Heimdal to Brae Alpha Condensate Pipeline PL301 - Decommissioning

Comparative Assessment

March 2020

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Title: Comparative Assessment		
Document no.: A-400300-S00-REPT-005	Contract no.:	Project: Heimdal-Brae Alpha Gas Condensate Pipeline (PL301) Decommissioning

Classification: Internal	Distribution: Offshore Decommissioning Unit - Offshore Petroleum Regulator for Environment and Decommissioning (OPRED)
Expiry date:	Status: For Review

Distribution date:	Rev. no.:	Copy no.:
31 March 2020	R04	

Author(s)/Source(s): Prepared by Xodus under management of Equinor	
Subjects: Comparative Assessment	
Remarks: 4th pre-draft updated with OPRED comments	
Valid from:	Updated: 30. June 2020
Responsible publisher:	Authority to approve deviations:

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Terms and Abbreviations

Abbreviation	Explanation
AHP	Analytical Hierarchy Process
BEIS	Department of Business, Energy and Industrial Strategy
CA	Comparative Assessment
CSV	Construction Support Vessel
DP	Decommissioning Programme
HSE	Health and Safety Executive
IP	Institute of Petroleum
ISBN	International Standard Book Number
JNCC	Joint Nature Conservation Committee
MCDA	Multi-Criteria Decision Analysis
MEI	Major Environmental Incident
MFE	Mass Flow Excavator
MS	Much Stronger
MW	Much Weaker
NCS	Norwegian Continental Shelf
NORM	Naturally Occurring Radioactive Material
OD	Outside Diameter
ODU	Offshore Decommissioning Unit
OGUK	Oil & Gas UK
OPRED	Offshore Petroleum Regulator for Environment & Decommissioning
PLL	Potential for Loss of Life
S	Stronger
SFF	Scottish Fishermen's Federation
VC	Video Conference
VMS	Very Much Stronger
VMW	Very Much Weaker
W	Weaker

EXECUTIVE SUMMARY

Equinor Energy AS have conducted a Comparative Assessment (CA) for the decommissioning of the UK section of PL301. The following steps from the Oil and Gas UK CA Guidelines have been completed:

This CA report for the pipeline presents the methodology, decisions taken, the preparation works carried out, and the outcomes (recommendations) from the internal and external (with stakeholders) workshops.

The CA was conducted on a single group, as described in the table below with the outcome of the CA process making the following recommendation:

Group	Title	Decommissioning Approach
1	Trenched & Buried Rigid Pipeline	Option 4a – Rock Cover Areas of Spans / Exposure Removal and recovery of short surface laid section out with existing trench Rock placement or trenching to remediate snag risk from cut end Rock placement at all areas of spans and exposure

The decisions were reached on completion of an appropriate amount of preparatory study work, with clear decision outcomes.

1 INTRODUCTION

The Heimdal license currently operate the PL301 in its entirety. PL301 is owned by the Heimdal license and is a gas condensate export pipeline running from the Heimdal Platform in the Norwegian Sector of the Northern North Sea (NNS) to the Brae Alpha installation in the UK sector on the NNS. The water depth along the route of PL301 varies from 100 m to 123 m, respectively. The pipeline is trenched and is believed to be 94% buried as per 2017 survey data.

Decommissioning of PL301 means operation in close proximity to the Brae Alpha installation and risk associated with removal activities on a live platform. It is therefore most safe and efficient to decommissioning the PL301 Brae end section at the same time as decommissioning of the Brae Alpha installation under management of one operator.

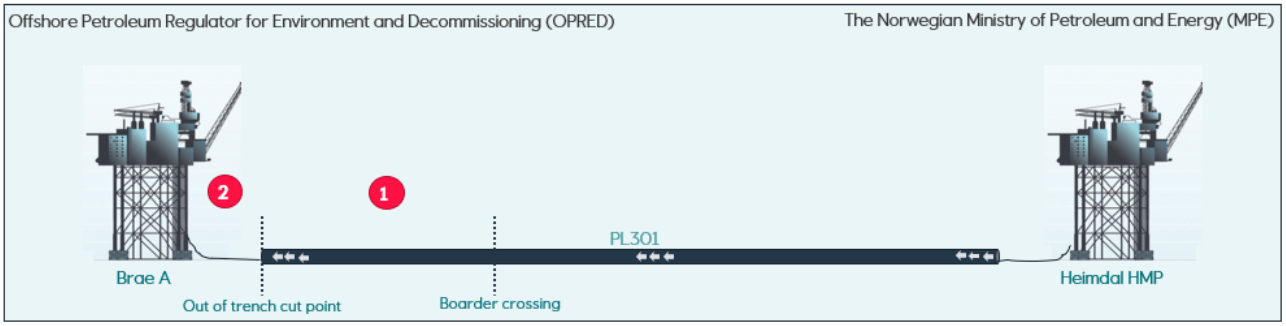


Figure 1 UK Decommissioning Programme concept for PL301

In addition, the decommissioning of PL301 in the UKCS is to be carried out as part of a greater campaign, decommissioning the whole length of PL301 and the Heimdal field on NCS. Alignment between Norwegian and UK governmental body is required for the decommissioning of PL301.

The decommissioning of PL301 will therefore be split into two Decommissioning Programmes as illustrated in Figure 1 above.

1. The trenched and/or buried length of PL301 running from the Norwegian/UK boundary to cut point KP 116.028 within Brae Alpha safety zone, including cut and removal of the 20-meter section of PL301 (KP 116.008 – KP 116.028)
2. The surface laid length of PL301, entirely within the Brae Alpha safety zone, running from cut point KP 116.028 to the Brae Alpha installation. OPRED will be advised of any agreement made for the decommissioning of this remaining section of PL301.

The section 2 of PL301 from cut point KP 116.028 to Brae Alpha topside will be decommissioned at a later date. Discussions are ongoing and agreement will be made with the Brae Alpha operator. The section of PL301 that is left exposed will not pose any risk to other users of the sea. The justification for leaving this section exposed is that by doing so the decommissioning options for the Brae Alpha facilities will not be influenced or limited by previous work. The removed section of PL301 is to ensure physical split between the two Decommissioning Programmes.

A Norwegian decommissioning plan has been submitted by Equinor to the Norwegian Ministry of Petroleum and Energy (MPE) to allow decommissioning of the Norwegian section of PL301.

The two DPs will be supported by separate Comparative Assessment (CA) and Environmental Appraisal (EA) processes. This CA assesses the project scope for the first DP only, the second DP will be considered at a later date and aligned with future decommissioning of Brae Alpha Platform.

Within the scope of work, KP 78.620 to KP 116.028, PL301 is crossed by a total of seven pipeline assets. For all seven of the crossings PL301 is the pipeline that is crossed over and in six of the seven instances both PL301 and the other pipeline asset crossing over it are covered by protective material e.g. mattresses/ gravel, in the other instance both PL301 and the other product are covered in mattresses. Currently the seven crossings will remain intact, consideration of decommissioning will occur at a time when those assets overlaying the PL301 are decommissioned themselves and are the responsibility of their respective operators. The stabilisation features on the four crossings within the Brae Alpha safety zone will be considered with the Brae Alpha facilities. More detailed information regarding PL301 crossings are found in Appendix E of the Decommissioning Programme. PL301 within the Brae Alpha safety zone is covered by gravel or mattresses for a total of 385 m. Mattress coverage accounts for 82 m of this, with the mattresses being associated with two crossing areas and protection/stability in the area immediately adjacent to the Brae Alpha Platform.

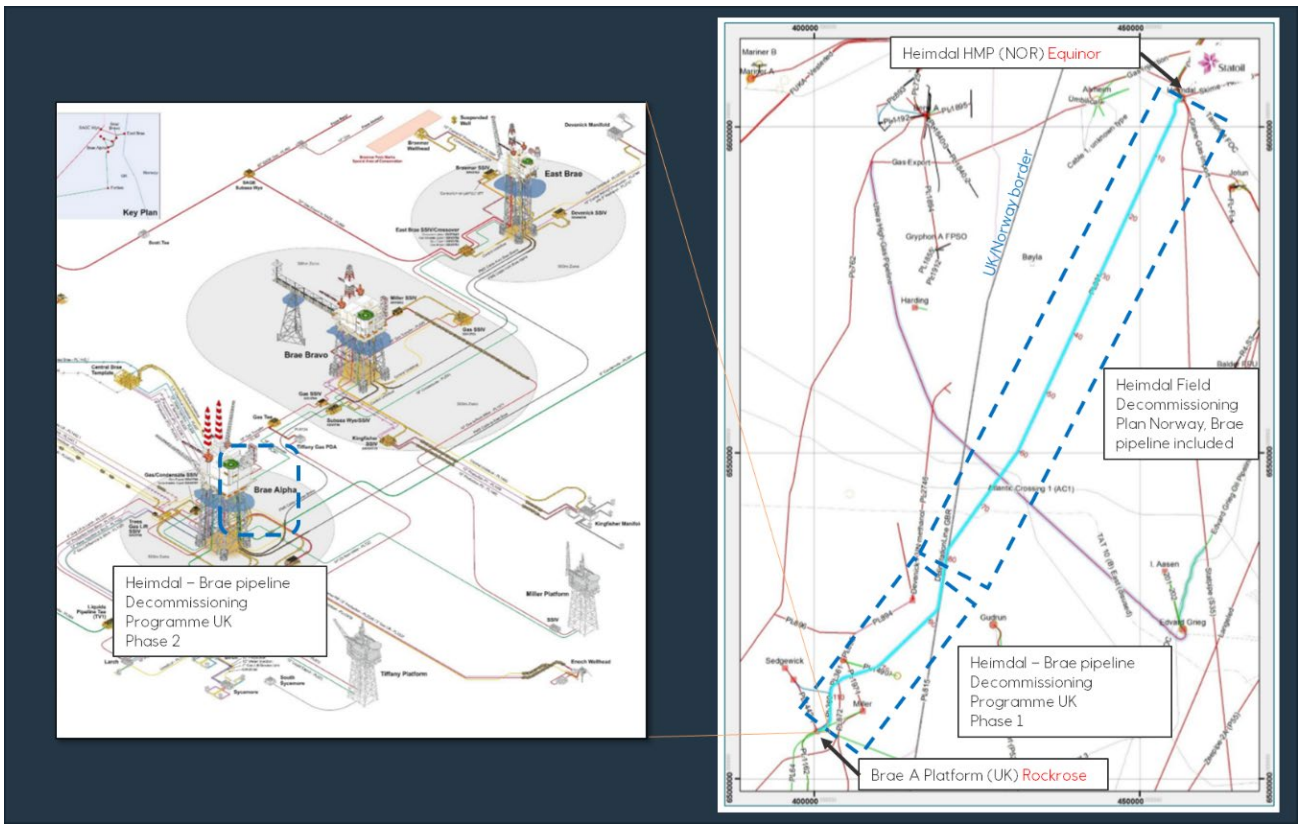


Figure 2 The location and boundaries of PL301

1.1 Purpose

The purpose of this document is to present a Comparative Assessment (CA) for the trenched and/or buried length of PL301 running from the Norwegian/UK boundary to cut point KP 116.028 within Brae Alpha safety zone, including cut and removal of the 20-meter section of PL301. It is produced to satisfy the requirement to carry out a CA as detailed in the OGUK Decommissioning CA Guidelines ref. [1].

It describes the field infrastructure addressed, the decommissioning options considered, the CA methodology and the recommendations made during the CA process.

1.2 Report Structure

This CA Report contains the following:

- Section 1 – An introduction to the document and project, including acronyms and references.
- Section 2 – An overview of the CA methodology and definition of the scoping and boundaries of the CA.
- Section 3 – The CA outcome obtained for Group 1 – Trenched & Buried Rigid Pipeline.
- Appendix A – Evaluation Methodology.
- Appendix B – Stakeholder CA Workshop Minutes.
- Appendix C – Group 1 –Detailed Screening Results.
- Appendix D – Group 1 – Detailed Evaluation Results.

2 COMPARATIVE ASSESSMENT METHODOLOGY

2.1 Overview

Comparative Assessment is a process by which decisions are made on the most appropriate approach to decommissioning. As such it is a core part of the overall decommissioning planning process being undertaken by Equinor for the decommissioning scope of the PL301.

The OGUK Decommissioning CA Guidelines ref. [1] were prepared in 2015 by Oil and Gas UK, where seven steps to the CA process were recommended. Table 1 introduces each of these steps, along with a status and commentary to demonstrate the current position.

Title	Scope	Status	Commentary
Scoping	Decide on appropriate CA method, confirm criteria, identify boundaries of CA (physical and phase).	✓	CA methodology and criteria established for screening to ensure appropriate evaluation phase.
Screening	Consider alternative uses and deselect unfeasible options.	✓	Screening workshop held in Q1 2020 with Screening outcomes documented in Section 3.2.
Preparation	Undertake technical, safety, environmental and other appropriate studies. Undertake stakeholder engagement.	✓	Studies identified during screening phase undertaken to inform the evaluation of the remaining options detailed in Section 2.4.
Evaluation	Evaluate the options using the chosen evaluation methodology.	✓	Internal workshop held Q1 2020 and Stakeholder Workshop on 11th February 2020. Evaluation methodology described in Section 2.5 and outcome detailed in Section 3. Additional detail can be found in Appendix A.
Recommendation	Document the recommendation in the form of narrative supported by charts explaining key trade-offs.	✓	The emerging recommendation for decommissioning the pipeline is as identified during the Stakeholder Workshop and as detailed in the CA Report (this document). Recommendation can be found in Section 4.
Review	Review the recommendation with internal and/or external stakeholders.	✓	The Stakeholder CA Review Workshop was held on 11th February 2020 with the minutes in Appendix B.
Submit	Submit to OPRED alongside the Heimdal Decommissioning Programme.	✓	1st pre-draft submitted Q1 2020 2nd pre-draft submitted Q2 2020.

Table 1 CA Process Overview and Status

2.2 Scoping

The scoping phase of the CA process addresses the following elements:

- Boundaries for the CA;
- Physical attributes of equipment;
- Decommissioning options.

These are addressed in the following sub-sections.

2.2.1 CA Boundaries

The applicable boundaries for the CA are as follows:

- The following will be complete prior to the PL301 decommissioning scope commencing:
  - The pipeline will be cleaned and flushed
  - The pipeline will be disconnected at the Heimdal end
- The scope of PL301 being considered is from the UK / Norwegian boundary, to cut point KP 116.028 within Brae Alpha safety zone.

2.2.2 Physical Attributes of Equipment

The physical attributes of PL301 are recorded to define the line. Attributes considered include the following:

- Pipelines / Flowlines / Spools:
  - Pipeline number;
  - Type (rigid / flexible);
  - Service (gas / oil / water);
  - Material / diameter / wall thickness / coatings / length;
  - Seabed configuration (trenched / buried / surface laid);
  - Details of crossings / mattresses;
  - As-left cleanliness / ability to clean lines;
  - Integrity issues.

