Shell U.K. Limited

Indefatigable Field
Platforms and Pipelines
Decommissioning Programmes

Juliet

Kilo

Mike

November

Lima

30 May 2007

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Shell U.K. Limited

30 May 2007

Indefatigable Field Platforms and Pipelines

Decommissioning Programmes

Keywords: Decommissioning, DTI, Inde, Indefatigable Field

Foreword

In accordance with the requirements of Part IV, Section 29 of the United Kingdom Petroleum Act 1998 (“the Act”), this document is submitted by Shell U.K. Limited on behalf of the Section 29 Notice Holders for the Indefatigable Field to the United Kingdom Department of Trade and Industry as the Decommissioning Programme in respect to the following installations and associated infield subsea pipelines:-

- Six Fixed Steel Platforms: “JD”, “JP”, “K”, “L”, “M”, “N” located in blocks 49/24 and 49/19
- Export Pipelines: PL 80, PL81,
- Infield Pipelines & Hose Bundles: PL82, PL302, PL303, PL402 and PL479 to PL487

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Approval for the decommissioning programmes for the facilities in the Indefatigable Field by the Section 29 Notice Holders

The Section 29 Notice Holders for the Indefatigable facilities are:-

- Shell U.K. Limited (Operator)
- Esso Exploration and Production UK Limited (Esso)

The Indefatigable Section 29 Notice Holders each confirm that they authorise Shell U.K. Limited, as operator of the Indefatigable Field, to submit a decommissioning programme relating to the Indefatigable Field facilities, as directed by the UK Secretary of State. They also each confirm that they support the proposals detailed in the Decommissioning Programme, dated 30 May 2007, (which in the case of the Indefatigable Field is known as the Indefatigable Field Platforms and Pipelines Decommissioning Programmes) submitted by Shell U.K. Limited.

Letters from the Section 29 Notice Holders for the Indefatigable Field facilities confirming these matters are attached herewith

Shell Exploration & Production

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Offshore Decommissioning Unit
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For the Attention of Ms Thomson

Your Ref: 01.08.07.08/3C

11 June 2007

Dear Ms. Thomson

PETROLEUM ACT 1998

DECOMMISSIONING OF THE INDEFATIGABLE FACILITIES

We acknowledge receipt of your letter dated 17 May 2007.

We hereby jointly submit with our co-ventures the abandonment programme in respect of the decommissioning of the Indefatigable Field installations/pipelines referred to in your letter of 17th May 2007, which complies fully with the provisions of section 29(4) of the Petroleum Act 1998. (Indefatigable Installations, JD, JP, K, L, M, N, and pipelines, PL80, PL81 (excluding apparatus and risers) PL82, PL302, PL303, PL402, and PL479 to PL487) We also submit the originals of our co-venturers' letters of support in respect of the abandonment programme.

We look forward to receiving at your earliest convenience notification of the Secretary of State's approval of the abandonment programme.

Yours sincerely
Shell U.K. Limited

John Hollowell
Vice President - Europe

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Shell Exploration & Production

Encl. (1) Indefatigable Field Installations and pipelines Decommissioning Programmes – dated 30 May 2007 (3 paper copies and 5 CD-Rom)

Encl. (2) Letter of Support:

Esso Exploration and Production UK Limited dated 30/05/07

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Date: 30th May 2007

Dear Sir or Madam

PETROLEUM ACT 1998
INDEFATIGABLE FIELD PLATFORMS AND PIPELINES DECOMMISSIONING PROGRAMMES

We acknowledge receipt of your letter dated 17 May 2007.

We, Esso Exploration and Production UK Limited confirm that we authorise Shell U.K. Limited to submit on our behalf an abandonment program relating to the Indefatigable field facilities as directed by the Secretary of State on 31 May 2002 and 29 April 2004.

We confirm that we support the proposals detailed in the Indefatigable Field Platforms and Pipelines Decommissioning Programs dated 30 May 2007, which is to be submitted by Shell U.K. Limited in so far as they relate to those facilities in respect of which we are required to submit an abandonment program under section 29 of the Petroleum Act 1998.

Yours faithfully

G.R. Borghesi
ONEGas/Netherlands Asset Manager
For and on behalf of Esso Exploration and Production UK Limited

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CONTENTS

1 INTRODUCTION

1.1 Decommissioning Programmes for Shell-Operated Side of Indefatigable Field

The Indefatigable gasfield, consisting of fixed steel platforms known as Juliet-D, Juliet-P, Kilo, Lima, Mike and November located in Blocks 49/19 and 49/24 on the United Kingdom Continental Shelf, has reached the end of its economic life. Following application from the Indefatigable field operator, Shell U.K. Limited (Shell), and co-venturer, Esso Exploration and Production UK Limited (Esso), the Department of Trade and Industry (DTI) granted consent to cease production on or after 01/10/04.

The field was discovered in 1966 and was brought on stream in 1971 and lies some 75km off the East Anglian coast. It has been subjected to various upgrades to improve and maximise production during its lifetime, including additional platforms M,N in the 1980's, upgrade, demanning and compressor reconfiguration in mid 1990's and installation of an eductor to further lower suction pressure in 2001. Production from the Indefatigable Field (Shell Side) ceased on 5th July 2005. At Cessation of Production, it is estimated that the Shell/Esso side of the Inde field had produced 1793.6 bscf (49.9 BCM) of natural gas and 3.6 MMbbl (0.57 MMm3) of condensate.

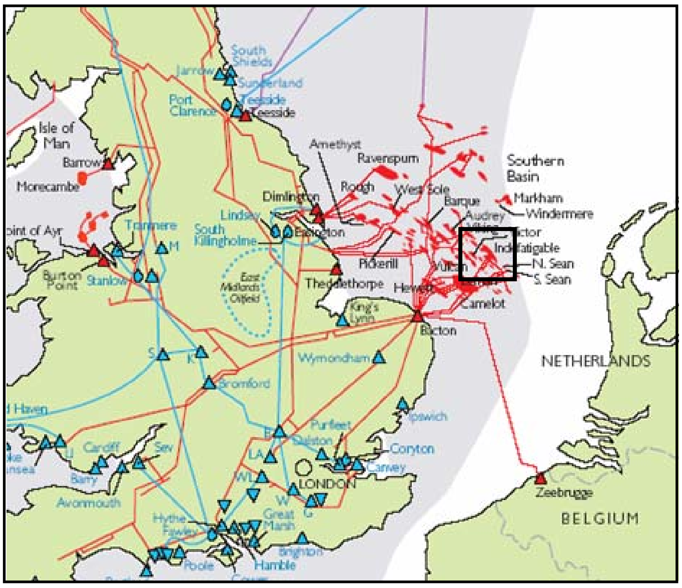


Figure 1.1.1 Location of the Indefatigable Field

As the facilities no longer serve their intended purpose, the operator and co-venturer have prepared the Decommissioning Programmes covering the elements of the Indefatigable facilities corresponding to separate Notices (Section 29 of Petroleum Act 1998) as detailed below:

- Decommissioning Programme 1 covers all six Indefatigable platforms Juliet-D, Juliet-P, Kilo, Lima, Mike and November of Notice with DTI reference RDBF/001/00132C.

- Decommissioning Programme 2 covers the infield pipelines PL82, PL302 and PL402 and hose bundles PL303 and PL479-487 of Notice with DTI reference RDBF/002/00223C.

- Decommissioning Programme 3 covers the export pipelines PL80 and PL81 from Juliet-D and Kilo respectively to the Inde 23AT platform, which is operated by others. These pipelines are Part 1 of the Notice with DTI reference RDBF/002/00345C. Part 2 of this Notice, consisting the risers and platform apparatus associated with these pipelines, are excluded, as they will be subject to a separate decommissioning exercise together with the Inde 23AT platform.

In order to present the background and the inter-related activities involved for the facilities covered in these Decommissioning Programmes, they are presented as one document, as permitted by the DTI guidelines.
These Decommissioning Programmes are prepared in accordance with the requirements of the Petroleum Act 1998 and follows the DTI guidance notes for industry on the "Decommissioning of Offshore Installations and Pipelines under the Petroleum Act 1998". These programmes are submitted on behalf of the Section 29 Notice holders for the Indefatigable facilities; Shell U.K. Limited and co-venturer Esso Exploration and Production UK Limited (Esso).

1.2 Document Sections Comprising the Three Decommissioning Programmes

For ease of reference, the following Table 1.2.1 identifies the sections in this document covering the three Decommissioning Programmes.

	Document Heading	Decommissioning Programme 1	Decommissioning Programme 2	Decommissioning Programme 3
Installations	Description	Fixed Steel Platforms	Infield Pipelines & Hose Bundles	Export Pipelines
	Reference	JD, JP, K, L, M & N	PL82, PL302 & PL402; PL303 & PL479-487	PL80 & PL81
Applicable Sections of this Document	Introduction	1	1	1
	Executive Summary	2	2	2
	Background	3	3	3
	Items to be Decommissioned	4.1	4.2	4.2
	Inventory of Materials	5.1, 5.2 & 5.4	5.3 & 5.4	5.3 & 5.4
	Potential Re-use Opportunities	6.1	6.2	6.2
	Short List of Decommissioning Options	7.1 – 7.5	7.1, 7.6 – 7.8	7.1, 7.6 & 7.7
	Comparative assessment of Short List & Selected Options	8	8	8
	Well decommissioning	9	-	-
	Environmental Impact Assessment	10	10	10
	Consultations	11	11	11
	Costs	12	12	12
	Schedule	13	13	13
	Permits and Consents	14.1	14.2	14.2
	Monitoring and Maintenance	15.1	15.2	15.2
	Project Management	16	16	16
	References	17	17	17

Table 1.2.1 – Document Sections Comprising the Three Decommissioning Programmes

2 EXECUTIVE SUMMARY

This document presents an assessment of the potential decommissioning options for the Inde Field facilities and pipelines and the process adopted to select the preferred options.

The Shell-Operated side of the Indefatigable field in Blocks 49/19 and 49/24 of the UK Continental Shelf (UKCS) presently contain a number of gas production facilities, which are at the end of their useful productive life.
The field was discovered in 1966 and was brought on stream in 1971 and lies some 75km off the East Anglian coast. It has been subjected to various upgrades to improve and maximise production during its lifetime, including additional platforms M,N in the 1980's, upgrade, de-manning and compressor reconfiguration in mid 1990's and installation of an eductor to further lower suction pressure in 2001. Production from the Indefatigable Field (Shell Side) ceased on 5th July 2005. At Cessation of Production, it is estimated that the Shell/Esso side of the Inde field had produced 1793.6 bscf (49.9 BCM) of natural gas and 3.6 MMbbl (0.57 MMm3) of condensate.

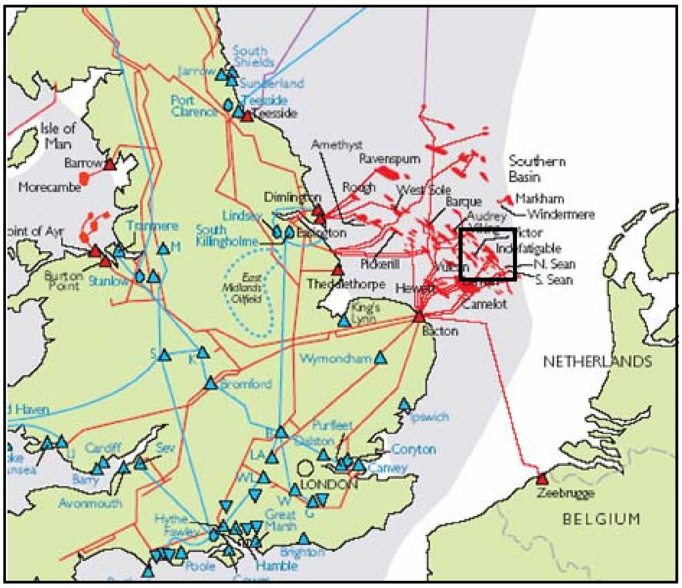


Figure 2.1 Location of the Indefatigable Field

The field lies in an area known as the Norfolk Banks in water depths of approximately 31m. The area is considered typical of the offshore regions of the Southern North Sea where hydrographical, meteorological, geological and biological characteristics are relatively constant over large areas.

The decommissioning programmes present plans for the total removal of the Juliet-D, Juliet-P, Kilo, Lima, Mike and November platforms from the site and their return to shore for re-use, recycling or disposal as appropriate. They also present plans for the decommissioning of the five pipelines and two hose bundles by in-situ decommissioning or by removal to shore for re-use, recycling or disposal as appropriate.

This document describes how the operator, Shell, and its co-venturer, Esso, have:

- Reviewed a range of potential options for decommissioning the wells, platforms, pipelines and hose bundles;
- Examined the advantages and disadvantages in terms of safety, technical feasibility, environmental impact, effect on other users of the sea, and cost;
- Selected a short list of options that would achieve the desired outcome for the decommissioning;
- Considered the environmental impact for the recommended options;
- Developed an appropriate consolidated programme for the implementation.

The studies and programmes support the conclusion that the following options represent acceptable methods of decommissioning the wells and facilities in terms of safety, environmental and social impact, and economic value:

2.1 Installations

Following the permanent plugging and decommissioning of wells and preparing the facilities, the platform topsides will be completely removed to shore for dismantling by any of the following methods:

- Installation reversal using heavy lift vessels (HLVs); or
- Integrated removal using large semi-submersible crane vessels (SSCVs); or
- Integrated removal using novel single lift technology; or
- Piece small removal.

Platform jackets will be completely removed to shore for dismantling by:

- Installation reversal using HLV; or
- Removal using added buoyancy.

Due to the age and condition of the structures and equipment it is considered unlikely that re-use opportunities will be forthcoming, recycling rather than disposal will be maximised.

This is fully in accordance with the presumption of removal for offshore installations contained in OSPAR decision 98/3

2.2 Pipelines

The pipelines have a history of stable burial demonstrated by survey records. Using a comparative assessment of the technical, safety, environmental and societal impacts, it is recommended that pipelines will be decommissioned by:

- In-situ decommissioning, with appropriate remedial work at pipe ends and crossings by Re-trenching, burying or cutting out offending sections where practical.

2.3 Hose Bundles

Using the same comparative methodology, hose bundles will be decommissioned by:

- Pull and re-reel for disposal on-shore; or
- Cut and remove to shore for disposal.

These recommendations have been informed by an open, transparent and inclusive engagement process with interested stakeholders and have been subject to further public consultation in accordance with the DTI 'Guidance Notes for Decommissioning of Offshore Installations and Pipelines under the Petroleum Act 1998'.(DTI Guidance Notes). No objections to the proposals were made during formal consultation.
The environmental impacts of the recommended decommissioning programme have been considered and assessed as acceptable.
The exact method of decommissioning will be finalised and agreed with the successful contractor following detailed technical and commercial analysis of tenders. It is the Operator's and the Co-venturer's desire to seek economies of scale and logistical synergies by providing flexible programmes for contractors interested in the decommissioning of these facilities. This is in line with the recommendations contained in the above DTI Guidance Notes. Obligations under the 'The Offshore Petroleum Activities (Conservation of Habitats) Regulations 2002' will be checked and any obligations met when final decommissioning schemes are known.

The area will be subject to a post decommissioning environmental survey, and the pipelines will remain Shell and Esso responsibility and will be subject to an agreed monitoring programme to ensure the lines remain free of hazards to other sea users.

Current expectations are that removal work will take place between 2008 and 2011 at an expected total project cost, for the Shell/Esso side of the Indefatigable field, of £61.3 million, excluding well decommissioning. Final timing will depend on availability of equipment for decommissioning the wells and marine vessel spread for removal of the platforms. The proposed schedule of activity is shown below. At this stage these are indicative timings and durations. The indicative programme provides relatively wide windows for offshore activities, which are not necessarily continuous, but indicate timely removal.

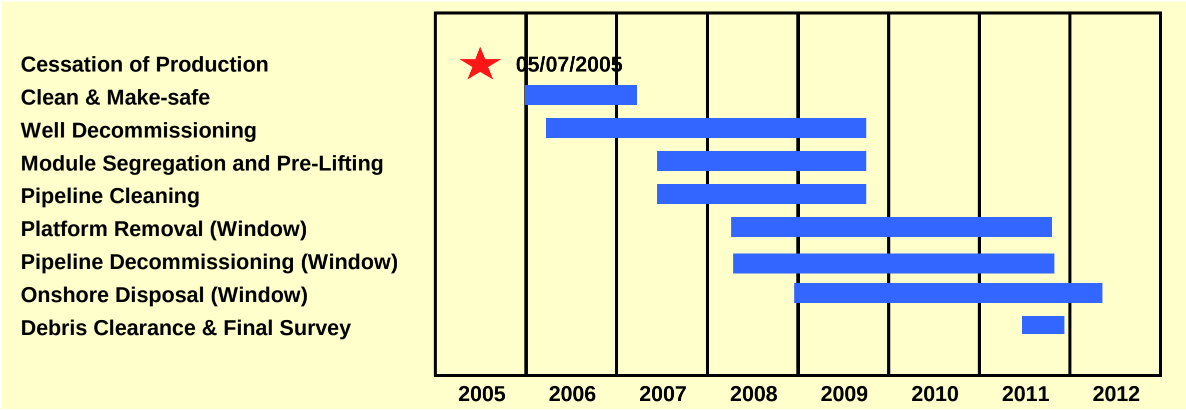


Figure 2.3.1 – Indefatigable Decommissioning Overall Project Plan

Further details including outputs from stakeholder dialogue sessions are included on the redundant facilities – Inde field website at http://www.shell.co.uk/indedecom.

3 BACKGROUND

3.1 Decommissioning of Indefatigable Field Facilities

It is proposed that the decommissioning of the Shell-operated Indefatigable facilities will be performed in a phased manner following the permanent abandonment of the platform wells, isolation and making the facilities hydrocarbon-free. The planned phases of the decommissioning are as follows:

- Pre-decommissioning inspections, surveys and engineering development studies.
- Plugging and permanent abandonment of the wells.
- Removal of residual hydrocarbons from the platform facilities and associated pipelines.
- Removal to shore of the platform structures and equipment.
- In-situ decommissioning of the pipelines.
- Removal of the hose bundles.
- Post decommissioning seabed clearance and surveys.
- Onshore dismantling and disposal.

The arrangement of the platforms and pipelines in the Indefatigable field are shown schematically in Figure 3.1.1.

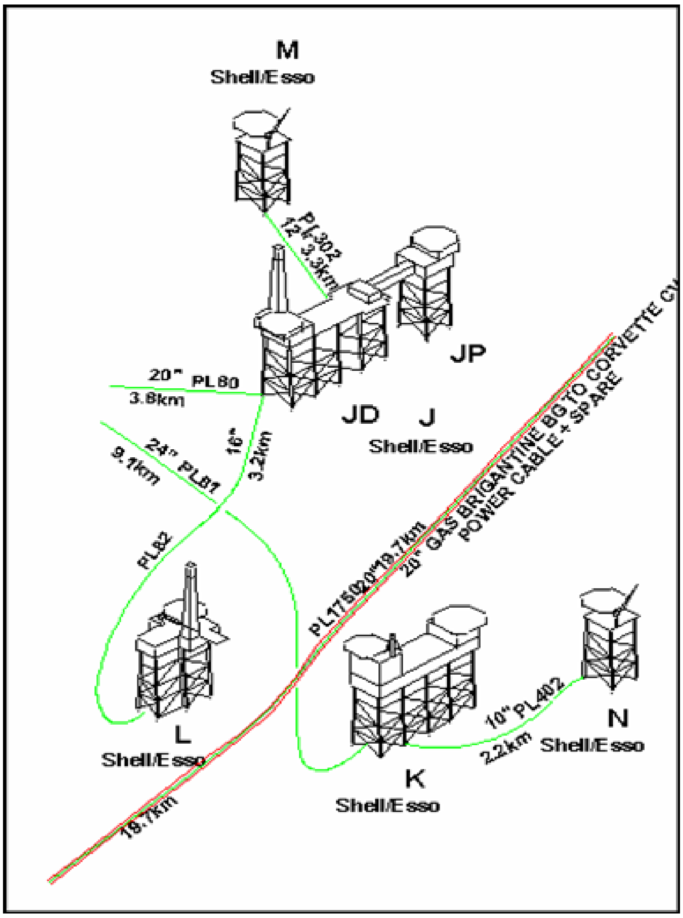


Figure 3.1.1 Indefatigable Field Schematic Arrangement

Notes:
1. The two hose bundles with designations PL303 and PL479-487, not shown on the field layout, follow the pipeline routes from platforms Mike and November to Juliet and Kilo respectively.
2. The two export pipelines from Juliet and Kilo platforms terminate at the Inde platform 23AT, which continues to be operated by others.

3.2 Environmental Conditions

3.2.1 Environmental Assessment

This section presents information on the physical and biological environment of the Indefatigable field, and on other commercial activities in the Indefatigable area.

A detailed assessment of the environmental conditions in the Indefatigable field is given in the Environmental Impact of the Decommissioning Options that was prepared in support of these Decommissioning Programmes which is presented in Appendix C to this report. This section is a summary from the Environmental Impact report.

Table 3.2.1.1 summarises information on the characteristics of the area in which the platforms and pipelines are located and Table 3.2.1.2 summarises the environmental features.

Feature	Data
Seabed sediment	Predominantly silty sands
Water depth	31m approximately
Nearest land	94 km North-East of Great Yarmouth, Norfolk, UK
Distance to median line	21 km from UK/Dutch transboundary median line
Surface currents	Wind driven and variable
Tidal currents	1.07 m/s N-S (extreme 1 year return)

Table 3.2.1.1 – Physical, meteorological and oceanographic conditions, Indefatigable field

Feature	Data
Benthic (seabed) communities	Typical of the Southern North Sea Basin, dominated by polychaetes (worms) that live in silt sediment.
Fish spawning	The Indefatigable Field lies within extensive areas used as spawning grounds by mackerel (May-Aug), plaice (Dec-Mar), sprat (May-Aug)and nephrops (shellfish). Spawning grounds for cod and lemon sole also occur within the general vicinity.
Fish nursery areas	The Indefatigable Field coincides with nursery grounds for whiting, cod, lemon sole, nephrops and sprat.
Seabirds	Several species are found in the area including fulmar, common gull, kittiwake, guillemot, razorbill, gannet, skua, black headed gull, little auk and puffin. Seabird vulnerability is rated high during October through to April and very high during March.
Marine mammals	Harbour porpoises are the most commonly observed mammals and can be found in low numbers in Feb, Apr, May and Aug and in moderate numbers in March with up to 4 sightings / month between Jan-Apr .White-beaked dolphins are less common and have only been observed in April and May. Common seals are expected to be present but little information is known.

Table 3.2.1.2 – Environmental characteristics, Indefatigable field

3.2.2 Fishing and Other Sea Users

3.2.2.1 Commercial fisheries

The area around the Indefatigable Field is of low commercial fishing value compared to surrounding areas. Fish species near the seabed such as whelks, crabs, brown shrimp and mussels historically dominate the landings in this area. Cod, sole and plaice are also important catches in the area and are usually caught by trawling.

Figure 3.2.2.1.1 below shows breakdown by weight of the main species landed from the Indefatigable area in 2003.

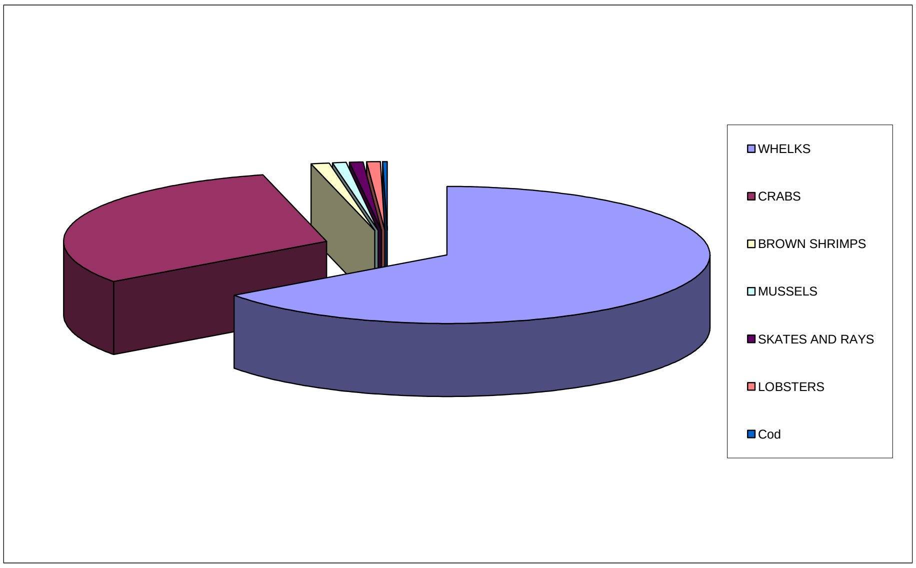


Figure 3.2.2.1.1 – Main species landed by weight in 2003
(Source: DEFRA, 2004)

Figure 3.2.2.1.2 below shows the monthly fishing effort (hours spent fishing) within the Indefatigable area in 2003.

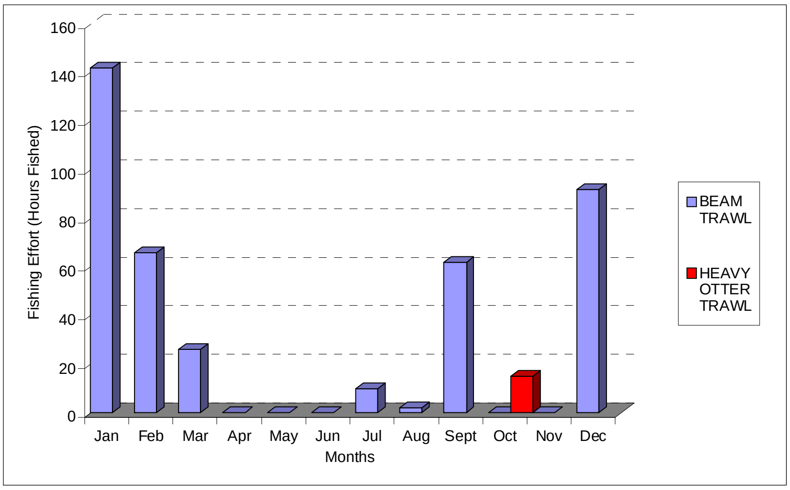


Figure 3.2.2.1.2 – Monthly fishing effort in 2003
(Source: DEFRA, 2004)

The above figure indicates that the maximum fishing effort in any month in 2003 is approximately 140 hours and there is a recent trend of decreasing fishing efforts in the general area. 140 hours per month is less than one boat in five days and, while it is not insignificant, it does not warrant the need to restrict offshore decommissioning operations to lower fishing activity months.

The environmental risk assessment for each of the selected decommissioning options indicated that all options have the potential to cause environment impact as a result of planned and accidental events. However, none of the options was assessed to have any risks in the 'highly significant' category.

3.2.2.2 Oil and Gas activity

The Indefatigable field lies in the Southern Basin of the North Sea where there are numerous gas developments that surround this field.

3.2.2.3 Shipping

The Indefatigable field is located in an area of moderately high shipping activity. There are 12 common shipping routes nearby with vessels including merchant craft, tankers, ferries standby and supply vessels with a measured total traffic volume of 6,771 vessels per annum. While the decommissioning activities themselves will have a limited negative effect on shipping activity, the removal of the platforms will have a long-term positive impact when completed. Activities during decommissioning and updating of chart data will be duly notified to the Hydrographic Office.

3.2.2.4 Ministry of Defence

There are six coastal Ministry of Defence (MOD) sites between Flamborough Head and Great Yarmouth. These sites are used for military training and some are designated conservation sites with limited public access. There are no significant offshore MOD areas, although all offshore activities require clearance through the MOD.

3.2.3 Conservation status

The Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001 implement the EC Habitats Directive (92/43/EEC) in UK Law. These regulations apply to UK waters beyond 12 nautical miles and up to 200 nautical miles offshore. The UK government, with guidance from the Joint Nature Conservation Committee (JNCC) and the Department of Environment, Food and Rural Affairs (DEFRA), has statutory jurisdiction under the EC Habitats Directive to propose offshore areas or species (based on the habitat types and species identified in Annexes I and II) to be designated as Special Areas of Conservation (SAC). These designations have not yet been finalised, but will be made to ensure that the biodiversity of the area is maintained through conservation of important, rare or threatened species and habitats of certain species.

'Sandbanks which are slightly covered by sea water all the time' and 'biogenic reefs' formed by *Sabelleria spinulosa* are habitat categories identified under Annex I of the Habitats Directive are known to occur in the region of the southern North Sea which is occupied by the Indefatigable Field. There is no indication from historical survey data that the areas immediately around the Indefatigable field facilities is subject to the migrating sand waves unique to the Norfolk Bank. It is unlikely that the seabed in the vicinity of the Indefatigable will be designated as an SAC for 'sandbanks which are slightly covered by sea water all the time'. The presence of biogenic reefs (Sabelleria spinulosa) is not expected but once removal methods are confirmed any EU Habitats Directive requirements will be followed, including side scan sonar to check potential sites of disturbance. Results of these surveys will be submitted to the DTI and JNCC, giving sufficient time for consideration, before the decommissioning work commences.

The harbour porpoise is one of four species listed in Annex II of the Habitats Directive, which is known to occur in the vicinity of the Indefatigable Field. They are found in low numbers in Feb, Apr, May and Aug and in moderate numbers in March. Studies indicate that common seals (also an Annex II species) may forage in the region occupied by the Indefatigable Field, but there is little known information on their numbers.

4 ITEMS TO BE DECOMMISSIONED

This section provides a description of the platforms, pipelines and hose bundles to be decommissioned and their layout in the Indefatigable field.

4.1 Platforms (Programme 1)

4.1.1 Description

There are five platform groups in the Indefatigable field named Juliet, Kilo, Lima, Mike and November. The Juliet group has two bridge-linked platforms whilst the others are single platforms.

Figure 4.1.1 Photographs illustrating platforms

The **Juliet** platform complex consists of a four-leg fixed steel platform, which is linked by a bridge to a ten-leg fixed steel platform supporting seven wells, of which one is suspended.

The jacket structure of the ten-leg platform called Juliet-D was installed in two parts. The six-leg and four-leg parts were connected on site above water after installation. Module support frames were then installed on the six-leg and four-leg jackets followed by packages or modules on these support frames. The cellar deck level contains wellheads, manifolds, tankage and facilities associated with the gas production. On top of this deck are a glycol dehydration package, power generation, condensate storage tank, vent stack and crane along with other support equipment. The vent stack has a number of telecommunication discs mounted on it. There is an obsolete helideck.

The four-leg platform called Juliet-P has accommodation and some utility equipment with a helideck on top. The accommodation facilities have been reduced to emergency overnight facilities but the helideck remains in use. The boat landing platform, and access from the sea, have been removed.

The **Kilo** platform is a ten-leg platform supporting five wells, similar to the Juliet-D platform. The facilities are also similar to those on the Juliet-D platform with the following exceptions:

- An accommodation unit (subsequently down-graded to emergency overnight facilities) is located at one end of the Kilo platform where the glycol dehydration package is located on the Juliet-D platform.
- There is no large condensate storage tank on the Kilo platform.
- The large vent stack has been removed and replaced with a short cable stayed pipe.
- The helideck on top of the accommodation unit is operational.
- Solar panels are located on the other obsolete helideck.

The **Lima** platform is an integrated six-leg platform supporting six wells. The jacket structure is unique in that it is narrower at one end to facilitate jack-up legs to be placed on either side for drilling. The integrated deck was installed in a single lift. The cellar deck level contains wellheads, manifolds, tankage and facilities associated with the gas production. Power generation, control rooms, crane and limited accommodation and messing facilities are located on the top deck level along with a tall vent stack and a helideck.

The **Mike** platform is a four-leg platform installed as a minimal facilities wellhead platform. It supports four wells and the deck was installed as a single lift. The topside contains wellheads and manifolds along with emergency overnight accommodation. A crane and helideck are also present.

The **November** platform is a four-leg platform with very similar facilities to the Mike platform. It supports four wells, of which two are suspended and another has been isolated.

The overall weights of the Indefatigable platforms are presented in Table 4.1.1.1.

Platform	Juliet-D	Juliet-P	Kilo	Lima	Mike	November	Total
Topside weight (tonnes)	2,345	655	2,818	1,448	522	495	8,283
Jacket weight * (tonnes)	910	363	816	836	637	703	4265
Total (tonnes)	3,255	1018	3,634	2,284	1159	1198	12,548

Table 4.1.1.1 – Overall Weights of Indefatigable Platforms

Note: ***** Only the weight of pile sections which are to be removed together with the jacket is included.

4.1.2 History

The Juliet, Kilo and Lima platforms in the Indefatigable field were installed over a period from 1970 to 1977. They were originally manned platforms that were converted in the 1980's to "normally unmanned installations" (NUIs) with limited accommodation facilities. Glycol dehydration facilities and condensate tank on the Juliet and Kilo platforms were decommissioned but were not removed. The last time the platform wells were visited by drilling rigs were in 1992, 1988 and 1992 for Juliet, Kilo and Lima respectively.

Mike and November were designed as NUIs and installed in 1985 and 1987 respectively. The platform wells were drilled by jack-up rigs in 1985/86 and 1987/88 respectively.

4.1.3 Condition

In general, the primary structures, wells and process facilities of all the Indefatigable platforms are considered to be in good condition for their age. The condition is monitored and maintained to allow safe operation and decommissioning. However, some redundant parts of the platforms, including all walkways at the top of the jackets, have not been maintained and have been cordoned off. These areas should not be relied upon for safe access. Detailed consideration will be given to safe access for decommissioning.

4.2 Pipelines and Hose Bundles (Programmes 2 and 3)

4.2.1 Description

There are five pipelines to be decommissioned in the Indefatigable field. Three of these are inter-platform pipelines from Lima, Mike and November to Juliet or Kilo. The other two pipelines are the main export pipelines that run from Juliet and Kilo to the receiving platform Indefatigable 23AT, which is operated by others. The main export lines have been positively isolated from the Indefatigable 23AT processing facilities. No impact on the Perenco 49/23 platforms is expected during the final decommissioning of these lines. The Indefatigable 23AT platform is not part of this decommissioning scope.

Summary details of all five pipelines are shown in Table 4.2.1.1.

DTI Pipeline No.	PL80	PL81	PL82	PL302	PL402
Route	J-AT	K-AT	L-J	M-J	N-K
Length (km)	3.88	9.14	3.22	3.35	2.40
Year Installed	1971	1972	1977	1985	1987
Nominal diameter (in)	20	24	16	12.75	10.75
Wall thickness (mm)	15.9	17.5	15.9	15.9	15.9
Material	API5LX52	API5LX52	API5LX52	Duplex SS	API5LX60
External wall coating	Coal tar enamel	Coal tar enamel	Coal tar enamel	Neoprene	Bitumen enamel
Concrete coating thickness (in)	1.5	1.5	1.5	3	3
Anode material	Zinc	Zinc	Zinc	Zinc/Al.	Zinc
Service	Wet gas	Wet gas	Wet gas	Wet gas	Wet gas
Trenched	Yes	Yes	Yes	Yes	Yes
Self burial status (in 2004)	100%	99%	95%	95%	94%
Crossing	None	Crossed by PL82 Crossed by 20" PL 1750 Brigantine to Corvette & power cables (in use)	Crosses PL81, separation by 35 high density asphalt bitumen mattresses	None	None

Table 4.2.1.1 – Pipeline Details

There are two infield hose bundles from Juliet to Mike and Kilo to November. These bundles were intended for the delivery of diesel, methanol and corrosion inhibitor to the Mike and November satellite platforms.

Summary details of the hose bundles are shown in Table 4.2.1.2 below.

DTI Pipeline No.	PL303	PL479-487
Route (parallel to pipeline)	M-J	N-K
Length (km)	3.5	2.5
Year installed	1985	1987
Outside diameter (mm)	76.6	76.6
Manufacturer	Multiflex UK Inc.	Multiflex UK Inc.
Description	9 individual hoses (polyurethane and hytrel with Kevlar braiding) within polyethylene and steel armour sheath	9 individual hoses (polyurethane and hytrel with Kevlar braiding) within polyethylene and steel armour sheath
Service	Conveyance of methanol, diesel fuel and corrosion inhibitor in condensate	Conveyance of methanol, diesel fuel and corrosion inhibitor in condensate
Trenched	Yes	Yes
Self burial status (in 2004)	96%	99%
Stated breaking strength (kN)	315	315

Table 4.2.1.2 – Hose Bundle Details

4.2.2 History

The pipelines and hose bundles in the Indefatigable field are all trenched and naturally backfilled and no mattresses (Ref. Nr 19) were installed adjacent to any of the platforms in the Inde field. There are about 35 high density asphalt bitumen mattresses installed where the 16" Lima to Juliet pipeline crosses 24" Kilo to Perenco pipeline. These mattresses were placed at a depth of 1.5m to 3.0m below seabed and will be left in place to maintain stability after pipeline decommissioning. It should be noted that they were installed in 1976 while they were designed for a service life of 15 to 25 years. Regular surveys have indicated that the burial depth of the lines has remained generally stable over this period. PL81 and PL82 have some exposed sections along their lengths, all of which also appear to be generally stable.

Refer to Appendix E for details of the burial history of the pipelines and hose bundles and section 5.4 indicates other seabed materials protecting the lines.

4.2.3 Condition

Little information is available regarding the external condition. It is assumed that the 1.5" thick external concrete coating (reinforced with small-diameter chicken wire mesh) of the three pipelines installed in the 1970s will, having exceeded their design life by now, be experiencing some deterioration and that the concrete outer coating may be subject to spalling if the pipelines are extracted from the seabed. The steel pipe wall and the thicker 3" concrete outer coating of the two pipelines installed in the mid 1980s can, however, be expected to be in good condition. Similarly, the hose bundles installed in the mid 1980s are expected to show little evidence of deterioration.

5 INVENTORY OF MATERIALS

5.1 Major Platform Materials

The inventory of the various materials on each of the platforms is presented in the tables below:

Item No.	Description	Weight (tonnes)	Material
1	Structural steel	984	Carbon steel
2	Piping	637	Carbon steel
3	Vessels	329	Carbon steel
4	Mechanical equipment	217	Carbon steel
5	Electrical & instrument cables	7	Plastic coated copper
6	Cable trays	33	Galvanised steel
7	Electrical cabinets & equipment	19	Miscellaneous
8	HVAC/Architectural	1	Miscellaneous
9	Safety (includes fire water piping)	84	Carbon steel
10	Decking	34	Timber
	Total	**2345**	

Table 5.1.1 – Inventory of JD Platform Topside

Item No.	Description	Weight (tonnes)	Material
1	Jacket structure	604	Carbon steel
2	Piles (see Note 1 below)	265	Carbon steel
3	Risers	15	Carbon steel
4	Risers	5	SS Duplex
5	Anodes (see Note 2 below)	21	Aluminium alloy
	Total	**910**	

Table 5.1.2 – Inventory of JD Platform Jackets

Item No.	Description	Weight (tonnes)	Material
1	Structural steel	300	Carbon steel
2	Piping	100	Carbon steel
3	Vessels	55	Carbon steel
4	Mechanical equipment	10	Carbon steel
5	Electrical & instrument cables	3	Plastic coated copper
6	Cable trays	17	Galvanised steel
7	Electrical cabinets & equipment	10	Miscellaneous
8	HVAC/Architectural	150	Miscellaneous
9	Safety	10	Carbon steel
	Total	**655**	

Table 5.1.3 – Inventory of JP Platform Topside (estimated values, see Note 3 below)

Item No.	Description	Weight (tonnes)	Material
1	Jacket structure	268	Carbon steel
2	Piles (see Note 1 below)	88	Carbon steel
3	Anodes (see Note 2 below)	7	Aluminium alloy
	Total	**363**	

Table 5.1.4 – Inventory of JP Platform Jacket

Item No.	Description	Weight (tonnes)	Material
1	Structural steel	1557	Carbon steel
2	Piping	314	Carbon steel
3	Vessels	415	Carbon steel
4	Mechanical equipment	260	Carbon steel
5	Electrical & instrument cables	10	Plastic coated copper
6	Cable trays	45	Galvanised steel
7	Electrical cabinets & equipment	26	Miscellaneous
8	HVAC/Architectural	80	Miscellaneous
9	Safety (includes fire water piping)	81	Carbon steel
10	Decking	30	Timber
	Total	**2818**	

Table 5.1.5 – Inventory of Kilo Platform Topside

Item No.	Description	Weight (tonnes)	Material
1	Jacket structure	546	Carbon steel
2	Piles (see Note 1 below)	236	Carbon steel
3	Risers	14	Carbon steel
4	Anodes (see Note 2 below)	20	Aluminium alloy
	Total	**816**	

Table 5.1.6 – Inventory of Kilo Platform Jackets

Item No.	Description	Weight (tonnes)	Material
1	Structural steel	929	Carbon steel
2	Piping	144	Carbon steel
3	Mechanical equipment & vessels	210	Carbon steel
4	Electrical & instrument cables	6	Plastic coated copper
5	Cable trays	27	Galvanised steel
6	Electrical cabinets & equipment	16	Miscellaneous
7	HVAC/Architectural	71	Miscellaneous
8	Decking	45	Timber
	Total	**1448**	

Table 5.1.7 – Inventory of Lima Platform Topside

Item No.	Description	Weight (tonnes)	Material
1	Jacket structure	531	Carbon steel
2	Piles (see Note 1 below)	281	Carbon steel
3	Riser	6	Carbon steel
4	Anodes (see Note 2 below)	18	Aluminium alloy
	Total	**836**	

Table 5.1.8 – Inventory of Lima Platform Jacket

Item No.	Description	Weight (tonnes)	Material
1	Structural steel	400	Carbon steel
2	Piping	13	SS Duplex
3	Mechanical equipment & vessels	9	Carbon steel/ SS Duplex
4	Electrical & instrument cables	50	Plastic coated copper
5	Cable trays	4	Galvanised steel
6	Electrical cabinets & equipment	20	Miscellaneous
7	HVAC/Architectural	10	Miscellaneous
8	Safety (includes fire water piping)	16	
	Total	**522**	

Table 5.1.9 – Inventory of Mike Platform Topside (estimated values, see Note 3 below)

Item No.	Description	Weight (tonnes)	Material
1	Jacket structure	370	Carbon steel
2	Piles (see Note 1 below)	236	Carbon steel
3	Riser	5	SS Duplex
4	Anodes (see Note 2 below)	26	Aluminium alloy
	Total	**637**	

Table 5.1.10 – Inventory of Mike Platform Jacket

Item No.	Description	Weight (tonnes)	Material
1	Structural steel	375	Carbon steel
2	Piping	11	Carbon steel
3	Vessels	9	Carbon steel
	Mechanical equipment	50	Carbon steel
4	Electrical & instrument cables	4	Plastic coated copper
5	Cable trays	19	Galvanised steel
6	Electrical cabinets & equipment	11	Miscellaneous
7	Safety (includes fire water piping)	16	Carbon steel
	Total	**495**	

Table 5.1.11 – Inventory of November Platform Topside

Item No.	Description	Weight (tonnes)	Material
1	Jacket structure	433	Carbon steel
2	Piles (see Note 1 below)	241	Carbon steel
3	Riser	4	Carbon steel
4	Anodes (see Note 2 below)	25	Aluminium alloy
	Total	**703**	

Table 5.1.12 – Inventory of November Platform Jacket

Note 1: The pile weight included in the above tables is the weight of the piles to be removed from 3m below seabed level.

Note 2: The anode weight included in the above tables is the original weight with no allowance for degradation of the anodes.

Note 3: Estimated values have been presented where indicated above where documented values have not been available. These values will be checked and updated if necessary when the data become available.

5.2 Platform Hazardous Materials

The following hazardous materials have been identified as being either present or potentially present on the platform topsides and will require appropriate handling:

Hazardous Material	Description
Asbestos	The corrugated wind walls on the Juliet, Kilo and Lima platforms are constructed from "Galbestos" which contains asbestos in the coating. Asbestos is also assumed to be present in solid form in pipe gasket material. All material will be transported onshore and handled and disposed of by approved methods.
Paint	The original paint used on the Juliet, Kilo and Lima platforms is assumed to contain lead that may give off toxic fumes if flame cutting is used.
LSA	LSA has not been detected in any pipework or vessels, however its absence is to be confirmed by on-site testing.
Heavy Metals	Heavy metals such as Mercury and Lead are expected to be present inside instruments, batteries and the like. This equipment will be transported to shore intact and disposed of onshore by appropriate approved methods.
Radioactive Isotopes	Minute amounts of radioactive isotopes may be present in smoke detectors. These detectors will be transported to shore intact and disposed of onshore by appropriate approved methods.

Table 5.2.1 – Hazardous Materials in Indefatigable Field

5.3 Pipeline and Hose Bundle Materials

5.3.1 Pipelines

The inventory of the various materials on each of the pipelines is presented in the table below:

DTI Pipeline No.		PL80 (see Note)	PL81	PL82 (see Note)	PL302	PL402
Material	**Unit**					
Carbon steel	Tonnes	747.1	2331.7	491.7	-	227.6
Duplex stainless steel	Tonnes	-	-	-	403.8	-
Coal tar enamel	Tonnes	32.2	145.9	33.0	-	-
Neoprene	Tonnes	-	-	-	20.8	-
Bitumen enamel	Tonnes	-	-	-	-	12.9
Zinc/Aluminium anodes	Tonnes	3.4	12.1	3.7	5.3	3.0
Reinforced concrete	Tonnes	782.5	2197.8	506.8	985.2	362.6

Table 5.3.1.1 – Inventory of Indefatigable Pipelines

Note: PL80 and PL82 have “Double Glass Fibre and impregnated Asbestos” in external coating.

5.3.2 Hose Bundles

The total of 5.9 km of 75 mm nominal diameter hose bundles weighs 57.9 tonnes. The materials in the bundles consist of polyurethane and polyethylene sleeves reinforced with Kevlar braid and protected by two layers of galvanised steel armour wires. Refer to Appendix F for the cross-section representations of the hose bundles.

5.4 Seabed Materials

Further investigations including a recent survey have shown that the 12” pipeline from Mike to Juliet, PL302, is protected by gravel in its final 50m approach to the Juliet-D jacket. Other parts of this pipeline, as well as the other pipelines and hose bundles in the Indefatigable field, are naturally backfilled with a few asphalt bitumen mattresses protecting the Inde L-J and K-AT pipeline crossing. There are also approximately 18 concrete mattresses protecting the 10" gas line (PL402) close to the Inde N platform.

Prior to the early 1980’s the Indefatigable jacket bases were protected from scour by a layer of inert graded heavy slag material laid after the installation of each jacket and the well conductors. This slag material (refer appendix C6) has since blended and dispersed into the seabed, and recent surveys indicate that it does not pose any risk to other users of the sea. Since that time gravel has been used for scour protection and this has been regularly replenished as required based on survey data.
Due to the swift currents in the region, there is no visible trace of the drill cutting materials around the base of any of the Indefatigable platforms. Visual checks of the seabed material were carried out as part of the 2005 debris surveys to confirm the absence of cutting material. (refer Appendix C6). This confirmed earlier (1986) environmental survey reports which indicated there were no obvious platform related effects on benthic fauna in the vicinity.

Routine debris survey around the base of the platforms were performed following all major topside construction activities. The most recent debris survey performed in July 2005 showed a significant amount of construction debris present on the seabed around the Juliet and Kilo platforms. A complete debris survey around each platform is planned following the field decommissioning activities to confirm the absence of man-made items that could pose a risk to other users of the sea.

6 POTENTIAL RE-USE OPPORTUNITIES

There is a desire to treat decommissioned facilities in accordance with the Waste Hierarchy, which stipulates that re-use is preferred to recycle, and recycle preferred to disposal. A study of the potential re-use of the Indefatigable field facilities has determined some possible re-use opportunities. These possibilities are presented in this section.

6.1 Topsides and Jackets

There is no known potential for re-use of any of the topsides and jackets in their current locations. Considering the depleted Indefatigable reservoir, for the topsides and jackets to be re-used *in-situ*, a re-use of the field would have to be found. A possibility was the use of the field for CO_2 sequestration or gas storage. This, however, has not been seriously considered due to:

- CO_2 sequestration is not yet a mature technical or commercial opportunity. The industry estimate is that it is at least 5 years away from reality;
- Although gas storage is a commercial reality, the Indefatigable field is a shared reservoir and so would have to be jointly exploited. The other side, however, will continue to produce for an estimated further 5 years;
- It is unlikely that the existing wells could be re-usable for injection due to their design and condition;
- It is not considered economical, nor desirable from a safety point of view, to retain the Indefatigable facilities in a dormant state for at least 5 years pending an opportunity.
- There are other candidate decommissioning fields in the near-term future which may be more suitable for such re-use and may be exploited at a more appropriate time.

There is little potential for re-use of the Juliet, Kilo and Lima topsides and jackets in new locations because of their age and condition. There exists a possibility for re-use of the Mike and November topsides and jackets in new locations either as hydrocarbon development platforms or as renewable energy hubs but it is thought unlikely because of the improved low cost designs currently being implemented for new developments. There is potential for re-use of some of the topside equipment, in particular the cranes and the power generation equipment. These re-use opportunities will be reviewed following removal.

All of the potential re-use options require the facilities to be recovered to shore for detailed inspection, cleaning and refurbishment. This makes the re-use of whole platforms economically less attractive than modern cost-efficient platforms. Platform components, however, may be recovered to shore, refurbished and re-used. Although re-use is considered unlikely for the platforms, it is not discounted.

6.2 Pipelines and Hose Bundles

As for the platforms, there is no known potential for re-use of any of the pipelines and hose bundles in their current locations.

There is no potential for re-use of the PL80, PL81 and PL82 pipelines as pipes elsewhere due to the age and condition of these lines. There may be some limited potential for the re-use of pipelines PL302 and PL402 as pipes elsewhere, meeting lower specifications such as sewer outfalls or agricultural uses. However, these are small-diameter pipelines and appear to be inappropriate.

There is no potential for re-use of the hose bundles elsewhere. For re-use, the lines would have to be shown to be free from contamination. Any re-use is unlikely to be in an offshore oil and gas application where hose bundles are considered critical components of any development. The very small flow-paths of ½" and ¼" diameters do not make the hose bundles suitable for non-oil and gas uses.

Potential options for re-use elsewhere require the pipelines to first be recovered to shore for detailed inspection, cleaning, refurbishment and re-certification. This makes the re-use of pipelines technically and economically unfeasible.

7 LONG LIST OF DECOMMISSIONING OPTIONS, AND SELECTION OF A SHORT LIST

This section presents the potential decommissioning options for the Indefatigable facilities identified by Shell and Esso.

Note that in preparation for any of the following decommissioning options, the facilities will be inspected for safe access, and, where necessary, remedial work will be carried out to ensure that the facilities are safe for the access required by the decommissioning project. This work will be part of the overall decommissioning project scope.

As well as ensuring safe access, the facilities and pipelines will be de-pressurised and hydrocarbon-freed prior to decommissioning. In the case of the pipelines, this will involve the installation of temporary pig launchers and receivers at the platform topsides for pigging with sphere pigs to clear the bulk of the pipeline contents. The pipelines will then be flushed with seawater and sampled to meet a specified target hydrocarbon cleanliness level of no worse than produced water discharge of 30mg/l. The fluids generated from all of the hydrocarbon-freeing will be contained and disposed of appropriately according to legislative requirements.

In the case of the hose bundles, due to the small bore, they are unlikely to be pigged, but will be flushed if feasible to clear as much contaminant as possible. Specific details of this work would be discussed and agreed with the appointed specialist topsides, pipelines and hose bundles cleaning contractors to ensure safety and compliance with waste management requirements.

7.1 Option Identification Process

A brainstorming session was held to generate a list of possible options for decommissioning the Indefatigable field facilities. The participants included those with decommissioning experience in the North Sea oil and gas industry.

The generated list included all possible options, but no attempt was made to rate them with regard to practicality, cost, safety or environmental impact. Not included in the list, however, were ideas that could not be developed within the required time frame for Indefatigable.

This ‘long list’ of decommissioning options that resulted from this exercise is described and briefly assessed for legislative compliance below. Some options were rejected as part of this process, leaving a short list for further assessment in Section 8.0.

7.2 Decommissioning Options for the Platform Topsides

7.2.1 Leave *in-situ*

This is not a legally or environmentally acceptable option, regardless of whether the facilities are maintained, and therefore it was rejected.

7.2.2 Re-use *in-situ*

There are a number of possible *in-situ* uses for the topsides but practically only for the relatively newer Mike and November platforms. The others are of such an age that condition and changing design code requirements make *in-situ* re-use an unfeasible solution.

The possible *in-situ* re-uses for the topsides include using them as:
- Renewable energy hub
- Fish farm
- Prison
- Military applications
- Navigation beacon
- Communications hub
- CO_2 sequestration or gas storage

All these options are opportunity driven and can only be considered if the opportunity arises within the right time frame. There would be significant issues that would have to be resolved about ownership and responsibility of removal at the ultimate end of their useful life. This option was rejected.

7.2.3 Re-use in another location

It is technically possible that the Mike and November topsides may be re-usable in new locations. The other topsides are of such an age that re-use is not feasible.

The possible re-use for the topsides in new locations include:

- Hydrocarbon development platform
- Renewable energy hub

This option requires the topsides to first be removed to shore and, although re-use is considered unlikely, it was not discounted.

7.2.4 Remove and recycle

This is one of the most likely futures for the topsides because of the low probability of finding a suitable re-use opportunity. Various removal methods were reviewed and are described later in this section.

7.2.5 Rigs to reefs disposal

This is not considered a practical option for the topsides. The permits necessary for this method of disposal are not likely to be forthcoming in the foreseeable future. This option was rejected.

7.2.6 Deep sea disposal

This method of disposal is not legally acceptable in North East Atlantic waters under OSPAR obligations. This option was rejected.

7.2.7 Delay decommissioning awaiting novel new technology

A number of marine contractors are known to be in the process of producing novel concept designs for offshore equipment that are specifically tailored to meet the offshore platform decommissioning market. The concepts include jack-up platforms and floating barges. Initial discussions with the contractors indicate that the equipment, if developed, is not likely to be available within a suitable timeframe to be acceptable for the Indefatigable field decommissioning schedule. This option was therefore rejected.

Decommissioning Option	Status
Leave in-situ	Rejected
Re-use *in-situ*	Rejected
Re-use in other location	Further consideration
Remove and recycle	Further consideration
Rigs to reefs disposal	Rejected
Deep sea disposal	Rejected
Await new technology	Rejected

Table 7.2 – Summary of Topsides Decommissioning Options

7.3 Possible Topside Removal Methods

From the review of the topside decommissioning options, the only viable options involve removal of the topsides to shore. The following possible removal methods were considered.

7.3.1 Installation reversal using heavy lift vessel (HLV)

This removal method is simply the reverse of the installation sequence for each of the platform topsides. The work can be undertaken using an HLV of approximately 1,600 tonne lifting capacity. Prior to the major lifting operations, preparation works are required to disconnect and isolate topside packages, attach lifting points and riggings, internally sea-fasten loose items on the topsides and cut the topsides from the jackets. A significant amount of preparatory work is expected for the larger Juliet-D and Kilo topsides, which were originally installed by many major lifts and the separate packages hooked-up offshore.

7.3.2 Topside integrated removal using semi-submersible crane vessel (SSCV)

This method is applicable to the Juliet-D and Kilo topsides that were installed by HLV employing many major lifts. The SSCV concept involves removing the entire topside (lift weight 2,400 – 2,800 tonnes) in a single lift. Substantial preparation work would be necessary to connect, strengthen the decks and install lifting beams for an integrated lift. This method is not applicable for the smaller topsides as they are already considered for single major lift removal under the HLV option.

7.3.3 Topside integrated removal using novel new technology

A number of potential novel methods of removing the topside in a single piece was considered. They each involve a high marine work content.

Versatruss is a proprietary hinged framing arrangement that, when attached to two barges and the barges pulled together, will lift the load attached to the top of the framing. This method has been successfully used for installing and removing topsides in Lake Maracaibo, Venezuela and in the Gulf of Mexico. It is, however, technically more challenging in the North Sea environment. Substantial preparation work would be necessary to strengthen the decks and install lifting beams and lower tie members.

A number of submersible barges exist which are normally used for transporting vessels such as jack-up rigs in the dry. These barges can submerge their decks and float underneath their cargo. They then de-ballast and lift the cargo out of the water. This ability could be used to lift platform topsides off their supporting jackets by placing one barge on either side of the platform. Similarly, substantial preparation work would be necessary to strengthen the decks and install lifting beams.

7.3.4 Piece small topside removal

A marine work vessel, most probably a jack-up barge set up next to the platform, would support this topside removal method. The labour force from the vessel would dismantle the topsides into sections that can be easily handled by the available platform and vessel cranes. The individual pieces will be loaded onto supply boats for transport to shore.

7.3.5 Shearleg and grab

The shearleg and grab method is a method that is sometimes employed in salvage operations. It involves the use of hydraulic guillotines and grabs to break up facilities in a crude manner and dump the pieces in barges for transport to shore.

It is unlikely to be an acceptable method for decommissioning platforms because of safety issues, hazardous material handing issues and the likelihood of debris falling into the sea. This method was rejected.

7.3.6 Removal using drilling jack-up rig

This method has been employed by Shell to install small platforms such as Skiff and Brigantine in the Southern North Sea. This method of topside removal was deemed impractical for any of the Indefatigable topsides due to platform geometry and weight limitations.

Removal Method	Status
HLV	Further consideration
SSCV	Further consideration
Novel technology	Further consideration
Piece small	Further consideration
Shearleg and grab	Rejected
Jack-up rig	Rejected

Table 7.3 – Summary of Topsides Removal Methods

7.4 Decommissioning Options for the Platform Jackets

7.4.1 Leave in place

As for the topsides, this is not a legally or environmentally acceptable option, regardless of whether the structures are maintained, and is therefore rejected.

7.4.2 Re-use *in-situ*

As the in-situ re-use of the jackets is reliant upon the re-use of the topsides, this option was similarly rejected. See section 7.2.2 above.

7.4.3 Re-use in another location

It is technically possible that the Mike and November jackets may be re-usable in new locations. The other jackets are of such an age that re-use is not feasible.

The possible re-use for the jackets in new locations is similar to those for the topsides. See section 7.2.3 above. This option requires the jackets to be removed to shore and, although re-use is considered unlikely, it was not discounted.

7.4.4 Remove and recycle

This is one of the most likely futures for the jackets because of the low probability of finding a suitable re-use opportunity. Various removal methods were reviewed and are described later in this section.

7.4.5 Rigs to reefs disposal

This is not considered a practical option for the jackets in the North Sea although it has some environmental benefits. The permits necessary for this method of disposal are not likely to be forthcoming in the foreseeable future. This option was rejected.

7.4.6 Deep sea disposal

As for the topsides, this method of disposal is not legally acceptable in North East Atlantic waters under OSPAR obligations and was rejected.

7.4.7 Delay decommissioning awaiting novel new technology

As for the topsides, initial discussions with the contractors producing novel new concepts indicate that the equipment, if developed, is not likely to be available within a suitable timeframe to be acceptable for the Indefatigable field decommissioning schedule. Therefore this option was rejected.

Decommissioning Option	Status
Leave in-situ	Rejected
Re-use *in-situ*	Rejected
Re-use in other location	Further consideration
Remove and recycle	Further consideration
Rigs to reefs disposal	Rejected
Deep sea disposal	Rejected
Await new technology	Rejected

Table 7.4 – Summary of Jackets Decommissioning Options

7.5 Possible Jacket Removal Methods

From the review of the jacket decommissioning options the only viable methods involve removal of the jackets to shore. The following possible removal methods were considered.

7.5.1 Installation reversal using heavy lift vessel (HLV)

As described earlier, this removal method is simply the reverse of the installation sequence. The work can be undertaken using an HLV of approximately 1600 tonne lifting capacity. Prior to the major lifting operations, preparation works are required to separate the risers and J-tube connections from pipelines and hose bundles, clear any debris on the jackets, install lifting points and cut the piles below seabed level. The larger Juliet-D and Kilo jackets, which were originally installed in two parts, would first have to be separated back into the two parts before they can be removed by HLV.

7.5.2 Jacket removal using novel technology

A novel removal method entails floating the jacket by adding buoyancies below the waterline and towing it to a deepwater quayside where it can be lifted onshore by an in-shore crane barge. Once onshore, the jacket could be refurbished for re-use or broken up for recycling.

It is only deemed practical to float the jackets vertically because the bottom of jacket dimensions are not compatible with rotating them for floating and towing in the horizontal position. The larger Juliet-D and Kilo jackets would also first have to be separated back into their original two parts before the installation of buoyancies for removal.

7.5.3 Piece small jacket removal

This jacket removal method would be supported by a diving support vessel (DSV). Using remotely operated vehicles (ROVs) and divers operating from the DSV, the jacket would be divided into sections that can be handled by the vessel cranes. The individual pieces will be loaded onto supply boats for transport to shore. This method was rejected because of the risks associated with the excessive diving content in the operations and the potential instability of a sectioned jacket.

7.5.4 Shearleg and grab

As for the topsides, this is unlikely to be an acceptable method for decommissioning jackets because of safety issues and the likelihood of debris falling into the sea. This method was rejected.

Removal Method	Status
HLV	Further consideration
Novel technology (buoyancy)	Further consideration
Piece small	Rejected
Shearleg and grab	Rejected

Table 7.5 – Summary of Jackets Removal Methods

7.6 Decommissioning Options for the Pipelines and Hose Bundles

7.6.1 Decommission and leave *in-situ*

This is an acceptable decommissioning option for subsea lines when certain criteria such as cleanliness, stability and safety for other uses of the sea are met, particularly when the lines are trenched and buried. This option was considered as being worthy of further consideration.

7.6.2 Re-use *in-situ*

Such an option is closely reliant upon the *in-situ* re-use of the platforms. See section 7.2.2. It is only practical if an opportunity for re-use arises within the right time frame. This not being the case, the option was rejected.

7.6.3 Re-use in other locations

It is technically possible that relatively new pipelines and hose bundles may be reusable in new locations. The PL80, PL81 and PL82 pipelines, however, are past their design life and are of such an age that re-use is not a feasible solution.

Although there may be some limited potential for the re-use of PL302 and PL402 as pipes elsewhere meeting lower specifications such as sewer outfalls or agricultural uses, these lines are small-diameter and are inappropriate. There is little potential for re-use of the hose bundles elsewhere as detailed in section 6.2. This option was rejected.

7.6.4 Remove and recycle or dispose in landfill

This is a possible option and various removal methods were reviewed and are described later in this section.

Decommissioning Option	Status
Leave in-situ	Further consideration
Re-use *in-situ*	Rejected
Re-use in other location	Rejected
Remove and dispose in landfill	Further consideration

Table 7.6 – Summary of Pipelines and Hose Bundles Decommissioning Options

Recycling of the pipeline sections is not likely to be practical due to the difficulties of removing the coatings and material contamination. Recycling the hose bundles is also considered impractical due to the construction and mixture of materials. Disposal in landfill is therefore the most likely disposal method for the pipelines and hose bundles in the event that they are recovered to shore.

7.7 Pipeline Removal Methods

From the review of the pipeline decommissioning options, one of the viable options involve removal of the pipelines to shore. The following possible removal methods were considered.

7.7.1 Reverse S-lay

This method involves using a pipeline lay-barge vessel to pull the pipeline onto the vessel deck where it will be cut into sections for transport to shore. This method has been used to recover sections of unburied pipeline during installation operations, due to weather or logistical interruptions, or sections damaged during installation. This is an acceptable methodology for new pipelines but is not preferred and highly risky for pipelines close to or past their design lives due to the deterioration of the coatings and the general uncertainty of pipeline integrity.

7.7.2 Cut and lift

This method requires the pipeline to be fully uncovered before it is cut into sections on the seabed using a special cutting tool attached to an ROV. The sections would then be lifted to the water surface and transported to shore. This methodology has a high safety risk exposure but is considered practical for short pipeline sections that are not buried.

7.7.3 Surface tow

In this option, the pipeline would be uncovered and have buoyancy units attached along its length such that it floats to the surface of the sea. It could then be towed to shore or to a re-use location. The practical difficulties involved with this methodology combined with the safety considerations associated with the large diving content, however, exclude this method from further consideration.

7.7.4 Controlled depth tow

This method is similar to the surface tow except that chains are attached to the lines to make them float at a controlled depth off the seabed. This method was rejected for the same reasons as for the surface tow method.

Removal Method	Status
Reverse S-lay	Further consideration
Cut and lift	Further consideration
Surface tow	Rejected
Controlled depth tow	Rejected

Table 7.7 – Summary of Pipelines Removal Methods

7.8 Hose Bundle Removal Methods

From the review of the hose bundle decommissioning options, one of the viable options involve removal of the bundles to shore. The following possible removal methods were considered.

7.8.1 Lift and reel

This is a reversal of the lay method. The hose bundle would be pulled out of the seabed and onto the deck of a vessel by a cable tensioner or capstan. Once on deck, the cable will be stored on a powered reel or carousel. This methodology is acceptable for relatively new hose bundles that are lying on the seabed or not deeply buried.

7.8.2 Lift and cut

This is similar to the cut and reel method except that the hose bundle is cut into lengths on the deck rather than stored on a reel.

Removal Method	Status
Lift and reel	Further consideration
Lift and cut	Further consideration

Table 7.8 – Summary of Hose Bundles Removal Methods

8 COMPARATIVE ASSESSMENT OF SHORT LIST OF OPTIONS AND SELECTION OF PREFERRED OPTION

This section presents the short list assessment and selection process of the decommissioning options for the Indefatigable facilities & pipelines. The short-listed options are first briefly described (more detail is available in Appendix A), and then a comparative assessment is carried out for each option – leading to a preferred option.

8.1 Option Selection Methodology

Shell and Esso carried out the assessment and selection of options from the feasible short-list identified in the previous section, in consultation with decommissioning specialist consultants, experienced contractors and external stakeholders. In addition, the short-listed options were presented for discussion in a public stakeholders engagement session and key opinions formed were taken into consideration. Each of the options were examined with regard to the following:

- **Technical risk and complexity**;
- **Personnel safety**. The following two activities were undertaken in the assessment:
  - A full hazard identification (HAZID) exercise on the "long-list" of options;
  - A quantitative risk assessment (QRA) of the selected options.

  Potential Loss of Life, (PLL) is one of the prime outputs of a QRA. It provides a simple long term total measure of societal risk to all personnel from an activity and is expressed as the number of fatalities per specified time period. Though not an absolute measure, it can however be used to compare societal risk between activities.
  (The results are given in Appendix B and summarised in this section).
- **Environmental and social impact.** A detailed environmental impact assessment for each option is given in Appendix C, with a summary presented in this section:
- **Energy consumption**. Similarly, Appendix D contains details of the energy consumption of each option, with a summary given below. The total amounts of gaseous emissions are very closely linked to the total amounts of energy used, and so for the sake of clarity this discussion deals only with the estimated net energy use of each option
- **Cost.** A high level cost estimate has been made for each option.

This section presents a summary of the above assessments, along with a summary of the preferred decommissioning options for the Indefatigable field facilities.

Any option that was considered 'not acceptable' in any of the categories was rejected from further consideration unless constraints could be placed to mitigate the 'not acceptable' rating. As a result of the above process, the preferred decommissioning methods were derived.

8.2 Comparative Assessment and Selection of Preferred Option for Topsides

All of the short-listed decommissioning options for the Indefatigable platforms topsides require them to be removed to shore. The comparative assessments were therefore carried out on the removal methods.

8.2.1 Description of Topsides Removal Options

Four of the Inde field platform topsides, Juliet JP, Lima, Mike and November, were installed in single lifts with the maximum lift weight of approximately 1400 tonnes. The other two topsides, Juliet JD and Kilo, were installed in multiple lifts and subsequently hooked together.

The selected topside removal methods are described in greater detail in Appendix A, and summarised below. Some of the topside removal methods are dependent upon the platform involved.

8.2.1.1 Installation reversal using HLV

This method of topside removal is simple for the topsides that were installed as a single lift, i.e. Juliet JP, Lima, Mike and November. A slightly more complicated methodology is required for the two larger platforms, Juliet JD and Kilo, which were installed with multiple topside lifts.

Prior to lifting off these topsides, it is necessary to carry out preparation or reverse hook-up work. The preparatory work includes separating the risers, caissons and J-tubes from the jacket; rigging the conductors (if not removed during well plugging and abandonment) and topside for lift; preparing the leg cuts and internal sea-fastening.

Once the preparation work is complete, an HLV will arrive to prepare to remove the topsides modules.

After anchoring and mooring a cargo barge alongside, the HLV will attach the lift rigging to the crane hook, cut the deck legs and lift the platform topsides modules onto the cargo barge. The modules will then be sea-fastened to the barge and the barge will be towed to shore. The conductors may be lifted and removed when the cargo barge is being prepared.

8.2.1.2 Topside removal using SSCV

This method involves lifting the topsides of the platforms in one single lift using a twin crane semi-submersible crane vessel of lift capacity in excess of 3,000 tonnes. This method is only applicable to the Juliet JD and Kilo platforms as the others are within the single lift capability of an HLV.

In order to lift these topsides in a single piece, it will be necessary to install lifting beams under the deck and to undertake deck strengthening.

The SSCV will arrive at location once all the preparatory work is complete. After attaching the lift rigging and cutting the deck legs, the topside will be lifted as a single unit and placed on a cargo barge.

8.2.1.3 Topside removal using novel technology (Versatruss)

Versatruss is a proprietary arrangement for lifting platform decks and the like without the use of conventional craneage or jacks. The sketches (Fig 8.2.1.1 & 8.2.1.2) below demonstrate how the system works.

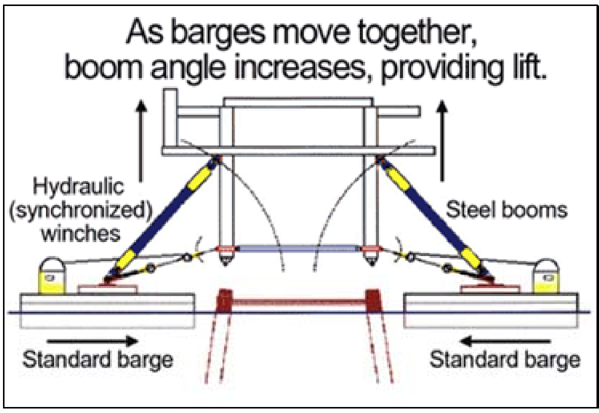


Figure 8.2.1.1

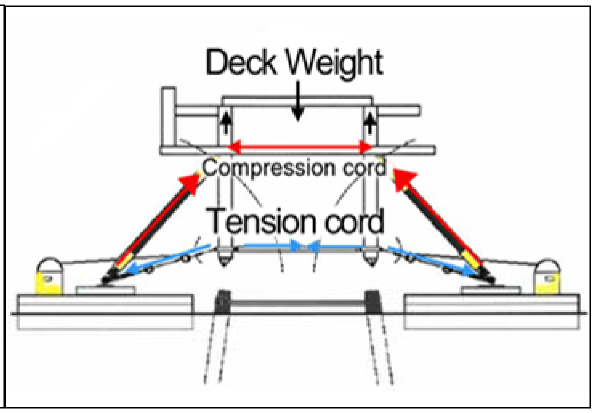


Figure 8.2.1.2

The Versatruss option is applicable to the removal of all six Inde platform topsides.

