Minke Decommissioning Comparative Assessment Report

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Minke Comparative Assessment Report

Revision Change Notices

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<tr>
<td>A02</td>
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<td>Report updated based on external CA workshop discussions and findings</td>
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<td>Clearance of HOLDS</td>
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Classification Definitions

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<th>Classification Level</th>
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<tr>
<td>Unclassified</td>
<td>Information which may be made public without consequences for the entity or Neptune Energy.</td>
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<tr>
<td>Internal</td>
<td>Information intended to remain within Neptune Energy. Permission from a direct manager is required to disclose it outside Neptune Energy.</td>
</tr>
<tr>
<td>Restricted</td>
<td>Information which, if disclosed outside the appropriate perimeter, may have a serious impact on the entity or a serious impact on Neptune Energy. Access is limited to specific individuals or groups.</td>
</tr>
<tr>
<td>Confidential</td>
<td>Information which, if disclosed to people other than those specifically designated to receive it, would have a major impact on the entity or a major impact on Neptune Energy. In such cases, very strict rules apply to the information chain.</td>
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Contractor Details*

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*where CONTRACTOR aligns to COMPANY Document Numbering convention there is no requirement to complete this information
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TERMS, ABBREVIATIONS AND ACRONYMS

AHP  Analytical Hierarchy Process
BAT  Best Available Technology
BEIS Department of Business, Energy and Industrial Strategy
BEP  Best Environmental Practice
CA   Comparative Assessment
CoP  Cessation of Production
CSV  Construction Support Vessel
DSV  Dive Support Vessel
EMT  Environmental Management Team
ENVID Environmental factors Identification
FAR  Fatal Accident Rate
HIRA Hazard Identification and Risk Assessment
HSE  Health & Safety Executive
JNCC Joint Nature Conservation Committee
MCDA Multi-Criteria Decision Analysis
MFE  Mass Flow Excavation
NFFO National Federation of Fisherman’s Organisations
ODU  Offshore Decommissioning Unit
OGA  Oil & Gas Authority
OPRED Offshore Petroleum Regulator for Environment & Decommissioning
OSPAR Oslo/Paris convention (for the Protection of the Marine Environment of the North-East Atlantic)
P&A  Plugging & Abandonment
PLL  Potential for Loss of Life
TGT  Theddlethorpe Gas Terminal
ToR  Terms of Reference
UKCS United Kingdom Continental Shelf
1 EXECUTIVE SUMMARY

A Comparative Assessment (CA) Evaluation Workshop for the short-listed decommissioning options for the Minke subsea pipelines and infrastructure was held at Neptune Energy Aberdeen office on Thursday 20th September with external stakeholders. This followed an internal workshop involving Neptune, Minke field partners and Xodus.

Included in the Evaluation Workshop was one minimal intervention option and two full removal options. These options are summarised below.

- Option 1B – Leave in situ Minimal Intervention – Disconnect Ends, Rockdump Ends.
- Option 5A – Full Removal – Deburial and Reverse Reel.
- Option 5C – Full Removal – Deburial, Pipeline Cut and Lift, Umbilical Reverse Reel.

These options were compared based on the CA sub-criteria previously agreed with Neptune. This sub-criteria was based on Safety, Environmental, Technical, Societal and Economic considerations. The results of the assessment showed that Option 1B (Leave in situ) ranked the highest for eight of the twelve sub-criteria (four of the five main criteria). These findings are summarised in Figure 1.1.
As the above figure shows, Option 1B is the overall preferred decommissioning solution for the Minke pipelines and associated stabilisation material. Based on the discussions from all CA workshops (internal and external), sensitivities were performed on many of the sub-criteria including:

- Sub-Criteria 4.1 – Societal impact on fishing activities
- Sub-Criteria 5.1 – Operational and legacy costs.

The sensitivity cases did not alter the findings of the assessment therefore no single criterion was adversely driving the results of the CA.

Please note that these findings are based on the discussions from the external CA workshop however the conclusions are consistent with the internal session held on Wednesday 22nd August.
# 2 INTRODUCTION

## 2.1 BACKGROUND

The Minke Field is located in the Southern Basin of the UKCS in Block 44/24a and lies approximately 15km south-west of the D15-FA platform, operated by Neptune Energy Netherlands BV, located in the Dutch sector. The field is produced via a single subsea horizontal well tied back by a ~15km 8” diameter production pipeline to a riser at the D15-FA platform.

The Minke Field layout is shown in Figure 2.1 below.

![Minke Field Layout](image_url)
The well and 3.7km of the pipelines are within the UK sector, the D15-FA platform and remaining 12km of the pipeline are located in the Dutch sector, block D15. The Minke field Cessation of Production (CoP) was granted in 2016.

2.2 COMPARATIVE ASSESSMENT OVERVIEW

The decommissioning of offshore oil and gas installations and pipelines on the United Kingdom Continental Shelf (UKCS) is controlled through the Petroleum Act 1998, as amended by the Energy Act 2008. In the UK, decommissioning is also regulated under the Marine and Coastal Act 2009 and Marine (Scotland) Act 2010. The UK’s international obligations on decommissioning are primarily governed by the 1992 Convention for the Protection of the Marine Environment of the North East Atlantic (the OSPAR Convention). The responsibility for ensuring compliance with the Petroleum Act 1998 rests with Department of Business, Energy and Industrial Strategy (BEIS). BEIS is also the Competent Authority on decommissioning in the UK for OSPAR purposes and under the Marine Acts.

The Minke subsea infrastructure is the subject of a comparative assessment (CA) of options under guidance provided by the BEIS forming a core part of the overall decommissioning planning process. The methodology for Comparative Assessment is described in detail in the Minke CA Terms of Reference Report [1]. This Comparative Assessment Report will be submitted alongside the DP (BEIS).