2.2.3 Decommissioning Options

All potential decommissioning options for the UK portion of PL301 are identified. Alongside full removal options, the following partial removal scenarios should be considered as specified in the BEIS Guidance Notes ref. [2] and OGUK North Sea Pipeline Decommissioning Guidelines ref. [6].

- Re-Use.
- Full Removal:
  - Cut and Lift – Cut pipe into small sections and recover;
  - Reverse Installation without de-burial – Recover pipe using reverse s-lay or reverse reeling;
  - Reverse Installation with de-burial – Recover pipe using reverse s-lay or reverse reeling.
- Leave In-situ with Major Intervention:
  - Rock cover entire length including surface laid sections out with trench / cover;
  - Re-Trench and bury entire length including surface laid sections out with trench / cover.
- Leave In-situ with Minor Intervention:
  - Rock cover areas of spans, exposure and shallow burial. Remove surface laid sections out with trench / cover;
  - Trench and bury areas of spans, exposure and shallow burial. Remove surface laid sections out with trench / cover;
  - Cut and Lift areas of spans, exposure and shallow burial. Remove surface laid sections out with trench / cover;
- Leave In-situ – ongoing monitoring.

2.3 Screening Phase

The screening phase of the comparative assessment was carried out during a series of workshops held in Q1 2020. The methodology is briefly summarised below.

- Review proposed decommissioning options for the group.
- Assess decommissioning options and record assessment and outcome in screening worksheets.
- Record actions required to support retained decommissioning options.

The decommissioning options were assessed against the primary assessment criteria suggested in the OGUK Decommissioning CA Guidelines ref. [1]. These are:

- Safety;
- Environmental;
- Technical;
- Societal; and
- Economic.

The assessment was performed using a coarse Red / Amber / Green method, as recommended in the OGUK Decommissioning CA Guidelines ref. [1]. An additional category of 'showstopper', coloured dark grey, was used. These categories are described in Table 2.

Category	Description
Attractive	The option is considered attractive i.e. it has positive attributes in terms of the criterion being assessed.
Acceptable	The option is considered acceptable i.e. its attributes are not positive or negative in terms of the criterion being assessed.
Unattractive	The option is considered unattractive i.e. it has negative attributes in terms of the criterion being assessed.
Showstopper	The option is considered unacceptable. Should an option be assessed as unacceptable against any of the criteria, no further assessment is required.

Table 2: Screening Assessment Categories

The cumulative assessment for each decommissioning option was then captured based on some basic ground rules. These are:

- Three or more criteria assessed as red resulted in the option being screened out (red).
- For similar full removal options, the likely least onerous option was retained (green) with any more onerous option considered as a sub-set of the less onerous option (light grey).
- For similar leave in-situ options, the most onerous option was retained (green) with any less onerous options considered as a sub-set of the more onerous option (light grey).
- This approach was considered appropriate to ensure that the worst-case full removal options were compared to the less onerous leave in-situ options. This ensures, during the evaluation phase, that the assessment is not skewed such that leave in-situ options are selected over full removal options.

The outcomes for each option are summarised in Table 5.

2.4 Preparation Phase

During the preparation phase, detailed studies / analyses are conducted to provide information to support the Evaluation phase of the Comparative Assessment. The detailed studies / analyses that may be required are often identified early in the CA process. These studies / analyses are then supplemented by additional studies / analyses identified during the screening phase of the CA.

The studies / analyses conducted during the preparation phase of the CA process are as follows:

- High Level Integrity Review — Where the integrity associated with performing removal of the line using reverse reeling techniques was considered.
- Decommissioning Method Statements — Detailed method statements were developed for options carried forward for evaluation to ascertain the activities and resources required to deliver the option.
- Decommissioning Cost Estimates — Cost estimates for each decommissioning option, derived based on the decommissioning method statements.
- Emissions Assessment — Fuel consumption and atmospheric emissions assessment performed for options carried forward based upon activities and resources identified in method statements.
- Environmental Impact Review — Environmental impact reviews were conducted for options carried forward in areas of planned discharges, unplanned discharges and seabed disturbance based on activities and resources identified in method statements. Underwater noise impact was based on a qualitative assessment of the vessels and activities employed as detailed in the method statements.

The findings of the studies / analyses are gathered in preparation for the evaluation phase of the CA. The key information obtained from these studies / analyses, used during the evaluation phase are provided in the attributes table, included in Appendix D.

2.5 Evaluation Phase

The evaluation phase of the comparative assessment is where the remaining decommissioning options for each group are evaluated against each other. This evaluation process is conducted according to the OGUK Decommissioning CA Guidelines ref. [1] and employs the data obtained during the preparation phase as summarised in the attributes tables, included in Appendix D.

The evaluation phase was performed during an evaluation workshop where the decommissioning project team were represented. This enabled the supporting information for the decommissioning options to be interrogated and increased in maturity and definition as required.

Once the evaluation of the remaining decommissioning options was ready, a CA Workshop was convened with external stakeholders; the CA process to date was described and the evaluation of the remaining options was reviewed. This CA Stakeholder Workshop enabled the invited stakeholders to gain familiarity with the evaluation methodology and the information generated through the supporting studies and analyses. It also allowed the evaluation to be challenged in key areas and, at the culmination of the workshop, the outcome for Group 1 was validated.

The CA Stakeholder Workshop was held at Xodus' office in Aberdeen on Tuesday 11th February 2020. The attendees were as detailed in Table 3.

Name	Company / Organisation	Role
Audrey Banner	BEIS OPRED ODU	Head of Policy
Helen McArthur		Assistant Decommissioning Manager
Sam Pattie		Administrative Officer
Hannah Hood	JNCC	Industry Advisor
Sarah Canning		Industry Advisor
Dan Stewart	Marine Scotland	Advisor
Abdulgani Oseni	HSE	Pipeline Inspector
Andrew Third	SFF	Industry Advisor
Steven Alexander		Offshore Liaison
Annette Veka	Equinor Energy AS	Subsea Engineer (via VC)
Jon Harald Johansen		Health, Safety, Environment & Authority Relations
Kristian Kudsk Andreasen		Heimdal Project Manager
Gareth Jones	Xodus	Decommissioning Division Manager
John Foreman		Comparative Assessment Lead
Nick Moore		Project Manager
Will Garston		Graduate Decommissioning Engineer

Table 3: Stakeholder Workshop Attendees & Roles

3 CA - GROUP 1 - TRENCHED & BURIED RIGID PIPELINE

3.1 Group 1 Characteristics

There is a single item in Group 1 with the key characteristics are listed in Table 4.

ID	Description	OD (inches)	Length (km)	Weight (T)
PL301	38 km 8" Condensate Pipeline, Rigid, Concrete Coated, Trenched and Buried	8	37.408	5,778

Table 4: Group 1 Items

3.2 Group 1 Decommissioning Options & Screening Outcome

During the Screening Phase, all potential decommissioning options were assessed against the Safety, Environmental, Technical, Societal and Economic criteria using a coarse, red / amber / green methodology. The assessment performed is detailed fully in Appendix C and summarised in Table 5 herein.

Group 1 – Trenched & Buried Rigid Pipelines			
Category	**Option**	**Description**	**Discussion**
Re-use	1 – Re-use	- Leave rigid pipeline in-situ for use in any potential new developments	Ruled out as a showstopper as there were no potential re-use in-situ options for the pipeline.
Full removal	2a – Cut and lift with de-burial	- De-burial of rigid pipeline using MFE - Recover by cutting into sections (using hydraulic shears) and removal	Retained as the least onerous and most credible Full Removal option.
	2b – Reverse reel without de-burial	- No de-burial prior to removal - Recover by reverse reel	Ruled out as a technical showstopper on the basis that the concrete coating on the line / the line itself does not have the required integrity for reverse reeling without de-burial.
	2c – Reverse reel with de-burial	- De-burial of rigid pipelines using MFE - Recover by reverse reel	Ruled out as a technical showstopper on the basis that the concrete coating on the line / the line itself does not have the required integrity for reverse reeling with de-burial.
Leave in-situ (major intervention)	3a – Rock placement over entire line	- Rock placement over full length of rigid pipeline to address areas of spans and exposure - No recovery of rigid pipelines	Ruled out as an environmental showstopper due to the large quantity of rock required to cover 38 km of line. Additionally, the line is sufficiently trenched / buried along the vast majority of its length so little benefit in introducing large quantity of rock cover.
Leave in-situ (major intervention)	3b – Retrench and bury entire line	- Re-trench and backfill full length of rigid pipeline to remove areas of spans and exposure - No recovery of rigid pipelines - No introduction of new material	Ruled out as a technical showstopper as the as installed evidence shows that there were areas of seabed where trenching was not fully successful originally. It is expected that the required depth of lowering may not be achievable.

Group 1 – Trenched & Buried Rigid Pipelines			
Category	**Option**	**Description**	**Discussion**
Leave in-situ (minor intervention)	4a – Rock placement over areas of spans / exposure	- Removal and recovery of short surface laid section out with existing trench - Rock placement or trenching to remediate snag risk from cut end - Rock placement at all areas of spans and exposure	Assessed as being attractive (green) against the Technical and Economic criteria and acceptable (yellow) against the Safety, Environmental and Societal criteria. Retained as an option for evaluation.
	4B – Trench & bury areas of spans / exposure	- Removal and recovery of short surface laid section out with existing trench - Rock placement or trenching to remediate snag risk from cut end - Trench / bury areas of spans and exposure - Minimal introduction of new material	Ruled out as a technical showstopper as the as installed evidence shows that there were areas of seabed where trenching was not fully successful originally. It is expected that the required depth of lowering may not be achievable.
	4C – Remove areas of spans / exposure	- Removal and recovery of short surface laid section out with existing trench - Rock placement or trenching to remediate snag risk from cut end - Removal of areas of spans and exposure using cut and lift techniques, including de-burial where required	Assessed as being attractive (green) against the Technical criteria and acceptable (yellow) against the Safety, Environmental, Societal and Economic criteria. Retained as an option for evaluation.
Leave in-situ – ongoing monitoring	5 – Leave as-is	- There will be no planned subsea intervention - Appropriate legislative considerations shall be addressed and any advisory zones implemented for remaining subsea infrastructure	Ruled out as a safety showstopper due to the existing spans and exposures presenting an unacceptable potential snagging risk.

Table 5: Group 1 Decommissioning Options & Screening Summary

3.3 Group 1 Decommissioning Options for Evaluation

The decommissioning options for Group 1 that remained after screening and which were taken forward to the evaluation phase are therefore:

Full Removal

- 2a – Cut and lift with de-burial

Leave in-situ (minor intervention)

- 4a – Rock placement and over areas of spans / exposures
- 4c – Remove areas of spans / exposures

3.4 Group 1 Evaluation Summary

Group 1 – Trenched & Buried Rigid Pipeline		
Note: for full attributes tables and assessment see Appendix D		
Evaluation	Safety	**Option 4a is assessed as the most preferred option.** Option 4a is preferred to Option 2a from a risk exposure to Operations Personnel perspective. This is due to the increased risk profile associated with the longer durations associated with the offshore scope to de-bury and cut the entire line into sections and recover in Option 2a versus rock cover of selected sections in Option 4a. Option 4c is also less preferred to Option 4a, again due to the increased risk profile from the longer durations to de-bury, cut and recover the areas of spans and exposure. With respect to Other Users, Option 2a has a much higher number of vessel days and a higher number of vessel transits to and from site compared to the other options. While the increased safety impact on Other Users is expected to be small, it is sufficient to express a small equal preference for Option 4a and 4c. Option 4a is preferred from a High Consequence Events perspective as it has much lower potential for dropped objects than either of the other options as they both have lots of lifting of equipment (MFE) into and out of the water and recovery of sections of line through the water column to the vessel. Option 2a, full removal, is preferred to either of the leave in-situ options against the Legacy Risk criterion due to the line being fully removed. The difference in risk profile between the full removal options and the leave in-situ options is assessed as minimal as the remaining line is fully trenched / buried with areas of spans and exposure either removed or rock covered. Overall, Option 4a is preferred over the other options as it is preferred against all safety criteria other than legacy risk.
	Environment	**Option 4a is assessed as the most preferred option**. Option 4a and Option 4c are preferred to Option 2a from an Operational Marine Impact perspective as 2a requires extended vessel operations and MFE operations which increases the noise impact and potential for planned and unplanned discharges. Option 4a is preferred from an Emissions and Consumptions perspective as it is the shortest duration of offshore operations. Option 2a is preferred from an Other Consumptions perspective as there is no rock cover in the full removal option. Option 4a is preferred from a short-term seabed impact perspective as there is no MFE used in the option whereas there is use of MFE for line de-burial in both Option 4c and extensively in Option 2a. Option 2a is preferred from a Legacy Marine Impacts perspective as there is no legacy marine impact as line is removed and there are areas of permanent habitat change caused by rock cover in both Option 4a and Option 4c. Overall, Option 4a is preferred over the other options as it is preferred in three of the five environmental criteria.
	Technical	**Option 4a and Option 4c are assessed as being equally preferred options.** All operations across all options i.e. line de-burial, cutting with shears or rock cover are considered routine. There is a preference for Option 4a and Option 4c over Option 2a due to the potential for equipment failures and schedule increase from the length of operations associated with Option 2a, a function of the full removal of a 38 km line. Overall, Option 4a and 4c are equally preferred from a technical perspective.
	Societal	**Option 2a is assessed as the most preferred option.** With respect to Societal impact on Fishing, Option 2a is preferred over the leave in-situ options as, while there is potential impact to fishing operations from removing the line, this is the preferred end solution. Option 4a and Option 4c are preferred from a Societal impact on Other Users perspective as, while there is more useful steel being returned than in Option 2a, this is offset by the large quantity of contaminated concrete that would go to land-fill. Overall, the preference from the fishing industry for the line being removed dominates the assessment making Option 2a being the preferred option from a Societal perspective.
	Economic	**Option 4a is assessed as the most preferred option.** From a short-term cost perspective, Option 2a is 20 times more than Option 4a and more than 5 time more than Option 4c. Option 4c itself is around 3 times higher cost than Option 2a. For long-term costs, there are none associated with Option 2a as it is full removal but for the leave in-situ options, there are legacy costs associated with monitoring, surveying and managing potential snag hazards associated with the left line. Overall, the short-term costs dominate the assessment with Option 4a being preferred from an econiomics perspective.

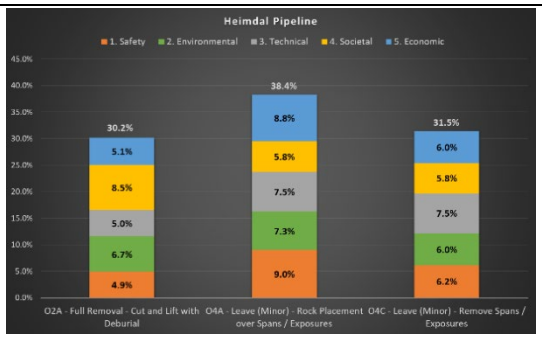
	Summary	**Overall, Option 4a is assessed as the preferred option.** Option 4a was preferred against the Safety, Environment and Technical criteria whereas Option 2a was preferred marginally from a Societal perspective. Once the Economics criterion was considered, this strengthens the preference for Option 4a as it is by far the least expensive option. Option 4a – Rock placement over areas of spans/exposure will form the emerging recommendation for the decommissioning option for Group 1.	