In order to remove the topsides in this manner, it will be necessary to strengthen and install lifting lower tie members between the deck legs. The Versatruss equipment will be fitted out inshore on barges and towed to site where the barges will be anchored out. The system will be fitted up to the prepared decks and the deck legs cut. The barges will then be winched together and the deck will lift off the jacket. The deck and the barges will then move forward and lower the deck onto a transport barge for transit to shore.

8.2.1.4 Topside removal using novel technology (Submersible Barges)

This method of topside removal is similar to the Versatruss method except that submersible barges are used to provide the lift, rather than the Veratruss system.

The operations are shown diagrammatically in figures 8.2.1.3 to 8.2.1.6 below for the Kilo platform.

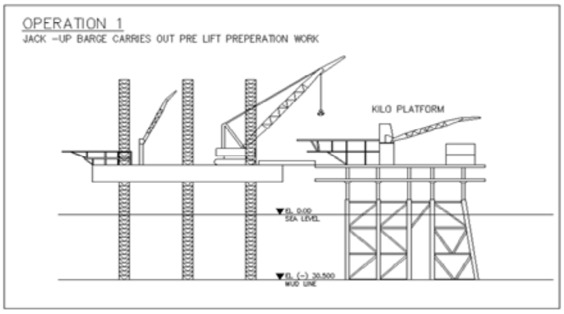


Figure 8.2.1.3

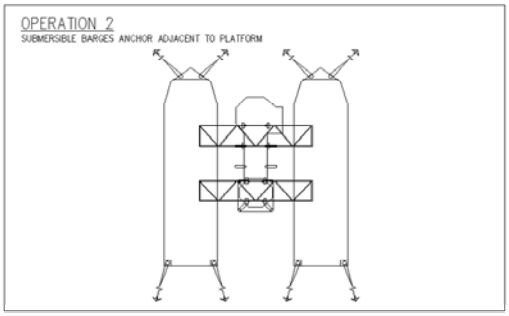


Figure 8.2.1.4

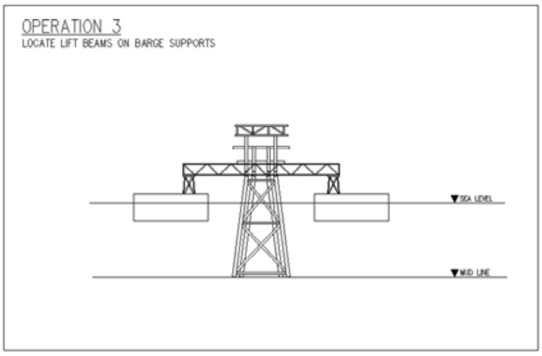


Figure 8.2.1.5

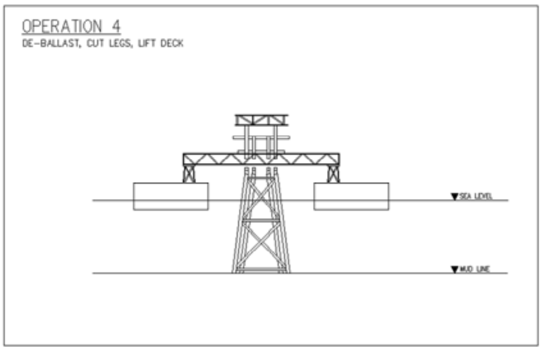


Figure 8.2.1.6

8.2.1.5 Piece small removal of topsides

This topside removal method will be undertaken by a marine work vessel, most probably a jack-up barge that will break the platforms up into sections that can be easily handled by the available cranes. The individual pieces will be loaded onto supply boats for transport to shore.

It is envisaged that a large crawler or ringer crane (such as a Manitowoc 4100) would be on the deck of the jack-up which would be able to handle 100 tonne lifts at most parts of the platforms.

As this is a time consuming method it is possible that two jack-up vessels may be used in parallel for the Juliet and Kilo platforms.

8.2.2 Comparative Assessment of Topsides Removal Options

8.2.2.1 Technical risk and complexity

All of the options are technically feasible. The reverse installation and SSCV options are similar in terms of technical risk but the novel lift technologies carry a higher technical risk due to the difficulties of operating in the shallow water and high tide/currents of the SNS. The piece-small option also carries higher technical risk due to the longer offshore deconstruction duration.

8.2.2.2 Safety

It can be seen from Table 8.2.1 below that the HLV and SSCV options carry the lowest safety risk, and that the Versatruss, Submersible Barge and Piece Small options all carry a significantly higher risk. In the case of the novel technologies, this is due to the greater marine activity, whereas for the piece-small option this is due to the greater number of offshore man-hours involved.

The onshore risk, which contributes on average 14% of the risk, is constant since the same tonnage of steel has to be cut up onshore regardless of the offshore option recovery option. The offshore work carries on average 86% of the risk.

If the offshore risk for the HLV option is taken as the norm with a risk value of 1.00, then the SSCV option is essentially the same at 0.99, the Piece Small option has a higher risk at 1.58, the Versatruss option is higher still at 1.95, and the Submersible Barge option is highest at 2.05.

Decommissioning Options / Inde Platform		HLV	SSCV	Versatruss	Submersible Barges	Piece Small
		Potential Loss of Life				
Juliet	Offshore	1.30E-02	1.25E-02	2.16E-02	2.20E-02	1.65E-02
	Onshore	3.05E-03	3.05E-03	3.05E-03	3.05E-03	3.05E-03
	Total	**1.60E-02**	**1.55E-02**	**2.46E-02**	**2.51E-02**	**1.95E-02**
Kilo	Offshore	9.28E-03	9.35E-03	1.40E-02	1.58E-02	1.60E-02
	Onshore	2.86E-03	2.86E-03	2.86E-03	2.86E-03	2.86E-03
	Total	**1.21E-02**	**1.22E-02**	**1.68E-02**	**1.87E-02**	**1.89E-02**
Lima	Offshore	3.93E-03	3.93E-03	9.82E-03	9.71E-03	1.13E-02
	Onshore	1.44E-03	1.44E-03	1.44E-03	1.44E-03	1.44E-03
	Total	**5.37E-03**	**5.37E-03**	**1.13E-02**	**1.12E-02**	**1.27E-02**
Mike	Offshore	3.31E-03	3.31E-03	9.29E-03	9.62E-03	4.11E-03
	Onshore	5.30E-04	5.30E-04	5.30E-04	5.30E-04	5.30E-04
	Total	**3.84E-03**	**3.84E-03**	**9.82E-03**	**1.01E-02**	**4.64E-03**
November	Offshore	3.31E-03	3.31E-03	9.29E-03	9.62E-03	4.11E-03
	Onshore	5.02E-04	5.02E-04	5.02E-04	5.02E-04	5.02E-04
	Total	**3.81E-03**	**3.81E-03**	**9.79E-03**	**1.01E-02**	**4.61E-03**
Total Offshore		3.28E-02	3.23E-02	6.39E-02	6.68E-02	5.20E-02
Total Onshore		8.38E-03	8.38E-03	8.38E-03	8.38E-03	8.38E-03
Overall Total		**4.12E-02**	**4.07E-02**	**7.23E-02**	**7.52E-02**	**6.03E-02**

Table 8.2.1: PLL for Topsides Decommissioning Options

Note 1: SSCV values for Lima, Mike and November are assumed the same as HLV value
Note 2: Total offshore values are excluding activities related to mobilisation.
Note 3. PLL of 1x10-03 represents a risk of one fatality in 1000 operations.

8.2.2.3 Environmental & Societal Impact

Table 8.2.2 gives the results of the screening of all environmental risks associated with the short-listed options for decommissioning the topsides. All of the options exhibited about the same number of "not significant" and "significant" impacts. In all options, 4 of the "significant" impacts arise as a result of a large accidental spill of fuel oil to sea, following a vessel collision. In the piece-small option, a further impact might arise as a result of the exposure of personnel offshore to excessive dust and fumes during the extensive dismantling and cutting operations within the confines of the topsides.

Removal Option	Numbers of impact			
	Positive	Not significant	Significant	Highly significant
Installation reversal with HLV	0	75	4	0
Single lift with SSCV	0	75	4	0
Novel technology (*Versatruss*)	0	75	4	0
Novel technology (submersible barges)	0	75	4	0
Piece-small removal	0	74	5	0

Table 8.2.2 – Impacts associated with short-listed removal options for the Topsides

The net energy use of the different options for the topsides of the facilities is shown in Table 8.2.3 below.

Option	Platform				
	Juliet	Kilo	Lima	Mike	November
Reverse installation by HLV	117	94	50	37	36
Single lift	136	105	N/A	N/A	N/A
Versatruss	177	136	87	73	71
Twin barge	212	132	93	78	66
Piece-small	257	205	111	61	64

Table 8.2.3: Total net energy use for decommissioning the topsides of each facility

Values are rounded, and in units of 1,000GJ.
N/A = Option Not Applicable.
For context 1 household energy usage/ year is approx 80GJ

For **Juliet**, the total energy use of different options ranges from 117,000GJ to 257,000GJ (in round numbers). "Reverse installation by HLV" is the least energy-intensive, and is less than half that of the most energy-intensive, "piece-small". The difference between "reverse installation by HLV" and "single lift" (about 19,000GJ, 16%) may not be significant. However, the difference between these two options and the other 3 options may be significant. As presently planned, the "piece small" option would be clearly the most energy-intensive option and this is largely as a result of the simultaneous use of two jack-ups during offshore dismantling.

This pattern of energy use is repeated for **Kilo**, **Lima**, **Mike** and **November**. For **Kilo** the difference between the "reverse installation" and the "single lift" options may not be significant, but the other 3 options are probably actually more energy-intensive. For **Lima**, **Mike** and **November**, the "reverse installation" option is clearly significantly less energy-intensive than the nearest other option; for

Lima, "Versatruss is 37,000GJ, 74% more energy-intensive; for **Mike** it is 36,000GJ, 97% more intensive; and for **November** "piece-small" is 28,000GJ, 78% more energy-intensive.

No social impact, including impacts on fishing and fish spawning, is considered to be significant to differentiate between any of the preferred decommissioning options.

8.2.2.4 Costs

For the larger three platforms (J, K & L), the costs for the HLV and SSCV options are likely to be similar, with the other options likely to be 25-50% more expensive due to either the additional marine activity or the greater offshore man-hours.

For the two smaller platforms (M & N), the HLV and piece-small options are similar, with the novel technology options 50-100% more expensive.

8.2.3 Summary of Selected Topsides Decommissioning Options

Based on the comparative assessment considering the above criteria, the preferred method of removal for all the Indefatigable topsides is the installation reversal using HLV. This is a technically proven method and is simply the reverse of the original installation sequence. The operation is subject to standard offshore construction personnel safety risk and environmental risk exposures that can be managed. There are a number of contractors who can offer this removal service in the North Sea.

For the larger topsides (Juliet-D and Kilo), a feasible alternative to the HLV removal option is single lift removal using SSCV. The topsides would first have to be structurally linked and strengthened such that the multiple packages can be lifted in one piece. This would require a significant amount of offshore preparatory work but it avoids the need to isolate and individually rig the packages for separate lifts. This method is rated similar in terms of technical, personnel safety and environmental risks to the HLV option. However, this alternative removal method limits the number of contractors who can perform the offshore as well as the onshore work.

For the smaller topsides (Juliet-P, Mike and November), a feasible alternative to the HLV removal option is piece small removal using a marine work vessel. This option has an increased offshore scope and duration. As such, it has higher technical, personnel safety and environmental risks when compared to the HLV option. These risks would have to be properly managed during execution.

There can be other acceptable removal methods for the topsides and jackets using novel technologies commensurate with contractors' experience and resources as described in Section 7. These cannot be discounted and ought to be assessed on a case-by-case basis at the contracting stage of the project.

Although a preferred removal method was identified, none of the short-listed topsides removal methods was rejected outright. As such, notwithstanding the above assessment, contractors tendering for the decommissioning work will not be excluded from offering other decommissioning methods that are commensurate with their experience and resources. However, any alternative method proposed by a contractor would be reviewed to ensure that it meets or exceeds all of the assessment criteria.

Platform Component	Selected Decommissioning Option	Preferred Removal Option	Possible Alternatives
Larger Topsides (Juliet-D, Kilo, Lima)	Remove to shore for re-use, recycling or disposal	HLV	SSCV; Novel technology
Smaller Topsides (Juliet-P, Mike, November)	Remove to shore for re-use, recycling or disposal	HLV	Piece small; Novel technology

Table 8.2.4 – Summary of Selected Topsides Decommissioning Options

8.3 Comparative Assessment and Selection of Preferred Option for Jackets

All of the short-listed decommissioning options for the Indefatigable platforms jackets require them to be removed to shore. The comparative assessments were therefore carried out on the removal methods.

8.3.1 Description of Jacket Removal Options

Only two methods of jacket removal were deemed feasible after the review of the long list of options. These methods are:

- Installation reversal using HLV
- Jacket removal using added buoyancy

8.3.1.1 Installation reversal using HLV

As with the topsides, it is necessary to carry out some preparation works prior to lifting the jacket. This involves removal of the connections between the pipelines and the hose bundles to the risers and J-tubes and the cutting of the piles below mudline. The connection of the lift rigging for the jacket will also be carried out in the preparation phase to save the more expensive HLV time.

The subsea work of cutting the lines and clearing the seabed will be supported by a diving support vessel (DSV). It is envisaged that most of the work may be accomplished by ROVs however some manual diving is also expected to be necessary. The other preparation work involves cutting the piles and installing the lift rigging.

When the preparation work is complete the HLV will arrive and anchor in position. The jacket will be lifted and placed on a cargo barge where it will be sea fastened and transported to shore.

The jackets for the Juliet JD and Kilo platforms are ten-leg jackets that were installed as separate four-leg and six-leg jackets that were connected above waterline after installation. These jackets will be removed as two jackets after cutting the connecting braces.

8.3.1.2 Jacket removal using novel technology (Added Buoyancy)

This method of removing the jackets involves adding buoyancy in the form of tanks to the jackets in order that they will float clear of the seabed after the piles are cut. This will enable them to be towed to a deepwater inshore location where they can be lifted clear of the sea by a shearleg barge. The shearleg will then move to a nearby quayside and place the jackets on land.

The preparation works necessary for this operation include those required for the HLV removal method plus the attachment and de-ballasting of the buoyancy tanks.

Figures 8.3.1 to 8.3.6 below give a diagrammatic representation of the buoyant jacket removal method.

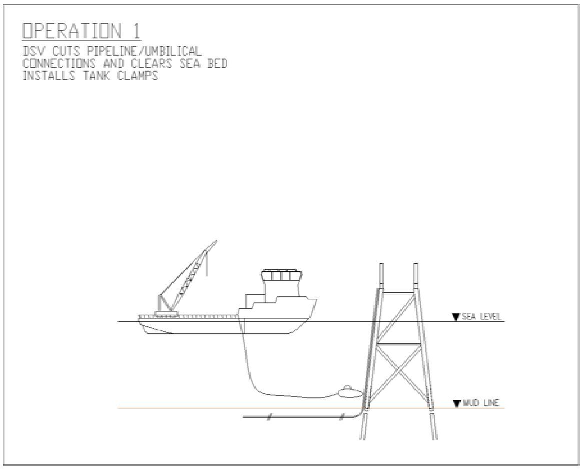


Figure 8.3.1

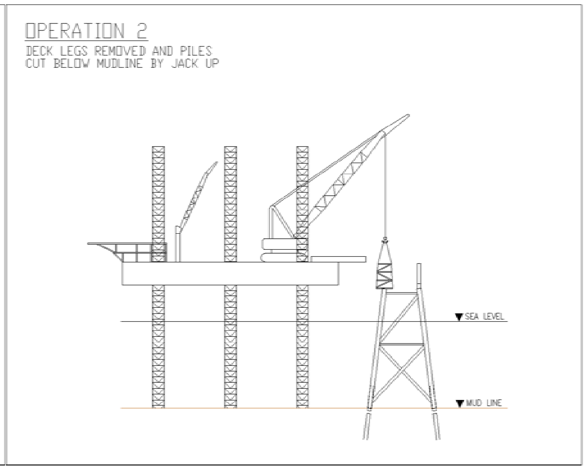


Figure 8.3.2

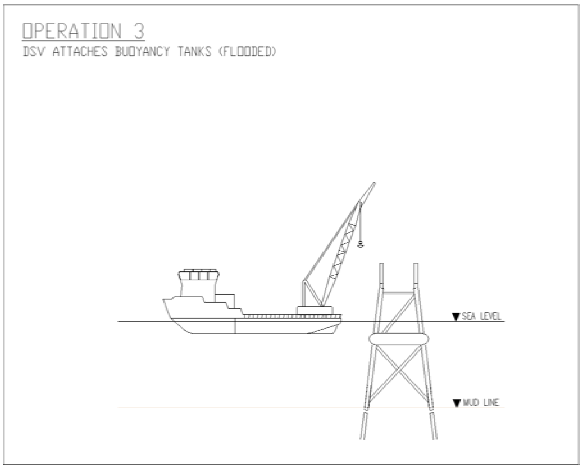


Figure 8.3.3

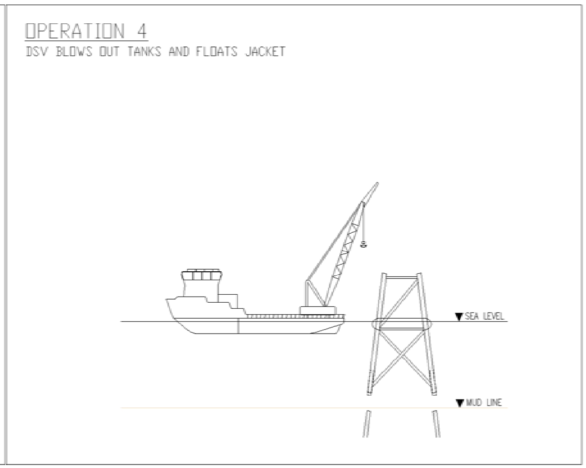


Figure 8.3.4

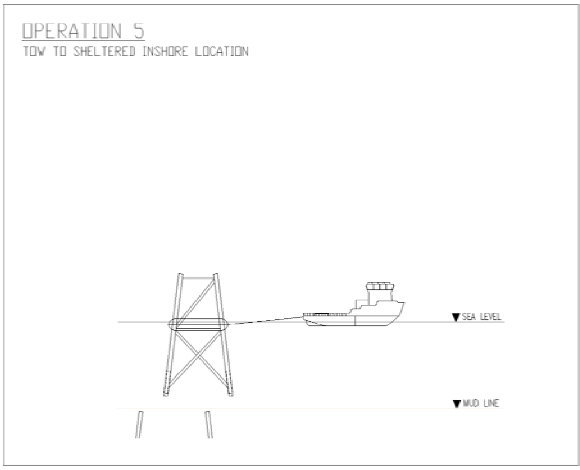


Figure 8.3.5

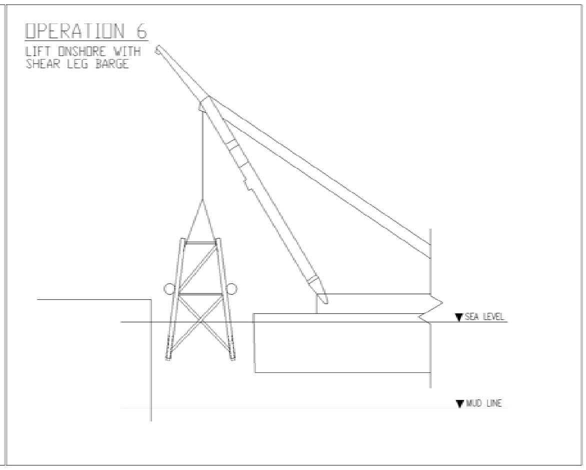


Figure 8.3.6

8.3.2 Comparative Assessment of Jacket Removal Options

8.3.2.1 Technical risk and complexity

All of the options are technically feasible. The reverse installation carries the lowest risk as it is a well proven technique which can be carried out by a number of contractors. The added buoyancy technology carries a higher technical risk due to the difficulties of operating in the shallow water and high tide/currents of the SNS.

8.3.2.2 Safety

Table 8.3.1 below shows that the Added Buoyancy option carries roughly double the risk of the HLV option. On average the onshore work contributes 7% of the risk and the offshore work contributes 93%.

As for the topsides, the onshore work remains constant. If the offshore work is considered by itself, the Added Buoyancy option carries 2.26 times the risk of the HLV option.

Decommissioning Options / Inde Platform	HLV	Added Buoyancy
	Potential Loss of Life	
Juliet Offshore	6.88E-03	2.14E-02
Juliet Onshore	1.28E-03	1.28E-03
Juliet Total	**8.16E-03**	**2.27E-02**
Kilo Offshore	6.90E-03	1.20E-02
Kilo Onshore	8.29E-04	8.29E-04
Kilo Total	**7.73E-03**	**1.28E-02**
Lima Offshore	4.12E-03	9.83E-03
Lima Onshore	8.49E-04	8.49E-04
Lima Total	**4.97E-03**	**1.07E-02**
Mike Offshore	3.96E-03	7.57E-03
Mike Onshore	6.46E-04	6.46E-04
Mike Total	**4.61E-03**	**8.22E-03**
November Offshore	3.96E-03	7.57E-03
November Onshore	7.14E-04	7.14E-04
November Total	**4.67E-03**	**8.28E-03**
Total Offshore (Excl Mob)	2.58E-02	5.84E-02
Total Onshore	4.32E-03	4.32E-03
Total (Excl Mob)	**3.01E-02**	**6.27E-02**

Table 8.3.1: PLL for Jacket Decommissioning Options

8.3.2.3 Environmental & Societal Impact

Table 8.3.2 gives the results of the screening of all environmental risks associated with the short-listed options for decommissioning the jackets. Both options exhibited about the same number of "positive", "not significant" and "significant" impacts. The single positive impact was the effect on fishing operations of removing an obstruction (the jacket) from the seabed. In each case the 4 "significant" impacts would arise as a result of a large accidental spill of fuel oil to sea, following a vessel collision. Additional "not significant" impacts were found in the buoyancy option, as a result of lifting the floating jacket onto a barge at an inshore site.

Removal Option	Numbers of impact			
	Positive	Not significant	Significant	Highly significant
Installation reversal with HLV	1	96	4	0
Novel technology (buoyancy)	1	98	4	0

Table 8.3.2 – Impacts associated with short-listed removal options for the Jackets

The net energy use of the different options for the topsides of the facilities is shown in Table 8.3.3 below.

Removal Option	Platform				
	Juliet	Kilo	Lima	Mike	November
Installation reversal with HLV	84	50	35	35	32
Novel technology (buoyancy)	130	81	59	54	49

Table 8.3.3: Total net energy use for decommissioning the jackets of each facility

Values are rounded, and in units of 1,000GJ.For context 1 household energy usage/ year is approx 80GJ

For Juliet, the option "reverse installation by HLV" is less energy-intensive than that of "removal with buoyancy". The difference, about 46,000GJ (55%) is probably significant and real, and results from the need to construct new rigid buoyancy tanks, and engage in a longer tow, in the "removal by buoyancy" option.

This finding applies to the other platforms. In each case "reverse installation" is less energy-intensive than removal with buoyancy", and the difference ranges from 53% (**November**) to 69% (**Lima**).

No social impact, including impacts on fishing and fish spawning, is considered to be significant to differentiate between any of the preferred decommissioning options.

8.3.2.4 Costs

The cost of the HLV option is likely to be 50-75% of the cost of the buoyancy option due to the high cost of fabricating the buoyancy tanks and the amount of marine activity.

8.3.3 Summary of Selected Jacket Decommissioning Options

Based on the comparative assessment considering the above criteria, the preferred method of removal for all the Indefatigable jackets is the installation reversal using HLV. This is a technically proven method and is simply the reverse of the original installation sequence. The operation is subject to standard offshore construction personnel safety risk and environmental risk exposures that can be managed. There are a number of contractors who can offer this removal service in the North Sea.

Although a preferred removal method was identified, the alternative buoyancy option is not rejected outright. As such, notwithstanding the above assessment, contractors tendering for the decommissioning work will not be excluded from offering other decommissioning methods that are commensurate with their experience and resources. However, any alternative method proposed by a contractor would be reviewed to ensure that it meets or exceeds all of the assessment criteria.

Platform Component	Selected Decommissioning Option	Preferred Removal Option	Possible Alternatives
Jackets (All)	Remove to shore for re-use, recycling or disposal	HLV	Novel technology (buoyancy)

Table 8.3.4 – Summary of Selected Jacket Decommissioning Options

8.4 Comparative Assessment and Selection of Preferred Option for Pipelines

8.4.1 Description of Pipeline Decommissioning Options

The possible decommissioning options for pipelines are decommission *in-situ,* or remove to shore for disposal in landfill.

8.4.1.1 Decommission in-situ

Decommissioning pipelines *in-situ* require their ends to be cut from the platforms at the base of the risers and made safe from being a potential snagging hazard for other users of the sea once the platforms are removed. Any exposed sections or spans along their lengths that may pose a snagging hazard would have to be similarly remedied.

Such remedy can be achieved by:
- Re-trenching and burying of any exposed sections;
- Recovery of mattresses where their condition allows safe lifting
- Cutting out the offending sections for recovery to shore for disposal and remedying the cut ends as above.

And where there are mitigating reasons achieved by:
- Dumping rock over the exposed sections;
- Covering the exposed sections with mattresses;

As the pipelines would be flushed clean of contaminants at this stage, the ends can be left open to the sea. The pipelines would become more stable in the seabed when sea-water filled than they were when gas-filled during their service lives.

A leave in situ solution will require remedial works to ends, crossings and significant spans as part of the scope. The final selection of which of the above remedial measures is appropriate will be made after discussion with key consultees.

Table 8.4.1 gives high level details of the burial history of the five Inde pipelines. In summary, there is a good history of stable burial over the field life, with burial depth measurements from survey work going back to the 1980’s. From the latest 2004 survey data the pipeline burial status is:

Pipeline	%age Buried	Burial Depth & Exposure Details
PL80	100%	No exposures; average burial depth >0.6m
PL81	99%	Minimal exposure; average burial depth c. 0.5m
PL82	95%	c. 50m exposure where it crosses PL81; average burial depth c. 0.5m
PL302	95%	Only exposed at platform ends; average burial depth >0.6m
PL402	94%	Only exposed at platform ends; average burial depth >0.6m.

Table 8.4.1 – Summary of Pipeline burial status

Exposures can vary from loss of cover on the crown or top of the line which still stays below surrounding seabed level, to spanning where there is a gap below the line.
Looking at each line burial history in more detail, and where anomalies occur also looking at exposure and spanning records:

Depth of burial survey data for PL80 for the period up to 2003 has been plotted in graph below. Burial depth varies in time but the top of the pipeline is constantly below 0.5m below seabed. This line has no exposures or spans identified during inspections.

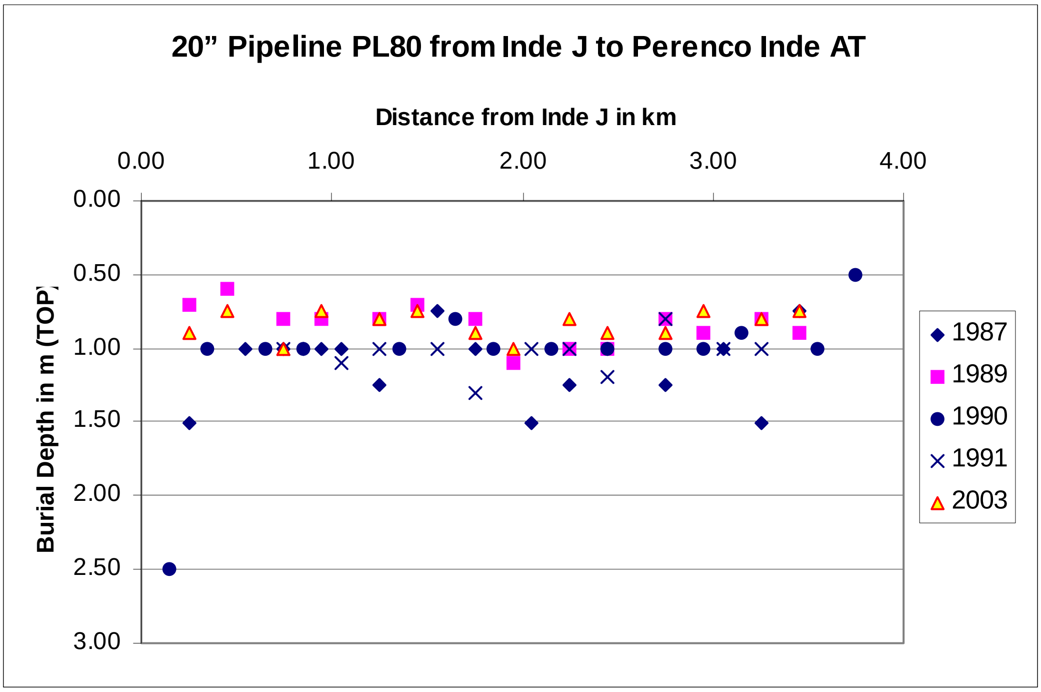


Figure 8.4.1: 20” Pipeline PL80 Inde J to Perenco Inde AT

Survey results of the year 2004 have not been included in the graph as it was a continuous trace rather than spotdepths, but are shown in Appendix E. It confirms no spans and no exposures were identified and indicated pipeline burial to at least 0.75m.

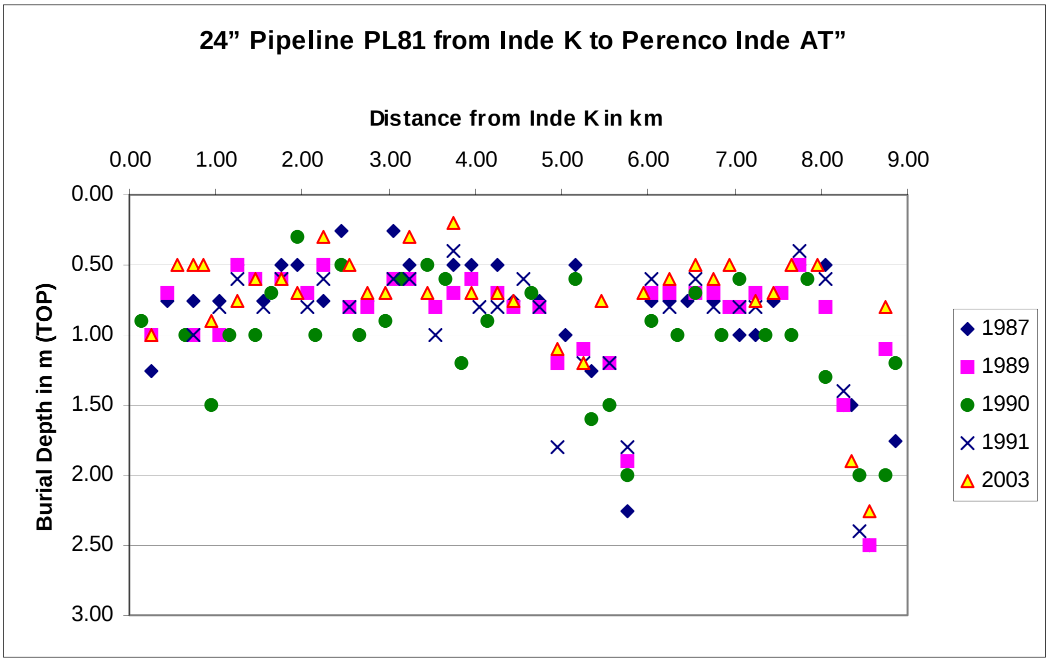


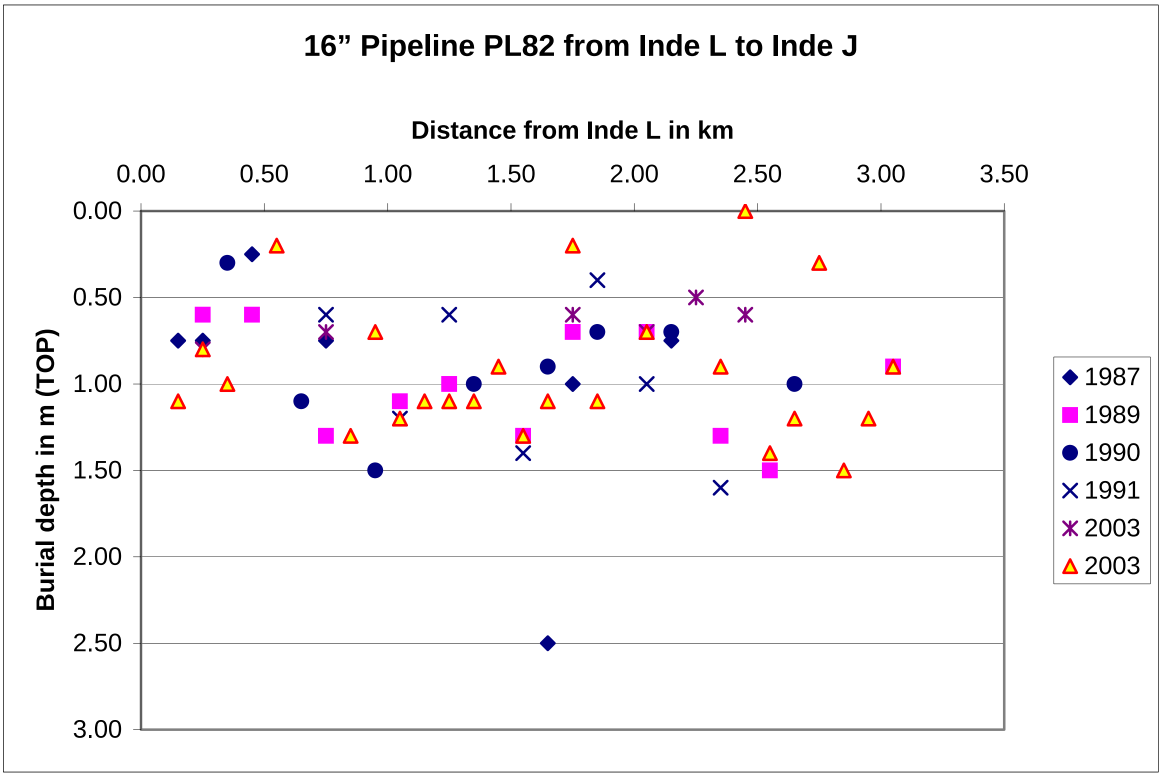
Figure 8.4.2: 24" Pipeline PL81 from Inde K to Perenco Inde AT

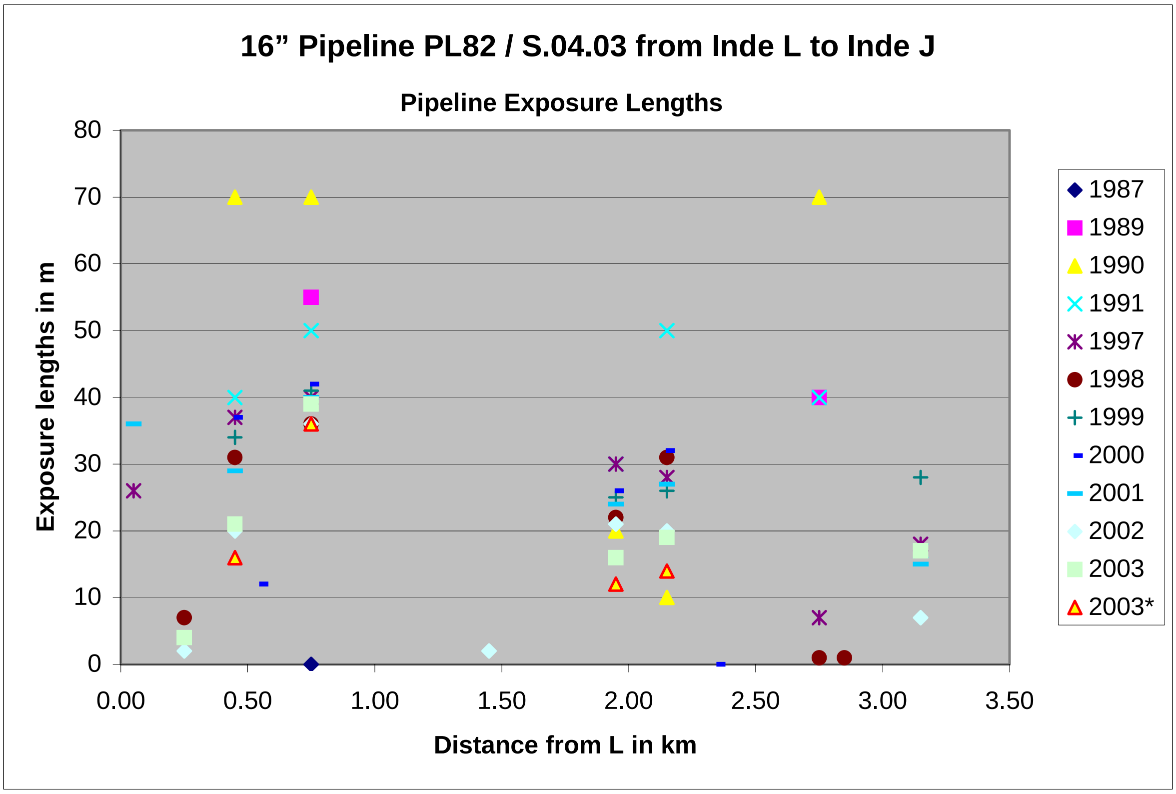
Depth of burial survey data for PL81 for the period up to 2003 has been plotted in graph above. Burial depth varies in time. This line is orientated such that the effect of ripples, typically 0.2m height, caused by sand transport have a more noticeable effect but the line remains substantially buried over the 17 years of records.

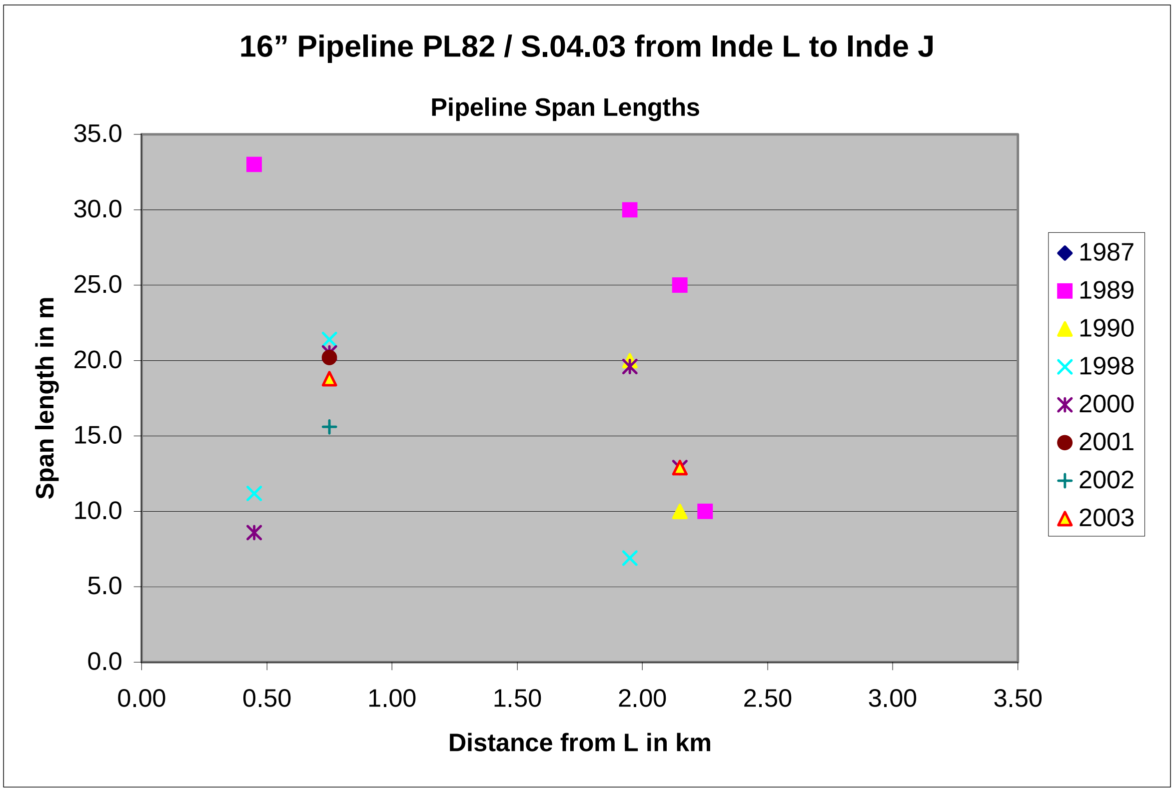
The pipeline showed a limited number of exposures during these surveys, a maximum of 4 but typically 3 varying in 2003 from 2-25m in length but never greater than 30m. The 2004 survey confirms this continuing trend of limited number and size of exposures.

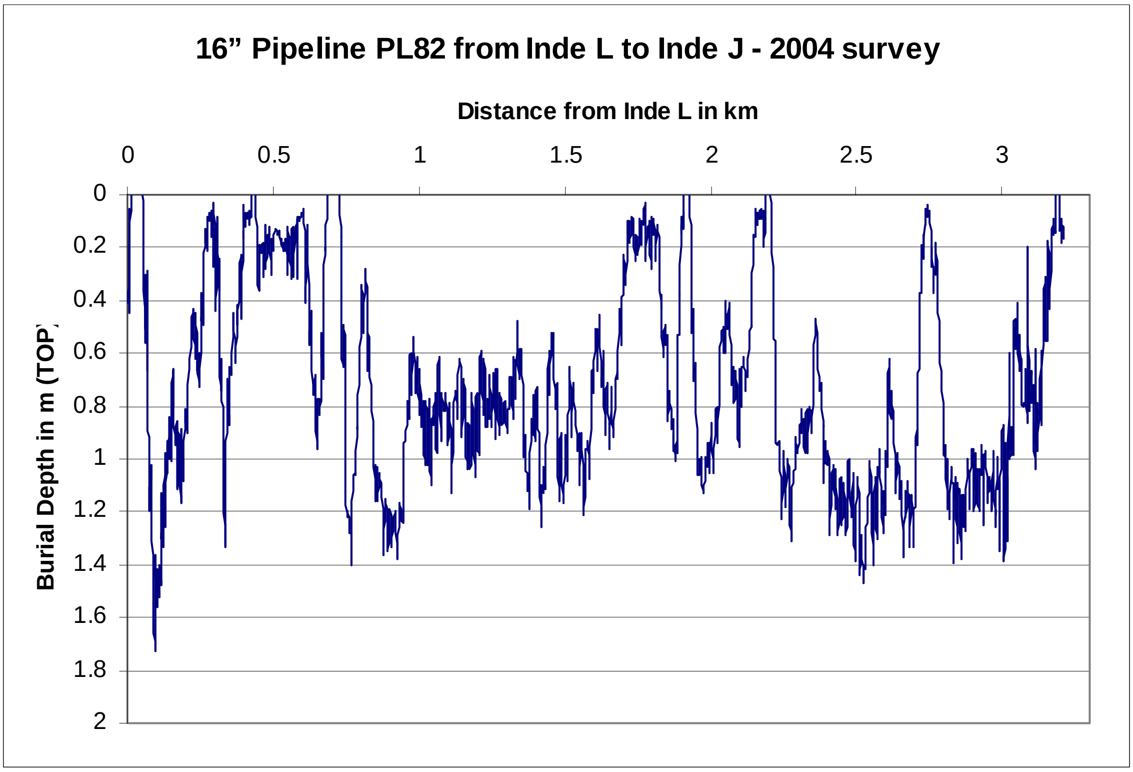
Depth of burial survey data for PL82 for the period up to 2003 has been plotted in graph below. Burial depth shows more variation in time than other lines but it remains substantially buried along its length at typical depths of 0.5m. There is more evidence of exposures and spans for this line and these have been looked at in more detail in figure b and c, This line crosses PL81 at around 0.7 km mark which accounts for the first exposure and there is further evidence of some stable exposures around the 2 km mark. Exposure lengths originally up to 70m have generally decreased with time with maximum around 40m in 2003.

Thus exposure or spanning does not appear to have worsened over this time with the latest 2004 (figure d) survey reporting a total exposure of 146m (4.5%) and a single 30m span at the cross over with an under line gap of 0.34m.


16” Pipeline PL82 from Inde L to Inde J
Distance from Inde L in km
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
Burial depth in m (TOP)
0.00
0.50
1.00
1.50
2.00
2.50
3.00
1987
1989
1990
1991
2003
2003


16” Pipeline PL82 / S.04.03 from Inde L to Inde J
Pipeline Exposure Lengths
Exposure lengths in m
80
70
60
50
40
30
20
10
0
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
Distance from L in km
1987
1989
1990
1991
1997
1998
1999
2000
2001
2002
2003
2003*





Figures 8.4.3a/b/c/d : 16" Pipeline PL82 from Inde L to Inde J

Depth of burial survey data for PL302 has been plotted in graph below and demonstrates a burial depth typically well below 0.6 m, the later 2004 survey (App E) also confirms this trend.

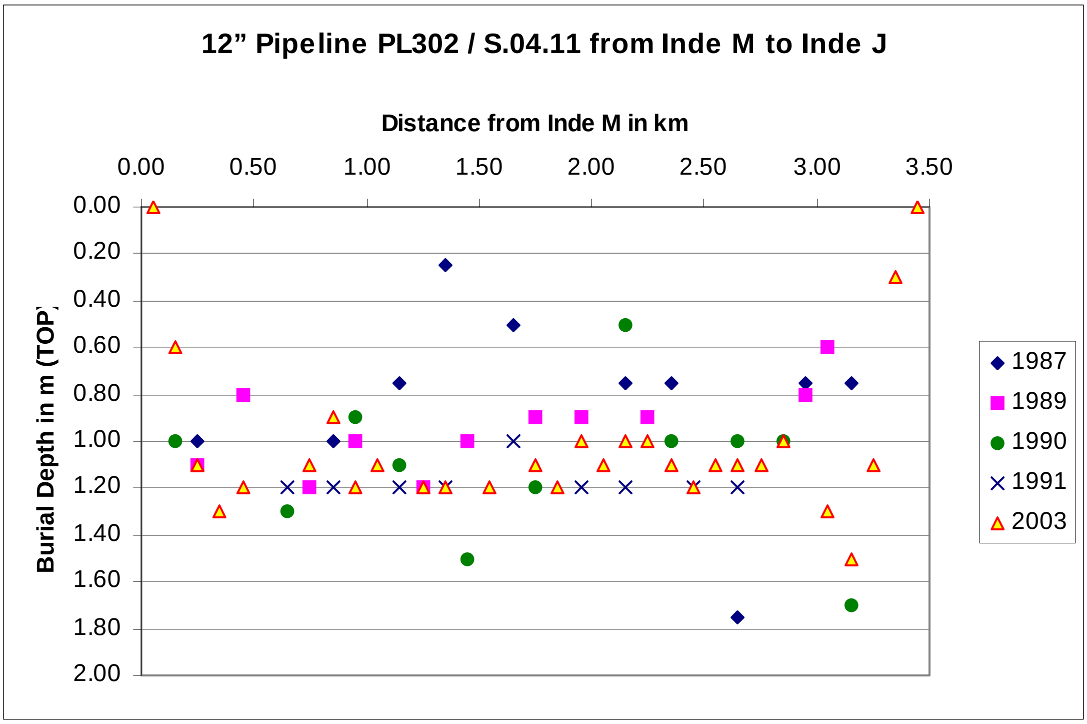


Figure 8.4.4: 12" Pipeline PL302 from Inde M to Inde J

Depth of burial survey data for PL402 up to 2003 has been plotted in graph below and although less historical data points shows a stable line well below 0.6m. This burial depth stability is also confirmed by the 2004 survey (Appendix E)

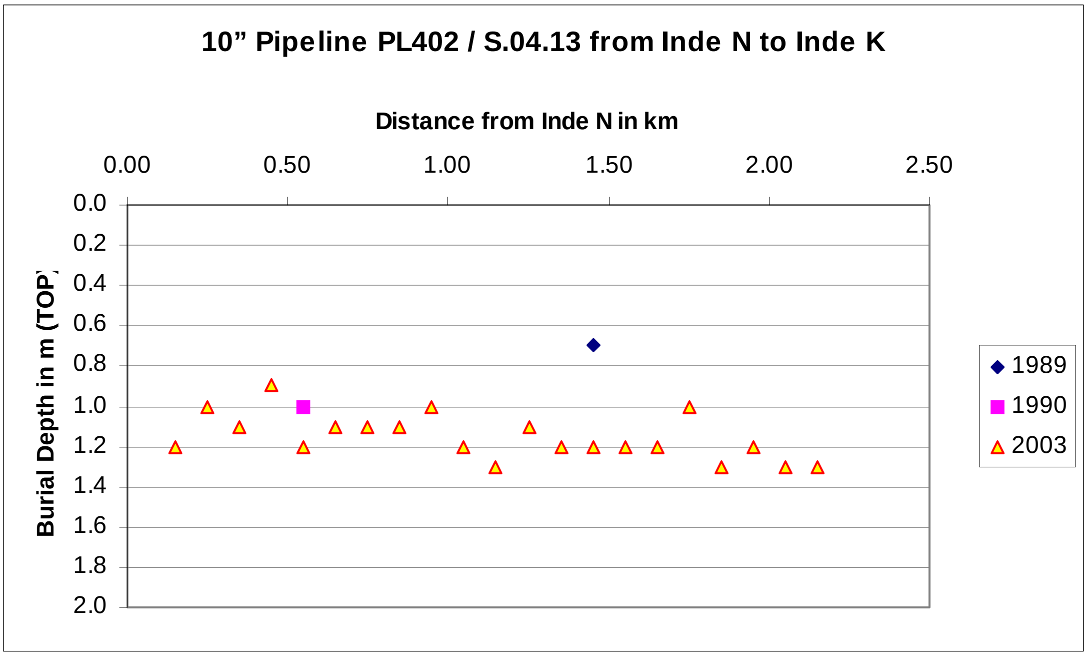


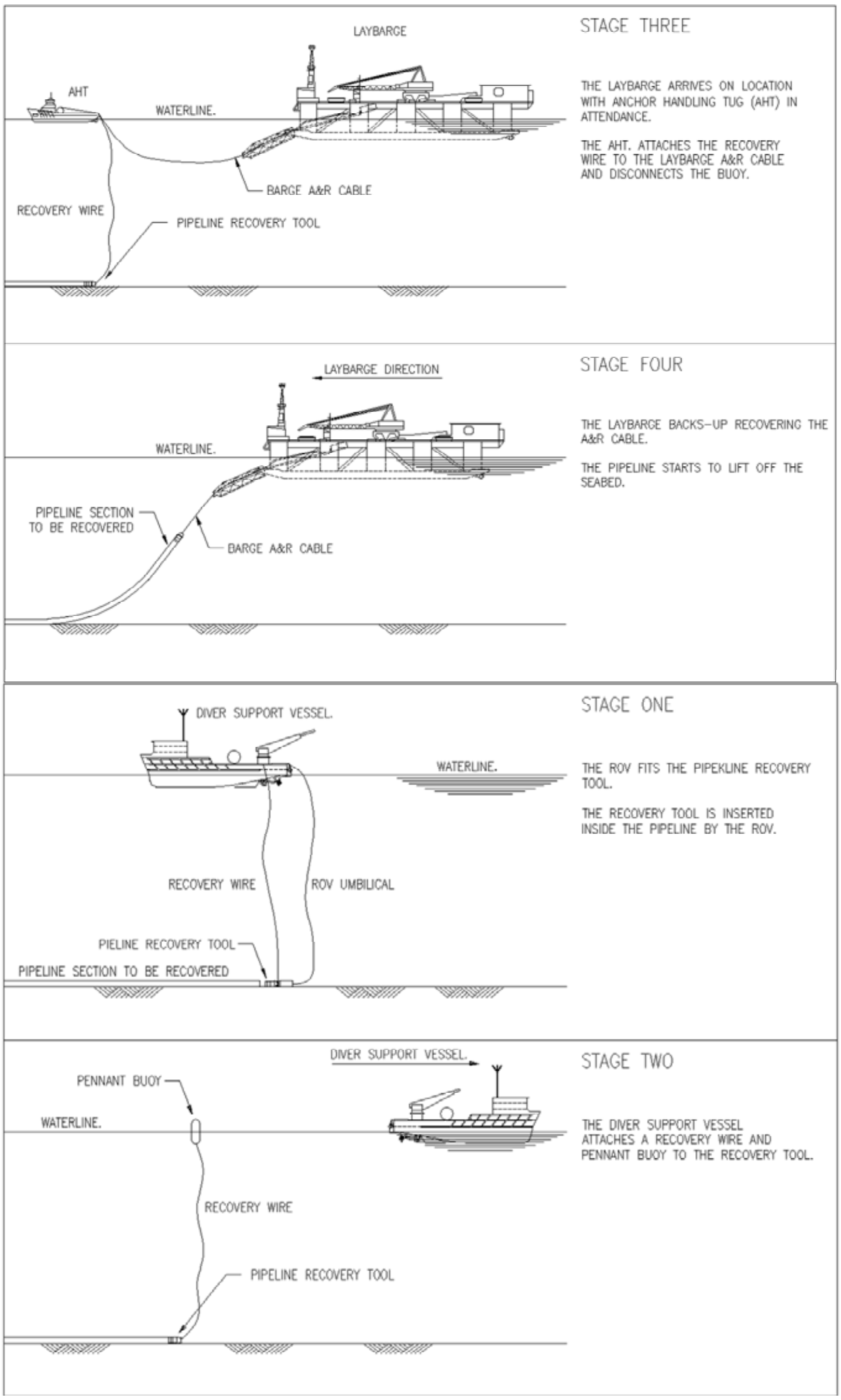
Figure 8.4.5: 10" Pipeline PL402 from Inde N to Inde K

8.4.1.2 Remove pipelines by reverse S-lay for on-shore disposal

This pipeline decommissioning method removes the pipelines by a reversal of the method used to lay the line. It involves pulling the pipe back up the stinger on the lay-barge and cutting it into suitable lengths to enable it to be shipped to shore on a cargo barge.

Because of the large diameter and unknown condition of the pipe and coatings on the PL80, PL81 and PL82 pipelines it would be prudent to 'un-bury' these lines prior to recovery by this method. The 'un-burial' will significantly reduce the tension required to recover the lines.

The sequence of initiating the pipeline recovery is shown in Figure 8.4.1 below.



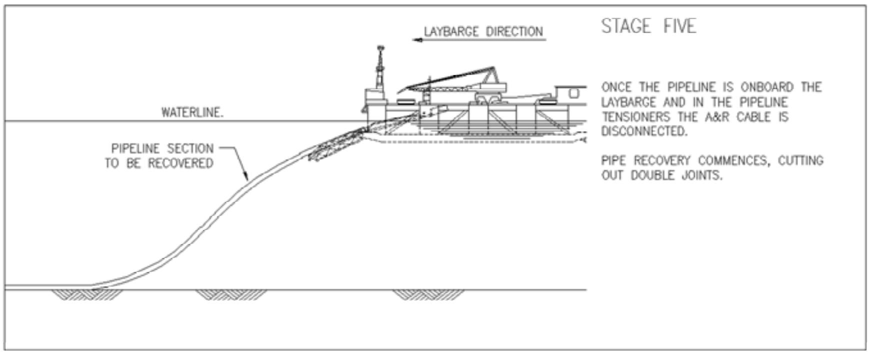


Figure 8.4.1 – Pipeline Removal y Reverse S-Lay

8.4.1.3 Remove pipelines by subsea cut and lift for on-shore disposal

This method entails the decommissioning of the pipelines by exposing the lines, cutting them into short lengths on the seabed, lifting them above water and transporting them to shore for disposal.

In order to cut and lift the pipelines it would be necessary to un-bury them along their entire length. This could be done by either jetting the soil away from the pipes or by ploughing a trench along the pipes. Because of the relatively loose sand on the seabed the jetting method is more suitable.

The pipeline cutting and removal would be undertaken with a diving support vessel. The majority of the pipe cutting and rigging work would be undertaken by purpose adapted ROV however a crew of divers would be onboard the vessel to undertake specific tasks and in particular intervention for unplanned events.

For practicality it would be probable that the trenching, cutting and lifting operations are supported by the same DSV.

The cutting and lifting sequence of events is shown diagrammatically in Figure 8.4.2 below.

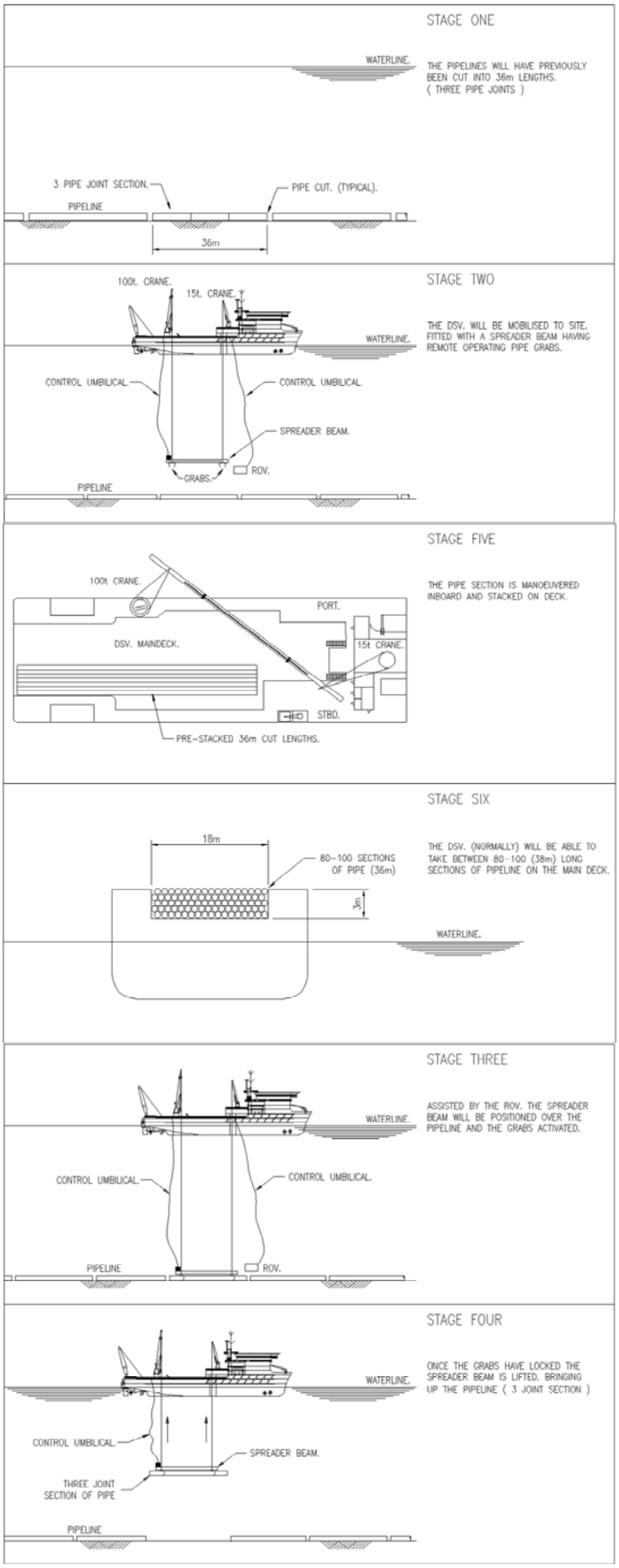


Figure 8.4.2 – Pipeline Removal in Sections

8.4.2 Comparative Assessment of Pipeline Decommissioning Options

8.4.2.1 Technical risk and complexity

The activities required for decommissioning *in-situ* and the required remedial operations are considered routine operations and do not have significant technical risk. Removing new pipelines by reverse S-lay is within the technical capability of existing purpose-built pipelay vessels. Diving preparatory work will be required to install the pulling head for the pipelay vessel to pick the pipeline up at one end and to install an anchor pile at the other pipeline end. The removal operation would be increasingly more complex if the burial depth is significant and if the integrity of the pipe or the coating is poor. This removal method is therefore considered to be technically risky for the Indefatigable pipelines as they are expected to have experienced some deterioration having passed their design lives by the time of decommissioning.

The cut and lift removal method requires the pipeline to be unburied and an automated and repetitive subsea pipeline cutting technique to be developed. Uncovering can be achieved by the conventional remotely operated methods of using either a pipeline plough or an ROV-operated mass flow equipment. The cutting techniques would require development from those used for subsea conductor and jacket leg cuts. The cut lengths would have to be recovered to the surface efficiently using specially adapted lifting bars. There would be uncertainty regarding the reliability of these specially designed equipment. In addition, the Indefatigable field has a significant subsea current speed and is subject to semi-diurnal tides which make prolonged subsea work unproductive. There is therefore a high potential for scope growth for this removal method due to the high subsea work content and the reliance on special equipment. This removal method thus has higher technical risk compared to the reverse S lay method. However, this method would be required if the integrity of the pipeline or its coating is such that it is unable to withstand being recovered by the reverse S lay method.

8.4.2.2 Safety

It can be seen from Table 8.4.1 below that leaving the pipelines in-situ carries effectively a negligible risk, and that the Reverse S-Lay and Cut & Lift options both carry a significant risk.

On average the onshore work for the Reverse S-Lay and Cut & Lift options contributes 9% of the risk and the offshore work contributes 91%. There is no onshore contribution for the In-Situ option.

Decommissioning Options / Inde Pipeline	Insitu	Reverse S-Lay	Cut & Lift
	Potential Loss of Life		
PL80,81&82 Offshore	1.90E-04	9.00E-03	1.06E-02
PL80,81&82 Onshore	0.00E+00	2.09E-03	5.17E-04
PL80,81&82 Total	**1.90E-04**	**1.11E-02**	**1.11E-02**
PL302 & 402 Offshore	1.90E-04	5.57E-03	4.78E-03
PL302 & 402 Onshore	0.00E+00	1.48E-04	1.48E-04
PL302 & 402 Total	**1.90E-04**	**5.72E-03**	**4.93E-03**
Total	**3.80E-04**	**1.68E-02**	**1.60E-02**

Table 8.4.1: PLL for Pipeline Decommissioning Options

Personnel safety risk is relatively high for the removal options compared to the decommission *in-situ* option due to the overall increased manhour exposure, especially those involving diving and manual handling.

8.4.2.3 Environmental & Societal Impact

Table 8.4.2 gives the results of the screening of all risks associated with the short-listed options for decommissioning the pipelines. All the options would result in 1 "positive" impact, the effect on fishing operations of ensuring that the line did not represent an obstruction on the seabed.

The "leave in-situ" option clearly has the fewest number of "not significant" impacts, because of the small amount of operational activity associated with this option. However, it would present 2 short term "significant" impacts as a result of the need for additional areas of rock dump at the cut ends of the pipes, but these are limited due to the stable burial status of the Indefatigable field pipelines. And in any case these significant impacts would be mitigated if the pipelines ends are trenched and are back-filled naturally. The environmental assessment indicates that the pipelines would disintegrate over a long period and so there is no long term impact.

The options "reverse S-lay" and "Cut-and-lift" presented about the same number of "not significant" impacts, most of which would arise as a result of "normal" offshore operations and vessel activities, and some local impacts at onshore receiving and recycling sites. In both these options, the single "significant" impact would arise as a result of the displacement of large amounts of (clean) seabed sediment into the water column by water-jetting, to uncover the pipes so that they could be retrieved. There is, however, no long-term liability for these options.

Decommissioning Option	**Numbers of impact**			
	Positive	**Not significant**	**Significant**	**Highly significant**
Leave in-situ	1	35	2	0
Remove by reverse S-lay	1	68	1	0
Remove by subsea cut and lift	1	72	1	0

Table 8.4.2 – Impacts associated with short-listed decommissioning options for the pipelines

The net energy use of the different options is shown in Table 8.4.3.
For context 1 household energy usage/ year is approx 80GJ

Decommissioning Option	**Pipelines**
Leave *in-situ*	119
Remove by reverse S-lay	113
Remove by subsea cut-and-lift	146

Table 8.4.3 – Total net energy use of each option for decommissioning the pipelines

Values are rounded, and in units of 1,000GJ.

The above assessment shows that the decommissioning options use approximately the same amount of energy. However this analysis assumes that the removal options result in full recycling, which means they do not then incur the "energy penalty" because recyclable material is left in the sea.

In reality the pipeline material is unlikely to be fully recycled, and thus the *in-situ* option is likely to have a much lower energy use.

No social impact, including impacts on fishing and fish spawning, is considered to be significant to differentiate between any of the preferred decommissioning options.

8.4.2.4 Costs

Due to the minimum activities and resources required, decommissioning *in-situ* is the lowest cost option, with an order of magnitude lower cost. There is, however, a long-term cost commitment for ongoing monitoring. The frequency of such monitoring should be based on a risk analysis.

The removal options are both very costly, either because of the need to mobilise a relatively large pipelay vessel, or due to the substantial subsea work involved.

Decommissioning Option	Relative Cost
Leave *in-situ*	1
Remove by reverse S-lay	17
Remove by subsea cut-and-lift	12

Table 8.4.4 –Relative cost of each option for decommissioning the pipelines

8.4.4 Summary of Selected Pipeline Decommissioning Option

From the foregoing comparative assessment, decommissioning the pipelines by leaving them *in-situ* in a flushed, water-filled and stably buried condition is the recommended option. The environmental and energy consumption impacts of this option are mitigated by the limited remediation work required to make them safe from being a snagging risk due to their substantially buried and stable status (at least 94% buried in the 2004 survey).

No lines have spans reportable under the 'FishSafe' notification system where spans greater than 10m with 0.8m gaps are logged. Although coverage of the lines varies in a few locations the great majority meets the recommended 0.6m cover, even in the less well covered areas, burial depth is below 0.2m and unlikely to cause a significant risk to fishing activities considering the long term burial history available.

The trenched pipelines are naturally back-filled. Filling the pipelines with seawater will increase the lines weight/buoyancy ratio by a factor of between 1.4 and 1.8 further improving their buried stability.

Remedial work will be carried out at pipeline ends and crossings to mitigate any risk to other sea users. The final selection of these measures will be subject of detailed design and further engagement with stakeholders.

These lines will continue to be monitored as indicated in section 15.

The removal options are not preferred as the pipelines are unlikely to be fully recycled or re-used elsewhere and therefore would be sent to land-fill sites only to be re-buried on land. In addition, the removal options incur greater exposures to personnel safety, are technically higher risk, and much higher cost due to the pipelines being mostly buried.

Component	Selected Decommissioning Option
Pipelines	Leave in-situ, flood and remedy exposed ends, crossings and significant spans

Table 8.4.5 – Summary of Selected Pipeline Decommissioning Option

8.5 Comparative Assessment and Selection of Preferred Option for Hose Bundles

8.5.1 Description of Hose Bundle Decommissioning Options

The feasible decommissioning options for hose bundles are decommission *in-situ* or remove to shore for disposal in landfill.

8.5.1.1 Decommission *in-situ*

Decommissioning hose bundles *in-situ* require their ends to be cut from the platforms at the base of the risers and made safe from being a potential snagging hazard for other uses of the sea once the platforms are removed. Any exposed sections or spans along their lengths that may pose a snagging hazard would also have to be similarly remedied. Such remedy can be achieved by:

- Dumping rock over the exposed sections;
- Covering the exposed sections with concrete mattresses;
- Re-trenching and burying;
- Cutting out the offending sections for recovery to shore for disposal and remedying the cut ends as above.

As the hose bundles would be flushed clean of contaminants at this stage, the ends can be left open to the sea.

Appendix E gives details of the burial history of the two Inde hose bundles. From the latest 2004 survey data the hose bundle burial status is:

Pipeline	% age Buried	Exposure Details
PL303	96%	Only exposed at platform ends
PL479-487	99%	Only exposed at platform ends

Table 8.4.6– Summary of Hose Bundle Burial Status

Compared with steel pipelines, the burial status of hose bundles are generally more difficult to detect and assess due to its make-up of synthetic materials. Based on available records, hose bundle PL303 has a history of remaining buried to at least 0.3m depth. The burial depth is currently 0.4m with some variation of burial depth over time (first increasing then reducing). There is no history of this hose bundle becoming exposed apart from 50m and 80m at the two platform ends. It was 96% buried in the 2004 survey.

Hose bundle PL479-487 is buried to at least 0.2m depth apart from the first 200m from November platform. There is no history of this umbilical becoming exposed apart from 20m at the platform end. It was 99% buried with an average burial depth of about 0.5m in 2004. As the two earlier burial depth records were based on very limited field measurements (thus the apparent consistent depths shown in the chart), there is insufficient data to make meaningful statements about the change of burial depth over time.

8.5.1.2 Remove hose bundles by lift and reel/cut for on-shore disposal

This work would be undertaken by a vessel, such as a supply boat, fitted out with a powered cable reel, a cable tensioner (linear winch or capstan), a small crane and an ROV. The method of recovery is simply to pick up the end of the line and feed it through a tensioner or capstan and feed it on to the recovery reel. The tensioner then continues to pull the line out of the soil and feed it onto the reel while the vessel moves along the route. When the end of the line is reached the operation is complete.

The hose bundle can either be reeled or cut into pieces once on board the vessel. The hose bundle will then be transported to shore for re-use or disposal.

A typical vessel deck layout and recovery arrangement are shown in Figures 8.5.1 and 8.5.2 below.