2.3 COMPARATIVE ASSESSMENT PROCESS

The Comparative Assessment utilises a Multi Criteria Decision Analysis (MCDA) tool which employs pairwise comparison of quantitative and qualitative data [2]. A detailed description of this process is described in the Terms of Reference for Minke Comparative Assessment [1].

A schematic of the Comparative Assessment process is detailed in Figure 2.2 below.
**Figure 2.2  Overview of the Comparative Assessment process**

**Scope**
- Decide on appropriate CA method, confirm criteria, identify boundaries of CA (physical and phase).

**Screen**
- Consider alternative uses and deselect unfeasible options.

**Prepare**
- Undertake technical, safety, environmental and other appropriate studies. Undertake stakeholder engagement.

**Evaluate**
- Evaluate the options using the chosen evaluation methodology.

**Recommend**
- Create recommendation in the form of narrative supported by charts explaining key trade-offs.

**Review**
- Review the recommendation with internal and/or external stakeholders.

**Submit**
- Submit to BEIS as part of/alongside Decommissioning Programme.
3 COMPARATIVE ASSESSMENT WORKSHOP

3.1 OVERVIEW

As outlined in the Terms of Reference for Minke Comparative Assessment Report [1], the Minke Field Decommissioning Project External CA Workshop was held from 13:00 to 16:00 on Thursday 20th September at Neptune Energy’s Aberdeen Office at 16 North West Esplanade, Aberdeen, AB11 5RJ. The workshop was facilitated by Xodus Group.

3.2 ATTENDEES

The attendees of the Minke Field Decommissioning Project External CA Workshop are detailed in Table 2-1 below.

<table>
<thead>
<tr>
<th>Name</th>
<th>Company</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alan Muirhead</td>
<td>Neptune Energy</td>
<td>Developments and Decommissioning Manager</td>
</tr>
<tr>
<td>Pierre Girard</td>
<td>Neptune Energy</td>
<td>Asset Manager</td>
</tr>
<tr>
<td>Eddie Anderson</td>
<td>Neptune Energy</td>
<td>HSE</td>
</tr>
<tr>
<td>David Hawkins</td>
<td>Neptune Energy</td>
<td>Environment</td>
</tr>
<tr>
<td>Joanne Rostant</td>
<td>Neptune Energy</td>
<td>Tech Safety</td>
</tr>
<tr>
<td>Justin Heath</td>
<td>Neptune Energy</td>
<td>Communications</td>
</tr>
<tr>
<td>Francis Barrett</td>
<td>Xodus Group</td>
<td>Subsea and Pipelines</td>
</tr>
<tr>
<td>Rebecca Allan</td>
<td>Xodus Group</td>
<td>Project Representation</td>
</tr>
<tr>
<td>Gareth Jones</td>
<td>Xodus Group</td>
<td>Facilitator</td>
</tr>
<tr>
<td>Kim Woods</td>
<td>BEIS OPRED ODU</td>
<td>Stakeholder Representative</td>
</tr>
<tr>
<td>Audrey Banner</td>
<td>BEIS OPRED</td>
<td>Stakeholder Representative</td>
</tr>
<tr>
<td>Fiona Livingston</td>
<td>BEIS</td>
<td>Stakeholder Representative</td>
</tr>
</tbody>
</table>

Table 3.1 CA Workshop Attendees
Please note that a representative from the NFFO was invited to the workshop but unfortunately could not attend. The NFFO were informed of the workshop outcome and confirmed they were in agreement with what had been presented and had no further comments to add.

3.3 OUTCOMES AND ACTIONS

This report summarises the finding from the external presentation of the Minke Field Decommissioning Project CA Workshop.
4 PROJECT DESCRIPTION

4.1 GROUPINGS

The decommissioning programme underwent a scoping process in which four groupings of subsea infrastructure were identified (Table 4.1). Each component has been allocated to a common scoping group based on physical properties and installation conditions.

<table>
<thead>
<tr>
<th>Group Number</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>M1</td>
<td>Trenched and Buried Pipelines and Umbilicals</td>
</tr>
<tr>
<td></td>
<td>- PL2401</td>
</tr>
<tr>
<td></td>
<td>- PLU2402</td>
</tr>
<tr>
<td>M2</td>
<td>Surface Laid Spoolpieces</td>
</tr>
<tr>
<td>M3</td>
<td>Subsea Structures</td>
</tr>
<tr>
<td></td>
<td>- Wellhead Protection Structures</td>
</tr>
<tr>
<td>M4</td>
<td>Mattresses and Grout Bags</td>
</tr>
</tbody>
</table>

Table 4.1 Minke Scoping Groups

The wellhead protection structures (Group M3) form part of the definition of an Installation under OSPAR and therefore require to be fully removed as they do not meet any of the derogation criteria laid out in the guidance. As a result, these structures do not require comparative assessment.

Through the internal screening process, it was acknowledged that removal of trenched and buried pipelines and umbilicals would require removal of the overlaid mattresses and grout bags. Consequently, these two groupings have been distilled into a single group which includes trenched and buried pipelines, umbilicals, mattresses and grout bags.
(which are also buried). This group was then subjected to additional screening in the evaluation phase of the Comparative Assessment (see Section 4.2 below).

Additionally, during the internal CA workshop between Neptune and Xodus personnel it was acknowledged that there was no supportable justification for leaving the surface laid spoolpieces *in situ* therefore these items are assumed to be fully removed. Group M2 was therefore removed from the CA Evaluation Stage.

