# Document Control

## Approvals

<table>
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<th>Name</th>
<th>Date</th>
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<tbody>
<tr>
<td>Prepared by</td>
<td></td>
</tr>
<tr>
<td>Louisa Dunn</td>
<td>June 2017</td>
</tr>
<tr>
<td>Advanced Environmental Professional</td>
<td></td>
</tr>
<tr>
<td>Reviewed by</td>
<td></td>
</tr>
<tr>
<td>Chris Wicks</td>
<td>June 2017</td>
</tr>
<tr>
<td>Decommissioning Compliance Manager</td>
<td></td>
</tr>
<tr>
<td>Approved by</td>
<td></td>
</tr>
<tr>
<td>David Wilson</td>
<td>June 2017</td>
</tr>
<tr>
<td>Decommissioning Manager</td>
<td></td>
</tr>
</tbody>
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## Revision Control

<table>
<thead>
<tr>
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<td>0</td>
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1. Executive Summary

Marathon Oil is planning to decommission the Brae Bravo platform. As part of this process, Marathon Oil is considering the preferred option for decommissioning the platform sub-structure.

Since the platform sub-structure was installed prior to 1999, and the weight in air of the sub-structure is greater than 10,000 tonnes, it is a candidate for derogation from OSPAR Decision 93/8 which otherwise requires the complete removal of redundant offshore installations.

Marathon Oil has therefore conducted a comparative assessment of the two viable decommissioning options for the Brae Bravo sub-structure, full removal, or partial removal.

The comparative assessment has two objectives, to inform Marathon Oil’s selection of the preferred decommissioning option, and, in the event that the preferred option is partial removal, to meet OSPAR’s requirement that any request for a derogation to leave part of an offshore installation in place is supported by a comparative assessment.

Marathon Oil’s comparative assessment process follows the Department for Business, Energy and Industrial Strategy (BEIS formally known as DECC\(^\text{1}\)) and Oil and Gas UK guidance [2], [11].

The main elements of the process are:

- Identification of viable decommissioning options and methods
- Preparation of method statements detailing the steps involved in the options and methods
- Assessments of the options and methods against safety, environmental, technical, societal and economic criteria
- Stakeholder engagement to understand their issues associated with the criteria
- A comparative assessment workshop involving key stakeholders to ensure that the assessments have captured all of the stakeholders’ issues and concerns
- Decision on the preferred decommissioning option taking cognisance of the results of the workshop and supporting assessments

There is a drill cuttings pile at the base of the Brae Bravo sub-structure. The presence of the cuttings pile was not included in the comparative assessment to avoid prejudice in the assessment of the sub-structure decommissioning options. The cuttings pile is the subject of a separate assessment process.

The comparative assessment process concluded that the preferred decommissioning option for the Brae Bravo sub-structure is partial removal.

\(^{1}\) DECC became part of the Department for Business, Energy and Industrial Strategy (BEIS) in July 2016
2. **Background**

2.1 **Regulatory Requirements**

The UK’s international decommissioning obligations are principally governed by the 1992 Convention for the Protection of the Marine Environment of the North East Atlantic (OSPAR Convention [1]). The Department of Business, Energy and Industrial Strategy (BEIS) is the competent authority on decommissioning in the UK for OSPAR purposes. In July 1998, the OSPAR Commission adopted a binding Decision (OSPAR Decision 98/3) to prohibit the disposal of offshore installations at sea.

OSPAR Decision 98/3 recognises that there may be difficulty in removing the ‘footings’ of large steel installations weighing more than 10,000 tonnes. Therefore, the decision includes the possibility of derogation from the requirement to completely remove such installations. Nevertheless, there is a presumption in the OSPAR decision that installations will be removed entirely and exceptions will only be granted, if a comparative assessment and consultation process shows that there are significant reasons why leaving footings in place is preferable to reuse, recycling or final disposal on land.

Within the United Kingdom Continental Shelf (UKCS), the Petroleum Act 1998 is the principal legislation governing decommissioning of oil and gas installations. The Act is administered by BEIS. If the duty holder for an installation wishes to obtain derogation from OSPAR Decision 98/3 to leave part of an installation in place, the duty holder must first make a case to BEIS. BEIS will then take the derogation request forward to the other members of OSPAR.

The Brae Bravo sub-structure meets the OSPAR Decision 98/3 criteria for derogation. Marathon Oil and its partners therefore wish to determine if leaving part of the Brae Bravo sub-structure in place is the preferred decommissioning option, and, if it is, to make the case for derogation to BEIS and ultimately to OSPAR. Since the OSPAR decision contains a presumption of complete removal, this is used as the baseline, or default option, when comparing alternatives.

The BEIS (formally DECC) Guidance Notes on decommissioning [2] identify comparative assessment criteria in five areas: safety, environment, technical, societal and economic. Marathon Oil’s aim for the comparative assessment is to ensure that the preferred decommissioning option for the Brae Bravo sub-structure represents the best balance of impacts against these five criteria.

The comparative assessment only considers the Brae Bravo platform sub-structure. The Brae Bravo platform topsides and associated pipelines, subsea infrastructure and stabilisation features are excluded from the scope of this comparative assessment. These aspects of the Brae Area infrastructure are subject to separate assessment. The Brae Bravo flare stack is supported on a 1,000 tonne tripod sub-structure. The flare sub-structure will be completely removed, and therefore does not form part of the comparative assessment scope.

