cost less than the operations associated with complete removal and dealing with the associated waste materials onshore.

For the purposes of the cost assessment, because of the uncertainties relating to integrity it is assumed that full recovery of PL2581 and PL2582 would be carried out using ‘cut and lift’ using a subsea support vessel or an anchor handling tug supported by the necessary equipment spreads

such as ROVs, excavation tools, hydraulic shears, etc. Full recovery of the umbilicals PLU2576, PLU2577, PLU2585 would be done using the same type of vessel.

Using a by difference calculation of the costs, for PL2581 and PL2582 the complete removal option would cost more than an order of magnitude (i.e. more than 10x) than the leave *in situ* option. For PL2582 using 'cut and lift', and assuming 99 exposures the partial removal method would take longer and cost slightly more than complete removal. This is because of the additional time needed to find, excavate, cut, and remediate the cut pipeline ends. Otherwise, for PL2581 the partial removal option would cost less than the complete removal option but still an order of magnitude more than the leave *in situ* option.

For PLU2576, PLU2577, and PLU2585 the complete removal option the incremental difference in cost is less than an order of magnitude greater than leave *in situ*. The incremental difference in cost for the partial removal option is less than complete removal and less than an order of magnitude greater than leave *in situ*. The assessment assumes 1x post decommissioning survey would be required irrespective of the decommissioning options, and 2x legacy surveys would be required for any pipelines or umbilicals being left i*n situ*.

Due to the disruption that would be caused by removing just one of the adjacent pipelines and umbilicals in a trench it was worth exploring combining the by difference costs for all of the pipelines. For this situation, the complete removal option cost by difference would be an order of magnitude greater than leave *in situ*. Partial removal would also be an order of magnitude greater than leave *in situ*. Although not calculated, by inspection it can be expected that the deposition of rock would cost significantly less than partial removal.

6. CONCLUSIONS

6.1 Overview

The comparative assessment was undertaken with a focus on the decommissioning options for the various pipelines associated with the Don South West and West Don developments. The pipelines were split into three groups as indicated in Table 4.1.1. Pipeline groups 1 & 2 were assessed for the complete removal and leave *in situ* decommissioning options, while pipeline group 3 was assessed for partial removal as well as the complete removal and leave *in situ* decommissioning options.

The assessments considered five criteria for both the short-term decommissioning activities and the longer-term for 'legacy' related activities. The criteria were: technical feasibility, safety related risks with three sub-criteria, environmental with four sub-criteria, societal effects with three sub-criteria and cost.

Since the decommissioning of the surface laid ends at Don South West, Conrie, Ythan and West Don is the same irrespective of which option is pursued, decommissioning of these is not included in the assessment. Therefore, any differences are incremental to the activities associated with surface laid infrastructure.

6.2 Conclusion for pipelines in groups 1 & 2

All pipelines are trenched and buried with no exposures evident from when they were first installed or from most recent survey data. The assessment found that for the complete removal option the technical feasibility, short-term safety risk to project personnel both offshore and onshore would be 'tolerable' rather than broadly acceptable or preferred. Otherwise, except for cost there was little to differentiate the options.

From a purely technical perspective, the 'cut and lift' method would likely be the most viable for complete removal but usually this approach would only be used for relatively short lengths of pipeline. Reverse reel could be considered technically feasible for the two flexible flowlines.

In practical terms *in situ* decommissioning would be easier to achieve technically.

Many of the health and safety hazards described herein are common to both decommissioning options. Based on the differences, in the short-term the leave *in situ* option gives rise to lower risks to project personnel.

Differences are found between the safety assessment with more work required offshore and onshore for complete removal than leave *in situ* and consequently higher safety risk. Conversely there would be lower safety risks to mariners arising from complete removal than for leave *in situ* because the pipelines would no longer be present as a potential snag hazard. However, the assessment concluded that even with the pipelines remaining *in situ* the snagging risk posed to fishermen and other users of the sea would remain low on the basis that the pipelines would remain buried and because currently there is a low incidence of fishing activity in the area.

Finally, there is an order of magnitude in the incremental difference in cost for complete removal of the piggybacked pipelines versus leave *in situ*., while the incremental difference in cost for removing the flexible flowlines would be less than an order of magnitude greater than leave *in situ*.

In conclusion, based on the comparative assessment leave *in situ* is the recommended option for decommissioning the pipelines in groups 1 and 2.

6.3 Conclusions for pipelines in group 3

Please refer section 6.2 as we believe that the various environmental and societal impacts for the pipelines in group 3 are broadly similar for rigid pipeline or umbilical removal operations. Therefore, for brevity, the discussion will not be repeated here, but focus instead on two elements – technical

assessment and safety, where partial removal option might make a small, but material change to the results of the assessment.

As mentioned earlier, there is a complication. PLU2576 & PLU2577 were laid in the same trench as PL2581, and PLU2585 was laid in the same trench as PL2582. This could mean that removal of one or the other – either the umbilical or the adjacent pipeline, would likely result in a disruption to the other lying nearby. This means that the complete removal option would need to apply to none or all of the pipelines and umbilicals in any one trench. The situation would be similar for the removal of just part of a pipeline or umbilical; another lying nearby in the same trench would also likely be disrupted. Should only one or other pipeline or umbilical be removed from a trench it can be expected that remedial work such as deposition of additional rock, would need to follow.

From a purely technical perspective, the 'cut and lift' method would likely be the most viable for complete removal and partial removal options but usually this approach would only be used for relatively short lengths of pipeline.

Should removal operations be non–preferred, there remains the possibility of depositing rock over existing exposures or spans. While this operation is technically feasible and could be carried out without incident, this approach would have the disadvantage of requiring new material, and of introducing additional hard strata onto the seabed. The area of seabed impacted could be expected to be similar to the area impacted by any removal operations. If we assume a 10m corridor of additional rock, the total area of seabed affected in this way would measure up to ~0.081km^2.for the combined lengths of PLU2576, PLU2577 & PL2581 and PLU2585 & PL2582.

In practical terms, *in situ* decommissioning would be easier to achieve. The two former water injection pipelines PL2581 and PL2582 are known to have integrity issues, therefore, it has been assumed that removal using reverse reel would not be viable. Technically, using the 'cut and lift method for complete and partial removal of the rigid pipelines the partial removal option would likely be feasible, although the piece-meal nature of operations would be non-preferred, as would the need for local excavations and remediation of the several tens of cut pipeline ends.

It would be feasible to remove completely, or partially the three umbilicals using the reverse reel method.

Many of the health and safety hazards described herein are common to all three decommissioning options. Based on the differences, in the short-term the leave *in situ* option gives rise to lower risks to project personnel than either complete or partial removal of the pipelines or remediation using deposited rock.

Differences are found between the safety assessment with more work required offshore and onshore for complete removal or partial removal than for leave *in situ* and consequently higher safety risk. The level of risk can be considered proportionate to the amount of material handled, both offshore and onshore. Conversely there would be lower safety risks to mariners arising from complete removal than for leave *in situ* because the pipelines would no longer be present as a potential snag hazard. It could be argued that in the short-term the partial removal option would present a higher risk of snagging than leave *in situ* because of an increased number of pipeline ends being present, even though they would have been remediated in some way. This on the basis that to have any cut ends at all would be worse than having none, and when tens of cut pipeline ends exist the probability of just one becoming exposed over time would increase.

It can be concluded that from a snagging risk perspective the complete removal option would be preferred followed by the leave *in situ* options. As long as pipelines remain *exposed* rather than become reportable spans this would be acceptable from the snagging risk perspective and there would be no need to deposit additional rock. However, over time the pipelines would degrade so this would need to be monitored with remedial work being carried out as and when required.

Due to the disruption that would be caused by removing just one of the adjacent pipelines and umbilicals in a trench, the by difference costs were combined for all of the pipelines and umbilicals in

this group. For this situation, the complete removal option cost by difference would be an order of magnitude greater than leave *in situ*. Partial removal would also be an order of magnitude greater than leave *in situ*. Although not calculated, by inspection it can be expected that the deposition of rock would cost significantly less than partial removal.

In conclusion, based on the comparative assessment leave *in situ* is the recommended option for decommissioning the pipelines in group 3, but the pipelines would need to be monitored for any changes. This would avoid the deposition of rock in the short-term and allow then trenches and exposures to be monitored.