Table 6: Group 1 Evaluation Summary

3.5 Group 1 Evaluation Sensitivities

There were a number of areas during the Stakeholder workshop where sensitivities were identified to check whether the outcome obtained was robust. The sensitivities identified were:

Sensitivity 1 – Modified assessment in the Safety – Other Users criterion

Sensitivity 2 – Modified assessment in the Safety – Legacy Risk criterion

Sensitivity 3 – Modified assessment in the Environmental – Other Consumptions criterion

Sensitivity 4 – Modified assessment in the Environmental – Seabed Disturbance criterion

Sensitivity 5 – Modified assessment in the Environmental – Legacy Marine Impacts criterion

Sensitivity 6 – Modified assessment in the Societal – Other Users criterion

Each of these sensitivities are addressed in the following sub-sections, in summary, none of the sensitivities conducted resulted in a change to the original outcome.

3.5.1 Sensitivity 1

There was a requirement to look at the assessment between Option 2A – Full removal – Cut and lift with de-burial and the two partial removal options. This was requested as the base case assessment was that the impact in terms of safety of other users of the sea between Option 2A and the partial removal options was Weaker. This was based on the increased offshore scope for Option 2A resulting in a much higher number of vessel days and, more significantly from a safety risk to other users, a higher number of transits of vessel to and from shore.

The sensitivity required was to increase the comparative assessment from Option 2A being Weaker than the partial removal options to Much Weaker to reflect a greater safety impact on other users of the sea from the higher number of vessel days and transits.

This adjustment had the effect of increasing the preference for the partial removal options over the full removal option and as such, strengthened the original outcome.

3.5.2 Sensitivity 2

The second sensitivity requested was to look at increasing the legacy risk associated with the partial removal options. The base assessment indicated that the full removal option was Stronger than the partial removal options as removing the line removes the legacy risk. The base assessment was based on the fact that the majority of PL301 is trenched / buried and the commitment to address areas of spanning and exposure, alongside future surveying and monitoring of the line in the partial removal options was less preferable but only marginally so.

The sensitivity required was to increase the comparative assessment from the full removal option being Stronger than the partial removal options to Much Stronger reflecting an increase preference between the full removal of PL301 over the partial removal options.

This adjustment had the effect of increasing the preference for Option 2A but not sufficiently to change the outcome that Option 4A was the overall preferred option.

An additional sensitivity where the base assessment between Option 4A – Rock placement over areas of spans and exposures and Option 4C – Removal of areas of spans and exposure was adjusted from Neutral to Weaker, to reflect the position that rock covered areas of spans and exposure left a higher potential snag risk than removing them, resulted in a minor increase for the preference for Option 4C, but again, did not change the outcome that Option 4A was the overall preferred option.

3.5.3 Sensitivity 3

The third sensitivity related to the impact associated with the Environment – Other Consumptions criterion. The base assessment indicated that the full removal option was Much Stronger than the partial removal options, mainly due to the requirement to use around 5,000 tonnes of rock for both partial removal options versus no rock required for the full removal option.

The sensitivity conducted was to reduce this assessment from Much Stronger to Stronger showing, from an impact from consuming raw materials perspective, the difference between no rock and 5,000 tonnes of rock was less significant.

This adjustment had the effect of reducing the preference for the full removal option and thus strengthened the overall preference for Option 4A.

3.5.4 Sensitivity 4

The fourth sensitivity related to the impact in the Environment – Seabed Disturbance criterion. The base assessment showed that the impact in terms of short-term seabed disturbance for the partial removal options was greater for Option 4C due to the impact associated with the use of MFE for de-burial operations. Option 4A was therefore considered Stronger than Option 4C.

The sensitivity was to make the assessment between the partial removal operations Neutral to reflect the position that, while there are differences in the short-term seabed disturbance between the partial removal options, these differences are insufficient to express a preference.

This adjustment had the effect of reducing the overall preference for Option 4A slightly but was insufficient to alter the overall outcome.

3.5.5 Sensitivity 5

The fifth sensitivity related to the impact in the Environment – Legacy Marine Impacts criterion. The base assessment showed that the legacy impact for the partial removal options was similar, due to the amount of PL301 and associated degradation profile being largely similar and as such, Option 4A was assessed as being Neutral to Option 4C.

The sensitivity was to make Option 4A Weaker than Option 4C to reflect the higher area of permanent habitat change in Option 4A (14,120 m^2) than Option 4C (10,100 m^2).

This adjustment had the effect of reducing the overall preference for Option 4A slightly but was insufficient to alter the overall outcome.

3.5.6 Sensitivity 6

The sixth and final sensitivity conducted related to the Societal – Other Users criterion. The base assessment considered the full removal option Weaker than the partial removal option as, while more useful material (steel) is returned to shore in the full removal option, more than 60% of the material returned is contaminated concrete and would take up limited landfill capacity.

The sensitivity conducted was to change the assessment of the full removal option versus the partial removal options from Weaker to Neutral to reflect the uncertainty that this would be less preferred from a Societal – Other Users perspective.

This adjustment had the effect of increasing the preference for the full removal option but not sufficiently to change the outcome that Option 4A was the overall preferred option.

4 DECOMMISSIONING RECOMMENDATION

The outcome obtained from performing the comparative assessment of the UK section of PL301 is:

Option 4a – Rock placement over areas of spans / exposure

- Removal and recovery of short surface laid section out with existing trench
- Rock placement to remediate snag risk from cut end
- Rock placement at all areas of spans and exposure

The following sections provide a summary of the evaluation of the remaining Group 1 decommissioning options (Option 2a, Option 4a and Option 4c) against the five criteria and why this recommendation has been made.

4.1.1 Safety

Option 4a has the lowest risk exposure of all options due the shortest offshore durations. It also has the lowest impact on the safety of Other Users as it has the fewest days of offshore operations and the lowest number of transits. The potential for High Consequence Events is also lowest for Option 4a as there is minimal lifting with this option versus the others.

Option 2a carries the lowest legacy risk due to it being fully removed. The risk associated with PL301 being left in-situ with rock cover over areas of spans and exposure is considered acceptable, as the future risk is mitigated by a survey and monitoring programme. Consideration will be given to a survey and monitoring programme which has additional focus on areas of the pipeline that have experienced spanning in the past.

Overall, there is a preference for Option 4a from a Safety perspective.

4.1.2 Environment

Option 4a has the lowest environmental impact in terms of Operational Marine Impacts and Atmospheric Emissions and Consumptions, due to it being the shortest offshore duration. It is also equal lowest in terms of short-term seabed disturbance.

Option 2a has the lowest impact in terms of Other Consumptions as it is the only option that does not use rock. It is also preferred from a legacy environmental impact as it is fully removed and there is no permanent habitat change as there is no rock introduced.

Overall, there is a preference for Option 4a from an Environmental perspective as it is preferred in 3 of the five environmental sub-criteria.

4.1.3 Technical

While all options use largely routine activities and methods, Option 2a carries a higher risk of technical failure due to the longer duration cut and lift operations associated with the full PL301 removal. As such, Option 4a and Option 4c are equally preferred from a Technical perspective.

4.1.4 Societal

Option 4a is preferred from a Societal – Fishing perspective as PL301 is fully removed. This was considered a lower overall impact despite the short-term disruption caused by removing PL301. Option 4a and Option 4c were preferred over Option 2a from a Societal – Other Users perspective as, while there is more useful material being returned with the full PL301 removal, there is a large quantity of contaminated concrete returned with PL301 which would have to consume land-fill capacity which was conserved societally less attractive.

Option 2a is preferred overall from a societal perspective with the stronger preference in the Societal – Fishing criterion influencing the overall outcome.

4.1.5 Economic

The short-term costs associated with executing Option 2a where PL301 is fully removed are much higher (around 20 times higher) than for the much smaller scope associated with executing Option 4a – Rock Cover which is the least expensive option. Option 4a does however, have long-term costs associated with monitoring and surveying required to manage potential snag risks in the future (as does Option 4c), but these are calculated to be <£1m and therefore relatively insignificant in economic terms.

The total costs (short-term + long-term) are significantly less for Option 4a than the other options and therefore this is preferred from an Economic perspective.

5 REFERENCES

1.	OGUK Decommissioning CA Guidelines	Oil & Gas UK – Guidelines for Comparative Assessment in Decommissioning Programmes, Dated: October 2015, ISBN: 1 903 004 55 1, Issue: 1.
2.	BEIS Guidance Notes	BEIS, Guidance Notes: Decommissioning of Offshore Oil and Gas Installations and Pipelines, Nov 2018.
3.	Decommissioning Option Methodologies Technical Note	Xodus, Pipeline CA Cost Estimates & Datasheets Technical Note, Doc. No.: A-400300-TECH-002, Rev.: R01, Dated: 31/01/2020
4.	Risk Analysis of Decommissioning Activities	Safetec, Joint Industry Project Report “Risk Analysis of Decommissioning Activities (http://www.hse.gov.uk/research/misc/safetec.pdf), 2005
5.	Analytical Hierarchy Process	T.L. Saaty, The Analytical Hierarchy Process, 1980
6.	OGUK North Sea Pipeline Decommissioning Guidelines	Decommissioning of Pipelines in the North Sea Region – 2013, Issued by Oil & Gas UK
7.	IP 2000	Institute of Petroleum, Guidelines for the Calculation of Estimates of Energy Use and Gaseous Emissions in the Decommissioning of Offshore Structures, ISBN: 9780852932551, Dated: February 2000

APPENDIX A EVALUATION METHODOLOGY

Appendix A.1 CA Evaluation Methodology

Equinor has selected a Multi Criteria Decision Analysis (MCDA) methodology for the evaluation phase of the CA. This methodology uses a pairwise comparison system based on the methodologies of the Analytical Hierarchy Process (AHP) by T.L. Saaty, described in various publications, such as Analytical Hierarchy Process ref. [5]. This allows the relative importance of each differentiating criteria to be judged against each other in a qualitative way, supported by quantification where appropriate. The key steps for the evaluation phase of the CA are as follows:

- Define Differentiating Criteria – listed in Appendix A.2
- Define Options – completed as part of CA Screening;
- Pre-populate worksheets for internal CA workshops – based on all the studies undertaken the worksheets were pre-populated in advance of the internal CA workshops;
- Perform internal CA workshop;
- Discuss attributes of each option against each differentiating criteria – the discussion was recorded 'live' during the workshop in order that informed opinion and experience was factored into the decision-making process;
- Perform scoring (see Section Appendix A.5);
- Perform sensitivity analyses to test the decision outcomes;
- Export worksheets as a formal record of the workshop attendees' combined opinion on the current preferred options, the 'Emerging Recommendations';
- Evaluate whether the CA needs to 'recycle' to the Preparation phase to obtain any further information to help inform decision making;
- Discuss Emerging Recommendations with stakeholders (February 2020); and
- Recycle process as required prior to decision on the selected options which will be presented in the Decommissioning Programme and assessed in the Environmental Impact Assessment.

The sections below describe how the MCDA methodology has been applied.

Appendix A.2 Differentiating Criteria & Approach to Assessment

A key step in setting up the CA was agreeing and defining the appropriate criteria that differentiates between each of the tabled options. As a starting point, the criteria considered for this CA were taken from the BEIS Guidelines for Decommissioning of Offshore Oil and Gas Installations and Pipelines which are as follows:

- Safety
- Environmental
- Economic
- Technical
- Societal

These differentiating criteria were found to be appropriate for the decommissioning options tabled and were taken forward as the primary differentiating criteria for the CA. Additional sub-criteria and definitions were added for clarity and are shown in Table 7.

Criteria	Sub-Criteria	Description	Approach to Assessment
1. Safety	1.1 Operations Personnel	This sub-criterion considers elements that impact risk to operations personnel and includes, project team, project vessel crew, diving teams, supply boat crew, and survey vessel crew. It should be noted that crew changes are performed via port calls. Any requirement for handling HazMat / NORM shall also be addressed here.	Potential for Loss of Life (PLL) metrics were calculated for each option. This allows a quantified direct comparison between options.
	1.2 Other Users	This sub-criterion covers the impact associated with the risk to other users. Considers elements such as collision impact whilst performing activities. Users such as fishing vessels, commercial transport vessels and military vessels are considered.	Days of vessel operations and numbers of vessel transits provided to allow assessment of safety risk to other users to be conducted.
	1.3 High Consequence Events	This sub-criterion relates to any inherent potential for high consequence events i.e. major accident hazard. It applies to all onshore and offshore personnel involved in the project. Considerations such as dropped object concerns, support vessel risks, are considered.	Assessment conducted based on number of lifts expected for each option as, given the option definitions, the potential for dropped object during lifts is the key operation where there is potential for High Consequence Events.
	1.4 Legacy Risk	This sub-criterion addresses residual safety risk to other sea users i.e. fishermen, military vessel crews, commercial vessel crews and passengers, other sea users, that is provided by the option. Issues such as residual snag risk, collision risk, etc. may be considered.	Narrative assessment of the as left status and the associated legacy safety risk provided based on the defined options. Additionally, the safety risk associated with any legacy surveying and monitoring provided as PLLs.