The drill cuttings pile at the base of the Brae Bravo sub-structure has also been excluded from the comparative assessment. This ensures that the conclusion on the preferred decommissioning option for the sub-structure is drawn purely on the basis of arguments pertaining to the sub-structure itself.
2.2 Brae Area Overview

The Brae Area lies approximately 175 miles (282 km) north-east of Aberdeen, principally within three UK Blocks: 16/7a, 16/3a and 16/3b. Marathon Oil U.K. LLC is the operator of the Brae Bravo platform. The other equity partners are TAQA Bratani Limited, TAQA Bratani LNS Limited, Centrica Resources Limited and JX Nippon Exploration and Production (U.K.) Limited. Under the Petroleum Act, the partners are jointly responsible with Marathon Oil for decommissioning the Brae Bravo sub-structure.

Liquids from the Brae Bravo are exported via Brae Alpha and then, with the rest of the liquids from the Brae Area, via the Forties pipeline to Cruden Bay, and then on to Kinneil near Grangemouth. Gas is exported via the Scottish Area Gas Evacuation (SAGE) pipeline to the St. Fergus terminal.

The overall layout of facilities in the Brae Area and its surroundings is shown in Figure 2.1.
2.3 Sub-Structure Technical Summary

The Brae Bravo sub-structure key parameters are listed in Table 2.1 and illustrated in Figure 2.2.

<table>
<thead>
<tr>
<th>Table 2.1: Brae Bravo Sub-Structure Technical Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location</strong></td>
</tr>
<tr>
<td><strong>Water Depth</strong></td>
</tr>
<tr>
<td><strong>Number of Platforms</strong></td>
</tr>
<tr>
<td><strong>Production Start Date</strong></td>
</tr>
<tr>
<td><strong>Sub-Structure Design</strong></td>
</tr>
<tr>
<td><strong>Sub-Structure Steel Weight</strong></td>
</tr>
<tr>
<td><strong>Height of Jacket</strong></td>
</tr>
</tbody>
</table>
Note: The flare jacket is not part of the Comparative Assessment process and is assumed for the purpose of this review that it will be fully removed.

2.4 Comparative Assessment Methodology

OSPAR Decision 98/3 recognises that there are technical challenges associated with the removal of very large steel sub-structures. Therefore, Decision 98/3 includes the possibility of an exemption, or derogation, from the requirement for complete sub-structure removal if comparative assessment shows
that it is appropriate to remove the upper part of the sub-structure and leave the lower part of the sub-structure in place.

The purpose of the Brae Bravo sub-structure comparative assessment is to provide a balanced appraisal of the options of full removal versus partial removal of the sub-structure. This will allow Marathon Oil to identify the preferred decommissioning option for the sub-structure, and support an application for derogation under Decision 98/3 if the preferred option is partial removal.

Before determining the methodology to be used to complete the comparative assessment for the Brae Area platform sub-structures, Marathon Oil completed a review of the BP Miller [12] and CNRI Murchison [13] installations’ decommissioning programmes to identify any lessons to be learnt. As a result of planning for the decommissioning of these installations, the key issues to be addressed in decommissioning North Sea oil and gas platforms and sub-structures are now better understood. It was therefore possible to optimise the studies required to support the comparative assessment process for the Brae Area platform sub-structures without impacting the validity of the process and its conclusions.

Decommissioning options that give rise to intolerable safety risks, involve unacceptable environmental impacts or are not technically feasible have been ruled out, and have not been taken forward for comparative assessment.

Marathon Oil's comparative assessment process[3] aligns with the expectations set down in the BEIS guidance notes [2] and further guidance published by Oil and Gas UK [11]. The BEIS guidance defines five criteria against which each option should be assessed:

1. Safety
2. Environmental
3. Technical
4. Socio-Economic
5. Economic

The overall comparative assessment methodology employed by Marathon Oil is shown in Figure 2.3. This methodology involves the following steps:

1. Identifying technically viable methods for full and partial sub-structure removal.
2. Preparing a detailed estimate of the resources required to implement each of the viable methods using ‘norms’ from verified databases. Resources include, but are not limited to personnel, vessels, port facilities, onshore transport, dismantling yards and disposal sites.
3. Carrying out further studies to facilitate assessment against each of the five criteria.
4. Appointing an independent body (IRC - Independent Review Committee) to review, verify and validate the comparative assessment and provide assurance that the process was unbiased and sufficiently detailed to support decision-making (See Appendix 1).
5. Consulting key stakeholders on the process to obtain their feedback.
6. Conducting a Comparative Assessment Workshop, taking inputs from all studies and feedback from stakeholders (see Section 3.1).
7. Documenting the Comparative Assessment and the decision reached.
2.5 Technical Studies

Technical assessments were commissioned to identify and review the options and methods available for the full and partial removal of the Brae Area platform sub-structures. The options and methods identified for technical assessment were:

- Section Cut and Lift using an HLV (Heavy Lift Vessel). The assessment included a number of sub-methods: full removal of the sub-structure in two, three or four sections and partial removal of the sub-structure in one or three sections.
- Buoyancy Aided Removal.
- Removal by SLV (Single Lift Vessel), for example Allseas Pioneering Spirit.