7. REFERENCES

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[2] EnQuest (2020) Combined Decommissioning Programmes for Northern Producer FPF Float-off and Disconnection of Risers and Pipelines, M4109-ENQ-NPR-DN-00-PRG-0001;

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APPENDIX A LAYOUTS OF FIELDS AFTER DEPARTURE OF NORTHERN PRODUCER

Appendix A.1 Field Layouts – Phase 2 Scope

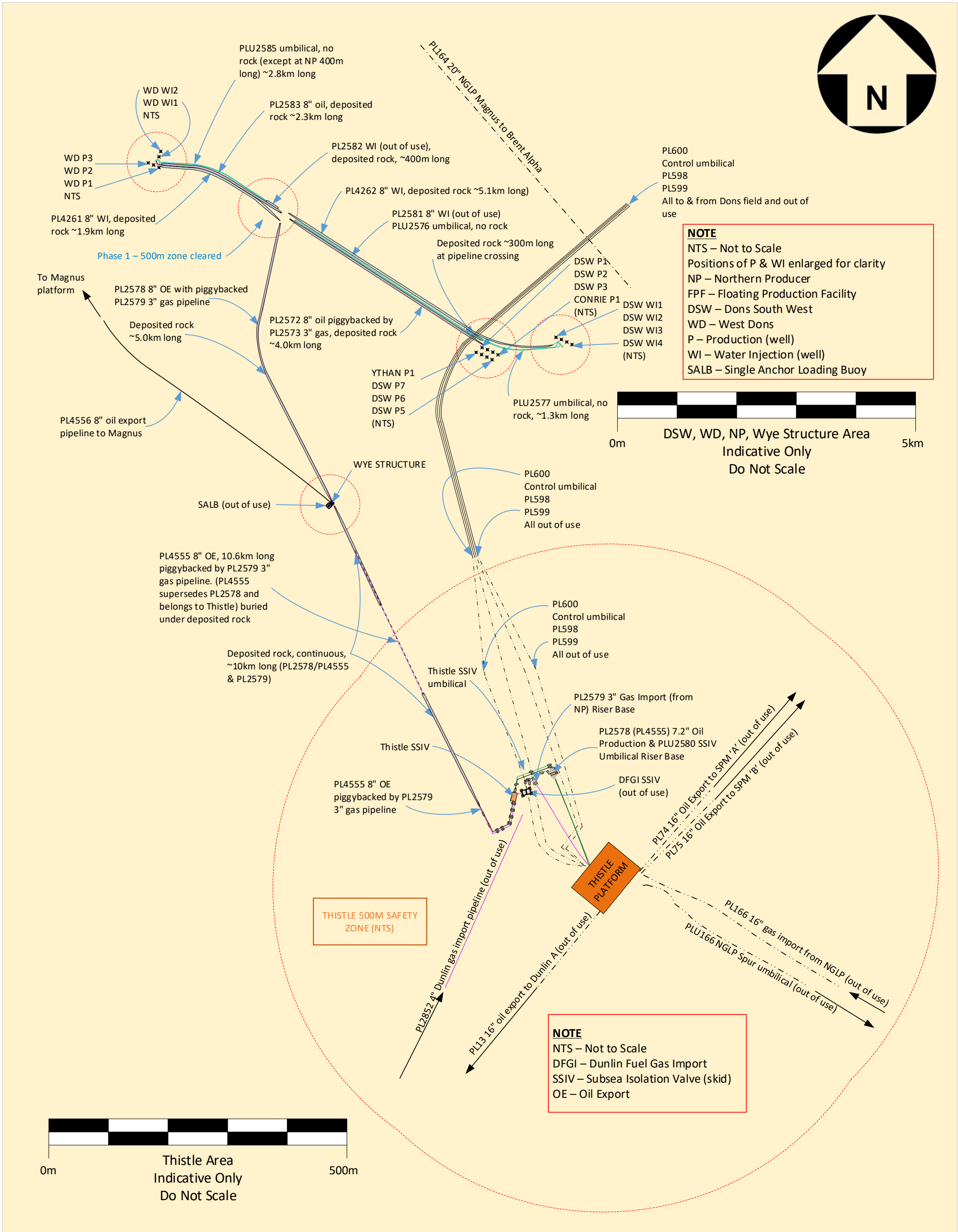

Figure A.1.1: Layouts of Conrie, DSW, WD and Ythan fields after departure of NP FPF)

APPENDIX B LAYOUTS OF CONRIE, DSW, WD AND YTHAN FIELDS

Appendix B.1 Don South West Production (with Conrie & Ythan)

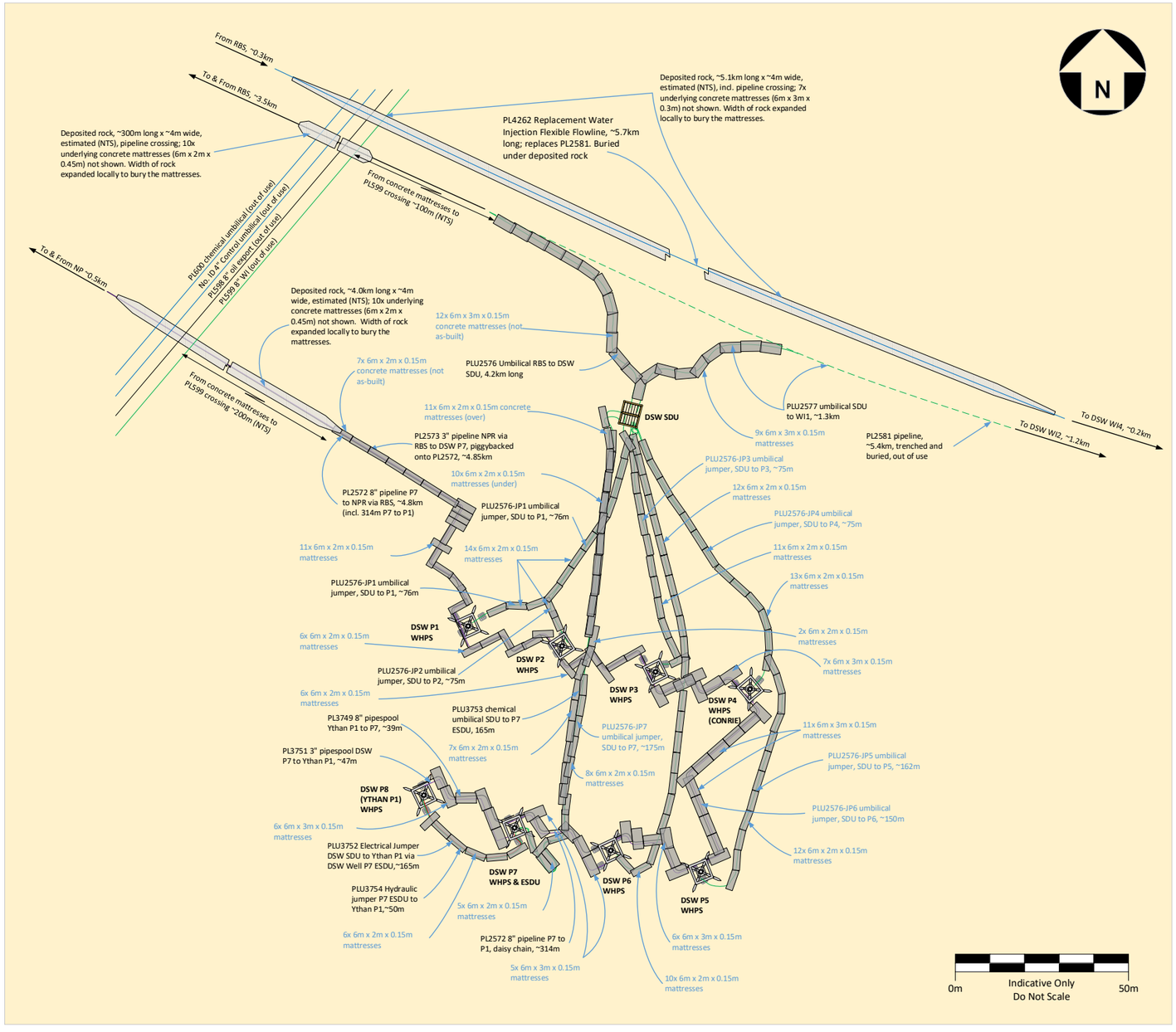

Figure B.1.1: Layout Showing DSW, Conrie & Ythan and associated infrastructure)[4]

[4] This layout has been included for information. Separate Decommissioning Programmes will be prepared to address future decommissioning activities.