### 4.2 OPTIONS

Following the initial scoping and screening, two Groups were selected for the evaluation phase of the Comparative Assessment: Groups M1 and M4 (for buried mattresses and grout bags only). The process behind this selection is detailed in reference [3]. During discussions in the internal CA workshop, it became apparent that the option for the Group 4 items were fully dependent on the Group 1 option. For example, if the pipeline is fully removed (Group 1), then all Group 4 items would be fully removed also. It was deemed unnecessary to take Group 4 items further in the CA process, since their outcome was dependent on Group 1.

A summary of the options identified for screening is detailed in Table 4.2. The highlighted options were selected in the internal validation workshop for further evaluation in the Comparative Assessment Workshop and subsequent External Stakeholder Engagement Workshop. These options are discussed in detail below.
### 4.2.1 Option 1B: Disconnect & Rock-dump Ends

For this option, the trenched and buried pipeline and umbilical will be left in situ and disconnected at the Minke end (where the pipeline and umbilical exits the trench) and the ends removed. It is noted the umbilical end is inclusive of ~175 m of surface laid umbilical, of which approximately 10 m is buried under rockdump.

Decommissioning of the Minke tie-in infrastructure at the D15-FA platform approach is planned to be deferred subject to agreement with the D15-FA owners and it is assumed that no preparatory activities (e.g. pipeline cut) will be undertaken during the first phase of decommissioning. The riser is the Minke owner’s responsibility however, there is a connection agreement that states the riser does not have to be decommissioned until the jacket is decommissioned. In addition, the umbilical approach at D15-FA Platform and umbilical riser within the j-tube shall be left “as is” and decommissioned when the jacket is decommissioned.

A comparison of the existing infrastructure and the results of the minimal intervention decommissioning programme proposed in Option 1B is illustrated in Figure 4.1.

To aid clarity, the following schematics are provided on a larger scale in Appendix 3.
Figure 4.1  Comparison of existing infrastructure (left) with Option 1B decommissioning outcome (right)
4.2.2 Option 5A: Deburial & Reverse Reel

The offshore operations for this option consist of performing a pre-works survey and deburial of the pipeline bundle along its length using a mass flow excavator (by CSV), followed by DSV operations to disconnect the pipeline and umbilical ends both at Minke and D15-FA Platform ends and connect recovery heads. The surface laid umbilical section shall be cut into sections and recovered to surface by the DSV.

A reel vessel will then recover the pipeline bundle via reverse reeling. The pipeline bundle will be separated on the back deck of the recovery vessel before being reeled onto the receiving drums. The items shall be returned to shore for recycling/ final disposal.

4.2.3 Option 5C: Deburial, Pipeline and Umbilical Cut & Lift

The offshore operations for this option consist of performing a pre-works survey and deburial of the pipeline bundle along its length using a mass flow excavator. The pipeline bundle shall then be cut every 24 m (2 pipe lengths). Each section shall be rigged and recovered to surface. A CSV is assumed for deburial and cutting operations. A DSV and barge are assumed for rigging and recovery of the cut pipeline bundle. The 175m surface laid umbilical section at Minke shall also be cut into 24m sections and recovered to surface.

The recovered items shall be returned to shore for recycling/ final disposal.

A comparison of the existing infrastructure and the results of the full removal decommissioning programmes proposed in Options 5A and 5C is illustrated in Figure 4.2.
Figure 4.2  Comparison of existing infrastructure (left) with Option 5A and 5C decommissioning outcomes (right)
5 COMPARITIVE ASSESSMENT

5.1 QUANTITATIVE REVIEW

Following the scoping and internal validation processes, further work was needed to refine the three identified options (using quantitative data (Table 5.1). This work included: outlining the cost and schedule for each option through a detailed methods and technical feasibility (methodology) review; study of environmental factors (e.g. characterisation of natural habitat, noise, seabed disturbance, and vessel emissions); study of safety risk to fishermen; assessment of safety risk to operational personnel, quantified as Potential for Loss of Life (PLL); Hazard Identification Risk Assessment (HIRA); and Environmental factors Identification (ENVID), including quantification of impacts required for differentiation.

The resulting quantified attributes for each option are then compared through the Comparative Assessment Tool, as described in reference [1]. The attributes for each option are summarised in Table 5.1 below.

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Option 1B</th>
<th>Option 5A</th>
<th>Option 5C</th>
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<tr>
<td>Life Cycle Emissions</td>
<td>2,355 te</td>
<td>1,260 te</td>
<td>1,260 te</td>
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<tr>
<td>Vessel Days (Total)</td>
<td>37</td>
<td>62</td>
<td>302</td>
</tr>
<tr>
<td>Overall PLL</td>
<td>1.4 e^{-3}</td>
<td>4.2 e-3</td>
<td>3.1 e-2</td>
</tr>
<tr>
<td>Seabed Disturbance</td>
<td>400 m^2</td>
<td>30,218 m^2</td>
<td>30,218 m^2</td>
</tr>
<tr>
<td>Risk to Fisherman</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Vessel CO₂ Emissions</td>
<td>852 te</td>
<td>4,223 te</td>
<td>21,085 te</td>
</tr>
<tr>
<td>Relative Cost</td>
<td>1x</td>
<td>2.8x</td>
<td>10.1x</td>
</tr>
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</table>

Note 1: Area of disturbance presented above is the differentiating element (i.e. excluding overtrawl footprint (1,510,900 m^2) which applies to all options).

Table 5.1 Quantitative data used in the Comparative Assessment of the three identified Options
Please note that the attributes given in Table 5.1 refer to the pipeline removal / remediation only. If the mattresses are to be removed, it will be executed in the same campaign as the pipeline activities hence the emissions, PLL, seabed disturbance and costs will be higher but only marginally. The safety risk to fisherman will still be classed as ‘Low’.

