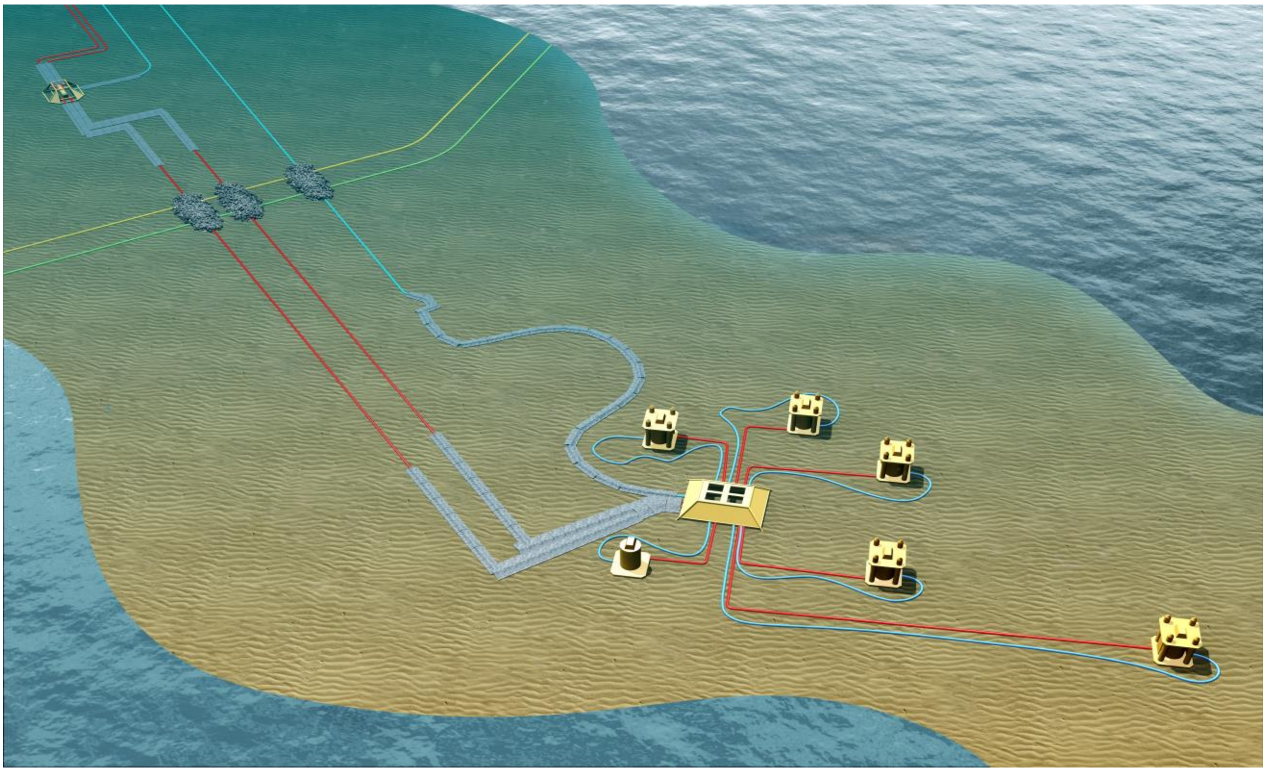
Kingfisher Field

Final Comparative Assessment

Part 1



Submitted to the U.K. Department for Business, Energy and Industrial Strategy

Shell Report Number KDP-PT-S-AA-7180-00004

22 June 2021

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Revision History

Rev #	Reason for Issue / Change
R01	Issued for review.
R02	Issued for final review (ER, Lega, BoM and Partners)
A01	Issued to OPRED for comments
A02	Updated with OPRED comments, issued for public consultation
A03	Updated to remove Scope 1 in support of the split DP
A04	Updated with partner comments. Amended references from Marathon to RockRose UKCS8 LLC
A05	Updated with OPRED comments and prepared for public consultation
A06	Updated with partner comments and issued for public consultation
A07	Updated with comments received during public consultation
A08	Final revision, issued for OPRED approval
A09	Updated in line with A09 revision of DP. Issued for OPRED approval.

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External stakeholders consulted during the Kingfisher Decommissioning Comparative Assessment process:

- Scottish Fishermen's Federation (SFF);
- Offshore Petroleum Regulator for Environment and Decommissioning (OPRED);
- Joint Nature Conservation Committee (JNCC);
- Marine Scotland.

"Collectively" referred to in this document as "**stakeholder consultees**".

1. Executive Summary

This document provides a record of the Comparative Assessment (CA) of credible decommissioning options, carried out for the Kingfisher Decommissioning Programmes Part 1. It presents the emerging recommendations for statutory and public consultation in support of the Kingfisher Decommissioning Programmes Part 1 [1].

A separate Kingfisher Decommissioning Programmes Part 2 will be submitted at a later date for the remaining infrastructure within the Kingfisher Field.

The Kingfisher field is located 280km north-east of Aberdeen in the Central North Sea (CNS) area of the U.K. Continental Shelf (UKCS). The field consists of six subsea wells tied-back to TAQA Bratani Ltd's Brae Bravo platform.

The subsea infrastructure associated with Kingfisher that is located outside of the Brae Bravo 500m safety-zone has been subjected to CA in order to determine the optimal solution for decommissioning. This infrastructure includes two 10", 9km production pipelines, an umbilical for providing electro-hydraulic control and chemical injection to the well sites and Kingfisher Manifold, as well as associated tie-in spools, jumpers, mattresses and grout bags.

The CA has been conducted in accordance with the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED) Guidance Notes on Decommissioning of Offshore Oil and Gas Installations and Pipelines under the Petroleum Act 1998 [2].

This CA is submitted by Shell U.K. Limited, registered company number 00140141 (Shell) as operator, on behalf of itself and its co-venturer Esso Exploration and Production UK Limited, registered company number 00207426 (Esso), being recipients of the Section 29 Notices, and throughout this document the terms 'owners', 'we' and 'our' refer to these co-venturers.

A summary of the recommendations for each scope is presented in Table 1-1 below.

Scope	Scope description	Emerging Recommendation
2	Surface-laid lines outside Brae Bravo 500m zone PL1488, PL1489, PLU1490, PLU1491, PLU1492, PLU1493, PLU1494, PLU1495, PLU1496, PL1497, PL1498, PL1499, PL1500, PL1501, PL1502	Pipeline spools and umbilical jumpers to be cut, recovered and returned to shore for recycling / disposal. Exposed mattresses and grout bags to be recovered and returned to shore for recycling / disposal.
5	Pipeline ends at manifold PL1488, PL1489	Exposed mattresses to be removed, pipelines to be cut where they leave existing rock berm with end recovered and returned to shore for recycling / disposal. Rock cover to be added to cut end to reduce snagging risk. Mattresses and grout bags beneath the existing rock berm will be decommissioned in situ
6	Trenched and buried sections PL1488, PL1489, PLU1490	Decommission in situ, the crossings will be revisited when the owners of the third party crossed lines receive approval for their decommissioning proposals from OPRED. At that time, we will discuss and agree appropriate decommissioning with OPRED
7	Umbilical end at manifold PLU1490	Exposed mattresses to be removed, umbilical end at manifold to be cut where it leaves the trench, end either to be lowered by fluidising the soil, or the surrounding soil to be excavated and the cut made at a point where the umbilical has reached 0.6m depth of cover. Cut off to be recovered and returned to shore for recycling / disposal

Table 1-1 – Emerging Recommendations Summary

All other infrastructure outside the Brae Bravo 500m zone will be removed during the decommissioning works:

- The production wells will be plugged and made safe;
- The Kingfisher Manifold will be removed and returned to shore for recycling.