Appendix B.2 Don South West WI

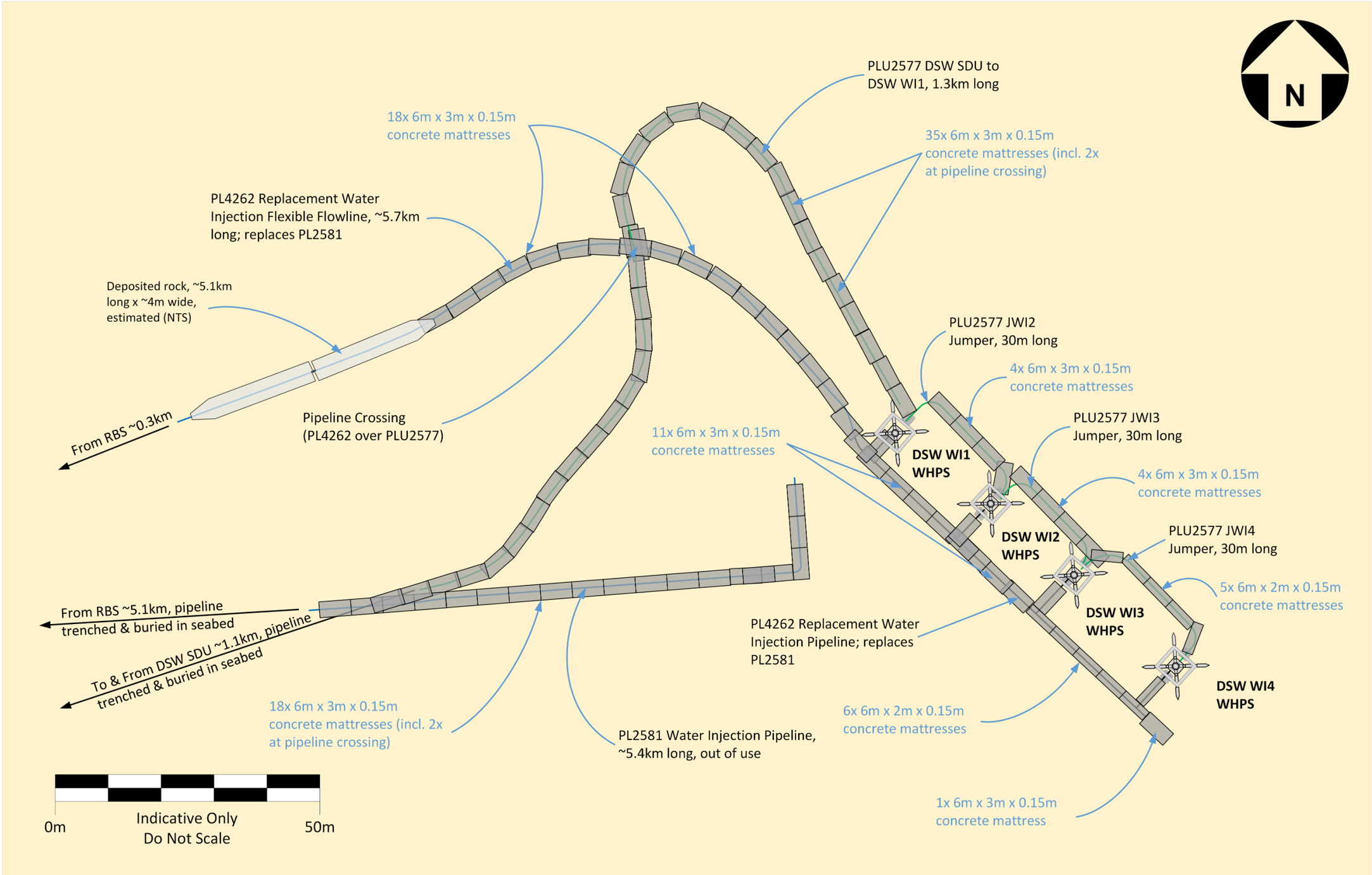

Figure B.2.1: Layout showing DSW WI and associated infrastructure[2]

Appendix B.3 West Don Production & WI

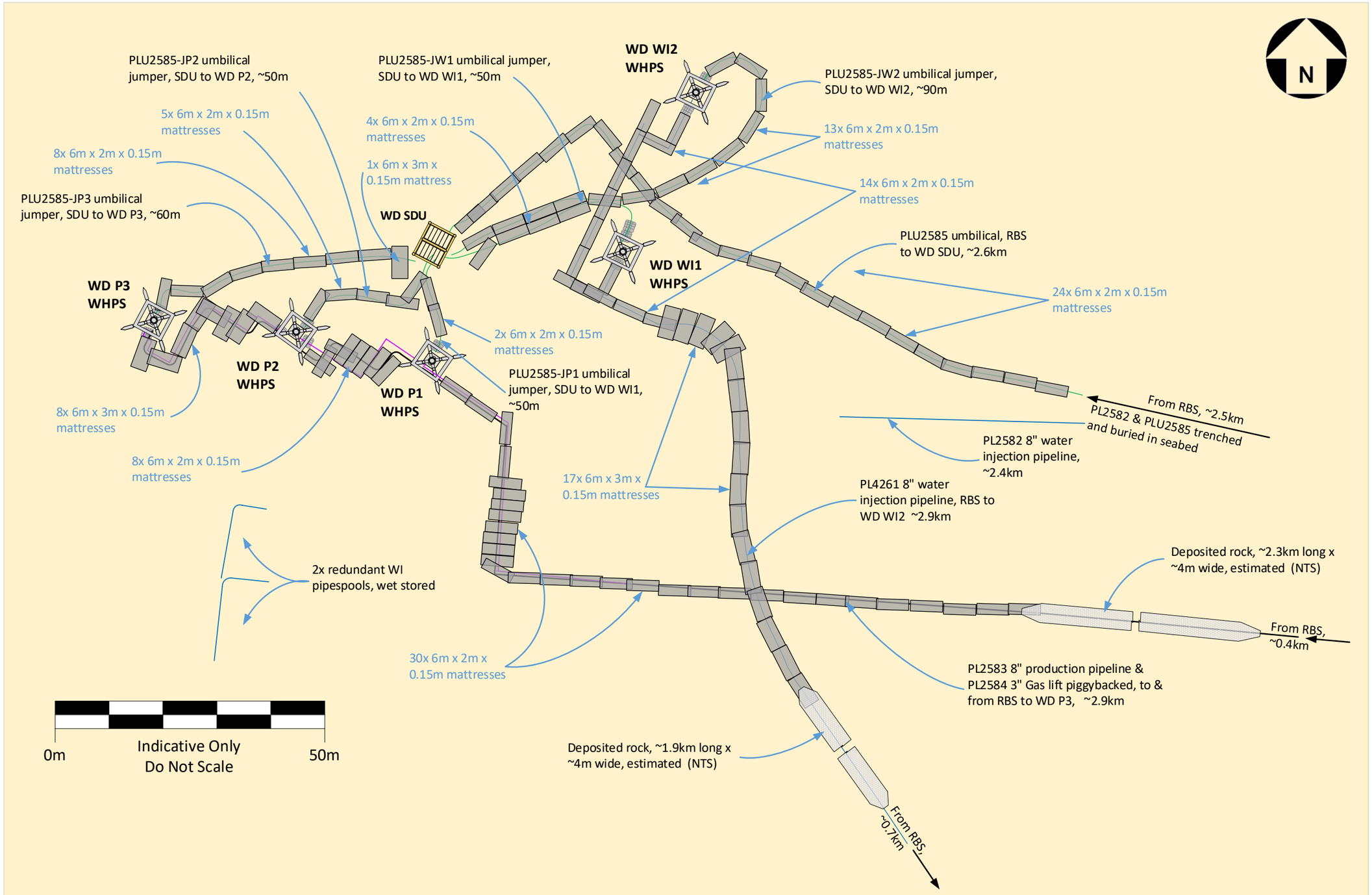

Figure B.3.1: Layout Showing WD Production & Water Injection[2]