### 5.2 EVALUATION METHODOLOGY

The options were evaluated using criteria defined by BEIS; they include the following equally-weighted factors: Safety; Environment; Technical; Societal; and Economics. These five criteria, their sub-criteria and relative weightings are detailed in Table 5.2 below.

<table>
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<td>Other Users [6.67%]</td>
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<tr>
<td></td>
<td>Legacy Risk [6.67%]</td>
</tr>
<tr>
<td>Environmental [20%]</td>
<td>Operational Marine Impacts [4%]</td>
</tr>
<tr>
<td></td>
<td>Fuel and Emissions [4%]</td>
</tr>
<tr>
<td></td>
<td>Legacy Marine Impacts [4%]</td>
</tr>
<tr>
<td></td>
<td>Materials and Residuals [4%]</td>
</tr>
<tr>
<td></td>
<td>Seabed disturbance [4%]</td>
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<td>Technical [20%]</td>
<td>Project Technical Risk [20%]</td>
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<tr>
<td>Societal [20%]</td>
<td>Fishing Industry [10%]</td>
</tr>
<tr>
<td></td>
<td>Socio-economic impacts on communities and amenities [10%]</td>
</tr>
<tr>
<td>Economics [20%]</td>
<td>Operational and Legacy Costs [20%]</td>
</tr>
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*Table 5.2 Evaluation criteria for Comparative Assessment*

The definitions of each sub-criteria addressed in the Comparative Assessment are specified in Table 5.3.
## Minke Comparative Assessment Report

### Criteria

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<tr>
<th>Sub-Criteria</th>
<th>Description</th>
<th>Approach to Assessment</th>
</tr>
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<tbody>
<tr>
<td>1.1 Operations Personnel</td>
<td>This sub-criterion considers elements that impact risk to offshore and onshore personnel. The offshore assessment 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. The onshore assessment considers any requirement for dismantling, disposal operations, material transfer and onshore handling may impact onshore personnel.</td>
<td>Potential for Loss of Life (PLL) metrics were calculated for each option. This allows a quantified direct comparison between options. A quantitative assessment based on the number of vessel days associated with each of the decommissioning options. This is considered acceptable as the safety impact on other users is a function of the operational vessel numbers / durations / movements.</td>
</tr>
<tr>
<td>1.2 Other Users</td>
<td>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.</td>
<td>A coarse HIRA was conducted to identify elements associated with the options that had potential for High Consequence Events. The HIRA also addressed the legacy risk component associated with the options.</td>
</tr>
<tr>
<td>1.3 Legacy Risk</td>
<td>This sub-criterion addresses any personnel risk exposure associated with long-term monitoring in a similar way to 1.1. The assessment considers all exposure activities associated with legacy future survey requirements and any intervention allowance. Hazards identified in the Safety Risk to Fisherman report are also considered here.</td>
<td>A qualitative risk assessment of the risk to fishermen as a result of potential subsea elements (pipelines / umbilicals and associated rock cover, mattresses and grout bags) left on/in the seabed was performed.</td>
</tr>
<tr>
<td>Criteria</td>
<td>Sub-Criteria</td>
<td>Description</td>
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<td>-------------</td>
</tr>
<tr>
<td>2.</td>
<td>2.1 Operational Marine Impacts</td>
<td>Marine environmental impact caused by: Project Vessels, Supply Boats, Survey vessels i.e. noise generated by vessels, cutting operations, any explosives etc. during the operational phase. This excludes any P&amp;A work.</td>
</tr>
</tbody>
</table>
| 2.       | 2.2 Fuel & Emissions | Marine environmental impact caused by: Project Vessels, Supply Boats, Survey vessels, etc. Assessment is for the atmospheric emissions associated with a particular option and covers fuel use which is tightly correlated to atmospheric emissions. This also includes energy / emissions / resource consumption required to replace materials not recovered for re-use or recycle i.e. indirect. NOTE: Onshore related emissions are excluded. This is calculated for both the operational phase and legacy phase of the project. Marine environmental impact caused by the amount of resource consumption associated with the option is included in this criterion. It covers elements such as environmental burden from processing returned materials, use of quarried rock or other new material and any production of replacement materials. | Assessment based on quantifying the volume of fuel used and the associated emissions. A life-cycle emissions assessment has been carried out capturing:  
- Recycling of materials  
- Reuse of materials  
- Production of new materials  
These life-cycle CO2 emissions figures allow a direct, quantitative comparison between options. |
<table>
<thead>
<tr>
<th>Criteria</th>
<th>Sub-Criteria</th>
<th>Description</th>
<th>Approach to Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.</td>
<td>2.3 Legacy Marine Impacts</td>
<td>Marine environmental impact caused by: Project Vessels, Supply Boats, Survey vessels i.e. noise generated by vessels, cutting operations, any explosives, survey/monitoring techniques or remediation requirements etc. during the legacy phase.</td>
<td>Combination of qualitative and quantitative assessments based on number of vessel days for this activity and quantifying noise generated by legacy inputs to the environment either from ongoing survey/monitoring requirements or from potential remediation works.</td>
</tr>
<tr>
<td>2.</td>
<td>2.4 Materials and Residuals</td>
<td>Assessment is made of the total weight/quantity of materials recovered or left in situ as well as the status of any minimal liquid volumes, including volume of hydraulic fluid left in the umbilical.</td>
<td>Assessment based on impact of weight of each type of material and final material location for each option. Weights based on asset inventory report. Volumes based on Methodology Reports.</td>
</tr>
<tr>
<td>2.</td>
<td>2.5 Seabed Disturbance</td>
<td>Both direct and indirect seabed disturbance, permanent and temporary in nature, caused by the operations.</td>
<td>Assessment based on quantifying the area (in m²) of disturbance by type of disturbance (rock placement, trenching, mass flow excavation and overtrawling), in combination with an understanding of the baseline environment in the area as shown by the outputs from the environmental surveys.</td>
</tr>
<tr>
<td>Criteria</td>
<td>Sub-Criteria</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>----------</td>
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<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>3. Technical</td>
<td>3.1 Technical Risk</td>
<td>This sub-criterion relates to the various technical risks that could result in a major project failure. Concepts such as: Technical Novelty 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. Long offshore campaigns are susceptible to risk of WoW delays. Contracting strategy is assessed with focus on the risk to the project of whether the contracting strategy is restricted by a particular option (e.g. if the option involves only one possible vendor). Technical Feasibility and Technical Maturity is also considered.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Qualitative assessment of technical risk for each decommissioning, including schedule. Application of Technology Readiness Level (TRL) for each option is proposed as per guidance in API RP 17N [Ref. 4].</td>
<td></td>
</tr>
<tr>
<td>Criteria</td>
<td>Sub-Criteria</td>
<td>Description</td>
<td>Approach to Assessment</td>
</tr>
<tr>
<td>--------------</td>
<td>--------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>4. Societal</td>
<td>4.1 Fishing</td>
<td>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.</td>
<td>A qualitative judgement that provides a narrative (rather than quantification) regarding the influence of each decommissioning option on the availability of the area of seabed for fisheries or any other commercial impacts.</td>
</tr>
<tr>
<td></td>
<td>4.2 Socio-Economic Impact on Communities and Amenities</td>
<td>This sub-criterion addresses any socio-economic impacts on other users both onshore where the impact may be from dismantling, treating, recycling and land filling activities relating to the option and offshore. 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 process which has a negative impact on communities, residual risk of snagging gear and consequential loss of gear, etc.</td>
<td>Assessment is made using a narrative of the positive and negative impact of the decommissioning option on all groups of society (excluding fishing industry).</td>
</tr>
<tr>
<td>5. Economic</td>
<td>5.1 Operational and Legacy Costs</td>
<td>This sub-criterion addresses the cost of delivering the option as described. This includes both operational phase and legacy phase costs (including intervention allowance).</td>
<td>Quantified in Methodology Reports.</td>
</tr>
</tbody>
</table>
6 RESULTS OF THE COMPARATIVE ASSESSMENT