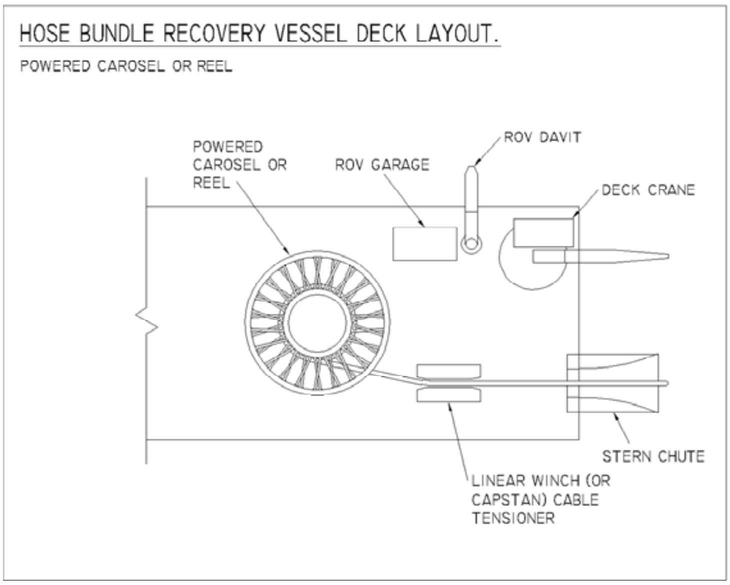


Figure 8.5.1 – Typical Vessel Deck Layout

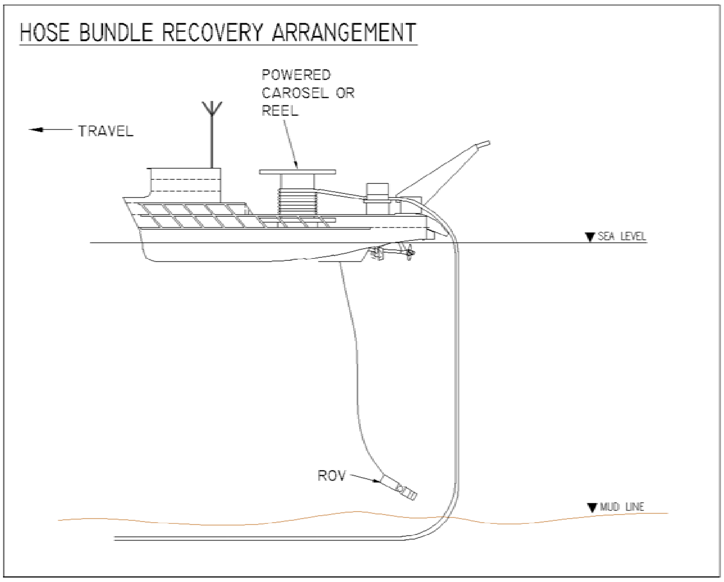


Figure 8.5.2 – Hose Bundle Recovery Arrangement

8.5.2 Comparative Assessment of Hose Bundle Decommissioning Options

8.5.2.1 Technical risk and complexity

The activities required for decommissioning *in-situ* are considered routine operations and do not have significant technical risk.

For the re-reel option the technical risks are slightly higher. The force required to pull the hose bundles out of the seabed is not expected to be excessive but a stand-by jetting spread for uncovering the line and limiting the pulling force would be prudent. There is a risk that divers may be required if the hose bundle breaks and it has to be found and reconnected. However this option is also considered routine.

8.5.2.2 Safety

Table 8.5.1 below shows that the two options both carry a relatively small risk, though the recovery option carries a slightly higher risk.

It is assumed that the hose bundles will be sent to landfill if recovered, and will therefore incur no onshore demolition risk.

Inde Hose Bundle \ Decommissioning Options	In situ	Recovery
	Potential Loss of Life	
PL303 & PL479-487 Offshore	1.90E-04	2.72E-04
PL303 & PL479-487 Onshore	0.00E+00	0.00E+00
Total	1.90E-04	2.72E-04

Table 8.5.1: PLL for Hose Bundle Decommissioning Options

8.5.2.3 Environmental & Societal Impact

Table 8.5.2 gives the results of the screening of all risks associated with the short-listed options for decommissioning the hose bundles. Both options would result in 1 "positive" impact, the effect on fishing operations of ensuring that the bundles did not represent an obstruction on the seabed.

The "leave in-situ" option clearly has the fewest number of "not significant" impacts, because of the small amount of operational activity associated with this option. However, it would present 2 "significant" impacts as result of the need for additional areas of rock dump at the cut ends of the pipes. However, these significant impacts would be mitigated if the hose bundles ends are trenched and are back-filled naturally.

The option "remove by reeling" presented a larger number of "not significant" impacts, most of which would arise as a result of "normal" offshore operations and vessel activities, and some local impacts at onshore receiving and recycling sites. In this option, the single "significant" impact would arise as a result of the displacement of large amounts of (clean) seabed sediment into the water column by water-jetting, in the event that this is used to uncover the pipes so that they could be retrieved. However, jetting may not be required for the Indefatigable hose bundles due to the sandy nature of the back-fill.

Decommissioning Option	Numbers of impact

	Positive	Not significant	Significant	Highly significant
Leave *in-situ*	1	35	2	0
Remove by reeling	1	64	1	0

Table 8.5.2 – Impacts associated with short-listed decommissioning options for the hose bundles

The net energy use of the different options is shown in Table 8.5.3

Decommissioning Option	Hose bundles
Leave *in-situ*	3
Remove by reeling	2

Table 8.5.3 – Total net energy use of each option for decommissioning the pipelines and hose bundles

Values are rounded, and in units of 1,000GJ. For context 1 household energy usage/ year is approx 80GJ

The above assessment shows that the estimated energy use of both options is quite small, reflecting the small amounts of material involved and the relative ease with which they could be retrieved by reeling. The option "remove by reeling" would use 66% of the energy of the option "leave *in situ*". This difference may appear to be significant in the context of the present estimations of total net energy use, but it is suggested that it should be viewed with caution, and not given undue prominence in the overall decision-making process, since the absolute values are relatively small and the actual energy use of the options could be subject to significant change depending on the specific programme that would be enacted to execute either option.

No social impact, including impacts on fishing and fish spawning, is considered to be significant to differentiate between any of the preferred decommissioning options.

8.5.2.4 Costs

The cost difference between the options is not material – the lower initial cost of the *in-situ* option being partially offset by the long-term liability.

Decommissioning Option	Relative Cost
Leave *in-situ*	1
Remove by reeling	2

Table 8.5.4 – Relative cost of each option for decommissioning the hose bundles

8.5.3 Summary of Selected Hose Bundle Decommissioning Options

The comparative assessment indicates little material difference between the options in terms of technical risk, environmental impact, energy usage and cost. Considering that it may be relatively more difficult to assure that the hose bundles can be flushed to the same level of cleanliness as the pipelines, and that the synthetic materials will not break down in time, there is a preference to fully recover them to shore for disposal to avoid long-term liabilities.

Component	Selected Decommissioning Option
Hose Bundles	Remove to shore for disposal by pulling onto vessel deck

Table 8.5.5 – Summary of Selected Hose Bundle Decommissioning Options

8.6 Disposal of Decommissioned Material

Disposal preference is governed by the Waste Hierarchy which states that re-use is preferred to recycle and recycle preferred to scrap as described in Section 6. Although there is no known re-use opportunity for any of the Indefatigable facilities, it is not discounted and will be pursued with the on-shore disposal contractor within a time frame that is yet to be specified. All hazardous materials will be appropriately handled and disposed of in accordance with the relevant legislations. The bulk of the recovered platform material is expected to be recycled, with possibly some residues that are difficult to separate out scrapped and sent to approved landfill sites.

Once removed from the field the topsides, jackets, pipelines and hose bundles will be transported to an onshore decommissioning facility. This facility will be licensed for the decommissioning activities including the handling and disposal of any hazardous materials that may be present. As such the facility will have appropriate quarantine.

The hierarchy of how the platform and pipeline components are disposed of is as follows:

- Refurbishment for re-use as unit
- Removal of equipment for reuse
- Segregation of pipes for reuse (recovered end sections and hose bundles)
- Segregation of steelwork and other materials for re-use
- Segregation of materials for re-cycling
- Segregation of materials (including hazardous materials) for disposal

Platform components, pipelines, etc. arriving at the quayside of the disposal facility on cargo barges or vessel decks will be offloaded by appropriate means. This may be by crane however larger deck sections are more likely to be offloaded using multi wheeled bogies.

Once on the quayside any components with marine fouling will be cleaned off and the fouling material is either reused as feed stock material for the cement industry or disposed of and sent to approved landfill sites.

Any large component scheduled for re-use or possible re-use will be stored in a designated area of the facility for refurbishment or preservation until its future is determined.

Other components that are not viable for re-use as a single unit will be stripped out and any equipment and/or materials suitable for re-use piece small will be stored and preserved in suitable warehouses or designated storage areas.

Any recovered concrete coated pipeline sections will have their anodes removed and collected for recycling. Where it is deemed practical the concrete coating on the pipelines will be stripped off and collected for use as hardcore leaving the steel pipes in a condition suitable for re-cycling in smelters.

Other materials will be collected by type and stored in separate areas for transhipment to smelters or other recycling facilities.

Materials not suitable for any of the above treatment (including hazardous materials such as asbestos, LSA contaminated materials, heavy metals and the like) will be collected and transported off site for disposal in landfill and/or other approved disposal facilities.
All wastes will be dealt with in accordance with the appropriate legislation, including the implications of Transfrontier Shipment of Waste Regulations should facilities be landed at a non UK North Sea site.

9 WELL DECOMMISSIONING

9.1 Description

There are a total of twenty six platform based gas producing wells in the Indefatigable field. The first well was drilled in 1967 prior to platform installation and the last drilling activity in the field was in 1992.

9.2 Drill Cuttings

A 1986 seabed survey completed after the majority of wells had been drilled indicated that there were no harmful impacts on the local biota. From regular ROV seabed surveys carried out since at all the Indefatigable platforms, it has been determined that no visible drill cuttings exist at any of the platforms (refer Appendix C6). The lack of any drill cuttings is due to the seabed currents that exist at the platform locations combined with the fact that no drilling activities have been undertaken at any of the platforms since 1992. The 2006 survey of soil samples around Indefatigable Juliet location has been completed to further support this conclusion. The Indefatigable Juliet platform location was chosen as a representative location for a baseline soil survey, as the seabed around this platform is typical for all the Indefatigable platform locations.

9.3 Well Decommissioning Plan

The platforms in the Indefatigable field have ceased production from July 2005. A programme of well decommissioning has commenced in 2006. This will involve flushing and cleaning the wells before setting permanent plugs at appropriate depths according to the specific features of the reservoirs, in order to abandon the wells. The fluids generated from the flushing will be contained and disposed of in compliance with applicable legislations.

The number and type of plugs will be designed in accordance with Shell Technical Standard, TS12 – "EPE Wells - Well Abandonment", which is in line with UKOOA Guidelines for the Suspension and Decommissioning of Wells.

Individual close-out reports will be prepared for each well and these will be submitted to and stored in the U.K. National Hydrocarbon Data Archive.

Well No.	DTI Ref.	UTM Coordinates		Function	Spud Date	Completion Date	Last Rig Entry
J1000	49/24-J	5912024.23N	675320.65E	Gas Producer	15.01.70	21.09.71	26.07.92
J1005	49/24-J5	5912025.85N	675323.24E	Gas Producer	11.07.70	16.12.71	16.12.71
J1010	49/24-J10	5912027.84N	675322.12E	Gas Producer	09.06.70	18.10.71	18.10.71
J1015	49/24-J15	5912026.36N	675319.47E	Gas Producer	19.02.70	20.09.72	20.09.72
J1020	49/24-J20	5912028.49N	675318.28E	Gas Producer	16.03.70	28.09.71	21.07.92
J1025	49/24-J25	5912029.84N	675321.02E	Gas Producer	21.08.70	02.11.71	02.11.71
J1030	49/24-J30	5912029.59N	675322.90E	Gas Producer	08.10.70	16.10.71	14.10.71

Table 9.1.1 – Summary Data of Juliet Platform Wells

Well No.	DTI Ref.	UTM Coordinates		Function	Spud Date	Completion Date	Last Rig Entry
K1100	49/24-1	5907026.98N	679492.90E	Gas Producer	04.11.67	27.01.68	14.01.73
K1110	49/24-K10	5907026.20N	679496.63E	Gas Producer	18.02.72	17.03.73	17.03.73
K1115	49/24-K15	5907028.27N	679495.66E	Gas Producer	10.09.88	16.10.88	16.10.88
K1120	49/24-K20	5907030.34N	679494.69E	Gas Producer	15.03.72	15.03.73	15.03.73
K1125	49/24-K25	5907029.05N	679491.93E	Gas Producer	02.01.72	18.03.73	18.03.73

Table 9.1.2 – Summary Data of Kilo Platform Wells

Well No.	DTI Ref.	UTM Coordinates		Function	Spud Date	Completion Date	Last Rig Entry
L1200	49/24-16	5908857.00N	674632.00E	Gas Producer	21.02.74	12.04.74	28.09.84
L1205	49/24-L5	5908857.00N	674632.00E	Gas Producer	24.06.84	24.08.84	07.08.87
L1210	49/24-L3	5908857.00N	674632.00E	Gas Producer	23.10.77	24.03.78	24.03.78
L1215	49/24-L2	5908852.85N	674619.80E	Gas Producer	09.09.77	08.03.78	16.09.84
L1220	49/24-L4	5908857.00N	674632.00E	Gas Producer	03.05.84	26.08.84	02.07.92
L1225	49/24-L1	5908857.00N	674632.00E	Gas Producer	10.08.77	17.03.78	17.03.78

Table 9.1.3 – Summary Data of Lima Platform Wells

Well No.	DTI Ref.	UTM Coordinates		Function	Spud Date	Completion Date	Last Rig Entry
M01	49/24-M3	5914933.85N	673559.92E	Gas Producer	30.03.86	18.07.86	18.07.86
M02	49/24-M1	5914933.70N	673557.42E	Gas Producer	20.04.85	21.08.85	21.08.85
M03	49/24-M4	5914936.35N	673559.78E	Gas Producer	17.05.86	06.07.86	15.08.86
M04	49/24-M2	5914936.20N	673557.28E	Gas Producer	17.06.85	17.08.85	17.08.85

Table 9.1.4 – Summary Data of Mike Platform Wells

Well No.	DTI Ref.	UTM Coordinates		Function	Spud Date	Completion Date	Last Rig Entry
N01	49/24-N1	5907997.10N	681478.40E	Gas Producer	28.01.87	02.04.87	02.04.87
N02	49/24-N2	5907996.00N	681480.60E	Gas Producer	01.03.87	06.04.87	06.04.87
N03	49/24-N3	5907994.90N	681477.30E	Gas Producer	19.06.88	04.09.88	04.09.88
N04S1	49/24-N4	5907993.80N	681479.60E	Gas Producer	06.11.90	06.11.90	06.11.90

Table 9.1.5 – Summary Data of November Platform Wells

10 ENVIRONMENTAL IMPACT ASSESSMENT

A detailed assessment of the environmental impact for the decommissioning of the Indefatigable field is given in the Environmental Impact of the Decommissioning Options Report that was prepared in support of these Decommissioning Programmes and is presented in Appendix C to this report. This section is a summary from the Environmental Impact report.

10.1 Introduction and method

The environmental risks associated with each of the preferred options for decommissioning the Indefatigable Field platforms and pipelines were assessed using a methodology based on the principles outlined in the Shell Corporate Guidance for Risk Assessment (Shell, 2000).

The assessment can be broken down into a number of steps: -

- Each of the short-listed options was reviewed to identify the potential causes of environmental risks in each of the activities involved in these options.
- The potential “receiving environment”, including natural and social aspects, was assessed in order to identify and characterise any sensitive elements.
- The risks identified and the relevant environmental sensitivities were brought together in order to describe and quantify the effects of each decommissioning option. The risks were quantified in accordance with pre-defined consequence and probability criteria. The assessment was based on experience and the knowledge of outcomes of similar events, published information or expert judgment. Any control or mitigation measures that may be in effect when the activity is carried out are also taken into account.
- An overall risk rating was assigned to each aspect of the decommissioning option under consideration using a two-dimensional Risk Assessment Matrix based on the principle that risk is a product of the two factors: ***probability*** and ***consequence***

10.2 Results of the environmental assessment

The environmental impact assessment provided a rigorous and quantitative method of: -

- Assessing the relative environmental “performance” of each option;
- Determining if any of the options offered a significantly “better” or “worse” environmental performance than others, and
- Evaluating if any apparent differences in environmental “performance” were real and significant.

10.2.1 Overview of results

All of the preferred decommissioning options have the potential to cause environmental impact, both as a result of planned activities and as a result of possible emergency or accidental events.

None of the options was assessed to have any risks in the ‘highly significant’ category, i.e. risks that would be intolerable and would represent a major constraint for the option. All of the options had a small number of risks that were rated as ‘significant’ (i.e. the project should seek to incorporate further risk-reduction measures and/or demonstrate that the risk was ALARP). All of the options also had a large number of risks that were rated ‘not significant‘ (i.e. indicating that the risk was acceptable but should be managed to achieve continuous improvement).

Many of the risks identified would arise as a result of activities and operations that are commonly performed offshore in the UKCS. These activities and their consequences are well understood, and may be subject to a range of potential mitigation measures depending on regulatory requirements and project- and site-specific circumstances. Other risks arise from accidental events and, again, there is a range of mitigation measures that is applied subject to regulatory requirements and the project-specific level of risk.

10.2.2 Impacts from decommissioning topsides

Table 10.2.2 gives the results of the screening of all risks associated with the short-listed options for decommissioning the topsides. All of the options exhibited about the same number of "not significant" and "significant" impacts. In all options, 4 of the "significant" impacts would arise as a result of a large accidental spill of fuel oil to sea, following a vessel collision. In the piece-small option, a further impact might arise as a result of the exposure of personnel offshore to excessive dust and fumes during the extensive dismantling and cutting operations within the confines of the topsides.

Removal Option	Numbers of impact			
	Positive	Not significant	Significant	Highly significant
Installation reversal with HLV	0	75	4	0
Single lift with SSCV	0	75	4	0
Novel technology (*Versatruss*)	0	75	4	0
Novel technology (submersible barges)	0	75	4	0
Piece-small removal	0	74	5	0

Table 10.2.2 – Impacts associated with short-listed removal options for the Topsides

10.2.3 Impacts from decommissioning options for jackets

Table 10.2.3 gives the results of the screening of all risks associated with the short-listed options for decommissioning the jacket. Both options exhibited about the same number of "positive", "not significant" and "significant" impacts. The single positive impact was the effect on fishing operations of removing an obstruction (the jacket) from the seabed. In each case the 4 "significant" impacts would arise as a result of a large accidental spill of fuel oil to sea, following a vessel collision. Additional "not significant" impacts were found in the buoyancy option, as a result of lifting the floating jacket onto a barge at an inshore site. It is not considered that use of explosives subsea will be required.

Removal Option	Numbers of impact			
	Positive	Not significant	Significant	Highly significant
Installation reversal with HLV	1	96	4	0
Novel technology (buoyancy)	1	98	4	0

Table 10.2.3 – Impacts associated with short-listed removal options for the Jackets

10.2.4 Impacts from decommissioning options for the pipelines

Table 10.2.4 gives the results of the screening of all risks associated with the preferred option of *in-situ* decommissioning the pipelines. It has 1 "positive" impact, the effect on fishing operations of ensuring that the line did not represent an obstruction on the seabed. The option also has 35 "not significant" impacts, because of the small amount of operational activity associated with this option. However, it would present 2 "significant" impacts as a result of the need for additional areas of rock dump at the cut ends of the pipes, but these significant impacts would be mitigated if the pipelines are trenched and are back-filled naturally.

Decommissioning Option	Numbers of impact			
	Positive	Not significant	Significant	Highly significant
Leave in-situ	1	35	2	0

Table 10.2.4 – Impacts associated with *in-situ* decommissioning of the pipelines

10.2.5 Impacts from decommissioning options for the hose bundles

Table 10.2.5 gives the results of the screening of all risks associated with the preferred decommissioning option of "recovery by re-reeling" the hose bundles. This option results in 1 "positive" impact, the effect on fishing operations of ensuring that the bundles did not represent an obstruction on the seabed. It also has 64 "not significant" impacts, most of which would arise as a result of "normal" offshore operations and vessel activities, and some local impacts at onshore receiving and recycling sites.

In addition, it does present 1 "significant" impact, which would arise as a result of the displacement of large amounts of (clean) seabed sediment into the water column by water-jetting, in the event that this is used to uncover the pipes so that they could be retrieved. However, jetting may not be required for the Indefatigable hose bundles due to the sandy nature of the back-fill.

Decommissioning Option	Numbers of impact			
	Positive	Not significant	Significant	Highly significant
Remove by reeling	1	64	1	0

Table 10.2.5 – Impacts associated with "Re-reeling" the hose bundles

10.3 Energy and Gaseous Emissions

All the decommissioning options will use energy, and give rise to gaseous emissions including CO_2, CO, NO_x, SO_x and VOC. With respect to decommissioning activities in the North Sea, experience to date has shown that the main sources of energy use and gaseous emissions are:

- the fuel consumed by vessels used offshore for dismantling and recovery operations;
- the manufacture of temporary steel structures on vessels and barges to hold or carry components; the recycling of material that is returned to shore; the energy that would be required to manufacture new material to replace recyclable material that is not retrieved but deliberately left in the sea.

The method used to quantify the energy usage accounts for all the energy used during offshore and onshore operations, including the energy needed to recycle recovered material, and also makes allowance for the replacement of otherwise recyclable material that is deliberately not recovered or brought back into the "chain of utility". The purpose of this assessment was to: -

- quantify the absolute net energy in each option, using a recognised method and values; and
- determine if there were significant differences in the net use of energy between options and identify the reasons for any such difference.

10.3.1 Results of energy usage study

Below are presented the results of the estimations of energy use and gaseous emissions of the different options. The total amounts of gaseous emissions are very closely linked to the total amounts of energy used, and so for the sake of clarity this discussion deals only with the estimated net energy use of each option.

10.3.1.1 Topsides

The net energy use of the different options for the topsides of the facilities is shown in Table 103.1.1

Removal Option	**Platform**				
	Juliet	**Kilo**	**Lima**	**Mike**	**November**
Installation reversal with HLV	117	94	50	37	36
Single lift with SSCV	136	105	N/A	N/A	N/A
Novel technology (*Versatruss*)	177	136	87	73	72
Novel technology (submersible barges)	212	132	93	78	77
Piece-small removal	257	205	111	61	64

Table 10.3.1.1 – Total net energy use of each option for removing the topsides

Values are rounded, and in units of 1,000GJ.
N/A = Option Not Applicable

For Juliet, the total energy use of different options ranges from 117,000GJ to 257,000GJ (in round numbers). "Reverse installation by HLV" is the least energy-intensive, and is less than half that of the most energy-intensive, "piece-small". The difference between "reverse installation by HLV" and "single lift" (about 19,000GJ, 16%) may not be significant. However, the difference between these two options and the other 3 options may be significant. As presently planned, the "piece small" option would be clearly the most energy-intensive option and this is largely as a result of the simultaneous use of two jack-ups during offshore dismantling.

This pattern of energy use is repeated for Kilo, Lima, Mike and November. For Kilo the difference between the "reverse installation" and the "single lift" options may not be significant, but the other 3 options are probably actually more energy-intensive. For Lima, Mike and November, the "reverse installation" option is clearly significantly less energy-intensive than the nearest other option; for Lima, "Versatruss" is 37,000GJ, 74% more energy-intensive; for Mike it is 36,000GJ, 97% more intensive; and for November "piece-small" is 28,000GJ, 78% more energy-intensive.

10.3.1.2 Jackets

The net energy use of the different options for the jackets of the facilities is shown in Table 10.3.1.2.

Removal Option	**Platform**				
	Juliet	**Kilo**	**Lima**	**Mike**	**November**
Installation reversal with HLV	84	51	35	35	32
Novel technology (buoyancy)	130	81	59	54	49

Table 10.3.1.2 – Total net energy use of each option for removing the jackets

Values are rounded, and in units of 1,000GJ.

For Juliet, the option "reverse installation by HLV" is less energy-intensive than that of "removal with buoyancy". The difference, about 46,000GJ (55%) is probably significant and real, and results from the need to construct new rigid buoyancy tanks, and engage in a longer tow, in the "removal by buoyancy" option.

This finding applies to the other platforms. In each case "reverse installation" is less energy-intensive than "removal with buoyancy", and the difference ranges from 53% to 69%.

10.3.1.3 Pipelines and hose bundles

The net energy use of the preferred options is shown in Table 10.3.1.3.

Decommissioning Option	Pipelines	Hose bundles
Leave *in-situ*	119	N/A
Remove by reeling	N/A	2

Table 10.3.1.3 – Total net energy use of the preferred options for decommissioning the pipelines and hose bundles

Values are rounded, and in units of 1,000GJ.
N/A = Option Not Applicable

For pipelines, the above assessment assumes that the "leave *in-situ*" option attracts an "energy penalty" since the pipelines left behind are not able to be re-cycled.

11 CONSULTATIONS

This section summarises the consultation process which has been conducted by the operator, Shell, with interested parties on the proposed activities for the decommissioning of the Indefatigable field facilities.

11.1 Communication Plan

The communication plan adopted by Shell for this project is designed to be flexible, to meet the needs of stakeholders and run in parallel with the technical option development process in accordance with the UKOOA guidance. The plan includes a public website (www.shell.co.uk/indedecom) and information circulars which are issued to interested groups and parties who have agreed to participate in the process. Dialogue sessions have been used to facilitate the dissemination of information on the project. A formal consultation process will be conducted with all statutory consultees at the appropriate phase of the development in accordance with the DTI Guidance Notes for Industry.

11.2 Stakeholders Dialogue Sessions

Stakeholders outside Shell and Esso were identified at the beginning of the project and they were sent letters notifying them of the imminent decommissioning of the Indefatigable field facilities in March 2005. A list of these consultees are given in Appendix G. An initial information dialogue session was held on 9th March 2005 to disseminate information on the decommissioning of the facilities. The responses made by the consultees at that session were taken into consideration in the comparative assessment of the decommissioning options. These responses can be grouped in the following categories:

- Assurance of a considered and orderly approach to decommissioning.
- Job and supply chain opportunities for the local communities.
- Release of information at appropriate time and continuing stakeholders engagement.

A follow up session was held in Norwich on 23 March 2006 to run through the project status and enable any issues to be raised. A record of the initial information dialogue session is maintained and follow-up dialogue sessions are planned at key milestones of the project to keep all interested parties informed and for Shell to keep abreast with any issues arising. The public website contains details of these sessions and also will be updated as the work progresses.

11.3 Consultation with Statutory Consultees and Public Notification

The statutory consultation were undertaken upon the completion of the draft Decommissioning Programmes to seek comments. Public notifications were also published on local and national newspapers to solicit representations regarding the programmes. There were no objections received to the proposals. Copies of responses are contained in Appendix G. All parties who have registered their interest during the earlier dialogue sessions will be informed of the public notice via e-mails.

12 COSTS

This section summarises the process to derive the overall cost estimates of the proposed activities for the decommissioning of the Indefatigable field facilities.

Each of the short-listed decommissioning options was progressed to an initial work execution plan and cost-estimate phase. The platform removals could be executed in a number of ways depending on the vessels available and the detailed programme offered by the selected contractor. The ultimate cost will be subject to a number of decisions to be made during the project development phases. Excluding the well decommissioning costs, the initial estimate of the total costs for the removal of the Indefatigable platforms (topsides and jackets) covering the activities identified below is approximately £ 61.3 million, being split as follows

		£M
Programme One –	Topside and Jacket removal (JD; JP; K; L; M and N):	51.1
Programme Two –	Interfield Pipelines/Hose bundles (PL82; PL302; PL402; PL303; PL479-487)	5.8
Programme Three –	Export Lines to 23AT platform (PL80; PL81)	4.4
Future Pipeline Survey costs (cost per field survey)		0.3

The work scope covered by this overall cost includes:

- Conceptual engineering studies and offshore surveys
- Engineering design for pipelines and topsides cleaning
- Procurement
- Pipelines cleaning
- Topsides cleaning and equipment isolation
- Offshore surveys
- Maintenance activities to ensure safe access
- Engineering design for removal
- Preparation for removal and disposal
- Offshore removal of facilities and hose bundles
- Remediation of pipeline ends and exposures
- Seabed debris clearance
- Transportation to shore
- Onshore dismantling and disposal
- Project management

Where possible, execution synergy opportunities with other ongoing work in the area are being pursued to help reduce the decommissioning costs. Cost-savings may be possible by combining offshore activities to create a campaign scenario leading to:

- Benefits of scale in contracts for the hire of vessels and the disposal of waste;
- Efficient use of accommodation vessels and barge time;
- A reduction in the relative costs for mobilisation and demobilisation;
- The greatest possible use of any temporary grillage, temporary steel, slings, or lifting aids that would have to be used; and
- A reduction in the design and project management cost for decommissioning in a combined campaign.

13 SCHEDULE

Well decommissioning on Inde Mike commenced in April 2006. A schedule has been developed which balances the following drivers:

- Avoid prolonged delay, which would extend safety exposure and incur operational costs;
- Allow contractors maximum flexibility over timing in order to optimise costs.

Current expectations are that well decommissioning activities will continue through 2006/7 before removal operations begin in 2008. It is the intent that schedule flexibility will be given to the removal contractor to allow operations to be carried out between 2008-11 to assist resource availability.

Final timing will depend on availability of equipment for decommissioning of the wells and marine vessel spread for removal of the platforms. The proposed schedule of activity is shown below. At this stage these are indicative timings and durations. The indicative programme provides relatively wide windows for offshore activities, which are not necessarily continuous, but indicate timely removal.

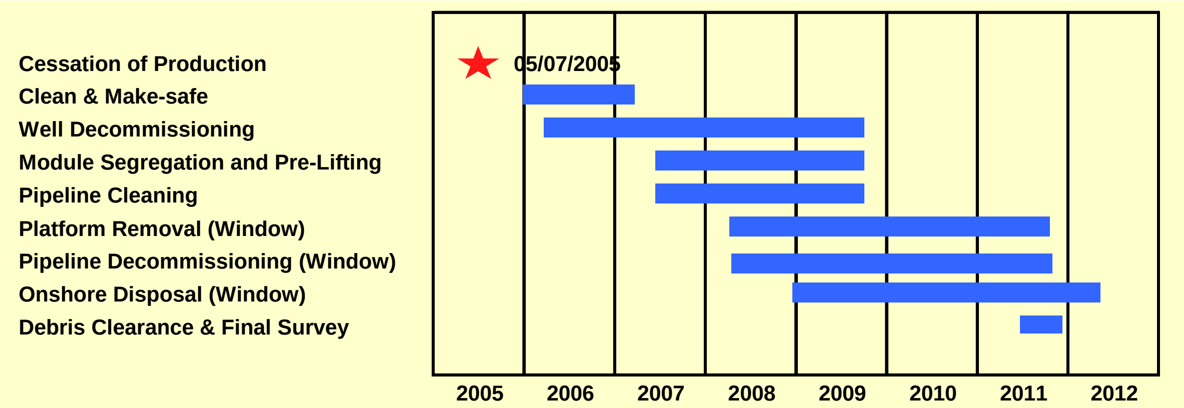


Figure 13.1 – Indefatigable Decommissioning Overall Project Plan

14 PERMITS AND CONSENTS

The proposed programmes for the decommissioning of the Indefatigable Field platforms, pipelines and hose bundles will fully comply with all applicable UK and international legislations covering activities offshore and onshore. The programmes are principally governed by the Petroleum Act 1998 and OSPAR 1992. The DTI Guidance notes provide a list of other relevant legislations.

A draft "Permits and Consents Register" prepared specifically for the Indefatigable Field decommissioning is presented on the following pages.

14.1 Permits and Consents Register - Platform, Wells and Seabed

Item No	Category	Title		Addressee	Reqd by	Responsibility		Progress to Date	Comments/ Actions Reqd
						Primary	Secondary		
Decommissioning Plan, Licences, Approvals, Consultations & Documentation									
1	B	Cessation of Production (COP) Approval.	Regulation	DTI				Achieved	Approval to CoP from 01/10/2004
2	B	Decommissioning Programme	Prepare & Submit	DTI					
3	H	Consultations with Various Statutory Consultees & Special Interest Groups		DTI					
4	F	Revised Oil Spill Contingency Plan	Revision	DTI					
5	B	Decommissioning of Helideck		BHAB					
6	H	Customs and Excise		UK & Norway					
Well decommissioning Programme									
7	C	Letter of intent to Plug & Abandon Wells		DTI/HSE					
8	B	Application for consent to Abandon Wells.		DTI - Well Consents					
9	D	Environmental Emissions Monitor System for Drilling/ Workover/ Cementing Chemicals		DTI					

Permits and Consents Register - Platform, Wells and Seabed (continuation)

Item No	Category	Title		Addressee	Reqd by	Responsibility		Progress to Date	Comments/ Actions Reqd
						Primary	Secondary		
10	B	Treatment of Drill Cuttings		DTI					
11	C	Notification to use Explosives		DTI/ HSE/ Coastguard/ UK Hydrographic Office + Various					Not anticipated but may be required as contingency option by removal contractors. If required JNCC guidelines will be followed.
12	B	Approval of Well decommissioning Programme		DTI/HSE					
13	C	Notification of Well decommissioning		DTI/ HSE					
14	B	Decommissioning Safety Case	Prepare & Submit	HSE					
	B		HSE Consultation	HSE					
15	B	Revisions to Operations Safety Case	Prepare & Submit	HSE					
16	G	Design Construction Regulation. Offshore Installations (Safety Case) Regulations.	Prepare M.O.V.E.S Document. Performance Standards and DWI's.	ICP					
17	F	Emergency Procedures Manual	Not formal submittal but may be required in support of safety case	HSE					

Permits and Consents Register - Platform, Wells and Seabed (continuation)

Waste Management and Environmental Discharge									
18	E	Platform Based Operations Waste Management Post COP	General Garbage						
	D		Hydrocarbon Contaminated Water	DTI					
	A		LSA Contaminated Water	EA/SEPA					
19		Field Decommissioning Activity Waste Management	Contaminated Water						
			Solids						
			LSA Contamination						
			Scrap						
24	A	Term Permit for the Use and Discharge of Chemicals During Decommissioning		DTI					
25	B	Survey of Sea-bed		DTI					
26	B	Clearance of Sea-bed Debris		DTI					
27	B	Discharge to the Environment of Fluids from Secondary Spaces During Decommissioning	Contaminated / Treated Water	DTI					
28	B	Disposal of Waste		Various					To be defined depending on location of dismantling site.

14.2 Permits and Consents Register - Pipeline and Hose Bundles

Item No	Category	Title		Addressee	Reqd by	Responsibility		Progress to Date	Comments/ Actions Reqd
						Primary	Secondary		
Pipelines and Hose Bundles									
1	B	PL80 20" J-AT PL81 24" K-AT PL82 16" L-J	Scheme detailed in Decommissioning Plan. PSR HSE notification	DTI/ HSE					
2	B	PL302 M-J PL402 N-K	Scheme detailed in Decommissioning Plan. PSR HSE notification	DTI/ HSE					
3	B	Hose Bundles PL303 M-J PL479-487 N-K	Scheme detailed in Decommissioning Plan. PSR HSE notification	DTI					
4	F	Pipelines Decommissioning Procedure manuals	Not formal submittal but may be requested	DTI/ HSE					

15 MONITORING AND MAINTENANCE

This section describes the planned monitoring and maintenance activities in the Indefatigable field for the offshore removal operations and after their completion.

15.1 Platforms

15.1.1 Interim safety management

It is possible that, due to the flexible execution schedule that will be offered to the decommissioning contractors, the offshore removal operations could be undertaken over a number of discrete operations. The topsides of certain platforms may be prepared for removal in one offshore campaign but the preparation and removal of other topsides may take place at a separate time. This is similar for the jackets. Limitations will be placed on the contract schedule to ensure that agreed completion dates are achieved within basic safety guidelines.

In the event of gaps in the decommissioning operations, appropriate interim measures as are deemed necessary, such as temporary navigational aids, will be put in place to ensure that there is safe access to the facilities, and that the facilities do not present a hazard to other users of the sea. A final decision on what safety measures will be used will be taken in discussion with the contractor taking into consideration the decommissioning methods and schedules.

15.1.2 Post-decommissioning survey and debris removal

A post decommissioning side scan sonar survey of the areas up to 500m around the platforms will be undertaken to identify any debris. Any unexplained anomalies will be visually surveyed, and any man made objects which could present a risk to other users of the sea, will be removed to shore for disposal. Evidence that the seabed is free of such obstructions, detailing the survey plots and recovery logs of items, will be provided to the DTI within four months of the completion of the decommissioning work as part of the project close out report.

15.2 Pipelines and hose bundles

15.2.1 Interim safety management

As for the platforms, the offshore operations relating to the pipelines and hose bundles could be undertaken over a number of discrete operations. Appropriate interim safety measures as are deemed necessary, such as temporary navigational aids, will therefore be put in place to ensure that the pipelines do not present a hazard to other users of the sea. A final decision on which safety measures will be used will be taken in discussion with the contractor, taking into consideration the decommissioning methods and schedules.

For decommissioning the pipelines *in-situ*, any interim snagging hazards before decommissioning of the line is finalised will be buoyed and guarded.

15.2.2 Post-decommissioning survey and debris removal

A post decommissioning side scan sonar survey along a 100m corridor each side of the pipeline and hose bundle routes will be undertaken to identify any debris for removal to shore for disposal. Evidence that the seabed conditions do not present a hazard to other users of the sea will be provided to the DTI within four months of the completion of the decommissioning work as part of the project close out report.

A longer-term monitoring programme will be carried out for the pipelines that are to be decommissioned *in-situ* to ensure stability and safety for other users of the sea. These pipelines will be retained in the Operator's North Sea pipeline survey programme. Anticipated frequency will be a post decommissioned survey within one year of completion with a further inspection within 3-5 years. For the two pipelines where localised burial depths are less than 0.6m i.e. PL 81 and PL82, survey inspection runs 2 and 4 years after the pipeline decommissioning completion dates will be carried out as a further confirmation of seabed stability.. The scope and frequency of further surveys will be subject to a risk assessment and agreed in consultation with DTI.

15.3 Post-decommissioning Environmental Survey

Following platform removal, the area will be subject to an environmental survey, including representative sediment sampling for chemical and biological analysis. The post-decommissioning environmental survey scope will be agreed with the DTI and survey results will be supplied to the DTI. The soil survey taken in 2006 around the Indefatigable Juliet platform location will be used as the baseline for all the Indefatigable platform locations.

16 PROJECT MANAGEMENT

This section provides information on the planned management process for the decommissioning of the Indefatigable field platforms, pipelines and hose bundles.

16.1 Project management

A full multi-discipline project team has been assembled within the operator's (Shell's) project execution organisation for the implementation of the Decommissioning Programmes. The team's responsibility will be to execute the decommissioning of the wells, platforms, pipelines and hose bundles within Shell's "Project Engineering A12 Process Management System" guidelines.

Key decisions will be made and management control will be achieved by the "Gate" mechanism in Shell's "Opportunity Realisation Process" where full monetary authorisation will be granted.

The strategy for this project will be to maximise the Operator's (Shell's) in-house resources and existing contracts for the preparatory work and to award a lump sum contract to pre-qualified prime contractors for the main decommissioning activities such as platform removal and disposal. The preparatory work includes well decommissioning, topside and pipeline flushing and cleaning, equipment isolation and making safe for handover to decommissioning contractors. The lump sum contract will be for the full life cycle of the decommissioning operation comprising:

- Engineering design
- Preparation for removal and disposal
- Offshore removal
- Offshore remedy operations
- Transportation to shore
- Onshore dismantling and disposal

If appropriate, a company representative will be posted to the contractor's offices and sites at key stages of the work to ensure compliance with procedures and principles.

16.2 Verification

The project will be subject to internal peer reviews at key stages. This will involve the Operator, Shell, the co-venturer, Esso, and other operating companies within the Shell group. Key technical decisions are also subject to approval from Shell's internal "technical authorities".

16.3 Reporting progress to the DTI

Upon the approval of the Decommissioning Programmes, DTI will be given quarterly progress reports until the offshore removal operations begin, during which monthly reports will be issued. The project close out report will be submitted within 4 months of the completion of the work under the programmes and this report will be in compliance with the DTI standard requirements.

The project team will consider the DTI 'Capturing the Energy ' Initiative to preserve historically important records in final archiving of documentation.

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13. Shell UK Limited, “Pipeline Summary Data Book – 10” Inde November to Inde Kilo”.
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18 GLOSSARY OF TERMS AND ABBREVIATIONS

A

ALARP	As Low as Reasonably Practical
Anthropogenic	The term for a substance or impact that arises from human activity.
Anodes	Blocks of alloy (aluminium & zinc) that protect steel against corrosion.

B

Benthic communities	The assemblages of plants and animals that live on and in the seabed.
Benthos	The bed of the sea and the water column immediately above it.
BPEO	Best Practicable Environmental Option
Biodiversity	A measure of the variety of living organisms found at a site.
Biogenic reefs	Reefs comprising the living or dead parts of marine organisms.

C

Caissons	Caissons are vertical steel pipes attached to the legs of the jacket, running from the topsides down into the water column. They are used to import seawater and discharge permitted aqueous waste to the sea.
Cetaceans	Collective name for the group of marine mammals comprising whales, dolphins, and porpoises.
CO2 (te)	Carbon dioxide tonnes equivalent, a measure of total greenhouse gas emissions.
Cold cutting	A cold method of cutting that does not require hot gas, i.e. hacksaw, diamond wire, abrasive water jet etc.
Conductors	Steel tubes running from the wells on the seabed to the topsides.
Cuttings	The fragments of rock generated during the process of drilling a well.

D

DEFRA	UK Government Department of Environment Food and Rural Affairs
Demersal	The term for organisms that live on or close to the seabed
DfT	Department for Transport
DSV	Diving Support Vessel
DTI	UK Government Department of Trade and Industry

E

EA	Environmental Act
EC	European Commission
EIA	Environmental Impact Assessment. A formal process, which assesses the potential environmental impacts from a proposed activity.
EPA	Environmental Protection Agency
EPE	Shell Exploration and Production – European Region
EU	European Union

F

Fauna	The collective term for all animals.
FAR	Fatal Accident Rate
FishSafe	FishSafe is a computer-based early warning system developed by UKOOA for the fishing industry to warn of the presence of underwater equipment and pipelines.
Flora	The collective term for all plants.
ft	Feet (a unit of length).

G

GJ	Gigajoule, a unit of energy equal to 1,000,000,000 joules.
Grillage	A welded framework of beams and plates several metres high built on a vessel or barge to support the weight of a load.

H

HAZID	Hazard Identification
HSE	Health and Safety Executive
HLV	Heavy Lift Vessels, used to install or remove offshore facilities.
Hook-up	The process of connecting all the pipework and other utilities in the topsides so that offshore production can begin.
Hot Cutting	Method of cutting using hot gas i.e. oxy-acetylene.
Hydrocarbons	Any compound containing only hydrogen and carbon.

I

ICES	International Council for the Exploration of the Sea, an organisation that coordinates and promotes marine research in the North Atlantic.
ICP	Independent Competent Party
IRPA	Individual Risk Per Annum.

J

Jacket	The steel structure that supports the topsides. The lower section, or "legs" of an offshore platform.
JNCC	Joint Nature Conservancy Council

K

Km	Kilometre
kp	Key Point

L

LSA scale	Low Specific Activity scale, derived from naturally occurring radioactive minerals in the rock strata.

M

M	Metre (a unit of length).
m/s	Metre per second.
Mattresses	Heavy mats used to protect and stabilise facilities on the seabed.
MARPOL	International Convention regarding pollution from shipping
MCA	Marine Coastguard Agency
Modules	Structural units, which are which are assembled to form the platform topsides.
MoD	UK Government Ministry of Defence

N

NGO	non-governmental organization.

O

OSPAR	Oslo and Paris Convention

P	
Pelagic	Organisms living in the water column.
PEP	Project Execution Plan.
Phytoplankton	The collective term for the microscopic plants that drift or float in the water column. Phytoplankton consists mainly of microscopic algae. They are the primary producers in the sea and form the basis of food for all other forms of aquatic life.
Pig	A device with blades or brushes inserted in a pipeline for cleaning purposes. The pressure of the stream of fluid behind the pig pushes the pig along the pipeline to clean out rust, wax, scale and debris. These devices are also called scrapers. An instrumented pig is a device made of rubber or polyurethane that has electronic devices. An instrumented pig is run through a pipeline to record irregularities that could represent corrosion. An instrumented pig is also called a smart pig.
Pigging	The act of forcing a device called a pig through a pipeline for the purposes of displacing or separating fluids and cleaning or inspecting pipelines.
Piles	Heavy beam of concrete or steel driven into the seabed as a foundation or support for the jacket structure.
Pinnipeds	Collective name for the group of marine mammals comprising seals, sea lions and walruses.
Plug	Rubber or cement fitting, filling the well to seal it.
PLL	Potential for Loss of Life - is one of the prime outputs of a QRA. It provides a simple long term total measure of societal risk to all personnel from an activity and is expressed as the number of fatalities per specified time period. Though not an absolute measure, it can however be used to compare societal risk between activities.
Polychaete	The class of annelid worms which possess distinct segments.
Q	
QRA	Quantitative Risk Assessment
R	
ROV	Remotely Operated Vehicle
Riser	A steel conduit connecting a pipeline to the production installation.
S	
SAC	Special Area of Conservation. Areas considered to be important for certain habitats and non-bird species of interest in a European context.
SEPA	Scottish Environmental Protection Agency
Shearleg	Heavy Lift Carne Barge
Span	A stretch of pipeline, which has become unsupported.
SSCV	Semi Submersible Crane Vessel (also Heavy Crane Vessel)
T	
Te	Tonne, a metric unit of mass equal to 1,000 kilogrammes.
Topsides	The term used to describe all the decks, accommodation and process modules that are located on top of the jacket.
Trench	A long deep furrow or ditch in the seabed.
Trenched	Placed in a trench.
U	
UKCS	United Kingdom Continental Shelf
UKOOA	United Kingdom Offshore Operators Association
Umbilical	Cable and tubing-like structure that provides utilities and communication to sub-sea equipment to allow it to be operated.
Units	The units throughout the document are imperial and metric, used appropriately as within the oil and gas industry.
V	
Vessel spread	The fleet of vessels used for any particular activity or operation.
VOC	Volatile Organic Compound.
W	
Wellhead	The system of spools, valves and assorted adapters that provide pressure control of a production well.

X	
X-mas Tree	Christmas Tree. The set of valves, spools and fittings connected to the top of a well to direct and control the flow of formation fluids from the well.
Z	
Zooplankton	The collective term for the animals that float/drift in the water column.

APPENDIX A

Decommissioning Options – Description and Sketches of Selected Options

APPENDIX A - CONTENTS

A.1 TOPSIDE REMOVAL METHODS

Four of the Inde field platform topsides, Juliet JP, Lima, Mike and November, were installed in single lifts with the maximum lift weight of approximately 1400 tonnes. The other two topsides, Juliet JD and Kilo, were installed in multiple lifts and subsequently hooked together.

The selected topside removal methods are described in greater detail below. Some of the topside removal methods are dependant upon the type of platform involved.

A.1.1 Installation reversal using HLV

This method of topside removal is simple for the topsides that were installed as a single lift, Juliet JP, Lima, Mike and November. Prior to lifting off these topsides, it is necessary to carry out preparation or reverse hook-up work.

For economy, the reverse hook-up and other preparation work will most probably be undertaken from a temporary jack-up platform. This vessel would have craneage, accommodation, helideck, bridge connection to the platform and necessary support systems. Once the jack-up is installed on location, the operations carried out from this vessel will be relatively insensitive to weather conditions. The preparatory work includes separating the risers, caissons and J-tubes from the jacket; rigging the conductors and topside for lift; preparing the leg cuts and internal seafastening.

Once the preparation work is complete, the jack-up will clear the site and an HLV will arrive to prepare to remove the conductors and the topside in one lift.

After anchoring and mooring a cargo barge alongside, the HLV will attach the lift rigging to the crane hook, cut the deck legs and lift the platform topside onto the cargo barge. The topside will then be seafastened to the barge and the barge will be towed to shore. The conductors may be lifted and removed when the cargo barge is being prepared.

These operations are shown diagrammatically in figures A.1.1.1 to A.1.1.3 below.

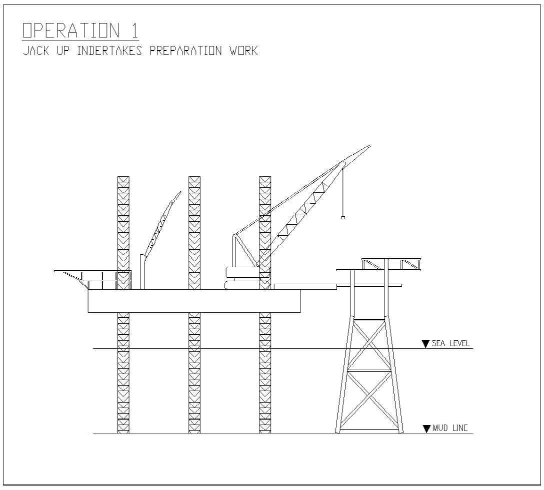
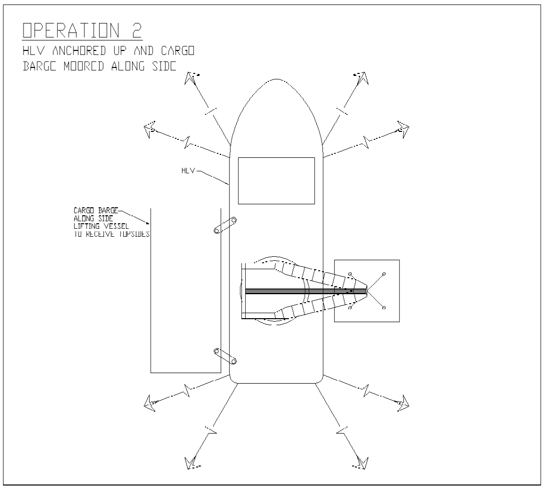


Figure A.1.1.1



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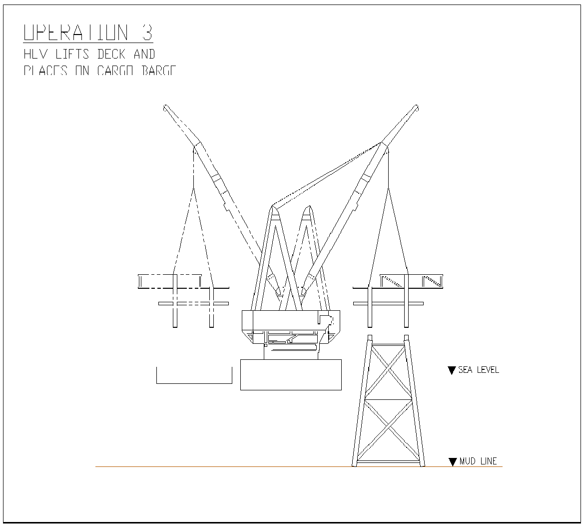


Figure A.1.1.3

A slightly more complicated methodology is required for the two larger platforms, Juliet JD and Kilo, which were installed with multiple topside lifts.

Both these platforms have ten legs. The decks were installed as a six-leg and a four-leg section that were connected after installation. Topside packages or modules were then lifted on.

Prior to the HLV lift operations, various reverse hook-up activities and lift preparation works are required. It is anticipated that a jack-up vessel will support the preparation work for reasons stated earlier. The preparation work is similar to that for the single topside lift platforms except that it is repeated for each lift package and access in between modules is difficult.

Once the preparation work is complete, the jack-up will clear the site and an HLV will arrive to remove the conductors and the topside in a number of lifts.

After anchoring and mooring a cargo barge alongside, the HLV will lift the various packages off the deck onto the cargo barge. The support frame will then be cut vertically into the original six-leg and a four-leg sections and these will in turn be lifted onto a cargo barge. After seafastening, the barge will be towed to shore. The conductors may be lifted and removed when the cargo barge is being prepared.

These operations are shown diagrammatically in figures A.1.1.4 to A.1.1.8 below for the Kilo platform.

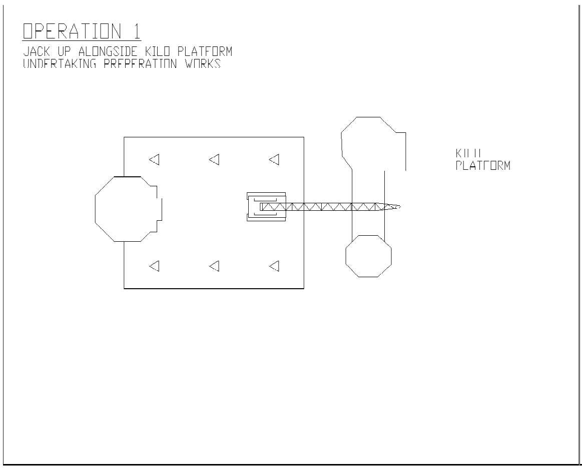
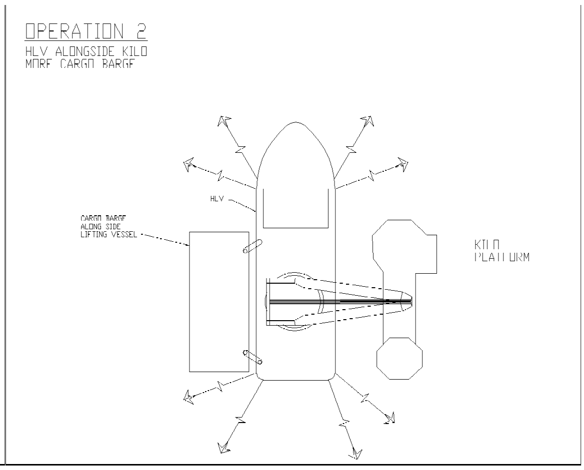


Figure A.1.1.4



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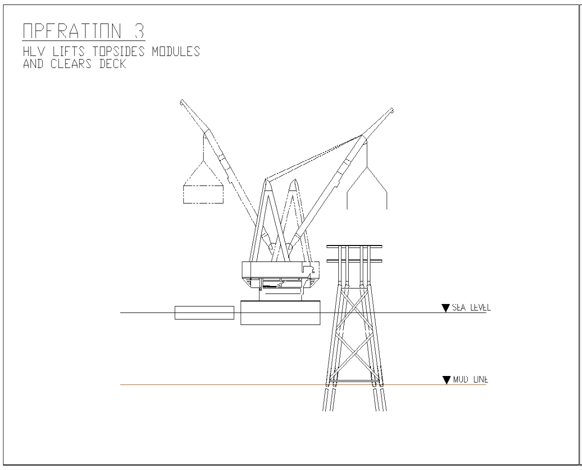

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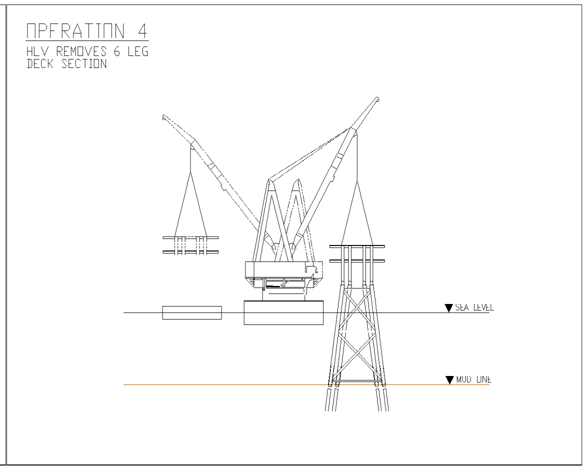


Figure A.1.1.7

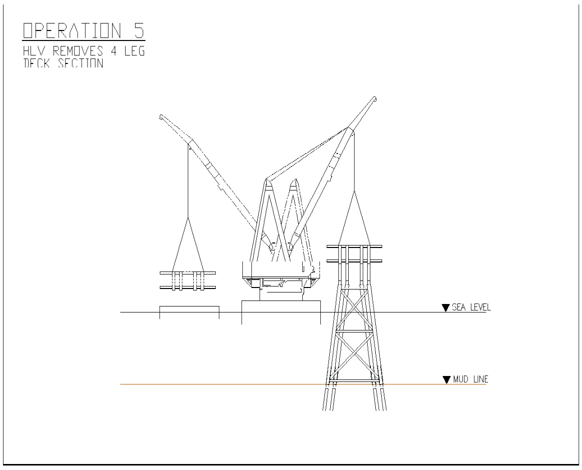


Figure A.1.1.8

A.1.2 Topside removal using SSCV

This method involves lifting the topsides of the platforms in one single lift using a twin crane semi-submersible crane vessel of lift capacity in excess of 3,000 tonnes. This method is only applicable to the Juliet JD and Kilo platforms as the others are within the single lift capability of an HLV.

In order to lift these topsides in a single piece, it will be necessary to install lifting beams under the deck and to undertake deck strengthening. This work will require the support of the jack-up vessel that will be undertaking the other preparatory work.

The SSCV will arrive at location once all the preparatory work is complete. After attaching the lift rigging and cutting the deck legs, the topside will be lifted as a single unit and placed on a cargo barge.

The operation is shown diagrammatically in figures A.1.2.1 to A.1.2.4 below for the Kilo platform.

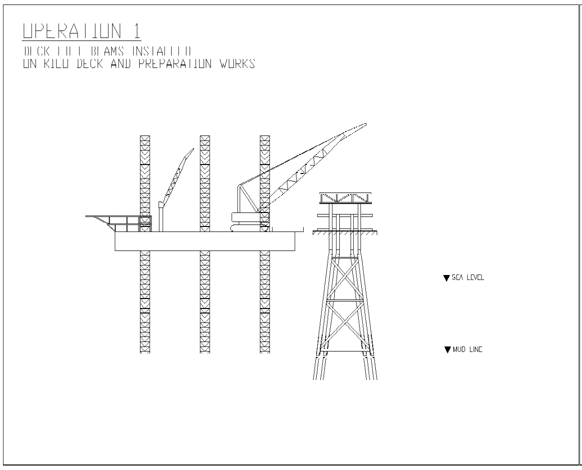


Figure A.1.2.1

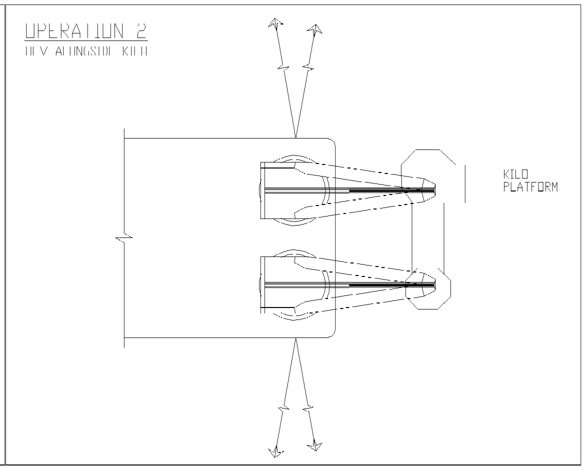
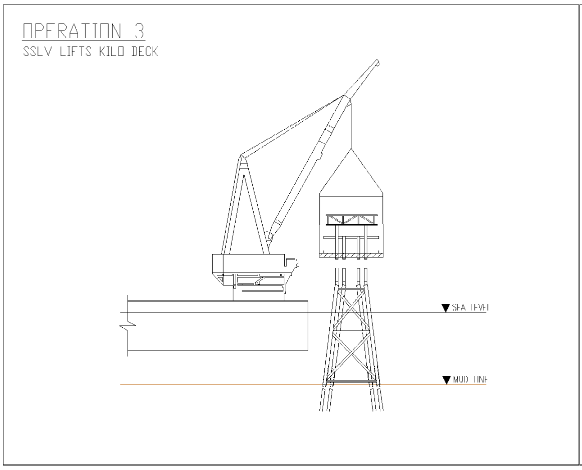


Figure A.1.2.2



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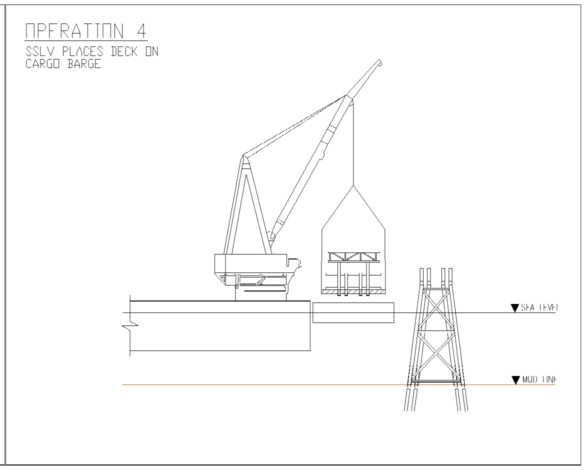


Figure A.1.2.4

A.1.3 Topside removal using Versatruss

Versatruss is a proprietary arrangement for lifting platform decks and the like without the use of conventional craneage or jacks. The sketches (Fig A.1.3.1 & A.1.3.2) below demonstrate how the system works.

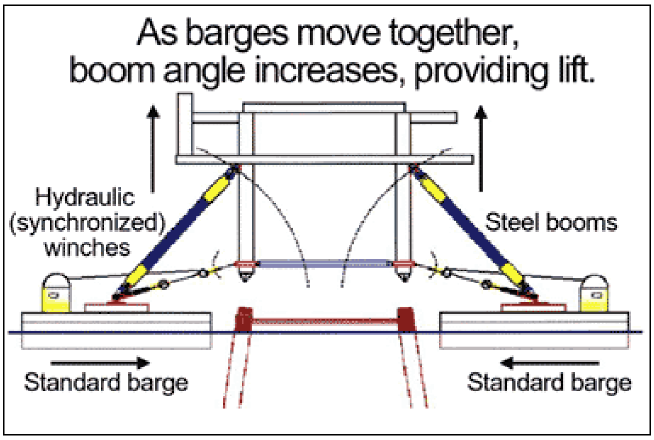


Figure A.1.3.1

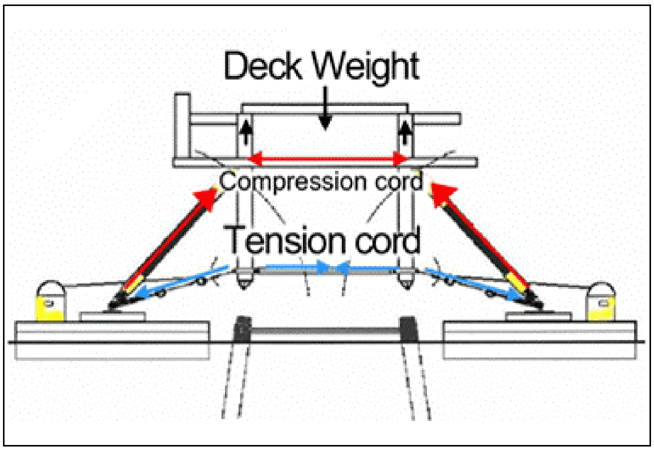


Figure A.1.3.2

The Versatruss option is applicable to the removal of all six Inde platform topsides.

In order to remove the topsides in this manner, it will be necessary to strengthen and install lifting lower tie members between the deck legs. This work will be undertaken with the support of a jack-up vessel that will be undertaking the other preparatory work.

The Versatruss equipment will be fitted out inshore on barges and towed to site where the barges will be anchored out. The system will be fitted up to the prepared decks and the deck legs cut. The barges will then be winched together and the deck will lift off the jacket. The deck and the barges will then move forward and lower the deck onto a transport barge for transit to shore.

These operations are shown diagrammatically in figures A.1.3.3 to A.1.3.8 below for the Kilo platform.

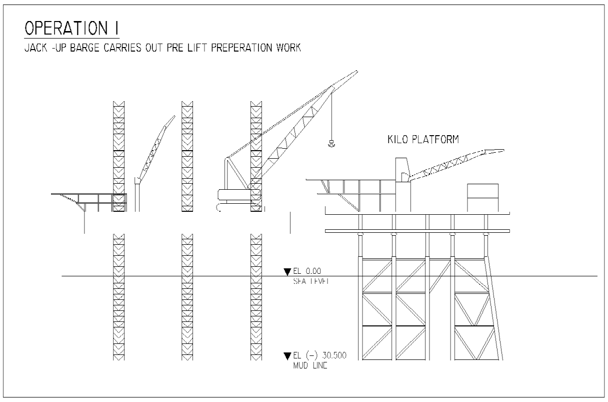


Figure A.1.3.3

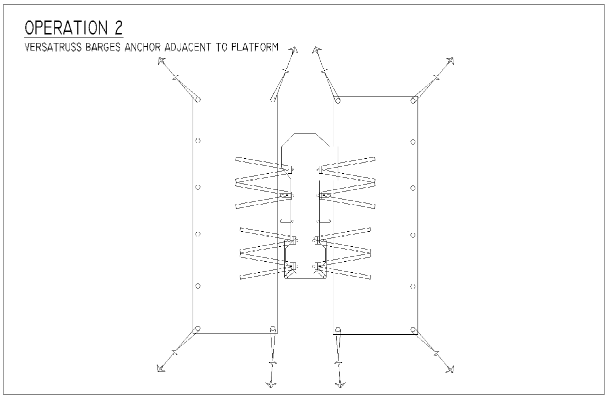


Figure A.1.3.4

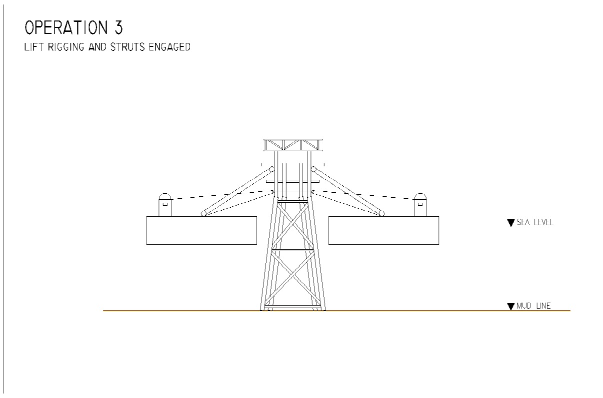


Figure A.1.3.5

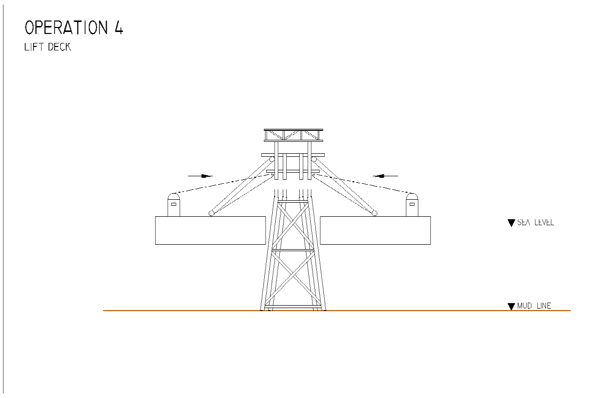
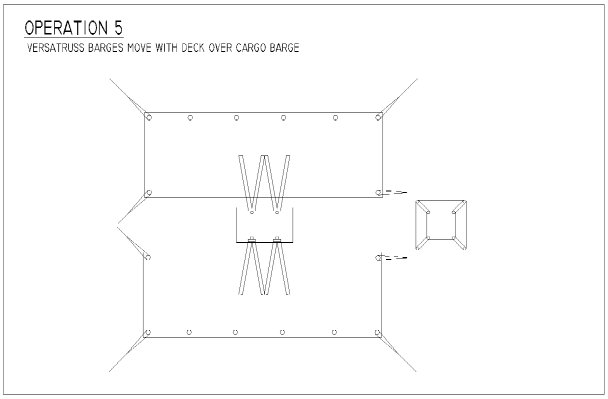


Figure A.1.3.6



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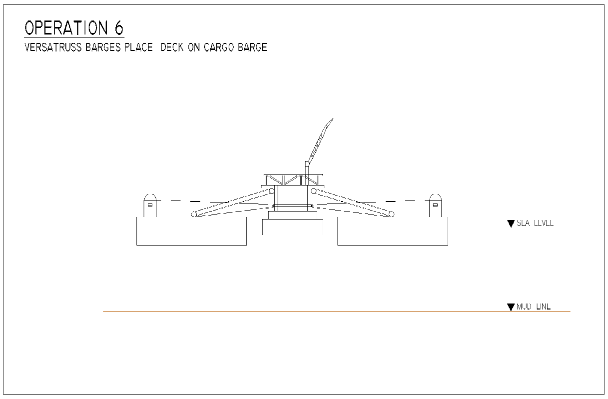


Figure A.1.3.8

A.1.4 Topside removal using Submersible Barges

This method of topside removal is similar to the Versatruss method except that submersible barges are used to provide the lift, rather than the Veratruss system.

The operations are shown diagrammatically in figures A.1.4.1 to A.1.4.6 below for the Kilo platform.

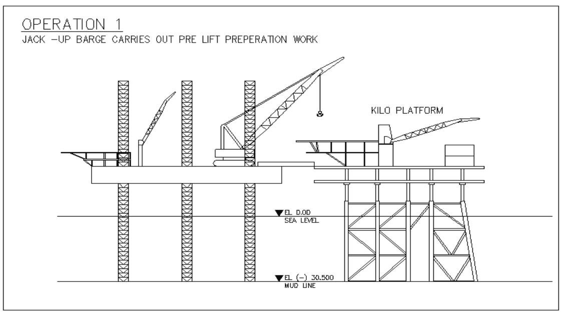


Figure A.1.4.1

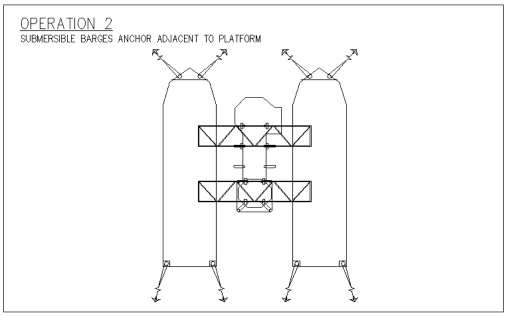


Figure A.1.4.2

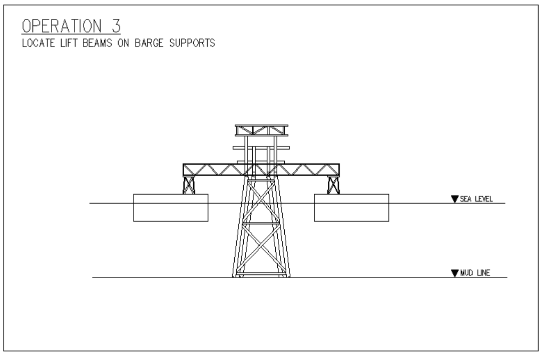


Figure A.1.4.3

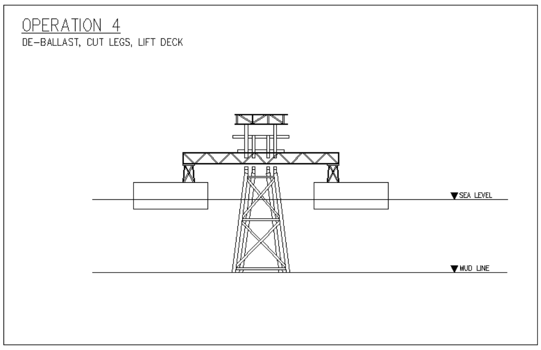
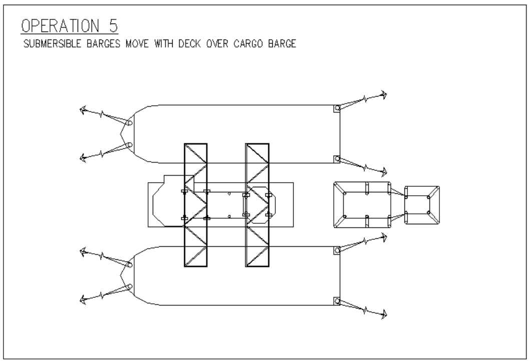


Figure A.1.4.4



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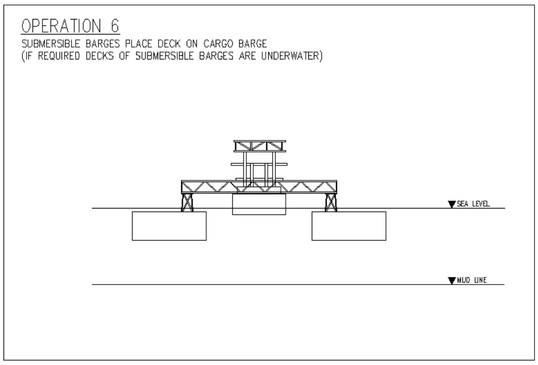


Figure A.1.4.6

A.1.5 Piece small removal of topsides

This topside removal method will be undertaken by a marine work vessel, most probably a jack-up barge, that will break the platforms up into sections that can be easily handled by the available cranes. The individual pieces will be loaded onto supply boats for transport to shore.