Appendix B.4 Wye Structure Approaches

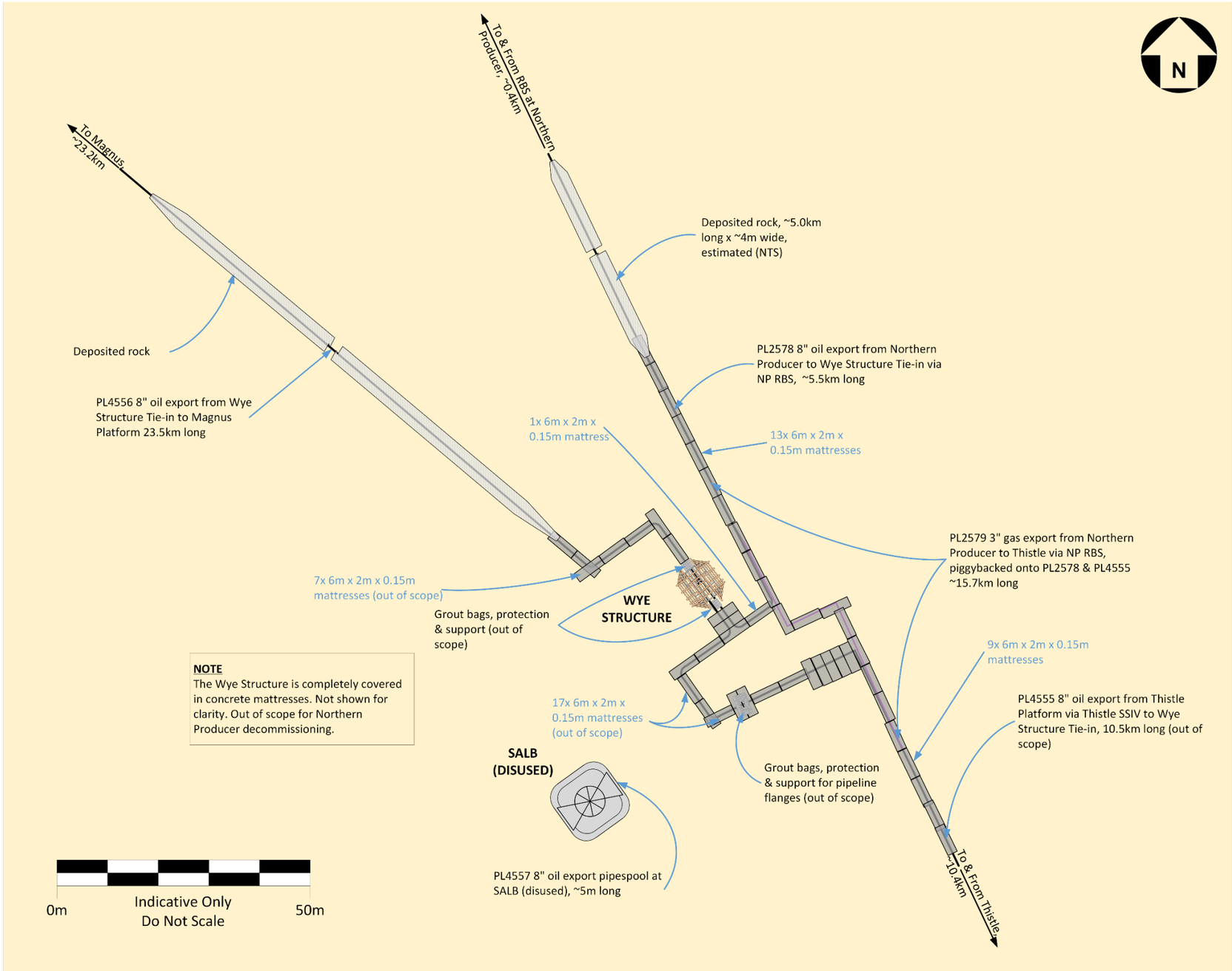

Figure B.4.1: Wye Structure Approaches

Appendix B.5 Thistle Alpha Approaches

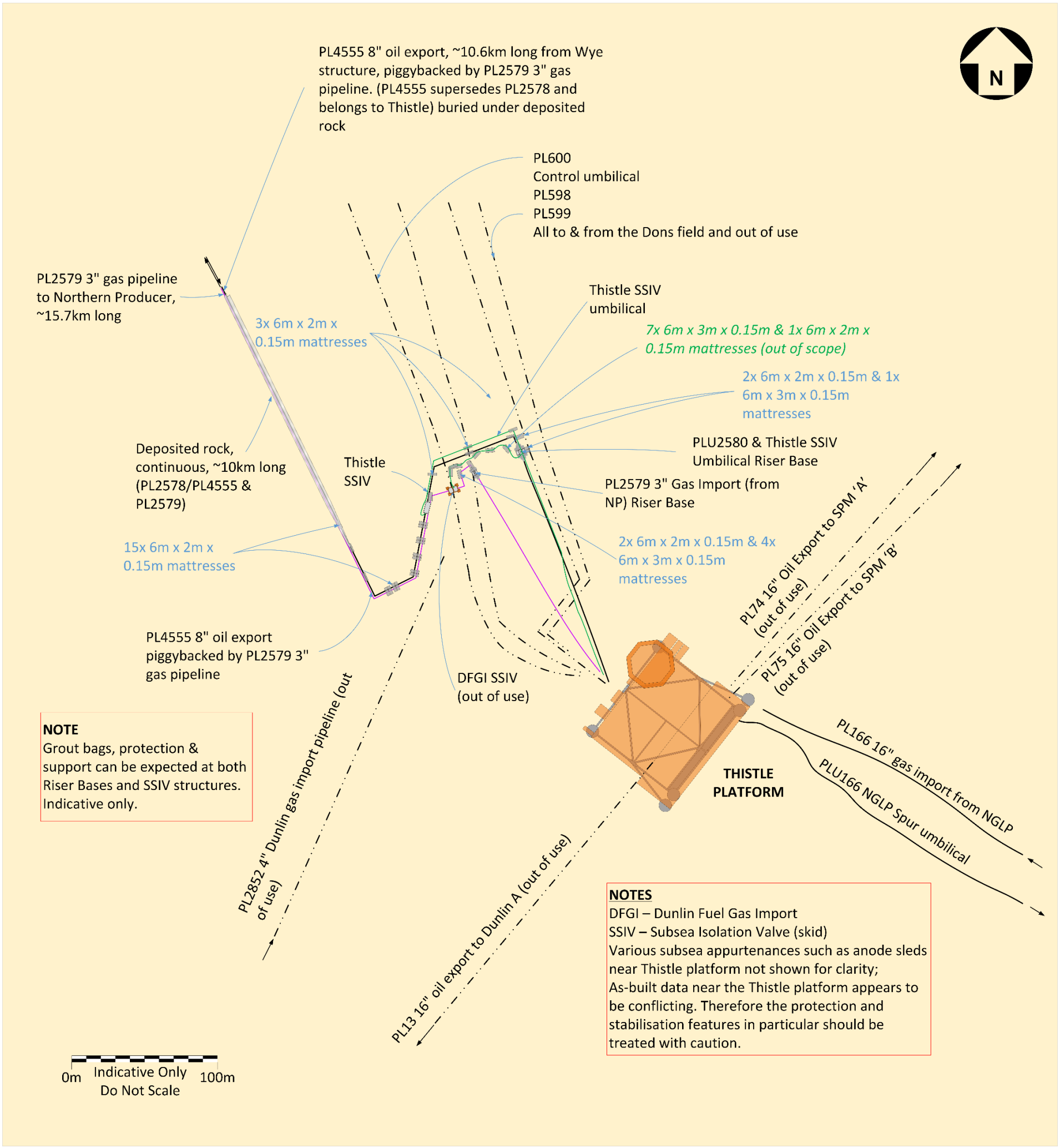

Figure B.5.1: Thistle Alpha Approaches

APPENDIX C PIPELINE GROUP 1 & 2 – COMPARATIVE ASSESSMENT TABLES

Appendix C.1 Groups 1 & 2 – Technical Assessment

CRITERIA	ASPECT	SUB-CRITERIA	OPTION 1 COMPLETE REMOVAL	OPTION 3 LEAVE *IN SITU*
Technical	**Offshore Execution**	Risk of project failure	Technically, complete removal of the pipeline(s) would most likely be achievable, but significant complications could arise because the pipelines are buried, and several are piggybacked.	Technically, the pipeline(s) could be left *in situ.*
		Technological challenge	Technology is currently available to excavate, cut and recover the pipelines to shore. Technology is currently available to excavate and reverse reel PL4261 and PL4262.	N/A
		Technical challenge	Excavation of pipeline(s) buried under deposited rock could prove problematic. 'Cut and lift' method would likely be the preferred method for removing the piggybacked pipelines, otherwise either the reverse reel or reverse S-lay method could be used for recovery of individual pipeline(s) whose integrity remains intact.	Stable and buried pipeline(s) have been left *in situ* before so this approach would be achievable.
Technical	**Legacy**	Risk of project failure	No pipeline surveys would be required in future.	Pipeline surveys have been undertaken in the past, so this is achievable with no complications.
		Technological challenge	No pipeline surveys would be required in future.	The technology is currently available for carrying out pipeline surveys.
		Technical challenge	No pipeline surveys would be required in future.	There would be no technical issues associated with carrying out pipeline surveys in future.