6.1 SAFETY DIFFERENTIATION

The safety criteria assessed in the Comparative Assessment considered safety risks to operations personnel and other users, and any legacy impacts on safety. Operational hours, operational PLL, vessel days, vessel transits, the number of vessels, and safety risks to fishermen were considered in this assessment.

In the review of safety risks to operations personnel, the minimal intervention option (Option 1B) came out stronger and much stronger than the two full removal options, 5A & 5C, respectively. This decision reflects the safety risks associated with the pipeline removal requirements for Options 5A & 5C, particularly the greater demand for personnel and protracted operations hours of each. Option 5C poses the greatest safety risks to operations personnel due to the prolonged period of operations, and the fact that divers are required for cutting and lifting of the pipeline. Option 5A would involve reverse reeling of the pipeline, which is a non-routine activity, and could pose unforeseen hazards to personnel, particularly if the pipeline integrity is compromised. In addition, the pipeline and umbilical bundle will require to be separated with the retaining strapping being severed as the pipeline comes onto the vessel deck, this operation will carry additional risk to operational personnel onboard the vessel. Consequently, the PLL values for Options 5A and 5C were over three times greater and two orders of magnitude greater than that of Option 1B, respectively.

In terms of safety impacts on other users, Option 1B had the least potential to generate vessel-related impacts. This option has 37 days of vessel time allocated to operations during a single transit (27 days), with a remaining balance of 10 days devoted to legacy operations and monitoring which are to be spread out over an anticipated 50-year period. Neither of the full removal options require legacy operations to be considered, however their vessel requirements during the operations phase is more extensive than the minimal intervention option. Option 5A has 62 vessel days allocated solely to operations; these are to be divided between 5 vessels and 6 vessel transits. Option 5C has a significantly greater vessel requirement: 302 total vessel days across divided between 5 vessels across 6 transits. The increased vessel days and number of transits are attributable to the
technical and personnel constraints associated with cutting and lifting the production pipeline during its removal. Moreover, the full removal options may impact other users as increased vessel presence will include vessels moving along the entirety of the pipeline length during operations for both options.

As discussed, neither of the full removal options have an associated legacy impact therefore for this sub-criteria Option 1B was viewed as the weakest option.

Given the increased requirement for vessels and the intrinsic risks to operations personnel posed in the full removal options, Option 1B was identified as the recommended option for minimising safety risks during the decommissioning of the Minke subsea infrastructure.

6.2 ENVIRONMENTAL DIFFERENTIATION

The Comparative Assessment addressed various environmental criteria, including operational marine impact, fuel and emissions, legacy marine impact, materials and residuals, and seabed disturbance. As with the safety criteria assessment, vessel days were also considered for impacts to the environment, but instead the cumulative marine noise emissions they generate were assessed. Total fuel usage, vessel CO₂ emissions, materials life cycle energy consumption and CO₂ emissions, total tonnage of material types, the requirement for additional rock-dump, discharge of control fluids, and Mass Flow Excavation (MFE), trenching and overtrawl ing impacts on seabed sediments were all additionally considered in the assessment of impacts of the project on the marine environment.