It is envisaged that a large crawler or ringer crane (such as a Manitowoc 4100) would be on the deck of the jack-up which would be able to handle 100 tonne lifts at most parts of the platforms.

As this is a time consuming method it is possible that two jack-up vessels may be used in parallel for the Juliet and Kilo platforms.

The operations for this method of topside removal are shown diagrammatically in Figures A.1.5.1 to A.1.5.6 below.

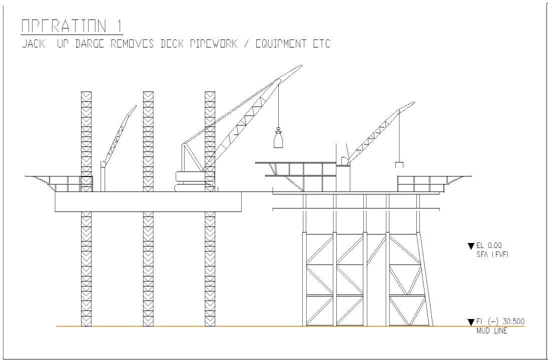


Figure A.1.5.1

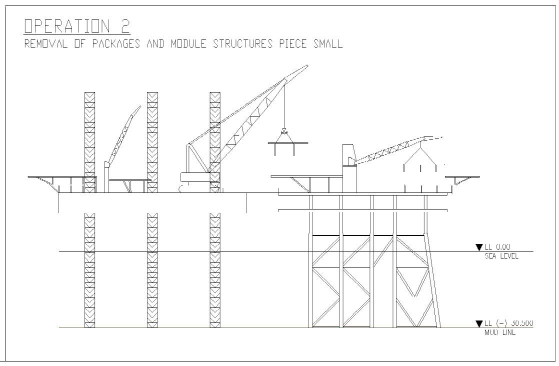


Figure A.1.5.2

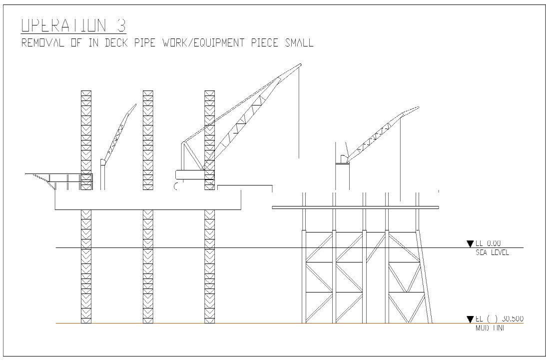


Figure A.1.5.3

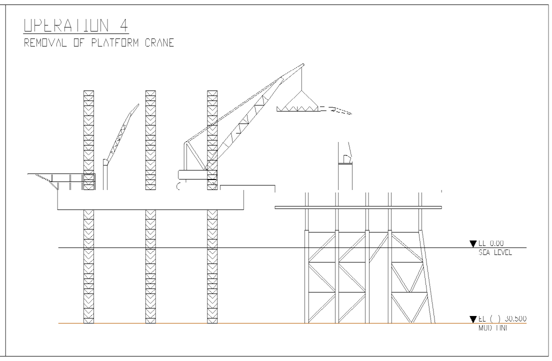


Figure A.1.5.4

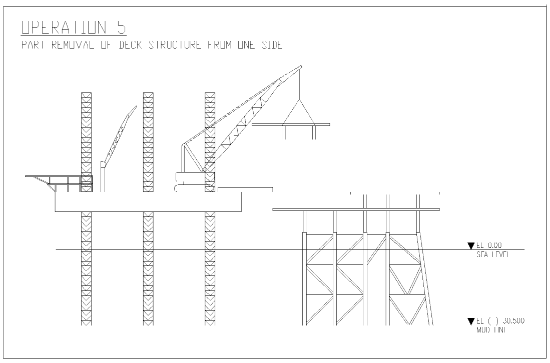


Figure A.1.5.5

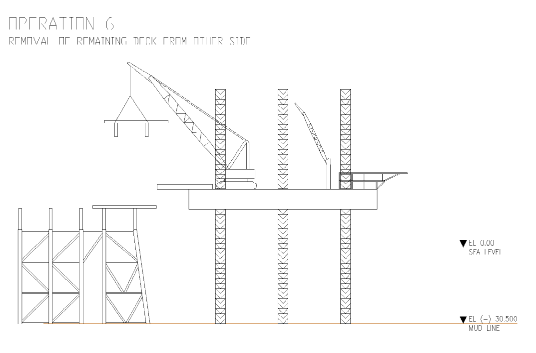


Figure A.1.5.6

A.2 JACKET REMOVAL METHODS

Only two methods of jacket removal were deemed feasible after the review of the long list of options. These methods are:

- Installation reversal using HLV
- Jacket removal using added buoyancy

The operations involved in these methods are described hereafter.

A.2.1 Installation reversal using HLV

As with the topsides, it is necessary to carry out some preparation works prior to lifting the jacket. This involves removal of the connections between the pipelines and the hose bundles to the risers and J-tubes and the cutting of the piles below mudline. The connection of the lift rigging to the jacket will also be carried out in the preparation phase to save the more expensive HLV time.

The subsea work of cutting the lines and clearing the seabed will be supported by a diving support vessel (DSV). It is envisaged that most of the work may be accomplished by ROVs however some manual diving is also expected to be necessary.

The other preparation work involves cutting the piles and installing the lift rigging. It is envisaged that this work will be supported from a jack-up barge which gives a stable work platform that is relatively unaffected by the weather. It is planned that the piles will be cut from inside using a proprietary abrasive jet cutting tool. To install this tool it will be necessary to remove the deck legs below the original joint line to provide access inside the piles. It will also be necessary to survey and possibly remove the soil plug inside the pile to reach the level of the desired cut.

When the preparation work is complete the HLV will arrive and anchor in position. The jacket will be lifted and placed on a cargo barge where it will be seafastened and transported to shore.

The jackets for the Juliet JD and Kilo platforms are ten-leg jackets that were installed as separate four-leg and six-leg jackets that were connected above waterline after installation. These jackets will be removed as two jackets after cutting the connecting braces.

The operations for this method of jacket removal are shown diagrammatically for the Kilo platform in figures A.2.1.1 to A.2.1.6 below.

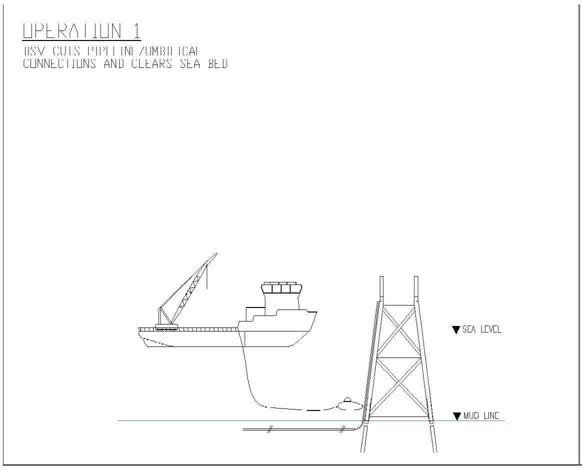


Figure A.2.1.1

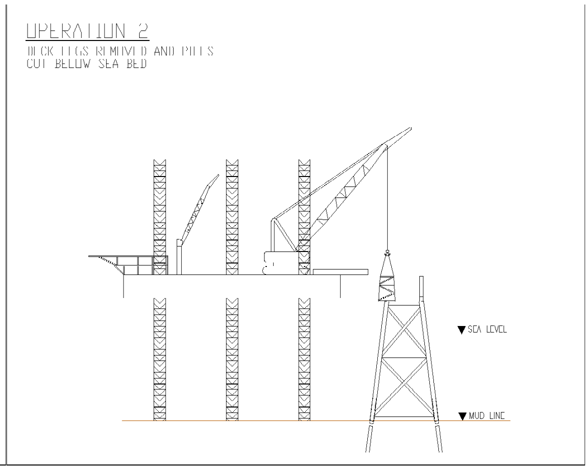


Figure A.2.1.2

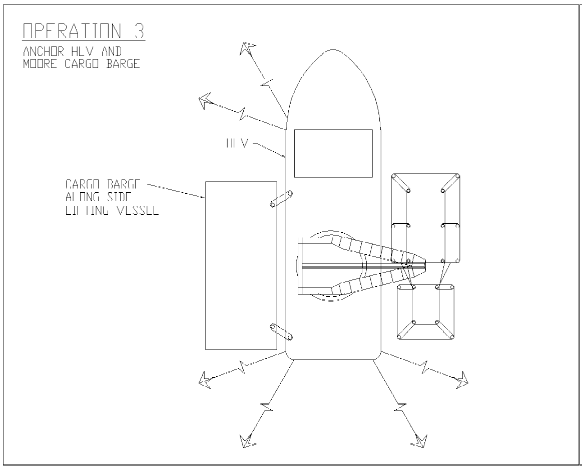


Figure A.2.1.3

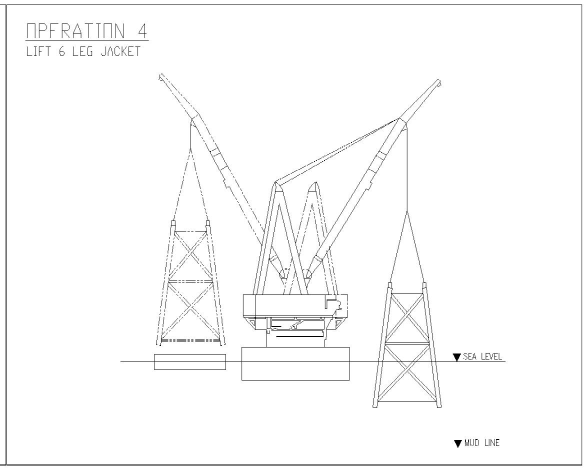
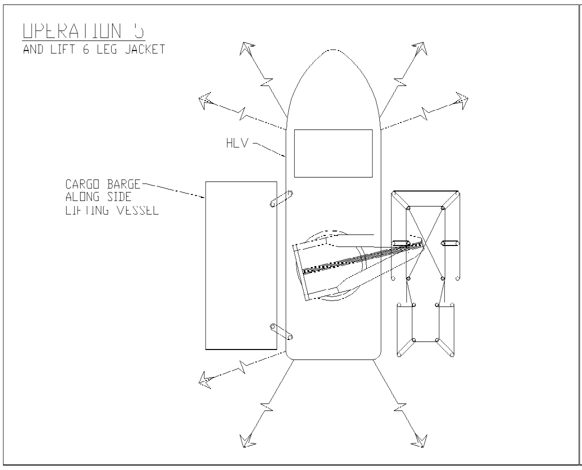


Figure A.2.1.4



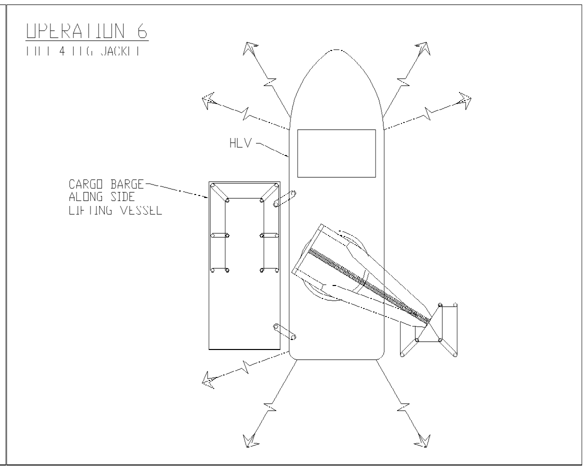


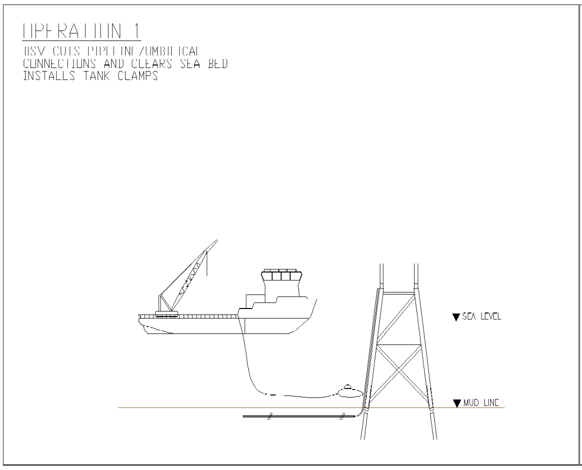
Figure A.2.1.5 **Figure A.2.1.6**

A.2.2 Jacket removal using added buoyancy

This method of removing the jackets involves adding buoyancy in the form of tanks to the jackets in order that they will float clear of the seabed after the piles are cut . This will enable them to be towed to a deepwater inshore location where they can be lifted clear of the sea by a shearleg barge. The shearleg will then move to a nearby quayside and place the jackets on land.

The preparation works necessary for this operation include those required for the HLV removal method plus the attachment and de-ballasting of the buoyancy tanks.

Figures A.2.2.1 to A.2.2.6 below give a diagrammatic representation of the buoyant jacket removal method.



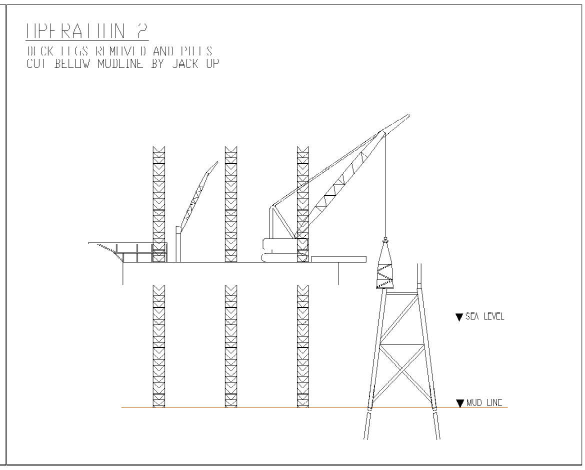


Figure A.2.2.1 **Figure A.2.2.2**

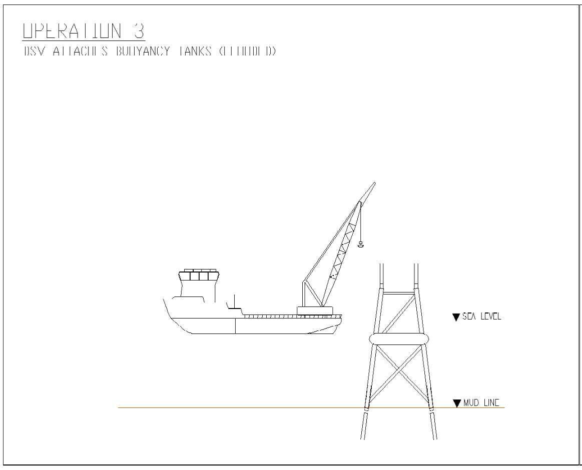


Figure A.2.2.3

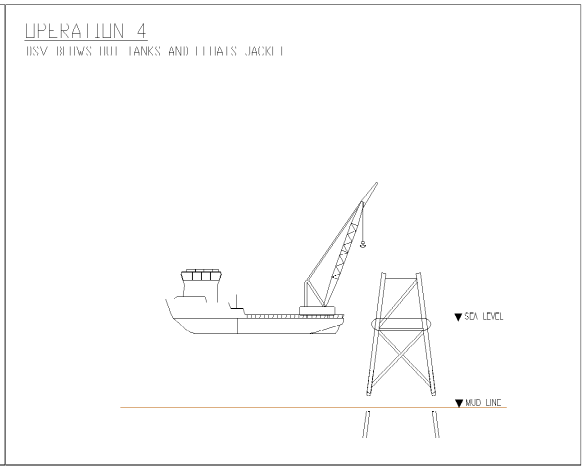


Figure A.2.2.4

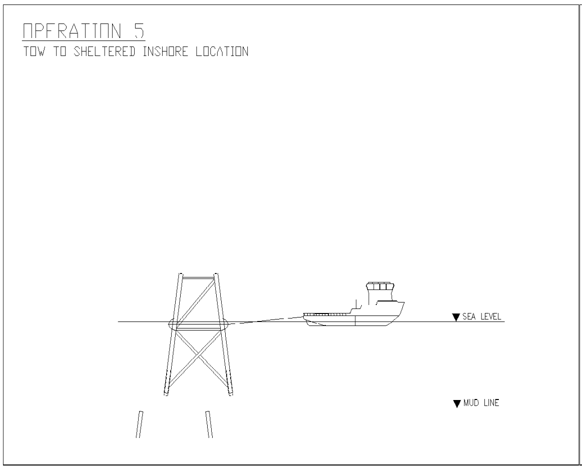


Figure A.2.2.5

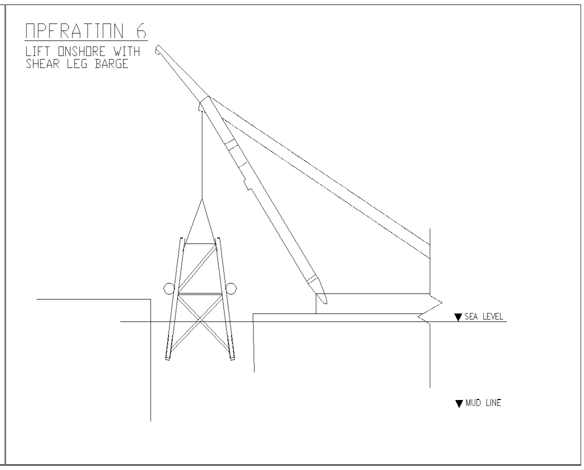


Figure A.2.2.6

A.3 DECOMMISSIONING OF PIPELINES AND HOSE BUNDLES

The remaining options for the decommissioning of the pipelines and hose bundles are to de-commissioning them in-situ or to remove them to shore for re-use, recycling or disposal. These options are described hereafter.

A.3.1 In-situ decommissioning of Lines

The DTI guidelines allow in-situ decommissioning of pipelines in certain cases where specific criteria are met. These criteria require that the lines must be buried to a minimum depth of 0.6 metres above the top of the line and that the burial must be reasonably stable and avoid disturbance to other users of the sea (they must be over-trawlable). The Inde in-field pipelines generally meet the criteria but the historical survey data indicates there are a few sections that may require some remedial action. This applies to the end of the lines where they approach the platforms and to a couple of mid line sections.

In order to decommission the lines in this manner, it will be necessary to re-survey the lines to determine the depth of burial and to compare any historical changes in the burial depth. Given that there will be some sections not meeting the required burial depth, remedial action can be taken by one of the following methods:

- Retrenching of the line allowing natural backfill.
- Rock-dumping
- Pipe removal in selected areas

In the event that this option for the lines decommissioning is chosen, it will be necessary to carry out surveys to demonstrate that the lines meet the required criteria. These possible solutions for insufficiently buried pipelines are shown diagrammatically in Figures A.3.1.1 to A.3.1.3 below.

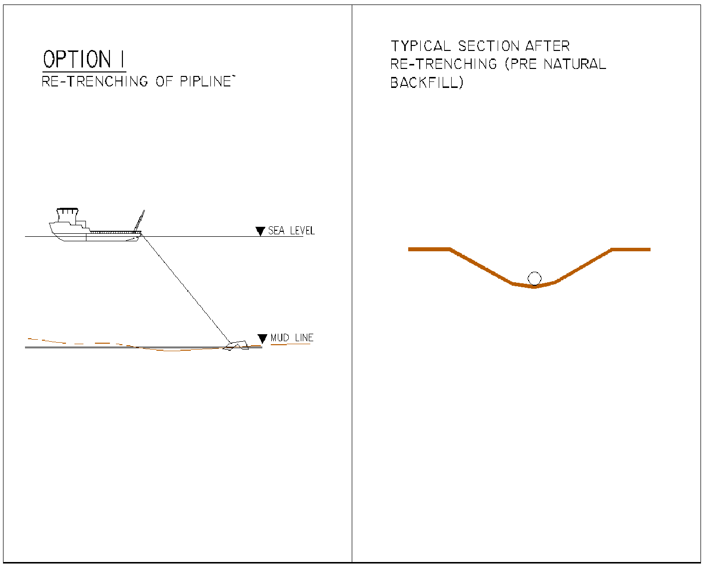


Figure A.3.1.1

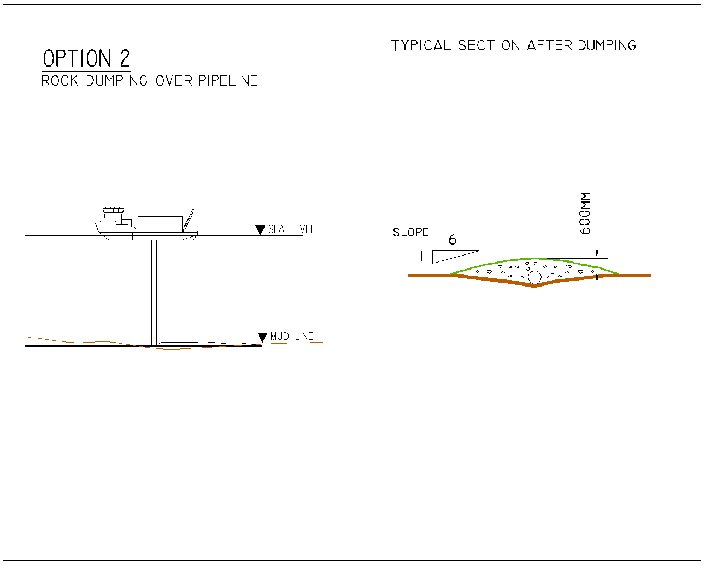


Figure A.3.1.2

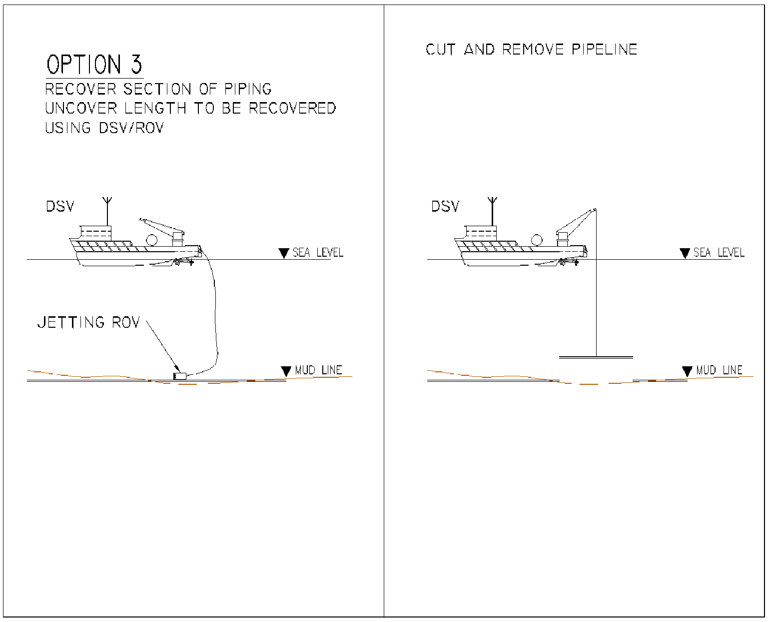


Figure A.3.1.3

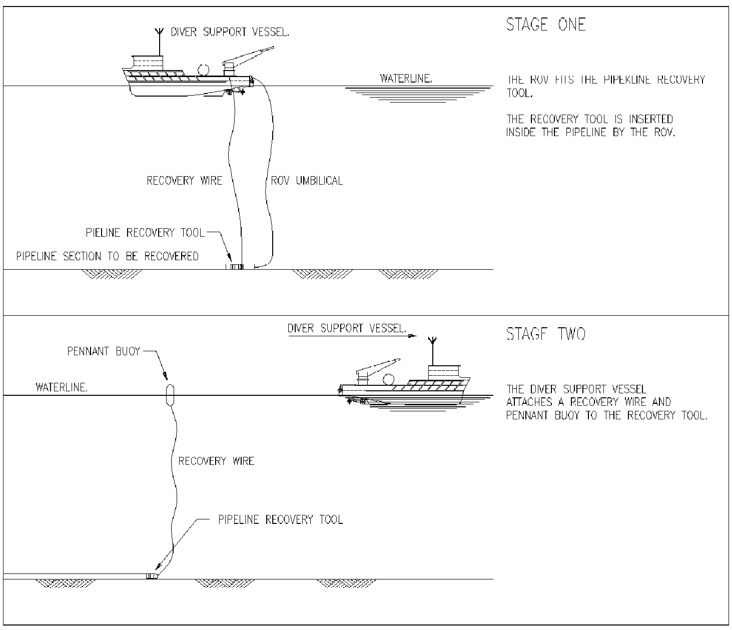
Note: The above are particularly applicable to hard pipelines but are also generally applicable to the hose bundles.

A.3.2 Reverse S-lay recovery of pipelines

This pipeline decommissioning method removes the pipelines by a reversal of the method used to lay the line. It involves pulling the pipe back up the stinger on the lay-barge and cutting it into suitable lengths to enable it to be shipped to shore on a cargo barge.

Because of the large diameter and unknown condition of the pipe and coatings on the PL80, PL81 and PL82 pipelines it would be prudent to 'un-bury' these lines prior to recovery by this method. The 'un-burial' will significantly reduce the tension require to recover the lines.

The sequence of initiating the pipeline recovery is shown in Figure A.3.2.1 and the pipeline end recovery is shown in Figure A.3.2.2 below.



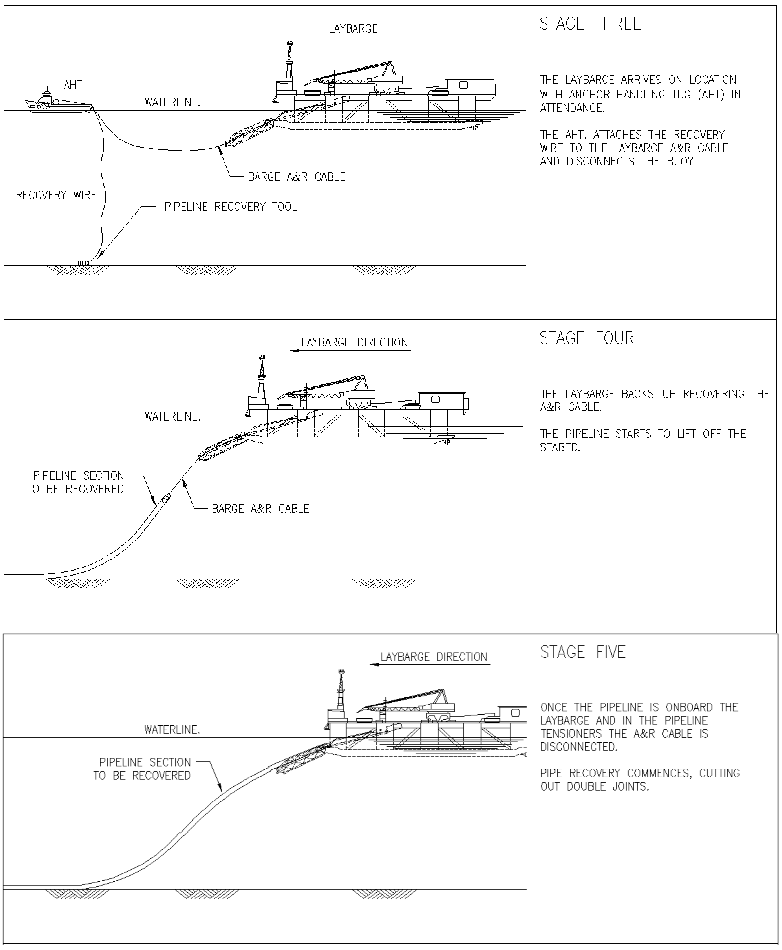
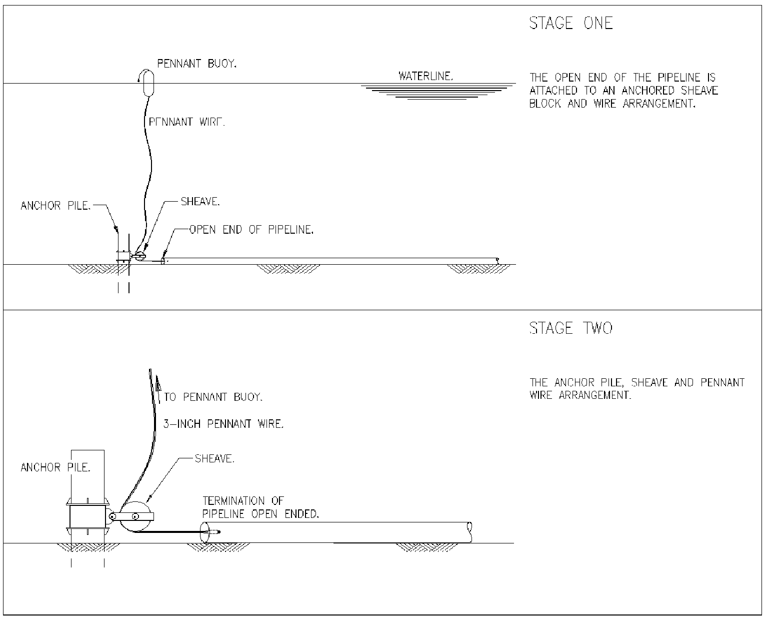


Figure A.3.2.1 - Pipeline Recovery Initiation



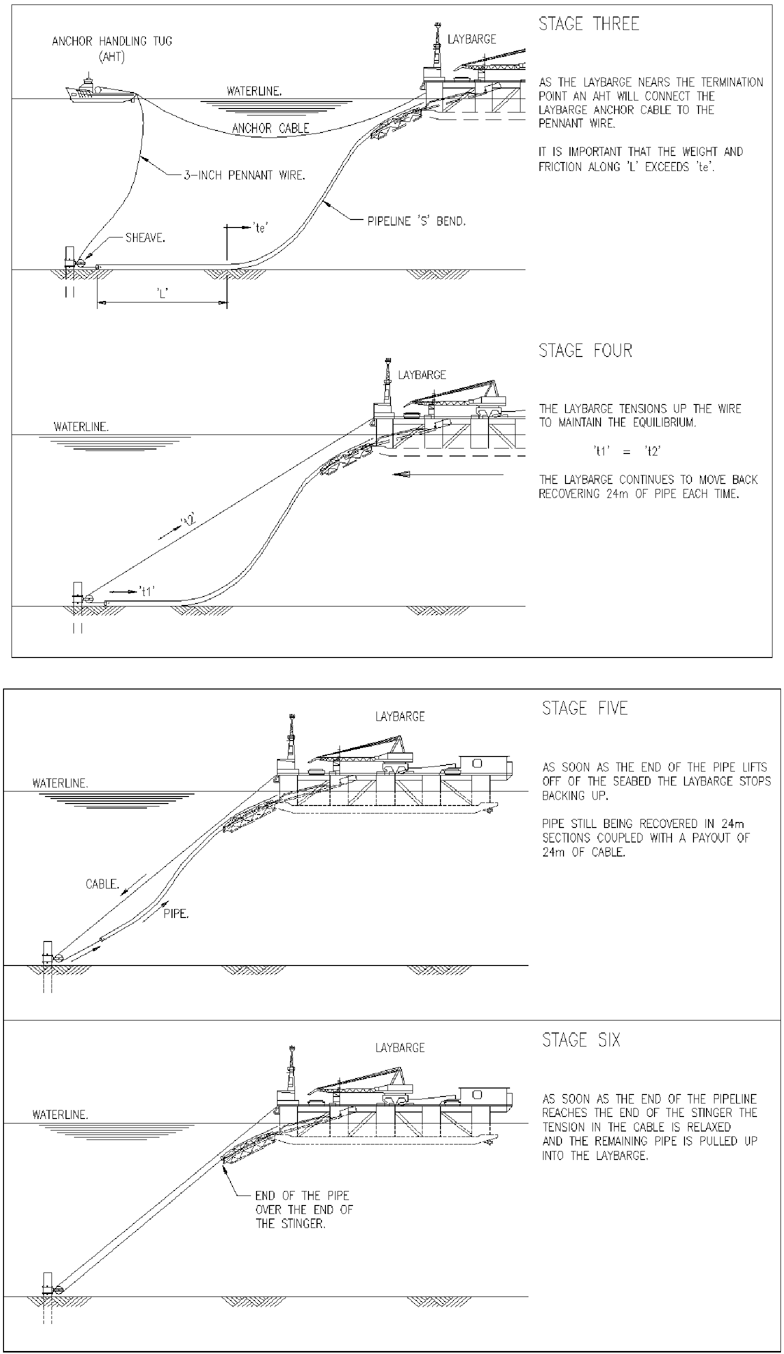


Figure A.3.2.2 – Pipe End Recovery

A.3.3 Cut & Lift recovery of pipeline

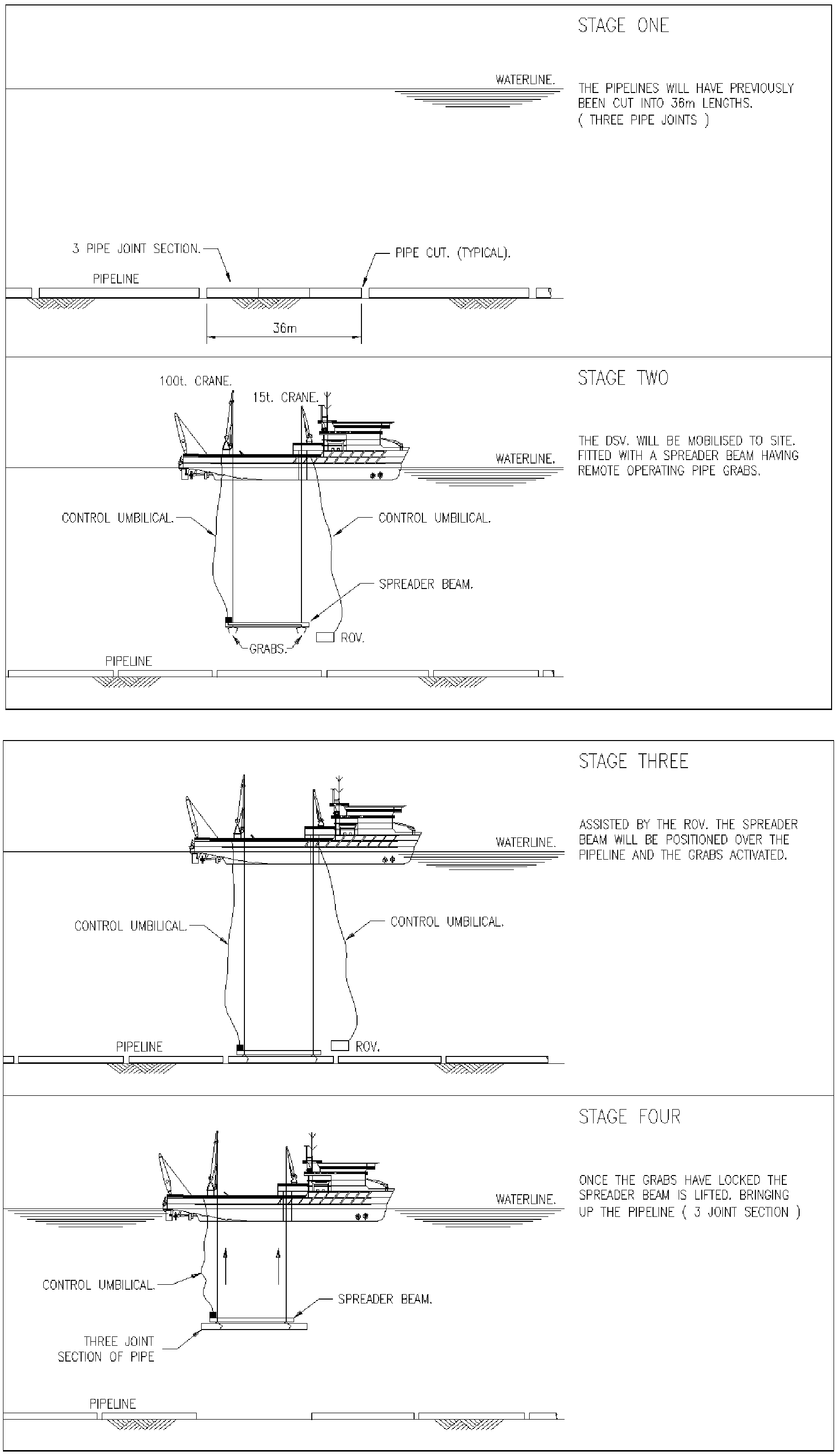
This method entails the decommissioning of the pipelines by exposing the lines, cutting them into short lengths on the seabed, lifting them above water and transporting them to shore for disposal.

In order to cut and lift the pipelines it will be necessary to un-bury them along their entire length. This could be done by either jetting the soil away from the pipes or by ploughing a trench along the pipes. Because of the relatively loose sand on the seabed the jetting method is more suitable.

The pipeline cutting and removal will be undertaken with a diving support vessel. The majority of the pipe cutting and rigging work will be undertaken by purpose adapted ROV however a crew of divers will be onboard the vessel to undertake specific tasks and in particular intervention for unplanned events.

For practicality it would be probable that the trenching, cutting and lifting operations are supported by the same DSV.

The cutting and lifting sequence of events is shown diagrammatically in Figure A.3.3.1 below.



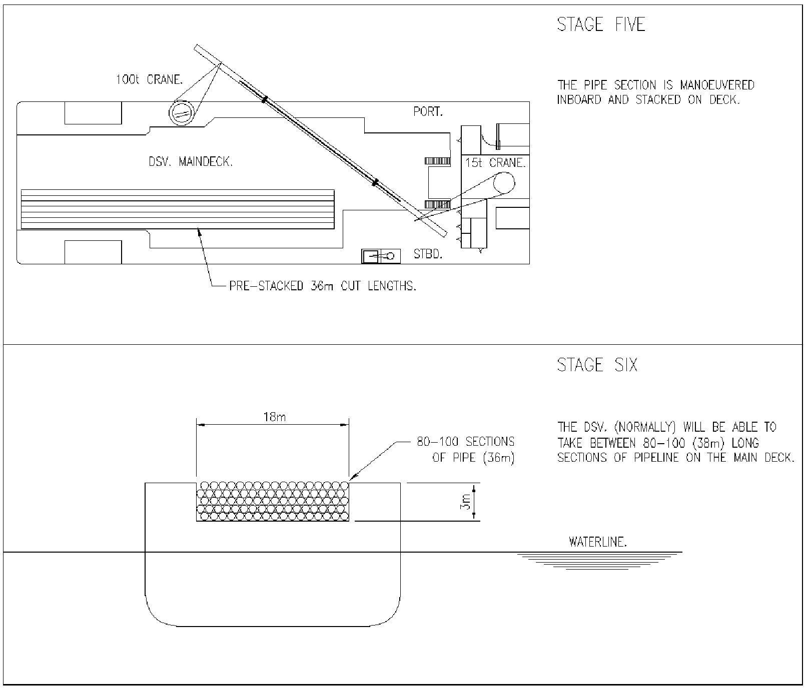


Figure A.3.3.1 – Pipeline Removal in Sections

A.3.4 Lift & Reel hose bundle removal

The method of recovering the hose bundles by the lift and reel option is described briefly hereafter.

This work would be undertaken by a vessel such as a supply boat fitted out with a powered cable reel, a cable tensioner (linear winch or capstan), a small crane and an ROV. It is not envisaged the force required to pull the umbilical out of the seabed will be excessive, however, in case it ever became large it will be prudent to carry a jetting spread to un-bury the line in this event, prior to removal.

The method of recovery is simply to pick up the end if the line and feed it through a tensioner or capstan and feed it on to the recovery reel. The tensioner then continues to pull the line out of the soil and feed it onto the reel while the vessel moves along the route. When the end of the line is reached the operation is complete.

The hose bundle will then be transported to shore for re-use or disposal.

A typical vessel deck layout and recovery arrangement are shown in Figures A.3.4.1 and A.3.4.2 below.

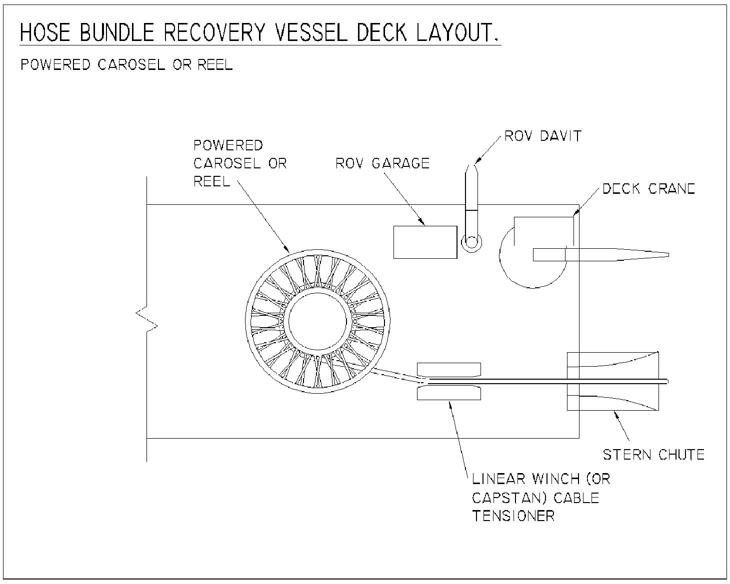


Figure A.3.4.1 – Typical Vessel Deck Layout

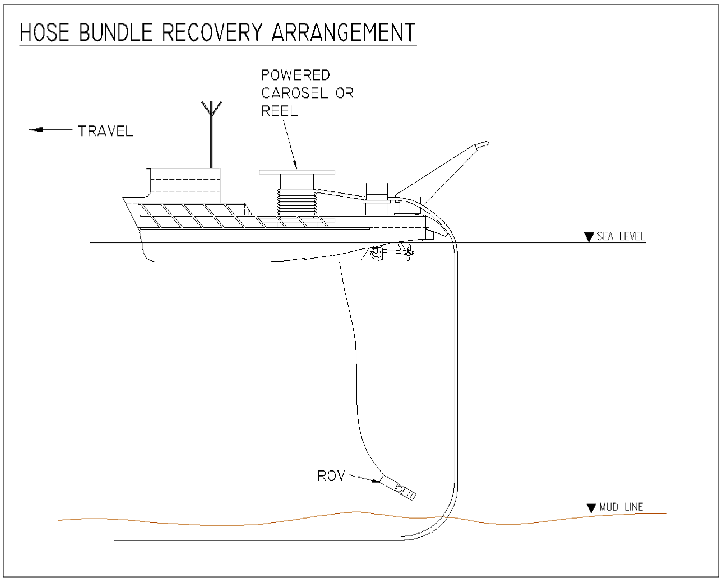


Figure A.3.4.2 – Hose Bundle Recovery Arrangement

A.4 ONSHORE DISPOSAL

Once removed from the field the topsides, jackets, pipelines and hose bundles will be transported to an onshore decommissioning facility. This facility will be licensed for the decommissioning activities including the handling and disposal of any hazardous materials that may be present. As such the facility will have appropriate quarantine.

The hierarchy of how the platform and pipeline components are disposed of is as follows:

- Refurbishment for re-use as unit
- Removal of equipment for reuse
- Segregation of pipes for reuse
- Segregation of steelwork and other materials for re-use
- Segregation of materials for re-cycling
- Segregation of materials (including hazardous materials) for disposal

Platform components, pipelines, etc. arriving at the quayside of the disposal facility on cargo barges or vessel decks will be offloaded by appropriate means. This may be by crane however larger deck sections are more likely to be offloaded using multi wheeled pneumatic tyred bogies.

Once on the quayside any components with marine fouling will be cleaned off and the fouling material is either reused as feed stock material for the cement industry or disposed of and sent to approved landfill sites.

Any large component scheduled for re-use or possible re-use will be stored in a designated area of the facility for refurbishment or preservation until its future is determined.

Other components that are not viable for re-use as a single unit will be stripped out and any equipment and/or materials suitable for re-use piece small will be stored and preserved in suitable warehouses or designated storage areas.

Concrete coated pipeline sections will have their anodes removed and collected for recycling. Where it is deemed practical the concrete coating on the pipelines will be stripped off and collected for use as hardcore leaving the steel pipes in a condition suitable for re-cycling in smelters.

Other materials will be collected by type and stored in separate areas for transshipment to smelters or other recycling facilities.

Materials not suitable for any of the above treatment (including hazardous materials such as asbestos, LSA contaminated materials, heavy metals and the like) will be collected and transported off site for disposal in landfill and/or other approved disposal facilities.

APPENDIX B

Safety Risk Assessment of Selected Decommissioning Options

APPENDIX B - CONTENTS

B.1 SAFETY RISK ASSESSMENT OF SELECTED DECOMMISSIONING OPTIONS

Safety is an integral part of the assessment process for the various decommissioning options. The following two activities were undertaken in the assessment:

- A full hazard identification (HAZID) exercise on the "long-list" of options;
- A quantitative risk assessment (QRA) of the selected options.

The objectives, methodology and results of these exercises are discussed below.

B.1.1 Hazard Identification (HAZID)

The HAZID exercise was undertaken over a two-day period and attended by Shell and Esso engineers and independent consultants. The exercise was conducted in accordance with the prescribed Shell procedure for undertaking such reviews.

The HAZID was undertaken prior to the short-listing of options and was instrumental in the rejection of some of the "long-list" of options. In addition to the rejection of certain options, the HAZID also produced a list of actions to mitigate risks in certain of the other options.

One recommendation that came from the HAZID was that a quantitative risk assessment should be carried out on the short-listed options and details of this exercise are given below.

B.2 QUANTITATIVE RISK ANALYSIS (QRA)

The QRA exercise was undertaken in accordance with the methodology and parameters proposed in the Joint Industry Project report on "Quantitative Risk Analysis of Decommissioning Activities" prepared by *Safetec* and published on 31st August 2004.

In this report, decommissioning operations have been broken down into more specific activities or work tasks, such as Rope Access, Scaffolding, Marine Operations and Lifting. Extensive data search has been undertaken to determine the best possible basis for establishing the FAR values estimates due to occupational accidents for these activities. (Note: 'FAR' is the fatal accident rate for the activity and is normally expressed as the number of fatalities that occur during a period of 100 million exposed working manhours.)

The summation of the exposed manhours multiplied by the appropriate FAR for each activity involved in a decommissioning option gives a Potential Loss of Life (PLL) value for the option being considered.

The activities reviewed in this exercise were the short-listed options for the decommissioning of the Indefatigable Field platforms, pipelines and hose bundles.

The results from this analysis are presented hereafter.

B.2.1 QRA Results

Topside Decommissioning

It can be seen from Table B.2.1.1 below that the HLV and SSCV options carry the lowest risk, and that the Versatruss, Submersible Barge and Piece Small options all carry a significantly higher risk.

The onshore risk, which contributes on average 14% of the risk, is constant since the same tonnage of steel has to be cut up onshore regardless of the offshore option recovery option. The offshore work carries on average 86% of the risk.

If the offshore risk for the HLV option is taken as the norm with a risk value of 1.00, then the SSCV option is essentially the same at 0.99, the Piece Small option has a higher risk at 1.58, the Versatruss option is higher still at 1.95, and the Submersible Barge option is highest at 2.05.

Table B.2.1.1: PLL for Topsides Decommissioning Options

Inde Platform	Decommissioning Options	HLV	SSCV	Versatruss	Submersible Barges	Piece Small
		Potential Loss of Life				
Juliet	Offshore	1.30E-02	1.25E-02	2.16E-02	2.20E-02	1.65E-02
	Onshore	3.05E-03	3.05E-03	3.05E-03	3.05E-03	3.05E-03
	Total	**1.60E-02**	**1.55E-02**	**2.46E-02**	**2.51E-02**	**1.95E-02**
Kilo	Offshore	9.28E-03	9.35E-03	1.40E-02	1.58E-02	1.60E-02
	Onshore	2.86E-03	2.86E-03	2.86E-03	2.86E-03	2.86E-03
	Total	**1.21E-02**	**1.22E-02**	**1.68E-02**	**1.87E-02**	**1.89E-02**
Lima	Offshore	3.93E-03	3.93E-03	9.82E-03	9.71E-03	1.13E-02
	Onshore	1.44E-03	1.44E-03	1.44E-03	1.44E-03	1.44E-03
	Total	**5.37E-03**	**5.37E-03**	**1.13E-02**	**1.12E-02**	**1.27E-02**
Mike	Offshore	3.31E-03	3.31E-03	9.29E-03	9.62E-03	4.11E-03
	Onshore	5.30E-04	5.30E-04	5.30E-04	5.30E-04	5.30E-04
	Total	**3.84E-03**	**3.84E-03**	**9.82E-03**	**1.01E-02**	**4.64E-03**
November	Offshore	3.31E-03	3.31E-03	9.29E-03	9.62E-03	4.11E-03
	Onshore	5.02E-04	5.02E-04	5.02E-04	5.02E-04	5.02E-04
	Total	**3.81E-03**	**3.81E-03**	**9.79E-03**	**1.01E-02**	**4.61E-03**
Total Offshore		3.28E-02	3.23E-02	6.39E-02	6.68E-02	5.20E-02
Total Onshore		8.38E-03	8.38E-03	8.38E-03	8.38E-03	8.38E-03
Overall Total		**4.12E-02**	**4.07E-02**	**7.23E-02**	**7.52E-02**	**6.03E-02**

Note 1: SSCV values for Lima, Mike and November are assumed the same as HLV value
Note 2: Total offshore values are excluding activities related to mobilisation.

Jacket Decommissioning

Table B.2.1.2 below shows that the Added Buoyancy option carries roughly double the risk of the HLV option. On average the onshore work contributes 7% of the risk and the offshore work contributes 93%.

As for the topsides, the onshore work remains constant. If the offshore work is considered by itself, the Added Buoyancy option carries 2.26 time the risk of the HLV option.

Table B.2.1.2: PLL for Jacket Decommissioning Options

Decommissioning Options / Inde Platform	HLV	Added Buoyancy
	Potential Loss of Life	
Juliet Offshore	6.88E-03	2.14E-02
Juliet Onshore	1.28E-03	1.28E-03
Juliet Total	**8.16E-03**	**2.27E-02**
Kilo Offshore	6.90E-03	1.20E-02
Kilo Onshore	8.29E-04	8.29E-04
Kilo Total	**7.73E-03**	**1.28E-02**
Lima Offshore	4.12E-03	9.83E-03
Lima Onshore	8.49E-04	8.49E-04
Lima Total	**4.97E-03**	**1.07E-02**
Mike Offshore	3.96E-03	7.57E-03
Mike Onshore	6.46E-04	6.46E-04
Mike Total	**4.61E-03**	**8.22E-03**
November Offshore	3.96E-03	7.57E-03
November Onshore	7.14E-04	7.14E-04
November Total	**4.67E-03**	**8.28E-03**
Total Offshore (Excl Mob)	2.58E-02	5.84E-02
Total Onshore	4.32E-03	4.32E-03
Total (Excl Mob)	**3.01E-02**	**6.27E-02**

Pipeline decommissioning

It can be seen from Table B.2.1.3 below that leaving the pipelines in-situ carries effectively a negligible risk, and that the Reverse S-Lay and Cut & Lift options both carry a significant risk.

On average the onshore work for the Reverse S-Lay and Cut & Lift options contributes 9% of the risk and the offshore work contributes 91%. There is no onshore contribution for the In-Situ option.

Table B.2.1.3: PLL for Pipeline Decommissioning Options

Decommissioning Options / Inde Pipeline	Insitu	Reverse S-Lay	Cut & Lift
	Potential Loss of Life		
PL80,81&82 Offshore	1.90E-04	9.00E-03	1.06E-02
PL80,81&82 Onshore	0.00E+00	2.09E-03	5.17E-04
PL80,81&82 Total	**1.90E-04**	**1.11E-02**	**1.11E-02**
PL302 & 402 Offshore	1.90E-04	5.57E-03	4.78E-03
PL302 & 402 Onshore	0.00E+00	1.48E-04	1.48E-04
PL302 & 402 Total	**1.90E-04**	**5.72E-03**	**4.93E-03**
Total	**3.80E-04**	**1.68E-02**	**1.60E-02**

Hose bundle decommissioning

Table B.2.1.4 below shows that the two options of leaving the hose bundles in-situ and recovery both carry a relatively small risk, though the recovery option carries a 1.43 times higher risk.

It is assumed that the hose bundles will be sent to landfill if recovered, and will therefore incur no onshore demolition risk.

Table B.2.1.4: PLL for Hose Bundle Decommissioning Options

Decommissioning Options / Inde Hose Bundle	Insitu	Recovery
	Potential Loss of Life	
PL303 & PL479-487 Offshore	1.90E-04	2.72E-04
PL303 & PL479-487 Onshore	0.00E+00	0.00E+00
Total	1.90E-04	2.72E-04

APPENDIX C

Environmental Impacts of Decommissioning Options

APPENDIX C – CONTENTS

C.1 Methods for assessing the environmental impacts of decommissioning

This section presents an assessment of the environmental risks that may arise directly or indirectly from routine, non-routine and emergency situations during implementation of each of the short-listed options for decommissioning the Indefatigable platforms, pipelines and hose bundles.

C.1.1 Risk assessment method

The environmental risks associated with each of the decommissioning options were assessed using a methodology based on the principles outlined in the Shell Corporate Guidance for Risk Assessment (Shell, 2000). The assessment can be broken down into a series of steps.

- Each of the short-listed options was reviewed to identify the potential causes of environmental risks in each of the activities involved in these options.

- The potential "receiving environment", including natural and social aspects, was assessed in order to identify and characterise any sensitive elements.

- The risks identified and the relevant environmental sensitivities were brought together in order to describe and quantify the effects of each decommissioning option. The risks were quantified in accordance with pre-defined consequence and probability criteria shown in Tables 1-1 and 1-2. The assessment was based on experience and the knowledge of outcomes of similar events, published information or expert judgment. Any control or mitigation measures which may be in effect when the activity is carried out are also taken into account.

- An overall risk rating was assigned to each aspect of the decommissioning option under consideration using a two-dimensional Risk Assessment Matrix based on the principle that risk is a product of the two factors: ***probability*** and ***consequence*** (Table 1-3).

Table 1-1: Consequence criteria for environmental risk assessment

Consequence	Description
Severe	Environmental issue, impact or risk that could constrain the Company's operations in a business area, sector or field. Degradation or loss of ecologically, commercially or culturally important species or biodiversity, typically on a regional, national or international scale, or an irreversible detrimental loss on a local scale. Atmospheric emissions at levels which compromise national targets or which result in detrimental transboundary or cumulative impacts. Loss with no potential of recovery of natural resources to the detriment of dependant users. Multiple fatalities or serious health impacts. Permanent disruption to business, communities or individuals, with consequential loss of revenue or amenity. Loss of control, loss of containment or emergency event with consequences on a national or international scale.
Major	Environmental issue, impact or risk that could constrain the viability of the option. Degradation or loss of ecologically, commercially or culturally important species or biodiversity, typically well beyond the source of the effect. In general, recovery potential over a long term (>5 year) period. Substantial source of atmospheric emissions or contributor to transboundary or cumulative impacts. Lasting impacts on natural resources to the detriment of dependent users. Detrimental effects on human health. Substantial disruption to business, communities or individuals, with consequential loss of revenue or amenity. Loss of control, loss of containment or emergency event with serious consequences. Emissions or spills which will jeopardise the ability to meet asset operational performance targets.
Moderate	Degradation or loss ecologically, commercially or culturally important species or biodiversity over a localised area, typically limited to the vicinity of the source of the effect. Generally, there is the potential for recovery to a normal healthy, representative state over a medium term period (2 to 5 years). Moderate contribution to global atmospheric, transboundary or cumulative processes. Atmospheric emissions generally at levels around 1% of daily national emissions for industry sector. Temporary (1 week to 6 months) impacts on natural resources to the detriment of dependent users. Temporary detrimental effects on well being (rather than health) of people Short-term disruption to business, communities or individuals, with consequential loss of revenue or amenity. Small-scale loss of control, loss of containment emergency event which can be remedied onsite. Emissions or spills which impact upon the operational performance targets for the asset.

Consequence	Description
Minor	Degradation or loss, ecologically, commercially or culturally important species or biodiversity over a localised area, typically limited to the vicinity of the source of the effect. Generally, there is the potential for recovery to a normal healthy, representative state over a short-term period (<2years). Minor contribution to global atmospheric, transboundary or cumulative processes. Atmospheric emissions generally at levels around the company target for installation/activity. Localised transient (<1 week) impacts on natural resources to the determent of dependent users. Transient (< 1 week) effects on well being (rather than health) of people. Transient disruption to business, communities or individuals, which causes nuisance rather than loss of revenue or amenity. Minor leaks, drips and incidents which can immediately remedied onsite. No impact on operational performance targets from emissions or spills.
Negligible	Localised, transient disruption to ecologically, commercially or culturally important species or biodiversity close to the source of the effect, with rapid recovery to a normal healthy, representative state. Negligibly small contribution to global atmospheric, transboundary or cumulative processes. Negligibly small impacts on resource quality or availability which is not to the detriment of dependent users. Transient nuisance which does not affect human health or well being. No disruption to business, communities or individuals. No apparent risk of spills or incidents.
Positive	Enhancement of habitats, or ecologically, commercially or culturally important species.

C.1.2 Assessment and comparison of environmental impacts of different options

Assigning the risks to one of four categories shown in table 1.3 allowed a wide range of potential risks to be screened, so that attention could be focussed on important risks that could be influential in the selection of an option, for those facilities where more than one option was available. Risks in these categories were then subjected to more detailed assessment in order to provide information about the absolute level of impact that might be experienced should the risk be realised.

Different options for any facility were compared by a combination of quantitative and qualitative examinations of their performance. The numbers of "positive outcomes", and "highly significant" and "significant" negative risks together with any "not significant" risks in each option were compared.

Table 1-2: Risk assessment probability criteria

CATEGORY	DESCRIPTION	PROBABILITY (indicative value)
Definite	Should definitely occur.	100%
Likely	Likely to occur during normal operation, given the controls and/or mitigation proposed.	1% to 99%
Possible	Could occur infrequently during normal situations given the controls and/or mitigation proposed, or more readily during abnormal or emergency situations.	0.01% to 1%
Unlikely	Unlikely during normal operation given the controls and/or mitigation proposed, but may occasionally occur during abnormal or emergency situations.	0.001% to 0.01%
Remote	Extremely unlikely during both normal and abnormal or emergency situations given the controls and/or mitigation proposed.	<0.001%

Table 1.3 provides a matrix that shows how the combined levels of probability and consequence have been used to determine the risk rating. These fall into three negative categories, and one positive category covering the beneficial outcomes of decommissioning. The four risk ratings are:

- **Highly Significant Risks** (Red zone in Table 1.3). Risk level is intolerable.
- **Significant Risks** (Amber zone in Table 1.3). Seek to incorporate further risk reduction measures and/or demonstrate that risk is ALARP (As Low As Reasonably Practicable).
- **Not Significant Risks** (Green zone in Table 1.3). Risk is acceptable but should be managed to achieve continuous improvement.
- **Positive Outcomes** (Blue zone in Table 1.3). These could be beneficial because they resulted in the avoidance of environmental harm, the enhancement of resource stewardship, or socio-economic or environmental gain.

Table 1-3: Matrix showing how the criteria of probability and consequence are combined to generate an overall risk rating

		Probability				
		Remote	Unlikely	Possible	Likely	Definite
Significance	Severe	R6	U6	P6	L6	D6
	Major	R5	U5	P5	L5	D5
	Moderate	R4	U4	P4	L4	D4
	Minor	R3	U3	P3	L3	D3
	Negligible	R2	U2	P2	L2	D2
	Positive	R1	U1	P1	L1	D1

Key:

Highly Significant Zone	Significant Zone	Not Significant Zone	Positive Zone

C.2 Offshore Environmental Description of the Indefatigable Field

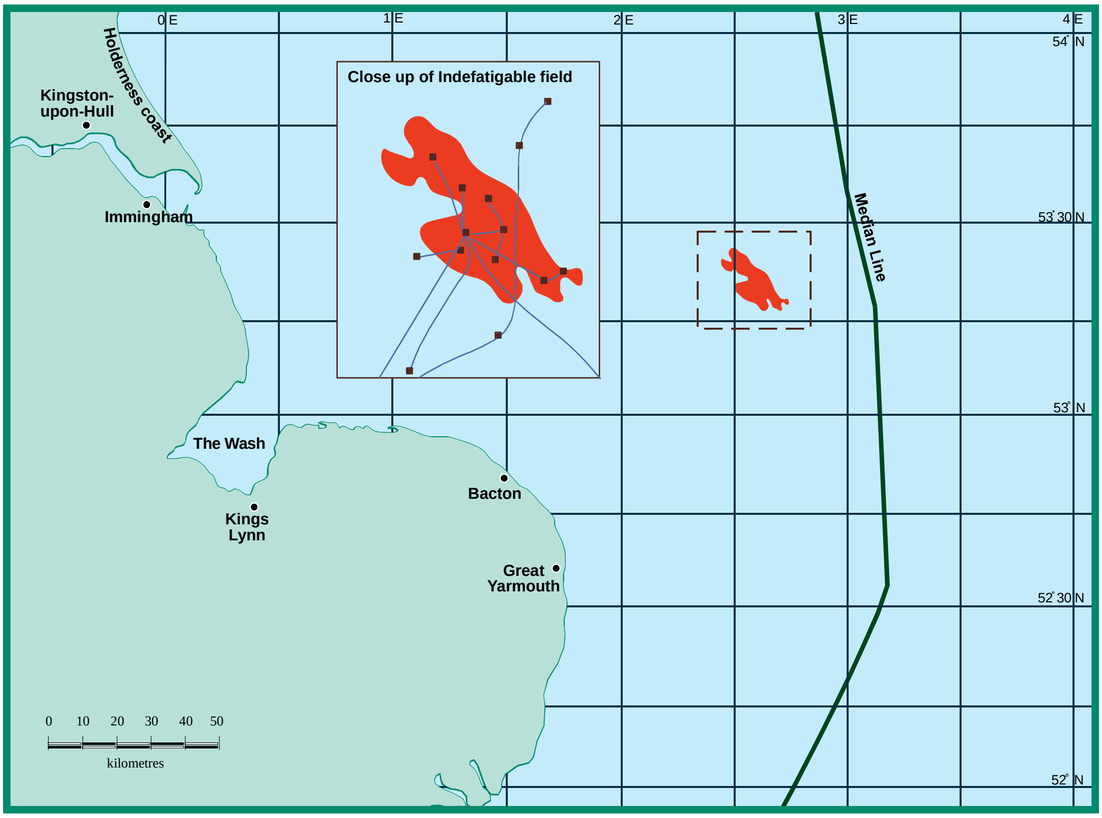
In order to assess the potential environmental impacts of decommissioning operations at the Indefatigable facilities, a description of the existing environment, and an assessment of the key offshore environmental sensitivities is given below.

C.2.1 Offshore Location

The Indefatigable Field lies in Quadrant 49 and spans Blocks 49/18, 49/19, 49/23 and 49/24 in the southern North Sea, in an area known as the Norfolk Banks. It is situated 94km northeast of Great Yarmouth and 21km from the UK/Dutch transboundary line, in water depths of approximately 31m (**Figure 2-1**).

The area is typical of the offshore regions in the southern North Sea, where hydrographical, meteorological, geological and biological characteristics are relatively constant over large areas (Shell, 2001). Sea users present in the area comprise oil and gas exploration and development, shipping and fishing (Shell, 2001).

Figure 2-1: Location of the Indefatigable Field in the southern North Sea



C.2.2 Meteorology

Seasonal wind roses for the area in the vicinity of the Indefatigable field are provided in **Figures 2-2a** and **2-2b**. The predominant wind direction throughout the year is westerly, although there are seasonal variations. Between September and February, wind direction is predominantly south-westerly, whereas between March to August winds from a north-westerly direction predominate. Wind speeds in the area of Indefatigable are mainly between 17 and 27 knots (fresh to strong breezes). Between the months of April to July, wind speeds ranging from 1 to 16 knots (light air to moderate breeze) are equally dominant. Strong winds (exceeding 28 knots) occur most frequently between September and March.

C.2.3 Seabed topography

This area of the southern North Sea is characterised by water depths that are frequently less than 50m (Shell, 2001). The water depth at Indefatigable is approximately 31m (**Figure 2-3**).

C.2.4 Currents

The shallower waters of the southern North Sea remain permanently mixed throughout the year due to the influence of strong tidal currents (maximum tidal stream at average spring tides is approximately 1.5 knots) (OSPAR Commission, 2000). The tidal streams flow in a predominant north-westerly to south-easterly direction. Two oceanic currents influence the current direction within the Blocks (Shell, 2001). The first floods southwards from the east coast of Scotland to the northern coast of Norfolk and turns to flow in an easterly direction through the Blocks, known as South North Sea water. The second is Channel water which flows through the English Channel and the Straits of Dover, following the coast of the Netherlands, Germany and Denmark (Shell, 2001). It approaches Indefatigable from the south, travelling in a northerly direction (UKDMAP, 1998).

Figure 2-2a: Seasonal wind roses for Indefatigable (January to June)

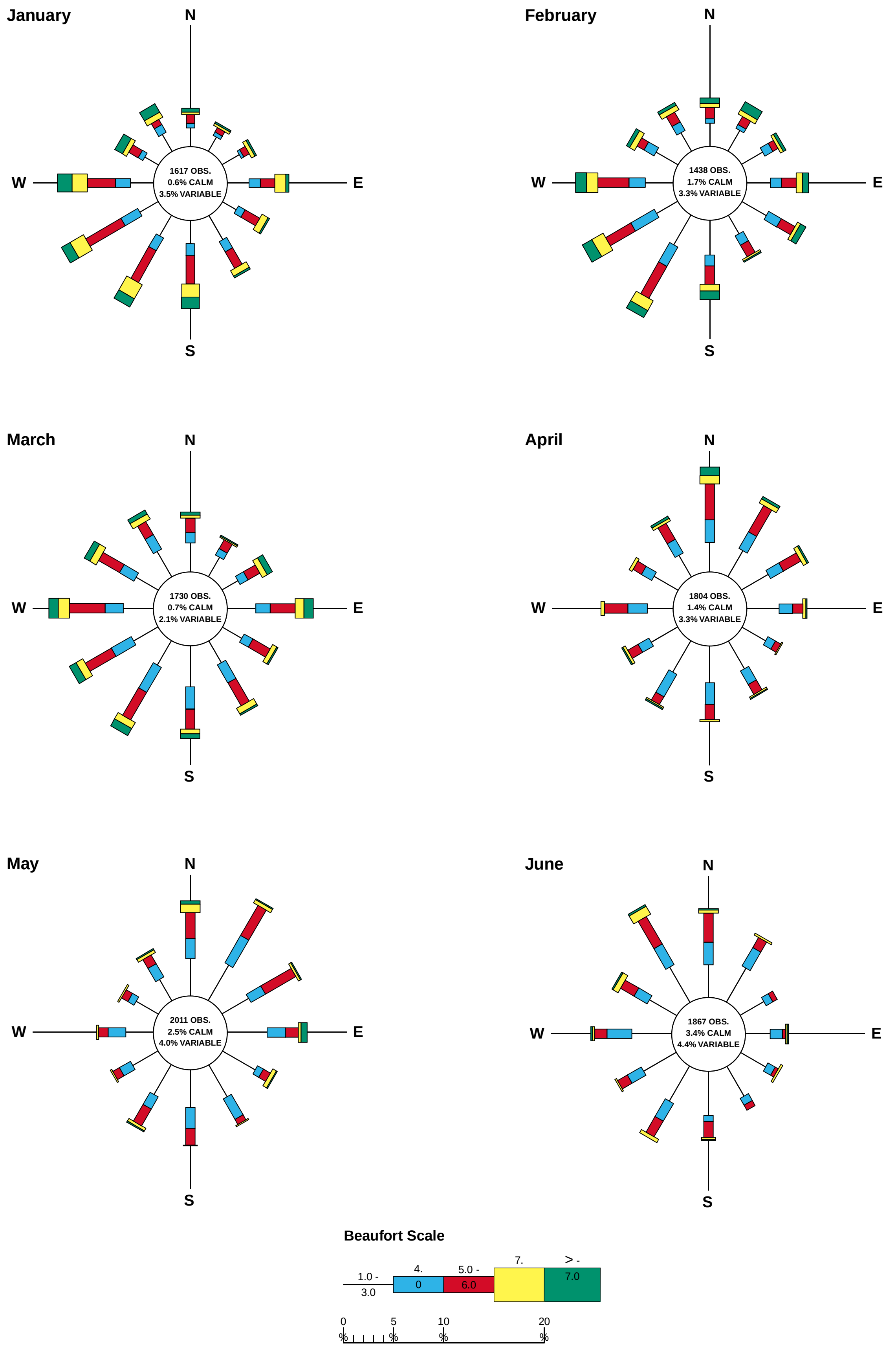
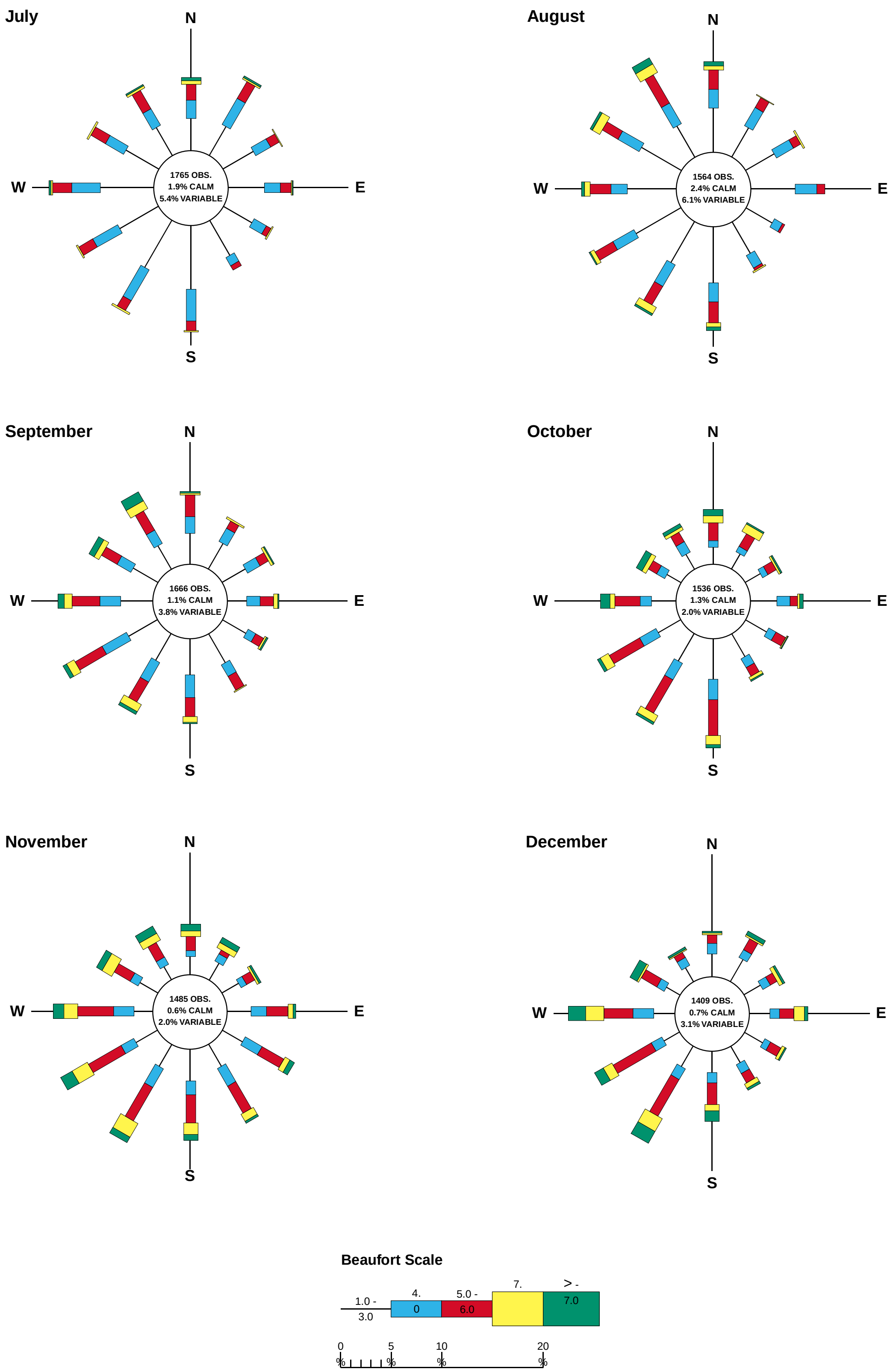


Figure 2-2b: Seasonal wind roses for Indefatigable (July to December)



Source: The Met Office (1998b), data for 52.9 - 53.9 N, 01.5 - 02.5 E for period June 1925 to July 1997

C.2.5 Temperature and salinity

The seasonal variation in sea temperature is shown in **Table 2-4**. Water temperature is relatively uniform through the water column during the winter and summer months. In general, all the areas south of 54°N remain vertically mixed all year round due to the influence of strong tidal currents, whereas in the deeper water to the north, thermal stratification occurs during the summer months. Minimum sea temperatures of approximately 5°C occur in February and water temperature increases to around 16°C in August (UKDMAP, 1998). Where there is a transition zone between mixed and stratified waters, a thermal front forms, and this is known as the Flamborough Front. During the summer months, this boundary indicates a marked difference in the water characteristics between the northern and southern North Sea. In the shallower water to the south of this area, tidal stirring is sufficient to overcome the inputs of thermal energy.