An external consultant’s database [16] was used as the basis to identify and assess viable removal methods. The database holds a significant quantity of data gathered from previous Decommissioning Programmes and from the experience gained during decommissioning projects. This database was independently verified to ensure its suitability for the Brae Area.

Method statements were generated for each removal technique. The statements identify the major activities involved and equipment required. Marathon Oil used information from the database to develop a detailed estimate of the resources required for each full and partial removal method, in terms of people, equipment, vessels, HLVs, etc. The method statements and resource estimates were then used as input data for further studies in the areas of safety, environment and socio-economics.

The technical assessments show that full and partial removal by section cut and lift using an HLV is technically feasible. It is a proven method that has been used to partially remove similar sub-structures in the UKCS and carries a relatively low element of technical risk. Removal by HLV in a single lift is not considered possible for either the full or partial removal options. Full removal in a single lift is not possible because the weight of the sub-structure exceeds HLV capacity. Partial removal in a single lift is not considered possible as it is not feasible to transfer the sub-structure to a barge at sea, and, if it is moved inshore suspended on the HLV hook, temporary footings will be required at the inshore location. The resources required to fabricate such footings are considered disproportionate to any benefit gained from this approach.
Brae Bravo Sub-structure Comparative Assessment

The technical studies have also shown that removal using buoyancy tanks may be possible. However, the depth of water in the Brae Area and the height of the sub-structure pose significant concerns if the sub-structure was to be floated to an inshore location for dismantling. Additionally, the sub-structure will ultimately have to be sectioned, cut and lifted at an inshore location in a similar manner to the offshore location. However, the additional preparation activities at the offshore location to install the buoyancy tanks and flotation to an inshore location introduce extensive additional work. This carries significant technical and safety risks during offshore installation of the tanks, transportation of the sub-structure, and set down at an inshore location. The technical studies concluded that buoyancy-aided removal is unlikely to reduce activity level, associated risks or offer a greater chance of success than section cut and lift at the offshore location.

The technical studies further showed that completely removing the Brae Bravo sub-structure with an SLV is very unlikely to be possible as the sub-structure does not have sufficient strength to withstand lifting and transportation as a single lift complete with piles and grout. Partial removal by SLV may be possible. For the purposes of the comparative assessment, removal by HLV was considered for both the full removal and partial removal options.

Table 2.2 summarises the findings of the reviews of feasible decommissioning methods. The table also provides an indication of technical feasibility in the form of colour-coding where dark green shows the method proposed is known and has a track record of success, pale green indicates that the method is feasible but has associated challenges, and amber or red signifies that there are significant issues associated with the method.
**Table 2.2: Summary of Technical Options for Sub-Structure Removal**

<table>
<thead>
<tr>
<th></th>
<th>Full Removal</th>
<th>Partial Removal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Section Cut and Lift</strong></td>
<td>Technically feasible with use of proven technology. Stability of cutting arrangement for sub-structure structural piles requires detailed analysis.</td>
<td>Technically feasible with use of proven technology.</td>
</tr>
<tr>
<td><strong>Buoyancy Tank Assemblies</strong></td>
<td>Significant concerns over the technical feasibility with respect to tank capacity, design and installation. Transit route over live pipelines with very shallow draft problematic. Still requires full marine lifting and transportation spread once in inshore waters to facilitate section cut and lift, and transfer to shore for final dismantling and disposal.</td>
<td>Significant concerns over the technical feasibility with respect to tank capacity, design and installation. Transit route over live pipelines with very shallow draft problematic. Still requires full marine lifting and transportation spread once in inshore waters to facilitate section cut and lift, and transfer to shore for final dismantling and disposal. The sub-structure will not include the footings, so set down in shallow waters an issue due to instability or additional fabrication/disposal required for temporary mud mats.</td>
</tr>
<tr>
<td><strong>HLV Single Lift</strong></td>
<td>Not considered possible. Sub-structure was barge launched so not retrievable to a barge at sea and weight exceeds HLV capacity.</td>
<td>Weight and buoyancy of sub-structure prevents rotation into horizontal at sea and therefore prevents transfer to barge at sea. Theoretical potential to transfer inshore 'on hook' but footings have been removed so temporary mud mats will need to be fabricated for use at inshore location.</td>
</tr>
<tr>
<td><strong>Single Lift</strong></td>
<td>Not considered possible. Concerns with the sub-structure integrity during transport phases with footings intact.</td>
<td>Conceptually possible subject to detailed structural analysis and lift and tilt assessment.</td>
</tr>
<tr>
<td><strong>E.g. Pioneering Spirit</strong></td>
<td></td>
<td>(Note: Not assessed further for the purpose of the comparative assessment process as section cut and lift assumed to be more onerous in terms of safety and environmental considerations).</td>
</tr>
</tbody>
</table>

**Most Feasible** | **Least Feasible**
2.6 Safety Studies

The safety studies involved identification of the hazards associated with decommissioning the sub-structure, and analysis of the associated risks to personnel. The method statements formed the basis of these studies.