Noise formed the primary concern in the assessment of operational marine impacts. Although the vessel noise levels generated are estimated to be marginally above the NOAA thresholds for injury, due to the duration of activities being very short and the behavioural natures of the marine mammals present, vessel noise was not considered a significant impact. This was discussed and agreed with the stakeholders present during the CA workshop. Marine mammals will avoid injury by temporarily displacing from the area during this short period of concentrated vessel activity.

Noise from mechanical cutting associated with Option 5C’s removal method was considered the biggest noise-related issue, however its potential impacts are minimised
by the fact that this activity will be temporary and spatially constrained. In this respect, Option 1B was only considered marginally better than Option 5A & much better than Option 5C.

The total fuel usage and vessel CO₂ emissions were greatest for Option 5C, which had values over five times greater than Option 5A and close to 20 times those of Option 1B. However, the greatest materials lifecycle CO₂ emissions came from Option 1B, which was nearly double both Option 5A and 5C. This is because the leave *in situ* method precludes recycling or reuse of the Minke infrastructure's component parts. Still, when considering the total CO₂ emissions (from vessels and materials combined), Option 5C came out the worst and Options 1B and 5A roughly the same. In the end, the increased fuel consumption of Option 5A made it slightly less desirable than Option 1B.

Legacy marine impacts were only described for Option 1B, as the full removal of the Minke subsea infrastructure precludes legacy operations obligations. Still, the legacy marine impacts of Option 1B were deemed minor, in that the number of vessel days and cumulative noise generated by legacy operations were minimal and the volume of additional rock-dump is not expected to have any significant impacts on the seabed habitat, with any impact being highly localised.

All three options had equivalent values for the discharge of control fluids, however, Option 1B would see residual fluids discharged over a period of decades rather than instantaneously, as is the case with the full removal options. Neither full removal option would leave any volume of material remaining on the seabed, nor would they require additional rock-dump. Option 1B, however, would have over 1,200 tons of steel, 70 tons of plastic and a little over 6 tons of non-ferrous materials decommissioned *in situ*. For this reason, Option 1B was seen as weaker than the other two options, which were equally desirable for their minimal materials and residuals impacts.

For the seabed disturbance impacts, decommissioning plans for Option 1B had an additional 100 m² of rock dump to consider, but this was considered to have a minor potential impact on the seabed habitat. The full removal options had significantly higher MFE values, however, making Option 1B a much stronger option for reducing seabed disturbance impacts.
Overall, Option 1B was identified as the recommended option because of its minimal impacts to the seabed habitat, reduced fuel and emissions impacts and its decreased marine impacts during the operations phase.

6.3 TECHNICAL DIFFERENTIATION

The technical risk criteria addressed in the Comparative Assessment included the contracting strategy, scheduling risk and technical maturity of each option. As the contracting strategies of each option are relatively flexible, the main differentiator for technical risk relates to scheduling. All of the options will incur risks associated with weather issues, but the potential impacts of scheduling issues are potentially more numerous and harder to recover from for both of the full removal options. The long schedule for Option 5C will inherently bring greater technical risk. The extended subsea works and risk of failure associated with this Option could result in significant cost and scheduling impacts and potentially the requirement for an alternative decommissioning method to be used.

There is significant technical risk associated with the reverse reeling of the pipeline in Option 5A. While reel installation of pipelines is a standard subsea operation and reverse reeling has been carried out elsewhere, there is a relatively limited track record of reverse reeling for removal of pipelines in the UKCS and a low track record of unburial over extensive distances. In addition, the pipeline and umbilical are strapped together for their length. This bonding requires to be separated on the back deck of the recovery vessel in Option 5A which add a significant degree of complexity to this option it is believed this hasn’t been attempted to date. As such, the technical maturity of Option 5A is considered very low.

After considering the schedule and technical maturity associated with each of the options, it was determined than Option 1B was the preferred option for minimising technical risks.

6.4 SOCIETAL DIFFERENTIATION

In the assessment of societal impacts, impacts to the fishing industry and communities and amenities were considered.
In regard to the fishing industry, the current state of the Minke subsea infrastructure is that it is overtrawlable. Pipeline surveys indicate that the pipeline has been increasing its depth of burial since installation, therefore although a risk of future exposure cannot be ruled out it is not perceived to be a significant risk. Given Options 5A and 5C remove legacy risk altogether, and that dispersed rock from the removal of the pipelines is likely to be better for fisheries, Option 1B is considered the weaker option and both full-removal options are deemed equally weighted.

Despite Option 1B not returning any material to shore, the amount of material generated by the other two options is so small that there is very little difference between the options in terms of socio-economic impacts on communities and amenities. While the majority of infrastructure can be recycled, all of the recycling will likely be processed at an existing facility and so is unlikely to create any additional jobs. Moreover, as full removal is likely to generate equal amounts of recycling and waste to go to landfill, the benefits of potential jobs created by recycling is outweighed by the cost of processing the waste going to landfill. As such, Options 5A and 5C are considered equally weighted and only slightly better than Option 1B.

6.5 ECONOMIC DIFFERENTIATION

The economic criteria covered in the Comparative Assessment focused on costs associated with operations and legacy activities. When undertaking the assessment, it was assumed that all activities are carried out successfully. As such, the economic assessment didn't consider costs associated with any technical risks, such as issues arising during reverse reeling or bad weather days. Rather, a 30% contingency value was added to each option once the operations and legacy costs were summed. This qualitative assessment resulted in costings of the full removal options at 3 times and 10 times the value of Option 1B for Options 5A and 5C, respectively. As a result, the leave in situ option was viewed as being the best option in terms of reducing economic impacts on the project.