In the open waters of the North Sea seasonal changes in sea surface salinity are comparatively small (OSPAR, 2000). **Table 2-4** illustrates that there is little seasonal variation in the salinity of the water column around Indefatigable (UKDMAP, 1998).

Table 2-4: Typical values for temperature and salinity for Indefatigable

	WINTER	**SUMMER**
Mean Sea Surface Temperature	5 ºC	15-15.5 ºC
Mean Bottom Temperature	5 ºC	15-16 ºC
Mean Sea Surface Salinity	34.50 ppt	34.50 ppt
Mean Bottom Salinity	34.4-34.6 ppt	34.4-34.6 ppt

Source: UKDMAP (1998)

C.2.6 Seabed and sediment characteristics

Seabed sediments in the vicinity of Indefatigable comprise predominantly silty sands (Shell, 2001). Holocene sands, which extend approximately 3.4m sub-seabed are underlain by fine, silty sands to 4.2m sub-seabed (Shell, 2001). A layer of very soft clays with occasional pockets and bands of slightly silty, fine sand and occasional shell fragments lies between 4.2m and 8.0m sub-seabed (Shell, 2001). Loose to dense, silty, fine sands underlie the clay layer to a depth of 11.0m sub-seabed (Shell, 2001). The underlying sediments are expected to comprise predominantly medium dense to dense, occasionally very dense, silty, fine sands to a depth of 22m sub-seabed (Shell, 1998).

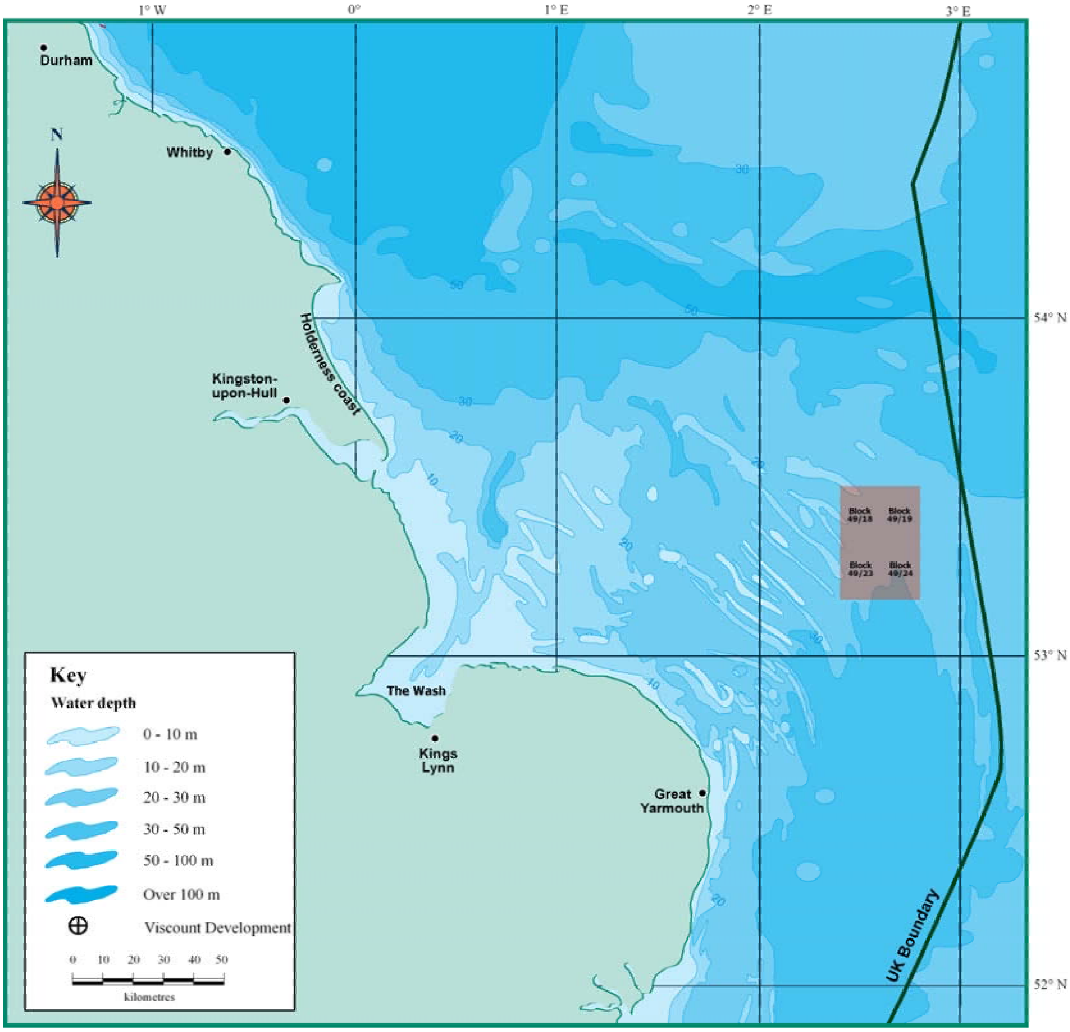


Figure 2-3: Bathymetry of the southern North Sea surrounding the Indefatigable Field

C.2.7 Seabed features

The four main groups of sandbanks in the southern North Sea are the East Bank Ridges, the Sand Hills, the Norfolk Banks and the Wash (BGS, 2001). The origins of the sandbanks in the area are largely linked to the history of Holocene sea-level rise after the last glacial period, and the evolution of Holocene coastlines in the area (Shell, 2001).

Indefatigable occurs within the area classified as the Norfolk Banks, which has both active and inactive sandbanks. These occur between latitudes 54°N and 53°N, and comprise numerous tidal ridges up to 40m in amplitude and between 20-60km in length (Shell, 2001). The banks consist of fine to medium grained sands which show a high degree of sorting (Cameron *et al.,* 1992). The shell content within the sediments of the banks is thought to be low (Shell, 2001). Lying in water depths of 18-40m off the north-east Norfolk coast (BGS, 2001; Huntley *et al.,* 1993), the Norfolk Banks can be divided into nearshore parabolic banks forming a zig-zag pattern, and an outer group of more linear banks (Cameron *et al.,* 1992). The north Norfolk sandbanks are reputed to be the most extensive examples of linear sandbanks with sand sediment in UK waters (JNCC, 2000).

During a DTI-commissioned survey, the surfaces of many of the Norfolk Banks were found to be covered in active sand waves (DTI, 2001). Sand waves, which are smaller scale features than the banks, are conspicuous over large areas of the southern North Sea (Shell, 2001). In this area, sand waves, with heights up to 4m and wavelengths of 50m, are maintained by the sand supplies provided by the modern tidal regime (Collins *et al.*, 1995). Sand waves have their crests aligned more or less at right angles to the bank crest, with their steep faces in opposing directions on either side of the sandbank, reflecting the dominance of a clockwise circulation of sand around the bank (DTI, 2001). These features are actively migrating, with estimates of an average migration rate of up to 15m/yr for southern North Sea sand waves (Cameron *et al.*, 1992). Large sand waves are present on the inner Norfolk banks, with size decreasing with increased distance from shore (Graham *et al.*, 2001). The presence of active bedforms in this part of the southern North Sea provides evidence of a mobile sandy bed and vigorous present-day sediment transport processes (Shell, 2001).

C.2.8 Other sea users

C.2.8.1 Shipping

Shell (2001) provides information on shipping within 10nm of the Brigantine field (adjacent to Indefatigable) using the COAST database. The search identified a total traffic volume of 6,771 vessels per annum using 12 common routes; vessels included merchant craft, tankers, ferries, standby and supply vessels (Shell, 2001).

C.2.8.2 Ministry of Defence

There are six coastal Ministry of Defence (MOD) sites between Flamborough Head and Great Yarmouth. These sites are used for military training and some are designated conservation sites with limited public access. There are no significant offshore MOD areas, although all offshore activities require clearance through the MOD.

C.2.8.3 Wrecks

There are five charted wrecks located in the vicinity of Indefatigable Field (Admiralty Chart 1503), located 7km north northwest, 8km northwest, 11km north northeast, 10.5km east and 12km northeast.

C.2.8.4 Submarine cables

There are no known submarine telecommunication or power cables in the vicinity of Indefatigable.

C.2.9 Offshore Conservation Areas

Environmental Sensitivity of Location

SENSITIVITY: 'Sandbanks which are slightly covered by sea water all the time' and 'biogenic reefs' formed by *Sabellaria spinulosa* are habitat categories identified under Annex I of the Habitats Directive, which are known to occur in the region of the southern North Sea occupied by the Indefatigable Field. The harbour porpoise is the only species defined under Annex II of the Habitats Directive which has been sighted in the vicinity of the Indefatigable Field.

The Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001 implemented the EU Habitats Directive (92/43/EEC) in UK law and is applicable to UK waters up to 200 miles offshore. Four Annex I habitats are currently under consideration for identification as possible Special Areas of Conservation (SACs) in the UK offshore waters (**Table 2-5**) (JNCC, 2002). There are four species listed in Annex II of the Habitats Directive known to occur in UK offshore waters; areas for these species are currently being considered further for identification as possible SACs (**Table 2-5**).

Table 2-5: Annex I and II habitats and species occurring in UK offshore waters

Annex I habitats considered for SAC selection in UK offshore waters	Species listed in Annex II known to occur in UK offshore waters
Sandbanks which are slightly covered by seawater all the time Reefs (bedrock, biogenic and stony) ▪ **Bedrock reefs** – made from continuous outcroppings of bedrock which may be of various topographical shape; ▪ **Stony reefs** – these consist of aggregations of boulders and cobbles which may have some finer sediments in interstitial spaces; and ▪ **Biogenic reefs** – formed by cold water corals (e.g. *Lophelia pertusa*) and *Sabellaria spinulosa*. Submarine structures made by leaking gases Submerged or partially submerged sea caves	▪ Grey seal ▪ Common seal ▪ Bottlenose dolphin ▪ Harbour porpoise

Source: JNCC, 2002.

C.2.9.1 Annex I habitats

Pockmarks (shallow, ovoid, sea-bed depressions) containing carbonate structures (Methane Derived Authigenic Carbonate (MDAC)) deposited by methane-oxidising bacteria from submarine structures, may fit within the definition of the Annex I habitat of "submarine structures made by leaking gases". Surveys and modelling studies have shown that the most readily pockmarked sediments are soft, silty muds (DTI, 2001).

The distribution of pockmarks in the UK North Sea is strongly correlated with that of the Witch Ground and Flags Formation sediments (DTI, 2001) and, therefore, they do not occur in the southern North Sea.

Submerged or partially submerged sea caves are widely distributed in inshore waters, but no examples are currently known offshore (between 12 and 200 nautical miles from the coast) (JNCC, 2004a) and, therefore, this habitat type is absent from this region of the southern North Sea.

C.2.9.1.1 Sandbanks

'Sandbanks which are slightly covered by sea water all the time' is one of the habitat categories identified under Annex I of the Habitats Directive (JNCC, 2002). This habitat type consists of soft sediment types that are permanently covered by shallow seawater, typically at depths of less than 20m below chart datum. Candidate sites have been selected to cover the geographical and ecological range of variation of the following categories:

- gravelly and clean sands;
- muddy sands;
- eelgrass *Zostera* marina beds; and
- maerl beds.

In 2001, the DTI commissioned a Strategic Environmental Assessment (SEA) of the mature areas of the North Sea (DTI, 2001). As part of the SEA2 process, habitats of potential conservation interest, including pockmarks and offshore shallow (<20m) sand areas within the SEA2 areas were surveyed. Some of the shallow sandbanks off the Norfolk Coast (Indefatigable, Swarte, Broken, Well, Inner, Ower and Leman banks), within the southern North Sea, may be designated as candidate Special Areas of Conservation (cSACs) under the Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001.

C.2.9.1.2 Biogenic Reefs

Biogenic reefs, including those that can be formed under certain conditions by the polychaete worm *Sabellaria spinulosa* (Ross worm), are defined under the Habitats Directive, and as such, may be subject to future designation under the Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001. Investigations by ConocoPhillips (unpublished data) suggest that there are extensive patches of *S.spinulosa* in parts of the southern North Sea. In June 2004, the Joint Nature Conservation Committee (JNCC) recommended that the *S.spinulosa* reef surrounding the Saturn development (ConocoPhillips), located between the Swarte and Broken banks, should be proposed as a SAC (JNCC, 2004a).

Sabellaria spinulosa builds tubes with sediment that has been removed from the water column through feeding, and in certain circumstances reefs are formed. *S.spinulosa* can form reefs in a variety of seabed types, including those on hard substrate, on shells and on sandy gravel (Holt *et al.*, 1998). The reefs are solid but fragile structures at least several centimetres thick, which are raised above the surrounding seabed and may persist for many years (UKBAP, 2004). As such, they provide a biogenic habitat that allows many other associated species to become established (UKBAP, 2004). The *S.spinulosa* reef habitats of greatest nature conservation significance are those which occur on predominantly sediment or mixed sediment areas (UKBAP, 2004). These enable a range of epibenthic species, with their associated fauna and a specialised 'crevice' infauna which would not otherwise be found in the area, to become established (UKBAP, 2004).

Sabellaria spinulosa is naturally common around the British Isles in the subtidal and lower intertidal/sublittoral fringe with a wide distribution throughout the north-east Atlantic, especially in areas of turbid seawater with a high sediment load (UKBAP, 2004). In most parts of its geographical range, *S.spinulosa* does not form reefs, but is solitary or occurs in small groups encrusting pebbles, shell, kelp holdfasts and bedrock (UKBAP, 2004). Where conditions are favourable, much more extensive thin crusts can be formed, sometimes covering extensive areas of seabed (UKBAP, 2004). However, these crusts may be only seasonal features, being broken up during winter storms and quickly reforming through new settlement the following spring (UKBAP, 2004). These crusts are not considered to constitute true *S.spinulosa* reef habitats because of their ephemeral nature (UKBAP, 2004).

It is probable that *S.spinulosa* can tolerate smothering for a number of weeks. *S.spinulosa* is reliant on suspended sediment and thus any increase in suspended sediment will facilitate tube construction and may result in increased populations. Prolonged periods of sediment disturbance, however, may hinder growth and reproduction (MarLIN, 2003). Although the larvae are known to be highly sensitive to chemical contaminants, some individuals have been found to thrive in contaminated areas (Holt *et al.*, 1998). Overall, it is thought that *S.spinulosa* can recover rapidly from physical disturbance.

Figure 2-4: Tubes built by the polychaete worm, *Sabellaria spinulosa* (Ross worm)

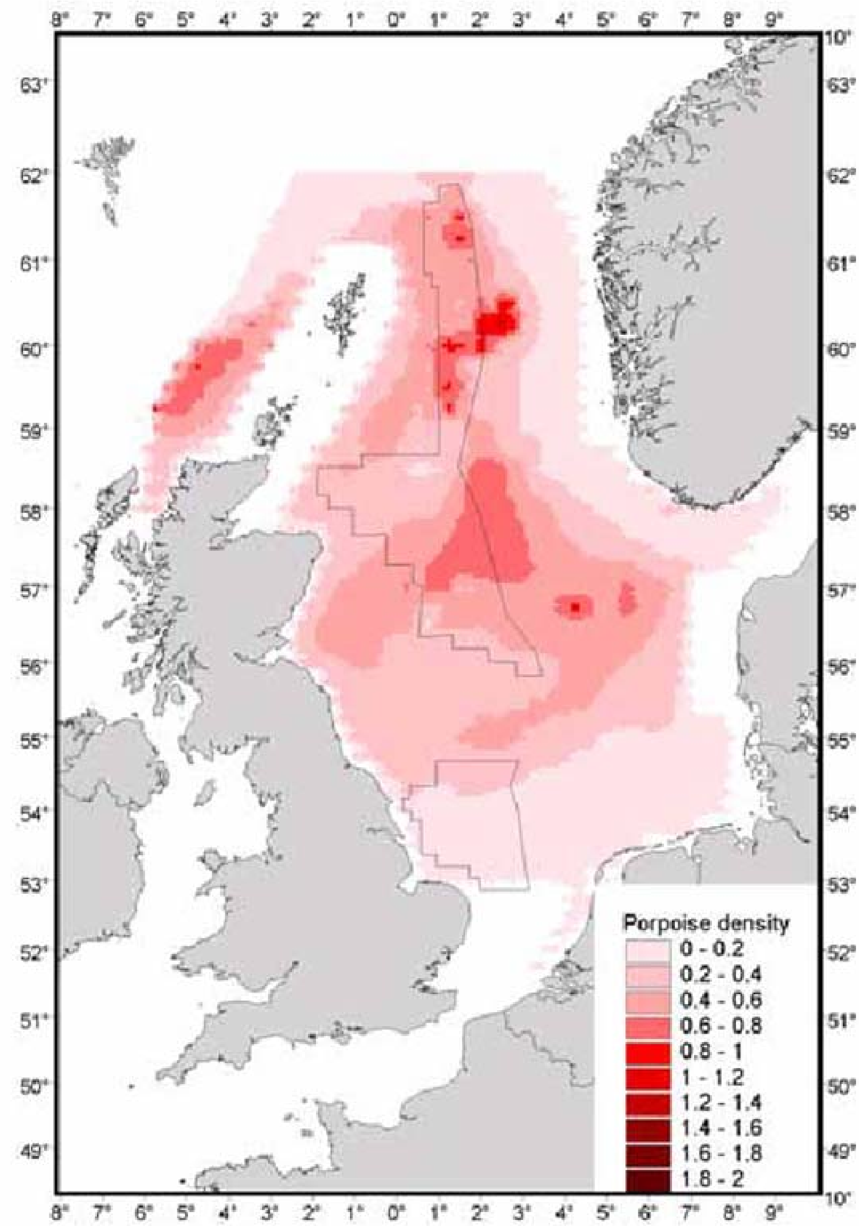
C.2.9.2 Annex II species

Harbour porpoise, which is listed in Annex II of the Habitats Directive, is known to occur in the vicinity of the Indefatigable Field. The frequency of sightings in the vicinity of the Indefatigable Field is generally very low, with the exception of the month of March, when moderate numbers have been recorded (UKDMAP, 1998). Little information exists for the overall distribution and abundance of this species in UK waters. A UK survey covering 60-70% of relevant habitat in UK waters was undertaken as part of the SCANS project (Hammond *et al.,* 1995). It estimated that the total population within the UK's Exclusive Economic Zone (EEZ), extending up to 200 nautical miles offshore, is approximately 150,000. However, the number of harbour porpoise present in UK waters varies seasonally, and more animals are likely to pass through UK waters than are present at any one time (Jackson & McLeod, 2002). The JNCC and other country agencies are currently analysing distribution data for harbour porpoise in UK waters to determine whether any suitable sites for SAC designation can be found (Jackson & McLeod, 2002). **Figure 2-5** shows the distribution of porpoise density (in schools km^{-2}) calculated from sightings made from ships during the SCANS surveys (Burt *et al.,* 1999).

Studies have shown that Common (harbour) seals forage over wide areas of the North Sea (Bjørge, 1991; Reijnders *et al.,* 1998; DTI, 2002). It is expected that the population inhabiting the east coast of England, of which The Wash is the largest concentration (representing 7% of the UK population), behaves similarly (DTI, 2002). The Wash has been proposed as a coastal SAC (JNCC, 2004b). Common seals are, therefore, likely to be distributed over much of the central and southern North Sea (DTI, 2002). There is little known information, however, on the number of Common seals likely to occur in the vicinity of the Indefatigable Field. Annex II species are typically wide ranging, thus making it difficult to identify specific marine areas which may be deemed essential to their life and reproduction, and which may, therefore, be considered for suitable SACs.

Figure 2-5: Harbour porpoise density (schools per square km) predicted from spatial modelling of the SCANS data

Source: DTI (2002)



C.2.10 Biological Resources

Operations associated with the decommissioning of offshore oil and gas structures may impact on the seabed and associated flora and fauna, as well as on the plankton, fish stocks, seabirds and mammals that live on or migrate through the area associated with the activity. An outline of susceptible flora and fauna in the region surrounding the Indefatigable Field, and their vulnerability to environmental conditions, is given below.

C.2.10.1 Plankton

SENSITIVITY: The planktonic community is potentially sensitive to oil and chemical discharges into the sea. The planktonic community at Indefatigable is typical of the area and has the capacity to recover quickly because there is a continual exchange of individuals with surrounding waters. Any impacts from offshore oil and gas operations are likely to be small in comparison with the natural variations. However, any decrease in the distribution and abundance of planktonic communities, which may result from discharges of e.g. biocides and oil, could result in secondary effects on higher organisms that depend on the plankton as a food source.

The planktonic community is composed of a range of plants (phytoplankton) and animals (zooplankton) that drift freely on the ocean currents, and together form the basis of the marine food chain. Planktonic organisms, primarily copepods, constitute a major food resource for many commercial fish species, such as cod and herring (Brander, 1992), and any changes in their populations are of considerable importance.

The majority of phytoplankton are uni-cellular, and include diatoms and dinoflagellates. Zooplankton is composed of a wide variety of multi-cellular herbivorous and carnivorous organisms. Typical zooplankton organisms are the copepods, arrow worms, krill, jellyfish and sea-gooseberries. Zooplankton also include the larval stages of non-planktonic organisms, such as fish, crabs and barnacles.

C.2.10.1.1 Phytoplankton

Phytoplankton are the primary producers of the marine environment and fix light energy by means of photosynthesis. Phytoplankton is grazed by the secondary producers, including some zooplankton species. In continental shelf waters, zooplankton are in turn consumed by fish (e.g. herring) and larger animals, including some cetaceans. Phytoplankton abundance and productivity is dependent on light intensity and nutrient availability, which is affected by water column stratification. Under optimal conditions they can reproduce quickly to produce 'blooms'.

Seasonal stratification, the separation of the water column into layers of different temperature, has an important impact on phytoplankton abundance. During the summer months stratification causes a depletion of nutrients in the surface water after rapid periods of phytoplankton growth. Typically, the abundance of phytoplankton peaks in spring when nutrients are abundant; following this numbers will decline through the summer with occasionally a small increase in the autumn as nutrient levels increase due to mixing of the water column.

The water column in the area of Indefatigable is generally well mixed, but species richness can change rapidly depending on nutrient input from the freshwater discharge from the east coast of England and mainland Europe. The typical diatom species in this area include *Ceratium tripos, Dinophysis norvegica* and *Noctiluca scintillans* (BMT Cordah, 2002).

C.2.10.1.2 Zooplankton

Zooplankton abundance in the area of Indefatigable is governed by their main food source, the phytoplankton; hence zooplankton abundance increases shortly after the phytoplankton bloom in spring. The principal organisms which constitute the zooplankton in the waters around Indefatigable include polychaetes, decapods and echinoderm larvae, fish eggs, and small neritic copepods, including *Temora longicornis, Labidocera wollastoni* and *Centropages hamatus* (Williams *et al.*, 1993). Other common copepods found in the area include *Isais clavipes, Phaeocystis pouchetii* and *Corycaeus* spp. (BMT Cordah, 2002).

C.2.10.2 Benthic communities

SENSITIVITY: Benthic infaunal communities are vulnerable to physical and chemical disturbances to the sediment. In the context of Indefatigable, sources of physical disturbance include smothering by sediment during decommissioning operations, or chemical discharges into the sea. Both these mechanisms can substantially alter the composition of the community within the disturbed area.
Benthic communities in the Indefatigable Field area are similar to those found throughout the surrounding area, but reports suggest that extensive patches of the reef-forming polychaete worm *Sabellaria spinulosa* occur in parts of the southern North Sea. Biogenic reefs formed by *S. spinulosa* are listed under the Annex I habitats, which are currently under consideration for identification as possible SACs in UK offshore waters. It is thought that *S. spinulosa* can recover rapidly from physical disturbance (MarLIN, 2003).

There have been several studies summarising the biology of the central and southern North Sea (Kingston and Rachor, 1982; Creutzberg *et al.*, 1984), including a number of classifications of the whole of the North Sea into distinct faunal regions (Petersen, 1914; Jones, 1950; Glémarec, 1973). Much of the survey work in different parts of the North Sea has been carried out using different methods and techniques and, as a consequence, the results are not comparable. During 1986 the whole of the North Sea was surveyed by an ICES working group using standard techniques and equipment (Künitzer *et al.*, 1992). This survey identified that species distributions and assemblages were influenced by temperature, sediment type and different water masses, and the food supply to the benthos. **Table 2-6** details the assemblages identified. Assemblages Ia and IIb are characteristic of the southern North Sea.

Table 2-6: Characteristic benthic fauna from sediments in the North Sea

Assemblage	Water depth (m)	Sediment type	Indicator species
Ia	<30	"Coarser"	Polychaete *Nephtys caeca*; Sea urchin *Echinocardium cordatum*; Amphipod *Urothoe poseidonis*.
IIa	30-50	Muddy fine sediment	Bivalve mollusc *Nucula nitidosa*; Crustacean *Callianassa subterranea*; Cumacean *Eudorella truncatula*.
IIb	30-70	Fine sand	Polychaete *Ophelia borealis*; Polychaete *Nephtys longosetosa*.
IIIa	70-100	"Finer"	No indicator Species

Source: Künitzer *et al*. (1992)

The polychaete worm *Sabellaria spinulosa*, which can form biogenic reefs, is known to occur in extensive patches in the southern North Sea (ConocoPhillips, unpublished data). Such reefs are of particular conservation value as they allow a range of epibenthic species, with their associated fauna and specialised infauna, to become established (UKBAP, 2004); biogenic reefs are defined under the Habitats Directive (JNCC, 2002).

Characteristic free-living epibenthic species of the southern North Sea were identified by Jennings *et al.* (1999) as the sand-dwelling brittle star *Ophiura ophiura,* hermit crab *Pagurus bernhardus*, common star fish *Asterias reubens* and the flying crab *Liocarcinus holsatus*. Data from the oil and gas industry's Strategic Environmental Assessment 2 (SEA2) survey show that the North Norfolk sand banks community is characterised by heart urchin *Echinocardium cordatum* and the bivalve *Fabulina fabula* (DTI, 2001).

C.2.10.3 Marine mammals

SENSITIVITY: There is evidence to suggest that marine mammals are potentially sensitive to chemical discharges, such as those that may occur during the Indefatigable decommissioning process. They may also be vulnerable to injury from collisions with vessels and sensitive to underwater noise resulting from any decommissioning activity, although the effects of the latter are not well documented.
The region around the Indefatigable Field is not particularly rich in cetaceans. Sensitivity is considered to be low even during the months with the highest populations in the area. Harbour porpoise is the only Annex II species to have been sighted in the Indefatigable area. Common seals may also occur in the region, but there is little information on their precise distribution and numbers.

Marine mammals include seals (pinnipeds), whales, dolphins and porpoises (cetaceans), all of which are susceptible to chemical and noise pollution from offshore oil and gas operations.
Common seals are one of the most widespread pinniped species and are found in all coastal waters around the North Sea, including Orkney and Shetland (DTI, 2001). Their distribution at sea is constrained by the need to return periodically to land (DTI, 2002). Until recently, the available data showed that Common seals were unlikely to be found more than 60km from shore (DTI, 2002). However, recent studies have revealed that this species forages much further offshore than previously thought (DTI, 2002).

Grey seals are mainly restricted to the North Atlantic (DTI, 2002); Grey seals that haul out along the western shores of the North Sea are distributed mainly to the west of 0° longitude (DTI, 2002). There are tracks in northern, central and southern North Sea areas, but these do not appear to be major areas for grey seals (DTI, 2002).

About 16 of the 80 known species of cetacean have been recorded off the UK coast (SMRU, 2003). These include the large baleen whales, notably fin, sei and minke whales, but also blue and humpback whales. The largest toothed whale, the sperm whale, also occurs around Britain, although only adult males have been seen (SMRU, 2003). Medium-sized whales are represented by the pilot and killer whales, while small species include Risso's dolphin, white-sided, white-beaked, common and striped dolphin, as well as the harbour (common) porpoise and bottlenose dolphin.

All species of cetacean are protected under the Wildlife and Countryside Act 1981 and the Wildlife (Northern Ireland) Order 1985, and are listed on Annex IV (Animal and Plant Species of Community Interest in Need of Strict Protection) of the EC Habitats Directive. Under Annex IV, the keeping, sale or exchange of such species is banned as well as their deliberate capture, killing or disturbance. In addition, the harbour porpoise, bottlenose dolphin, grey seal and harbour seal are also listed in Annex II of the Habitats Directive. Member countries of the EU are required to consider the establishment of Special Areas of Conservation (SACs) for Annex II species.

C.2.10.3.1 Cetacean abundance and distribution

The region around the Indefatigable field is not particularly rich in cetaceans; the most frequently occurring marine mammals in the area are those mainly associated with relatively shallow continental seas (Evans, 1995). The most frequently sighted marine mammal in the vicinity of Indefatigable is the harbour porpoise. Although harbour porpoise occur throughout the year in the southern North Sea, the frequency of sightings in the vicinity of the Indefatigable Field is generally very low, with the exception of the month of March (UKDMAP, 1998) (**Table 2-7**).

Although this species is known to be widespread in the North Sea, the animals are difficult to detect due to their small size and shy nature. White-beaked dolphins are also widely distributed in the offshore waters of the southern North Sea and have been recorded in the vicinity of the Indefatigable during the months of April and May (UKDMAP, 1998) (**Table 2-7**).

Table 2-7: Seasonal marine mammal sightings in the vicinity of Indefatigable in Quadrant 49

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Harbour porpoise	0	4	2	4	4	0	0	4	0	0	0	0
White-beaked dolphin	0	0	0	3	4	0	0	0	0	0	0	0

KEY
1 High numbers (>=0.5 animals per km)
2 Moderate numbers (0.20 to 0.49 animals per km)
3 Low numbers (0.10 to 0.19 animals per km)
4 Very low numbers (0.01 to 0.09 animals per km)

Source: UKDMAP (1998)

C.2.10.3.2 Pinniped abundance and distribution

Common seals have been tracked using satellite-link telemetry from Scotland (SMRU, University of St Andrews) and Denmark (Fisheries Museum, Esbjerg and ELSAM, Denmark); (DTI, 2002). These studies clearly show that Common seals forage over wide areas of the North Sea (Bjørge, 1991; Reijnders *et al.,* 1998; DTI, 2002). It is expected that the population inhabiting the east coast of England behaves similarly and is , therefore, likely to be distributed over much of the central and southern North Sea (DTI, 2002). There is little known information, however, on the numbers of Common seals likely to occur in the vicinity of the Indefatigable Field.

C.2.10.4 Fish populations/Spawning and nursery areas

SENSITIVITY: Fish are vulnerable to pollution, particularly during the egg, larval and juvenile stages of their lifecycle. Demersal spawning fish and fish/shellfish that live in close association with seabed sediments are vulnerable to sediment disruption resulting from the proposed decommissioning project. Spawning and nursery grounds for *Nephrops* coincide with the Indefatigable Field and therefore *Nephrops* are vulnerable to decommissioning operations. The Indefatigable Field also coincides with the spawning grounds of mackerel, cod, plaice, lemon sole and sprat. There is no direct threat to the viability of these populations as such fish communities are present throughout the area and elsewhere in the North Sea.

A total of 224 species of fish have been recorded in the North Sea, most of which are typical species of shelf seas, although deepwater species are found along the northern shelf edge and in the deepwater channel of the Norwegian Trench and the Skagerrak. It is estimated that fewer than 20 species constitute over 95% of the total fish biomass. North Sea finfish can be broadly classified as:

- pelagic species which occur in shoals swimming in mid-water, typically making extensive seasonal movements or migrations between sea areas. Pelagic species include herring, mackerel, blue whiting and sprat; and
- demersal species which live on or near the seabed and include cod, haddock, plaice, sandeel, sole, and whiting.

Shellfish species include demersal (bottom-dwelling) molluscs and crustaceans, such as shrimps, crabs, *Nephrops norvegicus* (Norway lobster), mussels and scallops.

Generally there is little interaction between fish species and offshore oil and gas developments. Some fish and shellfish species are, however, vulnerable to offshore installation activities and discharges to the sea. The most vulnerable period for fish species is during the egg and juvenile stages of their life cycles. Fish that lay their eggs on the sediment (e.g. herring and sandeels), or which live in intimate contact with sediments (e.g. sandeels and most shellfish) are susceptible to smothering by discharged solids. The industry-commissioned Fisheries Sensitivity Maps in British Waters and SEA2 Technical Report on North Sea Fish and Fisheries (Coull *et al.*, 1998; CEFAS,

2001) provide data on fish resources (spawning areas, nursery grounds and commercial fishing) in UK waters.

Indefatigable lies within the spawning grounds for the pelagic species mackerel (May to August) and sprat (May to August), and the demersal species plaice (December to March) (**Figure 2-6**). In addition, spawning grounds for cod (January to April) and lemon sole (April to September) occur within the general vicinity of the Indefatigable Field. Mackerel, plaice, lemon sole, and sprat are all pelagic spawners, releasing their eggs into the water column to be fertilised. The eggs and larvae of plaice, lemon sole and sprat remain planktonic after hatching; when mature they become demersal and settle on the seabed (CEFAS, 2001). The eggs and larvae of mackerel remain planktonic after maturation. Indefatigable also lies on the western edge of the southern North Sea spawning and nursery grounds for *Nephrops* (**Figures 2-6, 2-7**). It should be noted, however, that **Figure 2-6** relates to a generalised pattern of spawning. Many species have much more tightly defined peak spawning areas. Indefatigable also coincides with the nursery grounds for whiting, while nursery grounds for cod, lemon sole and sprat occur in close proximity to the Field (**Figure 2-7**).

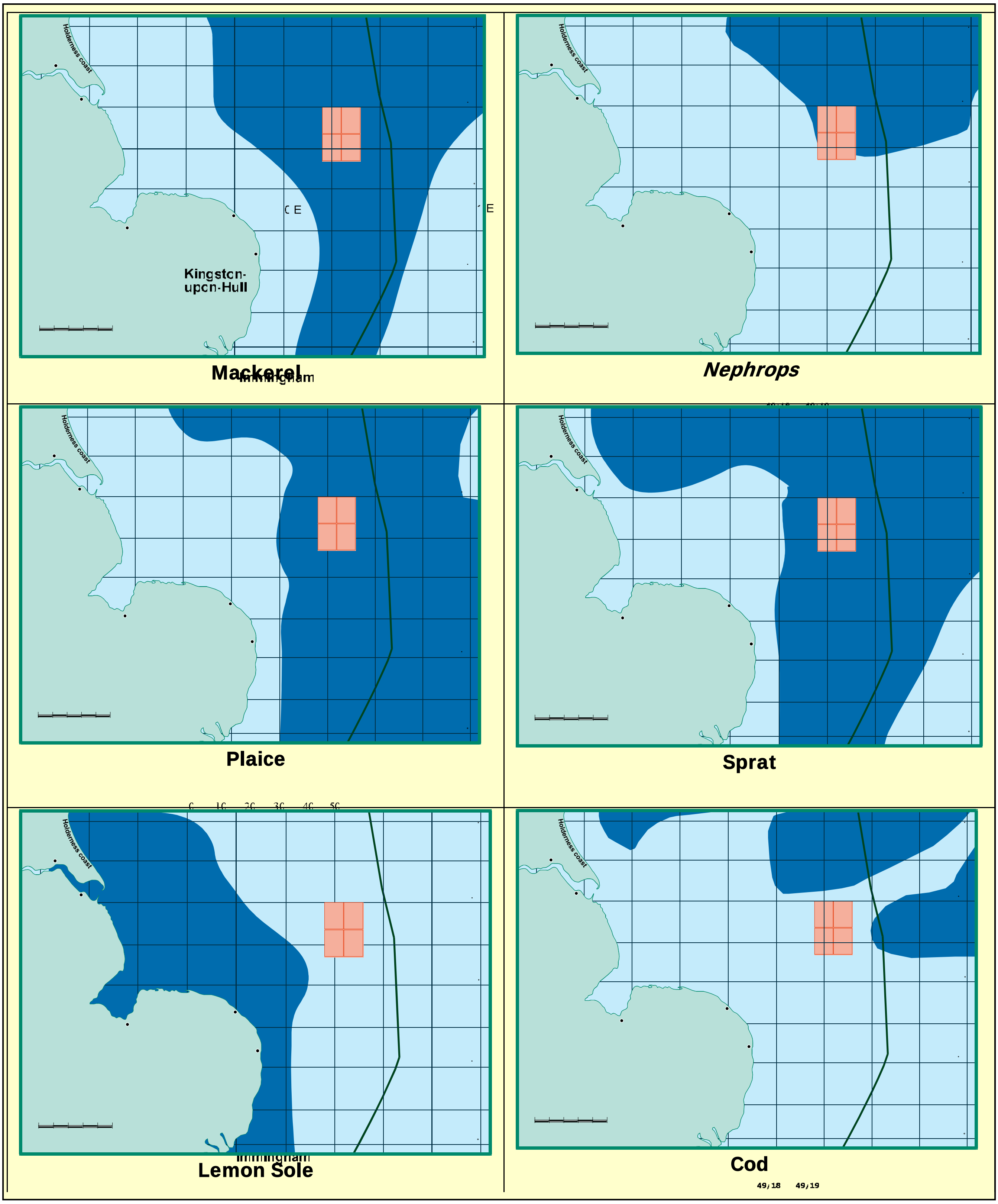


Figure 2-6: Fish spawning grounds in the region of the Indefatigable Field (Coull *et al.*, 1998)

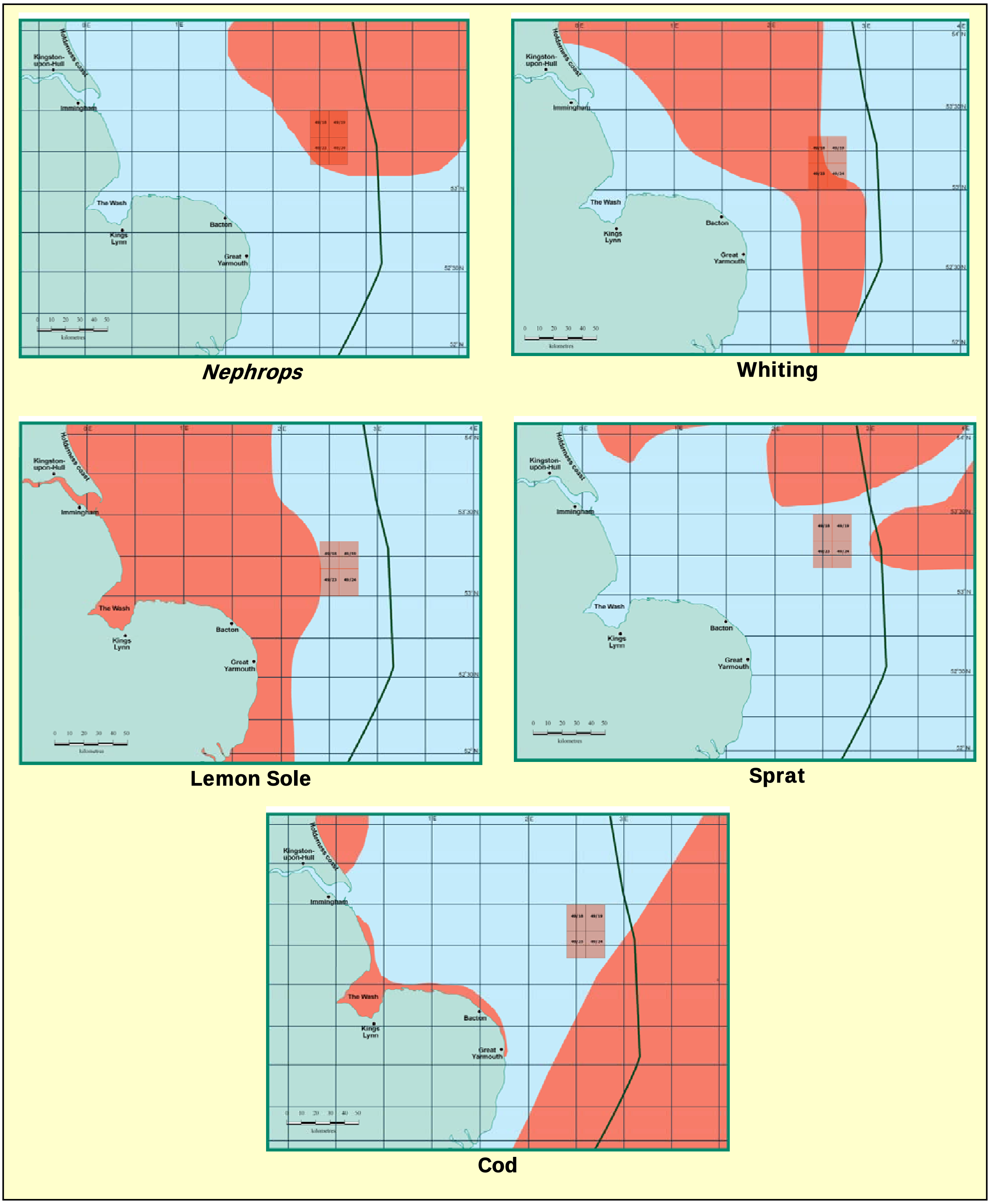


Figure 2-7: Fish nursery grounds in the region of the Indefatigable Field (Coull *et al.*, 1998)

C.2.10.5 Seabirds

SENSITIVITY: Seabirds populations are vulnerable to surface pollution, particularly oil. In the vicinity of the Indefatigable Field seabird densities and vulnerability to pollution have been described by the JNCC as moderate to high during the post-breeding and winter months. The area is most important for fulmar, common gull, kittiwake, guillemot and razorbill.

Internationally important numbers of seabirds breed on the North Sea coastal margin, and rely on the offshore North Sea for their food supply and habitat. Although some of these birds will range into Atlantic waters outside the breeding season, many are reliant on the North Sea at all seasons of the year.

Seabirds are not normally affected by offshore oil and gas operations, although they are vulnerable to oiling from surface oil pollution. The potential for hydrocarbon spillage from decommissioning operations would be from loss of containment, or the transport and storage of diesel fuel.

The Joint Nature Conservation Committee (JNCC) Seabirds at Sea Team (SAST) have developed an index to assess the vulnerability of bird species to the threat of oil pollution. This offshore vulnerability index is composed of the following four factors (Williams *et al.*, 1994):

- the amount of time spent on the water;
- the total biogeographic population;
- the extent to which they rely on the marine environment; and
- their potential rate of recovery.

The seasonal vulnerability of the seabirds in the vicinity of the Indefatigable field is derived from the JNCC block-specific vulnerability data (JNCC, 1999) and is presented in **Figure 2-8**. Data indicate that seabird vulnerability around the Indefatigable Field is lowest during the breeding period (June to September). During these months, most breeding seabirds are not found far offshore, as they feed in waters close to their colonies. Seabird vulnerability increases over the post-breeding and winter months, with the dispersal of many seabirds from the coastal colonies into offshore waters. High numbers of seabird species return to offshore waters to winter in the North Sea. The data presented in **Figure 2-8** indicate that seabird vulnerability at Indefatigable is high from October through to April, and is rated as very high during March. During this period, the area is most important for fulmar, common gull, kittiwake, guillemot and razorbill. Other species commonly found in the area include the gannet, skua, black headed gull, little auk and puffin.

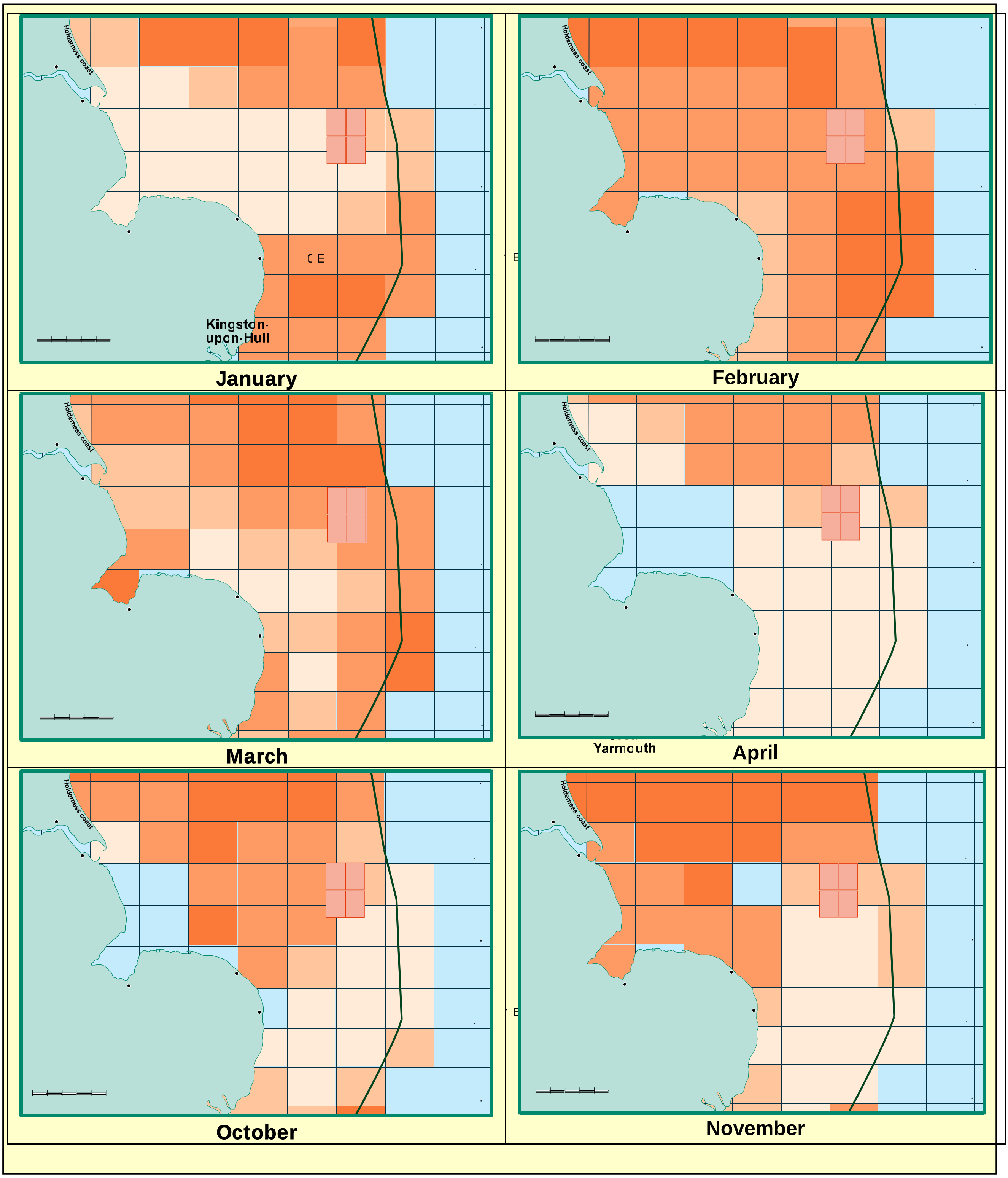


Figure 2-8: Seasonal seabird vulnerability to oil pollution the region of the Indefatigable Field (JNCC, 1999)

C.2.10.6 Fishing, Shipping Activity in Area

Commercial fisheries

SENSITIVITY: Commercial fisheries are sensitive to both natural changes in fish stocks and the high anthropogenic demand for fish, and several species are in an ecologically sensitive position. Such sensitive commercial species may be more vulnerable to the physical disturbances and possible chemical discharges that may arise from decommissioning operations.
The area around the Indefatigable Field is of low commercial value compared to surrounding ICES rectangles. Fish species on or near the seabed, including shellfish such as whelks, crabs, brown shrimp and mussels, historically dominate the landings in this area.

An assessment of the fishing industry in the area of the Indefatigable Field has been derived from International Council for the Exploration of the Seas (ICES) fisheries statistics, provided by DEFRA (2004). For management purposes the ICES collates fisheries information for individual rectangles measuring 30nm by 30nm. Data have been obtained for ICES rectangle 35F2, which corresponds to the Indefatigable Field.

The type of fishing gear and techniques employed by fishermen will depend on a variety of factors:

- species fished - demersal, pelagic or shellfish;
- depth of the water and seabed topography; and
- seabed characteristics.

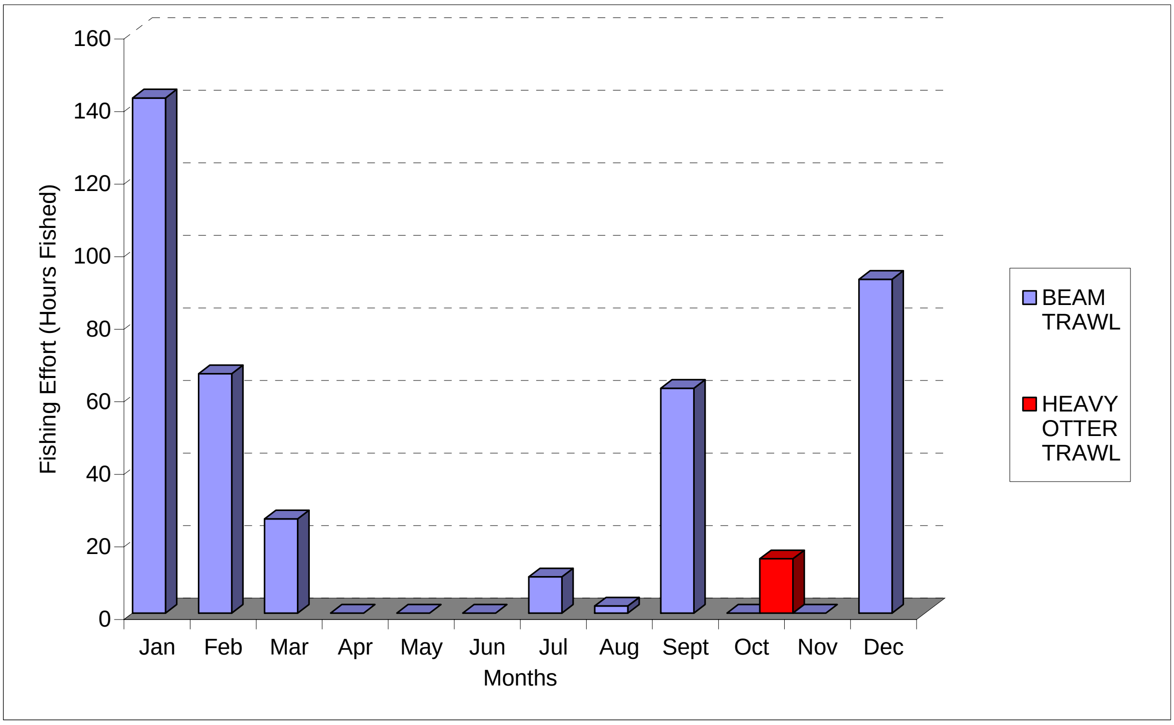
Species found in the water column (pelagic species) are fished using techniques that do not interact with the seabed. Demersal and shellfish species, however, are generally fished on or near the seabed and the prosecution of this fishery therefore has the potential to interact with structures placed on the seabed.

Trawling involves the towing of a net to catch fish. Beam trawling is used to catch flatfish (sole and plaice) and shrimps; a wooden or metal beam provides a rigid frame to hold the mouth of the net open. Otter trawling can be used on a variety of seabed types and conditions, where floats are attached to the headline along the top of the net mouth to hold it up. Otter trawling and seine net vessels are the most commonly used fishing methods used to target cod (CEFAS, 2001). Cod also form an important by-catch in the beam trawling fisheries targeting plaice and sole (CEFAS, 2001).

The monthly fishing effort (hours spent fishing) by the different trawling methods in the offshore area of ICES rectangle 35F2 in 2003 is presented in **Figure 2-9**. Beam trawling dominated the fishing effort in 2003. In 2003, UK vessel beam trawl usage equated to 93% of the overall UK fishing effort, while Dutch beam trawling equated to 89.3% of the overall foreign fishing activity over the same period. However, there was an 18.8% decrease in beam trawl effort between 2002 and 2003.

Figure 2-9: Monthly fishing effort (hours spent fishing) in 35F2 in 2003

(Source: DEFRA, 2004)



C.2.11 Fisheries Landings

Great Yarmouth and Lowestoft are the largest fishing ports in the southern North Sea. The coastal fishery here targets a variety of species including cod, plaice, bass, shrimp, skate, herring and sole by a combination of netting, trawling and long-lining (DTI, 2002). Crab, lobster and whelk fisheries off the English coast are predominantly by vessels from Bridlington, Grimsby and ports along the north Norfolk coast. Although crab grounds in this region are mainly inshore, they can extend eastwards into the gas fields beyond the Silver Pit. Plaice and sole are taken in a mixed flatfish fishery by beam trawlers in the southern and south-eastern North Sea, mainly by Dutch- and UK-registered trawlers.

In 2003, the total annual landings by UK vessels from ICES rectangle 35F2 were 1,046 tonnes. Shellfish such as whelks, crabs, brown shrimp and mussels dominated the landings, accounting for 98% of the total (**Figure 2-10**). Significant species among the remaining landings included lobster and the demersal species cod, skates and rays (**Figure 2-10**).

Although fishing activity and landings occur throughout the year, fishing effort and landings in ICES rectangle 35F2 is very low in comparison to other ICES rectangles.

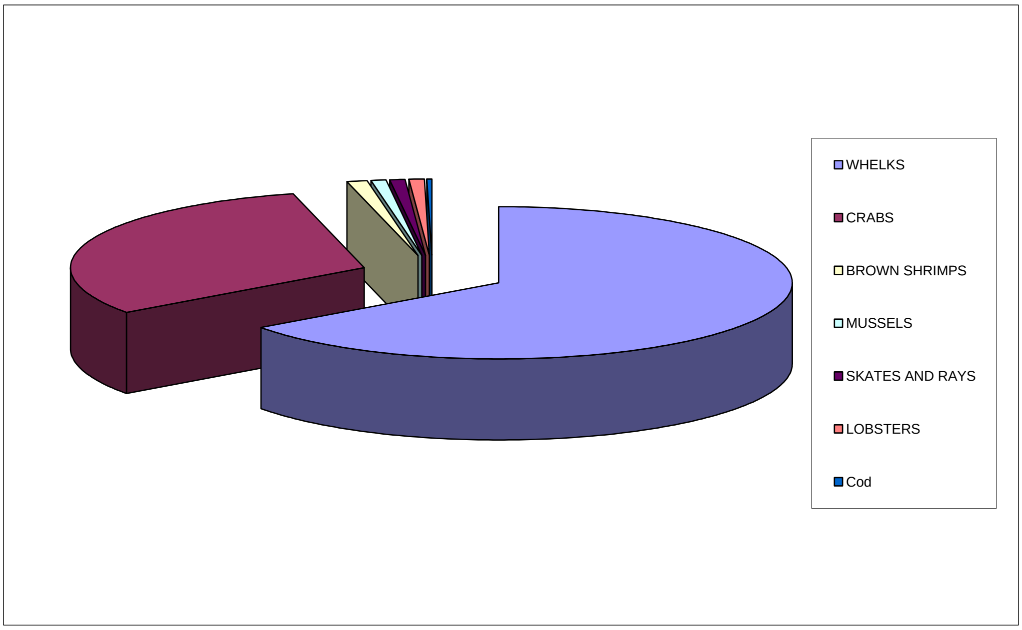


Figure 2-10: Main species landed by weight (tonnes) in 35F2 in 2003.

Source: DEFRA (2004)

C.2.11.1 Summary of Seasonal Environmental Sensitivities

The seasonal environmental sensitivities for the major environmental receptors in the Indefatigable field are shown in **Table 2-8**.

Table 2-8: Summary of the seasonal environmental sensitivities for the Indefatigable Field

KEY		
		Very high sensitivity in the month
		High sensitivity in the month
		Moderate sensitivity in the month
		Low sensitivity in the month

Conservation areas
'Sandbanks which are slightly covered by sea water all the time' and 'biogenic reefs' formed by *S. spinulosa* are habitat categories identified under Annex I of the Habitats Directive are known to occur in the region of the southern North Sea which is occupied by the Indefatigable Field. JNCC has recently recommended that one of the *S. spinulosa* reefs in the southern North Sea (Saturn reef) should be proposed as a candidate SAC.
Harbour porpoise is one of the four species listed in Annex II of the Habitats Directive, which is known to occur in the vicinity of the Indefatigable Field. With the exception of the month of March, the frequency of sightings of harbour porpoise in this area is very low. Studies indicate that Common seals may forage in the region occupied by the Indefatigable Field, but there is little known information on the number of Common seals that are likely to occur in the vicinity of the Indefatigable Field.

J	F	M	A	M	J	J	A	S	O	N	D

Plankton
Plankton is vulnerable to oil and chemical discharges. The Indefatigable Field is located within the South British Coastal sub-division of the North Sea and is typical of the Continental Shelf, although southern intermediate species are also present. However, because plankton is widely distributed over the area, there is no direct threat to the viability of the populations. Main periods of bloom are in spring and summer.

J	F	M	A	M	J	J	A	S	O	N	D

Benthic Fauna
Benthic fauna are vulnerable to seabed disturbance. They are also an important food resource for demersal fish and shellfish. Benthic communities in the Indefatigable Field area are similar to those found throughout the surrounding area, but reports suggest that extensive patches of the reef-forming polychaete worm S. spinulosa occur in parts of the southern North Sea. Biogenic reefs formed by S. spinulosa are listed under the Annex I habitats, which are currently under consideration for identification as possible SACs in UK offshore waters.

J	F	M	A	M	J	J	A	S	O	N	D

Marine mammals
The region around the Indefatigable Field is not particularly rich in cetaceans. Sensitivity is considered to be low even during the months with the highest populations in the area. Low to moderate numbers of harbour porpoise and low numbers of white-beaked dolphins have been sighted in the area. Marine mammals are vulnerable to acoustic disturbance from vessel operations and injury from collisions with vessels. Common seals may occupy this area, but there is little information on the numbers present.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
H. porpoise	0	4	2	4	4	0	0	0	0	0	0	0
W.B. dolphin	0	0	3	3	4	0	0	0	0	0	0	0

Finfish Populations
Fish are vulnerable to pollution, particularly during the egg, larval and juvenile stages of their lifecycle. Demersal spawning fish and fish/shellfish that live in close association with seabed sediments are vulnerable to sediment disruption. The fish communities found in proximity to the Indefatigable field are present throughout the area and elsewhere in the North Sea, so there is no direct threat to the viability of the populations. The Indefatigable Field is located within known spawning grounds of mackerel, cod, plaice, lemon sole, sprat and *Nephrops*.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mackerel	-	-	-	-	*S	*S	*S	S	-	-	-	-
Cod	S/N	*S/N	*S/N	S/N	N	N	N	N	N	N	N	N
Plaice	*S	*S	S	-	-	-	-	-	-	-	-	S
Lemon Sole	N	N	N	S/N	S/N	S/N	S/N	S/N	S/N	N	N	N
Sprat	N	N	N	N	*S/N	*S/N	S/N	S/N	N	N	N	N
Nephrops	S/N	S/N	S/N	*S/N	*S/N	*S/N	S/N	S/N	S/N	S/N	S/N	S/N
Whiting	N	N	N	N	N	N	N	N	N	N	N	N

Seabird populations

Seabirds are vulnerable to surface oil pollution. In the vicinity of the Indefatigable field Seabird densities and vulnerability to pollution have been described by the JNCC as moderate to high during the post-breeding and winter months. The area is most important for fulmar, common gull, kittiwake, guillemot and razorbill.

BLOCK												
49/18	2	2	1	2	3	4	4	3	3	2	2	3
49/19	2	3	2	3	3	4	4	4	4	3	2	4
49/23	3	2	2	4	3	4	4	3	4	3	4	2
49/24	3	3	2	4	3	4	4	3	4	4	4	2

Commercial fisheries

The area is of low commercial value compared to surrounding ICES rectangles. Fish species on or near the seabed historically dominate the landings in this area.

C.3 Description of potential environmental impacts due to decommissioning the Indefatigable facilities

The following pages briefly describe the possible nature of impacts that could arise during the different decommissioning options. For the sake of clarity and to avoid repetition, the wide range of impacts can be conveniently grouped under five headings:

- vessel operations (Section 1.3.1),
- preparatory work, cutting and lifting (Section 1.3.2),
- transportation (Section 1.3.3),
- reception, storage and dismantling (Section 1.3.4),
- recycling and reprocessing (Section 1.3.5).

These follow a logical sequence from offshore operations to onshore dismantling and disposal.

C.3.1 Vessel operations

C.3.1.1 Interference with other users

Decommissioning vessel activities in the Indefatigable field could potentially result in interference with commercial fishing and shipping activities in the vicinity of the decommissioning site and the tow routes. Interference with third party vessel operations would, at worst, have a low significance, because the majority of decommissioning operations will take place within the 500m designated safety zone of each of the five installations, and the project vessel spread would occupy a very small area of the sea. In addition, the decommissioning operations will be declared using 'Notices to mariners' and all vessels will use established lines of communication to liaise with fishermen.

C.3.1.2 Underwater noise from vessels

Underwater noise is a potential source of impact to marine mammals. Underwater noise could be caused by the extensive use of dynamic positioning (DP) by vessels during all stages of the offshore operations. The only marine mammals that are known to occur in the Indefatigable field are the Harbour porpoise and White-Beaked dolphin. The densities of these species range from very low (0.01 – 0.09 animals km^2) to moderate (0.10 – 0.19 animals km^2) between February and May; very low densities of Harbour Porpoise also occur in August.

Noise levels in the marine environment are attenuated by distance, and by absorption by the water. The degree of absorption is roughly in proportion to the square of the frequency. The potential effects of underwater noise at different distances from a source may be calculated using formulae presented in Richardson *et al*., 1995, and a formula for absorption from Erbe and Farmer (2000). With respect to the Indefatigable field, where the water depth is around 31m, noise would propagate according to a model of cylindrical spreading (which applies for depths less than 200m).

Table 3-1 outlines the underwater noise characteristics of different vessels and activities in the marine environment (Richardson *et al.* 1995). There are few published data on underwater noise levels associated with the types of activities taking place during decommissioning or on the responses of marine mammals near these activities, but underwater noise levels may often be low, steady and not very disturbing (Richardson *et al.* 1995).

A variety of vessels are likely to be used during the proposed decommissioning activities (e.g., SSCV, HLV, tugs, anchor-handlers, supply vessels, jack-up rigs). Every vessel has a unique signature, which changes with ship speed and the load being carried. The larger vessels will manoeuvre and maintain position using thrusters (propellers) located below the water line. Thrusters are expected to generate noise estimated at 171dB. There is limited information on noise levels produced by thrusters such as those that are fitted to a DP HLV.

Table 3-1: Examples of underwater noise levels produced by different types of vessel

Source	Source levels of underwater noise (dB re 1µPa at 1m)*
Median ambient level	80 to 100
Vessels	
Tug / barge / tanker / merchant vessel	140 to 170
Supply / support vessel	170 to 180
DP vessel (full continuous thrusters power)	180 to 190
Jack-up Drilling Rig	85 to 127

Key: dB re1µPa at 1m – unit of Sound Pressure Levels measured at a 1m range from source.

* Most data taken from 1/3-octave band centre frequencies (50-2000Hz).

Disturbance is the most commonly observed effect of underwater noise on marine mammals.

Behavioural studies commonly refer to three threshold response levels:

- First threshold where the animal is first able to detect the noise;
- Second threshold which elicits an overt behavioural reactions; and
- Third threshold which may temporarily or permanently damage hearing.

Behavioural responses in marine mammals have been observed in the range 40-130 dB and above. Erbe and Farmer (2000) report that for many marine mammals, disturbance occurs at a broadband received continuous noise level of about 120 dB. This is reinforced in Richardson *et al*. (1995) where 120 dB is proposed as an example level for a likelihood of an overt behavioural reaction.

Consequently, a fixed level of 120 dB is adopted as a significance level in this case. Noise levels in excess of 120 dB may still be tolerated for a period of time, but the likelihood of behavioural response being elicited increases. The following equation (Erbe and Farmer, 2000) can be used to calculate the attenuation of underwater noise from a 171dB (re –µPa.m) thrusters at the decommissioning site:

$$\text{dB @ distance R} = \text{Source}_{dB} - 15.\log(R_{km}) - 5.\log(\text{water depth}_{m}) - 60$$

The calculation predicts that the noise level would be 123dB at 50m, attenuating to 103dB at 1km from the source. Consequently, the impact of a noise source at this level is likely to be localised. None of the planned decommissioning activities at Indefatigable would bring on a sudden increase in noise and so the potential for disturbance to marine mammals will be reduced because a progressive increase will enable any mammals in the area to move away.

The use of well maintained equipment will help to reduce noise levels, and thus reduce the risk of this impact. When the plan for offshore operations is finalised, a discussion with JNCC may be appropriate to determine if further measures are required.

C.3.1.3 Anchor mounds and marks

Rather than using DP, vessels involved in pipeline removal could maintain their position using anchors. Typically, large vessels such as HLVs or SSCVs would maintain position using an 8 to 12 anchor spread. During anchor-laying, the anchors will be transferred to an anchor handling tug. When on station at required location, the tug will lower the anchor to seabed using a pennant wire, with a marker buoy. The pennant wire will also be used for anchor retrieval.

Retrieval of large anchors could potentially create ‘anchor mounds’ where localised piles of seabed sediments accumulate after the anchor is withdrawn. However, this effect is not likely to be pronounced in the predominantly sandy sediments of the Indefatigable field. Localised disturbance of sediments could also occur when anchor chains or wires move across the seabed during anchor tensioning. Benthic organisms could potentially be smothered in the area where seabed disturbance occurs. However, this effect is likely to be localised and transient given the hydrodynamic regime in this area of the southern North Sea. Consequently, natural re-colonisation by benthic organisms would not be impeded.

In some areas of the North Sea, anchor mounds can potentially create a physical obstruction for bottom-towed fishing gear (e.g. trawl gear). However, given the strong seabed currents, the effects of wave action on sediments, and the loose nature of the sediments in the Indefatigable field, anchor mounds are unlikely to persist.

Incorrect deployment or the slippage of anchors from vessels may potentially cause structural damage to pipelines. Moreover, if the pipeline is ‘live’, there is an added risk of hydrocarbon release. The mitigation for this risk will include the careful planning of operations, including handling and deployment of anchors. The PL81 pipeline (Kilo to 23AT) is crossed by a live gas pipeline and a live power line. It would not be the intention to remove the section of the PL81 line within 100m either side of the crossing to avoid the possibility of damage to the live gas pipeline and/or the live power line.

Physical disturbance of the area of seabed where cuttings have been previously deposited during drilling operations could potentially occur during the removal of the jacket or during the cutting and retrieval operations at the pipeline ends. Accordingly, should contaminated sediments become re-suspended, this could cause a transient and localised decrease in water quality around the area of disturbance, and the resettlement of material could cause a localised increase in any area of seabed currently affected by contaminants.