Quantitative Risk Assessment (QRA) techniques were used to provide a numerical evaluation of the risks that these hazards generate. These values are expressed as Potential Loss of Life (PLL\(^2\)) [5]. The QRA was undertaken using established techniques to provide an estimate of removal and disposal risks and has drawn on the experience and lessons from similar decommissioning projects such as the BP North West Hutton and Miller platforms.

2.6.1 Risk to Personnel Removing Sub-Structure

For the purpose of the comparative assessment, Marathon Oil has evaluated the difference in PLL between the full and partial removal options [6]. The results are presented in Table 2.3.

<table>
<thead>
<tr>
<th>Option</th>
<th>PLL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Removal</td>
<td>0.29</td>
</tr>
<tr>
<td>Partial Removal</td>
<td>0.12</td>
</tr>
<tr>
<td>Difference</td>
<td>59%</td>
</tr>
</tbody>
</table>

2.6.2 Risk to Fishermen

If the sub-structure footings remain in-situ, there is a risk to fishermen from fishing gear snagging on underwater obstructions. The predicted average increase of the individual risk for UK fishermen if the Brae Bravo sub-structure footings are left in place is $<0.1\%$ [7]. With appropriate mitigations, such as the use of FishSAFE [8] and Kingfisher charts [9], it is considered likely that the risk to fishermen will be reduced below this value.

\(^2\) PLL = Expected number of statistical fatalities arising from an activity.
2.7 Environmental Studies

The environmental studies reviewed the impacts of the sub-structure removal activities offshore and at onshore dismantling and disposal site(s). A generic assessment was conducted for a typical disposal site as the actual site that will be used has not yet been selected.

Studies were conducted as Brae Area wide assessments where practical and appropriate. Close alignment between the environmental studies and those required as part of the EIA (Environmental Impact Assessment) and ES (Environmental Statement) for the decommissioning programme as a whole have been maintained to ensure consistency of approach, and to eliminate duplicate or otherwise unnecessary study work.

2.7.1 Energy and Emissions

The Institute of Petroleum guidance [14] provides guidelines for assessing energy use and emissions associated with decommissioning. Marathon Oil used this guidance to calculate the energy use and gaseous emissions associated with decommissioning the Brae Bravo sub-structure.

Complete and partial removal of the sub-structure by section cut and lift using an HLV have been studied to estimate the energy consumption and emissions generated during the removal operations. The study took into consideration the types of vessels required during preparation and removal of the sub-structure, and the subsequent treatment of the sub-structure materials through dismantling, reuse, recycling or replacement.

The analysis of the partial removal option takes account of the energy that would be required to manufacture an equivalent amount of steel to that left in place in this option. This is greater than the energy that would be required to recycle the equivalent amount of steel in the full removal option.

The types of vessels and equipment used for full and partial removal are broadly the same. Complete removal requires more effort than partial removal, and therefore higher energy usage and atmospheric emissions are estimated for full removal. The total energy consumption of each option and the emissions expected to be released into the atmosphere from the consumption of the fuel to generate that energy were calculated. A comparison of the energy requirements and the carbon dioxide (CO₂) emissions is presented in Table 2.4.

Overall, partial sub-structure removal uses less energy and creates fewer emissions than the full removal option for the Brae Bravo platform sub-structure.
**Brae Bravo Sub-structure Comparative Assessment**

**Table 2.4: Comparison of Energy Consumption and CO₂ Emissions**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Full Removal</th>
<th>Partial Removal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials Processing (GJ)</td>
<td>243,500</td>
<td>462,500</td>
</tr>
<tr>
<td>Vessel Requirements (GJ)</td>
<td>866,000</td>
<td>354,500</td>
</tr>
<tr>
<td>Total Energy (GJ)</td>
<td>1,109,500</td>
<td>817,000</td>
</tr>
<tr>
<td>CO₂ Emissions (tonnes)</td>
<td>87,000</td>
<td>58,500</td>
</tr>
</tbody>
</table>

The tabulated figures for full and partial removal are for removal by HLV cut and lift. There is a possibility of achieving partial removal using an SLV. The use of an SLV would potentially use less fuel and generate fewer emissions than an HLV. Therefore, HLV is considered to be the worst case for partial removal.

The partial removal option uses less energy and emits less CO₂ than full removal.

Sulphur oxide (SO₂) and Nitrogen oxide (NOₓ) were assessed in the supporting studies. However, these emissions are proportionate to the energy used and CO₂ emitted, and therefore are not listed in Table 2.4. SOₓ and NOₓ emissions are greater in full removal than partial removal [17].

### 2.7.1.1 Underwater Noise

Underwater noise can be harmful or potentially fatal to marine wildlife, particularly marine mammals. The noise sources associated with sub-structure full and partial removal options are expected to be the same, i.e. both options will use similar types of vessels, and similar cutting methods. Therefore, it is the overall duration of the activities, or the number of events involved, that determine how the environmental impact differs between full and partial sub-structure removal.

Due to the longer duration and additional activities associated with full removal there is expected to be more noise emitted into the marine environment in this option than in partial removal. Full removal is likely to have an increased potential to impact marine mammal populations compared to partial removal. However, it is likely that mitigation measures could be deployed for both removal options that would reduce the likelihood of marine mammal injury and disturbance.