Criteria	Sub-Criteria	Description	Approach to Assessment
2. Environmental	2.1 Operational Marine Impact	This sub-criterion addresses the marine environmental impact caused by performing the decommissioning option. Covers both planned impacts (inherent to the option being assessed) and potential unplanned impacts (accidental releases, both large and small in scale and encompassing Major Environmental Incidents (MEIs)). Impacts may be from Project Vessels, Supply Boats, Survey vessels, etc. Examples include; Noise generated by vessels, cutting operations, any explosives, etc., discharges from vessels and from removing infrastructure such as residual pipeline contents.	Planned and unplanned marine impacts are narrative judgement informed by estimates of volumes (m^3) / composition of any releases. Impacts from vessels are qualitative in nature. Marine noise impact is calculated based on the vessel durations, subsea cutting operations and other operations that generate marine noise and is a qualitative measure of noise impact with impact on marine mammals is a key focus."
	2.2 Atmospheric Emissions & Fuel Consumption	This sub-criterion addresses the atmospheric emissions, fuel consumption and energy consumption from performing the decommissioning option. This may be from Project Vessels, Survey vessels, etc. Impacts may be greenhouse gas emissions such as CO_2, NO_x, SO_2, etc. Fuel and energy consumption is included and is tightly correlated to atmospheric emissions. Not considered: Energy / emissions / resource consumption required to replace materials not recovered for re-use or recycling which is covered in 2.3 Other Consumptions.	Fuel use, emissions and energy consumption are calculated from vessel operations using IP 2000 ref. [7] factors for vessel fuel use and emissions. Fuel use, and emissions provided in metric tonnes. Energy provided in joules.
	2.3 Other Consumptions	This sub-criterion addresses the environmental impact caused by the amount of resource consumption associated with the option. It covers elements such as environmental impact from processing returned materials, the use of quarried rock or other new material and any production of replacement materials for equipment left in-situ.	Consumptions such as rock / steel / other fabrications are quoted in metric tonnes. Impact of recycling / processing returned material and replacing leave in-situ material is quoted in metric tonnes of CO_2. The CO_2

Criteria	Sub-Criteria	Description	Approach to Assessment
			figures allow a direct, quantitative comparison between options.
2. Environmental	2.4 Seabed Disturbance	This sub-criterion addresses the direct and indirect seabed disturbance caused by performing the decommissioning option. Impacts that are both permanent and temporary in nature are considered. The level of impact caused and any specific seabed concerns, such as protected areas or habitat changes may be covered.	Assessment based on quantifying the area of disturbance and by type of disturbance (dredging, rock dump, trenching, backfilling, mass flow excavation) in combination with an understanding of the baseline environment in the area as shown by the outputs from the environmental surveys.
	2.5 Legacy Marine Impacts	This sub-criterion addresses the marine environmental impact caused after the decommissioning option has been performed. Covers the long-term impact of any infrastructure left in-situ such as release of materials into the marine environment, environmental impact from legacy monitoring and remediation i.e. planned and unplanned releases from vessels, vessel noise, etc. Also addresses permanent habitat loss / change as part of the decommissioning option i.e. introduction of rock cover.	Marine impacts are narrative judgement informed by estimates of volumes (m^3) / composition of any releases and the duration these may occur over. Impacts from vessels are qualitative in nature. Marine noise impact is calculated based on the vessel durations, subsea cutting operations and other operations that generate marine noise and is a qualitative measure of noise impact with impact on marine mammals is a key focus.

Criteria	Sub-Criteria	Description	Approach to Assessment
3. Technical	3.1 Technical Risk	This sub-criterion relates to the various technical risks that could result in a major project failure i.e. failure to deliver the decommissioning option broadly within the timescale / budget / endorsed decommissioning programme. Consideration is given to: Technical Novelty / Track Record, where the novelty of the technical solution is considered. Technical Challenges / Consequence of Failure to deliver the such as amendment to decommissioning approach and Potential for Showstoppers can be captured along with impact on the schedule due to overruns from technical issues such as operations being interrupted by the weather. Technical Feasibility and Technical Maturity is also considered.	Scored 1 – 3 with 1 being least technically feasible and 3 most technically feasible.
4. Societal	4.1 Fishing	This sub-criterion addresses the impact of the option on commercial fishing operations. It includes consideration of impacts from both the decommissioning activities any residual impacts post decommissioning such as reinstatement of access to area.	Scored 1 – 3 with 1 being a proportionally large area lost for fishing and 3 being a minimal area
	4.2 Other Users	This sub-criterion addresses any positive or negative socio-economic impacts on other users, where the impact may be from dismantling, transporting, treating, recycling and land filling activities relating to the decommissioning option. Additionally, Issues such as impact on the health, well-being, standard of living, structure or coherence of communities or amenities are considered here e.g. business or jobs creation, increase in noise, dust or odour pollution during the decommissioning option which has a negative impact on communities, increased traffic disruption due to extra-large transport loads, etc.	Scored 1 -3 with 1 being significant long-term impact to communities and 3 being minimal.
5. Economic	5.1 Short-term Costs	This sub-criterion addresses the cost of delivering the option as described. No long-term cost element is considered here.	Cost data (£ k)

Criteria	Sub-Criteria	Description	Approach to Assessment
	5.2 Long-term Costs	This sub-criterion addresses the costs associated with any long-term liabilities such as on-going monitoring and any potential future remediation costs.	Cost data (£ k)

Table 7: Sub-criteria Definition

Appendix A.3 Differentiator Weighting

The 5 differentiating criteria all carry a 20% weighting. That is, all criteria are neutral to each other. Figure 3 shows the pairwise comparison matrix. Equinor decided that equal weightings offer the most transparency and a balanced view from all perspectives.

Criteria	1. Safety	2. Environmental	3. Technical	4. Societal	5. Economic	Weighting
1. Safety	N	N	N	N	N	20%
2. Environmental	N	N	N	N	N	20%
3. Technical	N	N	N	N	N	20%
4. Societal	N	N	N	N	N	20%
5. Economic	N	N	N	N	N	20%

Figure 3: Example Pairwise Comparison Matrix (N = Neutral)

Appendix A.4 Option Attributes

The next step in the CA process was to describe and discuss the attributes of each option with respect to each of the differentiating criteria. In preparation, all relevant data and information developed during the preparation phase were pre-populated into the attributes table for each option. Appendix D contains the completed Attributes Table for Group 1.

Any additional discussion around the relative merits of the options was also recorded in the attributes matrix. A summary discussion of why options are considered more or less attractive with respect to each of the differentiating criteria was also recorded. An easy-to-read version of this matrix was supplied to stakeholders as part of the recommendation review process.

Appendix A.5 Option Pair-Wise Comparison

Once the option attributes were compiled and discussed, a pair-wise comparison was performed for each of the differentiating criteria where the proposed options were compared against each other. The pairwise comparison adopted in this case used phrases such as stronger, much stronger, weaker, much weaker, etc. to make qualitative judgements (often based on quantitative data) of the options against each other. Adopting these phrases rather than the more common numerical 'importance scale' from the Analytical Hierarchy Process (AHP) is often more intuitive and representative of the sentiment of a workshop.

One of the challenges of applying the numerical importance scale historically, is that often when scoring a pair of options against each other as a score of 3, delegates implied the comparison was 3 times better, etc. rather than 'slightly better' as the importance scale suggests.

To manage this, Equinor chose to apply the principles of the AHP by replacing numbers in the pairwise comparison matrix with a narrative or descriptive approach. This is already programmed into the AHP in the importance scale explanations (see Table 8). It was agreed that three positions from equal (and their reciprocals) would be sufficient for this CA. These positions were:

Title	Scope	Relative Preference Ratio
Neutral	Equal Importance, equivalent to 1 in the AHP importance scale.	50 / 50
Stronger (S) / Weaker (W)	Moderate importance of one criteria / option over the other, equivalent to 1.5 in the AHP importance scale.	60 / 40
Much Stronger (MS) / Much Weaker (MW)	Essential / strong importance of one criteria / option over the other equivalent to 5 or 6 in the AHP importance scale.	75 / 25
Very Much Stronger (VMS) / Very Much Weaker (VMW)	Extreme importance of one criteria / option over the other equivalent to 8 or 9 in the AHP importance scale.	90 / 10

Table 8: Explanation of Phrasing Adopted for Pairwise Comparison

Using this transposed scoring system made it simpler and, more importantly, more effective at capturing the mind-set and feeling of the attendees at the workshops. Phrases such as 'what are the relative merits of pipeline removal on a project versus rock dumping from a safety perspective? Are these Neutral to each other? Are they stronger? If so, how much stronger? If you had to prioritise one over the other, which would it be?' This promoted a collaborative dynamic in the workshop and enabled the collective mind-set of the attendees to be captured. Where there was quantitative data to provide back-up and evidence to support the collective assertions, so much the better.

A summary example of the completed pair-wise comparisons for differentiating criteria versus options are shown in Figure 4.

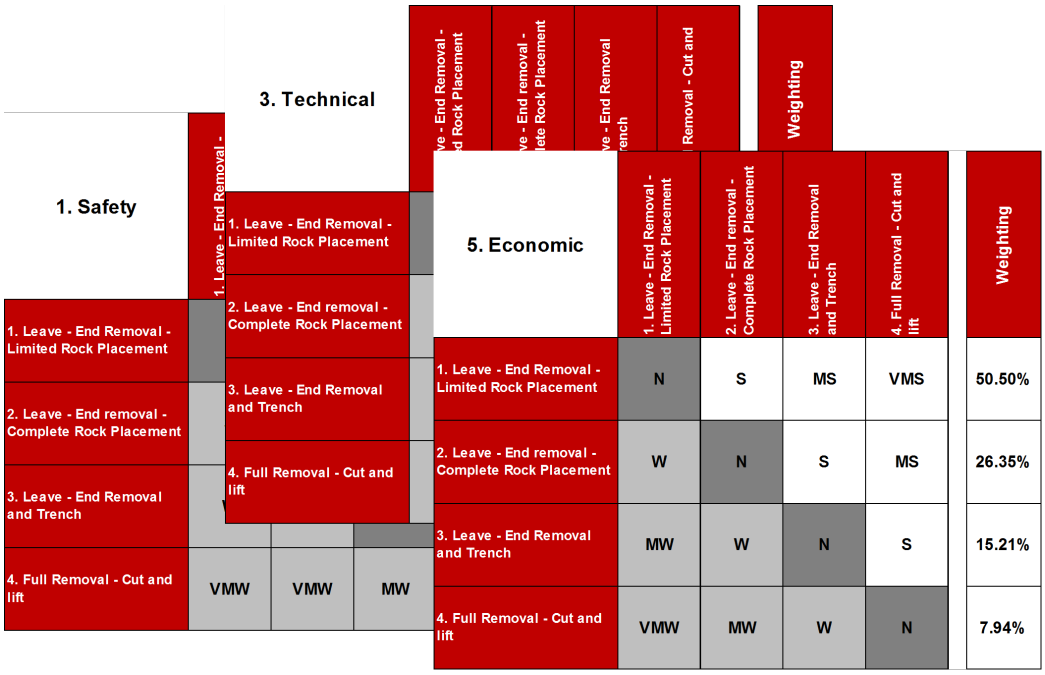


Figure 4: Example Option Pair-Wise Comparison

Appendix A.6 Visual Output and Sensitivities

The decision-making tool used the above pairwise comparisons to automatically generate a visual output indicating the highest scoring option i.e. the option which represents the most 'successful' solution in terms of its overall contribution to the set of differentiating criteria. At this stage, opportunity was provided to fine tune the judgements provided, to ensure that all attendees were happy to endorse the outcome. The visual output for Group 1 is included in Appendix D. An example of the visual output obtained is shown in Figure 5.

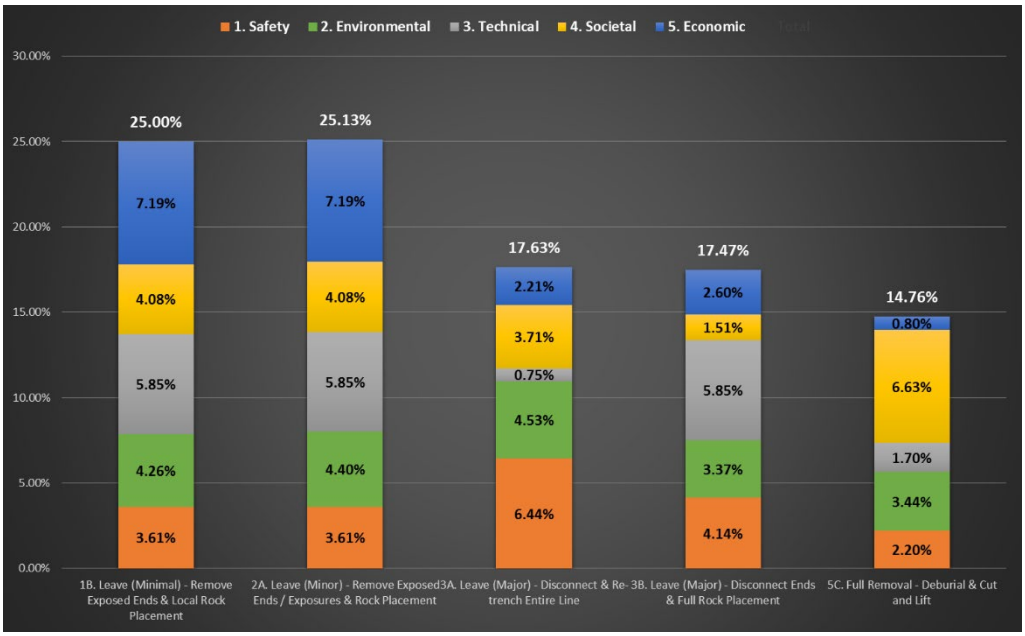


Figure 5: CA Visual Output Example

The CA output can then easily be stress tested by the workshop attendees by undertaking a sensitivity analysis:

- By applying a modification to the weighting of the criteria – bearing in mind that the base case for this assessment is to have all criteria equally weighted, and / or
- Modifying the pair-wise comparison of the options against each other within the criteria where appropriate.

These sensitivities will help inform workshop attendees as to whether a particular aspect is driving a preferred option, or indeed if the preferred option remains the same when the sensitivities are applied.

APPENDIX B STAKEHOLDER CA WORKSHOP MINUTES

Subject: Heimdal-Brae A Gas Condensate Pipeline PL301 - CA Stakeholder Workshop

Location: Xodus House, 50 Huntly Street, Aberdeen, AB10 1RS

Date: 11th February 2020

Assignment: A400300

Minutes by: Will Garston

Issued on: 14th February 2020

Attending:

BEIS OPRED ODU	Audrey Banner, Helen McArthur, Sam Pattie
JNCC	Hannah Hood, Sarah Canning
Marine Scotland	Dan Stewart
HSE	Abdulgani Oseni
SFF	Andrew Third, Steven Alexander
Equinor Energy AS	Annette Veka (via VC), Jon Harald Johansen, Kristian Kudsk Andreasen
Xodus	Gareth Jones, John Foreman, Nick Moore, Will Garston

Distribution: Attendees

Below in the table is a list of the questions, comments and statements made by those attending the CA workshop on the 11th February 2020.

Organisation	Comment	Action / Response
OPRED	What was the target depth of trenching during installation?	At the time of installation, the target depth was 0.9 m
OPRED	Are there berms present along the edge of the trenches?	Berms are still present, but they are relatively small and pose no hazard to fishing
SFF	Statement: “The low number of crossings is not purely down to low fishing effort across the pipeline but might also be due to the presence of the pipeline itself deterring fishing in the area”	Statement by SFF.
OPRED	How is the subsea cutting going to be conducted? Will it utilise divers or diver-less methods?	Cutting will be diver-less using hydraulic shears.
HSE	Is there any history of span intervention along the pipeline?	No there is not, while a number of spans are over the threshold in length, the overall height of the spans above the trench (in which it sits) is not.