(infrastructure within the Brae Bravo 500m zone is outwith the scope of this comparative assessment)

See Appendix D for a schematic of the main scope groupings 2, 5, 6 and 7 (excludes sub groupings 1, 3 and 4 which will be the subject of a separate Comparative Assessment Report and Decommissioning Programme).

2. Introduction

2.1. Purpose

The purpose of this report is to present the emerging recommendations from the comparative assessment for the Kingfisher subsea infrastructure in support of the Kingfisher Decommissioning Programmes Part 1 [1].

The following is included within this document:

- Description of the infrastructure to be decommissioned;
- Description of decommissioning options considered;
- Comparative assessment methodology;
- Emerging recommendations from the comparative assessment.

The decommissioning options for the pipelines have been subjected to a process of comparative assessment in order to determine the optimum method of decommissioning in compliance with the OPRED Guidance Notes [2].

The portions of the following pipelines that lie outside the Brae Bravo 500m zone are included in the comparative assessment:

PL Number	Name	Diameter	Approx. Length (km)
PL1488 to PL1502 and PLU1490 to PLU1496	Inclusive of the Kingfisher Production Pipelines including spools and jumpers and Kingfisher Manifold Control Umbilical	10” and smaller	Up to 8.9
		140mm and smaller	Up to 8.7

Table 2-1 – Pipelines subject to comparative assessment

2.2. Assumptions

Assumptions for the comparative assessment:

- All structures will be recovered as part of the overall decommissioning programme.

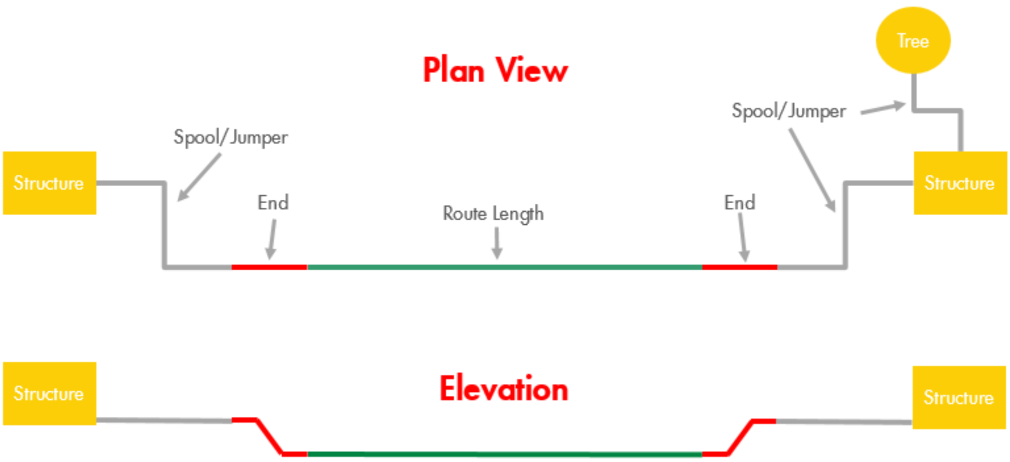
2.3. Regulatory Context

The decommissioning of offshore oil and gas installations and pipelines on the UKCS is regulated through the Petroleum Act 1998, as amended by the Energy Acts. It is a requirement of OPRED Guidance Notes [2] that operators conduct a Comparative Assessment when assessing pipeline decommissioning options.

Because of the widely different circumstances of each case, each pipeline must be considered in the light of a CA of the credible options, taking into account the safety, environmental, technical, societal and cost impacts of the options. Cost may only be a determining factor when all other criteria emerge as equal.

2.4. General Definitions

The following table specifies the meaning of wording in this report when it is used in a general context to avoid any confusion or doubt.

Wording	Definition for the purposes of this assessment
Pipeline	When pipeline is used in the general text, this should be assumed to mean pipeline in general and may also reference the pipeline system (including spools, cathodic protection etc.), e.g. this can refer to a rigid or flexible pipeline. If a specific pipeline is referenced, then this may also include "rigid" or "flexible" pipeline.
Protection	If protection is referenced this will refer to concrete mattresses and/or grout bags. Any other protection will be specifically referenced.
Structure	When structure is referenced this will refer to the following: • Kingfisher Production Manifold
Route Length / End / Spool / Jumper	A single pipeline is split into 3 different sections for the purpose of this comparative assessment. The route length, which can generally be described as the section of pipe on the bottom of the trench. The end of a pipeline in general is the section between the trench transition (as the line comes out of a trench) and the tie-in to the structure (including spools). Finally, the spool or jumper which is the section of pipe lain on the seabed and facilitates the tie-in to any structures. The diagram below illustrates the differences between the different sections: 

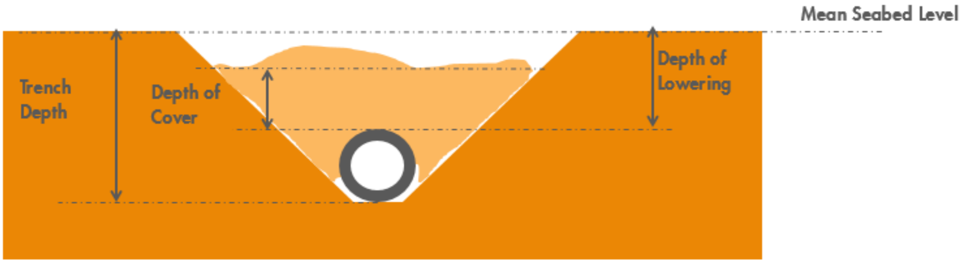
Wording	Definition for the purposes of this assessment
Burial Depth Definitions	Different definitions will be used for different burial depths. The following diagram illustrates the different burial depth definitions: 
Exposure	When an exposure is described this is essentially when the crown of the pipe or umbilical can be seen. This does not generally mean a hazard.
Reportable Span	A reportable span is a significant span which meets set criteria (FishSAFE criteria) of height above the seabed and span length.
Fluidising	Fluidising is the process of fluidising the seabed to the point where the soil has no inherent strength and hence the pipe or similar will simply fall to the bottom of the trench.

Table 2-2 – General Definitions

2.5. Abbreviations

BEIS	Department for Business, Energy and Industrial Strategy (formerly DECC)	OGA	Oil and Gas Authority
CA	Comparative Assessment	OGUK	Oil and Gas UK
CNS	Central North Sea	OOM	Order of Magnitude
CoP	Cessation of Production	OPRED	Offshore Petroleum Regulator for Environment and Decommissioning
DECC	Department of Energy and Climate Change (Now BEIS)	OSPAR	Oslo Paris Convention for the Protection of the Marine Environment of the North-East Atlantic
EAR	Environmental Appraisal Report	PMF	Priority Marine Feature
ERL	Effects Range Low	PMS	Power Management System
FAR	Fatal Accident Rate	POB	Persons on Board
FEED	Front End Engineering Design	QRA	Quantitative Risk Assessment
ICES	International Council for the Exploration of the Sea	ROV	Remotely Operated Vehicle
JNCC	Joint Nature Conservation Committee	SFF	Scottish Fishermen's Federation
KP	Kilometre Point	SIMOPS	Simultaneous Operations
MEG	Mono-Ethylene Glycol	SSIV	Sub-sea Isolation Valve
MLWS	Mean Low Water Springs	THC	Total HydroCarbons
(p)MPA	(proposed) Marine Protected Area	UKCS	United Kingdom Continental Shelf
OBM	Oil Based Mud	VMS	Vessel Monitoring System
		WBM	Water Based Mud

Table 2-3 – Table of Abbreviations

2.6. Field Overview

2.6.1. General

The Kingfisher field lies in Block 16/8 of the UK Sector of the North Sea and comprises three reservoirs: Brae I (Gas/Condensate), Brae II (Volatile Oil) and Heather (Gas/Condensate). The Kingfisher field is located 280km North East of Aberdeen and was developed as a subsea tie-back to the TAQA Bratani Ltd operated Brae Bravo platform. The field first produced in October 1997 and had a design life of 15 years. Produced oil was exported via the Forties pipeline system while gas was delivered to the Brae Bravo operators as part of the tariff structure.