The hydrodynamic regime in this area of the North Sea is such that extant cuttings piles are not generally found. Moreover, there was sufficient sediment scour around the legs of the Juliet, Kilo, Mike and November platforms that rock/mattresses had to be placed. It is unlikely from survey information and visual observation that any sediment that may become re-suspended during decommissioning would be contaminated by cuttings material. Its re-suspension would, therefore, be unlikely to constitute anything other than a minor transient environmental impact.

C.3.1.4 Disturbance from jack-up legs

The presence of jack-up legs at Indefatigable may cause a localised disturbance to seabed and benthos when positioning the rigs and could potentially result in interference with commercial fishing in the vicinity of the decommissioning site. The majority of decommissioning operations, however, will take place within the 500m designated safety zone of each of the five installations. Since a 500m exclusion zone is already in place, there will be no further reduction in fishing over the current area.

Hence there will be no addition to the area already under exclusion and this represents no additional navigational hazard. The rig will be fully lit in accordance with current regulations and the physical disturbance to the seabed will be minimal and temporary.

C.3.1.5 Gaseous emissions

Emissions of CO_2, CO, NO_X, SO_X and VOC to atmosphere from the combustion of diesel fuel by generators and plant on vessels could cause a local deterioration in air quality. These emissions will quickly disperse offshore, however, and it is highly unlikely that any cumulative effects will result. Gaseous emissions could also contribute to wider global atmospheric processes. Atmospheric emissions of CO_2 and CO may contribute to climate change, NO_X, and SO_2 contribute to acid rain, and NO_X also contributes to low level ozone. However, the contribution of such emissions on a regional scale would be negligible when compared to other industrial sources. In addition all generators and engines will be maintained and operated to the manufacturers’ standards to ensure they work as efficiently as possible. Additional mitigation is usually given by the use of low sulphur diesel on all vessels, in line with MARPOL.

C.3.1.6 Accidental spillage of fuel at sea while refuelling

Small fuel spills could occur during the routine re-fuelling of vessels and helicopters. Accidental fuel spills could cause a deterioration of water quality, and represent a potential hazard to surface-dwelling birds and other organisms. The mitigation measures for this risk could include adherence to bunkering procedures and initiation of the existing Indefatigable Field oil spill response plan.

C.3.1.7 Sewage and macerated food waste discharges

Relatively small quantities of wastes will be generated by the running, maintenance and manning of vessels involved in the project. The localised organic input of macerated food waste and sewage will cause an increase in BOD (biochemical oxygen demand) which may affect water quality. General refuse will be collected and returned to shore for disposal. Sewage will be treated before disposal at sea, or contained and returned to shore. Only small amounts of sewage will be generated; this will be readily broken down and dispersed. Macerated galley waste will also disperse and may provide food for various species at different levels within the food chain. The proposed mitigation measures for this risk would include compliance with MARPOL and the disposal of solid waste according to requirements of 'Duty of Care'.

C.3.1.8 Material from non-hazardous drains

Vessel discharges from non-hazardous drains may result in a slight deterioration in seawater quality around the point of discharge. Given the influence of strong tidal currents and the permanent mixing of water in this region of the southern North Sea, however, the discharges will have an insignificant effect on the marine environment and there will be no cumulative effects. The possible mitigation measures would be the same as for sewage and macerated waste discharges.

C.3.1.9 Ballast water discharges

The discharge of ballast water may cause an ecological impact if it resulted in the introduction of alien species into the North Sea. Viable individual marine plants and animals can survive long passages at sea within the ballast water that vessels take on board to maintain their stability.
If such organisms survive and thrive when liberated into a new environment when the ballast water is discharged (for example, when a vessel takes on a new cargo) this may result in the introduction of a species that is not native to that environment. The issue is of particular importance to coastal environments because ballast water is usually collected and discharged at such locations, so the transported organisms may have a higher chance of survival than if they were discharged far from the coast.

It is presumed that the majority of vessels involved in the Indefatigable decommissioning operations will originate from the North Sea, and there will therefore be no risk of introducing alien species. If vessels from international waters outside the North Sea area are used in the project, they will be required to replace their ballast water in the open sea, to minimize the potential for the introduction of alien species.

C.3.1.10 Treated bilge discharge

The routine discharge of treated oily bilge water (at less than 15ppm oil-in-water) from vessels may potentially result in a temporary and localised deterioration in the quality of seawater around the discharge point. This discharge would be rapidly dispersed and diluted, and its environmental impact would be negligible. The control and mitigation measures are specified under MARPOL and would be standard for all of the project vessels.

C.3.2 Preparatory work, cutting and lifting

C.3.2.1 Small items and debris

Debris from dropped objects & minor items/Swarf fragments & debris from cutting operations
A variety of small items (e.g. metal fragments and debris from cutting operations, hand tools, hose connectors, scaffold connectors, scaffold poles and welding rods) could be lost overboard accidentally during module disconnection or other activities. In the short-term, such materials would create artificial substrata that may be colonised by marine organisms. In the long-term, iron degrades to inert oxides (goethite) which are environmentally benign and would be incorporated into marine sediments. Larger items could possibly cause minor obstructions to fishing.

C.3.2.2 Minor spillage of residual contaminants

During lifting operations, the loss of residual fluids contained within the pipe-work and storage sumps may cause a deterioration in the quality of the seawater around the discharge point, and could result in the formation of a localised oil slick. This would impact on seawater quality, plankton, fish and shellfish and potentially affect nearby conservation sites. The risk of such spillages will be eliminated as far as practicable by cleaning the pipe work, sumps and tanks during the preparatory phase, and, if necessary, temporarily sealing the cut ends of process pipe work before the modules are removed. The HLV, SSCV, cargo barge and any other vessels receiving or handling modules or components will be equipped with their own SOPEP to deal with minor releases, and will have access to Shell's oil spill response plan and equipment. In the case of a minor spillage of contaminants it is likely that any reduction in water quality would be localised and temporary, and any contaminants released would be rapidly diluted and dispersed.

C.3.2.3 Gaseous emissions, dust and fumes

Emissions of CO_2, CO, NO_X, SO_x and VOC to the atmosphere from the combustion of diesel fuel by generators and plant, as well as dust and fumes from cutting and dismantling operations could cause a local deterioration in air quality. These emissions will quickly disperse offshore, however, and it is highly unlikely that any cumulative effects which result. Gaseous emissions could also contribute to wider global atmospheric processes.

Atmospheric emissions of CO and CO_2 may contribute to climate change, NO_X and SO_2 contribute to acid rain, and NO_X also contribute to low level ozone. However, the contribution of emissions from the decommissioning of the Indefatigable field on a regional scale would be negligible when compared to other industrial sources. Given the relatively small quantities of gases, dust and fumes involved, and the dispersive environment offshore, it is unlikely that these emissions would cause transboundary effects on humans or general flora and fauna.

C.3.2.4 Dropped component/module offshore with subsequent recovery

Overboard loss of large objects could occur if, for example, there were a failure of a crane, lifting frame, sling or pennant wire, or if a pipeline or a section of jacket or topside were to break up during lifting. However, given the level of detailed engineering analysis and design required for this type of project, the safeguards that would be developed during project design will reduce the likelihood of such an event to a level that is remote. In the event of the overboard loss of a major item, it is likely that the item would be recovered from the seabed.

C.3.2.5 Underwater noise due to cutting operations

Underwater noise is a potential source of impact to marine mammals and could be caused by the cutting operations during decommissioning at Indefatigable. The only marine mammals that are known to occur in the Indefatigable field are the Harbour porpoise and White-Beaked dolphin. The densities of these species range from very low (0.01 – 0.09 animals km^2) to moderate (0.10 – 0.19

animals km^2) between February and May; very low densities of Harbour Porpoise also occur in August. However, the impact of underwater noise due to cutting is likely to be localised. None of the planned activities would bring on a sudden increase in noise and so the potential for disturbance to marine mammals would be reduced because a progressive increase will enable any mammals in the area to move away.

C.3.2.6 Removal of item/component from seabed

The removal of an item or component from the seabed may affect sediment quality, seawater quality and the benthos. In addition there will be a positive impact for commercial fishing as a result of the removal of a snagging risk. The impact on the physical and ecological marine environment is considered to be low level because of the temporary and localised nature of the disturbance.

C.3.2.7 Removal/displacement of mattresses/rock dump/scour protection

The removal/displacement of mattresses/rock dump/scour protection from the seabed may affect sediment redistribution and quality, seawater quality, benthos, plankton, fish and shellfish. The impact on the physical and ecological marine environment is considered to be low, however, because of the temporary and localised nature of the disturbance.

C.3.3 Transportation

The environmental risks associated with the transportation of decommissioned modules to shore on cargo barges include interference with other users of the sea, the creation of underwater noise, the use of energy and the generation of gaseous emissions, and the accidental release of contaminants into the sea.

Large items such as modules are routinely transported in the North Sea, however, and the relatively short-lived operations to remove decommissioned modules from Indefatigable would not present any unique or long-lasting risks.

The proposed mitigation or control measures for damage or loss during deep tow include:

- specific planning of tow route;
- inspection of tow route as necessary;
- use of adequate towing power; and
- conducting the tow during a suitable weather window.

C.3.4 Reception, storage & dismantling

C.3.4.1 Dropped structure during lifting/transfer with recovery

Overboard loss of large objects could occur if, for example, there were a failure of a crane, lifting frame, sling or pennant wire, or if a pipeline or a section of jacket or topside were to break up during lifting. However, given the level of detailed engineering analysis and design required for this type of project, the safeguards that would be developed during project design will reduce the likelihood of such an event to a level that is remote. In the event of the overboard loss of a major item, it is likely that the item would recovered from the seabed.

C.3.4.2 Storage/handing/dismantling at onshore site

At the onshore receiving site, components would be dismantled using a combination of 'hot' and 'cold' cutting techniques. Some of the sections would be quite large, and will have to be lifted, manoeuvred and cut carefully.

C.3.4.3 Spill of fuel or chemicals at any onshore receiving site

Given the detailed planning and consultation that will take, the operational controls that apply to vessels, and the provisions for oil spill contingency planning and response that will apply to the project, the probability of this event occurring is considered remote.

The onshore disposal of materials could result in impacts to local infrastructure and local communities close to treatment and disposal sites. None of the impacts would be of a significantly different nature to those already experienced in and around such sites. The effects of disposing of non-recyclable material from the Indefatigable facilities are, therefore, likely to be very small, localised and transient.

C.3.5 Recycling and disposal

C.3.5.1 Recycling operations from components/material

Structural steel will be the major component in the materials produced from the decommissioning of the jackets, topsides and pipelines. It is envisaged that all of the steel that is brought ashore will be recycled. Concrete coatings, after stripping from the pipelines, and possibly other materials (e.g. plastics from the bundles) would be re-cycled or disposed to landfill. These will not require pre-treatment. Smelting of the recycled steel in a blast furnace at high temperatures (up to 2,000^{o}C) will generate gaseous emissions (mainly CO_2) from the furnace stack. Usually, solid impurities (slag) and contaminants such as benzene and ammonia are recovered for use in separate industries and do not constitute possible sources of contamination. The gaseous emissions may impact air-quality in the vicinity of the smelting plant.
It is not anticipated that these emissions would exceed the normal gaseous emissions from the plant, which is required to comply with relevant legislation on air emissions from industrial units.

C.3.5.2 Disposal to landfill site and use of landfill capacity

The majority of decommissioned material will be inert and will not require pre-treatment before entering a non-hazardous landfill site. A small amount of hazardous waste may not be reusable or recyclable and will require either further treatment or processing before being disposed of.

Landfill site operations in general have many potential impacts on the environment and the most significant of these are the production of leachate and landfill gas. Leachate is generated when rainwater percolates through the landfill, makes contact with the buried wastes and extracts the soluble components. It has a high biochemical oxygen demand (BOD) and often contains high concentrations of organic carbon, nitrogen, chloride, iron, manganese, and phenols. Landfill gas (LFG) is generated when refuse decomposes, and comprises carbon dioxide and methane. Methane is an important and relatively long-lived greenhouse gas, with a global warming potential 31 times greater than that of carbon dioxide over a 100 year time period. The majority of LFG emissions are quickly diluted in the atmosphere, but in confined spaces they pose a significant risk of explosion or asphyxiation. LFG is often burnt by flaring to prevent its accumulation and minimise its emission to the atmosphere.

Although the disposal of waste to landfill is the least attractive option in the waste hierarchy, it is the most widely used waste disposal route. This may even be the Best Practicable Environmental Option (BPEO) in certain instances, particularly where treatment will be too costly both economically, and in terms of the emissions and resource-use of some treatment processes.

The impacts associated with the disposal of waste in a landfill will come under the control of the waste-handling facility and landfill operator as soon as it is transferred to the contractor. Whilst there is no legal obligation upon the operator at this stage, Shell will follow the principles outlined within the Duty of Care, and ensure that waste is transferred only to sites that are operating according to all relevant legislation and conditions.
Treatment and/or disposal of residual operational wastes onshore

The onshore treatment and/or disposal of residual wastes onshore may impact on local infrastructure and local communities close to treatment and disposal sites which in turn may have implications for amenity and revenue coastal and onshore communities. However, none of the impacts would be of a significantly different nature to those already experienced in and around such sites. The majority of such material that might be received from the Indefatigable facilities will be relatively small in comparison to the other sources. Overall, the effects of treating and disposing of such waste from Indefatigable would be very small and localised.

C.4 Results of the Risk Assessment

C.4.1 Introduction

This Section presents the results of the environmental risk assessment for each of the short-listed options for the Indefatigable facilities. It provides a "screening" review of the numbers of impacts of different pre-defined severities, and thus permits the environmental performance of each option to be compared.

C.4.2 Overview of results

Appendix 1 gives the detailed results of the environmental risk assessments carried out for each of the short-listed options for each of the Indefatigable facilities.

All of the decommissioning options have the potential to cause environmental impact, both as a result of planned activities and as a result of possible emergency or accidental events.

None of the options was assessed to have any risks in the 'highly significant' category, i.e. risks that would be intolerable and would represent a major constraint for the option. All of the options had a small number of risks that were rated as 'significant' (i.e. the project should seek to incorporate further risk-reduction measures and/or demonstrate that the risk was ALARP). All of the options also had a large number of risks that were rated 'not significant' (i.e. indicating that the risk was acceptable but should be managed to achieve continuous improvement).

Many of the risks identified would arise as a result of activities and operations which are commonly performed offshore in the UKCS. These activities and their consequences are well-understood, and may be subject to a range of potential mitigation measures depending on regulatory requirements and project- and site-specific circumstances. Other risks arise from accidental events and, again, there is a range of mitigation measures that is applied subject to regulatory requirements and the project-specific level of risk.

C.4.3 Impacts from decommissioning options for Juliet Topsides

Table 4-1 gives the results of the screening of all risks associated with the short-listed options for decommissioning the topsides. All of the options exhibited about the same number of "not significant" and "significant" impacts. In all options, 4 of the "significant" impacts would arise as a result of a large accidental spill of fuel oil to sea, following a vessel collision. In the piece-small option, a further impact might arise as a result of the exposure of personnel offshore to excessive dust and fumes during the extensive dismantling and cutting operations within the confines of the topsides.

Table 4-1 Impacts associated with short-listed decommissioning options for Juliet Topsides

Decommissioning Option	Numbers of impacts			
	Positive	Not significant	Significant	Highly significant
Reverse installation with HLV	0	75	4	0
Single lift with SSCV	0	75	4	0
"Versatruss" with catamaran barges	0	75	4	0
Twin submersible barge	0	75	4	0
Piece-small removal	0	74	5	0

C.4.4 Impacts from decommissioning options for Juliet Jackets

Table 4-2 gives the results of the screening of all risks associated with the short-listed options for decommissioning the jacket. Both options exhibited about the same number of "positive", "not significant" and "significant" impacts. The single positive impact was the effect on fishing operations of removing an obstruction (the jacket) from the seabed. In each case the 4 "significant" impacts would arise as a result of a large accidental spill of fuel oil to sea, following a vessel collision. Additional "not significant" impacts were found in the buoyancy option, as a result of lifting the floating jacket onto a barge at an inshore site.

Table 4-2 Impacts associated with short-listed decommissioning options for Juliet Jackets

Decommissioning Option	Numbers of impacts			
	Positive	Not significant	Significant	Highly significant
Reverse installation with HLV	1	96	4	0
Removal using temporary buoyancy	1	98	4	0

C.4.5 Impacts from decommissioning options for Kilo Topsides

Table 4-3 gives the results of the screening of all risks associated with the short-listed options for decommissioning the topsides. All of the options exhibited about the same number of "not significant" and "significant" impacts. In all options, 4 of the "significant" impacts would arise as a result of a large accidental spill of fuel oil to sea, following a vessel collision. In the piece-small option, a further impact might arise as a result of the exposure of personnel offshore to excessive dust and fumes during the extensive dismantling and cutting operations within the confines of the topsides.

Table 4-3 Impacts associated with short-listed decommissioning options for Kilo Topsides

Decommissioning Option	Numbers of impacts			
	Positive	Not significant	Significant	Highly significant
Reverse installation with HLV	0	75	4	0
Single lift with SSCV	0	75	4	0
"Versatruss" with catamaran barges	0	75	4	0
Twin submersible barge	0	75	4	0
Piece-small removal	0	74	5	0

C.4.6 Impacts from decommissioning options for Kilo Jacket

Table 4-4 gives the results of the screening of all risks associated with the short-listed options for decommissioning the jacket. Both options exhibited about the same number of "positive", "not significant" and "significant" impacts. The single positive impact was the effect on fishing operations of removing an obstruction (the jacket) from the seabed. In each case the 4 "significant" impacts would arise as a result of a large accidental spill of fuel oil to sea, following a vessel collision. Additional "not significant" impacts were found in the buoyancy option, as a result of lifting the floating jacket onto a barge at an inshore site.

Table 4-4 Impacts associated with short-listed decommissioning options for Kilo Jacket

Decommissioning Option	Numbers of impacts			
	Positive	Not significant	Significant	Highly significant
Reverse installation with HLV	1	96	4	0
Removal using temporary buoyancy	1	98	4	0

C.4.7 Impacts from decommissioning options for Lima Topsides

Table 4-5 gives the results of the screening of all risks associated with the short-listed options for decommissioning the topsides. All of the options exhibited about the same number of “not significant” and “significant” impacts. In all options, 4 of the “significant” impacts would arise as a result of a large accidental spill of fuel oil to sea, following a vessel collision. In the piece-small option, a further impact might arise as a result of the exposure of personnel offshore to excessive dust and fumes during the extensive dismantling and cutting operations within the confines of the topsides.

Table 4-5 Impacts associated with short-listed decommissioning options for Lima Topsides

Decommissioning Option	Numbers of impacts			
	Positive	Not significant	Significant	Highly significant
Reverse installation with HLV	0	75	4	0
“Versatruss” with catamaran barges	0	75	4	0
Twin submersible barge	0	75	4	0
Piece-small removal	0	75	5	0

C.4.8 Impacts from decommissioning options for Lima Jacket

Table 4-6 gives the results of the screening of all risks associated with the short-listed options for decommissioning the jacket. Both options exhibited about the same number of “positive”, “not significant” and “significant” impacts. The single positive impact was the effect on fishing operations of removing an obstruction (the jacket) from the seabed. In each case the 4 “significant” impacts would arise as a result of a large accidental spill of fuel oil to sea, following a vessel collision. Additional “not significant” impacts were found in the buoyancy option, as a result of lifting the floating jacket onto a barge at an inshore site.

Table 4-6 Impacts associated with short-listed decommissioning options for Lima Jacket

Decommissioning Option	Numbers of impacts			
	Positive	Not significant	Significant	Highly significant
Reverse installation with HLV	1	96	4	0
Removal using temporary buoyancy	1	98	4	0

C.4.9 Impacts from decommissioning options for Mike Topsides

Table 4-7 gives the results of the screening of all risks associated with the short-listed options for decommissioning the topsides. All of the options exhibited about the same number of “not significant” and “significant” impacts. In all options, 4 of the “significant” impacts would arise as a result of a large accidental spill of fuel oil to sea, following a vessel collision. In the piece-small option, a further impact might arise as a result of the exposure of personnel offshore to excessive dust and fumes during the extensive dismantling and cutting operations within the confines of the topsides.

Table 4-7 Impacts associated with short-listed decommissioning options for Mike Topsides

Decommissioning Option	Numbers of impacts			
	Positive	Not significant	Significant	Highly significant
Reverse installation with HLV	0	75	4	0
"Versatruss" with catamaran barges	0	75	4	0
Twin submersible barge	0	75	4	0
Piece-small removal	0	74	5	0

C.4.10 Impacts from decommissioning options for Mike Jacket

Table 4-8 gives the results of the screening of all risks associated with the short-listed options for decommissioning the jacket. Both options exhibited about the same number of "positive", "not significant" and "significant" impacts. The single positive impact was the effect on fishing operations of removing an obstruction (the jacket) from the seabed. In each case the 4 "significant" impacts would arise as a result of a large accidental spill of fuel oil to sea, following a vessel collision. Additional "not significant" impacts were found in the buoyancy option, as a result of lifting the floating jacket onto a barge at an inshore site.

Table 4-8 Impacts associated with short-listed decommissioning options for Mike Jacket

Decommissioning Option	Numbers of impacts			
	Positive	Not significant	Significant	Highly significant
Reverse installation with HLV	1	96	4	0
Removal using temporary buoyancy	1	98	4	0

C.4.11 Impacts from decommissioning options for November Topsides

Table 4-9 gives the results of the screening of all risks associated with the short-listed options for decommissioning the topsides. All of the options exhibited about the same number of "not significant" and "significant" impacts. In all options, 4 of the "significant" impacts would arise as a result of a large accidental spill of fuel oil to sea, following a vessel collision. In the piece-small option, a further impact might arise as a result of the exposure of personnel offshore to excessive dust and fumes during the extensive dismantling and cutting operations within the confines of the topsides.

Table 4-9 Impacts associated with short-listed decommissioning options for November Topsides

Decommissioning Option	Numbers of impacts			
	Positive	Not significant	Significant	Highly significant
Reverse installation with HLV	0	75	4	0
"Versatruss" with catamaran barges	0	75	4	0
Twin submersible barge	0	75	4	0
Piece-small removal	0	74	5	0

C.4.12 Impacts from decommissioning options for November Jacket

Table 4-10 gives the results of the screening of all risks associated with the short-listed options for decommissioning the jacket. Both options exhibited about the same number of “positive”, “not significant” and “significant” impacts. The single positive impact was the effect on fishing operations of removing an obstruction (the jacket) from the seabed. In each case the 4 “significant” impacts would arise as a result of a large accidental spill of fuel oil to sea, following a vessel collision. Additional “not significant” impacts were found in the buoyancy option, as a result of lifting the floating jacket onto a barge at an inshore site.

Table 4-10 Impacts associated with short-listed decommissioning options for November Jacket

Decommissioning Option	Numbers of impacts			
	Positive	Not significant	Significant	Highly significant
Reverse installation with HLV	1	96	4	0
Removal using temporary buoyancy	1	98	4	0

C.4.13 Impacts from decommissioning options for the PL80s pipelines

Table 4-11 gives the results of the screening of all risks associated with the short-listed options for decommissioning the PL80s pipelines. All the options would result in 1 “positive” impact, the effect on fishing operations of ensuring that the line did not represent an obstruction on the seabed. The “leave *in situ*” option clearly has the fewest number of “not significant” impacts, because of the small amount of operational activity associated with this option. However, it would present 2 “significant” impacts as result of the need for additional areas of rock dump at the cut ends of the pipes.

The options “reverse S-lay” and “Cut-and-lift” presented about the same number of “not significant” impacts, most of which would arise as a result of “normal” offshore operations and vessel activities, and some local impacts at onshore receiving and recycling sites. In both these options, the single “significant” impact would arise as a result of the displacement of large amounts of (clean) seabed sediment into the water column by water-jetting, to uncover the pipes so that they could be retrieved.

Table 4-11 Impacts associated with short-listed decommissioning options for PL80s pipelines

Decommissioning Option	Numbers of impacts			
	Positive	Not significant	Significant	Highly significant
Leave in situ	1	35	2	0
Reverse S-lay	1	68	1	0
Subsea cut and lift	1	72	1	0

C.4.14 Impacts from decommissioning options for the PL302 and PL402 pipelines

Table 4-12 gives the results of the screening of all risks associated with the short-listed options for decommissioning the PL302 and PL304 pipelines. All the options would result in 1 “positive” impact, the effect on fishing operations of ensuring that the line did not represent an obstruction on the seabed. The “leave *in situ*” option clearly has the fewest number of “not significant” impacts, because of the small amount of operational activity associated with this option. However, it would present 2 “significant” impacts as result of the need for additional areas of rock dump at the cut ends of the pipes. The options “reverse S-lay” and “Cut-and-lift” presented about the same number of “not significant” impacts, most of which would arise as a result of “normal” offshore operations and vessel activities, and some local impacts at onshore receiving and recycling sites. In both these options, the single “significant” impact would arise as a result of the displacement of large amounts of (clean) seabed sediment into the water column by water-jetting, to uncover the pipes so that they could be retrieved.

Table 4-12 Impacts associated with short-listed decommissioning options for PL302 and PL402 pipelines

Decommissioning Option	Numbers of impacts			
	Positive	Not significant	Significant	Highly significant
Leave in situ	1	35	2	0
Reverse S-lay	1	68	1	0
Subsea cut and lift	1	72	1	0

C.4.15 Impacts from decommissioning options for the hose bundles

Table 4-13 gives the results of the screening of all risks associated with the short-listed options for decommissioning the hose bundles. Both options would result in 1 "positive" impact, the effect on fishing operations of ensuring that the bundles did not represent an obstruction on the seabed. The "leave *in situ*" option clearly has the fewest number of "not significant" impacts, because of the small amount of operational activity associated with this option. However, it would present 2 "significant" impacts as result of the need for additional areas of rock dump at the cut ends of the pipes. The option "remove by reeling" presented a larger number of "not significant" impacts, most of which would arise as a result of "normal" offshore operations and vessel activities, and some local impacts at onshore receiving and recycling sites. In this option, the single "significant" impact would arise as a result of the displacement of large amounts of (clean) seabed sediment into the water column by water-jetting, to uncover the pipes so that they could be retrieved.

Table 4-13 Impacts associated with short-listed decommissioning options for hose bundles

Decommissioning Option	Numbers of impacts			
	Positive	Not significant	Significant	Highly significant
Leave in situ	1	35	2	0
Remove by reeling	1	64	1	0

C.5 Discussion Of Results Of Screening Of Potential Environmental Impacts

C.5.1 Introduction

The screening study has shown that the differences in the “environmental performance” of the different short-listed options for each of the Indefatigable facilities are generally small. Most options would result in a number of “not significant” impacts, as a result of planned, unplanned and accidental events. No option for any facility exhibited an impact that was categorised as being “highly significant”. Furthermore, in most options, the small number of impacts categorised as being “significant” would arise as the result of accidental events, in particular the possible spillage of fuel after a vessel collision. This event could have serious consequences for the marine environment, depending on the time of year, but its likelihood would be low, given the industry-standard and project-specific safeguards and mitigation measures that would presumably be in place.

Options which resulted in the removal of material from the seabed, or its complete burial, were accorded a “positive impact”. This reflected the view that this would be of benefit to commercial fishing by removing a potential source of underwater obstruction and thus permitting commercial fishing operations to be prosecuted over a slightly larger area of seabed than is presently the case.

C.5.2 ”Significant” impacts and their mitigation

The remainder of this Section is a narrative describing the significant environmental risks and impacts associated with vessel operations and each of the options. It also summarises some of the standard or project-specific measures that could or would be taken to control or mitigate the identified risks. It would be incumbent on the project team to identify levels of mitigation appropriate for the perceived risk in the finalised option, and ensure that any such agreed measures were incorporated in the project execution plan. The majority of these mitigation measures would be standard practice for marine and offshore operations.

C.5.3 Major oil spill

A major, accidental loss of containment from a heavy lift vessel or another vessel working on the project could potentially occur during an accidental collision between vessels, or if an anchor or dropped object were to fracture a ‘live’ pipeline. An uncontrolled release of hydrocarbons could occur following an impact with an anchor from a large vessel such as the SSCV or from the semi-submersible rig, or from large objects dropped accidentally from barges or other vessels in transit over a live pipeline. All options which require the use of an SSCV/HLV have risk of damage to live pipelines.

The only live pipeline in the area is the 20” gas line from Brigantine to Corvette, which passes between platforms Lima and Kilo, and south-east of Juliet (Figure 2). However, dropped objects have the potential to damage gas or oil pipelines along the route between the Indefatigable field and the onshore receiving location.

A worst-case spill could arise if there were a large loss of fuel from a vessel in transit in inshore waters or estuaries, which are generally vulnerable to spills because conservation sites, natural resources, human populations, businesses, infrastructure and recreational areas are concentrated around coastlines.

The SSCV is the largest vessel on the decommissioning project, but as the chances of the SSCV’s entire fuel inventory being lost are extremely small, the release of the contents of the largest fuel tank can be considered as a realistic worst-case. Such an emergency event could be caused by a serious collision between large vessels. It should be stressed that major collisions between vessels are rare, but UK marine accident statistics show that these events tend to occur in congested inshore waters or the approaches to ports (Safetec, 2001). Since even relatively small spills can have serious consequences, the oil and gas industry routinely puts in place stringent control and mitigation measures for spill prevention from vessel operations. The control and mitigation for this potential impact could include the following measures:

- During project planning, systematic risk identification and assessment studies will be conducted, and emergency procedures will be developed for marine operations and other project activities. Project-specific procedures will include bridging documents to define the responsibilities and actions to be taken by the operator and the various contractors during emergencies.

- A marine surveyor will inspect any vessel which is not already covered by Shell inspection before they are contracted to the project. The surveyor's remit will include assurance of the adequacy of spill and pollution prevention measures.

- Vessels will have shipboard oil pollution prevention plans, be equipped with spill kits, and have personnel trained to deal with minor on-board spills. Specialist oil spill contractors will be available if a response to a larger spill is required.

- Vessels will follow pre-determined routing and towing plans, and pilots will be used where required.

- All of the vessels will be equipped with satellite positioning equipment, navigational aids and communication technology.

C.5.4 Effects on offshore personnel during piece-small dismantling

The screening study found that offshore personnel engaged in piece-small dismantling could be exposed to elevated levels of noise, dust and fumes. Such pollutants might arise from a variety of sources during cutting, lifting, moving and dismantling operations, particularly where work is being undertaken in confined spaces in offshore modules. While the management of such potential impacts would properly be a matter to be addressed in the safety case for the programme, its inclusion in the environmental assessment recognizes the fact that the offshore workforce too is a "receptor" that must be taken into account.

A wide range of management and operational measures would be available to ensure that personnel offshore worked safely and were not exposed to potentially damaging impacts, and the description of these measures is outwith the scope of this study.

C.5.5 Effects of rock-dumping operations

If pipelines were left *in situ*, their cut ends, which are exposed where they join spool-pieces, may be buried by rock-dumping to ensure that they were completely buried and did not pose a snagging hazard to bottom-towed fishing gear. The effects of rock-dumping were accorded a "significant" impact in the screening study. Rock-dumping may result in disturbance to normal seabed sediments, with consequent smothering effects as described in section 2.3.2.4, and it also introduces a new type of substrate onto the seabed which can alter the local composition of benthic communities. However, the amount of rock–dumping that may be required in the Indefatigable decommissioning programme is relatively small, and the areas of seabed that would be so covered are very limited.

C.5.6 Redistribution of sediment during pipeline removal operations

If buried pipelines were to be removed, they would have to be exposed by removing the over-burden of sediment. This would be achieved by jetting away the sediment with a jet-prop or other similar underwater jetting device. This operation would result in the re-suspension of a large volume of sediment into the water column. This would drift in the prevailing currents before eventually settling on the seabed “downstream” of the pipeline location.

There are no extant cuttings piles at any of the Indefatigable platforms, and so exposing the ends of the pipelines here would disturb only clean sediment. Nonetheless, the relatively rapid re-suspension of a significant volume of material into the water column could have effects on both the pelagic and benthic environments. An increased loading of particulate material in the water column could affect plankton and fish, by clogging respiratory organs. The resettlement of this material onto the seabed could impact benthic communities, by smothering them or interfering with their normal respiratory or feeding activities.

There are no obvious mitigation measures that could be taken to reduce potential impacts. The Indefatigable area is shallow, with strong tides and currents, and so marine life in the area may experience naturally high levels of sediment-loading in the water column from time to time. While locally high, the loading from pipeline-exposure operations would cause transient impacts from which the marine community would quickly recover.

C.5.7 Long-term impacts of pipelines and hose bundles decommissioned in situ

If the pipelines and pipeline bundles were to be decommissioned *in situ*, i.e. left buried in the seabed sediment, then, apart from the activities associated with burial of the ends, none of the environmental impacts that might arise would be categorised as “significant”. As the pipes disintegrated over a long period of time some residual contaminants remaining in the pipes might escape into the sediment and thence into the overlying water column. The amounts of contaminants and their rate of escape would be low, however, and the effects on any such releases on the marine environment would be negligible.

Following the exhaustion of the remaining anodes on the pipelines, the steel pipes would to corrode and form inert corrosion products; concrete coatings would deteriorate very slowly. In time, the pipe would disintegrate and collapse, creating a line of material comprising corroded steel and broken sections of concrete. Provided that these materials remain buried, and were not exposed by sediment movements or relocated to the surface of the seabed by other external forces, their long-term presence would have no impact on the marine environment and other users of the sea.

The plastics and other synthetic materials in the hose bundles would essentially be inert and would not deteriorate. They would therefore have no effect on the marine sediments in which they were buried or on benthic communities along the route of the bundles. However, the bundles would essentially remain extant in perpetuity, and care would have to be taken to ensure that they remained buried and did not pose a snagging risk to bottom-towed fishing gear.

C.6 Additional Environmental Data Typical Analysis of Slag Material

Mineralogische samenstelling LD-staalslak

mineraal		gemiddeld gehalte (%)	standaarddeviatie (1σ)
a`-C_2S	Ca_2SiO_4	22	7
a-C_2S	Ca_2SiO_5	1	3
larniet	Ca_2SiO_6	18	10
srebrodolskiet	$Ca_2(Fe,Ti,Al)O_5$	22	5
wuestiet	(Mg,Fe,Mn)O	31	6
magnetiet	Fe_3O_4	2	3
vrije kalk	Ca(Fe,Mn)O	4	3

Chemische samenstelling LD-staalslak

component	eenheid	gemiddeld gehalte	standaarddeviatie (1σ)
MgO	%	8	1
Al_2O_3	%	1,5	0,4
SiO_2	%	13	2
P_2O_5	%	2	0,1
CaO	%	41	1
TiO_2	%	2	0,4
MnO	%	5	1
Fe_2O_3	%	29	3
Ba	%	0,009	0,002
Cr	%	0,2	0,02
V	%	0,6	0,10
As	mg/kg	< 2	0
Cd	mg/kg	< 1	0,8
Cu	mg/kg	7	12
Hg	mg/kg	< 0,01	0,005
Mo	mg/kg	4	11
Ni	mg/kg	36	32
Pb	mg/kg	< 5	0
Sn	mg/kg	< 5	7
Zn	mg/kg	1	3

Key:
Mineralogische Samenstelling – Mineral composition
Chemische samenstelling – chemical composition
Gemiddeld gehalte – average percentage
Standarddeviatie – standard deviation
Eenheid - unit

Typical seabed material a) Beneath platforms b) Adjacent to platforms
Showing granular character

APPENDIX D

Evaluation of Energy and Gaseous Emissions

APPENDIX D – CONTENTS

D.1 METHOD FOR ESTIMATING ENERGY USE AND GASEOUS EMISSIONS

All the decommissioning options will use energy, and give rise to gaseous emissions including CO_2, CO, NO_x, SO_x and VOC. With respect to decommissioning activities in the North Sea, experience to date has shown that the main sources of energy use and gaseous emissions are:

- the fuel consumed by vessels used offshore for dismantling and recovery operations;
- the manufacture of temporary steel structures on vessels and barges to hold or carry components;
- the recycling of material that is returned to shore; the energy that would be required to manufacture new material to replace recyclable material that is not retrieved but deliberately left in the sea.

This section describes the method that was used to calculate energy use and gaseous emissions, and presents data showing the total net energy use and total gaseous emissions of the short-listed options for each of the Indefatigable facilities.

D.1.1 General approach

The total energy used and CO_2 emissions generated in each option were calculated according to the guidelines developed by The Institute of Petroleum (IoP, 2000). The IoP document provides a standardised set of guidelines which allow oil and gas operators to make predictions of the energy use and gaseous emissions when assessing the options for decommissioning offshore structures. The guidelines were subject to external peer review during their preparation and present an agreed set of data on:

- the absolute energy values of certain types of fuel;
- the unit fuel consumption values for different vessels under different conditions;
- the factors that can be used to calculate the emission of certain gases when different types of fuel are burnt; and
- the unit energy use for the manufacture or processing of certain materials.

The purpose of the guidelines is to enable operators to calculate the absolute energy use and gaseous emissions of various options to a reasonable level of accuracy, and, importantly, to provide a standard set of data and a standard method that permits operators to compare the relative energy use and gaseous emissions of different options.

D.1.2 Recyclable material left in the sea

If recyclable material is deliberately left in the sea, the energy use of that option will appear much lower than that of an option in which vessel time is used to retrieve and transport material to the shore, and then more energy used onshore to recycle it. One of the main purposes of retrieving valuable material would be to recycle it and thus make it available to the “chain of utility”. There would be an energy cost to recycle this material, but this would be lower than the cost of manufacturing the feedstock from raw materials. It is therefore important to account properly for the energy “saved” by recycling such material, by adding an energy “penalty” to those options in which material that would otherwise enter the “chain of utility” and be recycled is not retrieved. The IoP guidelines support this approach and describe how it should be executed.

Table D.1.2.1: Major sources of energy use and CO_2 emissions

Activity	Source	Examples	Energy use type
Offshore operations	Use of vessels for dismantling, lifting, transportation	Heavy lift vessel, dive support vessel, crane barge, supply vessel, tugs, anchor handling vessel, pipe reel barge, multi-purpose support vessel, floatel	Combustion engines generally using marine diesel at different consumption rates according to vessel type and activity
	Fabrication of temporary steel	Standard steel production	Smelting and manufacturing
Offshore end points	Replacement of otherwise recyclable materials	Steel, aluminium, copper and zinc	Smelting and manufacturing
Onshore operations	Use of equipment to dismantle structure		Combustion engines
Onshore end points	Reprocessing of material, once it has arrived at the reprocessing plant	Steel, aluminium, copper and zinc	Smelting

D.2 CALCULATION OF NET ENERGY USE

The total energy used in each of the options (and correspondingly the total amounts of gases emitted) is the sum of the following components:

Total Energy = Direct Energy + Recycling Energy + Replacement Energy

Where "Total Energy" is the total net amount of energy used.

Direct Energy is all the energy used offshore and onshore to carry out the operations, including the energy required to manufacture any temporary structures, the energy used by vessels and the energy used on transportation to onshore.

Recycling Energy is the energy used to recycle any materials that are brought back to shore
Replacement Energy is the estimate of the energy that would be required to manufacture from raw feedstock the mass of any material that was not recovered or recycled that could otherwise be recycled and enter the chain of utility.

D.2.1 Standard values and factors

The standard values and factors are used in the calculation of energy use and gaseous emissions.

D.2.2 Option-specific data

The descriptions of the options were reviewed and the following key data obtained:

- inventory of the different types of material in or on the components, and their masses;
- a breakdown of which components were to be retrieved or left in situ;
- a breakdown of which components were to be re-used, re-cycled or disposed of;
- details of the types and numbers of vessels to be used and the duration of their activities; and
- details of the numbers of trips to shore that would be required and the time vessels would spend in port and travelling to the Indefatigable Field.

D.3 ENERGY USE AND GASEOUS EMISSIONS OF EACH SHORT LISTED OPTION

D.3.1 Limitations of energy estimates

Calculations of energy use and gaseous emissions deliver values that, at best, are accurate to +/- 25%. The reason for this large confidence limit is that, despite the use of agreed values and factors (as described in the Methods section), the efficiency of combustion engines, other types of machinery, and commercial and industrial processes offshore and onshore, varies considerable. Their performance depends on a range of factors such as age and condition, the particular use to which they are being put, the care with which they are being operated, the inherent efficiency of the primary combustion or energy-generating system upon which they rely, and the quality and origin of the fuel that they are using. The results of the energy and emissions calculations should be viewed in the light of this caveat.

D.3.2 General observation

In all options where material is retrieved from the site, the majority of energy used and CO_2 generated is attributable to the operations of the marine spread. In those options where material is left in the sea, little energy is expended offshore but the option is debited with the energy cost of manufacturing new materials to replace recyclable material that is discarded.

D.3.3 Results for the platform topside removal options

Five options were identified for removing the topside removal and in each case the platform steel is taken onshore for reprocessing. The removal methods identified would require different vessel utilisations and requirements for temporary steel structures. The removal options, in summary, are:

1. Reverse installation with HLV: this option reverses the installation sequence for each platform. The work would be carried out by a HLV supported by a jack-up work vessel.

2. Single lift removal with SSCV: this option reverses the installation sequence for the suitable platforms. The work would be carried out by a SSCV supported by a jack-up work vessel.

3. Removal using versatruss system: this option is a proprietary framing arrangement that is attached to two barges. When the two barges are pulled together the load attached to the framing is lifted.

4. Piece small deconstruction: this option involves breaking up the platform into small easily-handled pieces for loading onto supply boats for transfer to shore. The work would be carried out from a marine work vessel.

5. Removal with submersible barges: this option involves the use of vessels that can submerge their decks and float underneath their cargo. The barges then deballast and lift the cargo out of the water.

The results for the different options are given in Tables D.3.3.1 to D.3.3.5 and illustrated in Figures D.3.3.1 to D.3.3.10. These show the total energy used and the total CO_2 emissions associated with each of the four main aspects of each option, and the total net energy use and total gaseous emissions for each option.

Table D.3.3.1: Estimates of total energy use and CO_2 emissions for the different options for the topside removal for Juliet JD and JP platform

Option for Topside removal	Measure	Aspect of the decommissioning operation				Total for options
		Temporary steelwork	Marine Vessels	Dismantling	Materials reprocessing	
Option 1 Reverse installation with HLV	Total Energy (GJ)	7,480	80,610	1680	27,504	**117,274 GJ**
	Total CO_2 (te)	626,780	5,929,661	ND	2,814,464	**9,370,905 te**
Option 2 Reverse installation with single lift	Total Energy (GJ)	17,000	89,698	1,680	27,504	**135,882 GJ**
	Total CO_2 (te)	1,424,500	6,598,116	ND	2,814,464	**10,837,080 te**
Option 3 Removal using versatruss system	Total Energy (GJ)	17,000	130,722	1,680	27,504	**176,906 GJ**
	Total CO_2 (te)	1,242,500	9,616,650	ND	2,814,464	**13,673,614 te**
Option 4 Removal by barge	Total Energy (GJ)	27,200	155,302	1,680	27,504	**211,686 GJ**
	Total CO_2 (te)	2,279,200	10,733,750	ND	2,814,464	**15,827,414 te**
Option 5 piece small dismantling	Total Energy (GJ)	0	226,016	3,450	27,504	**256,970 GJ**
	Total CO_2 (te)	0	16,626,300	ND	2,814,464	**19,440,764 te**

Key: ND = No data

Table D.3.3.2: Estimates of total energy use and CO_2 emissions for the different options for the topside removal for Kilo platform

Option for Topside removal	Measure	Aspect of the decommissioning operation				Total for options
		Temporary steelwork	Marine Vessels	Dismantling	Materials reprocessing	
Option 1 Reverse installation with HLV	Total Energy (GJ)	8,840	58,304	1,578	25,821	**94,543 GJ**
	Total CO_2 (te)	740,740	4,288,908	ND	2,646,023	**7,675,671 te**
Option 2 Reverse installation with single lift	Total Energy (GJ)	11,220	65,913	1,578	25,821	**104,532 GJ**
	Total CO_2 (te)	940,170	4,848,481	ND	2,646,023	**8,434,674 te**
Option 3 Removal using versatruss system	Total Energy (GJ)	11,900	96,673	1,578	25,821	**135,972 GJ**
	Total CO_2 (te)	997,150	7,112,350	ND	2,646,023	**10,755,523 te**
Option 4 Removal by barge	Total Energy (GJ)	22,100	82,782	1,578	25,821	**132,281 GJ**
	Total CO_2 (te)	1,851,850	6,089,939	ND	2,646,023	**10,587,812 te**
Option 5 piece small dismantling	Total Energy (GJ)	0	176,064	3,241	25,821	**205,126 GJ**
	Total CO_2 (te)	0	12,951,250	ND	2,646,023	**15,597,273 te**

Key: ND = No data

Table D.3.3.3: Estimates of total energy use and CO_2 emissions for the different options for the topside removal for Lima platform

Option for Topside removal	Measure	Aspect of the decommissioning operation				Total for options
		Temporary steelwork	Marine Vessels	Dismantling	Materials reprocessing	
Option 1 Reverse installation with HLV	Total Energy (GJ)	3,750	32,551	811	13,316	**50,428 GJ**
	Total CO_2 (te)	299,145	2,394,503	ND	1,370,858	**4,064,506 te**
Option 2 Reverse installation with single lift	Total Energy (GJ)	N/A	N/A	N/A	N/A	**N/A**
	Total CO_2 (te)	N/A	N/A	N/A	N/A	**N/A**
Option 3 Removal using versatruss system	Total Energy (GJ)	8,500	64,521	811	13,316	**87,148 GJ**
	Total CO_2 (te)	712,250	4,746,750	ND	1,370,858	**6,829,858 te**
Option 4 Removal by barge	Total Energy (GJ)	13,600	65,456	811	13,316	**93,183 GJ**
	Total CO_2 (te)	1,139,600	4,815,539	ND	1,370,858	**7,325,997 te**
Option 5 piece small dismantling	Total Energy (GJ)	0	95,607	1,665	13,316	**110,588 GJ**
	Total CO_2 (te)	0	7,032,963	ND	1,370,858	**8,403,821 te**

Key: ND = No data N/A = Not applicable

Table D.3.3.4: Estimates of total energy use and CO_2 emissions for the different options for the topside removal for Mike platform

Option for Topside removal	Measure	Aspect of the decommissioning operation				Total for options
		Temporary steelwork	Marine Vessels	Dismantling	Materials reprocessing	
Option 1 Reverse installation with HLV	Total Energy (GJ)	3,468	27,390	292	5,566	**36,716 GJ**
	Total CO_2 (te)	290,598	1,903,311	ND	459,990	**2,653,899 te**
Option 2 Reverse installation with single lift	Total Energy (GJ)	N/A	N/A	N/A	N/A	**N/A**
	Total CO_2 (te)	N/A	N/A	N/A	N/A	**N/A**
Option 3 Removal using versatruss system	Total Energy (GJ)	8,500	58,875	292	5,566	**73,233 GJ**
	Total CO_2 (te)	712,250	4,331,300	ND	459,990	**5,503,540 te**
Option 4 Removal by barge	Total Energy (GJ)	11,900	59,810	292	5,566	**77,568 GJ**
	Total CO_2 (te)	997,150	4,400,089	ND	459,990	**5,857,229 te**
Option 5 piece small dismantling	Total Energy (GJ)	0	54,931	600	5,566	**61,097 GJ**
	Total CO_2 (te)	0	4,041,275	ND	459,990	**4,501,265 te**

Key: ND = No data N/A = Not applicable

Table D.3.3.5: Estimates of total energy use and CO_2 emissions for the different options for the topside removal for November platform

Option for Topside removal	Measure	Aspect of the decommissioning operation				Total for options
		Temporary steelwork	Marine Vessels	Dismantling	Materials reprocessing	
Option 1 Reverse installation with HLV	Total Energy (GJ)	3,468	27,390	277	4,676	**35,811 GJ**
	Total CO_2 (te)	290,598	1,903,311	N/D	464882	**2,658,791 te**
Option 2 Reverse installation with single lift	Total Energy (GJ)	N/A	N/A	N/A	N/A	**N/A**
	Total CO_2 (te)	N/A	N/A	N/A	N/A	**N/A**
Option 3 Removal using versatruss system	Total Energy (GJ)	7,650	58,875	277	4,676	**71,478 GJ**
	Total CO_2 (te)	641,025	4,331,300	N/D	464882	**5,437,207 te**
Option 4 Removal by barge	Total Energy (GJ)	1190	59,810	277	4,676	**65,953 GJ**
	Total CO_2 (te)	997,150	4,400,089	N/D	464882	**5,862,121 te**
Option 5 piece small dismantling	Total Energy (GJ)	0	58,271	568	4,676	**63,515 GJ**
	Total CO_2 (te)	0	4,286,950	N/D		**4,286,950 te**

Key: ND = No data N/A = Not applicable

Figure D.3.3.1 - Total net energy used in each option for the Juliet Topside removal

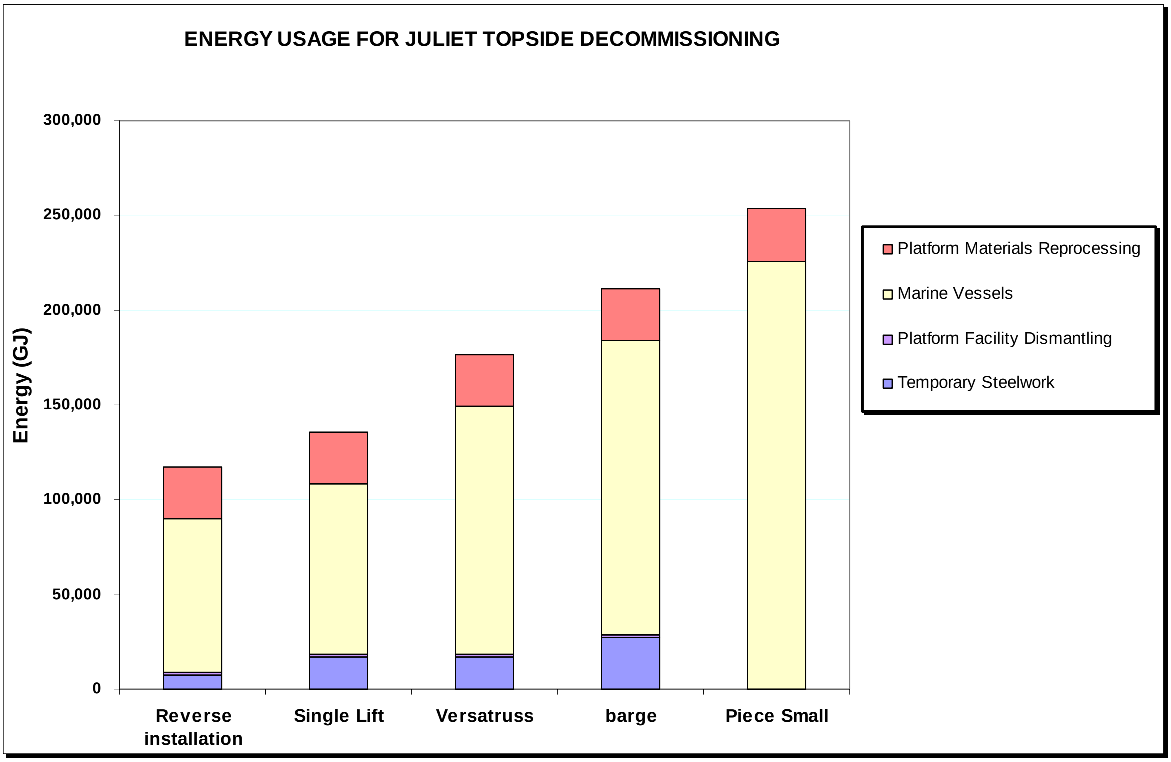


Figure D.3.3.2 - Estimates of the total CO_2 produced in each option for the Juliet Topside removal

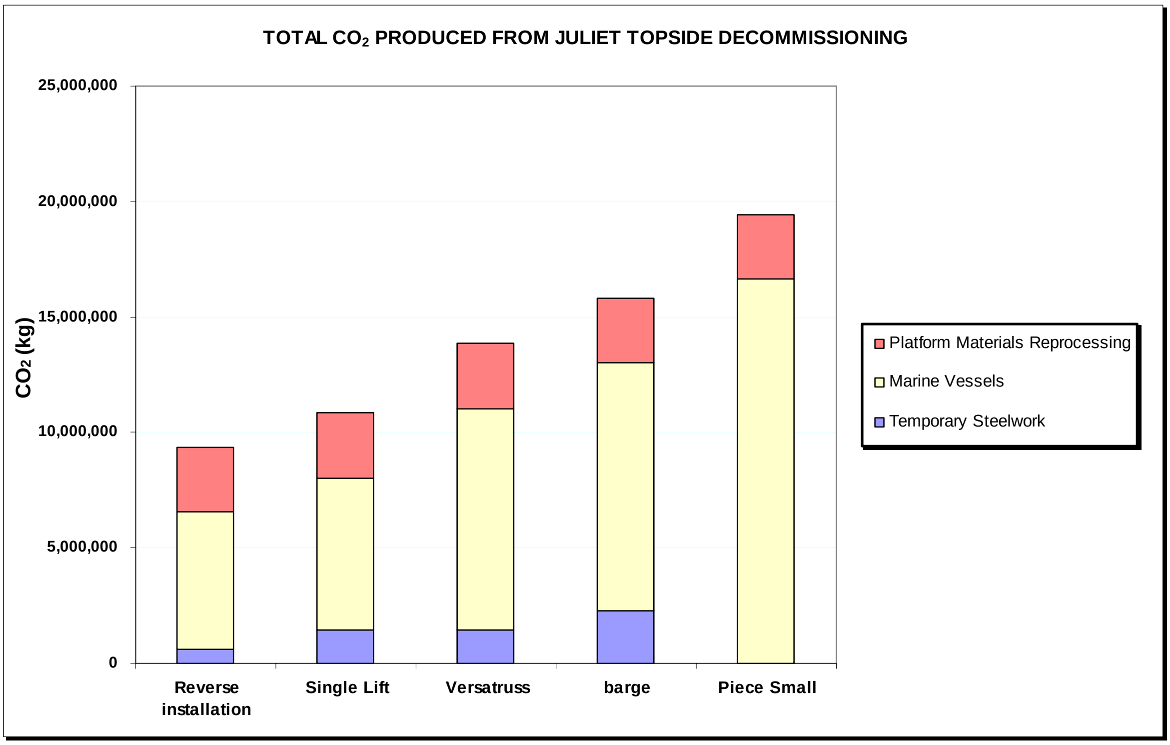


Figure D.3.3.3 - Total net energy used in each option for the Kilo Topside removal

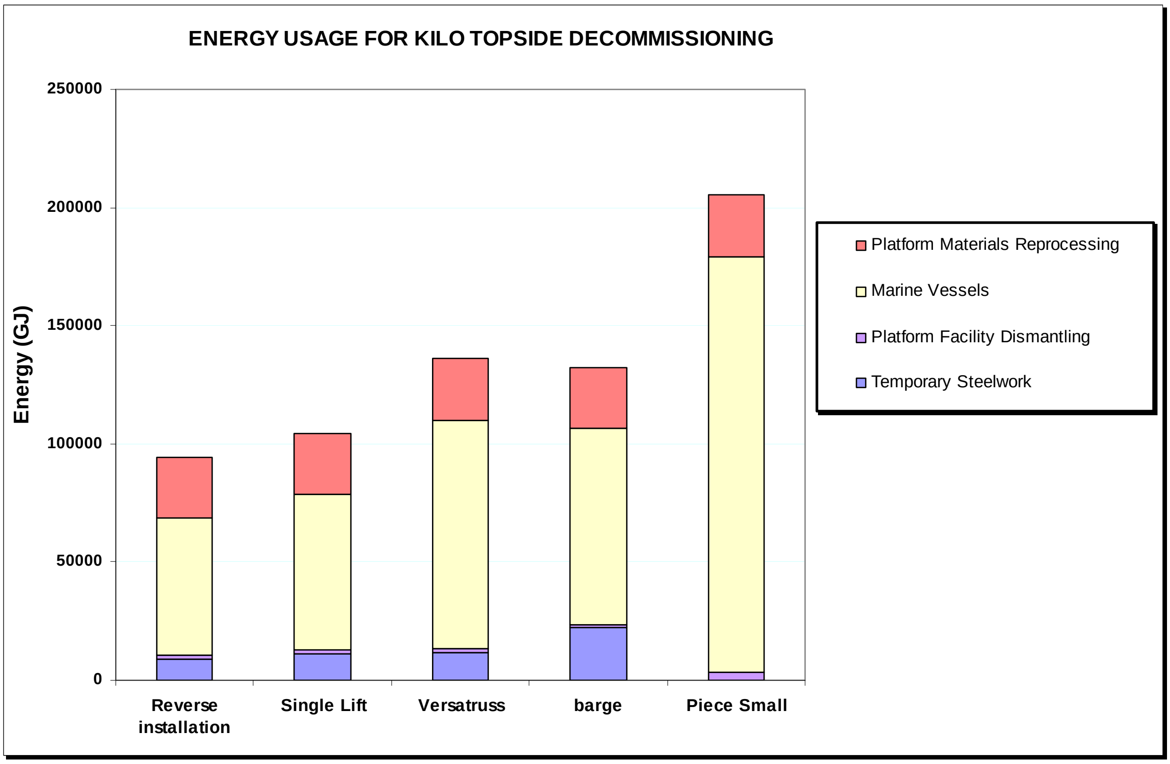


Figure D.3.3.4 -Estimates of the total CO_2 produced in each option for the Kilo Topside removal

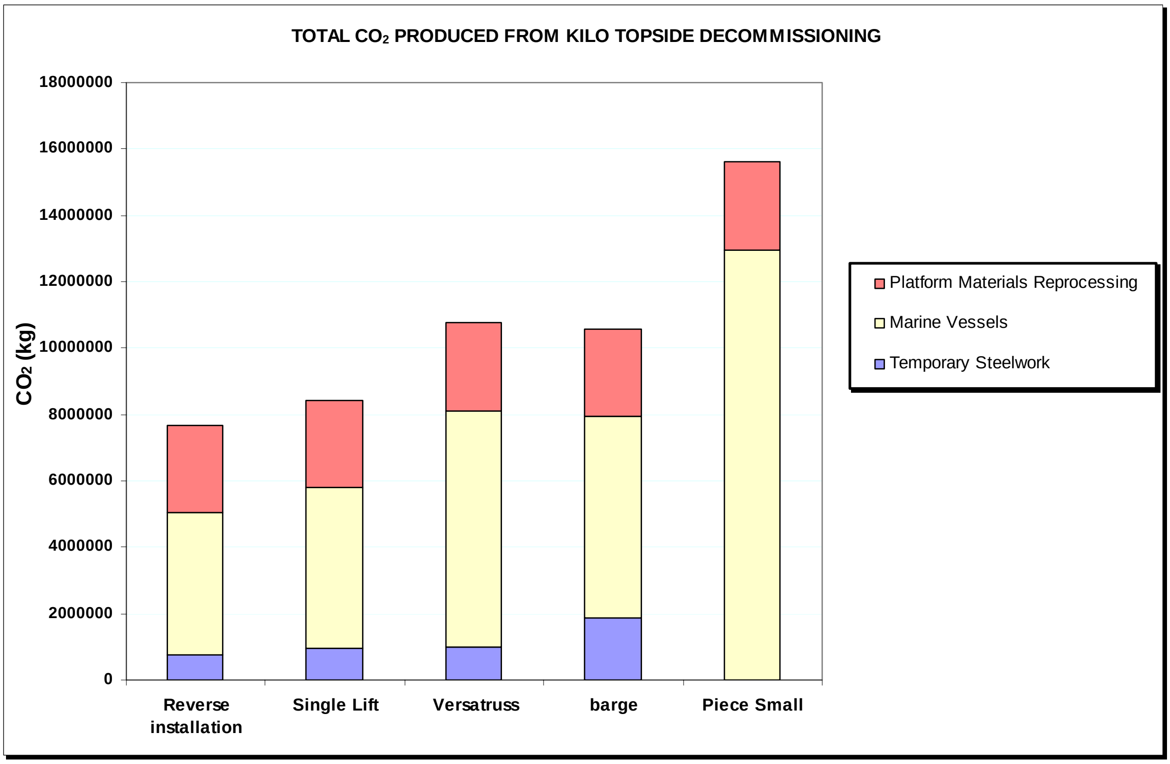


Figure D.3.3.5 - Total net energy used in each option for the Lima Topside removal

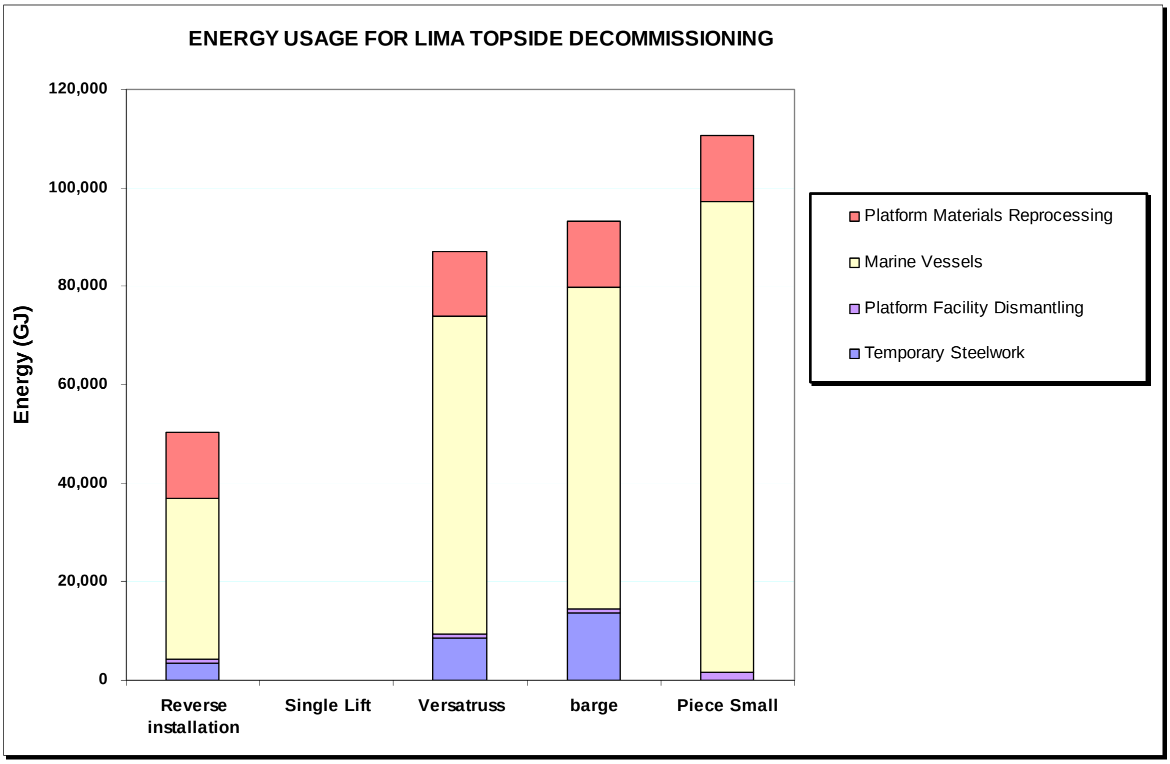


Figure D.3.3.6 - Estimates of the total CO_2 produced in each option for the Lima Topside removal

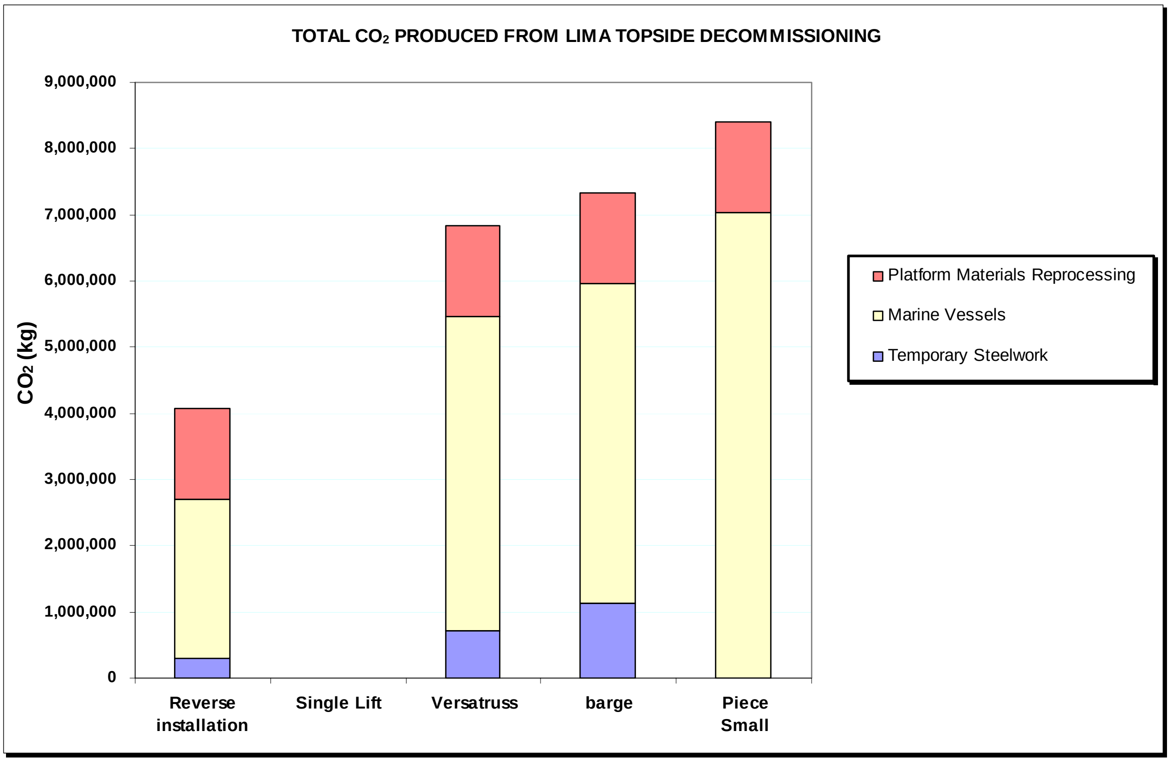


Figure D.3.3.7 - Total net energy used in each option for the Mike Topside removal

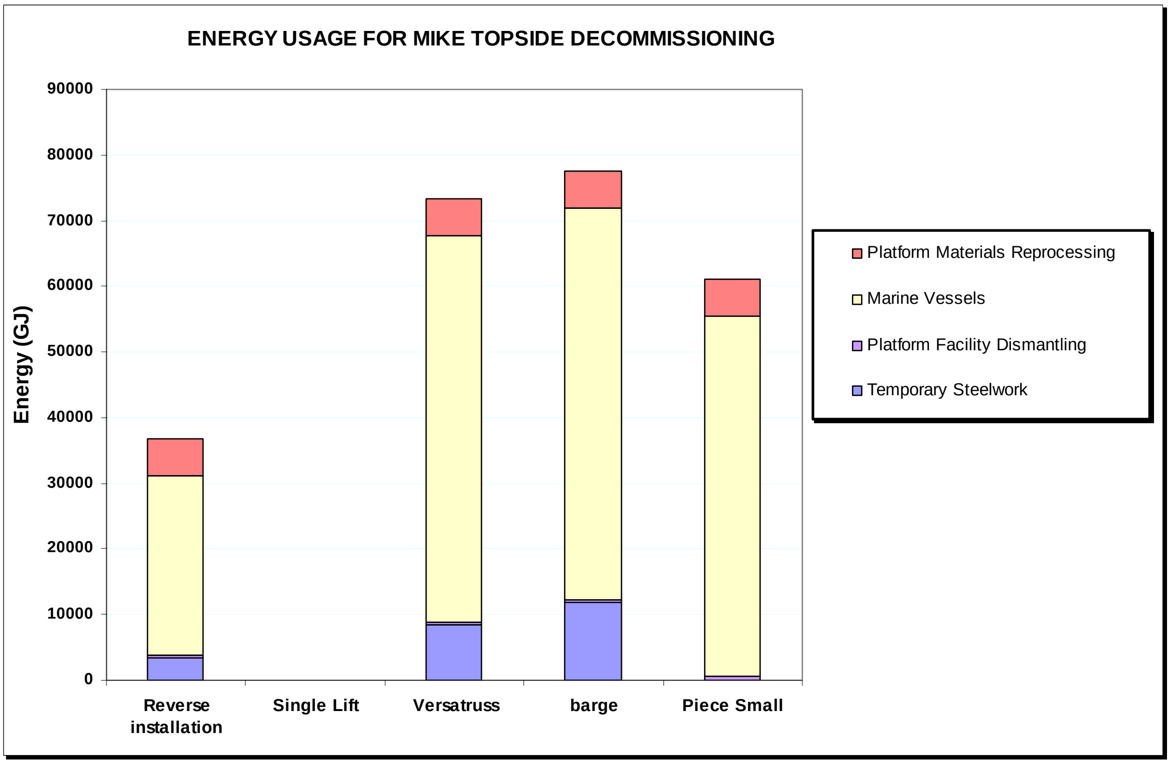


Figure D.3.3.8 - Estimates of the total CO_2 produced in each option for the Mike Topside removal

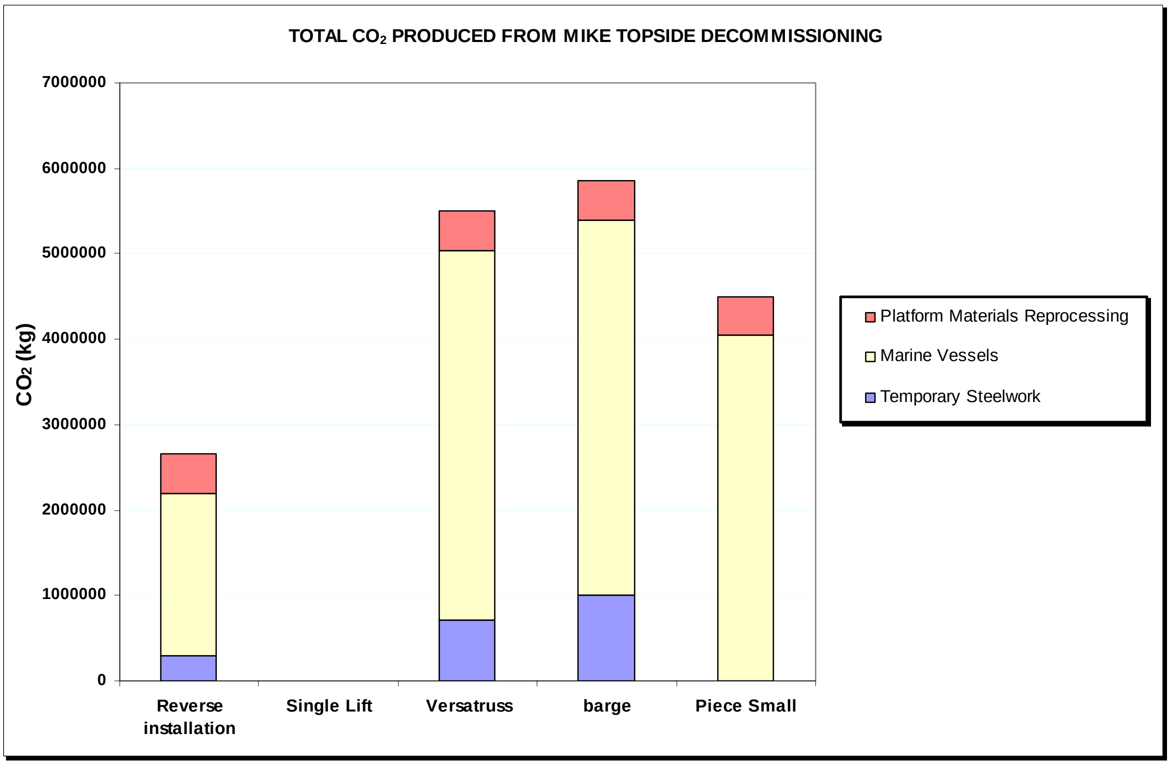


Figure D.3.3.9 - Total net energy used in each option for the November Topside removal

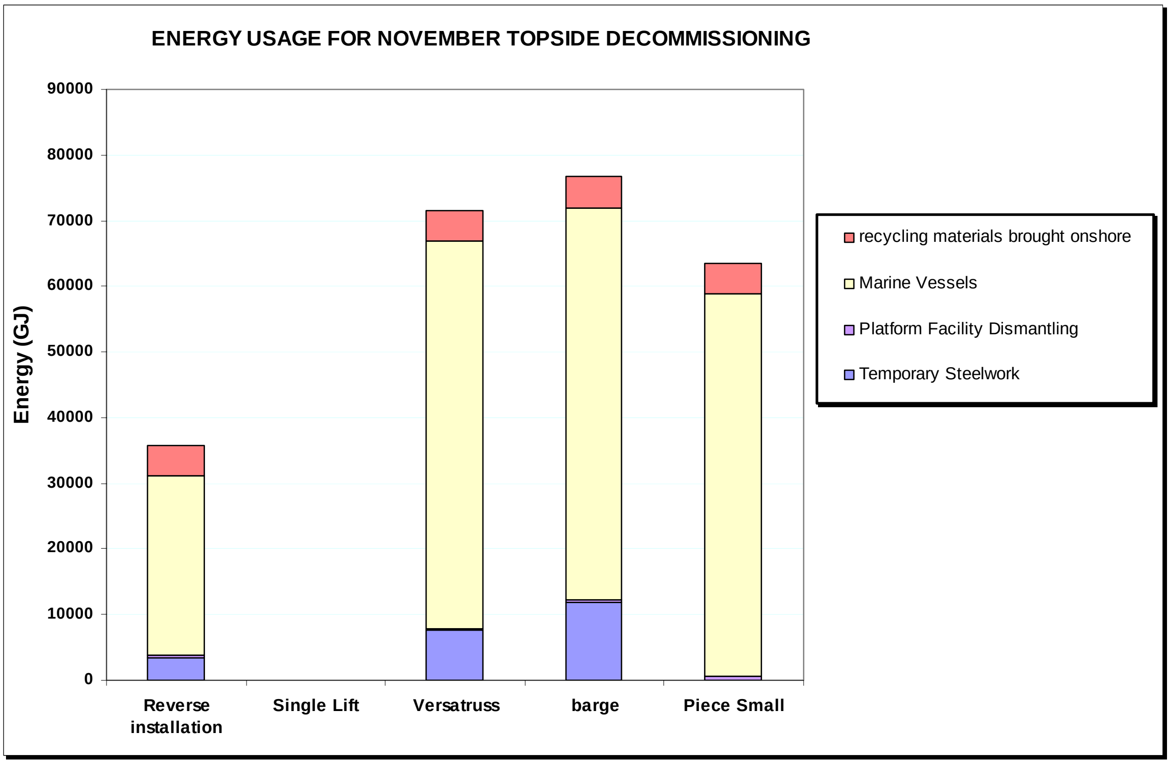
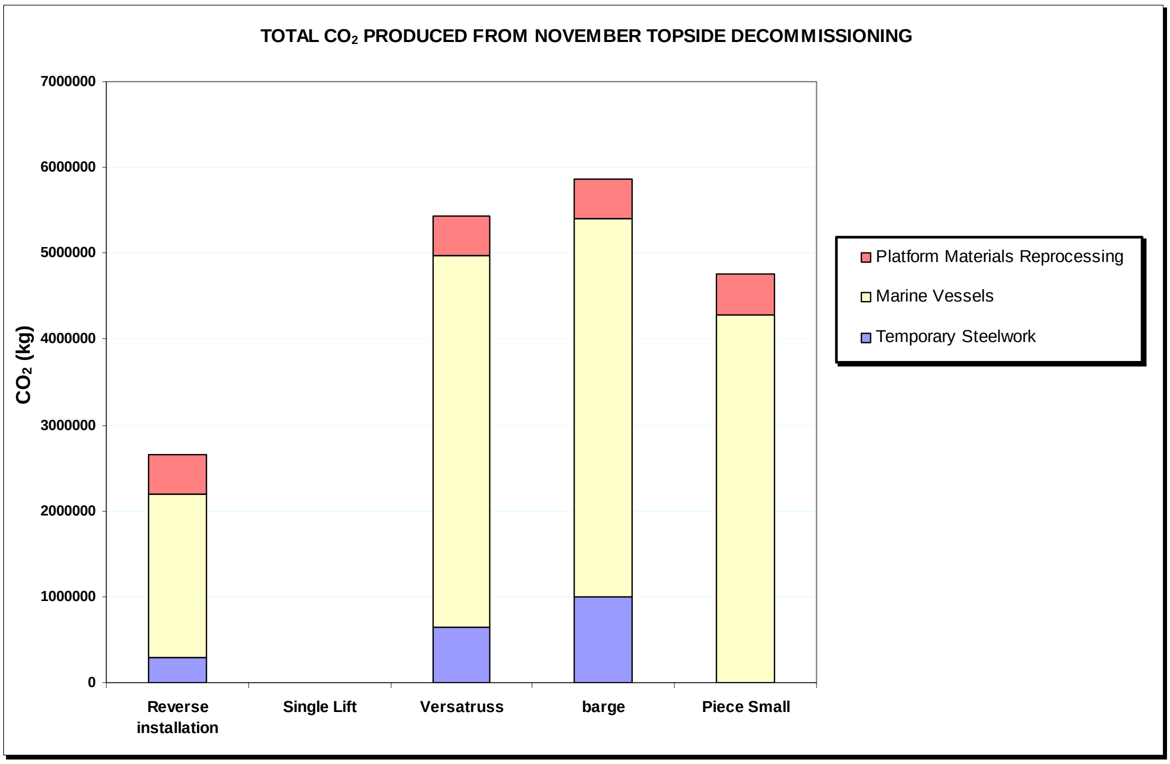


Figure D.3.3.10 - Estimates of the total CO_2 produced in each option for the November Topside removal



D.3.4 D.3.4 Results for the platform jacket removal options

Two options have been identified for the removal of the jackets. In each case the platform steel and aluminium anodes will be taken onshore for reprocessing. The removal methods identified require varying vessel utilisation and requirements for temporary steel structures. The removal options, in summary, are:

1. Reverse installation by HLV: this option involves cutting the jacket leg piles to below the mud line and lifting the jacket on to a cargo barge using an HLV. A jack-up leg cutting vessel and a dive support vessel will support the operation.