Organisation	Comment	Action / Response
OPRED	Have other simultaneous decom operations (Brae A and adjacent fields) been considered as activities by other users of the sea?	This can be looked at in further detail.
OPRED	How many surveys (post decom) have been allowed for?	Three in total, one none invasive post decommissioning survey, then two further surveys, one at 5 years and one at 10 years post decom.
JNCC	In the marine impacts criteria what is included within the number of days?	Only on-site durations, no mob/demob or transit time
Marine Scotland	Is rock placement included within the operational marine impact section?	No, the rock placement is captured within another section '2.4 Seabed Disturbance'.
OPRED	Do the emissions values capture the emissions generated by future monitoring work?	Yes, the emissions include the outlined 3 post decom surveys.
OPRED	Is it possible to separate between the execute stage fuel and the residual monitoring fuel use?	Yes, this can be done if required.
SFF	"If rock dumping is properly carried out then there should not be a residual safety issue, however, in SFF opinion the number of post decom surveys is a bit light especially if interaction between the rock placement and fishing equipment occur over a prolonged period of time after decommissioning has been undertaken. Consideration needs to be taken in planning future survey requirements".	Better visualisation of where fishing activity occurs and where rock placement will be considered as part of the DP.
SFF	Does the outcome of the CA (emerging recommendation) match the proposed decommissioning strategy in Norwegian water?	Equinor - Yes it does. Option 4A is preferred option on the NCS.

After an initial run through the of the CA matrix any criteria that were marked for sensitivity checking were revisited, however, the running of sensitivities did not change the emerging recommendation of the CA workshop.

A brief discussion was held over whether to combine all the sensitivities however it was explained that sensitivities are run individually unless there is a good reason for combining them.

APPENDIX C GROUP 1 –DETAILED SCREENING RESULTS

Group 1 - PL301 - 8" Rigid Pipeline - Concrete Coated, Trenched and / or Buried	Re-use	Full Removal		
	Option 1 - Re-use	Option 2A - Cut and Lift with Deburial	Option 2B - Reverse Installation (S-lay or Reel) without Deburial	Option 2C - Reverse Installation (S-lay or Reel) with Deburial
	- Leave line in-situ for use in any potential new developments	- Deburial required - Recover by cutting into sections (assumed by hydraulic shears) and removal - Rigid pipeline, 8" diameter and 38 km in length (UK waters) - Line is Bitumen Enamel (6.5mm) and Concrete (40mm) coated and is Trenched and / or Buried along the majority of its length.	- Buried line for majority of its length, deburial will be required - Recover by reverse installation (S-lay) & cut into sections on vessel - Rigid pipeline, 8" diameter and 38 km in length (UK waters) - Line is Bitumen Enamel (6.5mm) and Concrete (40mm) coated and is Trenched and / or Buried along the majority of its length.	- Deburial required - Recover by reverse installation (S-lay) & cut into sections on vessel - Rigid pipeline, 8" diameter and 38 km in length (UK waters) - Line is Bitumen Enamel (6.5mm) and Concrete (40mm) coated and is Trenched and / or Buried along the majority of its length.
Safety	Technical showstopper	More offshore operations and vessel durations compared to other full removal options. Quantity returned to shore for disposal increases personnel exposure (compared to leave in-situ options) and will include material handling, some of which may be contaminated with hazardous materials, such as NORM. Less onshore cutting than other full removal options. Many (potentially hundreds) of tubular lifts of sections of cut flowline through water column and splash zone carries higher risk of High Consequence Events from dropped object. Additional risk from dropped object from potentially loose internals of pipe-in-pipe hybrid. Base premise is no diver support required. Very attractive from a residual risk perspective as full removal option. Overall extended durations of operations and numerous lifts through splash zone make option considered red - unattractive from a safety perspective.	Technical showstopper	Technical showstopper
Environment	Technical showstopper	Fuel and emissions potentially the highest of all options due to the large amount of subsea cutting and lifting operations. Unlikely to be significant in environmental terms. Moderate to high seabed disturbance due to deburial along full length. (38 km) Some discharge of residual pipeline contents during subsea cutting and lifting operations, however, any discharge will be residual pipeline contents post flushing. Small amount of bitumen on pipe will be released to environment at every cut. No legacy environmental risk as line fully removed. Minimal / no introduction of new material. Overall, considered yellow - acceptable from an environmental perspective.	Technical showstopper	Technical showstopper
Technical	Integrity is unknown and would be unlikely to be reused accordingly. A review of potential reuse options has indicated that there are no viable reuse options in this location. Technical showstopper.	Hydraulic shears are available / proven at this diameter of pipe. Longer durations to cut line into short sections so risk of schedule impact. Cut and lift approach proven. Overall, given the length of line and the potential for technical challenges considered yellow - acceptable from a technical perspective.	Integrity / strength of pipe never designed for Reverse Installation. Likely to be technical showstopper but require an integrity study to inform and to provide evidence. It is noted there are other technical issues associated with reverse installation of concrete coated pipes but the integrity of the pipe dominates the technical assessment. Visual evidence from ROV survey shows several areas of degraded pipeline coating.	Integrity / strength of pipe never designed for Reverse Installation. Likely to be technical showstopper but require an integrity study to inform and to provide evidence. It is noted there are other technical issues associated with reverse installation of concrete coated pipes but the integrity of the pipe dominates the technical assessment. Visual evidence from ROV survey shows several areas of degraded pipeline coating.
Societal	Technical showstopper	Option is attractive from an impact on fishing operations perspective due to it being a full removal option although there is disturbance to the fishing industry associated with removal. Also attractive from a 'removing old infrastructure' perspective which has become a recent societal focus for some stakeholders. Potentially some challenges in recycling returned line due to bitumen and contaminated concrete coating which may have to be separated and go to landfill. Quantities of steel returned should be useful if recycled. There are no perceived detrimental societal impacts Overall considered green - attractive from a societal perspective	Technical showstopper	Technical showstopper
Economic	Technical showstopper	Option estimated to be more time consuming than other full removal operations due to subsea cutting operations and likely to be most expensive. No residual survey / monitoring required. Overall considered red - unattractive from an economic perspective	Technical showstopper	Technical showstopper
Summary	A review of potential reuse options has indicated that there are no viable reuse options in this location. Ruled out as a technical showstopper accordingly.	This option has been assessed as being unattractive in 2 of the 5 criteria, it is also acceptable in 2 of the 5 criteria and attractive in the remaining criterion which makes it bordeline for elimination, however it is retained as the most likely full removal option and shall be carried forward for further assessment. A high level methodology, personnel exposure and cost estimate should be constructed to allow this option to be evaluated against other remaining options.	Although an integrity study is needed to inform and provide evidence re: ability to Reverse Install concrete coated line due to pipe integrity, it is felt that visual evidence supports the theory that structural integrity of concrete coating is already compromised and would therefore make this a show stopper on both technical and safety grounds.	Although an integrity study is needed to inform and provide evidence re: ability to Reverse Install concrete coated line due to pipe integrity, it is felt that visual evidence supports the theory that structural integrity of concrete coating is already compromised and would therefore make this a show stopper on both technical and safety grounds.

Group 1 - PL301 - 8" Rigid Pipeline - Concrete Coated, Trenched and / or Buried	Leave in-situ - Major Intervention	
	Option 3A - Rock Placement over Entire Line	**Option 3B - Re-trench & Bury Entire Line**
	- Rock placement over full length of line to address areas of spans and exposures - No recovery of line - Rigid pipeline, 8" diameter and 38 km in length (UK waters) - Line is Bitumen Enamel (6.5mm) and Concrete (40mm) coated and is Trenched and / or Buried along the majority of its length.	- Re-trench and backfill full length of line to remove areas of spans and exposures - Trenching by plough - No recovery of line - No introduction of new material - Rigid pipeline, 8" diameter and 38 km in length (UK waters) - Line is Bitumen Enamel (6.5mm) and Concrete (40mm) coated and is Trenched and / or Buried along the majority of its length.
Safety	Environmental showstopper	Technical showstopper
Environment	Although technically feasible, this option is considered an Environmental showstopper due to the large volume of rock that required to bury the entire length (circa 38km in UKCS) to an adequate depth of rock cover. The resulting biological impact and permanent changes in sediment type would be considered extensive and therefore will not be taken forward for futher assessment as a viable decommissioning option.	Technical showstopper
Technical	Environmental showstopper	As installed status / evidence suggest that sections of the pipeline were not trenched initially due to seabed / sediment conditions. Video evidence suggest sections of shell deposits under stiff sediments which may cause problems in getting required depth of lowering. Would have to address existing areas of stabilisation material. May need areas of spot rock for problem areas. Overall, given the challenges associated with achieving depth of lowering over the entire pipeline length, considered a technical showstopper.
Societal	Environmental showstopper	Technical showstopper
Economic	Environmental showstopper	Technical showstopper
Summary	Although technically feasible this option is considered an Environmental showstopper due to the large volume of rock required to bury the entire length of the pipeline within the UKCS (circa 38km), and the resulting permanent biological impact and changes sediment type rock placment would cause	Overall, given the challenges associated with achieving depth of lowering over the entire pipeline length, considered a technical showstopper.

Group 1 - PL301 - 8" Rigid Pipeline - Concrete Coated, Trenched and / or Buried	Leave in-situ - Minor Intervention			Leave In-situ - Ongoing Monitoring
	Option 4A - Rock Placement Over Areas of Spans / Exposure	Option 4B - Trench & Bury Areas of Spans / Exposure	Option 4C - Remove Areas of Spans / Exposure	Option 5 - Leave as is
	- Rock placement to remediate snag risk from cut ends - Rock placement at all areas of spans and exposures - Rigid pipeline, 8" diameter and 38 km in length (UK waters) - Line is Bitumen Enamel (6.5mm) and Concrete (40mm) coated and is Trenched and / or Buried along the majority of its length.	- Re-trench and backfill areas of spans, exposures - Rigid pipeline, 8" diameter and 38 km in length (UK waters) - Line is Bitumen Enamel (6.5mm) and Concrete (40mm) coated and is Trenched and / or Buried along the majority of its length.	- Removal and recovery of surface sections out with existing trench. - Rock placement to remediate snag risk from cut ends - Removal of areas of spans, and exposures using cut and lift techniques (including deburial where required) - Rigid pipeline, 8" diameter and 38 km in length (UK waters) - Line is Bitumen Enamel (6.5mm) and Concrete (40mm) coated and is Trenched and / or Buried along the majority of its length.	- There will be no planned subsea intervention - Appropriate legislative considerations shall be addressed and any advisory zones implemented for remaining subsea infrastructure - Existing ends relatively low snag-risk but may degrade overtime - Existing pipeline average burial depth 0.28m - Line will remaining in-situ - PL301 - Line 8" pipe, coating 6.5 mm bitumen enamel and 40 mm concrete - Circa 38 km in length (UK waters)
Safety	Moderate offshore operations and vessel durations to rock cover areas of spans / exposure / shallow burial. No material returned so no onshore handling / exposure. Rock cover is a low risk operation. No diver support needed. Residual risk remains as line remains - snag risk managed by spot rock cover which may be long / high in areas. Overall, the offshore scope will be moderate but there will be areas of spot rock cover (which may be long / high in areas) to manage the residual risk. Considered yellow - acceptable from a safety perspective	Technical showstopper	Slightly more offshore operations and vessel durations compared to other leave in situ options. Much lower than full removal options. Quantity returned to shore for disposal increases personnel exposure (compared to other leave in-situ options). Will include material handling, some of which may be contaminated with hazardous materials, such as NORM. More lifts of sections of cut pipeline through water column and splash zone than other leave in-situ options. Carries higher risk of High Consequence Events from dropped object. Base premise is no diver support required. Overall slightly extended durations of operations, material handling and lifts through splash zone make option considered yellow - acceptable from a safety perspective	Leaving the ends of this line and shallow burial depth as is would present an unacceptable snag hazard. Considered a safety showstopper accordingly.
Environment	Fuel and emissions moderate due to offshore operations. Unlikely to be significant in environmental terms. Moderate seabed disturbance from rock cover. Limited discharge of residual line contents from cut end. Any discharge will be residual contents post flushing. Legacy environmental impact due to line remaining. This would be a slow release over a long period. Any discharge will be residual contents post flushing. Bitumen will remain. Moderate additional quantity of rock introduced. Moderate area of habitat change / loss due to rock cover. Overall, due to moderate area of habitat change / loss, considered yellow - acceptable from an environmental perspective.	Technical showstopper	Fuel and emissions moderate due to offshore operations. Unlikely to be significant in environmental terms. Limited short term seabed disturbance from removal of problem areas. Some discharge of residual pipeline contents during subsea cutting and lifting operations, however, any discharge will be residual pipeline contents post flushing. Small amount of bitumen on pipe will be released to environment at every cut. Legacy environmental impact due to line remaining. This would be a slow release over a long period. Any discharge will be residual contents post flushing. Bitumen coatings will remain. Moderate additional quantity of rock introduced. Moderate area of habitat change / loss due to rock cover. Overall, due to moderate area of habitat change / loss, considered yellow - acceptable from an environmental perspective.	Safety showstopper
Technical	Rock cover is routine operation. Overall, given the routine operations considered green - attractive from a technical perspective	As installed status / evidence suggest that sections of the pipeline were not trenched initially due to seabed / sediment conditions. Video evidence suggest sections of shell deposits under stiff sediments which may cause problems in getting required depth of lowering. Would have to address existing areas of stabilisation material. May need areas of spot rock for problem areas. Overall, given the challenges associated with achieving depth of lowering in problem areas, considered a technical showstopper.	Hydraulic shears are available / proven at this diameter of pipe. Shorter durations to cut line due to short sections being removed. Cut and lift approach proven. Rock cover is a routine operation. Overall, given the largely routine nature of operations, considered green - attractive from a technical perspective.	Safety showstopper.
Societal	Option is unattractive from an impact on fishing operations perspective due the moderate levels of rock berms introduced. Also unattractive from a 'removing old infrastructure' perspective which has become a recent societal focus for some stakeholders. Large quantity of useful steel left in-situ. Overall, impact on fishing operations and lack of returned material make this considered acceptable but less preferred from a societal perspective	Technical showstopper	Option is unattractive from an impact on fishing operations perspective as the majority of the line will remain in-situ. There is also disturbance to the fishing industry associated with the removal of teh problem areas. Also unattractive from a 'removing old infrastructure' perspective, which has become a recent societal focus for some stakeholders. Potentially some challenges in recycling returned pipe due to bitumen coating which would have to go to landfill. Quantities of steel returned should be useful if recycled. Overall considered yellow - acceptable from a societal perspective.	Safety showstopper.
Economic	Option estimated to be amongst the least time consuming and lowest cost to execute. There would be long-term costs from the required residual survey / monitoring. Overall considered green - attractive from an economics perspective	Technical showstopper	Option estimated to be more time consuming and higher cost than rock cover problem areas option (O4A). There would be long-term costs from the required residual survey / monitoring. Overall considered yellow - acceptable from an economics perspective.	Safety showstopper
Summary	This option has been assessed as being acceptable in 3 of the 5 criteria and attractive in remaining 2 criteria and should be retained and carried forward for further assessment. A high level methodology, personnel exposure and cost estimate should be constructed to allow this option to be evaluated against other remaining options.	Overall, given the challenges associated with achieving depth of lowering in problem areas, considered a technical showstopper.	This option has been assessed as being acceptable in 4 of the 5 criteria and attractive in the remaining criterion and therefore carried forward for further assessment. A high level methodology, personnel exposure and cost estimate should be constructed to allow this option to be evaluated against other remaining options.	Leaving this pipeline would present an unacceptable snag hazard. Considered a safety showstopper accordingly.