The Kingfisher development comprises six subsea wells with rigid pipeline jumpers to a subsea manifold. The production fluids from the Brae and Heather wells were commingled in the manifold and routed to the Brae Bravo platform via the two production pipelines. The production pipelines are linked at the Kingfisher manifold to provide a pigging loop to allow round trip pigging.

A single composite control and chemical injection umbilical from the Brae Bravo platform to the Kingfisher manifold provided all the utilities required for operation of the manifold facility.

A SSIV control umbilical from the Brae Bravo platform to the SSIV structure controls the SSIV, although as the SSIV and its control umbilical fully reside within the Brae Bravo 500m zone these are not considered in this comparative assessment.

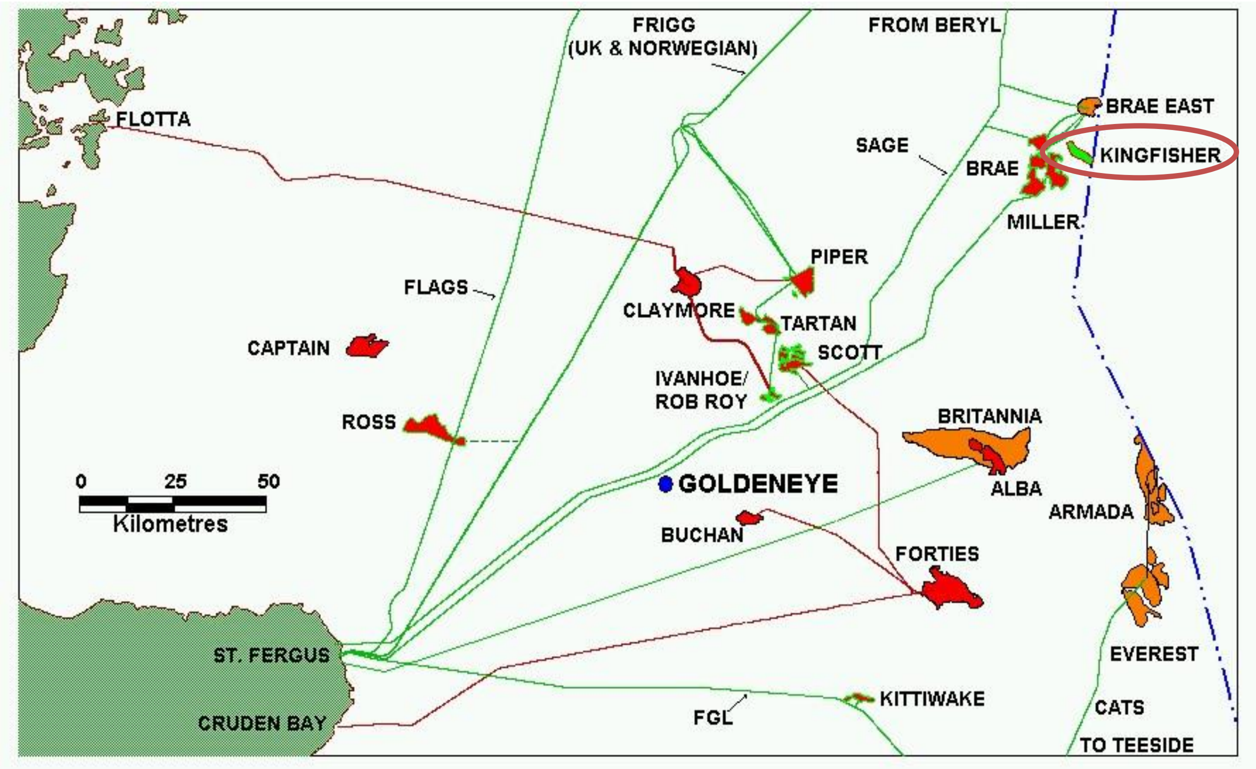


Figure 2-1 – Kingfisher Field Location

2.6.2. Environmental Summary of Kingfisher Field

The Kingfisher field is located in the Central North Sea (CNS), approximately 280 km north-east of Aberdeen.

Environmental surveys completed during summer 2017 around the Kingfisher infrastructure observed sediments to be 'fine sand' or 'very fine sand' with mean particulate size generally lower within the cuttings pile than the surrounding sediments. Hydrocarbon distribution in the seabed sediments out with 200m of the Kingfisher wellheads were typical of low level, weathered petroleum residues commonly found in the North Sea. Likewise, recorded levels of endocrine disruptors and heavy metals outside 200m were comparable to reference stations and below Effects Range Low (ERL) values. Elevated levels of Total Hydrocarbons (THC) were recorded from cores within the drill cuttings pile itself including evidence of relatively un-weathered Ultidrill drilling fluid, of the type used to drill the wells in 1997. A Stage 1 OSPAR assessment (OSPAR 2006/5) of rate of oil loss to water column and persistent rates calculate both measurements to be well below the OSPAR 2006/5 thresholds.

The Kingfisher field lies at a mean water depth of 114 m with near seabed water currents likely in the region of 1 to 1.5 m/s in a north easterly direction, allowing for some movement and dispersion of any contaminant release into the water column.

Benthic Environment

Benthic communities in the Kingfisher field reflect two different biotopes:

- 'circalittoral muddy sand' with silt content typically between 5 and 20% and supporting animal-dominated communities including polychaete worms and echinoderms (star fish, urchins etc). Seapens, bivalve siphons including potentially the Priority Marine Feature (PMF) Ocean Quahog (*Arctic Islandic*); and
- 'circalittoral mixed sediments' which are well mixed muddy gravel sands with poorly sorted mosaics of shell cobbles and pebbles embedded in mud, sand or gravel. This habitat type supports a wide range of infaunal polychaete worms, bivalves, echinoderms and burrowing anemones.

Fish and Shellfish

Several fish species are known to be present in the CNS including in the area around the Kingfisher infrastructure, although species richness in the CNS is lower than in more coastal areas of the North Sea (ICES, 2008). The Kingfisher infrastructure lies within or in close proximity to known spawning areas for: Blue Whiting (*Micromesistius poutassou*); Cod (*Gadus morhua*), Haddock (*Melanogrammus aeglefinus*); Norway Pout (Trispoterus esmarkii); Saithe (*Pollachinus spp.*); Sandeels (*Ammodytidae spp.*); Norway lobster (*Nephrops norvegicus*); Herring and mackerel (*Scomber scombrus*). The area is also used as nursery grounds for those listed above as well as Whiting (*Merlangius merlangus)*, Ling (*Molva molva*), Hake and Angler fish (*Lophius piscatorius*) (Marine Scotland, 2018). In all cases, the area represents a small proportion of the grounds available for spawning for these species.

Cetaceans and pinnipeds

Whilst a wide range of marine mammal species have been recorded in the waters around the British Isles, only a small number are regularly recorded in the area around the Kingfisher infrastructure. The most commonly sighted species include Harbour Porpoise (*Phocoena phocoena*); White beaked dolphin (*Laegenorhynchus albirostris*); Killer whale (*Ochinus orca*); and the Minke whale (*Balenoptera acutorostrata*). The most abundant marine mammal species in the North Sea are important predators influencing the food chain and feeding on a wide range of prey including a number of commercially important fish species.