Table C.1.1: Pipeline Groups 1 & 2 - Technical Assessment

Appendix C.2 Groups 1 & 2 – Safety Assessment

CRITERIA	ASPECT	SUB-CRITERIA	OPTION 1 COMPLETE REMOVAL	OPTION 3 LEAVE *IN SITU*
Safety	**Offshore Execution**	Health & safety risk offshore project personnel	More offshore work than leave *in situ*. Excavation of the pipeline. No experience in the UKCS of either reverse reel or reverse S-lay of piggybacked, trenched, and buried pipelines as a method of removal although there is some experience of using the 'cut and lift' method for short pipelines. There is experience of recovering individual pipelines by reverse reel. Use of the 'cut and lift' method for removal would be repetitive, with the number of repetitions increasing with the length of pipeline.	Only the pipeline ends would be dealt with; Less offshore work than for complete removal. Experience in the UKCS a of removal of pipeline sections. Significantly less work and therefore a shorter duration of activities than for complete removal.
		Health & safety risk to mariners	Duration of vessels in the field would be longer than for leave *in situ*. Reverse reel or reverse S-lay would mean that the vessel is attached to a pipeline and could not move out of the way quickly. The risk to mariners in the short-term is aligned with the duration the activities would be undertaken in the field.	Only the pipeline ends would be dealt with; duration of vessels in the field would be shorter than for complete removal.
		Safety risk onshore project personnel	Safety risk is linked to the quantity of material returned to shore. Therefore, there would be significantly more onshore cutting, lifting, and handling for complete removal than for leave *in situ*.	No onshore work except for that associated with the pipelines ends, which would be common for both options.
Safety	**Legacy**	Health & safety risk offshore project personnel	No pipeline surveys or remediation related activities.	Pipeline surveys would be required, but this activity is considered routine with well managed risks and would be of short duration.
		Health & safety risk to mariners	No infrastructure left therefore no residual snag hazards. Lower risk as potential snag hazards completely removed. Although bottom dredging, demersal fishing nets should not adversely interact with the temporary excavations.	Post decommissioning surveys and existing data provide evidence that any pipeline spans or exposures are limited, and therefore the risk to mariners from snagging would be low. Degradation of the pipeline if it remains buried, would not change the risk. If exposures occur the degradation could change the risk, but the risks of snagging individual exposures would remain low.
		Safety risk onshore project personnel	Nothing to differentiate the options.	

Table C.2.1: Pipeline Groups 1 & 2 - Safety Assessment

Appendix C.3 Groups 1 & 2 – Environmental Assessment

CRITERIA	ASPECT	SUB-CRITERIA	OPTION 1 COMPLETE REMOVAL	OPTION 3 LEAVE *IN SITU*
Environmental	**Offshore Execution**	Energy & emissions	Use of energy and emissions to air is aligned with the duration the activities are undertaken in the field. Duration of vessels in the field is longer than for leave *in situ*. Emissions and use of energy greatest for this option but no offset would be generated because of the energy and emissions needed to create new material to replace any that may be left *in situ*.	Least amount of energy used, and lowest emissions generated in the short-term, although this is slightly counteracted by the energy and emissions required to create new material.
		Seabed disturbance, area affected	The amount of seabed disturbed is directly related to the length of pipeline being removed and extent of any remedial works. The area affected would be largest for the complete removal option.	The smallest area of seabed would be disturbed in the short-term with the leave *in situ* option.
		Disturbance to Protected Area	The DSW, WD, Conrie and Ythan pipelines do not currently reside within Special Conservation Area or a Marine Protected Area, so there is nothing to differentiate the options.	
		Effect on Water Column: • Liquid discharges to sea; • Liquid discharges to surface water; • Noise.	Discharges and releases to the water column are related to the duration of activities being undertaken and would therefore be greatest for the complete removal option.	Discharges and releases would be least for the leave *in situ* option, particularly in the short-term.
		Waste creation and use of resources such as landfill. Recycling and replacement of materials	This option would result in the largest quantity of material being returned to shore. No material would be lost as no material would be left *in situ*.	No material would be returned to shore for recycling and therefore the material would be lost. Newly manufactured material would be needed to replace the material not recovered to shore.
Environmental	**Legacy**	Energy & emissions	No pipeline burial surveys or remedial would be required as the pipelines would have been completed removed.	Assume pipeline burial surveys would be required.
		Seabed disturbance, area affected	No pipeline burial surveys or remedial would be required as the pipelines would have been completed removed.	Pipeline burial surveys do not usually involve disturbance to the seabed, and we assume that no remedial activities would be required otherwise, so no impact.
		Disturbance to Protected Area	The DSW, WD, Conrie and Ythan pipelines do not currently reside within Special Conservation Area or a Marine Protected Area, so there is nothing to differentiate the options.	
		Effect on Water Column: • Liquid discharges to sea; • Liquid discharges to surface water; • Noise.	No pipeline burial surveys or remedial would be required as the pipelines would have been completed removed.	Assume pipeline burial surveys would be required.
		Waste creation and use of resources such as landfill. Recycling and replacement of materials	As the pipeline(s) would have been removed, no further waste would be created.	It is assumed that no pipeline related remedial activities would be required, as the surveys to date have indicated that the pipelines would remain stable. Therefore, as part of legacy related activities there is nothing to differentiate the options from a waste perspective.

Table C.3.1: Pipeline Groups 1 & 2 – Environmental Assessment

Appendix C.4 Groups 1 & 2 – Societal Assessment

CRITERIA	ASPECT	SUB-CRITERIA	OPTION 1 COMPLETE REMOVAL	OPTION 3 LEAVE *IN SITU*
Societal	**Offshore Execution**	Effect on commercial activities	The impact of decommissioning vessel traffic on local commercial activities such as fishing would be greatest for complete removal.	The impact of decommissioning vessel traffic on local commercial activities such as fishing would be least for leave *in situ*.
		Employment	Decommissioning activities associated with the complete removal of pipelines would contribute greatest to the continuity of employment.	Should the pipeline(s) be left *in situ* surveys would need to be carried out. Some jobs would be associated with the manufacture of new material to replace that which is left *in situ*.
		Communities or impact on amenities	Once the pipelines have been removed there would be few opportunities for continuity of work in ports and disposal sites.	Should the pipeline(s) be left *in situ* there would be few opportunities for continuity of work in ports and disposal sites other than associated with survey related and possible remedial work.
Societal	**Legacy**	Effect on commercial activities	Environmental and pipeline route surveys might be required following completion of decommissioning works, but this is the same for all options. No pipeline surveys would be required in future.	Impact of survey vessel traffic on local commercial activities such as fishing would be slightly more with the leave *in situ* option
		Employment	Should the pipeline(s) have been completely removed, the opportunity for continuation of employment would be minimal once the post decommissioning surveys had been completed.	Should the pipeline(s) be left *in situ* surveys would need to be carried out. Some jobs would be associated with the manufacture of new material to replace that which is left *in situ*.
		Communities or impact on amenities	Should the pipeline(s) have been removed there would be few opportunities for continuity of work in ports and disposal sites	Should the pipeline(s) have been left *in situ* there would be few opportunities for continuity of work in ports and disposal sites other than associated with survey related and possible remedial work.

Table C.4.1: Pipeline Groups 1 & 2 – Societal Assessment

Appendix C.5 Groups 1 & 2 – Cost Assessment

CRITERIA	ASPECT	SUB-CRITERIA	OPTION 1 COMPLETE REMOVAL	OPTION 3 LEAVE *IN SITU*
Cost	**Offshore Execution**	Group 1 – Piggybacked pipeline(s)	Using the assumption that piggybacked pipeline(s) would be removed using the 'cut and lift' method, the cost of complete removal would cost an order of magnitude more than the cost of leave *in situ*.	The cost of leave *in situ* would be the least expensive of the two options.
		Group 2 – Individual pipeline(s)	Using the assumption that individual pipelines could be removed using the reverse reel method, the costs would be greater than for leave *in situ*, but less than an order of magnitude greater when taking into account the need for post-decommissioning surveys and removal of the pipeline ends, which would be the same for both options.	The cost of leave *in situ* would be the least expensive of the two options.
Cost	**Legacy**	Piggybacked pipelines	Should the pipeline(s) have been completely removed no pipeline burial surveys would be required in future.	Future burial surveys would be required. The premise is that if two successive surveys demonstrate that the pipeline remains stable no more surveys would be required.
		Individual pipeline	Should the pipeline(s) have been completely removed no pipeline burial surveys would be required in future.	Future burial surveys would be required. The premise is that if two successive surveys demonstrate that the pipeline remains stable no more surveys would be required.