The estimated numbers of ‘vessel days’ for the full and partial removal options are shown in Table 2.5. These are the total number of days for which vessels of all types will be required for the removal operations, and this metric is used as an indicator of the amount of underwater noise and disturbance associated with each option.
Table 2.5: Removal Operation Durations (Vessel Days)

<table>
<thead>
<tr>
<th>Option</th>
<th>Vessel Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Removal</td>
<td>1,475</td>
</tr>
<tr>
<td>Partial Removal</td>
<td>623</td>
</tr>
</tbody>
</table>

The tabulated figures are for full and partial removal by cut and lift using an HLV. Partial removal is considered the preferred option against this criterion.

2.7.1.2 Inshore Environmental Impacts

The full removal option includes operations that could result in increased interaction with sites of conservation importance. The scale of this interaction will depend on the inshore locations selected for either option. With appropriate management procedures, the magnitude of the impacts of both full and partial removal are likely to be similar.

2.7.1.3 Onshore Environmental Impacts

There are potential impacts associated with bringing quantities of marine growth onshore, and for there being potential contaminants or pollution associated with the dismantling and treatment of the sub-structure. Although the extent of these impacts is undefined, the quantity of material (such as the sub-structure and marine growth) is greater for full removal. Therefore, the partial removal option is likely to have less impact than full removal. However, site environmental management systems and local environmental regulatory controls should ensure that the environmental impact of both full and partial decommissioning options is low.

2.7.1.4 Waste

Overall, the impact of waste to landfill may be considered small, but this will depend on a number of factors, including the nature and condition of the recovered materials and the availability of reuse or recycle opportunities.

The key variable is the quantity of materials removed. The full removal option will result in a greater quantity of materials returned to shore, and therefore potentially a greater quantity going to landfill.
2.7.2 Socio-Economic

The review of the impact on society of all sub-structure decommissioning activities and potential removal options took cognisance of:

- The impact on other sea users, primarily the commercial fishing industry.
- The impact on onshore dismantling and disposal sites' neighbours.
- The employment and regional development opportunities.

2.7.2.1 Offshore Societal Impacts

The impact from full or partial sub-structure removal may be so small as to render the difference effectively irrelevant in societal terms. However, partial removal will result in part of the sub-structure remaining on the seabed, therefore restricting access for fishing in the immediate area. The impact on fishermen of leaving part of the sub-structure in place is a differentiator between decommissioning options.

In terms of interactions with other sea users during the execution of the decommissioning project, the full removal option will require more vessel days than the partial removal option, presenting an increased potential for vessel collision, obstruction of usual access, etc. However, with deployment of appropriate mitigation measures, the difference in vessel days between decommissioning options may result in no real difference in the magnitude of the impacts.

2.7.2.2 Onshore Societal Impacts

There may be disturbance to onshore communities that are in close proximity to decommissioning yards and waste treatment facilities. As much of the detail around the disposal of the sub-structures is currently unknown, the number of trips and quantity of material to be disposed of has been used as a proxy for comparison. However, any resulting issues should largely be mitigated and managed within existing site environmental management plans and permits. There are likely benefits to local communities through increased employment and other direct or indirect economic activities associated with decommissioning. The duration and volume of work associated with full removal is likely to be greater than that associated with partial removal and to have a correspondingly larger positive benefit to communities.

On balance, given that both the benefits and disadvantages to communities are likely to be proportionate to the amount of material brought ashore for treatment, onshore societal impacts are not considered a differentiator in the comparative assessment.
2.8 Economics

The economics associated with decommissioning the sub-structure are expressed as costs in money of the day. From a project perspective, it is important to develop representative cost estimates based on current industry experience.

For the purpose of estimating, the costs associated with the removal of the sub-structure have been assumed to be proportionate to the weight of steel to be removed. This approach is in line with industry practice. However, it results in the costs associated with full removal being under-predicted as the estimate does not include the expense associated with cutting piles or any seabed preparatory works. However, for comparative assessment purposes, this is considered an appropriate indicative approximation. The cost difference is presented in Table 2.6.

<table>
<thead>
<tr>
<th>Option</th>
<th>Cost</th>
</tr>
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<tbody>
<tr>
<td>Full Removal</td>
<td>100%</td>
</tr>
<tr>
<td>Partial Removal</td>
<td>56%</td>
</tr>
</tbody>
</table>

(Based on Industry Norms per tonne of Steel)

The tabulated figures are based on the HLV cut and lift method for both full and partial removal.
2.9 HAVR – Hazard Assessment Verification Review

Following completion of the sub-structure decommissioning supporting studies, Marathon Oil performed a Hazard Assessment Verification Review (HAVR) to confirm that all significant hazards had been identified. The HAVR was conducted as a structured brainstorming workshop.

The HAVR was primarily concerned with major hazards. However, other issues identified by the HAVR that may require management once detailed engineering and decommissioning plans have been developed, were recorded and added to a global risk register to ensure that they are addressed as decommissioning planning and implementation progresses.

The study assessed hazards and issues to a level that would facilitate comparative assessment between the removal options and allow verification that the hazard had been accounted for in one of the supporting studies. Where a gap was identified, an action was taken and appropriate assessments completed outside the workshop to address the gap.