APPENDIX D GROUP 1 – DETAILED EVALUATION RESULTS

Appendix D.1 Group 1 Attributes Table

Heimdal to Brae Condensate Pipeline (PL301)

38 km 8" Concreted Coated Rigid Pipeline - from UKCS / Norway boundary (kp 78.046) to Brae Alpha Installation. Line largely trenched with natural burial. Section considered up to 20m beyond where the line exits the trench / gravel cover (kp 116.02).

		O2A - Full Removal - Cut and Lift with Deburial	O4A - Leave (Minor) - Rock Placement over Spans / Exposures	O4C - Leave (Minor) - Remove Spans / Exposures
		- Flowline disconnected - Line deburied prior to removal using MFE - Line removed by cutting (assume hydraulic shears) into short sections and lifting to surface - Line is 8" internal diameter	- Flowline disconnected - Rock placement to remediate snag risk from spans / exposures - No material recovered - Line is 8" internal diameter	- Flowline disconnected - Removal and recovery of surface sections out with existing trench - Rock placement to remediate snag risk from cut ends - Removal of areas of spans and exposures (and shallow burial potentially less than 0.6m ToP) using cut and lift techniques (including deburial where required) - Line is 8" internal diameter
1. Safety	1.1 Operations Personnel	Vessel Type: PoB / Days / Hours / PLL Survey Vessel: 44 / 11.2 / 5,898 / 4.42E-04 CSV: 76 / 438.9 / 400,277 / 3.00E-02 Total offshore hours: 406,175 hrs Total offshore PLL: 3.05E-02 Resource Type: Days / Hours / PLL Engineering & Management: 5,513.2 / 44,106 / 1.76E-04 Project Management: 5,644.0 / 45,152 / 1.81E-04 Onshore Operations (includes Cleaning & Disposal): 73.0 / 584 / 7.18E-05 Total onshore hours: 89,842 hrs Total onshore PLL: 4.29E-04 Total operational hours: 496,016 hrs Total operational PLL: 3.09E-02	Vessel Type: PoB / Days / Hours / PLL Survey Vessel: 44 / 11.2 / 5,898 / 4.42E-04 CSV: 76 / 4.6 / 4,150 / 3.11E-04 Rockdump Vessel: 20 / 22.3 / 5,362 / 4.02E-04 Total offshore hours: 15,409 hrs Total offshore PLL: 1.16E-03 Resource Type: Days / Hours / PLL Engineering & Management: 280.9 / 2,247 / 8.99E-06 Project Management: 256.0 / 2,048 / 8.19E-06 Onshore Operations (includes Cleaning & Disposal): 1.0 / 8 / 9.84E-07 Total onshore hours: 4,303 hrs Total onshore PLL: 1.82E-05 Total operational hours: 19,712 hrs Total operational PLL: 1.17E-03	Vessel Type: PoB / Days / Hours / PLL Survey Vessel: 44 / 11.2 / 5,898 / 4.42E-04 CSV: 76 / 68.9 / 62,873 / 4.72E-03 Rockdump Vessel: 20 / 22.3 / 5,340 / 4.01E-04 Total offshore hours: 74,111 hrs Total offshore PLL: 5.56E-03 Resource Type: Days / Hours / PLL Engineering & Management: 1,076.5 / 8,612 / 3.44E-05 Project Management: 982.0 / 7,856 / 3.14E-05 Onshore Operations (includes Cleaning & Disposal): 3.0 / 24 / 2.95E-06 Total onshore hours: 16,492 hrs Total onshore PLL: 6.88E-05 Total operational hours: 90,603 hrs Total operational PLL: 5.63E-03
		VMW W	S	
	Summary	The assessment of the Operations Personnel sub-criterion is as follows: Option 2A is assessed as being Very Much Weaker than Option 4A as the risk exposure is around twenty-five times higher due to the extended durations required to debury and cut the 38 km of line versus rockcover of problem areas only. Option 2A is assessed as being Much Weaker than Option 4C as the risk exposure is around 5 times higher to remove the line versus removing just those areas of spans / exposure. Option 4A is assessed as being Stronger than Option 4C as the risk exposure is around a fifth due to the extended operations required to remove the areas of spans / exposure. **Overall, Option 4A is preferred from a risk to Operations Personnel perspective.**		
1. Safety	1.2 Other Users	Vessel Days: Survey Vessel: 11.2 CSV: 438.9 Total vessel days: 450.1 days Transits: 46	Vessel Days: Survey Vessel: 11.2 CSV: 4.6 Rockdump Vessel: 22.3 Total vessel days: 38.1 days Transits: 8	Vessel Days: Survey Vessel: 11.2 CSV: 68.9 Rockdump Vessel: 22.3 Total vessel days: 102.4 days Transits: 16
		W W	N	
	Summary	The assessment of the Other Users sub-criterion is as follows: Option 2A is assessed as being Weaker than Option 4A and Option 4C due to the significantly higher number of vessel days required to deliver Option 2A and the greater number of transits to and from the decommissioning site in Option 2A. Option 4A and Option 4C are assessed as being Neutral to each other as the number of vessel days and the number of transits are similar. **Overall, Option 4A and 4C are equally preferred from a risk to Other Users perspective.**		
1. Safety	1.3 High Consequence Events	Operations are largely routine however there is a large number of lifts required through the water column to deploy / recover the baskets of pipeline lengths so the potential for High Consequence Events (such as dropped objects) is increased (634 lifts). In addition, there is the potential for High Consequence Event from the dropped object associated with deploying and recovering the MFE and shears each day (32 days of operations, 1 deployment and 1 recovery per unit = 128 lifts). Total Lifts = 762	Operations are routine with minimal lifting (1 lift).	Operations are largely routine however there is a large number of lifts required through the water column to recover the cut sections of pipeline so the potential for High Consequence Events (such as dropped objects) is increased (97 lifts). In addition, there is the potential for High Consequence Event from the dropped object associated with deploying and recovering the MFE and shears at each location (67 locations, 1 deployment and 1 recovery per unit = 268 lifts). Total Lifts = 365
		MW W	S	
	Summary	The assessment of the High Consequence Events sub-criterion is as follows: Option 2A is assessed as being Much Weaker than Option 4A due to the significantly higher number of lifting operations required to recover the sections of pipeline (in baskets) and the deployment and recovery of other equipment in Option 2A. Option 2A is assessed as being Weaker than Option 4C due to the higher number of lifting operations to recover the sections of pipeline and equipment in Option 4C. Option 4A is assessed as being Stronger than Option 4C due to the higher number of lifting operations to recover the sections of pipeline and equipment in Option 4C. **Overall, Option 4A is preferred from a High Consequence Events perspective.**		
1. Safety	1.4 Legacy Risk	No legacy risk from this full removal option.	The line would remain in-situ with this option although the majority of its length would be in a trench with natural burial. Areas of spans / exposure will be rock covered to mitigate potential snag hazard. The survey & monitoring programme is committed to ensuring that the potential snag hazard from left in-situ infrastructure continues to be managed & mitigated as appropriate. There is a legacy risk exposure from the survey & monitoring of PLL = 4.46E-04.	The line would remain in-situ with this option although the majority of its length would be in a trench with natural burial. Areas of spans / exposure will be removed with small areas of rock cover to mitigate potential snag hazard from cut ends. The survey & monitoring programme is committed to ensuring that the potential snag hazard from left in-situ infrastructure continues to be managed & mitigated as appropriate. There is a legacy risk exposure from the survey & monitoring of PLL = 4.42E-04.
		S S	N	
	Summary	The assessment of the Residual Risk sub-criterion is as follows: Option 2A is assessed as being Stronger than Option 4A and Option 4C as, while the lines remain in-situ in the other options, they are fully buried / covered and any potential snag risk is managed by the survey and monitoring programme. Option 4A is assessed as being Neutral to Option 4C as the legacy risk presented by these two options is expected to be similar. **Overall, Option 2A is preferred from a Legacy Risk perspective.**		

		O2A - Full Removal - Cut and Lift with Deburial	O4A - Leave (Minor) - Rock Placement over Spans / Exposures	O4C - Leave (Minor) - Remove Spans / Exposures
2. Environmental	2.1 Operational Marine Impact	Vessel Noise (days on-site): Survey Vessel = 3.16 days | CSV = 374.89 days Total = 378.06 days Hydraulic Shears = 329.78 days MFE = 31.65 days Operation Discharges: Lines will be cleaned and flushed prior to decommissioning. There will be a limited release of residual contents to the sea during the pipeline cuts. This option is likely to have the highest volume of discharge to sea from the multiple cuts but is still considered to have a low environmental impact. Spalling of concrete could occur at every cut location with associated debris clearance. Vessel Discharges: This includes Ballast, Grey and Black Water, this is driven by duration of vessel operations and therefore at around 380 days will be the highest of all options. The environmental impact is considered to be negligible.	Vessel Noise (days on-site): Survey Vessel = 3.16 days | CSV = 0.54 days | Rockdump Vessel = 18.33 days Total = 22.04 days Hydraulic Shears = 0.29 days Operation Discharges: Lines will be cleaned and flushed prior to decommissioning. There will be a limited release of residual contents to the sea during the cut and removal of the line end at Brae. These releases will be limited in volume and will be the lowest of all options and will have a minimal environmental impact. Vessel Discharges: This includes Ballast, Grey and Black Water, this is driven by duration of vessel operations and therefore at 23 days will be the lowest of the options. The environmental impact is considered to be negligible.	Vessel Noise (days on-site): Survey Vessel = 3.16 days | CSV = 52.94 days | Rockdump Vessel = 18.25 Total = 74.35 days Hydraulic Shears = 24.06 days MFE = 20.63 days Operation Discharges: Lines will be cleaned and flushed prior to decommissioning. There will be a limited release of residual contents to the sea during the cut and removal of areas of spans and exposure. These releases will be limited in volume although will be greater than Option 4A and will have a minimal environmental impact. Vessel Discharges: This includes Ballast, Grey and Black Water, this is driven by duration of vessel operations and therefore at 75 days. The environmental impact is considered to be negligible.
		MW MW	N	
	Summary	The assessment of the Operational Marine Impact sub-criterion is as follows: Option 2A is assessed as being Much Weaker than Option 4A and Option 4C due to this option having the largest release of residual contents to the sea and the largest impact from vessels and noise. Option 4A is assessed as being Neutral to Option 4C as the environmental impact of the releases, noise and vessels is largely similar. **Overall, Option 4A and Option 4C are equally preferred from an Operational Marine Impact perspective.**		
2. Environmental	2.2 Atmospheric Emissions & Fuel Consumption	Vessel Emissions (in tonnes): Fuel: 10,962 CO2: 34,749 NOx: 651.12 SO2: 43.85 Vessel Energy Use: 471,352 GJ	Vessel Emissions (in tonnes): Fuel: 580 CO2: 1,839 NOx: 34.45 SO2: 2.32 Vessel Energy Use: 24,940 GJ	Vessel Emissions (in tonnes): Fuel: 2,273 CO2: 7,207 NOx: 135.04 SO2: 9.09 Vessel Energy Use: 97,755 GJ
		MW W	S	
	Summary	The assessment of the Atmospheric Emissions & Consumptions sub-criterion is as follows: Option 2A is assessed as being Much Weaker than Option 4A as the emissions and fuel use are around 20 times higher. Option 2A is assessed as being Weaker than Option 4C as the emissions and fuel use are around four times higher. Option 4A is assessed as being Stronger than Option 4C as the emissions and fuel use are around a quarter. **Overall, Option 4A is preferred from an Atmospheric Emissions & Consumptions perspective.**		
2. Environmental	2.3 Other Consumptions	Material Emissions (CO2 in tonnes): Recovered Material: 5,779 Remaining Material: Total: 5,779 Rock: N/A tonnes	Material Emissions (CO2 in tonnes): Recovered Material: 4 Remaining Material: 7,109 Total: 7,113 Rock: 5,757 tonnes	Material Emissions (CO2 in tonnes): Recovered Material: 182 Remaining Material: 6,890 Total: 7,072 Rock: 5,025 tonnes
		MS MS	N	
	Summary	The assessment of the Other Consumptions sub-criterion is as follows: Option 2A is assessed as being Much Stronger than Option 4A and Option 4C as, while the emissions associated with processing recovered material / replacing left in-situ material are largely similar, there is no requirement for rock in Option 2A. Option 4A is assessed as being Neutral to Option 4C as the consumptions are similar. **Overall, Option 2A is preferred from an Other Consumptions perspective.**		
2. Environmental	2.4 Seabed Disturbance	Short Term Disturbance (MFE): 189,895 m2 No rock cover required.	Short Term Disturbance (MFE): N/A Rock cover area = 14,120 m2.	Short Term Disturbance (MFE): 1,650 m2 Rock cover area = 10,100 m2.
		MW MW	S	
	Summary	The assessment of the Seabed Disturbance sub-criterion is as follows: Option 2A is assessed as being Much Weaker than Option 4A and Option 4C due to the large area of seabed disturbed using MFE to debury the line and the significant water quality impact from fluidisation and light particle movement of the sediments during the MFE operations. Option 4A is assessed as being Stronger than Option 4C as while the area of seabed impact from rock cover is larger for Option 4A, the short-term seabed disturbance from MFE operations in Option 4C is ore significant from a short-term seabed disturbance perspective. **Overall, Option 4A is preferred from Seabed Disturbance perspective.**		
2. Environmental	2.5 Legacy Marine Impacts	No legacy marine impact from this full removal option. Habitat Loss (Rockdump): N/A	The legacy marine impact from the slow release of the residual contents of these lines is expected to be low overall. It is noted that there is bitumen coating on the line which will remain in-situ and there is the potential for degradation products from the material left in-situ. The lines are fully buried / covered. Habitat Loss (Rockdump): 14,120 m2 Legacy atmospheric emissions (from survey activities): 535.14 tonnes of CO2	The legacy marine impact from the slow release of the residual contents of these lines is expected to be low overall. It is noted that there is bitumen coating on the line which will remain in-situ and there is the potential for degradation products from the material left in-situ. The lines are fully buried / covered. The releases from the lines under this option are likely to be over a shorter period of time as the lines are cut in multiple locations. Habitat Loss (Rockdump): 10,100 m2 Legacy atmospheric emissions (from survey activities): 524.91 tonnes of CO2
		MS MS	N	
	Summary	The assessment of the Legacy Marine Impacts sub-criterion is as follows: Option 2A is assessed as being Much Stronger than Option 4A and Option 4C as the line is fully removed and there is no permanent habitat change as there is no rock introduced versus significant area of permanent habitat change for Option 4A and Option 4C. Option 4A is assessed as being Neutral to Option 4C as while there is a larger area of impact from the rock cover resulting in permanent change to the habitat in Option 4A, the increase over Option 4C was considered insufficent to express a preference. **Overall, Option 2A is preferred from a Legacy Marine Impacts perspective.**		