NOTES:

1. For assumptions refer Appendix E.2;
2. The assessment assumes 1x post decommissioning survey would be required irrespective of the decommissioning options, and 2x legacy surveys would be required for any pipelines or umbilicals being left *in situ.*

Table C.5.1: Pipeline Groups 1 & 2 - Economic Assessment

APPENDIX D PIPELINE GROUP 3 – COMPARATIVE ASSESSMENT TABLES

Appendix D.1 Group 3 – Technical Assessment

CRITERIA	ASPECT	SUB-CRITERIA	OPTION 1 COMPLETE REMOVAL	OPTION 2 PARTIAL REMOVAL	OPTION 3 LEAVE *IN SITU*
Technical	**Offshore Execution**	Risk of project failure	Technically, complete removal of the pipelines would most likely be achievable, but complications could arise because the pipelines are buried. Reverse reel of PL2581 & PL2582 would likely be compromised by the pipeline wall thinning due to corrosion issues. Efficiency of the 'cut and lift' method for PL2581 and PL2582 could be compromised by wall thinning and integrity issues.	Buried pipe has been uncovered and the 'cut and lift' method can and has been used for removing relatively short sections of pipe so this would be achievable. Rock has also been deposited with no technical issues.	Technically, the pipeline(s) could be left *in situ*
		Technological challenge	Technology is currently available to excavate, cut, and recover the pipelines to shore.		N/A
		Technical challenge, PL2581 & PL2582.	Excavation from deposited rock could prove problematic, but this would be limited to the Don field pipeline and umbilical crossings and the dropped object protection near NP. Depth of cover in seabed should not be prohibitive. 'Cut and lift' method could be used but classed as 'tolerable' and non-preferred. Reverse reel classed as 'not tolerable'.	Excavation from deposited rock could prove problematic, but this would be limited to the Don field pipeline and umbilical crossings and the dropped object protection near NP. Depth of cover in seabed should not be prohibitive. 'Cut and lift' method could be used. Deposition of additional rock has been done before and would not present a technical challenge. Post trenching has been used for installing pipelines.	Stable and buried pipeline(s) have been left *in situ* before so this approach would be achievable.
		Technical challenge, PL2581 & PL2582	Excavation from deposited rock could prove problematic, but this would be limited to the Don field pipeline and umbilical crossings and the dropped object protection near NP. Depth of cover in seabed should not be prohibitive. The reverse reel method could also be used for recovery of individual pipeline(s) whose integrity remain intact. However, PL2581 and PL2582 had been used for water injection and had been replaced for integrity reasons.	As above.	As above.
		Technical challenge PLU2576, PLU2577, & PLU2585.	Excavation from deposited rock could prove problematic, but this is limited to the Don field pipeline and umbilical crossings and the dropped object protection near NP. Depth of cover in the seabed should not be prohibitive. Reverse reel method could be used for recovery of umbilicals whose integrity remain intact.	Excavation from deposited rock could prove problematic, but this is limited to the Don field pipeline and umbilical crossings (PLU2576 & PL2581) and the dropped object protection near NP. Depth of cover in the seabed should not be prohibitive. Reverse reel method could be used for recovery of individual lengths, but this would be more problematic than complete removal.	Stable and buried umbilical(s) have been left *in situ* before so this approach would be achievable.
			As above.	Deposition of additional rock has been done before and would not present a technical challenge. This would likely be preferred to post trenching and complete removal.	As above.
Technical	**Legacy**	Risk of project failure	No pipeline surveys would be required in future.	Pipeline surveys have been undertaken in the past, so this is achievable with no complications.	
		Technological challenge	No pipeline surveys would be required in future.	The technology is currently available for carrying out pipeline surveys.	
		Technical challenge	No pipeline surveys would be required in future.	There would be no technical issues associated with carrying out pipeline surveys in future although the stop-start nature of the remaining pipeline could lead to spurious results. Surveys have been completed with deposited rock in place.	There would be no technical issues associated with carrying out pipeline surveys in future.

Table D.1.1: Pipeline Group 3 - Technical Assessment

Appendix D.2 Group 3 – Safety Assessment

CRITERIA	ASPECT	SUB-CRITERIA	OPTION 1 COMPLETE REMOVAL	OPTION 2 PARTIAL REMOVAL	OPTION 3 LEAVE *IN SITU*
Safety	**Offshore Execution**	Health & safety risk offshore project personnel (PL2581 & PL2582)	More offshore work than leave *in situ*. Excavation of the pipeline and recovery. There is experience of recovering individual pipelines, but integrity concerns would likely mean that 'cut and lift' method would be used. This method is repetitive, with the number of repetitions increasing with the length of pipeline. There is experience in the North Sea of removing sections of pipeline using 'cut and lift' albeit for relatively short lengths of pipeline.	For PL2582 in particular the amount of offshore work would be at least comparable to that associated with complete removal. For PL2581 less work would be required. There is experience in the North Sea of removing sections of pipeline using 'cut and lift' albeit for relatively short lengths of pipeline. Piece-meal nature of the work associated with locating exposed pipelines and excavating cut points could be a source of frustration leading to accidents.	Only the pipeline ends would be dealt with. Less offshore work than for complete removal or partial removal. Experience in the UKCS a of removal of pipeline sections. Significantly less work and therefore a shorter duration of activities than for complete or partial removal.
			As above.	Deposition of rock has been carried out on plenty of occasions and would be safety to achieve than pipe recovery operations. Post trenching has been used for installing pipelines.	As above.
		Health & safety risk offshore project personnel (PLU2576, PLU2577 & PLU2585)	More offshore work than partial removal and leave *in situ*. Excavation of the umbilical and recovery. There is experience of recovering individual umbilicals by reverse reel.	For PLU2576, PLU2577 and PLU2585 the amount of offshore work would be less than that for complete removal. Experience in the North Sea of removal of umbilical sections. Piece-meal nature of the work associated with time for locating exposed umbilicals, excavating cut points and recovery could be a source of frustration leading to accidents. Water depth could be a factor for recovering short lengths of umbilical using reverse reel.	As above.
			As above.	Deposition of rock has been carried out on plenty of occasions and would be safer to achieve than pipe recovery operations. It would be preferred to post trench activities.	As above.
		Health & safety risk to mariners	Duration of vessels in the field would be longer than for leave *in situ* but for PL2581 & PL2582 would be comparable with the duration for partial removal. For PLU2576, PLU2577 & PLU2585 the duration associated with complete removal would be longer than for partial removal. Using the reverse reel or reverse S-lay method would mean that the vessel would be attached to a umbilical and could not move out of the way quickly. The risk to mariners in the short term is aligned with the duration of activities in the field. Probably little to choose between complete removal and partial removal options.	For PL2582, the associated vessels would be present in the field for a time comparable with that required for complete removal, and for much longer than for leave *in situ*. For PL2581, less of the pipeline would need to be recovered so the vessels would be on location for less time than for complete removal. Assuming umbilicals would be recovered using the reverse reel method, the vessel would be attached to a pipeline and could not move out of the way quickly although the durations involved would be shorter than for complete removal option. The risk to mariners in the short term is aligned with the duration the activities would be undertaken in the field. Probably little to choose between the complete removal and partial removal options.	Only the pipeline ends would be dealt with; duration of vessels in the field would be shorter than for complete removal.
			As above.	Deposition of rock would take less time than removal and could be 'aborted' relatively quickly.	As above.
		Safety risk onshore project personnel	Significantly more onshore cutting, lifting, and handling associated with disposal of the pipelines or umbilicals; presents an increased safety risk to personnel.	Safety risk is directly associated with the duration and repetitive nature of the work. Less onshore cutting, lifting, and handling so less safety risk to onshore personnel.	No onshore work except for that associated with the pipelines ends, which would be common for all three options.
Safety	**Legacy**	Health & safety risk offshore project personnel	No pipeline surveys or remediation related activities.	Pipeline surveys would be required, but this activity is considered routine with well managed risks and would be of short duration. May take slightly longer than for leave *in situ* due to fragmented nature of remaining pipeline but otherwise little to differentiate partial removal from the leave *in situ* option.	Pipeline surveys would be required, but this activity is considered routine with well managed risks and would be of short duration.
		Health & safety risk to mariners	No infrastructure left *in situ* therefore no residual snag hazards. Lower risk as potential snag hazards completely removed. Although bottom dredging, demersal fishing nets should not adversely interact with the temporary excavations.	Degradation of the remaining pipeline(s) and umbilicals will occur over a long period within seabed sediment. Post decommissioning surveys and existing data would provide evidence that exposures and the associated potential snagging risks remain limited. Although they would be cut and then post trenched or buried under rock, there would be more of a possibility that these be exposed than if they had not been cut. On this basis it could be argued that the risk of snagging would be higher than for either the complete removal or leave *in situ* options due to increased number of cut pipeline ends. This is because they would now exist.	Safer to leave pipelines *in situ* with exposures intact, although the rate of degradation would need to be monitored. The expectation is that the pipelines would remain intact for tens rather than hundreds of years; this would need to be monitored with remedial works being done as necessary.
			As above.	Deposition of rock as a solution would reduce snagging hazards; possibly more acceptable than leave *in situ* with no remediation and likely more acceptable than removal of individual exposures. Post-trenching would likely be non-preferred compared to deposition of additional rock.	As above.
		Safety risk onshore project personnel	Nothing to differentiate the options		