2. Removal using added buoyancy: this option involves cutting the jacket leg piles to below the mud line and fixing temporary rigid buoyancy tanks with which to float the structure. The jacket would then be towed to a deepwater near-shore site and then lifted onto a barge for final transportation to the dismantling site.

The results are given in Tables D.3.4.1 to D.3.4.5 and illustrated in Figures D.3.4.1 to D.3.4.10.

Table D.3.4.1: Estimates of total energy use and CO_2 emissions for the different options for the jacket removal for Juliet JD and JP platforms

Option for Jacket removal	Measure	Aspect of the decommissioning operation				Total for options
		Temporary steelwork	Marine Vessels	Dismantling	Materials reprocessing	
Option 1 Reverse installation with HLV	Total Energy (GJ)	7,480	64,235	696	11,607	**84,018 GJ**
	Total CO_2 (te)	626,780	4,725,013	ND	1,223,676	**6,575,469 te**
Option 2 Removal with buoyancy system	Total Energy (GJ)	18,292	99,197	696	11,607	**129,792 GJ**
	Total CO_2 (te)	1,532,762	7,297,115	ND	1,223,676	**10,053,553 te**

Key ND = No data

Table D.3.4.2: Estimates of total energy use and CO_2 emissions for the different options for the jacket removal for Kilo platform

Option for Jacket removal	Measure	Aspect of the decommissioning operation				Total for options
		Temporary steelwork	Marine Vessels	Dismantling	Materials reprocessing	
Option 1 Reverse installation with HLV	Total Energy (GJ)	5,780	36,794	457	7,465	**50,496 GJ**
	Total CO_2 (te)	484,330	2,706,677	ND	786,012	**3,977,019 te**
Option 2 Removal with buoyancy system	Total Energy (GJ)	11,628	61,199	457	7,465	**80,749 GJ**
	Total CO_2 (te)	974,358	4,502,020	ND	786,012	**6,262,390 te**

Key ND = No data

Table D.3.4.3: Estimates of total energy use and CO_2 emissions for the different options for the jacket removal for Lima platform

Option for Jacket removal	Measure	Aspect of the decommissioning operation				Total for options
		Temporary steelwork	Marine Vessels	Dismantling	Materials reprocessing	
Option 1 Reverse installation with HLV	Total Energy (GJ)	3,060	24,205	468	7,631	**35,364 GJ**
	Total CO_2 (te)	256,410	1,780,780	ND	804,624	**2,841,814 te**
Option 2 Removal with buoyancy system	Total Energy (GJ)	12,580	38,085	468	7,631	**58,764 GJ**
	Total CO_2 (te)	1,054,130	2,192,499	ND	804,624	**4,051,253 te**

Key ND = No data

Table D.3.4.4: Estimates of total energy use and CO_2 emissions for the different options for the jacket removal for Mike platform

Option for Jacket removal	Measure	Aspect of the decommissioning operation				Total for options
		Temporary steelwork	Marine Vessels	Dismantling	Materials reprocessing	
Option 1 Reverse installation with HLV	Total Energy (GJ)	3,060	25,756	356	5,880	**35,052 GJ**
	Total CO_2 (te)	256,410	1,894,630	ND	613,836	**2,764,876 te**
Option 2 Removal with buoyancy system	Total Energy (GJ)	9,180	38,537	356	5,880	**53,953 GJ**
	Total CO_2 (te)	769,230	2,834,874	ND	613,836	**4,217,940 te**

Key ND = No data

Table D.3.4.5: Estimates of total energy use and CO_2 emissions for the different options for the jacket removal for November platform

Option for Jacket removal	Measure	Aspect of the decommissioning operation				Total for options
		Temporary steelwork	Marine Vessels	Dismantling	Materials reprocessing	
Option 1 Reverse installation with HLV	Total Energy (GJ)	3,060	21,702	394	6,479	**31,635 GJ**
	Total CO_2 (te)	256,410	1,596,460	ND	678,084	**2,530,954 te**
Option 2 Removal with buoyancy system	Total Energy (GJ)	10,200	32,219	394	6,479	**49,292 GJ**
	Total CO_2 (te)	854,700	2,370,120	ND	678,084	**3,902,904 te**

Key ND = No data

Figure D.3.4.1 - Total net energy used in each option for the Juliet JD and JP jacket removal

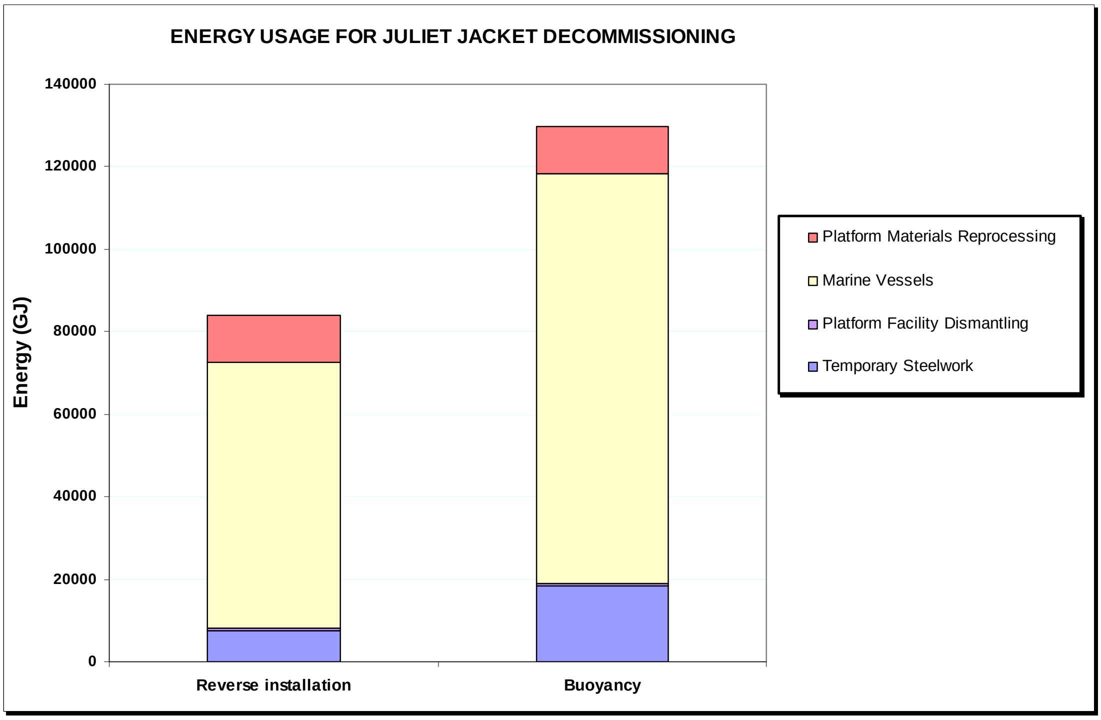


Figure D.3.4.2 - Estimates of the total CO_2 produced in each option for the Juliet JD and JP jacket removal

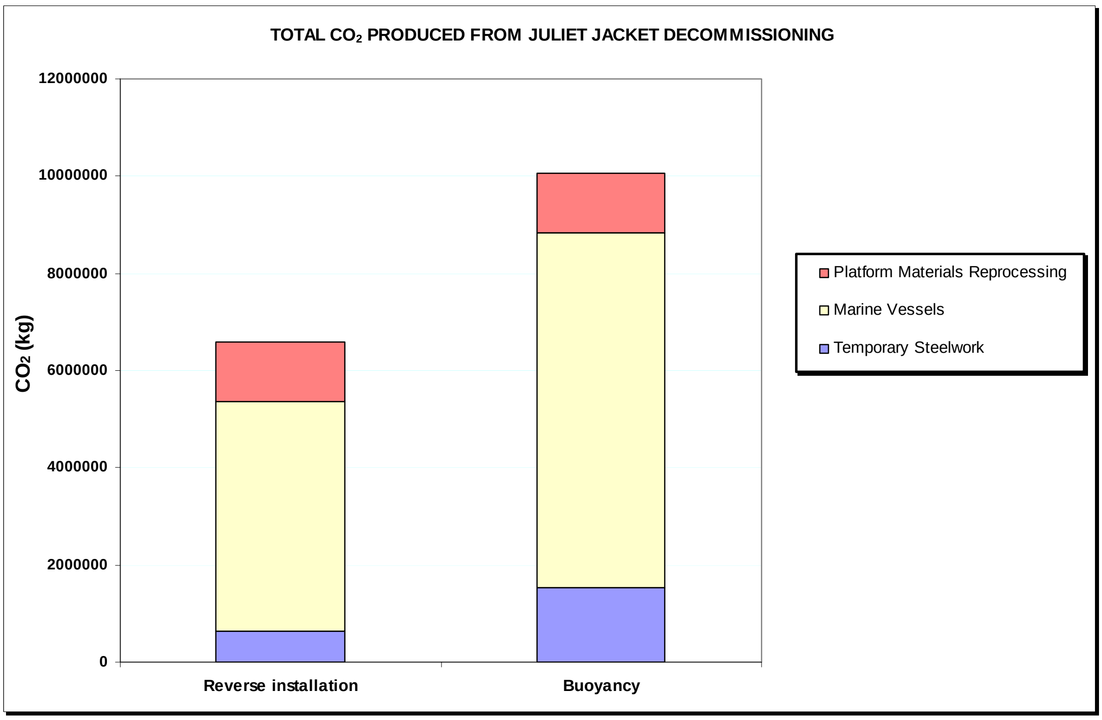


Figure D.3.4.3 - Total net energy used in each option for the Kilo jacket removal

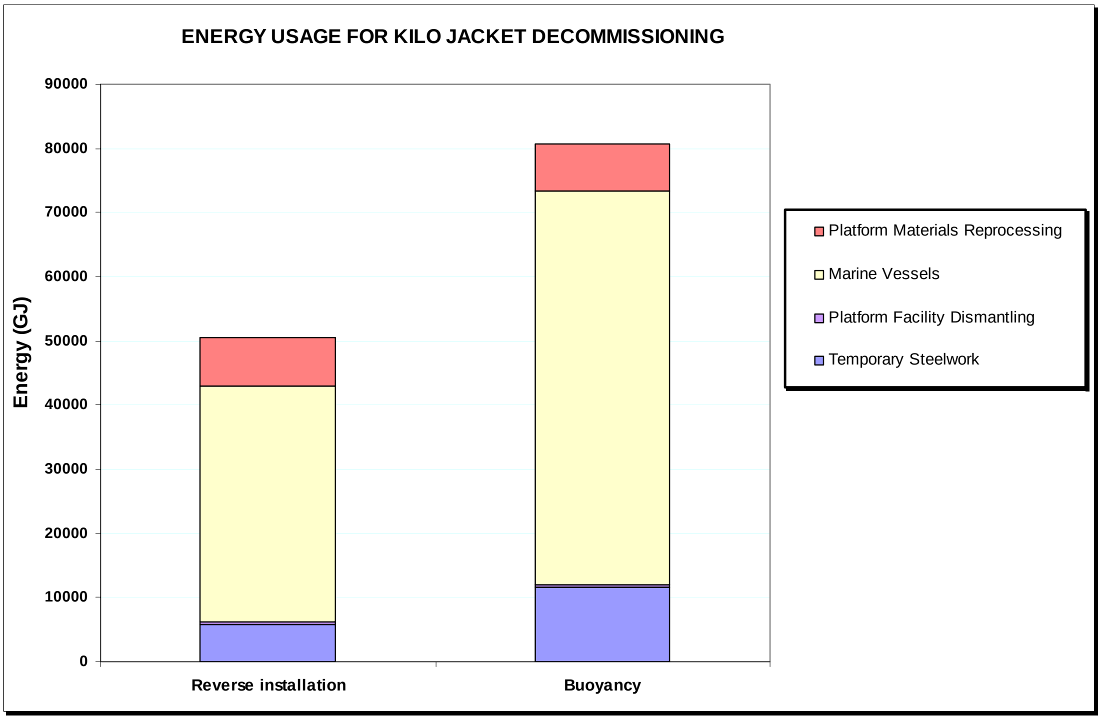


Figure D.3.4.4 - Estimates of the total CO_2 produced in each option for the Kilo jacket removal

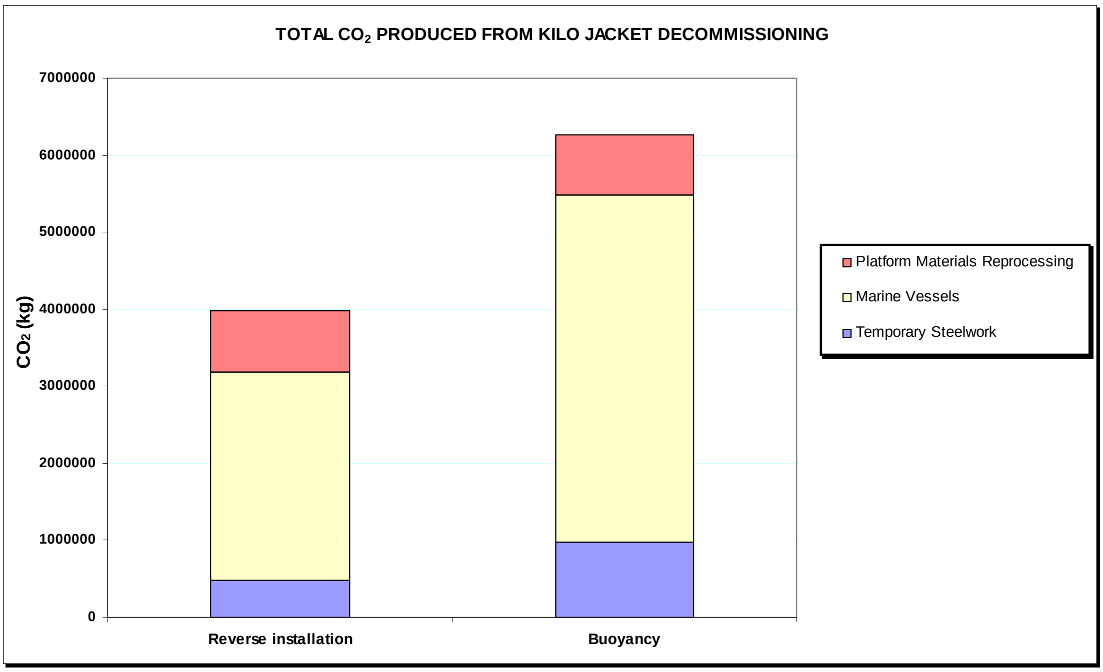


Figure D.3.4.5 - Total net energy used in each option for the Lima jacket removal

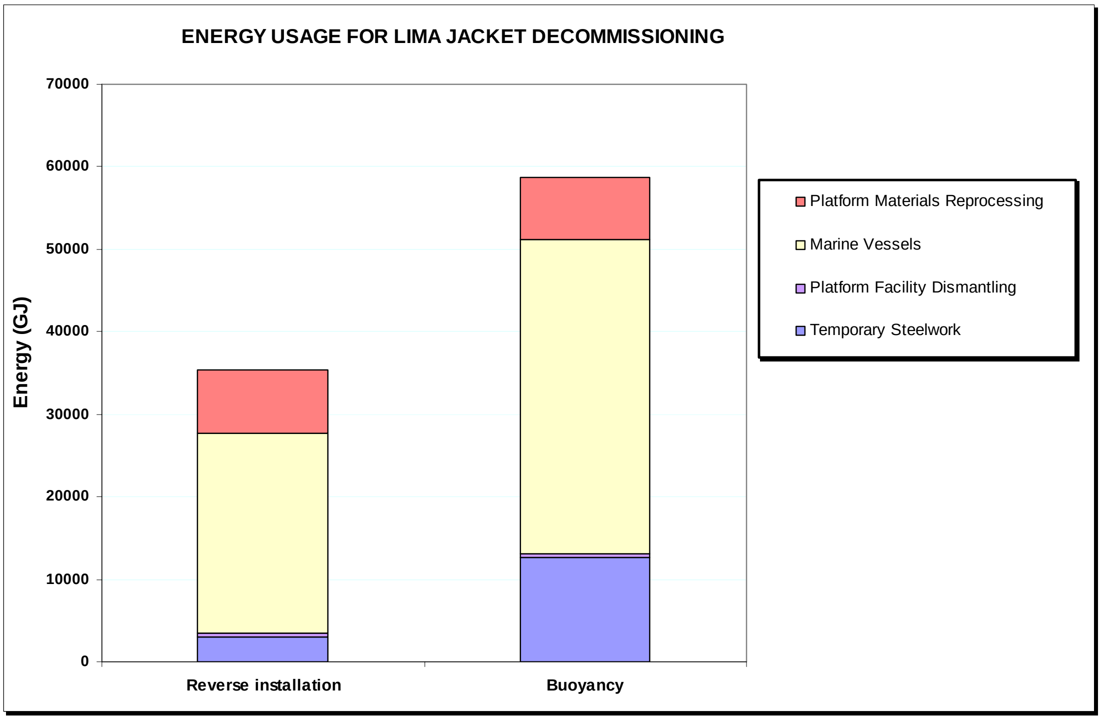


Figure D.3.4.6 - Estimates of the total CO_2 produced in each option for the Lima jacket removal

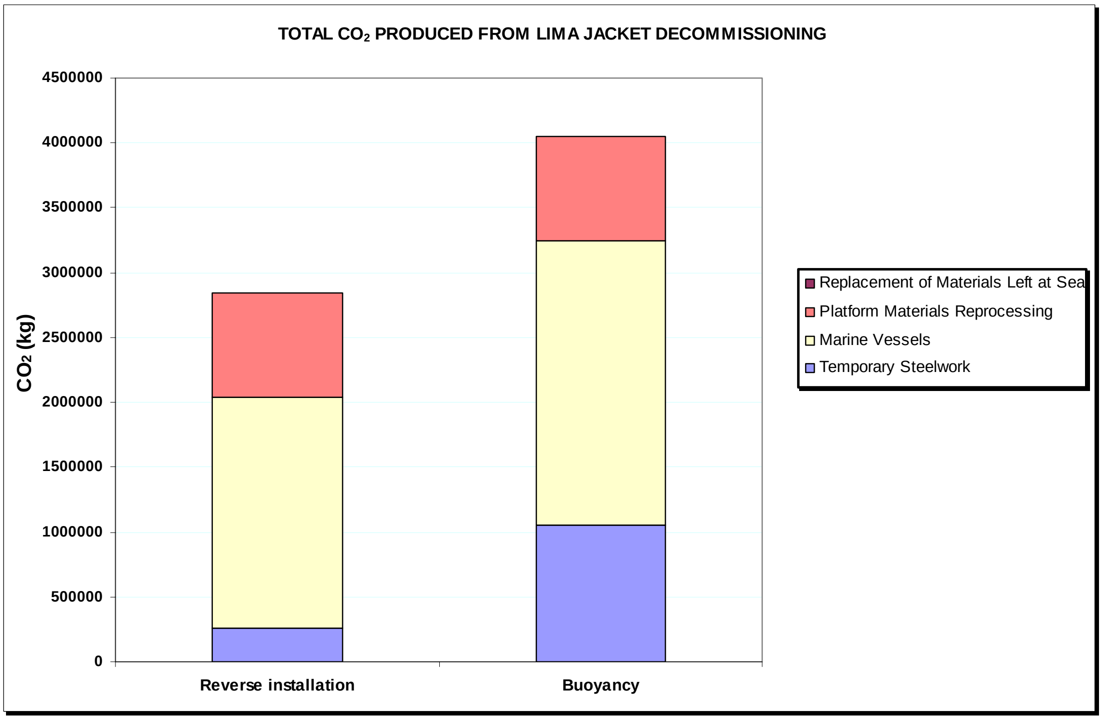


Figure D.3.4.7 - Total net energy used in each option for the Mike jacket removal

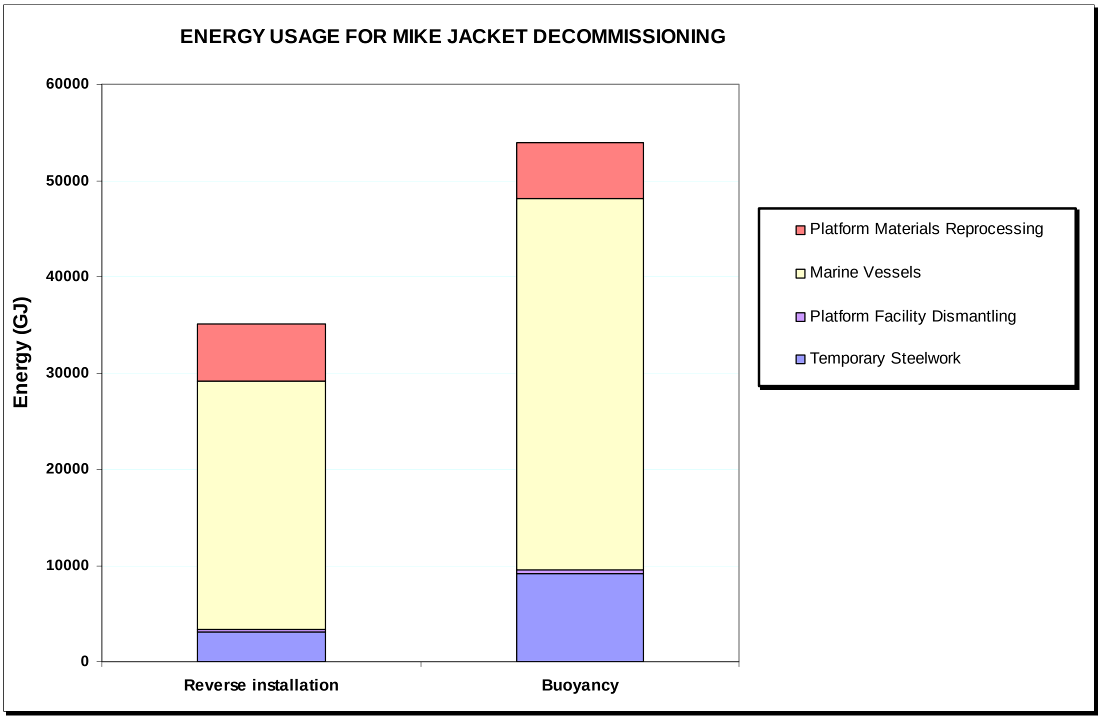


Figure D.3.4.8 - Estimates of the total CO_2 produced in each option for the Mike jacket removal

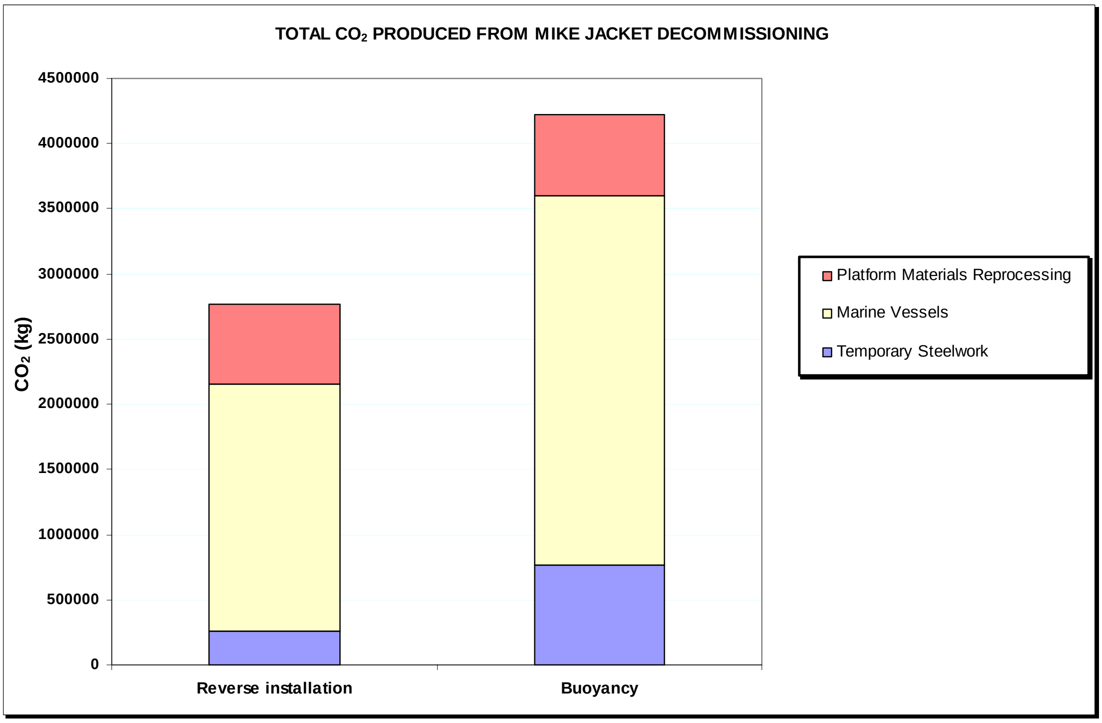


Figure D.3.4.9 - Total net energy used in each option for the November jacket removal

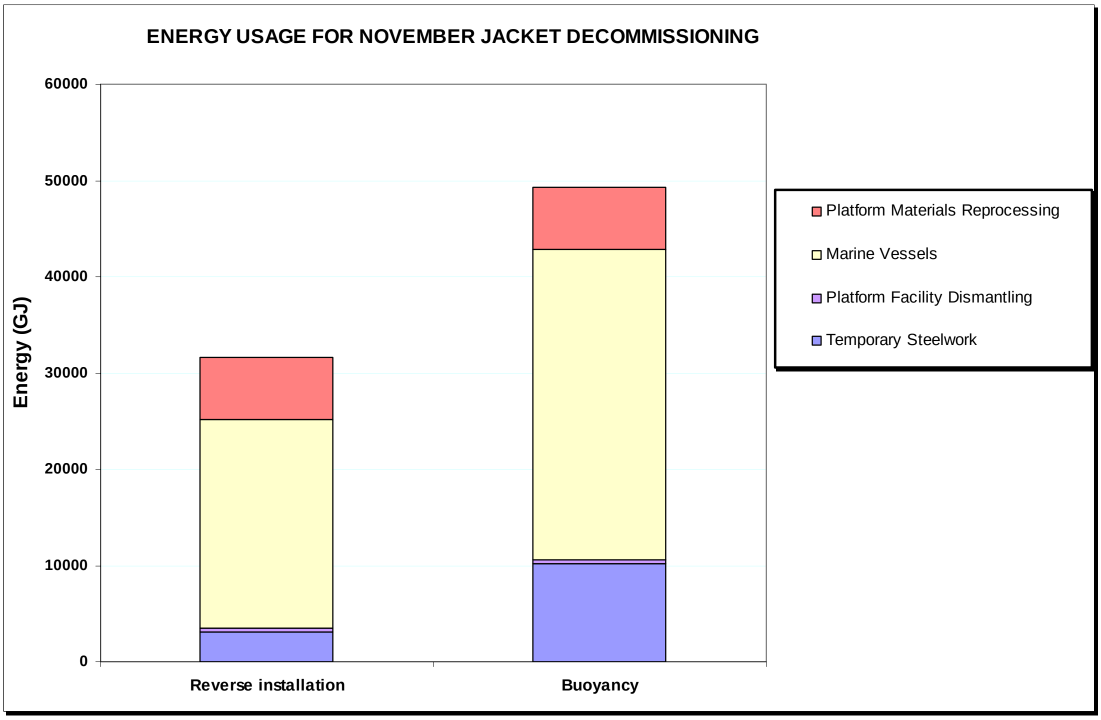
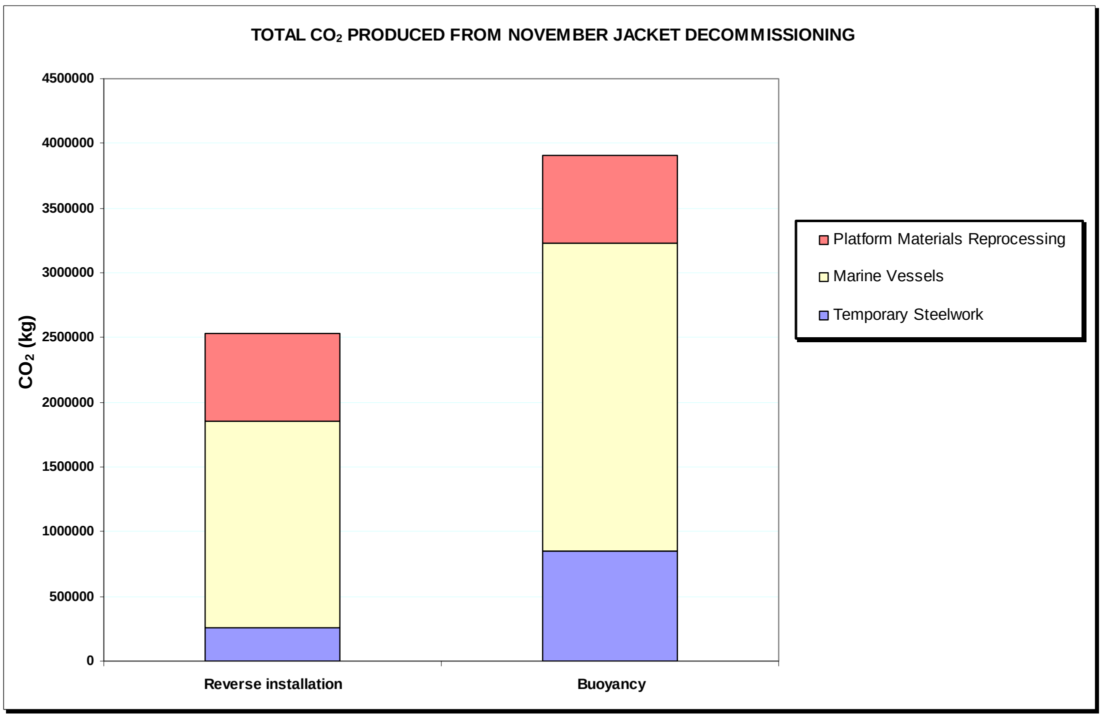


Figure D.3.4.10 - Estimates of the total CO2 produced in each option for the November jacket removal



D.3.5 Pipelines & Hose Bundles

Energy and emissions calculations were completed for the P80, P81, P82, P302 and P402 pipelines and the two hose bundles. For each of these groups, a range of options was examined. This permitted an analysis of the influence on the energy budget of different removal methods, and the recycling of different amounts of recovered material. The sub-options for both of these groups are summarised as follows:

1. In-situ decommissioning: in this option, remediation activities are undertaken. These activities may include removing spans, or burying exposed parts of the line by trenching or rock dumping.

2. Cut and lift: in this option the pipeline is cut on the seabed, lifted to the surface, and returned to shore for recycling.

3. Reverse lay: in this option the pipeline is removed by reverse S-lay, and returned to shore for recycling.

4. Re-reeling: in this option the hose bundles are recovered by being re-reeled.

The results are given in Tables D.3.5.1 to D.3.5.3 and illustrated in Figures D.3.5.1 to D.3.5.6.

Note that the energy figures for the pipeline removal options are optimistic, as they assume that the pipelines are fully recycled. In reality this material is unlikely to be fully recycled, and thus their energy usage would be greater.

Table D.3.5.1: Estimates of total energy and CO_2 emissions for the different options for the PL80, PL81 & PL82 pipelines

Option for Pipeline removal	Measure	Aspect of the decommissioning operation				Total for options
		Temporary steelwork	Marine Vessels	Materials reprocessing	Materials replacement	
Option 1 Leave in situ	Total Energy (GJ)	0	5,101	0	92,998	**98,099 GJ**
	Total CO_2 (te)	0	375,170	0	6,847,263	**7,222,433 te**
Option 2 Reverse S-Lay removal	Total Energy (GJ)	4,080	32,699	43,814	0	**80,593 GJ**
	Total CO_2 (te)	431,880	2,406,216	5,616,240	0	**8,454,336 te**
Option 3 Reverse Cut and lift removal	Total Energy (GJ)	4,080	61,113	43,814	0	**109,007 GJ**
	Total CO_2 (te)	431,880	4,495,830	5,616,240	0	**10,543,950 te**

Table D.3.5.2: Estimates of total energy and CO_2 emissions for the different options for the PL302 and PL402 pipelines

Option for Pipeline removal	Measure	Aspect of the decommissioning operation				Total for options
		Temporary steelwork	Marine Vessels	Materials reprocessing	Materials replacement	
Option 1 Leave in situ	Total Energy (GJ)	0	3,780	0	17,674	**21,454 GJ**
	Total CO_2 (te)	0	6,082	0	1,207,868	**1,213,950 te**
Option 2 Reverse S-Lay removal	Total Energy (GJ)	3,740	21,188	7,114	0	**32,042 GJ**
	Total CO_2 (te)	313,390	1,558,852	1,792,208	0	**3,664,450 te**
Option 3 Cut and lift removal	Total Energy (GJ)	3,740	25,046	7,114	0	**35,900 GJ**
	Total CO_2 (te)	313,390	1,842,750	1,792,208	0	**3,948,348 te**

Table D.3.5.3: Estimates of total gaseous emissions for the different options for the PL303 and PL479-487 hose bundles

Option for Hose bundle removal	Measure	Aspect of the decommissioning operation		Total for options
		Temporary steelwork	Marine Vessels	
Option 1 Leave in situ	Total Energy (GJ)	0	3,039	**3,039 GJ**
	Total CO_2 (te)	0	223,545	**223,545 te**
Option 2 Remove	Total Energy (GJ)	680	1,739	**2,419 GJ**
	Total CO_2 (te)	56,980	127,970	**184,950 te**

Figure D.3.5.1 - Total net energy used in each option for P80's pipelines decommissioning

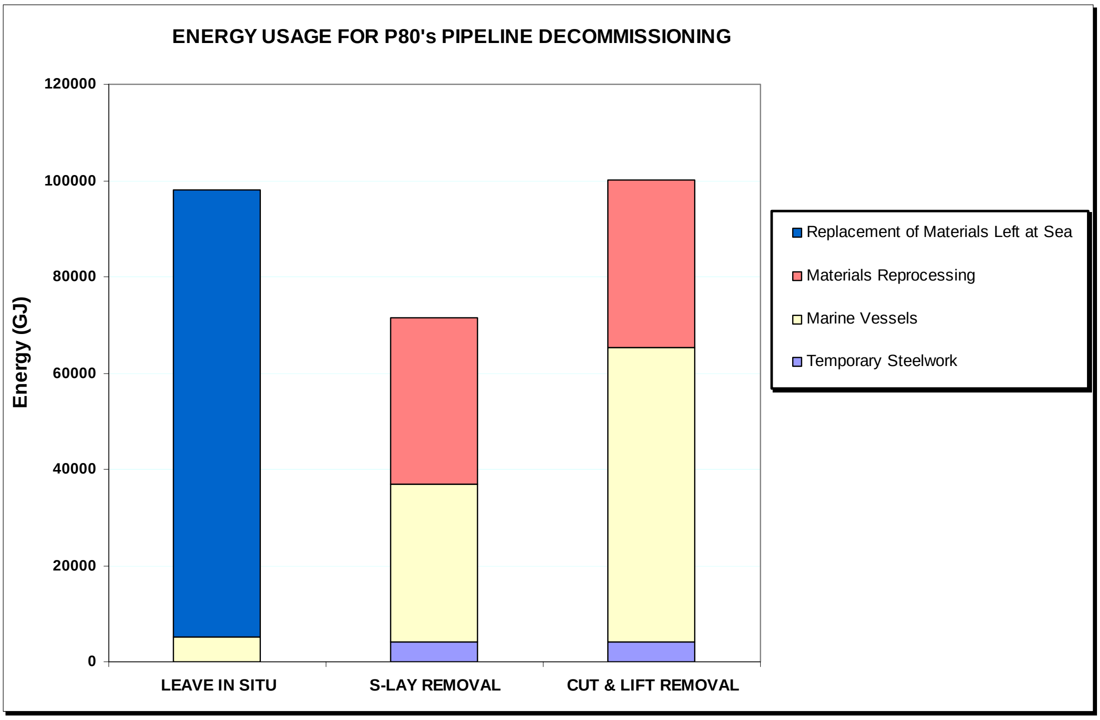


Figure D.3.5.2 - Estimates of the total CO2 produced in each option for P80's pipelines decommissioning

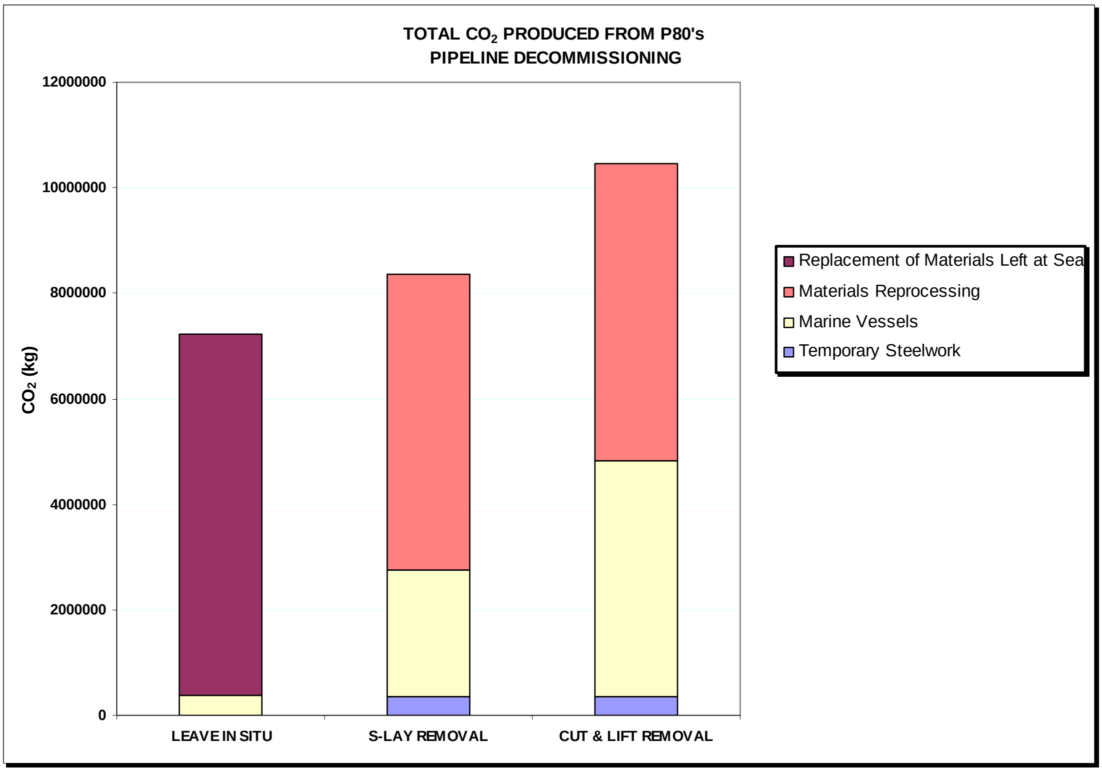


Figure D.3.5.3 - Estimates of the total CO2 produced in each option for P320 and P403 pipelines decommissioning

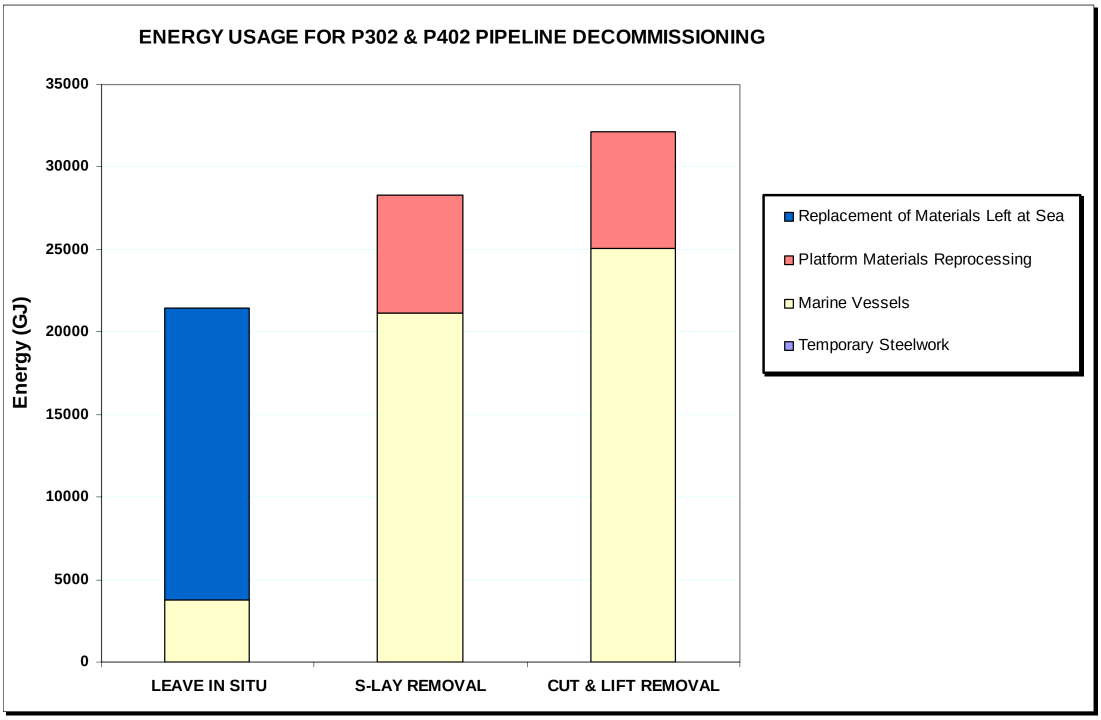


Figure D.3.5.4 - Estimates of the total CO2 produced in each option for P302 and P402 pipelines decommissioning

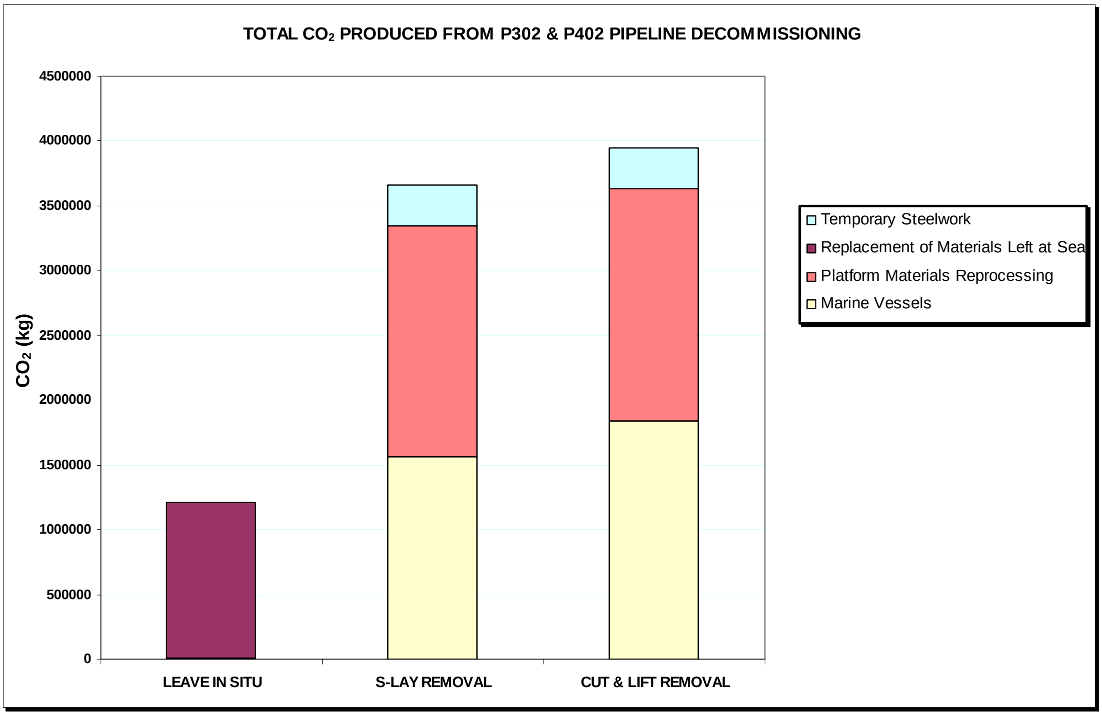


Figure D.3.5.5 - Estimates of the total CO2 produced in each option for Hose Bundles decommissioning

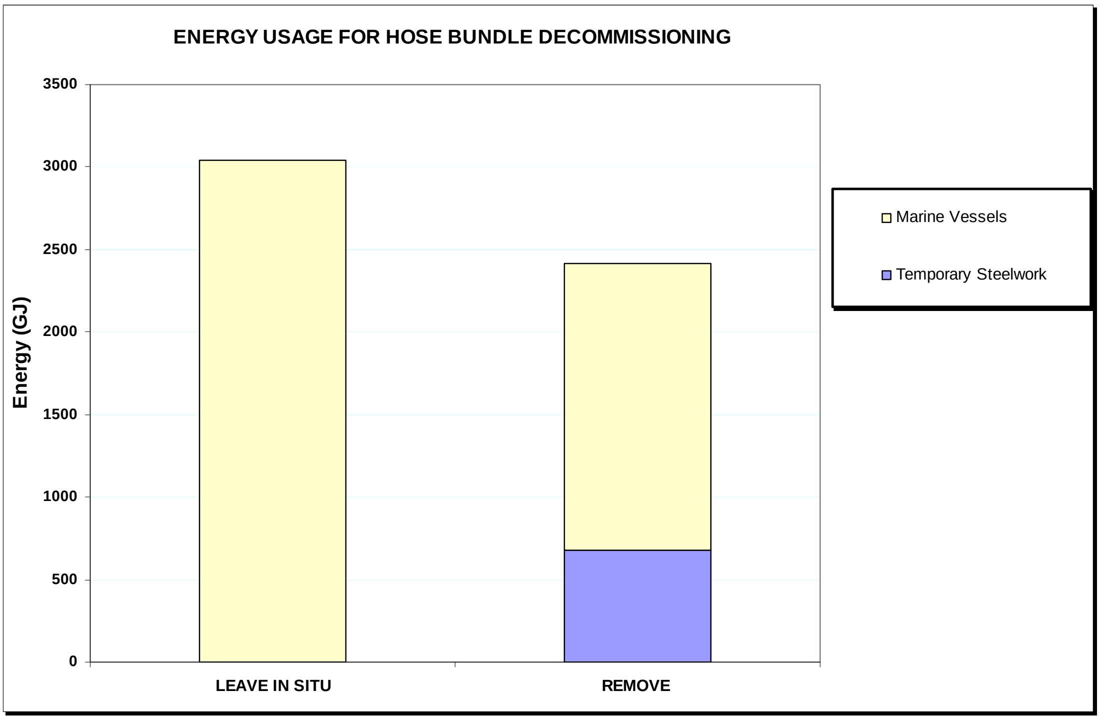
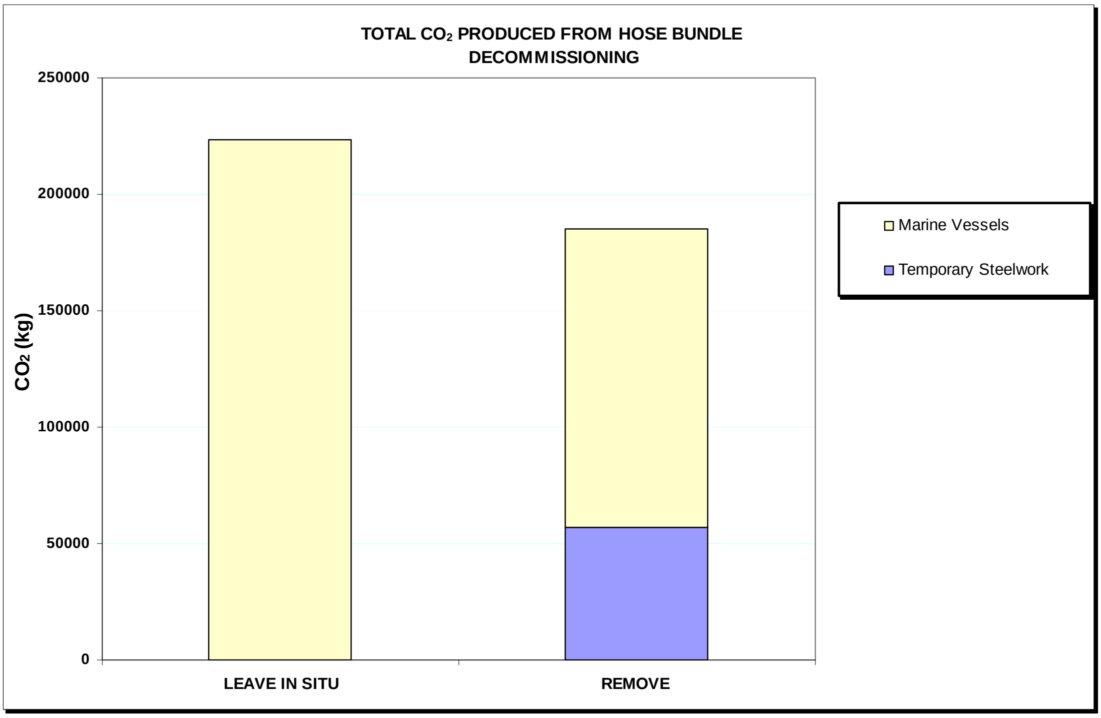


Figure D.3.5.6 - Estimates of the total CO2 produced in each option for Hose Bundles decommissioning



D.4 DISCUSSION

D.4.1 Introduction

This section reviews the results of the estimations of energy use and gaseous emissions of the different options. The total amounts of gaseous emissions are very closely linked to the total amounts of energy used, and so for the sake of clarity this discussion deals only with the estimated net energy use of each option.

D.4.2 Topsides

The net energy use of the different options for the topsides of the facilities is shown in Table D.4.2.1.

Table D.4.2.1: Total net energy use for decommissioning the topsides of each facility

Option	Platform				
	Juliet	Kilo	Lima	Mike	November
Reverse installation by HLV	117	94	50	37	36
Single lift	136	105	N/A	N/A	N/A
Versatruss	177	136	87	73	71
Twin barge	212	132	93	78	66
Piece-small	257	205	111	61	64

Values are rounded, and in units of 1,000GJ.
N/A = Option Not Applicable

For **Juliet**, the total energy use of different options ranges from 117,000GJ to 257,000GJ (in round numbers). “Reverse installation by HLV” is the least energy-intensive, and is less than half that of the most energy-intensive, “piece-small”. The difference between “reverse installation by HLV” and “single lift” (about 19,000GJ, 16%) may not be significant. However, the difference between these two options and the other 3 options may be significant. As presently planned, the “piece small” option would be clearly the most energy-intensive option and this is largely as a result of the simultaneous use of two jack-ups during offshore dismantling.

This pattern of energy use is repeated for **Kilo**, **Lima**, **Mike** and **November**. For **Kilo** the difference between the “reverse installation” and the “single lift” options may not be significant, but the other 3 options are probably actually more energy-intensive. For **Lima**, **Mike** and **November**, the “reverse installation” option is clearly significantly less energy-intensive than the nearest other option; for **Lima**, “Versatruss is 37,000GJ, 74% more energy-intensive; for **Mike** it is 36,000GJ, 97% more intensive; and for **November** “piece-small” is 28,000GJ, 78% more energy-intensive.

D.4.3 Jackets

The net energy use of the different options for the jackets of the facilities is shown in Table D.4.3.1.

Table D.4.3.1: Total net energy use for decommissioning the jackets of each facility

Option	Platform				
	Juliet	Kilo	Lima	Mike	November
Reverse installation by HLV	84	50	35	35	32
Removal with buoyancy	130	81	59	54	49

Values are rounded, and in units of 1,000GJ.

For **Juliet**, the option "reverse installation by HLV" is less energy-intensive than that of "removal with buoyancy". The difference, about 46,000GJ (55%) is probably significant and real, and results from the need to construct new rigid buoyancy tanks, and engage in a longer tow, in the "removal by buoyancy" option.

This finding applies to the other platforms. In each case "reverse installation" is less energy-intensive than removal with buoyancy", and the difference ranges from 53% (**November**) to 69% (**Lima**).

D.4.4 Pipelines & Hose Bundles

The net energy use of the different options for the three groups of pipelines is shown in Table D.4.4.1.

Table D.4.4.1: Total net energy use for decommissioning the different pipeline groups

Option	Pipeline group		
	PL80s	PL302 & 402	Hose bundles
Leave *in situ*	98	21	3
Remove by reverse S-lay	81	32	N/A
Remove by cut-and-lift	110	36	N/A
Remove by reeling	N/A	N/A	2

Values are rounded, and in units of 1,000GJ.
N/A = Option Not Applicable

For the **PL80s** group of pipelines, the options "leave *in situ*" and "remove by cut-and-lift" appear to both use about the same about of energy. They would use more energy than the option "remove by reverse S-lay", and the difference (17,500GJ, 22%) may be significant given the accuracy of the method used to estimate energy use.

However this analysis assumes that the Removal options result in full recycling, which does then not incur the "energy penalty" because recyclable material is left in the sea. In reality the pipeline material is unlikely to be fully recycled, and thus the *in-situ* option is likely to have a lower energy use.

For the **PL302 and 402** group, the two removal options ("remove by reverse S-lay" and "remove by cut-and-lift") would use approximately the same amounts of energy; the difference between the estimated values is probably not significant given the accuracy of the method used to estimate energy use. The option “leave in situ” is estimated to use less energy than either of the removal options, and the difference, 11,000GJ (52%) is probably real and significant.

In the case of this pipeline group, the option “leave *in situ*” incurs an “energy penalty” because recyclable material is left in the sea, but the amounts that would be left are relatively small, and so the effect of this aspect of the energy equation is not as significant as it is for the PL80s group. Having said that, if the pipeline material is not fully recycled in the Removals options, it makes the *in-situ* option even more favourable.

For the **Hose bundles**, the estimated energy use of both options is quite small, reflecting the small amounts of material involved and the relative ease with which they could be retrieved by reeling. The option “remove by reeling” would use 66% of the energy of the option “leave *in situ*”. This difference may appear to be significant in the context of the present estimations of total net energy use, but it is suggested that it should be viewed with caution, and not given undue prominence in the overall decision-making process, since the absolute values are relatively small and the actual energy use of the options could be subject to significant change depending on the specific programme that would be enacted to execute either option.

APPENDIX E

Pipelines and Hose Bundles – Burial Status and Condition

APPENDIX E - CONTENTS

E.1 PIPELINES AND HOSE BUNDLES – BURIAL STATUS AND CONDITION

The pipelines and hose bundles are all trenched and naturally backfilled, with some parts close to the base of platforms protected by concrete mattresses. They were designed for a theoretical service life of 15 to 25 years and were installed between 1971 and 1987. Regular surveys have indicated that the burial depth of the lines has remained generally stable over this period. PL81 and PL82 have some exposed sections along their lengths, all of which also appear to be generally stable.

See charts below for burial details and history. These charts have a resolution of 100m, but recent more detailed survey data of 1 to 2m resolutions are available. It is to be noted that due to the better precision in recent measurements (accuracy within centimetres) compared to the cruder 0.15 to 0.20m accuracy of earlier pinger / sub bottom profiler, there may appear to be some apparent differences in burial depths between earlier years and recent measurements in some of the lines.

Little information is available regarding the external condition. It is assumed that the 1.5" thick external concrete coating (reinforced with small-diameter chicken wire mesh) of the three pipelines installed in the 1970s will, having past their design life by now, be experiencing some deterioration and that the concrete outer coating may be subject to spalling if the pipelines are extracted from the seabed. The steel pipe wall and the thicker 3" concrete outer coating of the two pipelines installed in the mid 1980s can, however, be expected to be in good condition. Similarly, the hose bundles installed in the mid 1980s are expected to show little evidence of deterioration.

E.1.1 20" Pipeline PL80 / S.04.01 from Inde J to Perenco Inde AT

Pipeline PL80, 3182m long has outside steel diameter D=508mm, wall thickness t=5/32"=15.9mm (m_{st}=192.7kg/m), asphalt enamel coating t_{AE}=4.0mm/ρ_{AE}=1300kg/m^3 (m_{AE}=8.3kg/m), concrete weight coating t_c=1.5"=38mm/ρ_c=3044kg/m^3 (m_c=201.9kg/m). Total mass of water filled pipeline m_{tot}=585.4kg/m.
During operation condition gravity G=4127N/m and B=2769N/m resulting in G-B=1357N/m and factor G/B=1.39.
During abandoned condition gravity G=5743N/m and B=2769N/m resulting in G-B=2794N/m and factor G/B=2.07. This is a significant improvement for a stable buried condition.

Depth of burial survey data for the period up to 2003 has been plotted in graph below. Burial depth varies in time but the top of the pipeline is constantly below 0.5m below seabed. No exposures or spans have been identified during inspections.

PL80 has a history of remaining buried to at least 0.5m depth and had an average burial depth of about 0.8m in 2004. The burial depth has generally varied between 0.5 and 1.2m with some annual variations but no significant trends for burial increasing or decreasing over time. This line has no history of any section becoming exposed and was 100% buried in the 2004 survey
Together with the increased submerged weight of the pipeline the historic survey results give confidence the pipeline will remain well below seabed when left in place after abandonment

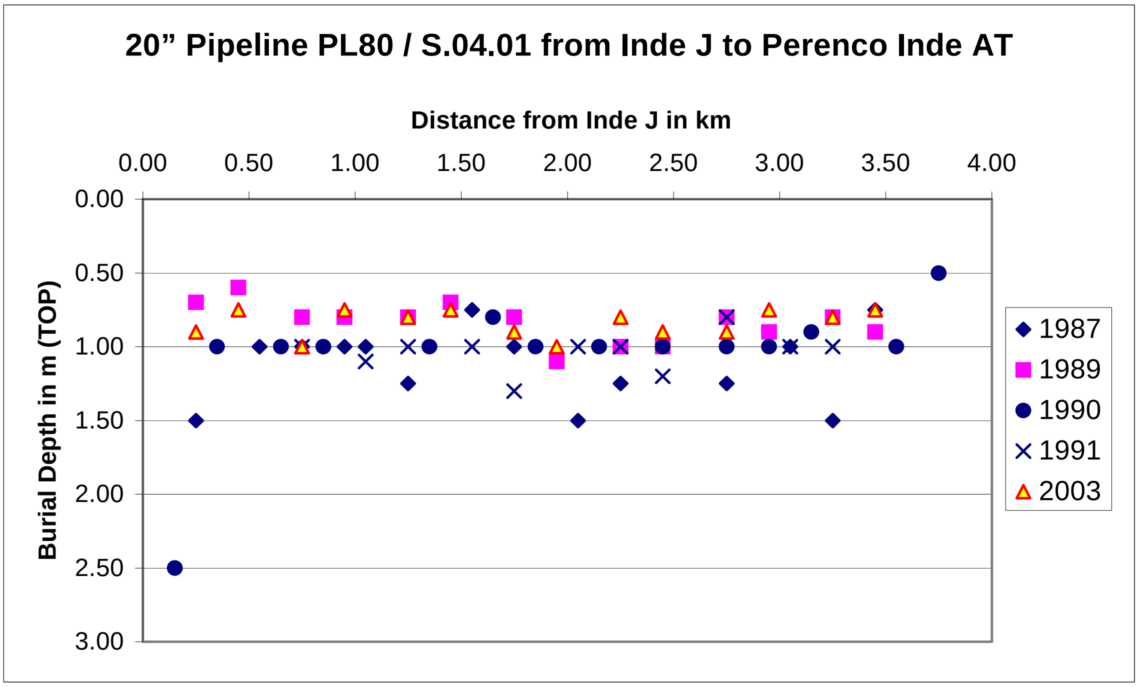


Figure E.1.1.1: Pipeline PL80 - Burial Depth surveys 1987-2003

Survey results of the year 2004 have not been included in the graph above. No spans and no exposures were identified during the 2004 survey. Report indicated pipeline burial to at least 0.75m. A separate graph of the 2004 burial depth survey is presented below

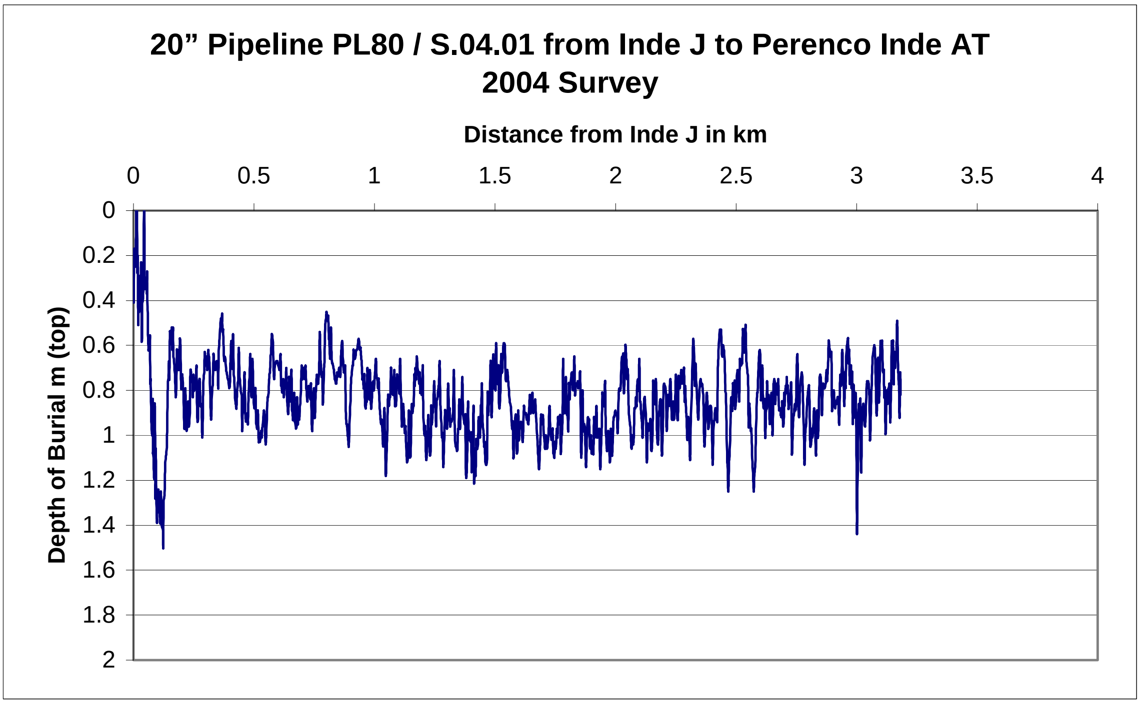


Figure E.1.1.2: Pipeline PL80 - Burial Depth survey 2004

Pipeline heading is approximately 260° and perpendicular to the main current direction, which is also the direction of sediment transport in this region.

E.1.2 24" Pipeline PL81 / S.04.02 from Inde K to Perenco Inde AT

Pipeline PL81, 8508m long, has outside steel diameter D=610mm, wall thickness t=0.688"=17.5mm (m_{st}=255.2kg/m), asphalt coating t_A=0.25"=6.4mm/ρ_A=1300kg/m^3 (m_A=16.0kg/m), concrete weight coating t_c=1.5"=38mm/ρ_c=3044kg/m^3 (m_c=240.6kg/m). Total mass of water filled pipeline m_{tot}=777.6kg/m.
During operation condition gravity G=5275N/m and B=3853N/m resulting in G-B=1422N/m and factor G/B=1.40.
During abandoned condition gravity G=7628N/m and B=3853N/m resulting in G-B=3775N/m and factor G/B=1.98. This is a significant improvement for a stable buried condition.