The area around the Kingfisher infrastructure is recorded as an area of low 'at sea' usage (0-<1 mean annual) for both Grey seal (*Halichoerus grypus*) and for Harbour seal (*Phoca vitulina*).

Seabirds

Seabirds are present in the area around the Kingfisher infrastructure throughout the year, although in low numbers as the area is at some distance from their breeding colonies. Aggregated density is expected to be lowest in the area in late spring/summer when many birds are nesting and therefore are in close proximity to coastal colonies. Diversity and density may increase in the offshore area once chicks have fledged as foraging behaviours allow for birds to travel further distances from their coastal colonies.

Seabirds anticipated to be present in the Kingfisher area in small numbers may include: Northern fulmar (*Fulmarus glacialis*), all year round; Northern gannet (*Morus bassanus*), May to February; European storm petrel (Hydrobates pelagicus); Pomerine skua (Stercorarius pomarinus) March to June; Arctic skua (Stercorarius parasiticus) May to August; Great skua (Stercorarius skua) May to August; Common gull (*Larus canus*), July to February; Herring gull (*Larus argentatus*), July to April; Great black-backed gull (*Larus marinus*), November to February; Kittiwake (*Rissa tridactyla*), all year; Guillemot (*Uria aalge*), all year; Little auk (*Alle alle*), November to February; and Puffin (*Fratercula arctica*). April to September.

Protected/Sensitive Habitats

There are no designated Marine Protected Areas, including Natura 2000 sites, in the area of the Kingfisher infrastructure.

The nearest designated site under the Habitats Directive (92/43/EEC) is the Braemar Pockmarks Special Area for Conservation (SAC) including the Annex I Habitat 'Submarine Structures made by leaking gases' which is located approximately 22km to the north of the Kingfisher manifold. The Braemar pockmarks are a series of crater-like depressions in the sea floor. Methane derived authogenic carbonate (MDACS) have been observed deposited within two of the recorded craters as a result of precipitation during the oxidation of methane gas. The Brae Area environmental survey (Fugro 2014) observed pockmarks out with the boundary of the Braemar Pockmarks SAC around the flowlines from TAQA Bratani Ltd's Braemar wells to the East Brae platform. No evidence of pockmarks in the seabed around the Kingfisher field has been observed.

Harbour Porpoise (*Phocoena phocoena*); as well as the Grey seal (*Halichoerus grypus*) and the Common seal (*Phoca vitulina*) are specifically identified as protected species under Annex II of the Habitats Directive (92/43/EEC).

All cetaceans are protected under Annex IV of the Habitats Directive, as well as Appendix II of the Bern Convention and under Schedule 5 of the Wildlife and Countryside Act 1981 (as amended).

As discussed above the potential for the presence of OSPAR threatened and or declining habitats and Priority Marine Features (PMFs):

- Seapens and Burrowing Megafauna Communities;
- Ocean Quahog (*A. Islandica*)

Fishing intensity

The Kingfisher field is located within ICES rectangle 46F1. 46F1 makes a low (1.8%) contribution to overall fishing effort in UK waters, based on 2017 ICES data for vessels of 15 m in length. ICES rectangle 46F1 also lies within spawning grounds for a number of fish species of commercial and/or conservation importance, including haddock, Norway pout and Norway lobster.

Fishing effort immediately around the Kingfisher and Brae Bravo infrastructure is notably lower than in the surrounding area. It is also noted that a number of significant pieces of oil and gas infrastructure exist within this area, with a number of currently operational safety zones which limit access to this area by fishing boats

Commercial Shipping

Shipping activity in the area around the Kingfisher infrastructure is classified by the OGA (2017) as low. An average weekly density of non-port service vessels is recorded in the adjacent block 16/7 which coincides with the location of TAQA Bratani Ltd's Brae Alpha and Bravo platforms. This is consistent with rig supply vessel activity which would be expected. A preferred North Sea cargo vessel transit route is evident passing on an east-west orientation approximately 40 km to the south of the area of the Kingfisher infrastructure

2.6.3. Kingfisher Field Infrastructure

The field is developed as a subsea tieback to the TAQA Bratani Ltd operated Brae Bravo Platform with the following pipelines and umbilicals.

PARAMETER	Production Pipelines	Manifold Control Umbilical
N# / PL#	N0509/ N0510 PL1488 / PL1489	N0889 PLU1490
Diameter	273.1mm (10")	132.8mm
Wall Thickness	17.5 – 13.8mm	N/A
Material	Super Duplex	N/A
Length	8.9km; 8.3km within the scope of DP Part 1 and this CA	8.7km; 8.1km within the scope of DP Part 1 and this CA
Service	Oil Production	Electro-Hydraulic Control and Chemical Injection
Current Contents	Hydrocarbon	Production chemicals
Coatings	4-layer Polypropylene	N/A
Offshore Crossings	3 per pipeline	3
	Note that there are an additional 5 of the crossings for each line within the 500m safety zone of the Brae Bravo Platform but these are not in scope of this CA.	

Table 2-4 – Main Pipelines and Umbilicals Summary

Production from Kingfisher's six wells is connected to a common production manifold via surface-laid tie-in spools and from there to the Brae Bravo facility via two 10" diameter, 8.9km super duplex production pipelines (PL1488 & PL1489), see Figure 2-2. The production pipelines were trenched and buried on installation.

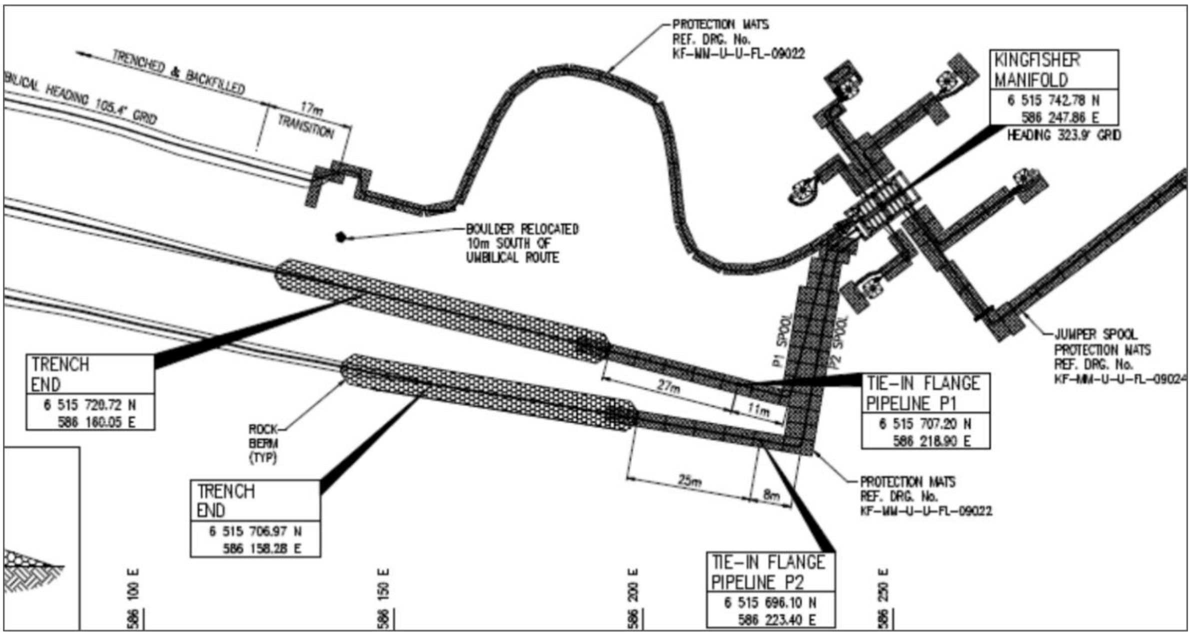


Figure 2-2 – Subsea Infrastructure at Kingfisher Manifold and Wells

The production pipelines PL1488 and PL1489 as well as the main umbilical PLU1490 are crossed by the BP Miller Pipeline PL1971 as they exit the Brae Bravo 500m zone; and cross over the Equinor Heimdal 8" Condensate Pipeline PL301 and Brae Alpha to East Brae Power Management System (PMS) Cable approximately 4.0km from the Brae Bravo 500m zone. The manifold umbilical, which is trenched from the Brae Bravo 500m zone, exits the trench on approach to the Kingfisher production manifold, with the surface-laid section of approximately 185m protected by mattresses. Surface-laid, mattress protected jumpers provide electro-hydraulic control and chemical injection from the production manifold to the wellheads, as shown in Figure 2-2.