The team that took part in the workshop included the following competencies:

- Management
- Compliance
- Technical Safety
- Occupational Health and Safety
- Subsea
- Environment
- Structural
- Decommissioning

Twenty recommendations arose from the HAVR workshop. The most critical actions were those pertaining to understanding the scope of diving activities required for sub-structure removal.

It was concluded that should full sub-structure removal be required, there is a possibility that divers would be required to support cutting the structural piles as the configuration and complexity of the sub-structure may prevent access by a suitably sized work class remotely operated vehicle (ROV). This and the other findings from the HAVR were fed into the assessments presented in this document.
2.10 IRC – Independent Review Committee

As part of the Decommissioning Programme and any Derogation Application process, it is imperative that the studies and the assessment process that support the chosen decommissioning option and Derogation Application are subject to independent expert verification. The purpose of this verification is to confirm that the assessments are reliable and the evaluation of the options is transparent.

Marathon Oil engaged a group of independent consultants to form an Independent Review Committee (IRC), and deliver this assurance and verification of the Brae Bravo sub-structure comparative assessment process. The key findings from the IRC review [4] have been addressed. The findings did not materially impact the validity or appropriateness of the methodology and assessments.
3. Comparative Assessment Workshop and Decision

3.1 Workshop

Marathon Oil conducted a Comparative Assessment Workshop on 10th March 2016 involving the statutory consultees and other stakeholders in the Brae Bravo sub-structure decommissioning process.

The purpose of the workshop was to:

- Ensure that the attendees were fully informed of the studies that support the comparative assessment. To this end a document summarising the results of the supporting studies was circulated to stakeholders prior to the workshop [18].
- Give stakeholders an opportunity to ask questions regarding the supporting studies, or any other aspects of sub-structure decommissioning.
- Populate the comparative assessment worksheets to:
  - Provide a record of the impact of the options against comparative assessment criteria.
  - Highlight any remaining questions from stakeholders regarding the comparative assessment supporting studies and the impacts of decommissioning the sub-structures.

The minutes from the workshop are reported in the Brae Area Sub-Structures Decommissioning Comparative Assessment Workshop Meeting Minutes [15]. The significant points raised by the stakeholders at the workshop were:

- **Why should the fishing industry accept an increase in risk and the reduction in the area potentially available for fishing as a result of parts of the Brae Area sub-structures being left in place? (Scottish Fishing Federation, SFF)**
  - Response: The comparative assessment seeks to identify the option that represents the best balance of impacts against the evaluation criteria, and recognises the negative impacts that leaving parts of the sub-structure in place may have on commercial fishing.

- **The comparative assessment should consider the cumulative effects of all operators leaving sub-structures or snagging hazards in place. (SFF)**
  - Response: Marathon Oil recognises that this is an issue for the industry as a whole. Although it is considered outside the scope of the Brae Area comparative assessment, Marathon Oil is continuing to engage with the industry and stakeholders on this issue.

- **Is it possible to manipulate a sub-structure before lifting it with the SLV such that the sub-structure would not require additional support to withstand transportation loads? (BEIS Environmental Management Team, EMT)**
  - Response: This is not possible because of the configuration of the lifting arms on the SLV.

- **Have SOx and NOx emissions been considered in the CA? (Scottish Environment Protection Agency, SEPA)**
  - Response: It is considered that SOx and NOx emissions will be proportionate to energy usage and CO2 emissions, therefore SOx and NOx are not considered separately in the comparative assessment.

- **Statement: Full removal is preferred from a nature conservation point of view – previously the area has been a soft sediment environment. JNCC’s preference is to remove the sub-structures, as they are a hard substrate, and leave the environment as it was before the Brae Area was developed. However, this comment was specific to the wording of the ‘Environmental Impacts of Option’ criteria; overall, JNCC feels that partial removal is preferable to full removal as there are**
fewer disturbances to the environment in the partial removal option. (Joint Nature Conservation Committee, JNCC)

- There is a requirement to consider foreign fishing vessel crews who are not familiar with regulations relating to trawling over subsea structures. Any mitigation measure must take account of foreign vessels. (SFF)
  - Response: In the event that the sub-structures are left in place, Marathon Oil will seek to ensure that mitigation measures address the issue of foreign flagged vessels.

- Why does partial removal result in less noise? (JNCC)
  - Response: The partial removal option potentially involves fewer cuts through structural members than full removal, which requires foundation piles to be cut.

- Narrative should consider temporal and spatial extent of environmental impacts. (BEIS, EMT)
  - Response: These aspects will be considered in the Environmental Impact Assessment and Environmental Statement.

- Statement: If the same method is considered for both full and partial removal, partial removal will always use fewer resources and emit less CO₂ than full removal as less work is involved in the former. (Oil and Gas Authority, OGA)

The evaluation system used to populate the comparative assessment worksheets is set out in the terms of reference for the workshop [10]. Under this process a score of ‘1’ represents the most preferred option against a particular criterion, and a score of ‘0’ represents the least preferred option against that criterion. Scores between these extreme values indicate a relative degree of preference.