Depth of burial survey data for the period up to 2003 has been plotted in graph below. Burial depth varies in time.
PL81 has a history of stable burial and had an average burial depth of about 0.5m in 2004. The burial depth has typically varied between 0.2 and 1.0m with some annual variations but no significant trends for burial increasing or decreasing over time. The 2004 detailed survey indicated that this line was 99% buried and had one exposed length of about 33m at Kilometre point 3.76km with a span of about 2m length with a gap of about 0.06m at its maximum. This span is not a snagging risk as it is small. There were short intermittent exposed crown sections of 1 to 6m lengths at Kilometre points 4.00km, 4.33km, 4.65km and 6.64km.

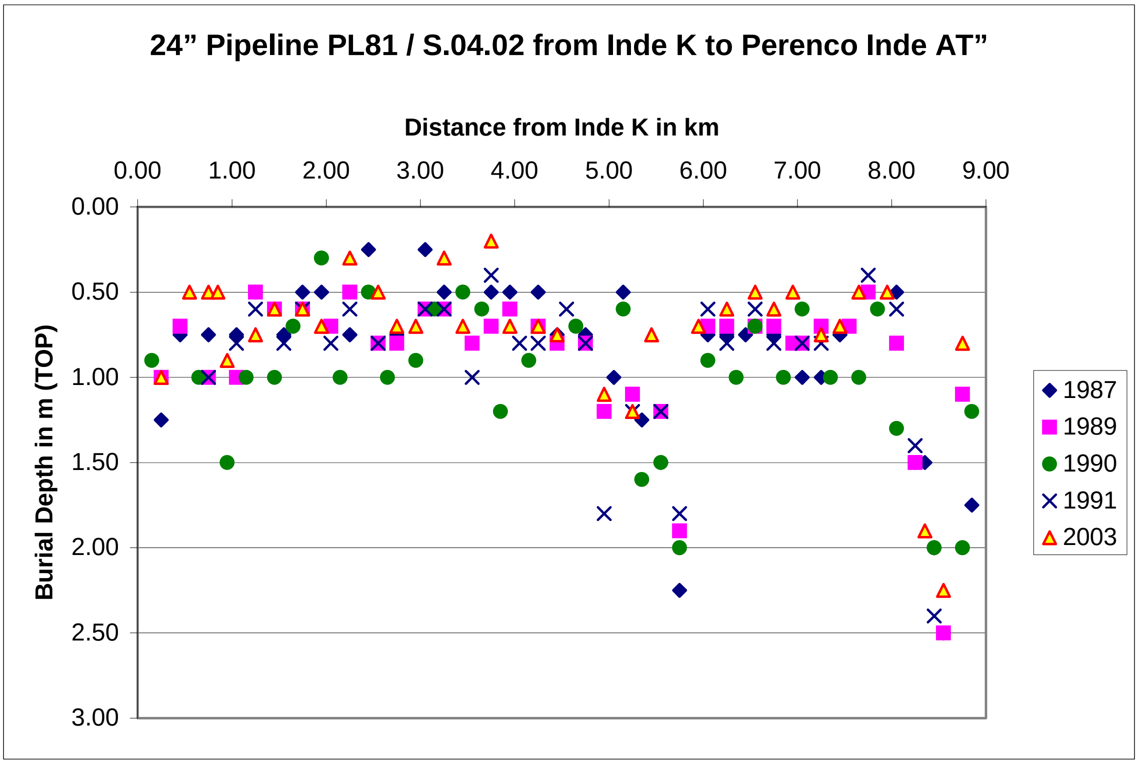


Figure E.1.2.1: Pipeline PL81 - Burial Depth surveys 1987-2003

The pipeline showed a number of exposures during the surveys. The lengths of these exposures have been plotted in the graph overleaf. Spans are not clearly identified.

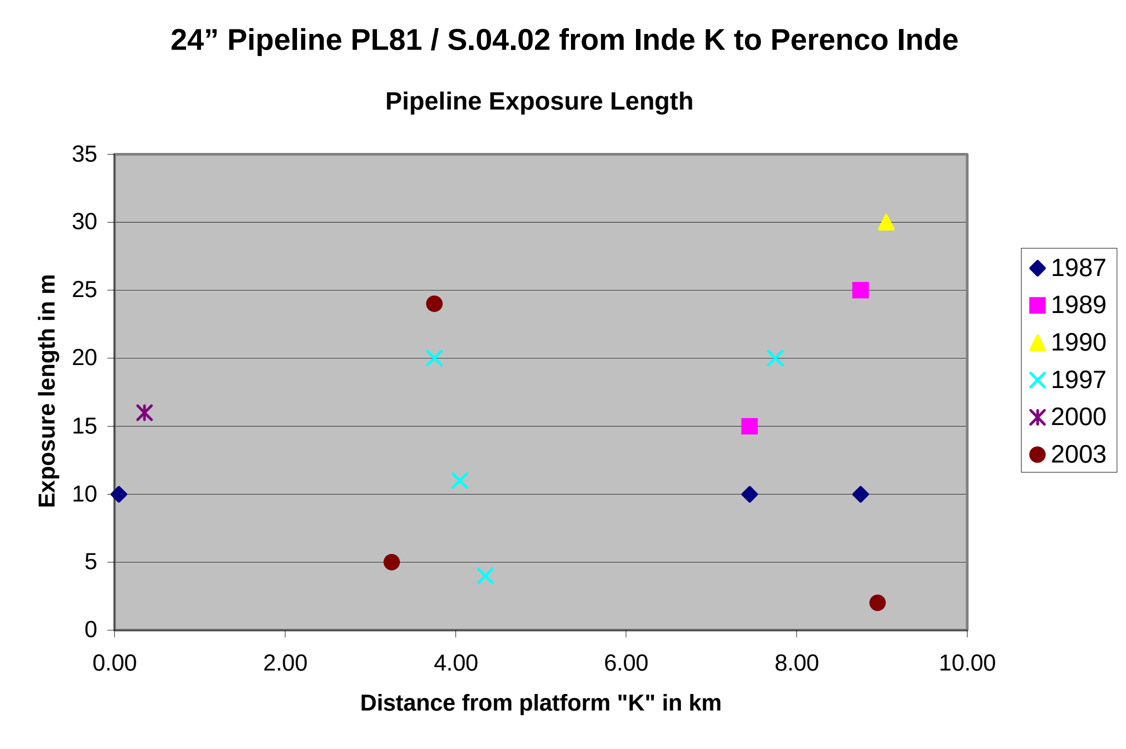


Figure E.1.2.2: Pipeline PL81 – Exposure Length surveys 1987-2003

Survey results of the year 2004 have not been included in the graphs above. No spans and no exposures were identified. The pipeline was found buried throughout the length of the pipeline. A separate graph of the 2004 burial depth survey is presented below.

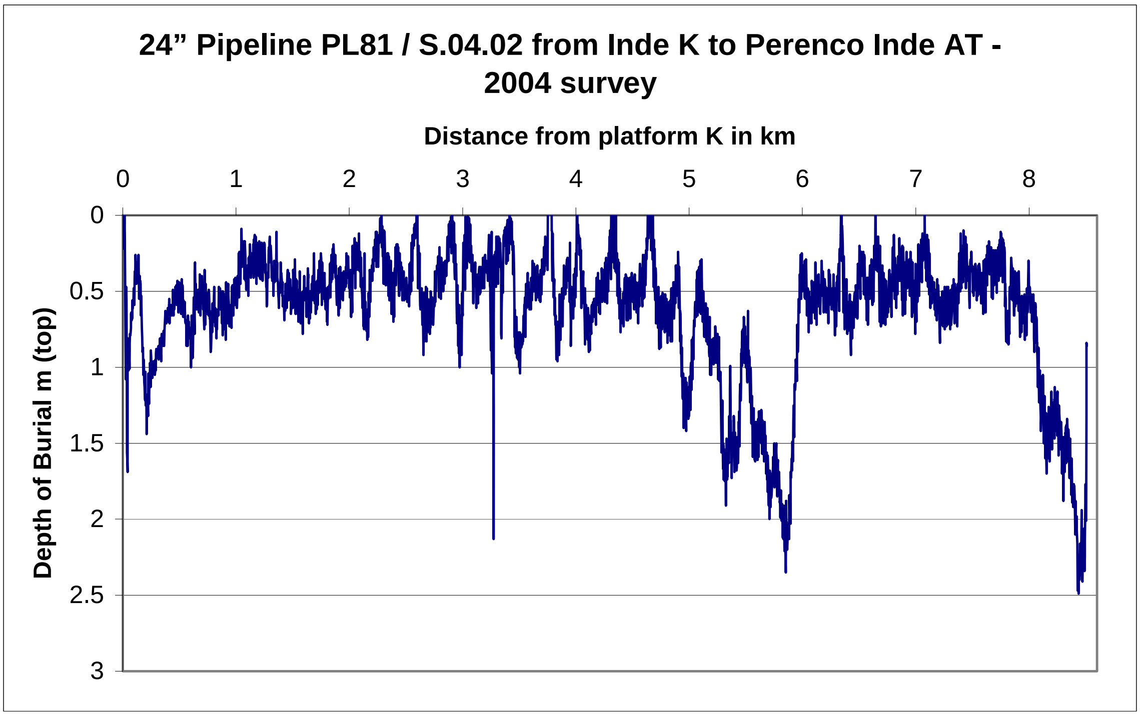


Figure E.1.2.3: Pipeline PL81 - Burial Depth survey 2004

Pipeline heading is approximately 280° and at an angle of about 45° to the main current direction, which is also the direction of sediment transport in this region. Variations of cover suggest a straight pipeline passing rippled seabed with typical ripple height of 0.2m with on top of it passing of mega-ripples heights in the range of 0.6m.

E.1.3 16" Pipeline PL82 / S.04.03 from Inde L to Inde J

Pipeline PL82, 3213m long, has outside steel diameter D=610mm, wall thickness t=0.625"=15.9mm (m_{st}=152.9kg/m), asphalt coating t_A=0.24"=6.1mm/r_A=1300kg/m^3 (m_A=10.3kg/m), concrete weight coating t_c=1.5"=38mm/r_c=2884kg/m^3 (m_c=157.6kg/m). Total mass of water filled pipeline m_{tot}=433.8kg/m.
During operation condition gravity G=3255N/m and B=1933N/m resulting in G-B=1322N/m and factor G/B=1.40.
During abandoned condition gravity G=4256N/m and B=1933N/m resulting in G-B=2322N/m and factor G/B=2.20. This is a significant improvement for a stable buried condition.

Depth of burial survey data for the period up to 2003 has been plotted in graph below. Burial depth varies in time.
PL82 has a history of stable burial. The 2004 detailed survey indicated that it was 95% buried and had one exposed length of about 45m at Kilometre point 0.70km with a span of 31m length and gap of 0.35m at its maximum. It is suspected that this is where PL82 crosses PL81. The span is not considered a snagging risk as it does not have a gap of 0.8m or larger. There were exposed crown sections of 14 to 17m lengths at Kilometre points 0.42km, 1.91km, 2.19km and 3.18km. These lengths have remained generally stable over time. (Note: Pipeline spans of 10m with gaps of 0.8m or larger are considered a snagging risk. These spans are reported and are included in the North Sea *FishSafe* database system, which warns fishing boats of the danger.)

Apart from these exposed lengths, the pipeline burial depth is around 0.3 to 1.2m with some annual variations but no significant trends for burial increasing or decreasing over time. PL82 had an average burial depth of about 0.6m in 2004.

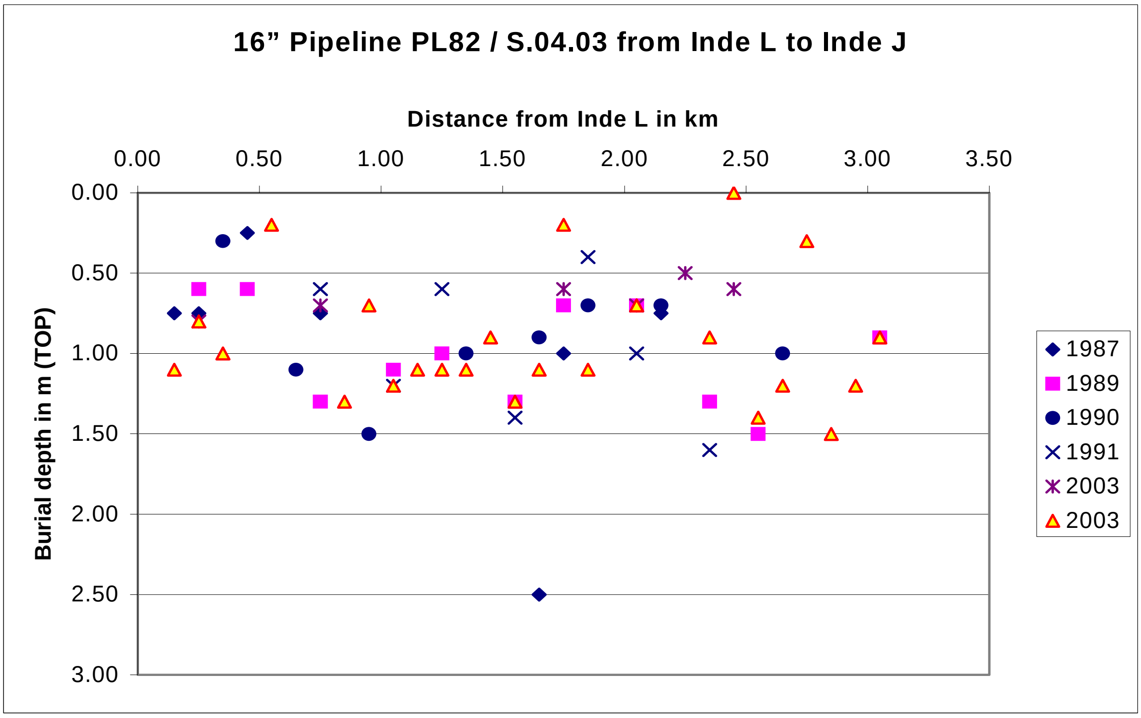


Figure E.1.3.1: Pipeline PL82 - Burial Depth surveys 1987-2003

The pipeline showed a number of exposures and spans during the surveys. Exposure lengths and span lengths identified during various surveys are plotted in the graphs overleaf. Exposures and spans vary in length.

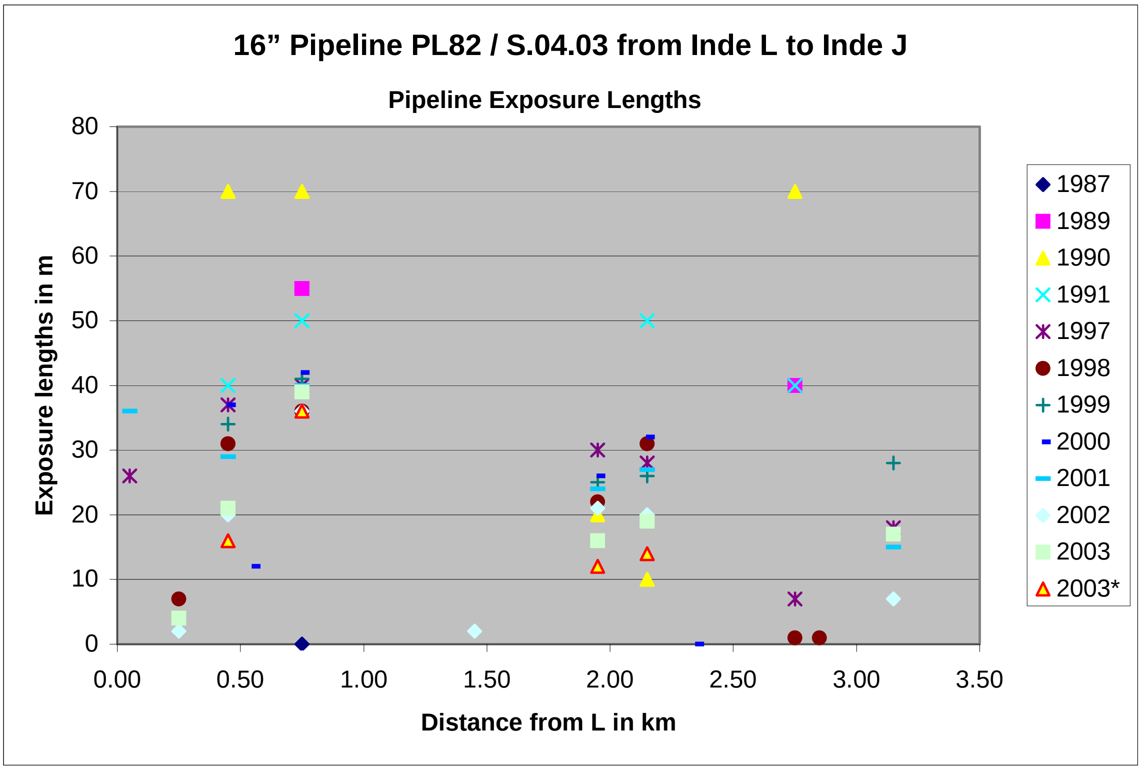


Figure E.1.3.2: Pipeline PL82 – Exposure Length surveys 1987-2003

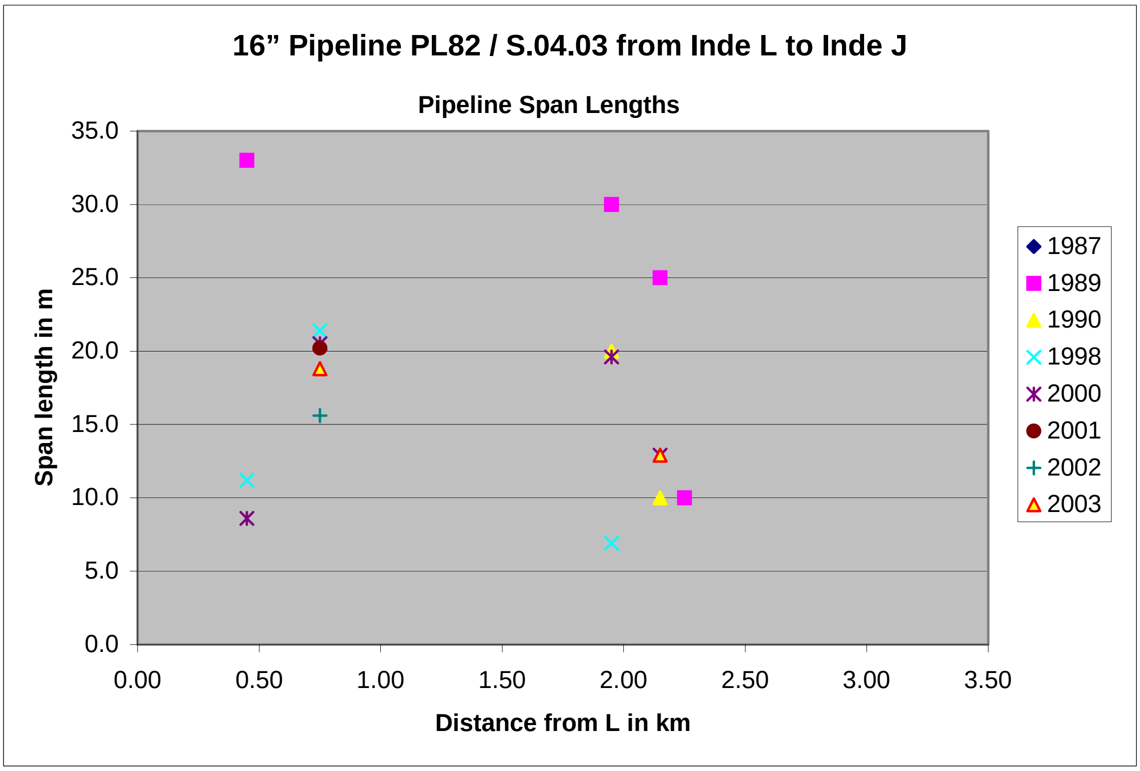


Figure E.1.3.3: Pipeline PL82 – Span Length surveys 1987-2003

Survey results of the year 2004 have not been included in the graphs shown at previous sheets. A separate graph of the 2004 burial depth survey is presented below. During 2004 survey one single span has been identified at kp 688m with length of 30m and height 0.34m. Total exposed length was 146m.

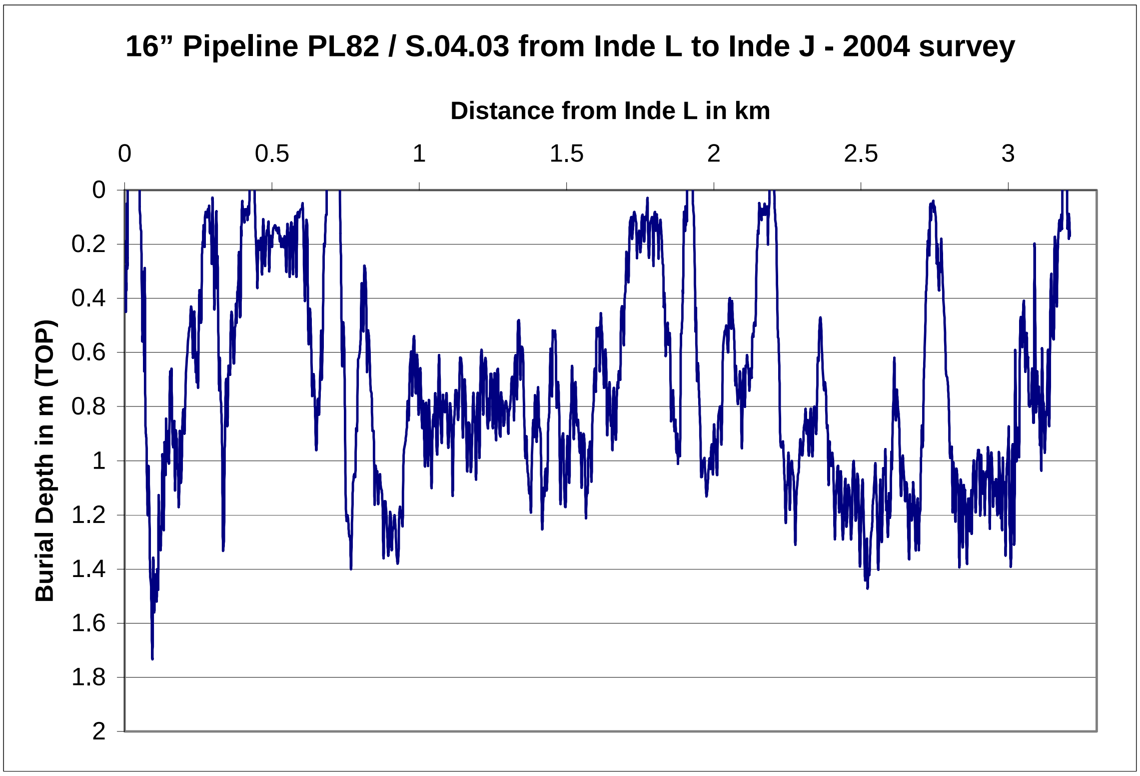


Figure E.1.3.4: Pipeline PL82 - Burial Depth survey 2004

Pipeline heading is approximately 10° and parallel to the main current direction, which is also the direction of sediment transport in this region. Variations of cover suggest a straight pipeline passing rippled seabed with typical ripple height of 0.2m with on top of it passing of mega-ripples in height range of 1.0m.

E.1.4 12" Pipeline PL302 / S.04.11 from Inde M to Inde J

Pipeline PL302, 3466m long, has outside steel diameter D=324mm, wall thickness t=0.625"=15.9mm (m_{st}=120.6kg/m), neoprene coating t_N=6.0mm/r_N=1300kg/m^3 (m_N=8.1kg/m), concrete weight coating t_c=75mm/r_c=3040kg/m^3 (m_c=294.3kg/m). Total mass of water filled pipeline m_{tot}=491.6kg/m.
During operation condition gravity G=4215N/m and B=1864N/m resulting in G-B=2351N/m and factor G/B=1.42.
During abandoned condition gravity G=4823N/m and B=1864N/m resulting in G-B=2959N/m and factor G/B=2.59. This is a significant improvement for a stable buried condition.

Depth of burial survey data has been plotted in graph below. Burial depth varies in time.
PL302 shows a relatively static burial profile over time. Burial depth is between 0.5 and 1.2m with some annual variations but no significant trends for burial increasing or decreasing over time. The pipeline has no history of becoming exposed apart from 60m and 110m at the two platform ends. It was 95% buried with an average burial depth of about 0.8m in 2004.

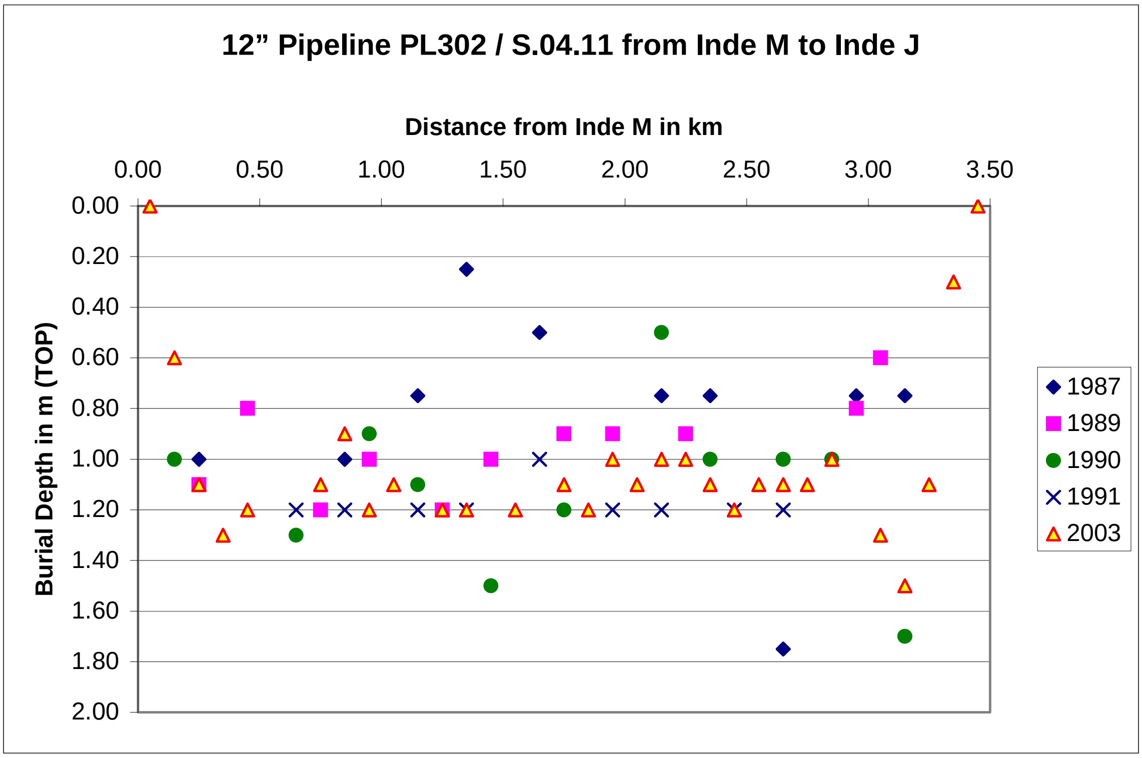


Figure E.1.4.1: Pipeline PL302 - Burial Depth surveys 1987-2003

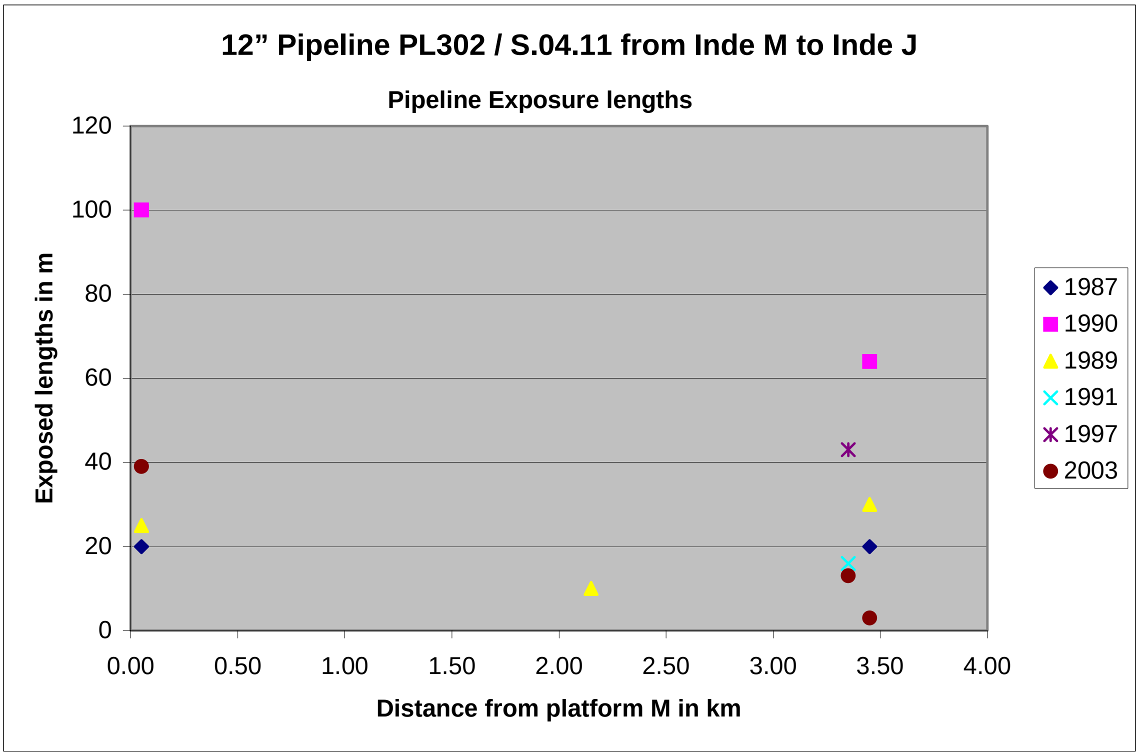


Figure E.1.4.2: Pipeline PL302 – Exposure Length surveys 1987-2003

Survey results of the year 2004 have not been included in the graphs above. One span 14m long and 1.32m high has been identified at the start of the pipeline and one span 16m long and 2.13m high at the end of the pipeline. Total exposed length was 146m. Separate graph for 2004 survey is presented overleaf.

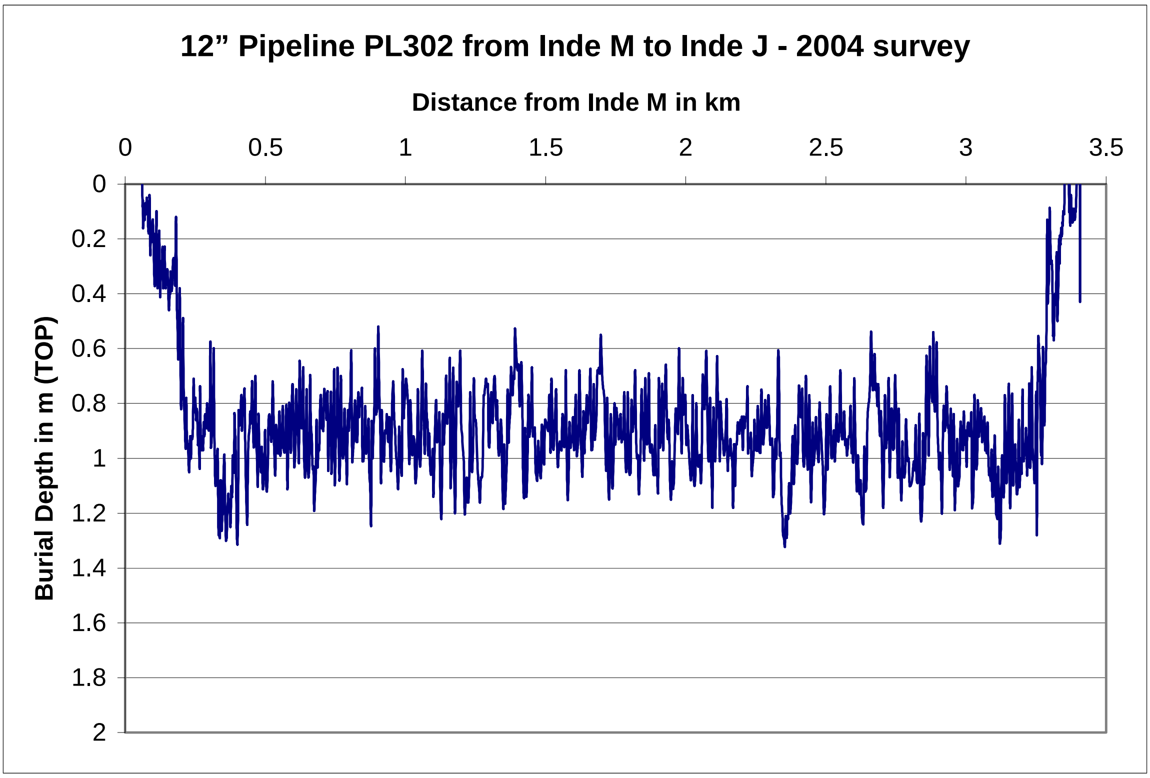


Figure E.1.4.3: Pipeline PL302 - Burial Depth survey 2004

Pipeline heading is approximately 160° and parallel to the main current direction, which is also the direction of sediment transport in this region. Variations of cover suggest a straight pipeline passing rippled seabed with typical ripple height of 0.3m.

E.1.5 10” Pipeline PL402 / S.04.13 from Inde N to Inde K

Pipeline PL402, 2289m long, has outside steel diameter D=273.1mm, wall thickness t=0.625”=15.9mm (m_{st}=100.7kg/m), asphalt enamel coating t_{AE}=6.0mm/ρ_N=1300kg/m^3 (m_{AE}=6.8kg/m), concrete weight coating t_c=51mm/ρ_c=3040kg/m^3 (m_c=162.9kg/m). Total mass of water filled pipeline m_{tot}=317.3kg/m.
During operation condition gravity G=2698N/m and B=1181N/m resulting in G-B=1517N/m and factor G/B=1.40.
During abandoned condition gravity G=3113N/m and B=1181N/m resulting in G-B=1932N/m and factor G/B=2.64. This is a significant improvement for a stable buried condition.

Depth of burial survey data has been plotted in graph below. Burial depth varies in time.
PL402 shows a burial depth of around 0.8 to 1.2m and an average burial depth of about 1.0m in 2004. The indication is that this pipeline has become more buried over time. However, the amount of data available before 2003 is limited. The pipeline has no history of becoming exposed apart from 60m and 80m at the two platform ends and was 94% buried in the 2004 survey.

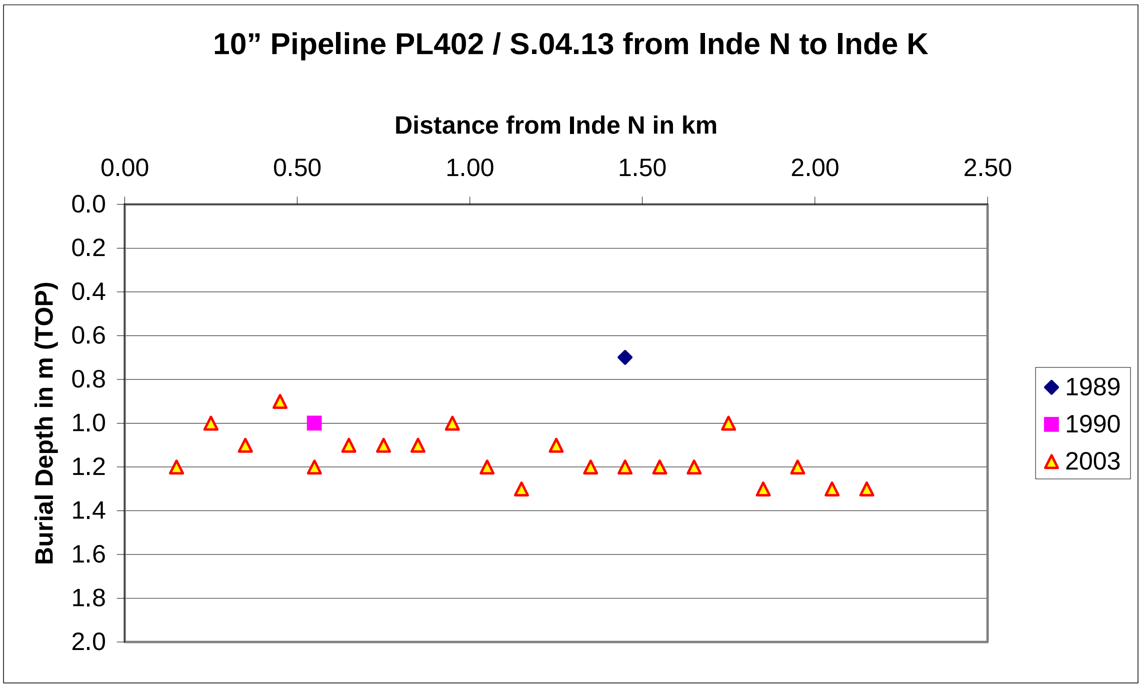


Figure E.1.5.1: Pipeline PL402 - Burial Depth surveys 1987-2003

Spans and exposures were been found at both ends of the pipeline. Results of the surveys have been presented in the graphs overleaf.

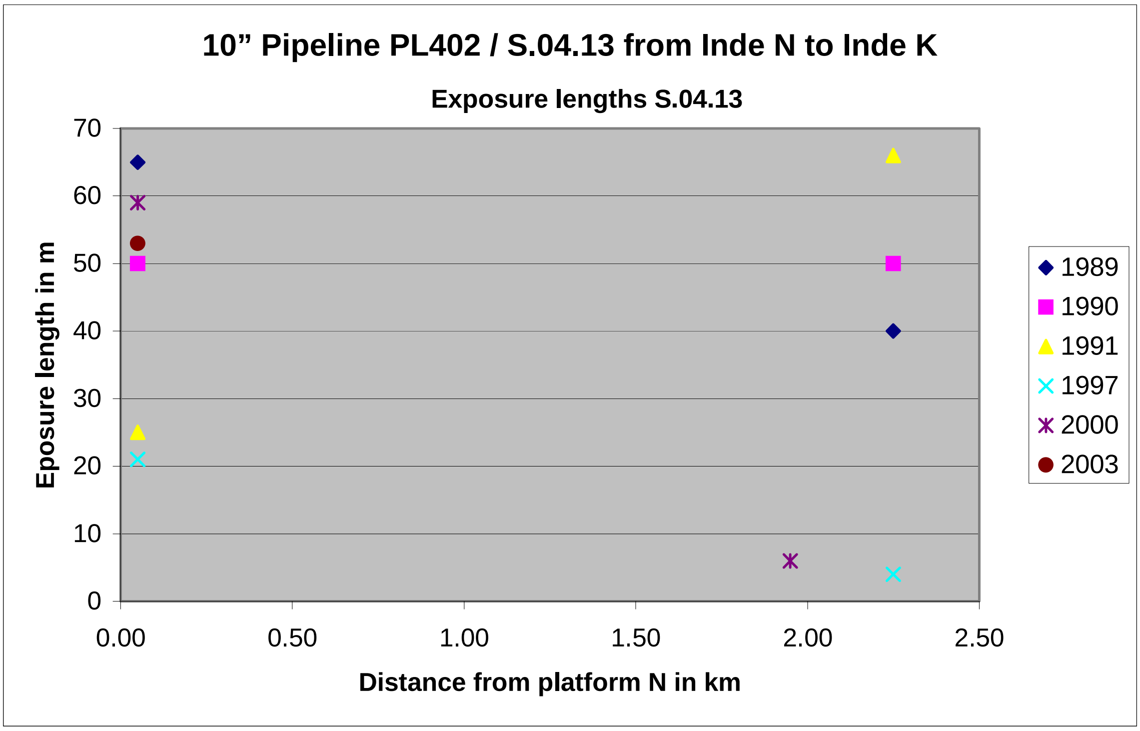


Figure E.1.5.2: Pipeline PL402 – Exposure Length surveys 1987-2003

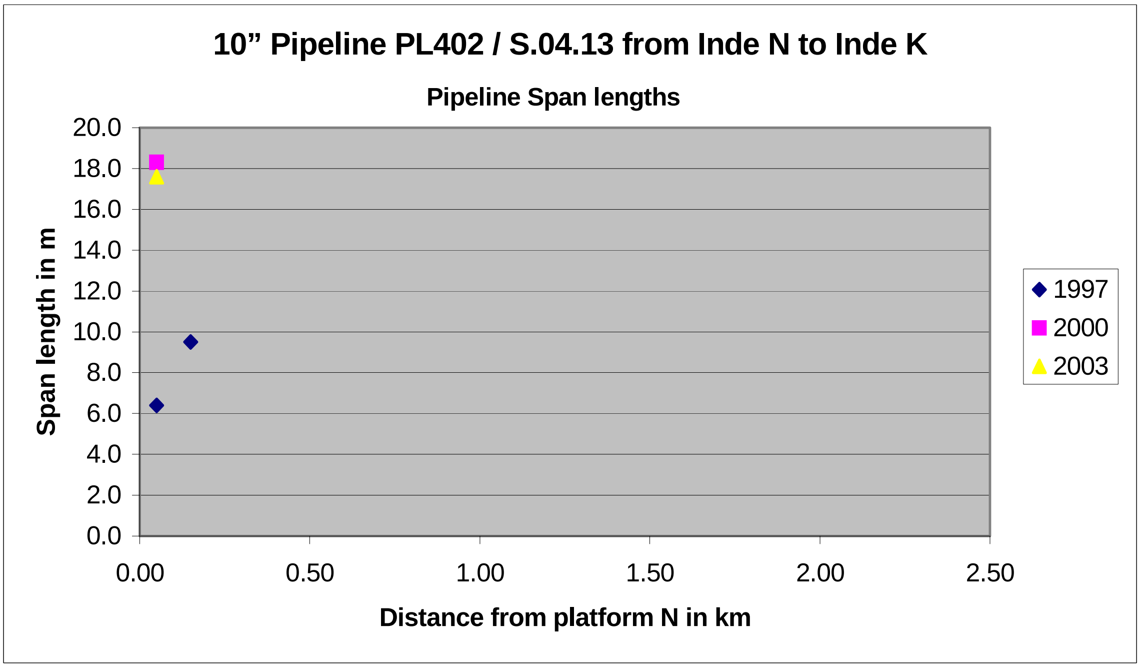


Figure E.1.5.3: Pipeline PL402 – Span Length surveys 1987-2003

Survey results of the year 2004 have not been included in the graphs above. One span 14m long and 0.46m high and one 16m long and 0.64 high have been identified at the start of the pipeline and one span 18m long and 0.40m high at the end of the pipeline. Total exposed length was 131m.

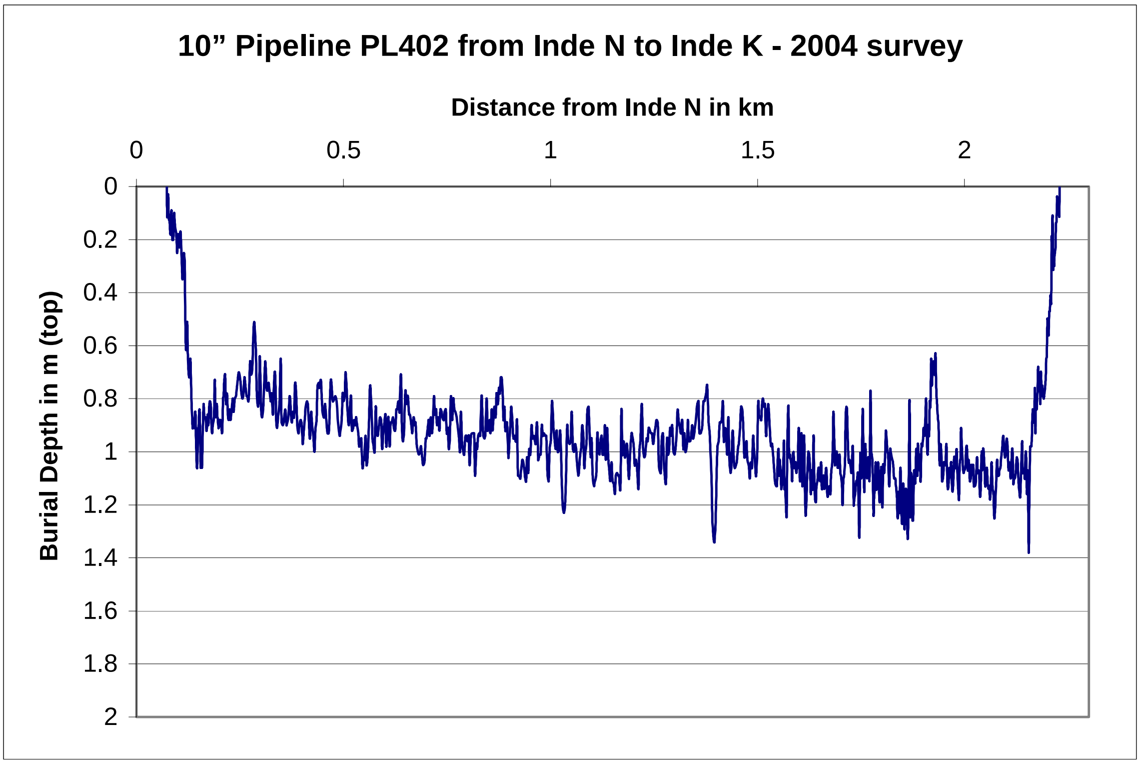


Figure E.1.5.4: Pipeline PL402 - Burial Depth survey 2004

Pipeline heading is approximately 250° and perpendicular to the main current direction, which is also the direction of sediment transport in this region. The cover is regular.

E.1.6 Umbilical PL303 – S0802 J - M

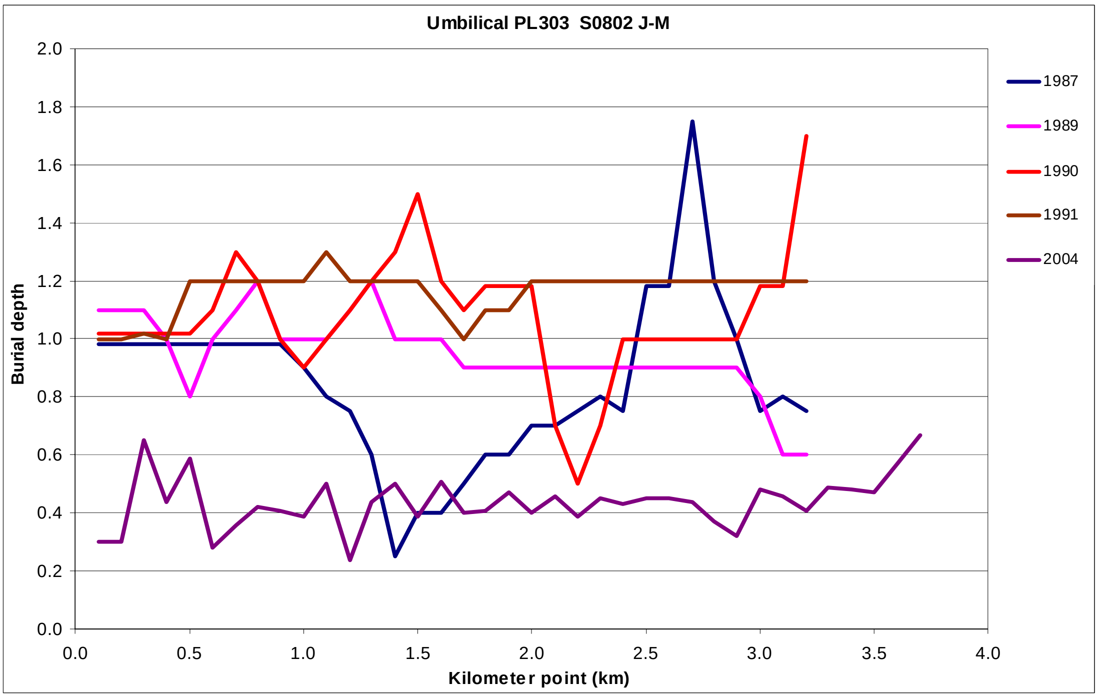


Figure E.1.6.1 – Hose Bundle PL303 Burial Depth

Compared with steel pipelines, the burial status of hose bundles are generally more difficult to detect and assess due to its make-up of synthetic materials. Based on available records, hose bundle PL303 has a history of remaining buried to at least 0.3m depth. The burial depth is currently 0.4m with some variation of burial depth over time (first increasing then reducing). There is no history of this hose bundle becoming exposed apart from 50m and 80m at the two platform ends. It was 96% buried in the 2004 survey.

E.1.7 Umbilical PL479-487 – S0804 K - N

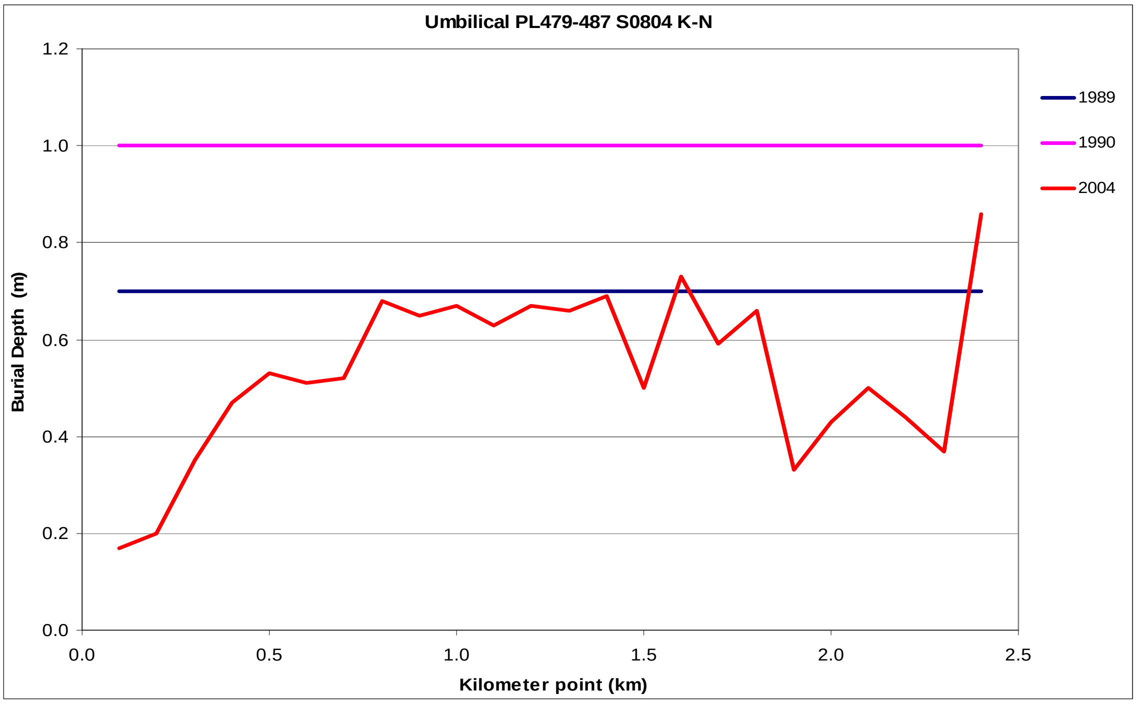


Figure E.1.7.1 – Hose Bundle PL479-487 Burial Depth

Hose bundle PL479-487 is buried to at least 0.2m depth apart from the first 200m from November platform. There is no history of this umbilical becoming exposed apart from 20m at the platform end. It was 99% buried with an average burial depth of about 0.5m in 2004. As the two earlier burial depth records were based on very limited field measurements (thus the apparent consistent depths shown in the chart), there is insufficient data to make meaningful statements about the change of burial depth over time.

APPENDIX F

Drawings – Hose Bundles Cross Section

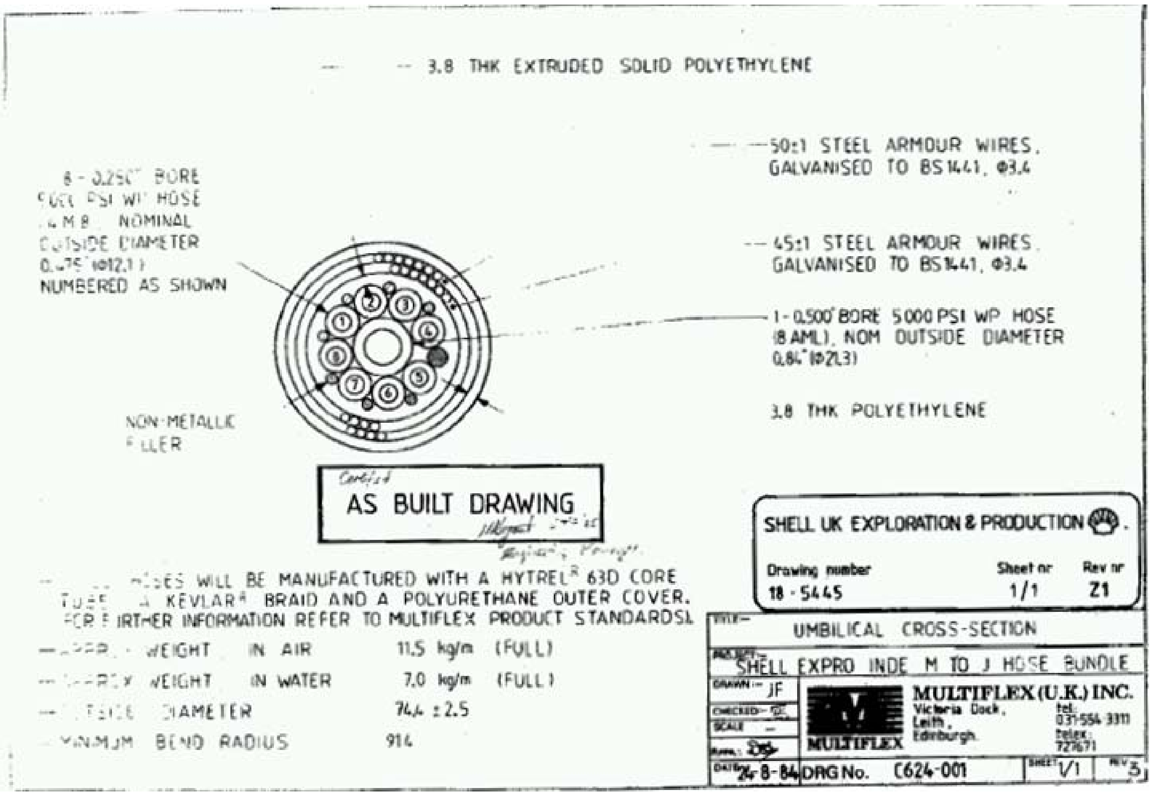


Figure F.1: M to J Hose Bundle drawing

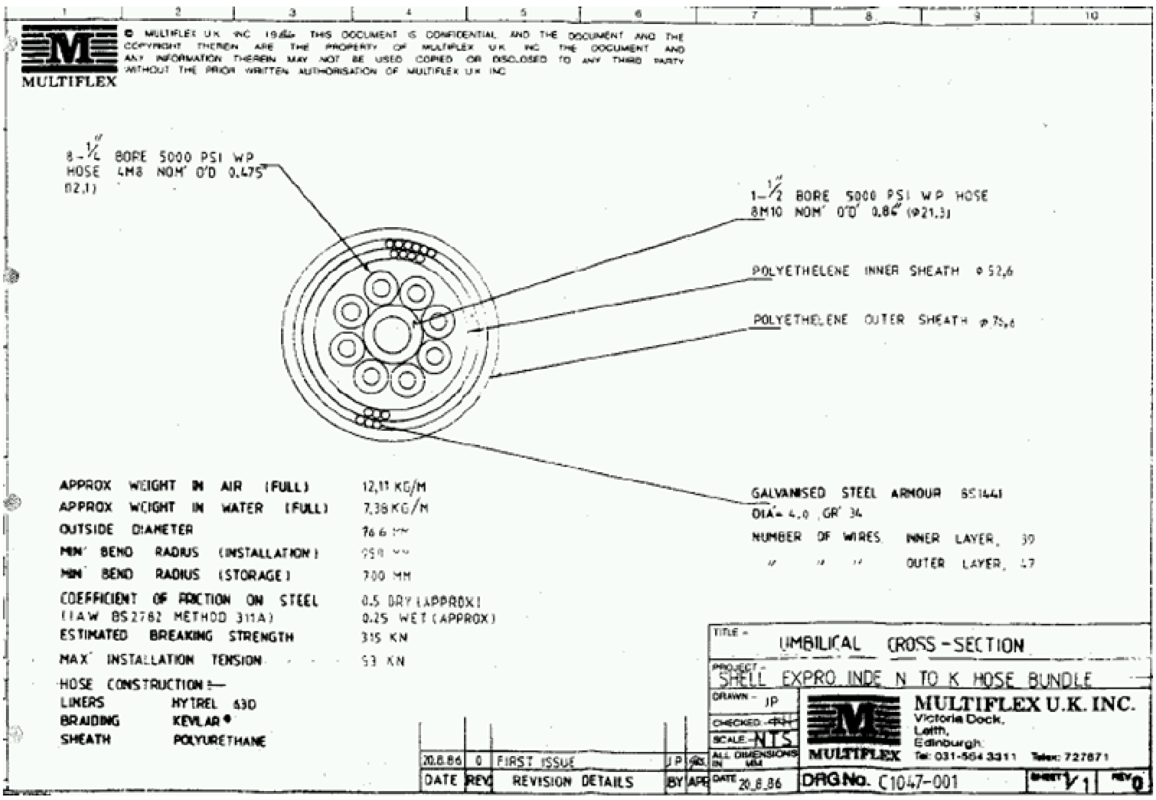


Figure F.2: N to K Hose Bundle drawing

APPENDIX G

Public Consultations

G.1 LIST OF STAKEHOLDERS CONTACTED

Name	Position/Organisation	Contact		
Alasdair McIntyre		AFEF	63, Hamilton Place,	Aberdeen
Graham Tran	Regional Officer	Amicus- AEEU	483, Crown Street	Aberdeen AB11 6EX
Mr S Jackman	Manager Marine Route Engineering	BT Worldwide	18-20 Millbrook Road East	Southampton SO15 1HY
John Edmunds	Chief Executive	GMB	National Office, 22/24 Worple Road	London SW19 4DD
Mark Tasker	Seabirds and Cetaceans Branch	JNCC	7 Thistle Street	Aberdeen AB10 IUZ
Zoe Crutchfield		JNCC	9, Gloucester Road, Ross on Wye	
Ray Johnstone	Manager	Marine Lab	PO Box 101, Victoria Road	Aberdeen AB11 8DE
Mr S Lambourn	President	National Federation of Fishermens Organisation	Marsden Road, Fish Dock	Grimsby DN31 3SG
Mr Ivan Large	Chairman	North Norfolk Fishermen's Society		
Mr Andy Roper	Secretary	North Norfolk Shell Fishermens Society		
Mr Dave Shilling	Spokesman,	North Norfolk	Gt Yarmouth and Lowestoft Fishermen's Society	
Mr R McColl	The Secretary	The Fishermens Association ltd	c/o McColl & Associates, 11 Burns Road	Aberdeen AB11 5AE
Marcus Armes		University of East Anglia		Norwich NR4 7TJ
Dave Bevan	Regional Officer	NFFO	Buckinghamshire Chilterns University College	High Wycombe HP11 2JZ
David Santillo	Regional Officer	Greenpeace		
Prof B W Sellwood		Reading University		
Dr Trevor Dixon		ACOPS Faculty of Technology	Atholl House, 86-88 Guild Street	Aberdeen AB11 6AR
Jim Campbell		DTI	1 Victoria Street	London SW1H OET
Irene Thomson	Asst Manager, Offshore Decom Unit	DTI	Atholl House, 86-88 Guild Street	Aberdeen AB11 6AR
Keith Mayo	Head Offshore Decommissioning Unit	DTI	Canterbury Villas	London N1 2PN
Tony Read		IMCA	7 Thistle Place,	Aberdeen AB10 1UZ
Calum Duncan / Elizabeth Salter		Marine Conservation Society	Marsden Rd Fish Docks,	Grimsby DN31 3SG
Torgeir Blake		Norwegian Institute for Water Research	PO Box 173, Kjelas,	N-0411, Oslo, Norway
	Manager	RSPB (Norfolk)	Stalham House	65 Thorpe Road, Norwich
Robert Napier	Chief Executive	WWF	Panda House, Catteshall Lane	Godalming GU7 1XR
Tim Watson	Director	4RS DECOMMISSIONING LTD	77 Marine Parade Gorleston, Gt Yarmouth	Norfolk NR31 6EZ
Claire Miller / Alan Lewendon	Director	Energy Industries Council	Newcombe House, 45 Notting Hill Gate	London W11 3LQ
Simon Gerrard	Director	University of East Anglia	School of Environmental Studies	
John Best	Project and Communications Officer	EEEGR (East of England Energy Group)	Beacon Innovation Centre, Beacon Park, Gorleston	Norfolk NR31 7RA
Pete Wilkinson	Env Consultant, (ex-Greenpeace)	wilx@btinternet.com		
Dr Sally Banham	British Marine Federation	sbanham@british marine.co.uk		
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Melissa Denton-Hawkes	Director, Port of Tyne	0191 440 7420		
Bob Blizzard MP	Member of Parliament	House of Commons	London SW1A OAA	
Tony Wright MP	Member of Parliament	House of Commons	London SW1A OAA	
Norman Lamb MP	Member of Parliament	House of Commons	London SW1A OAA	
Henry Bellingham MP	Member of Parliament	House of Commons	London SW1A OAA	
Bryony Rudkin	Leader	Suffolk County Council	Endeavour House	Russell Road Ipswich
Pat Gowan	North Sea Action Group			
Alison Drewett	MCA		alison_drewett@mcga.gov.uk	
Capt J.Drewett	Harbour Master, Teesport		harbourmaster@pdports.co.uk	
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Dr Chris Gibson	English Nature	Harbour House	Colchester CO28JF	
Linturn Hopkins	DfT Ports Division		tel. 02079445106	
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Gary James	DEFRA		gary.james.gsi.gov.uk	
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Alasdair Kerr	Environmental Officer. Port of Tyne		alasdair.kerr@portoftyne.co.uk	
Robert Kidd	Westminster Dredging		tel. 01489885933	
Richard Leafe	English Nature	Northminster House, Peterborough.		
Merle Leeds**	Env Agency		Merle.leeds@environment-agency.gov.uk	
David McLean	Clerk to the Authority	Gt Yarmouth Port	tel. 01493 335518	
Roger Morris	English Nature		roger.morris@english-nature.org.uk	
Colin Morris	DfT Ports casework Zone 2/31		colin.morris@dtlr.gsi.gov.uk	
Malcolm Peddar	Defra Marine Consents Environmental	Ergon House	London SW1P 2AL	
Dr John Roberts	Head Marine Division, Defra		John.roberts@defra.gsi.gov.uk	
Dr Susie Tomson	Planning & Environmental RYA		susie.tomson@rya.org.uk	
Matt Topsfield	The Environment Centre(TEC)		matthew.topsfield@environmetcentre.com	
Beverley Walker	Enviros 61	0131 555 9527		
Dr E Walmsley	WWF-UK	Panda House, Godalming, GU71XR		
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Sarah Wiggins	Univ of Southampton		s.wiggins@soton.ac.uk	
Ken Wind	Operations Mgr	Port of Sunderland,SR1 2BU		
Alex Woods	Port Manager, Gt Yarmouth		awoods@gypa.demon.co.uk	
Dr Chris Wooldridge	Dept Head, Earth Sciences	Cardiff University	wooldridge@cardiff.ac.uk	
Eileen Mobbs	Chair GY Tourist Authority	c/o Imperial Hotel , Gt Yarmouth		
Cllr Richard Packham	Leader of GY Borough Council	Town Hall, Gt Yarmouth NR30 2QF		

Joe Woodcock	Head of Economic Development	Gt Yarmouth Borough Council		
Chief Superintendent Ray Adcock	Norfolk Constabulory	Gt Yarmouth		
Richard Nickerson		Kimo Secretariat, Shetland Islands Council	Infrastructure Services Dept, Grantfield Lerwick	Shetlands ZE1 0NT
Stewart Risk	Chief Executive	Resource Environmental Solutions Group	Innovation Centre, Offshore Technology Park	Aberdeen AB23 8GX
Andy Ford	Chief Executive	Exterminator UK		
Robert Weir	Manager	LMG Marin AS		
Philip A. Pritchard	Managing Director	Deep Sea Recovery Ltd	88a Plains Road	Nottingham NG3 5RH
Chris Beer		Whale Watch Azores		
Paul Abernethy	Senior Executive	Energy Team, Scottish Enterprise	10 Queens Road	Aberdeen AB15 4ZT
Ed Smith	Chief Executive	Dundee and Angus Oil Venture Group		
Brian Menzies	Regional Manager	Environcentre	28 High Street	Stonehaven AB39 2JQ
Joanne McFadden	Business Development Manager	Scotoil Services, Sandilands Centre	Miller Street	Aberdeen AB11 5AN
Linda Thornton		Norfolk and Waveney Enterprise		
Tim Byles	Chief Executive	Norfolk County Council		
Sandra Dineen		Norfolk County Council	Economic Development	
	Chief Executive	Waveney District Council		

G.2 LIST OF STATUTORY CONSULTEES

Mr D Bevan
The National Federation of Fishermen's Organisations
NFFO Offices
Marsden Road
Fish Docks
Grimsby
DN31 3SG

Mr M Sutherland
Scottish Fishermen's Federation
24 Rubislaw Terrace
Aberdeen
AB10 1XE

Mr R James
Northern Ireland Fishermen's Federation
1 Coastguard Cottages
The Harbour
Portavogie
Co. Down
BT22 1EA

Ms Caroline Barker
Global Marine Systems Ltd
New Saxon House
1 Winsford Way
Boreham Interchange
Chelmsford
Essex
CM2 5PD

G.3 LIST OF LOCAL AND NATIONAL NEWSPAPERS FOR PUBLICATION OF PUBLIC NOTICES

The London Gazette
The Guardian
The Eastern Daily Press

G.4 STATUTORY CONSULTEES RESPONSES

Global Marine Systems Limited
New Saxon House
1 Winsford Way
Boreham Interchange
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United Kingdom

Tel. +44 (0) 1245 702000
Fax +44 (0) 1245 702206

www.globalmarinesystems.com

Mr Bob Hemmings
Decommissioning Manager
Shell UK Limited
1 Altens Farm Road
Nigg
Aberdeen AB12 3FY

12 September 2006

Your ref:
Our ref: OGD/222/CW

Dear Mr Hemmings

Indefatigable Field Decommissioning – Statutory Consultation Period

Thank you for the Decommissioning Programme document for Indefatigable field and pipelines dated 5 September 2006. Please update your records to reflect my change of surname for any future correspondence.

The area surrounding the project has been reviewed with regard to the presence of sub-marine telecommunications cables.

There are no further comments to be made, in this case, concerning the proposed operations.

Yours sincerely

C Wilson

Caroline Wilson
Permitting Manager
Global Marine Systems Limited

Registered Number: 1708481 England
Registered Office: New Saxon House
1 Winsford Way Boreham Interchange
Chelmsford Essex CM2 5PD

NORTHERN IRELAND FISHERMENS FEDERATION

1 COASTGUARD COTTAGES,
THE HARBOUR, PORTAVOGIE,
CO. DOWN, BT22 1EA

Telephone:
Portavogie 028 4277 1946
Kilkeel 028 4176 2901
Fax 028 4277 1696

Secretary:
Mr. R. H. James BSc.

Bob Hemmings
Shell UK Ltd
1 Altens Road
Nigg
Aberdeen
AB12 3PY

8th September 2006

Dear Sir,

Indefatigable Field Decommissioning

Further your letter of 5th September and enclosure. We have little interest in the sea area you are concerned with and therefore have no comment to make but I will pass on the information to an organisation with more interest in the North Sea.

Yours sincerely,

R.H James

National Federation of Fishermen's Organisations.

MARSDEN ROAD
FISH DOCKS
GRIMSBY
DN31 3SG
Tel 01472 349009
Fax 01472 242486
e-mail: dbevan@nffo.org.uk

7 November 2006

Shell Exploration & Production
Shell UK Ltd
1 Altens Farm Road
Nigg
Aberdeen

Att: **Bob Hemmings**

Dear sir

Indefatigable Field Decommissioning

Thank you for providing a copy of your draft submission to DTI regarding the above.

Please accept my apologies for this late submission of these comments due to the high level of other matters recently and our very limited human resources.

While there are many aspects and views on decommissioning we limit our comments to areas which may affect our industry.

Our primary objectives arising from decommissioning the Indefatigable Field are as follows;

- A safe operation for the decommissioning workforce and fishermen operating nearby
- The avoidance of any major marine pollution
- The removal of all structures
- The removal of any oil/gas related debris in the vicinity of the structures
- The removal or total burial of decommissioned pipelines and pipe-ends so that any potential long-term hazard for fishermen is removed
- A clean seabed which facilitates safe fishing operations in the areas that were once occupied by structures and safety zones.

It would appear through the discussions and meetings we have attended that these objectives will be achieved and on that basis we have no major concerns with your programme.

Yours sincerely

Dave Bevan

SCOTTISH FISHERMEN'S FEDERATION
24 Rubislaw Terrace · ABERDEEN · AB10 1XE

Telephone: 01224 646944 · Fax: 01224 647058
e-mail: sff@sff.co.uk
Website: www.sff.co.uk

Our ref: MJS/AMG/001

2 October 2006

Mr Bob Hemmings
Decommissioning Manager
Shell Exploration & Production
Shell UK Limited
1 Altens Farm Road
Nigg
ABERDEEN
AB12 3FY

Dear Mr Hemmings

Indefatigable Field Decommissioning
Statutory Consultation

Reference is made to your letter and enclosures of 5 September 2006 concerning the above. Our Federation has been regularly updated reference these proposals at all our Quarterly Meetings with Shell. We are also aware that your Company have also been in parallel bilateral discussions with the National Federation of Fishermen's Organisations.

Our Federation welcomes the fact that the Indefatigable Platforms will be totally removed from the seabed and returned to shore for onshore disposal. We further note that the two Infield hose bundles and associated subsea pipelines were installed buried, and will remain in situ as such and will also be the subject of a regular Shell Monitoring Programme going forward.

We would wish to be informed generally of progress but shall leave it the National Federation of Fishermen Organisations to address matters of detail with yourselves.

Yours sincerely

Michael Sutherland
Director of Operations

Cc: Phil Dyer
Duncan Cursiter
Fergus McGhie