Table D.2.1: Pipeline Group 3 - Safety Assessment

Appendix D.3 Group 3 – Environmental Assessment

CRITERIA	ASPECT	SUB-CRITERIA	OPTION 1 COMPLETE REMOVAL	OPTION 2 PARTIAL REMOVAL	OPTION 3 LEAVE *IN SITU*
Environmental	**Offshore Execution**	Energy & Emissions (PL2581 & PL2582)	Use of energy and the resulting emissions for this option would likely be slightly less than for partial removal, but no energy and emissions would be needed to create new material.	Use of energy and the resulting emissions for operational activities would likely be higher for this option than for either the complete removal or leave *in situ* options. Not helped by the additional energy and emissions needed to create new material to replace that which would be left *in situ*.	Least amount of energy used, and least emissions generated in the short term, although any gains would be offset by the energy and emissions required to create new material to replace that which would be left *in situ*.
			Use of energy would likely be more than required for the deposition of rock.	The energy required to quarry rock, to transport the rock to location and to deposit the rock would likely be less than required for full removal but more than for leave *in situ.*	As above.
		Energy & Emissions (PLU2577 & PLU2585)	Use of energy and resulting emissions would be greatest for this option.	Energy use and associated emissions for this option would be slightly less than for complete removal option but higher than for the leave *in situ* option. Not helped by of the energy and emissions needed to create new material to replace that which would be left *in situ*.	Least amount of energy used, and least emissions generated in the short-term, although this is counteracted by the energy and emissions required to create new material.
				The energy required to quarry rock, to transport the rock to location and to deposit the rock would likely be less than required for full removal but more than for leave *in situ*.	As above.
		Seabed disturbance, area affected, deposition of rock instead of partial removal	The amount of seabed disturbed is directly related to the length of pipeline being removed. The area affected would be largest for this option with the impacts being semi-permanent as the seabed in the area is relatively immobile.	This area of seabed disturbed would fall in-between the complete removal and leave *in situ* option.	The least area of seabed would be disturbed with the leave *in situ* option.
				The amount of seabed disturbed by the deposition of rock would be comparable to that disturbed for operations to remove the pipelines and umbilicals, albeit permanently.	As above.
		Disturbance to Protected Area	The DSW, WD, Conrie and Ythan pipelines do not currently reside within Special Conservation Area or a Marine Protected Area, so there is nothing to differentiate the options.		
		Effect on water column (PL2581 & PL2582): • Liquid discharges to sea; • Liquid discharges to surface water; • Noise.	Discharges and releases to the water column are related to the duration of activities being undertaken and would therefore be greatest for the complete removal option.	For PL2582 the associated vessels would be present in the field for a time comparable with that required for complete removal, and for much longer than for leave *in situ*. For PL2581 the time for vessels in the field would be less than for complete removal, but more than for leave *in situ*. Assuming that the exposed lengths of pipeline	Discharges and releases would be least for the leave *in situ* option in the short-term.
			As above.	Activities involving the deposition of rock take less time than complete removal operations but more time than leave *in situ*. The water column would also be impacted by plumes of sediment mobilised by the deposition of rock, albeit temporarily.	As above.
		Effect on water column (PLU2577 & PLU2585): • Liquid discharges to sea; • Liquid discharges to surface water; • Noise.	Discharges and releases to the water column are related to the duration of activities being undertaken and would therefore be greatest for the complete removal option.	Discharges and releases would be slightly less than generated for complete removal but more than leave *in situ*.	Discharges and releases would be least for the leave *in situ* option in the short-term.
			As above.	Activities involving the deposition of rock take less time than complete removal operations but more time than leave *in situ*. The water column would also be impacted by plumes of sediment mobilised by the deposition of rock, albeit temporarily.	As above.
		Waste creation and use of resources such as landfill. Recycling and replacement of materials	This option would result in the largest mass of material being returned to shore. No material would be lost as no material would be left *in situ*.	This option sits in-between complete removal and leave *in situ* decommissioning options	No material would be returned to shore for recycling and so the material would be lost, and new material would be needed to replace the loss.
			As above.	Deposition of rock would require more materials to be excavated and would be lost as the material would not be available for use elsewhere.	As above.
Environmental	**Legacy**	Energy & Emissions	No pipeline status or burial surveys required.	It can be expected that future survey requirements would be about the same for either partial removal or leave *in situ* decommissioning options. Little to choose between partial removal and leave *in situ*.	As ‘partial removal’ but there would be a small possibility of local (as opposed to wholesale) remedial works being required.
		Seabed disturbance, area affected	No pipeline status or burial surveys required.	Pipeline burial surveys do not usually involve disturbance to the seabed, and it is assumed that no remedial activities would be required otherwise, so no impact. Little to choose between partial removal and leave *in situ*.	As ‘partial removal’ but there would be a small possibility of local (as opposed to wholesale) remedial works being required.
		Disturbance to Protected Area	The DSW, WD, Conrie and Ythan pipelines do not currently reside within Special Conservation Area or a Marine Protected Area, so there is nothing to differentiate the options.		
		Effect on water column: • Liquid discharges to sea; • Liquid discharges to surface water; • Noise.	No pipeline status or burial surveys required.	It can be expected that future survey requirements would be about the same for either partial removal or leave *in situ* decommissioning options.	As ‘partial removal’ but there would be a small possibility of local (as opposed to wholesale) remedial works being required

CRITERIA	ASPECT	SUB-CRITERIA	OPTION 1 COMPLETE REMOVAL	OPTION 2 PARTIAL REMOVAL	OPTION 3 LEAVE *IN SITU*
		Waste creation and use of resources such as landfill. Recycling and replacement of materials	No activity required.	Assuming no pipeline remedial activities would be required as part of legacy related activities, there would be nothing to differentiate the partial removal and leave *in situ* options from a waste perspective.	As above.

Table D.3.1: Pipeline Group 3 – Environmental Assessment

Appendix D.4 Group 3 – Societal Assessment

CRITERIA	ASPECT	SUB-CRITERIA	OPTION 1 COMPLETE REMOVAL	OPTION 2 PARTIAL REMOVAL	OPTION 3 LEAVE *IN SITU*
Societal	**Offshore Execution**	Effect on commercial activities	The impact of decommissioning vessel traffic on local commercial activities such as fishing would probably be greatest for complete removal but there is probably little to choose between the complete removal and partial removal options.	The impact of decommissioning vessel traffic on local commercial activities such as fishing would probably be slightly less than for complete removal but there is probably little to choose between the complete removal and partial removal options.	Impact of decommissioning vessel traffic on local commercial activities such as fishing would least for leave *in situ*.
		Employment	Decommissioning activities associated with complete removal would contribute greatest to continuity of employment but there would probably be little to differentiate the complete removal and partial removal options.	Decommissioning activities associated with complete removal would contribute greatest to continuity of employment but there would probably be little to differentiate the complete removal and partial removal options.	Decommissioning activities associated with leave *in situ* would contribute the least to continuity of employment for leave *in situ*.
		Communities or impact on amenities	Decommissioning activities associated with complete removal would contribute the most to continuity of work in ports and disposal sites.	Decommissioning activities would contribute to continuity of work in ports and disposal sites less than for complete removal and more than for leave *in situ* option.	Decommissioning activities associated with leave *in situ* would contribute the least to continuity of work in ports and disposal sites.
Societal	**Legacy**	Effect on commercial activities	No impact as no legacy related activities would be required.	Impact of survey vessel traffic on local commercial activities such as fishing would be more than for complete removal but the same as for the leave *in situ* option.	Impact of survey vessel traffic on local commercial activities such as fishing would be more than for complete removal but the same as for the partial removal option.
		Employment	Should the pipeline(s) be completely removed, the opportunity for continuation of employment would be minimal.	Should the pipeline(s) be partially removed the opportunity for continuation of employment would be associated with survey work would probably be the same as for the leave *in situ* option with a small chance of remedial work being required due to the larger number of cut pipeline ends. However, this would not be a reason to pursue this option.	Should the pipeline(s) be left *in situ* the opportunity for continuation of employment would be associated with survey work and would be the same as for the partial removal option.
		Communities or impact on amenities	Once the pipeline(s) had been removed there would be no related opportunities for continuity of work in ports and disposal sites.	Should the pipeline(s) be partially removed there would be few opportunities for continuity of work in ports and disposal sites other than associated with survey related and possible remedial work. The possibility of remedial work would be slightly higher for the partial removal option due to the larger number of pipeline ends that could become exposed. However, this would not be a reason to pursue this option.	Should the pipeline(s) be left *in situ* there would be few opportunities for continuity of work in ports and disposal sites other than associated with survey related and possible remedial work.