		O2A - Full Removal - Cut and Lift with Deburial	O4A - Leave (Minor) - Rock Placement over Spans / Exposures	O4C - Leave (Minor) - Remove Spans / Exposures
3. Technical	3.1 Technical Risk	Concept Maturity: The concept is well proven. (Score 3) Technical Risks: The length of pipe to debury, cut and lift may present some technical challenges. (Score 2)	Concept Maturity: The concept is well proven. (Score 3) Technical Risks: Limited technical risks associated with option. (Score 3)	Concept Maturity: The concept is well proven. (Score 3) Technical Risks: Limited technical risks associated with option. (Score 3)
		W W	N	
	Summary	The assessment of the Technical Risk sub-criterion is as follows: Option 2A is assessed as being Weaker than Option 4A and Option 4C as while the operations are considered routine, the technical challenges associated with deburial and cutting of the 38 km line into short sections carries with it a higher risk of technical failures than the other options. Option 4A is assessed as being Neutral to Option 4C as they are largely routine operations. **Overall, Option 4A and Option 4C are equally preferred from a Technical Risk perspective.**		
4. Societal	4.1 Fishing	Vessels will be working in the area for a significant number of days causing disruption to any local fishing activities. (Score 2) but will mean line is removed and grounds returned for fishing which is preferred.	Short operation, small area of disturbance. (Score 3)	Short operation, small area of disturbance. (Score 3)
		MS MS	N	
	Summary	The assessment of the Societal impact on Fishing sub-criterion is as follows: Option 2A is assessed as being Much Stronger than Option 4A and Option 4C due to the full removal of the lines being more attractive than the addition of rock berms in the other options. Option 4A is assessed as being Neutral to Option 4C as the as left status of the lines from a fishing perspective are similar. **Overall, Option 2A is preferred from a Societal impact on Fishing perspective.**		
4. Societal	4.2 Other Users	A reasonable amount of steel can be recovered with this option with minimal material requiring to go to landfill. (Score 3) Materials Returned: Steel: 2,163 tonnes (recyclable) Concrete: 3,442 tonnes (landfill) Bitumen: 175 tonnes (landfill)	Minimal societal benefits / impacts with this option. (Score 3) Materials Returned: Steel: 2 tonnes (recyclable) Concrete: 2 tonnes (landfill) Bitumen: 1 tonnes (landfill)	Minimal societal benefits / impacts with this option. (Score 3) Materials Returned: Steel: 68 tonnes (recyclable) Concrete: 108 tonnes (landfill) Bitumen: 6 tonnes (landfill)
		W W	N	
	Summary	The assessment of the Societal impact on Other Users sub-criterion is as follows: Option 2A is assessed as being Weaker than Option 4A and Option 4C as, while additional useful material (steel) is returned, a significant quantity of the returned material (concrete / bitumen) would use up limited landfill capacity. Option 4A is assessed as being Neutral to Option 4C as, while there is more material returned and routed to landfill in Option 4C, this difference was considered insufficient to express a preference. **Overall, Option 4A and Option 4C are equally preferred from a Societal impact on Other Users perspective.**		
5. Economic	5.1 Short-term Costs	£55.223 Million	£2.688 Million	£9.774 Million
		VMW MW	S	
	Summary	The assessment of the Short-term Costs sub-criterion is as follows: Option 2A is assessed as being Very Much Weaker than Option 4A as the costs are around 20 times higher (52.5 million more). Option 2A is assessed as being Much Weaker than Option 4C as the costs are around 5.5 times higher (45.5 million more). Option 4A is assessed as being Stronger than Option 4C as the costs around a less than a third (7 million less). **Overall, Option 4A is preferred from a Short-term Cost perspective.**		
5. Economic	5.2 Long-term Costs	Surveys: N/A FLTC: N/A Total Legacy Cost: £0 Million	Surveys: £0.337 Million FLTC: N/A Total Legacy Cost: £0.337 Million	Surveys: £0.334 Million FLTC: N/A Total Legacy Cost: £0.334 Million
		S S	N	
	Summary	The assessment of the Long-term Costs sub-criterion is as follows: Option 2A is assessed as being Stronger than Option 4A and Option 4C as there is no long-term costs associated with the full removal option. Option 4A is assessed as being Neutral to Option 4C as the long-term costs are the same. **Overall, Option 2A is preferred from a Long-term Cost perspective.**		

Appendix D.2 Group 1 Pairwise Comparison Matrices - Safety

1.1 Operations Personnel	O2A - Full Removal - Cut and Lift with Deburial	O4A - Leave (Minor) - Rock Placement over Spans / Exposures	O4C - Leave (Minor) - Remove Spans / Exposures	Weighting
O2A - Full Removal - Cut and Lift with Deburial	N	VMW	W	11.0%
O4A - Leave (Minor) - Rock Placement over Spans / Exposures	VMS	N	S	62.6%
O4C - Leave (Minor) - Remove Spans / Exposures	S	W	N	26.3%

1.2 Other Users	O2A - Full Removal - Cut and Lift with Deburial	O4A - Leave (Minor) - Rock Placement over Spans / Exposures	O4C - Leave (Minor) - Remove Spans / Exposures	Weighting
O2A - Full Removal - Cut and Lift with Deburial	N	W	W	25.0%
O4A - Leave (Minor) - Rock Placement over Spans / Exposures	S	N	N	37.5%
O4C - Leave (Minor) - Remove Spans / Exposures	S	N	N	37.5%

1.3 High Consequence Events	O2A - Full Removal - Cut and Lift with Deburial	O4A - Leave (Minor) - Rock Placement over Spans / Exposures	O4C - Leave (Minor) - Remove Spans / Exposures	Weighting
O2A - Full Removal - Cut and Lift with Deburial	N	MW	W	18.6%
O4A - Leave (Minor) - Rock Placement over Spans / Exposures	MS	N	S	50.7%
O4C - Leave (Minor) - Remove Spans / Exposures	S	W	N	30.7%

1.4 Legacy Risk	O2A - Full Removal - Cut and Lift with Deburial	O4A - Leave (Minor) - Rock Placement over Spans / Exposures	O4C - Leave (Minor) - Remove Spans / Exposures	Weighting
O2A - Full Removal - Cut and Lift with Deburial	N	S	S	42.9%
O4A - Leave (Minor) - Rock Placement over Spans / Exposures	W	N	N	28.6%
O4C - Leave (Minor) - Remove Spans / Exposures	W	N	N	28.6%

Appendix D.3 Group 1 Pairwise Comparison Matrices - Environment

2.1 Operational Marine Impact	O2A - Full Removal - Cut and Lift with Deburial	O4A - Leave (Minor) - Rock Placement over Spans / Exposures	O4C - Leave (Minor) - Remove Spans / Exposures	Weighting
O2A - Full Removal - Cut and Lift with Deburial	N	MW	MW	14.3%
O4A - Leave (Minor) - Rock Placement over Spans / Exposures	MS	N	N	42.9%
O4C - Leave (Minor) - Remove Spans / Exposures	MS	N	N	42.9%

2.2 Atmospheric Emissions & Fuel Consumption	O2A - Full Removal - Cut and Lift with Deburial	O4A - Leave (Minor) - Rock Placement over Spans / Exposures	O4C - Leave (Minor) - Remove Spans / Exposures	Weighting
O2A - Full Removal - Cut and Lift with Deburial	N	MW	W	18.6%
O4A - Leave (Minor) - Rock Placement over Spans / Exposures	MS	N	S	50.7%
O4C - Leave (Minor) - Remove Spans / Exposures	S	W	N	30.7%

2.3 Other Consumptions	O2A - Full Removal - Cut and Lift with Deburial	O4A - Leave (Minor) - Rock Placement over Spans / Exposures	O4C - Leave (Minor) - Remove Spans / Exposures	Weighting
O2A - Full Removal - Cut and Lift with Deburial	N	MS	MS	60.0%
O4A - Leave (Minor) - Rock Placement over Spans / Exposures	MW	N	N	20.0%
O4C - Leave (Minor) - Remove Spans / Exposures	MW	N	N	20.0%

2.4 Seabed Disturbance	O2A - Full Removal - Cut and Lift with Deburial	O4A - Leave (Minor) - Rock Placement over Spans / Exposures	O4C - Leave (Minor) - Remove Spans / Exposures	Weighting
O2A - Full Removal - Cut and Lift with Deburial	N	MW	MW	14.2%
O4A - Leave (Minor) - Rock Placement over Spans / Exposures	MS	N	S	48.7%
O4C - Leave (Minor) - Remove Spans / Exposures	MS	W	N	37.1%

2.5 Legacy Marine Impacts	O2A - Full Removal - Cut and Lift with Deburial	O4A - Leave (Minor) - Rock Placement over Spans / Exposures	O4C - Leave (Minor) - Remove Spans / Exposures	Weighting
O2A - Full Removal - Cut and Lift with Deburial	N	MS	MS	60.0%
O4A - Leave (Minor) - Rock Placement over Spans / Exposures	MW	N	N	20.0%
O4C - Leave (Minor) - Remove Spans / Exposures	MW	N	N	20.0%

Appendix D.4 Group 1 Pairwise Comparison Matrices – Technical

3.1 Technical Risk	O2A - Full Removal - Cut and Lift with Deburial	O4A - Leave (Minor) - Rock Placement over Spans / Exposures	O4C - Leave (Minor) - Remove Spans / Exposures	Weighting
O2A - Full Removal - Cut and Lift with Deburial	N	W	W	25.0%
O4A - Leave (Minor) - Rock Placement over Spans / Exposures	S	N	N	37.5%
O4C - Leave (Minor) - Remove Spans / Exposures	S	N	N	37.5%

Appendix D.5 Group 1 Pairwise Comparison Matrices – Societal

4.1 Fishing	O2A - Full Removal - Cut and Lift with Deburial	O4A - Leave (Minor) - Rock Placement over Spans / Exposures	O4C - Leave (Minor) - Remove Spans / Exposures	Weighting
O2A - Full Removal - Cut and Lift with Deburial	N	MS	MS	60.0%
O4A - Leave (Minor) - Rock Placement over Spans / Exposures	MW	N	N	20.0%
O4C - Leave (Minor) - Remove Spans / Exposures	MW	N	N	20.0%

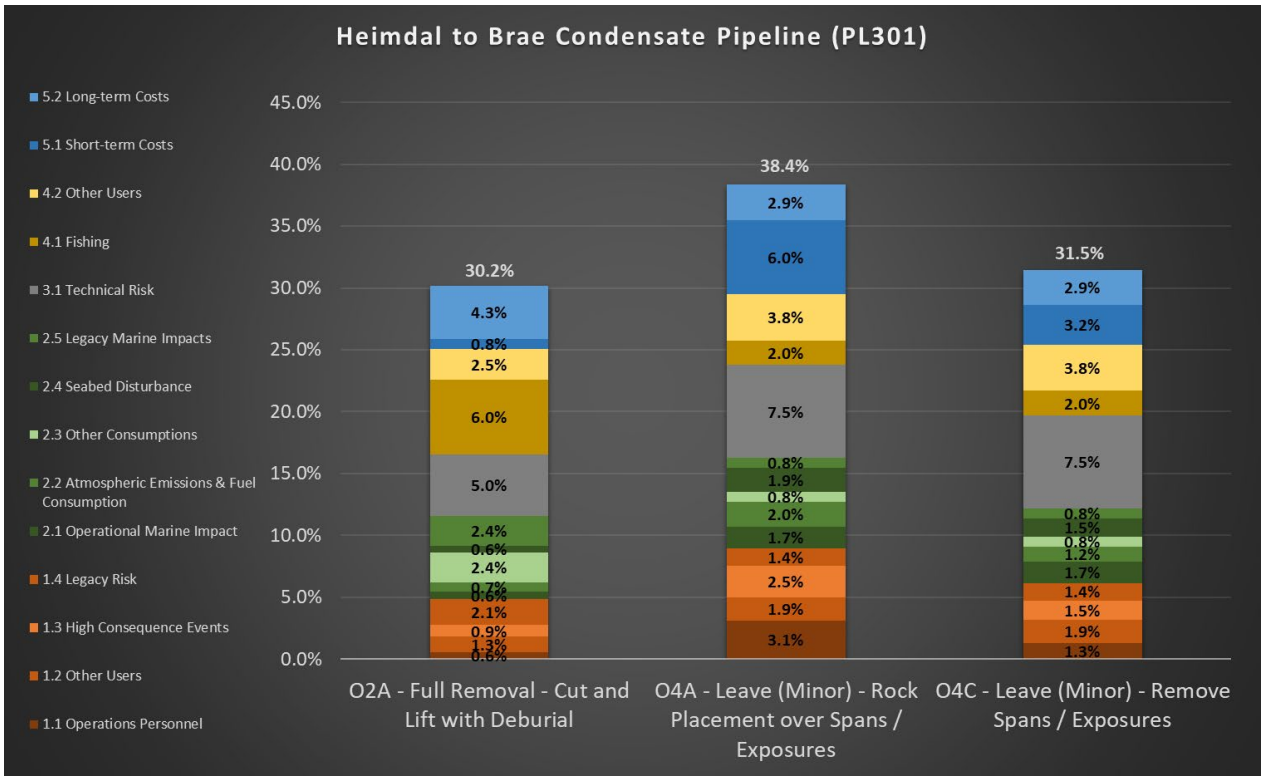
4.2 Other Users	O2A - Full Removal - Cut and Lift with Deburial	O4A - Leave (Minor) - Rock Placement over Spans / Exposures	O4C - Leave (Minor) - Remove Spans / Exposures	Weighting
O2A - Full Removal - Cut and Lift with Deburial	N	W	W	25.0%
O4A - Leave (Minor) - Rock Placement over Spans / Exposures	S	N	N	37.5%
O4C - Leave (Minor) - Remove Spans / Exposures	S	N	N	37.5%