6.6 CONCLUSIONS

While the full removal options were preferred to the leave in situ option for four of the twelve sub-criteria, Option 1B was the preferred option overall. This is due to the fact
that, when all of the sub-criteria were drawn together, Option 1B scored highest in four of the five main criteria categories.

The results suggest that there wasn't a single driving factor for this decision, rather, the majority of the sub-criteria indicated that the leave *in situ* option is best at minimising risks associated with safety, environment, technical operations, and economic expenditures.

The results of the Comparative Assessment, in which each of the criteria are weighted against one another are presented in Figure 6.1 below.
Figure 6.1  Graphical representation of the results of the Comparative Assessment
6.6.1 Sensitivity Analysis

There were a series of sensitivity analyses undertaken to provide additional support for the results of the Comparative Assessment. This included evaluating the sensitivity of the conclusion based on the sub-criteria relating to societal impacts on the fishing industry.

Moreover, the CA results were considered further by removing one criterion weighting at a time to look at the subsequent effects on the results for the other criteria. In this process, it became apparent that no single criterion was driving the results of the CA assessment. The following figure shows the assessment results with the Economics criteria removed.
Figure 6.2  Graphical representation of the results of the Comparative Assessment with economic risks removed
## REFERENCES

### SUPPORTING DOCUMENTATION

<table>
<thead>
<tr>
<th></th>
<th>Terms of References for Minke Comparative Assessment</th>
<th>MF00-09-AA-103-00001_C01, August 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Juliet and Minke Comparative Assessment Scoping and Screening Report</td>
<td>JF00-09AN-72-00302, C01, June 2018</td>
</tr>
<tr>
<td>4</td>
<td>API RP 17N</td>
<td>API RP 17N Recommended Practice for Subsea Production System Reliability, Technical Risk and Integrity Management 2014</td>
</tr>
</tbody>
</table>

All references available upon request.
## 8 APPENDICES

### APPENDIX 1: MEETING RECORD

<table>
<thead>
<tr>
<th>Name</th>
<th>Company / Position</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alan Muirhead</td>
<td>Developments and Decommissioning Manager, Neptune Energy</td>
<td>20/09/2018</td>
</tr>
<tr>
<td>Pierre Girard</td>
<td>Asset Manager, Neptune Energy</td>
<td>20/09/2018</td>
</tr>
<tr>
<td>Eddie Anderson</td>
<td>HSE, Neptune Energy</td>
<td>20/09/2018</td>
</tr>
<tr>
<td>David Hawkins</td>
<td>Environment, Neptune Energy</td>
<td>20/09/2018</td>
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<tr>
<td>Joanne Rostant</td>
<td>Tech Safety, Neptune Energy</td>
<td>20/09/2018</td>
</tr>
<tr>
<td>Justin Heath</td>
<td>Communications, Neptune Energy</td>
<td>20/09/2018</td>
</tr>
<tr>
<td>Francis Barrett</td>
<td>Subsea and Pipelines, Xodus Group</td>
<td>20/09/2018</td>
</tr>
<tr>
<td>Rebecca Allan</td>
<td>Project Representation, Xodus Group</td>
<td>20/09/2018</td>
</tr>
<tr>
<td>Gareth Jones</td>
<td>Facilitator, Xodus Group</td>
<td>20/09/2018</td>
</tr>
<tr>
<td>Kim Woods</td>
<td>Stakeholder Representative, BEIS OPRED ODU</td>
<td>20/09/2018</td>
</tr>
<tr>
<td>Audrey Banner</td>
<td>Stakeholder Representative, BEIS OPRED</td>
<td>20/09/2018</td>
</tr>
<tr>
<td>Fiona Livingston</td>
<td>Stakeholder Representative, BEIS</td>
<td>20/09/2018</td>
</tr>
</tbody>
</table>
APPENDIX 2: COMPARATIVE ASSESSMENT TOOL FOLLOWING INTERNAL WORKSHOP
1. Safety

1.1 Operations

1.3 Legacy Impact

Marine Impact

Personnel

biggest noise issue, however this would be temporary and spatially constrained. NOTE: Noise associated with legacy activities is very low. General vessel noise is not considered a significant contributor to marine mammal disturbance in the area. Mechanical cutting would be the only noise issue, however this would be temporary and spatially constrained. Noise levels for project works are below the threshold for marine mammals. Grading based on marked increase in days from leave in situ.

Cumulative Marine Noise = 3.4 TPaS^2

Vessel Days = 27 days

the ends.

A real vessel will then recover the pipeline bundle via reverse reeling. The items shall be returned to shore for recycling/ final disposal.

A trawl sweep and post-works survey will then be carried out.

Option 1B has a legacy element to it; 5A has a minor diver element, mostly surface operations; 5C, marked increase in operational hours and is diver led.

Option 1B has 27 days of vessel time allocation to operations in a single trip. There is a longer duration of operational days for Options 5A / 5C and higher risk with the activity spread along the whole length of the pipeline rather than being in a localised area (as is the case for Option 1B).

Total Days - 37 Vessel Days

Total total: 4 vessels operating for 27 days in total. Further legacy operations require 1 survey type vessel for a total duration of 10 days.

Total Days - 37 Vessel Days

1 transit associated with operations, a transit will be associated with each legacy monitoring event.

Short duration of activity and localised in one area

Legacy surveys will look at full pipeline length though, but this will be a short duration event as well.

6 Vessels for a total of 62 days will be used for the operational phase. The vessels will only be present for the operational phase of this option with no legacy as all equipment is removed.