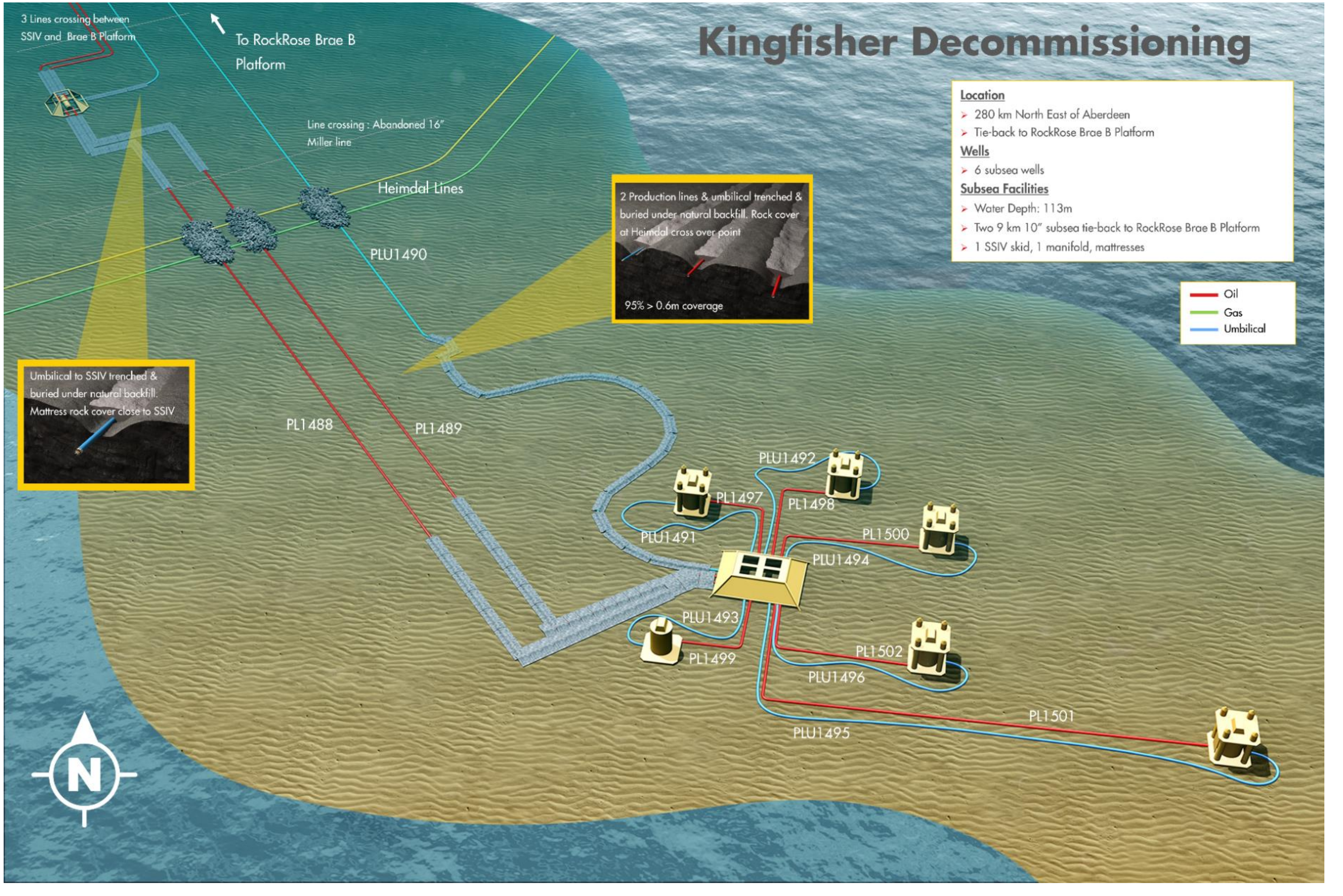


Figure 2-3 – Kingfisher Field Schematic

3. Comparative Assessment Process

3.1. General Process Description

The comparative assessment process was performed in accordance with the OPRED Decommissioning Guidance Notes [2] and guidance was used from the OGUK pipeline Comparative Assessment Guidelines [3].

The following sections present the comparative assessment methodology used for each of the Kingfisher scopes, however a summary of the process used is as follows:

- Scoping of subsea infrastructure to be decommissioned and inventory mapping;
- Decommissioning assessment criteria and sub-criteria;
- Decommissioning options to be considered;
- Screening workshop to initially agree the decommissioning options to take further and any grouping to be considered.
- Selection of groups with similar circumstances, to be assessed as a scope group;
- Traffic light assessment, as required;

Stakeholder engagement and multi-disciplinary reviews have formed an important part of the comparative assessment process.

3.2. Scoping and Inventory Mapping

The initial phase of the comparative assessment process was to identify the scope to be decommissioned and map the inventory which requires decommissioning. This is summarised in section 2.6.3.

3.3. Criteria and Sub-Criteria

The next step in the comparative assessment process is to agree the criteria and sub-criteria to be used. The following table presents the selected criteria and sub-criteria, which was used to assess each option for decommissioning during the comparative assessment process. The criteria are in line with the criteria recommended in the OGUK comparative assessment guidelines [3], except for the impact of operations and legacy impact of operations and legacy impact sub-criteria which have been adapted as shown in the table below.

Criteria	Sub-Criteria	Applicable to	Applicable When	Factors	Potential Sources of data
Safety	**Project risk to personnel – Offshore**	Project team offshore, project vessels crew, diving teams, supply boat crew, heli-ops, survey vessels crew	During execution phase of the project including any subsequent monitoring surveys	Type of activity Number of personnel involved & project duration. Number of crew changes (helicopter transfers) Number of vessels involved & SIMOP activity Numbers, durations and depth that divers are anticipated to work. Any unique or unusual handling or access activities required of personnel.	Decommissioning methodology for each option; vessel study; diving study; etc Coarse QRA data based on POB / exposure, durations and activity Fatal Accident Rate (FAR). Industry data will be used to derive the probability of loss of life.
	Project risk to other users of the sea	Navigational safety of all other users of the sea, fishing vessels, commercial transport vessels, military vessels	During execution phase of the project including any subsequent monitoring surveys	Likelihood of incursion into project exclusion zone by other users of the sea Number and type of transits by project vessels to and from the project work site	Fishing study on anticipated activity in area of activity Other vessels movements review, stakeholder engagement
	Operational risk to personnel – Onshore	Onshore dismantling and disposal sites personnel; extent of materials transfers/ handling on land	During execution phase of the project, through to final disposal of recovered materials	Extent of dismantling required & hazardous material handling anticipated. Numbers of road transfers from dismantling yard to final disposal site.	Decommissioning methodology for each option, considering volume and type of material to be returned to shore Coarse QRA data based on POB / exposure, durations and activity Fatal Accident Rate (FAR)
	Potential for a high consequence event	Project team offshore and onshore; project vessels; diving teams; supply boat crew; heli-ops; survey vessels; onshore dismantling and disposal sites personnel	During execution phase of the project including any subsequent monitoring surveys	Decommissioning philosophy; potential for dropped object over a live pipeline; degree of difficulty anticipated in onshore dismantling	Decommissioning methodology for each option; vessel study; diving study; etc
	Residual risk to other users of the sea	Fishing vessels, fishermen, supply boat crews, military vessel crews, commercial vessel crew and passengers, other users of the sea	Following completion of the Decommissioning project and residual / ongoing impact in perpetuity	Extent of facility / equipment / pipeline left in situ on completion of the project and its likelihood to form a future hazard; likelihood for further deterioration; predicted future fishing activity; proximity of retained facilities to main transport routes	Decommissioning methodology for each option, focussing on volume and type of infrastructure to be left in situ; fishing navigational safety study on anticipated activity in area(s) where infrastructure is decommissioned in situ; assessment(s) of degradation for infrastructure left in situ; stakeholder engagement
Environment al	**Impact of operations**	Environmental impact to the marine environment, nearshore areas and onshore caused by project activities	During execution phase of the project from mobilisation of vessels to the end of project activities at the waste processing / disposal site (does not	Associated planned discharges; marine noise; seabed disturbance, including seabed footprint (area), sediment suspension and contaminated sediment including drill cuttings; protected habitat and species in nearshore, marine and	Asset knowledge, decommissioning methodologies, Environmental Baseline Survey, Habitat Survey, Waste Inventory, Environmental Appraisal Report, project schedule, collision assessment, predicted discharges to sea, historic events