The completed comparative assessment worksheets are reproduced in Table 3.1 below.
### Table 3.1: Brae Bravo Comparative Assessment Summary

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Sub Criteria</th>
<th>Description</th>
<th>Removal</th>
<th>Supporting Information</th>
<th>Notes</th>
</tr>
</thead>
</table>
| Safety        | Risk to personnel | Safety risk to project personnel on and offshore during the implementation of the Option. | 0       | 1                      | **Full Removal**  
PLL = 0.29  
Partial Removal  
PLL = 0.12  
(Both figures are for cut and lift HLV). [18]  
The PLL values are from the QRA base case analysis; that is without sensitivities. [6]  
Full removal is likely to incur a larger PLL than partial removal as it involves a greater number of more cuts in harder to access locations than partial removal. Full removal also requires excavation to 3.5m below seabed to enable structural piles to be cut. The full removal case is also more likely to require the use of divers than the partial removal case. |
| Safety        | Risk to other users | Safety risk to other users of the sea such as fishing and other commercial vessels during or as a result of the Option. | 1       | 0                      | **Full Removal**  
leaves no residual risk to fishermen.  
Partial Removal results in a small increase in fishermen’s Individual Risk.  
[7]  
Leaving part of the Brae Bravo sub-structure in place increases annual Individual Risk to fishermen. The increased risk may be mitigated through the use of charts, FishSAFE, and potentially through retention of a safety zone around the parts of the sub-structure that remain in place. |
<table>
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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Environmental</td>
<td>Energy Consumption / Emissions</td>
<td>Total energy used and emissions arising from each Option (includes implementation and embodied energy in materials).</td>
<td>0</td>
<td>Full Removal</td>
<td>Energy use and CO₂ emissions for Partial Removal take account of energy consumption and CO₂ emissions associated with steel manufactured to replace any material that is left in place. [17]</td>
</tr>
<tr>
<td>Environmental</td>
<td>Impacts of Option</td>
<td>Impacts to the environment during, or as a result of the Option.</td>
<td>0</td>
<td>Full Removal results in noise and other disturbance, and disruption of the seabed. (1,475 vessel days).</td>
<td>At the sub-structure decommissioning CA workshop on 10th March 2016, JNCC stated that from the perspective of the marine environment full removal is preferable, as it removes the steel making up the sub-structure from the environment. JNCC also stated that on balance taking the disturbance to the environment and associated species within it into account, partial removal is preferable overall.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(All figures are for cut and lift using HLV).</td>
<td>1</td>
<td>Partial Removal results in less noise and disturbance, and less disruption to the seabed. However, it removes less foreign habitat from the environment than full removal. (623 vessel days).</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(All figures are for cut and lift using HLV).</td>
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<tr>
<td><strong>Technical</strong></td>
<td>Technical Feasibility / Challenge</td>
<td>Is the Option technically feasible? To what extent does the Option make use of proven technology, is it likely to fail?</td>
<td><strong>0.75</strong></td>
<td><strong>1</strong> Full Removal technically feasible using cut and lift. Partial Removal technically feasible using cut and lift and conceptually feasible using SLV. Subject to assessment of the tilt and lift phases of the operation. [17]</td>
<td>Full removal by HLV cut and lift has not been carried out on a sub-structure of this size in the UKCS. The technology is recognised, but there is no track record for full removal. Partial removal of large sub-structures by HLV cut and lift has been carried out successfully.</td>
</tr>
<tr>
<td><strong>Socio-Economic</strong></td>
<td>Commercial Impact on Fisheries</td>
<td>Impacts both during the implementation and as a result of the Option on commercial fisheries.</td>
<td><strong>1</strong></td>
<td><strong>0</strong> Full Removal of the sub-structure results in 0.79km² of additional seabed becoming available for fishing. Partial Removal results in between 0.0035 km² and 0.79km² seabed being unavailable for fishing. [19]</td>
<td></td>
</tr>
<tr>
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<td>Supporting Information</td>
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</tr>
<tr>
<td>Socio-Economic</td>
<td>Wider Community Impact</td>
<td>Impacts on the health, well-being, standard of living, structure or coherence of communities, both during the implementation and as a result of the Option.</td>
<td>0.5</td>
<td>Full Removal involves various interactions onshore, for example transport of materials, recycling, and waste disposal. Full removal may generate greater employment onshore. Partial Removal will result in fewer disturbances, but fewer employment opportunities than Full Removal. [19]</td>
<td></td>
</tr>
<tr>
<td>Economic</td>
<td>Total Removal Cost</td>
<td>Total costs incurred during implementation and as a result of the Option.</td>
<td>0</td>
<td>Full Removal cost = 100% Partial Removal cost = 56% [18]</td>
<td>Costs are based on Oil and Gas UK norms for tonnage of steel removed.</td>
</tr>
</tbody>
</table>
3.2 Decision

The final decision on the preferred decommissioning option for the Brae Bravo sub-structure was taken at an internal Marathon Oil meeting held in March 2016. This meeting reviewed the findings of the comparative assessment supporting studies and the completed comparative assessment worksheets from the stakeholder workshop, to arrive at a conclusion on the preferred decommissioning option. The conclusion reached by the comparative assessment process for the Brae Bravo sub-structure is that the preferred decommissioning option is partial removal.