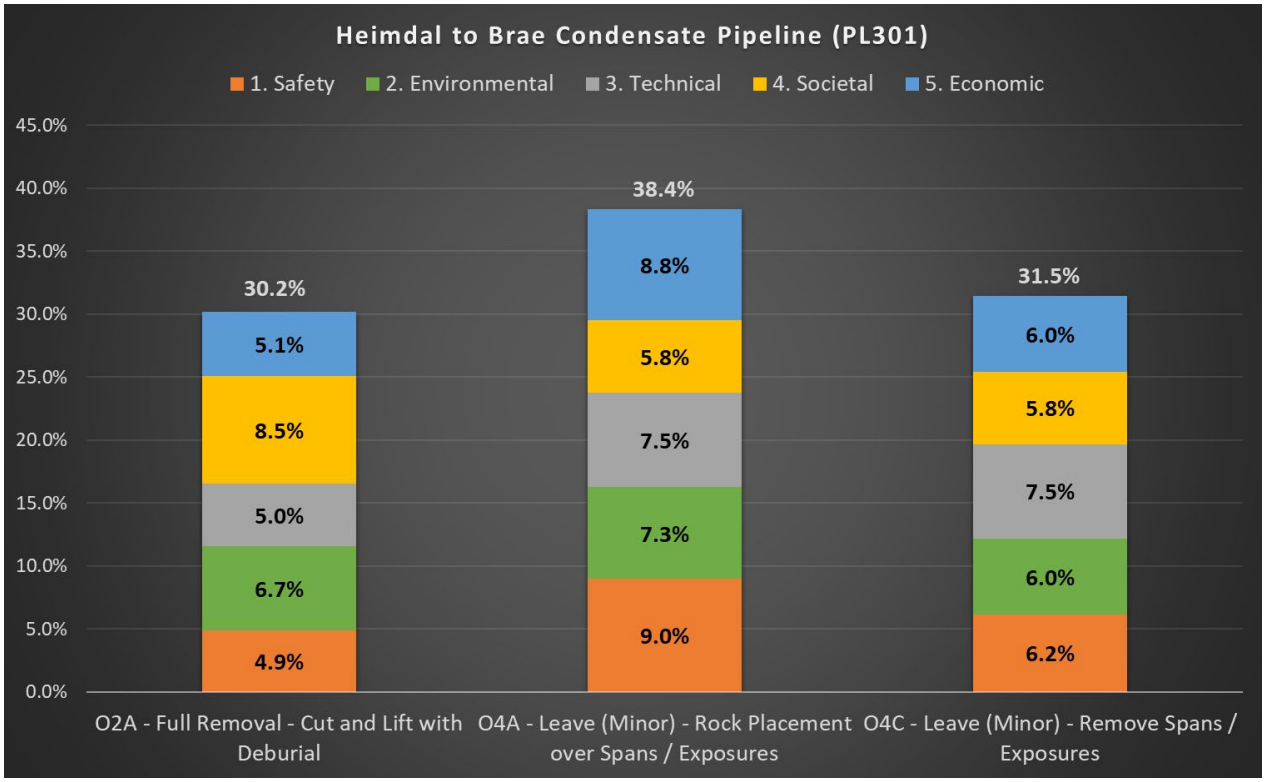
Appendix D.6 Group 1 Pairwise Comparison Matrices - Economic

5.1 Short-term Costs	O2A - Full Removal - Cut and Lift with Deburial	O4A - Leave (Minor) - Rock Placement over Spans / Exposures	O4C - Leave (Minor) - Remove Spans / Exposures	Weighting
O2A - Full Removal - Cut and Lift with Deburial	N	VMW	MW	8.4%
O4A - Leave (Minor) - Rock Placement over Spans / Exposures	VMS	N	S	59.9%
O4C - Leave (Minor) - Remove Spans / Exposures	MS	W	N	31.7%

5.2 Long-term Costs	O2A - Full Removal - Cut and Lift with Deburial	O4A - Leave (Minor) - Rock Placement over Spans / Exposures	O4C - Leave (Minor) - Remove Spans / Exposures	Weighting
O2A - Full Removal - Cut and Lift with Deburial	N	S	S	42.9%
O4A - Leave (Minor) - Rock Placement over Spans / Exposures	W	N	N	28.6%
O4C - Leave (Minor) - Remove Spans / Exposures	W	N	N	28.6%

Appendix D.7 Group 1 Results Charts





APPENDIX E PL301 EXPOSURES

Appendix E.1 Summary of past pipeline survey data, between 2009 and 2017, along PL301

Item	2009	2013	2017
Length of buried pipe (within EA scope) (m)	36322	35305	35807
% Coverage	95%	92%	94%
Number of freespans (within EA scope)*	1	6	3
Length of freespans (m) (within EA scope)*	6	34	28
Average Depth of Cover (m) (within EA scope)	-	0.21	0.19

*All spans within the scope of this DP are less than 0.8m in height or 10m in length and as such are non-reportable.

Appendix E.2 Summary of exposures and freespans along PL301 (Deepocean, 2017)

Exposure/Freespan	Number	Total Length (m)
Exposures < 5 m	67	175
Exposures 5-20 m	54	492
Exposures >20 m	13	678
Freespans	3	28

Appendix E.3 Location, length and depth of exposures along PL301 (Deepocean, 2017)

KP Point Start	KP Point End	Distance (km)	Depth to Top of Pipe (ToP) (m)	Depth of Adjacent Mean Seabed (m)	Depth of Trench (m)	Depth of Cover (DoC) (m)
78.148	78.153	0.005	121.42	120.76	0.66	0
79.447	79.447	0.000	122.10	121.55	0.55	0
79.879	79.879	0.000	121.29	120.71	0.58	0
80.961	80.962	0.001	120.88	120.42	0.46	0
83.131	83.132	0.001	120.64	120.17	0.47	0
85.617	85.618	0.001	118.92	118.47	0.45	0
85.813	85.814	0.001	118.66	118.24	0.42	0
86.665	86.666	0.001	117.39	117.01	0.38	0
86.771	86.772	0.001	117.29	116.92	0.37	0
86.747	86.749	0.002	117.27	116.92	0.35	0
87.683	87.748	0.065	116.24	116.16	0.08	0
88.004	88.005	0.001	116.59	116.29	0.30	0

88.282	88.284	0.002	116.62	116.21	0.41	0
88.303	88.304	0.001	116.65	116.25	0.40	0
88.455	88.456	0.001	116.66	116.25	0.41	0
88.586	88.595	0.009	116.60	116.33	0.27	0
89.603	89.607	0.004	116.26	116.01	0.25	0
89.610	89.616	0.006	116.25	116.09	0.16	0
89.631	89.637	0.006	116.23	116.05	0.18	0
89.642	89.645	0.003	116.21	116.07	0.14	0
89.655	89.657	0.002	116.22	116.08	0.14	0
89.688	89.690	0.002	116.79	116.11	0.68	0
89.870	89.873	0.003	116.00	115.61	0.39	0
90.080	90.081	0.001	115.80	115.42	0.38	0
90.104	90.104	0.000	115.79	115.36	0.43	0
90.407	90.410	0.003	115.53	115.19	0.34	0
90.521	90.522	0.001	115.30	115.03	0.27	0
90.578	90.581	0.003	115.25	114.95	0.30	0
90.819	90.822	0.003	114.96	114.54	0.42	0
91.056	91.058	0.002	114.16	113.98	0.18	0
91.265	91.268	0.003	113.63	113.47	0.16	0
91.286	91.393	0.107	113.57	113.42	0.15	0
91.462	91.466	0.004	113.74	112.98	0.76	0
91.487	91.487	0.000	113.69	112.97	0.72	0
91.527	91.529	0.002	113.59	112.94	0.65	0
91.537	91.538	0.001	113.55	112.96	0.59	0
91.606	91.623	0.017	113.08	112.96	0.12	0
91.630	91.631	0.001	113.06	112.94	0.12	0

92.154	92.182	0.028	111.58	111.45	0.13	0
93.440	93.449	0.009	107.65	107.52	0.13	0
93.655	93.659	0.004	108.87	108.74	0.13	0
93.660	93.677	0.017	108.88	108.76	0.12	0
93.687	93.713	0.026	109.09	108.97	0.12	0
93.777	93.778	0.001	109.71	109.24	0.47	0
94.788	94.788	0.000	110.12	109.92	0.20	0
94.791	94.815	0.024	110.11	109.92	0.19	0
94.865	94.865	0.000	110.26	110.04	0.22	0
94.924	94.925	0.001	110.11	109.97	0.14	0
95.075	95.075	0.000	110.27	110.02	0.25	0
95.409	95.409	0.000	109.92	109.77	0.15	0
95.414	95.416	0.002	109.91	109.75	0.16	0
95.452	95.471	0.019	109.85	109.70	0.15	0
95.490	95.492	0.002	109.75	109.62	0.13	0
95.587	95.591	0.004	109.61	109.49	0.12	0
95.609	95.615	0.006	109.71	109.55	0.16	0
95.637	95.649	0.012	109.75	109.58	0.17	0
95.976	95.976	0.000	109.43	109.35	0.08	0
96.013	96.013	0.000	109.38	109.30	0.08	0
96.018	96.019	0.001	109.38	109.30	0.08	0
96.039	96.121	0.082	109.39	109.28	0.11	0
96.251	96.257	0.006	109.50	108.77	0.73	0
96.417	96.426	0.009	108.70	108.03	0.67	0
96.442	96.450	0.008	108.54	108.06	0.48	0
96.462	96.468	0.006	108.39	108.03	0.36	0

96.571	96.579	0.008	107.91	107.77	0.14	0
96.926	96.937	0.011	108.28	107.78	0.50	0
98.165	98.172	0.007	106.84	106.43	0.41	0
98.485	98.486	0.001	106.40	106.14	0.26	0
98.727	98.731	0.004	106.33	105.97	0.36	0
100.987	101.002	0.015	105.45	105.35	0.10	0
101.073	101.078	0.005	105.56	105.10	0.46	0
101.088	101.110	0.022	105.57	105.14	0.43	0
101.138	101.141	0.003	105.58	105.07	0.51	0
101.158	101.162	0.004	105.46	105.02	0.44	0
101.353	101.359	0.006	105.23	104.86	0.37	0
101.364	101.366	0.002	105.10	104.80	0.30	0
101.370	101.374	0.004	105.11	104.83	0.28	0
101.379	101.388	0.009	105.24	104.81	0.43	0
101.586	101.759	0.173	104.87	104.45	0.42	0
101.789	101.902	0.113	104.99	104.87	0.12	0
101.979	101.980	0.001	105.33	104.87	0.46	0
102.406	102.407	0.001	104.93	104.65	0.28	0
102.469	102.492	0.023	105.02	104.59	0.43	0
102.507	102.516	0.009	104.90	104.55	0.35	0
102.610	102.610	0.000	104.53	104.39	0.14	0
102.627	102.639	0.012	104.49	104.35	0.14	0
102.663	102.663	0.000	104.43	104.28	0.15	0
103.023	103.040	0.017	103.73	103.48	0.25	0
103.046	103.052	0.006	103.82	103.45	0.37	0
103.135	103.140	0.005	103.55	103.16	0.39	0

103.309	103.327	0.018	103.01	102.96	0.05	0
103.372	103.376	0.004	103.32	102.96	0.36	0
104.098	104.105	0.007	103.34	103.24	0.10	0
104.189	104.189	0.000	103.36	103.19	0.17	0
104.664	104.697	0.033	102.77	102.66	0.11	0
104.714	104.751	0.037	102.77	102.64	0.13	0
104.879	104.919	0.040	102.67	102.60	0.07	0
105.070	105.073	0.003	102.61	102.43	0.18	0
106.359	106.363	0.004	102.40	102.09	0.31	0
106.419	106.422	0.003	102.54	102.17	0.37	0
106.563	106.583	0.020	102.76	102.66	0.10	0
106.612	106.618	0.006	103.00	102.90	0.10	0
106.677	106.679	0.002	103.37	103.24	0.13	0
106.863	106.863	0.000	104.45	104.17	0.28	0
106.986	106.994	0.008	104.86	104.72	0.14	0
107.030	107.053	0.023	105.00	104.79	0.21	0
107.063	107.095	0.032	105.23	104.83	0.40	0
107.164	107.204	0.040	105.20	105.17	0.03	0
107.415	107.430	0.015	105.90	105.76	0.14	0
107.499	107.505	0.006	106.37	105.94	0.43	0
107.563	107.564	0.001	106.50	106.12	0.38	0
107.675	107.677	0.002	106.81	106.47	0.34	0
108.056	108.056	0.000	107.03	106.70	0.33	0
108.934	108.936	0.002	106.76	106.64	0.12	0
108.993	108.996	0.003	106.93	106.83	0.10	0
109.097	109.102	0.005	107.27	107.16	0.11	0

111.848	111.848	0.000	109.20	108.90	0.30	0
112.093	112.127	0.034	109.89	109.54	0.35	0
112.150	112.150	0.000	110.21	109.73	0.48	0
112.166	112.166	0.000	110.25	109.81	0.44	0
112.248	112.254	0.006	110.37	110.09	0.28	0
112.263	112.278	0.015	110.50	109.97	0.53	0
112.316	112.318	0.002	110.76	110.44	0.32	0
112.394	112.398	0.004	111.31	110.58	0.73	0
112.562	112.566	0.004	111.82	111.00	0.82	0
112.574	112.576	0.002	111.79	111.00	0.79	0
113.957	113.972	0.015	110.31	110.11	0.20	0
114.162	114.162	0.000	110.63	109.93	0.70	0
114.191	114.195	0.004	110.56	110.03	0.53	0
114.251	114.265	0.014	110.60	110.11	0.49	0
114.280	114.285	0.005	110.61	110.13	0.48	0
114.335	114.337	0.002	110.64	110.25	0.39	0
114.350	114.350	0.000	110.69	110.28	0.41	0
114.359	114.360	0.001	110.77	110.12	0.65	0
114.368	114.373	0.005	110.81	110.32	0.49	0
114.478	114.478	0.000	110.97	110.71	0.26	0
114.492	114.493	0.001	111.03	110.70	0.33	0
114.511	114.516	0.005	111.18	110.74	0.44	0
114.572	114.572	0.000	111.27	110.94	0.33	0
114.593	114.597	0.004	111.41	110.97	0.44	0
114.606	114.608	0.002	111.32	110.98	0.34	0
114.613	114.617	0.004	111.39	110.96	0.43	0

114.634	114.635	0.001	111.40	111.05	0.35	0
114.649	114.649	0.000	111.45	111.07	0.38	0
114.653	114.656	0.003	111.44	111.15	0.29	0
114.712	114.713	0.001	111.62	111.28	0.34	0
114.860	114.869	0.009	112.07	111.69	0.38	0
114.888	114.888	0.000	111.99	111.73	0.26	0
114.957	114.982	0.025	112.05	111.86	0.19	0
114.988	114.988	0.000	112.14	111.89	0.25	0
115.008	115.021	0.013	112.13	111.93	0.20	0
115.033	115.035	0.002	112.21	111.99	0.22	0
115.043	115.054	0.011	112.18	112.01	0.17	0
115.073	115.100	0.027	112.32	112.08	0.24	0
115.119	115.142	0.023	112.58	112.16	0.42	0
115.162	115.170	0.008	112.91	112.25	0.66	0
115.189	115.189	0.000	112.73	112.36	0.37	0
115.213	115.224	0.011	112.90	112.43	0.47	0
115.275	115.275	0.000	112.93	112.61	0.32	0
115.387	115.404	0.017	113.11	112.82	0.29	0
115.418	115.418	0.000	113.19	112.89	0.30	0
115.505	115.505	0.000	113.20	112.90	0.30	0
115.562	115.700	0.138	113.06	112.83	0.23	0

Appendix E.4 Areas of possible pipeline spans along PL301

Start KP	End KP	Length (m)
91.332	91.335	3
91.344	91.365	21
91.371	91.375	4