Criteria	Sub-Criteria	Applicable to	Applicable When	Factors	Potential Sources of data
			include landfill and long-term storage impacts) For rock placement, trenching and dredging any seabed disturbance is included here, depending on area of impact – changes to habitat and species are covered in Legacy Impact.	onshore areas – conservation objectives, their presence, impacts, distance from activities; waste processing	
	Energy and emissions and resource consumption	Project activities from vessel mobilisation to the final destination of waste, including the energy and emissions penalty for leaving recyclable material in field. Includes vessel mobilisation, demobilisation, waiting on weather, post-decommissioning monitoring surveys.	During execution phase of the project from mobilisation of vessels to the end of project activities at the waste processing / disposal site (does not include landfill and long-term storage impacts) Not recovering and recycling the installations material will require that raw material and energy will be consumed to replace the materials which would have been recycled if the structure had been brought onshore	Number and type of vessels; duration of vessel activities; tasks vessels are fulfilling; vessel station keeping approach Energy and emissions required to replace recyclable materials not recovered for recycle of re-use Helicopter trips are not to be included as impact is marginal.	Energy and emissions assessment, undertaken per Institute of Petroleum: Guidelines for the Calculation of Estimates of Energy Use and Gaseous Emissions in the Decommissioning of Offshore Structures
	Legacy Impact	Ongoing long term environmental impact and benefit caused by materials left in place or long-term waste storage / landfill	Following completion of the Decommissioning project and residual / ongoing impact For rock placement, trenching and dredging any changes to habitat and species are included here - seabed disturbance is included in Impact of Operations, depending on area of impact.	Waste disposal including onshore landfill and long-term waste storage; habitat alteration and long-term changes in species composition; physical and chemical degradation of products left on the seabed (make and content of material like wax, chemicals, plastic and concrete, steel, debris). CA will be conducted with assumption that reasonable endeavours are used to clean the infrastructure.	Decommissioning methodology for each option, focussing on volume and type of infrastructure to be left in situ; Environmental Baseline Survey; Habitat Survey; Waste Inventory
Technical	**Risk of major project failure** Cost and Schedule overruns. Ease of recovery from excursion.	Overall Project	From project select phase through to completion, including monitoring surveys and ultimate disposal of materials returned to shore.	Maturity of scope definition, confidence level that project will proceed as foreseen; ability to recover from unplanned events which could impact completion of the project as planned; extent of potential re-engineering that may be required and its impact if strategy goes wrong	Decommissioning methodology for each option, concept / pre-FEED study, lessons learned from industry
	Technology demands, Availability / Track Record	Overall Project	From project select phase through to completion, including monitoring surveys and ultimate disposal of materials returned to shore.	Extent of new or emerging technology proposed by the option; extent of application of existing technology to different uses; extent that the approach has been completed before	Decommissioning methodology for each option, concept / pre-FEED study, lessons learned from industry

Criteria	Sub-Criteria	Applicable to	Applicable When	Factors	Potential Sources of data
Societal	**Commercial impact to fisheries**	Impacts from both the decommissioning operations and the end-points on the present commercial fisheries in and around the field	During and following completion of the Decommissioning project and residual / ongoing impact	Residual impact on fishing areas: • If exclusion zones are to be retained where equipment or materials are left in-situ • If fishing habitats are inhibited as a result of the decommissioning methods adopted	Fishing study on anticipated activity in area of activity; decommissioning methodology for each option focussing on volume and type of infrastructure to be left in situ; vessel study; publicly available data; stakeholder engagement
	Socio-economic impact on communities and amenities	The impact from any near shore and onshore operations and end-points (dismantling, transporting, treating, recycling, land filling) on the health, well-being, standard of living, structure or coherence of communities or amenities. E.g. business or jobs creation, job loss, increase in noise, dust or odour pollution during the process which has a negative impact on communities, increased traffic disruption due to extra-large transport loads.	During and following completion of the Decommissioning project and residual / on-going impact	May be positive or negative; jobs created; establishment of track record; improvements to roads and quaysides; use of limited landfill resource	Decommissioning methodology for each option; publicly available data; stakeholder engagement
Economic	**Cost**	Overall Project	Full decommissioning project cost including future monitoring surveys and proposed remediation, if required	Actual cost estimates are not to be included in the CA report, but a normalised scale can be produced to indicate the comparison between each option	Cost and schedule estimates
	Cost Risk / Uncertainty	Overall Project	Project execution phase and ongoing cost liability (surveys and potential remedial action)	Uncertainty in estimates prepared, potential for / risk of growth through the project, risk will be greater with a larger number of unknowns and where activities are weather sensitive	Risk and opportunity register

Table 3-1 – Comparative Assessment Criteria and Sub-Criteria

3.4. Decommissioning Options and Initial Screening Workshop

3.4.1. Decommissioning Options

The options available for decommissioning have been considered and were assessed as part of the initial screening process to assess each option's feasibility. The options for decommissioning being assessed are shown in section 4.

3.4.2. Initial Screening Workshop

An initial screening workshop was held where experts were consulted to assess the technical feasibility and practicality of each of the decommissioning options relating to each scope. The initial screening workshop also identified which scopes displayed similar characteristics and could therefore be grouped and assessed together.

Internal assessment was performed for each scope against the five Comparative Assessment criteria, with decommissioning recommendations identified for each scope. The options were assessed against assessment criteria parameters outlined in the Shell Comparative Assessment Procedure EOFL-PT-S-QA-6050-00001 and provided in Table 3.2 below. These parameters were developed from Appendix A of the Oil and Gas UK Guidelines for Comparative Assessment in Decommissioning Programmes [3], with two amendments for the sub-criteria "impact of operations" and "legacy impact".

Using the parameters outlined in Table 3.2, an internal screening workshop was held in December 2017. Internal attendees from the relevant subsea, engineering, safety, environmental, project services, project management and regulatory disciplines compared each of the identified options against the parameters provided. The options assessed and the output of this internal screening is summarised in Section 5 of this document.

3.5. Comparative Assessment Workshops

A Comparative Assessment (CA) workshop was held, including licence partners and the stakeholder consultees to inform the emerging recommendations. During the CA workshop, the scopes were presented to and discussed with the attendees detailing the circumstances associated with each item of infrastructure, the credible options identified, and the impacts against the five CA criteria. The decommissioning recommendations were presented for discussion with the stakeholders in attendance.