The main reasons for this decision are:

- The partial removal option results in a lower Potential Loss of Life for the personnel carrying out the work than full removal. The main reason for the difference is that a greater amount of preparatory work is required for full removal than for partial removal.

- The partial removal option results in lower energy use and emissions than full removal. The figures take account of the energy that will be required, and the emissions that will be generated, to replace the steel left in place in partial removal. These are ‘worst case’ figures for partial removal, and ‘best case’ figures for full removal. Therefore, Marathon Oil is confident that full removal has a greater impact than partial removal.

- In terms of disturbance to marine animals, the duration of the offshore work required to achieve full removal of the sub-structure is greater than the duration required for partial removal. This is because the number of cuts through structural piles that must be made in full removal is greater than the number of cuts that must be made through the structure for partial removal. Therefore, disturbance to marine life from the presence of the vessels carrying out the work, and the noise generated during the work, is greater for full removal than partial removal.

- In terms of disturbance of the seabed, full removal has a greater impact than partial removal as it will be necessary to excavate the seabed to cut structural piles, and when the sub-structure is removed, the footings will be lifted off the seabed which will cause further disturbance.

- Given that the duration of operations, and consequent disturbance of fauna, is greater in full removal, and that full removal will cause greater physical disturbance of the seabed, partial removal is the preferred option.

- A number of sub-structures of a similar size to those in the Brae Area have been partially removed by cut and lift using an HLV. Conversely, no sub-structures of this size have been fully removed by HLV. Thus, while both partial and full removal by HLV are considered technically feasible, partial removal is considered more likely to be technically successful than full removal and therefore is considered the preferred option.

The main residual issues resulting from partial removal are risk to fishermen, and the unavailability of the sea and seabed for fishing in the area containing, and immediately around, the part of the sub-structure that is left in place. Although the additional risk to fishermen is relatively small, the safety of fishermen is an important concern.

The risk to fishermen may be mitigated by a number of measures:

- Inclusion of any part of the sub-structure that is left in place on the FishSAFE system.

- Inclusion of any remaining parts of the sub-structure on Admiralty Charts.

- Maintaining an exclusion zone around any parts of the sub-structure that remain in place. Such an exclusion zone need not be 500m radius, it could be sized to address the hazard from the structure remaining in place, whilst maximising the area of seabed ‘released’ to other sea users.
For example, the selection of 300m from the centre of the sub-structure footings may facilitate sufficient ‘exclusion’ but release 64% of the ‘operational’ safety zone back to other users of the sea.

Marathon Oil will continue to consult with fishing industry bodies and other key stakeholders to ensure that the risk to fishermen from Brae Area decommissioning is reduced to a level that is tolerable and as low as reasonably practicable.

Taking all of these factors into consideration, **the preferred decommissioning option for the Brae Bravo sub-structure is partial removal.**
4. References

[10] Terms of Reference: Brae Area Sub-Structures Decommissioning Options Comparative Assessment Workshop, 9000-MIP-99-PM-RT-00006-000, Marathon Oil Decommissioning Services LLC.
[15] Brae Area Sub-Structures Decommissioning Comparative Assessment Workshop Meeting Minutes, 9000-MIP-99-PM-RT-00007-000, Marathon Oil Decommissioning Services LLC.
[17] Brae Bravo Decommissioning Comparative Assessment Energy and Emissions Inventory, 9010-XDS-99-EV-RP-00002-000, Marathon Oil Decommissioning Services LLC.
[18] Brae Area Decommissioning Overview, 9000-MIP-99-PM-XE-00001-000, Marathon Oil Decommissioning Services LLC.
[19] Brae Field Decommissioning: Environmental and Societal Comparative Assessment for Brae Bravo, 9010-XDS-99-EV-RT-00001-000, Marathon Oil Decommissioning Services LLC.
[20] Brae Field Decommissioning Services: Basis of Assessment for Brae Field Jacket Comparative Assessments, 9000-MIP-99-PM-FD-00001-000, Marathon Oil Decommissioning Services LLC.
Appendix 1 - IRC Certificate

29 March 2016

Independent Expert Verification Statement

Brae Bravo Jacket Removal - Verification of Options and Screening Metrics for Comparative Assessment

This statement has been prepared by Xodus Group Ltd (Xodus) in compliance with the UK Department of Energy and Climate Change (DECC) Decommissioning Guidance Notes on independent expert verification [Ref. 1].

Xodus has been appointed by Marathon Oil Decommissioning Services LLC (MODS) to independently verify that the documentation submitted to support the Comparative Assessment (CA) of the available options for the removal of the Brae Bravo jacket removal is of sufficient detail, clarity, accuracy and completeness such that any conclusions drawn from the studies are made in a sound manner.

Xodus has conducted the review of all supporting documentation with findings presented in the associated report [Ref. 2]. Xodus confirms that the information is adequate for use in the CA process.

Issued:  
Caroline Laurenson
Decommissioning Technical Authority

Checked:  
Joseph Carporan
Structural Consultant

Approved:  
Caragh McWhirr
Independent Review Consultant Project Manager

References:


2. Brae Bravo Jacket Removal, Comparative Assessment Verification: Options and Screening Metrics, Doc No: A-400053-S00-REPT-001, Rev. A03