Total Days - 62 Vessel Days

Longer duration and activity will be spread out along whole length of pipeline.

6 Vessels for a total of 302 days will be used for the operational phase. The vessels will only be present for the operational phase of this option with no legacy as all equipment is removed.

Total Days - 302 Days

Longer duration and activity will be spread out along whole length of pipeline.

Return survey type activities only has been assumed to be required for this option.

Total Legacy hours: 5,536

Total Legacy PLL: 4.15E-4

Currently pipeline is fully buried, no reported snagging incidents and survey data indicates increasing burial depth.

Low fishing effort and all bottom trawling. Key species are Nephrops and Flat Fish (Pisces, Turbot, Sole etc.)

STF2 (2017): Low Activity, 571 days, £2m landed

Higher trawling activity History offset by no history of pipeline spanning. Main trawling gear is beam trawling which is considered less vulnerable to snagging on spans and vessel pull over events.

Legacy operations allows for 2 post decommissioning surveys.

Vessels will be used to disconnect pipeline ends and rock dump end.

Vessel Days = 27 days

Cumulative Marine Noise = 3.4 TPaS^2

Vessels will be used to deploy and reverse reel the pipelines for this option.

Vessel Days = 61.8 days

Cumulative Marine Noise = 19.22 TPaS^2

Vessels will be used to deploy, cut and remove pipe for this option. The umbilical will be reverse reeled.

Vessel Days = 302 days

Cumulative Marine Noise = 125.66 TPaS^2

Vessel Days = 61.8 days

Cumulative Marine Noise = 19.22 TPaS^2

Vessel Days = 302 days

Cumulative Marine Noise = 125.66 TPaS^2

For this option, the trenched and buried pipeline and umbilical will be deburied and recovered from the seabed via the reverse reeling method.

The offshore operations for this option consist of performing a pre-works survey and deburial of the pipeline bundle along its length using a mass flow excavator (by CSV), followed by DSV operations to disconnect the pipeline and umbilical ends both at Minke and D15 FA Platform ends and connect recovery heads. The surface laid umbilical section shall be cut into sections and recovered to surface by the DSV.

A real vessel will then recover the pipeline bundle via reverse reeling. The items shall be returned to shore for recycling/ final disposal.

A trawl sweep and post-works survey will then be carried out.

All equipment removed and no further work required

All equipment removed and no further work required

All equipment removed and no further work required

As all equipment is removed.

As all equipment is removed.

As all equipment is removed.

As all equipment is removed.

As all equipment is removed.
Summary

2. Environmental

Sea bed disturbance data for this option is noted below:

- Rock dumping = 50 m²
- Mass flow excavation (MFE) = N/A
- Trenching = N/A
- Overtrawl = 1,510,900 m²

The following volumes of material will remain once the option has been completed:

- Steel = 1,235 te
- Plastic = 70 te
- Non-Ferrous = 6 te
- Rock dump required = 100 Te
- Control fluids discharged = 12.4 m³ over an extended period, several discrete releases

W W W W W

Summary

3. Technical Risk

Overall technical and technological risk is relatively minor across all options, the main differentiator relates to the long schedule for Option 5B, which will inherently bring greater technical risk. All have been upgraded by one level because of the risks associated with weather issues, which pose a significant risk to schedule. No example of this length and type of pipeline (bundle) being reverse reeled exists, so potentially Options 5A & 5C should be downgraded because of technical risk associated with using a technique which has not been proven for long distances. Pipeline and umbilical could also fail apart as removed due to loss of integrity of straps (that held umbilical to pipeline).

VMS MM MF

Summary

Contracting Strategy - Established methods and technology. No special requirements that would limit number of available decommissioning contractors. Good flexibility in terms of contracting strategy.

Schedule - No particular technological factors or major risk factors that could extend schedule. In field time of 27 days.


VMS MM MF
## 4. Societal

### 4.1 Impact on Fishing Industry

Pipeline and umbilical are permanently removed, leaving a clear seabed. Large area of seabed temporarily disturbed but this will revert to natural condition over time and there would be no impact on fisheries after this time.

### 4.2 Socio-Economic Impact on Communities and Amenities

Some impact on communities and amenities as majority of pipeline and umbilical would be returned to shore for dismantling/recycling.

### Summary

All overtrawlable. Pipeline in leave in situ option is well buried (below 1.6 m across its length). No previous history of free span developing. Depth of Burial (DOB) shows an increasing trend.

### Economic

#### 5.1 Operational & Legacy Costs

<table>
<thead>
<tr>
<th>Option</th>
<th>Total Cost including 30% contingency (Operational + Legacy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overtrawled</td>
<td>X</td>
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<tr>
<td>VMS</td>
<td>2.8X</td>
</tr>
<tr>
<td>MS</td>
<td>10.1X</td>
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</table>

*The costs do not allow for issues arising from reverse reeling. There is a 30% contingency to reflect cost estimate accuracy.*

### Summary

Overall there is very little difference between the options. For example, the majority of infrastructure can be recycled, all likely to be processed at an existing facility and unlikely to create any additional jobs. Assumption is receiving facility will also do the treatment, so no onshore transportation required. The volumes of recyclables and waste to landfill is small. Some of the subsea inventory is relatively new and shouldn’t be too depredated. Where possible items will be reused e.g. mattresses could be reused subject to testing. Most of the removed material shall be recycled.
APPENDIX 3: MINKE INFRASTRUCTURE SCHEMATICS – BEFORE AND AFTER DECOMMISSIONING

Figure 8.1   Existing Minke Infrastructure
Figure 8.2  Option 1B Decommissioning Outcome - Disconnect Pipeline & Rock-Dump Ends