Criteria	Sub-Criteria	Applicable to	Applicable When	Green	Amber	Red
Safety	Project risk to personnel – Offshore	Project team offshore, project vessels crew, diving teams, supply boat crew, heli-ops, survey vessels crew	During execution phase of the project including any subsequent monitoring surveys	Minimal preparatory activity to be completed prior to start of removal activity. No underdeck / overside working. Minimal materials handling on deck or barge during removal. Minimal diver activity.	Some preparatory activity to be completed prior to start of removal activity – but straight forward. Limited underdeck / overside working. Some materials handling activity on deck or barge during removal – but straight forward. Increased diver activity for short intervals and for less than 25% project duration.	High level of preparatory activity to be completed prior to start of removal activity. Significant underdeck / overside working. Multiple materials handling activity on deck or barge during removal. Extended diver activity throughout entire project phase.
	Project risk to other users of the sea	All other users of the sea, fishing vessels, commercial transport vessels, military vessels	During execution phase of the project including any subsequent monitoring surveys	Minimal project activity outside existing exclusion zone. Minimal additional vessels transits to and from shore.	Moderate project activity outside existing exclusion zones but for short durations. Some additional vessel transits to and from shore of significant sized vessels. No complex transits.	Significant project activity outside existing exclusions zones but for most of project duration. Some complex transits to shore.
	Operational risk to personnel – Onshore	Onshore dismantling and disposal sites personnel; extent of materials transfers/ handling on land	During execution phase of the project, through to final disposal of recovered materials	Medium sized / volume of structures returned as waste - moderate dismantling required onshore, minimal work at height. Minimal contaminated materials to be returned, capable of being processed in existing facilities without additional specialist equipment or treatment.	Large size / volume of structures returned as waste – more dismantling required onshore, some working at height possible. Some contaminated materials may be returned, may require some additional specialist equipment or treatment.	Significant sized or awkward shaped structures returned as waste – significant working at height required, significant and complex dismantling and materials handling activities required. Significant volumes of contaminated materials handling and clean up anticipated; or requires onerous levels of additional specialist equipment / treatment.
	Potential for a high consequence event	Project team offshore and onshore; project vessels; diving teams; supply boat crew; heli-ops; survey vessels; onshore dismantling and disposal sites personnel	During execution phase of the project including any subsequent monitoring surveys	Short vessel campaign (summer campaign); low level vessel SIMOPS; minimal helicopter crew changes anticipated; few lifting operations; all straightforward and not over live plant.	Prolonged vessel campaigns; some vessel SIMOPS; helicopter crew changes possible; some lifting operations; recovered structures lifted onto vessels for backload but not over live plant.	Extensive vessel campaigns; multiple mob / demob; multiple vessel SIMOPS; helicopter crew changes likely; major lifting operations, some very large lifts; possible lifts of structures over live trunk lines.
	Residual risk to other users of the sea	Fishing vessels, fishermen, supply boat crews, military vessel crews, commercial vessel crew and passengers, other users of the sea	Following completion of the Decommissioning project and residual / ongoing impact in perpetuity	None anticipated as clear seabed on completion of project, all material left in situ is adequately trenched or buried below mean seabed level.	Some materials which are proud of mean seabed level / not trenched or buried but are otherwise protected, i.e. rock-covered or present minimal risk of snagging due to their inherent structure (e.g. large diameter trunklines). Other mitigations in place (retention of exclusion zones).	Material left in situ is proud of the seabed and not protected by rock-cover and could represent a future snagging risk; mitigation available is limited to marking on admiralty charts. Material left in situ would require significant future monitoring and / or future mitigation measures.
Environmental	Impact of operations	Environmental impact to the marine environment, nearshore areas and onshore caused by project activities	During execution phase of the project from mobilisation of vessels to the end of project activities at the waste processing / disposal site (does not include landfill and long-term storage impacts) For rock placement, trenching and dredging any seabed disturbance is included here, depending on area of impact – changes to habitat and species are covered in Legacy Impact.	No associated discharges*1; No behavioural disturbance to any marine mammals; Area of disturbance equal or less than area disturbed during installation and/or operations; No disturbance to drill cuttings accumulation*2; Extend of the sediment resuspension equal or less than the extent caused during operations and/or installation; No protected / sensitive species and or habitats affected;	Non-SUB, GOLD or E/PLONOR chemicals discharges*1; Temporary changes to behaviour of any marine mammals i.e. temporary move away from the area; Area of disturbance is up to two times bigger than the area disturbed during installation and / or operation; Less than half the volume of the drill cuttings deposits*2 will be disturbed; Extent of the sediment resuspension is up to two times bigger than during operation and/or installation; Presence of protected / sensitive species and/or habitats identified and confirmed	Any other chemical discharges*1 (other than in Amber) e.g. SILVER, OCNS A-C or no longer CEFAS registered; Permanent damage / change to behaviour of any mammals (i.e. move away permanently and / or permanent damage to hearing); Area of disturbance more than two times bigger than the area disturbed during installation and / or operations; AND Greater than half the volume of the drill cuttings will be disturbed; AND Sediment resuspension is more than twice than during operation and/or installation; Presence of designated protected species and/or habitats*3;

Criteria	Sub-Criteria	Applicable to	Applicable When	Green	Amber	Red
				Onshore processing can be completed by existing facilities without additional specialist equipment / treatment*[4]	by a survey*[3]; Onshore processing requires moderate levels of specialist equipment / treatment, additional qualified personnel, etc	Onshore processing requires onerous or offsite levels of specialist equipment / treatment
	Energy, emissions and resource consumption	Project activities from vessel mobilisation to the final destination of waste, including the energy and emissions penalty for leaving recyclable material in field. Includes vessel mobilisation, demobilisation, waiting on weather, post-decommissioning monitoring surveys.	During execution phase of the project from mobilisation of vessels to the end of project activities at the waste processing / disposal site (does not include landfill and long-term storage impacts) Not recovering and recycling the installations material will require that raw material and energy will be consumed to replace the materials which would have been recycled if the structure had been brought onshore	Short duration and/or small number of vessels during decommissioning operation and future monitoring; Small volume of material left in situ	Moderate duration and number of vessels during decommissioning operation and future monitoring; Moderate volume of material left in situ	Significant duration and number of vessels required for operations and future monitoring; Significant volume of material left in situ
	Legacy impact	Ongoing long term environmental impact caused by materials left in place or long-term waste storage / landfill	Following completion of the Decommissioning project and residual / ongoing impact For rock placement, trenching and dredging any changes to habitat and species are included here - seabed disturbance is included in Impact of Operations, depending on area of impact.	Minor volumes of material to landfill; No hazardous waste requiring long-term storage; No change to habitat or species composition (introduction of no new materials); No material left ON the seabed; and / or inert material left IN the seabed (trenched or buried)	Moderate volumes of material to landfill; Non-hazardous waste requires disposal (landfill) OR Small amount of hazardous waste requiring treatment and / or long term-storage; Possible / temporary alteration of species composition due to habitat alteration with recovery and recolonization of the area by original species; Inert material left ON the seabed; or contaminated material left IN the seabed posing no significant threat to the environment *[5]	Majority of recovered material destined for landfill; Majority of hazardous waste long-term storage; Permanent habitat alteration with permanent changes in species composition; Material left ON or IN the seabed containing contaminated material that poses a significant long term threat to the environment*[6]
Technical	Risk of major project failure	Overall Project	From project select phase through to completion, including monitoring surveys and ultimate disposal of materials returned to shore.	High level of confidence that schedule slippage can be accommodated within the contingency and float in the plan; high level of confidence that cost increases can be accommodated by contingency UAP budget allocation; slippage to schedule and growth in cost anticipated is small; assets and equipment are immediately available to facilitate recovery and stabilise the situation after an incident; speed of recovery is anticipated to be swift; limited impact on planned campaign schedule is anticipated as remaining planned activities can continue in the interim.	Less confidence in cost and schedule, however moderate level of delay and cost overrun is anticipated as worst case; assets and equipment are available in a reasonable timeframe from onshore to stabilise the situation after an incident; speed of recovery is anticipated to be longer due to some re-engineering of activities being required; considerable impact on the planned campaign schedule is anticipated, as remaining planned activities cannot continue in the interim.	Significant delays are possible if upsets occur pushing removals phase into a separate season and increased cost overrun possible; re-engineering required to develop procedures and identify assets and equipment to stabilise the situation after an incident; speed of recovery is anticipated to be slow due to re-engineering and procurement of new equipment; significant impact on the entire project schedule and company reputation.