Table D.4.1: Pipeline Group 3 – Societal Assessment

Appendix D.5 Group 3 – Cost Assessment

CRITERIA	ASPECT	SUB-CRITERIA	OPTION 1 COMPLETE REMOVAL	OPTION 2 PARTIAL REMOVAL	OPTION 3 LEAVE *IN SITU*
Cost	Offshore Execution	PL2581, PL2582	Using the assumption that the individual pipeline could be removed using the 'cut and lift' method, the cost by difference would an order of magnitude greater than for leave *in situ* but for PL2582 the difference in cost comparable to partial removal.	Using the assumption that parts of the individual pipeline could be removed using the 'cut and lift'. method, the cost by difference would be an order of magnitude greater than for leave *in situ*. The cost by difference would be comparable to compete removal for PL2582 and less than complete removal for PL2581.	The cost of leave *in situ* would be the least expensive of the three decommissioning options.
		PLU2576, PLU2577, & PLU2585	Using the assumption that the individual umbilical(s) could be removed using the reverse reel method, the cost by difference would less than an order of magnitude greater than for leave *in situ*, and more expensive than partial removal.	Using the assumption that the individual pipeline could be removed using the reverse reel method, the cost by difference would less than an order of magnitude greater than for leave *in situ,* and cheaper than complete removal.	The cost of leave *in situ* would be the least expensive of the three decommissioning options.
		All Group 3 pipelines and umbilicals combined for reasons given in 5.3.2	Using the assumption that the individual pipeline could be removed using the 'cut and lift' method, and umbilicals could be removed using reverse reel, the cost by difference for completely removing all these would be an order of magnitude greater than leave *in situ*.	Using the assumption that the individual pipelines could be partially removed using the 'cut and lift' method, and umbilicals could be partially removed using reverse reel, the cost by difference for completely removing all these would be an order of magnitude greater than leave *in situ*.	The cost of leave *in situ* would be the least expensive of the three decommissioning options.
	Legacy		Should the pipeline(s) have been completely removed no pipeline burial surveys would be required in future.	Future burial surveys will be required. The premise is that if two successive surveys demonstrate that the pipeline remains stable no more surveys would be required. This will be the same for both the partial removal and leave *in situ* decommissioning options.	Future burial surveys will be required. The premise is that if two successive surveys demonstrate that the pipeline remains stable no more surveys would be required. This will be largely the same for both the partial removal and leave *in situ* decommissioning options assuming no extensive remedial works would be required in future.

NOTES:

1. For assumptions refer Appendix E.2;
2. The assessment assumes 1x post decommissioning survey would be required irrespective of the decommissioning options, and 2x legacy surveys would be required for any pipelines or umbilicals being left *in situ;*
3. By inspection it would be cheaper to deposit rock rather than execute partial removal operations but more expensive that the cost of leave *in situ*;
4. All Group 3 pipelines and umbilicals refers to the combination of PL2581, PLU2576 & PLU2577 and PL2582 & PLU2585, and assumes that a subsea support vessel or anchor handler would be used to recover the rigid pipelines using 'cut and lift' and the three umbilicals by reverse reel.

Table D.5.1: Pipeline Group 3 – Economic Assessment

APPENDIX E COST AS A DIFFERENTIATOR

Appendix E.1 Overview

The following section details the qualitative comparative assessment made to distinguish the decommissioning options. Note that the figures quoted do not account for the overall costs of decommissioning the pipelines – they only account for the difference in cost once activities common to both options have been discounted.

The costs have been normalised and categorised as indicated in Table E.1.1.

High / Intolerable & not acceptable	Medium / Tolerable non-preferred	Low/Broadly acceptable & most preferred	Low/Broadly acceptable but least preferred
More than 10x least cost	More than 2x least cost	Cheapest cost	Less than 2x cheapest cost

Table E.1.1: Categories of Impact – Cost Assessment

Appendix E.2 Assumptions

The following key assumptions have been used in the cost by difference assessment:

- Operator and contractor management and engineering costs are excluded on the basis that this cost would be incurred whichever decommissioning option would be pursued;
- Any pipelines being removed would need to be excavated;
- Mobilisation and demobilisation cost of vessels are *excluded* for two reasons: The first is because mobilisation and demobilisation costs would be incurred for the overall decommissioning activity, not just for one pipeline, and the other is that for the purposes of this assessment it has been assumed that the same type of vessel – an anchor handling vessel, furnished with reels, ROV equipment, excavation equipment and hydraulic cutting spread;
- For surveys it has been assumed that one post decommissioning pipeline survey would be required for each pipeline, and (at least) three legacy pipeline surveys for those instances where a pipeline or part thereof would be left *in situ* following completion of decommissioning activities.
- The costs associated with mobilisation and demobilisation of survey vessels is excluded since it is not a differentiator, and because mobilisation and demobilisation costs would be incurred for the overall survey activity, not just for one pipeline;
- It is assumed that the ‘cut and lift’ method would be used to remove piggybacked pipelines whereas individual umbilicals and parts thereof would be reeled onto a drum on the back of the subsea support vessel. PL2579 is a unique proposition. It is piggybacked onto PL2578 up to the Wye Structure, whereas it is piggybacked onto a Thistle pipeline (PL4555) between the Wye Structure and the Thistle SSIV. The cost by difference assessment accounts for this by assuming that the ‘cut and lift method would be used to remove PL2579 throughout its length;
- It is assumed that individual rigid pipelines (PL2581 & PL2582) would be removed using ‘cut and lift’ although costs are also shown for removal using reverse reel onto a pipelay vessel;
- It is assumed that individual flowlines (e.g. PL4261 & PL4262) would be reverse reeled onto a subsea support vessel;
- It is assumed that individual umbilicals would be reverse reeled onto a subsea support vessel;
- Trench backfill costs are not accounted for;

- Leave *in situ* assumes a length of surface laid pipelines and umbilicals being removed to burial depth at the end of transition either at the bottom of the trench or in deposited rock. Likely to be conservative meaning that if the length of pipeline recovered is less, the cost by difference between complete removal and partial removal would increase;
- The costs associated with piggybacked pipeline have been combined on the basis that none or both of the piggybacked pipelines would be dealt with at the same time.

A point to note is that although 'cut and lift' is used for the cost assessment for piggybacked pipelines should attempts be made to use a pipelay vessel there would be a cost over and above a standard mobilisation or demobilisation of a pipelay vessel as an auxiliary reel, deflector and ancillaries would be required.

Appendix E.3 Pipeline decommissioning cost by difference

PIPELINE ID	PIGGYBACKED	GROUP ID	END REMOVAL LENGTH	PARTIAL REMOVAL LENGTH	COMPLETE REMOVAL LENGTH	LEAVE *IN SITU* (£M)	PARTIAL REMOVAL (£M)	COMPLETE REMOVAL (£M)	LEAVE *IN SITU*	PARTIAL REMOVAL	COMPLETE REMOVAL
PL2578 & PL2579	Y	**1**	505m	-	14,670m	£1.34	-	£31.64	0.2		5.0
PL2572 & PL2573	Y	**1**	105m	-	3,922m	£0.49	-	£9.25	0.3		5.0
PL2581	N	**3**	250m	3,507m	4,987m	£0.82	£11.03	£15.00	0.3	3.7	5.0
PL4262	N	**2**	320m	-	5,230m	£0.19	-	£1.55	0.9		5.0
PLU2576	N	**3**	350m	-	3,812m	£0.17	£0.52	£0.67	1.6	4.2	5.0
PLU2577	N	**3**	300m	508m	1,012m	£0.15	£0.23	£0.27	3.1	4.4	5.0
PL2582	N	**3**	101m	1,015m	2,173m	£0.44	£6.72	£6.55	0.3	5.0	4.9
PL2583 & PL2584	Y	**1**	210m	-	2,090m	£0.25	-	£5.03	0.3		5.0
PL4261	N	**2**	590m	-	2,252m	£0.22	-	£0.74	1.6		5.0
PLU2585	N	**3**	505m	593m	2,095m	£0.18	£0.24	£0.54	1.8	2.4	5.0
All Group 3		**3**	1,506m	5,988m	14,079m	£1.76	£18.74	£23.04	0.4	4.1	5.0

NOTE:

1. The assessment assumes 1x post decommissioning survey would be required irrespective of the decommissioning option, and 3x legacy surveys would be required for any pipelines or umbilicals being left *in situ;*
2. All Group 3 pipelines and umbilicals refers to the combination of PL2581, PLU2576 & PLU2577 and PL2582 & PLU2585, and assumes that a subsea support vessel or anchor handler would be used to recover the rigid pipelines using 'cut and lift' and the three umbilicals by reverse reel.

Table E.3.1: Pipeline Decommissioning - Cost Assessment