Criteria	Sub-Criteria	Applicable to	Applicable When	Green	Amber	Red
	Technology demands, Availability / Track Record	Overall Project	From project select phase through to completion, including monitoring surveys and ultimate disposal of materials returned to shore.	The proposed concept has been successfully implemented in the past; technological feasibility of the concept is beyond doubt; industry and expert opinion consistently concludes that the proposed solution is technically robust and complies with existing legislation; vessels and most supporting equipment are industry-standard with good track record of successful operation with no new marine asset construction required; some minor supporting equipment may require investment to aid development or proof of use as planned, however it is anticipated that this can be completed successfully ahead of the project schedule; the supply chain is generally readily available in the present market; project schedule is reasonable and equipment availability is within project timetable.	The proposed concept has been seriously considered for several directly comparable assets in the past but has not yet been used; technological feasibility of the concept requires some additional engineering development; expert opinion is united in confidence that the proposed solution is generally technically sound and complies with existing legislation; some vessels require some investment to aid minor development, however there is widespread confidence within the industry that this shall be completed successfully; more supporting equipment requires early investment to aid development, however it is anticipated that this will be completed successfully ahead of the project schedule; the supply chain requires some engagement to meet project requirements; project schedule can be managed to suit equipment availability within the overall project timetable.	The proposed concept is not mature; technological feasibility of the concept requires considerable engineering to prove; there is some doubt within the industry and expert opinion is divided on whether the proposed solution is technically sound and can comply with existing legislation; vessel require investment to aid their development and construction; other supporting equipment requires investment to aid development; there is uncertainty within the industry that this will be completed successfully ahead of the project schedule; the supply chain requires development; project schedule is tight but may be managed to suit equipment availability.
Societal	Commercial impact to fisheries	Impacts from both the decommissioning operations and the end-points on the present commercial fisheries in and around the field	During and following completion of the Decommissioning project and residual / ongoing impact	The status of the area / site post-decommissioning will have no effect on commercial fisheries.	The status of the area / site post-decommissioning results in small areas of fishing ground or water column becoming inaccessible to fishing and is lost to fishing over prolonged period.	The status of the area / site post-decommissioning results in larger areas of fishing ground or water column becoming inaccessible to fishing and is lost to fishing over a prolonged period.
	Socio-economic impact on communities and amenities	The impact from any near shore and onshore operations and end-points (dismantling, transporting, treating, recycling, land filling) on the health, well-being, standard of living, structure or coherence of communities or amenities. E.g. business or jobs creation, increase in noise, dust or odour pollution during the process which has a negative impact on communities, increased traffic disruption due to extra-large transport loads.	During and following completion of the Decommissioning project and residual / on-going impact	No or minor negative impact: short-term (<6 months) impact on local communities causing potential minor nuisance from some aspects of the operations, but would cease and revert to previous condition on completion of specific short term operations. Short-term (<6 months) impact on local amenities for some or all of the operations, but would cease and revert to previous condition on completion of operations, without the need for mitigation. Positive impact: new business or long term employment created, extends beyond duration of the operation by more than 1 year. Permanent road and other infrastructure improvements created.	Some negative impact on local communities, leading some actual deterioration in quality of life, deterioration would exist while actual operations were being carried out but would essentially cease as soon as operations were completed and quickly revert to pre-operation condition; some impact on local amenities, leading to some actual deterioration in amenities; deterioration would exist whilst actual operations were being carried out. Some mitigation / remedial work would be required when operations were completed to restore amenities to pre-operational condition. Short term and local positive impact on communities as localised increased job prospects created for duration of the operation. No permanent positive impact on amenities anticipated.	Significant and long-term (>1 year) negative impact on local communities leading to noticeable deterioration in quality of life during the operations. Anticipated this would persist for a period of 6 months to 1 year after actual operations had ceased. Significant and long-term (>1 year) impact on local amenities, leading to noticeable deterioration during the operations. Mitigation / remedial work would be required when operations were completed to restore amenities to pre-operational condition. No positive impact on communities or amenities. Existing businesses and infrastructure can accommodate operations.
Econ omic	Cost	Overall Project	Full decommissioning project cost including future monitoring surveys and proposed remediation, if required	Lowest cost option	-	Highest cost option

Criteria	Sub-Criteria	Applicable to	Applicable When	Green	Amber	Red
	Cost Risk / Uncertainty	Overall Project	Project execution phase and ongoing cost liability (surveys and potential remedial action)	Scope reasonably defined and understood; estimate developed using recognised and validated estimating tools; validated cost basis industry norms from similar work already carried out.	Some uncertainty / information gaps in parts of the scope and / or equipment used; estimate developed using recognised and validated estimating tools; validated cost basis using industry norms, some information gaps in norms due to costs of new or emerging equipment rates not being available.	Uncertainty in many areas of the scope and in equipment used; OOM estimate only developed; significant information gaps in norms due to costs of new / emerging equipment rates not being available.

Table 3-2 – Summary of Decommissioning Options and Grouping

<u>Notes relating to the Environmental sub-criteria:</u>

Impact of Operations:

*[1] Discharges of pipeline and umbilical contents which have been cleaned to a cleanliness level as agreed with regulator;

*[2] Any drill cuttings deposits regardless of OSPAR 2006/05 definition;

*[3] must be supported by any survey (ignoring reference station);

*[4] this only applies if material is returned onshore for disposal

Associated discharges do not include accidental releases; these are not considered in the environmental evaluation of the options as they are probabilistic events and their inclusion would skew the data as the order of their impact is significantly higher than of the planned activities with build-in mitigations and controls

Legacy Impact:

Waste Disposal to include end-products of any cleaning operations; does not apply if all material is left in situ, i.e. nothing is brought onshore for disposal.

*[5] Example: steel pipeline which was cleaned to BAT, but the pipeline is still left in situ

*[6] Science immature on plastic content but it is an increasing problem with higher focus from society and environmental science community

4. Decommissioning Options

A brief discussion of the decommissioning options is presented below, which will cover the high-level options of pipeline removal, re-use, remediation or leave in-situ.

4.1. Re-use

There are no credible re-use opportunities as the host is being decommissioned and removed.

4.2. Removal

4.2.1. Cut and lift

The cut and lift method to date has been the most commonly used method to remove pipelines. The method requires the pipeline to be un-trenched and water flooded. The pipeline will then be cut into sections by an ROV using hydraulic shears and then recovered by a vessel using a hydraulic lifting beam ready for transport to shore and disposal. A simplified schematic of the cut and lift process is shown in Figure 4-1. The preferred method of cutting will generally be decided by the contractor performing the work, subject to risk assessment and endorsement by Shell, however will most likely be hydraulic shears.

The cut and lift method can be used for the entire pipeline removal or localised sections, such as spools or spans.

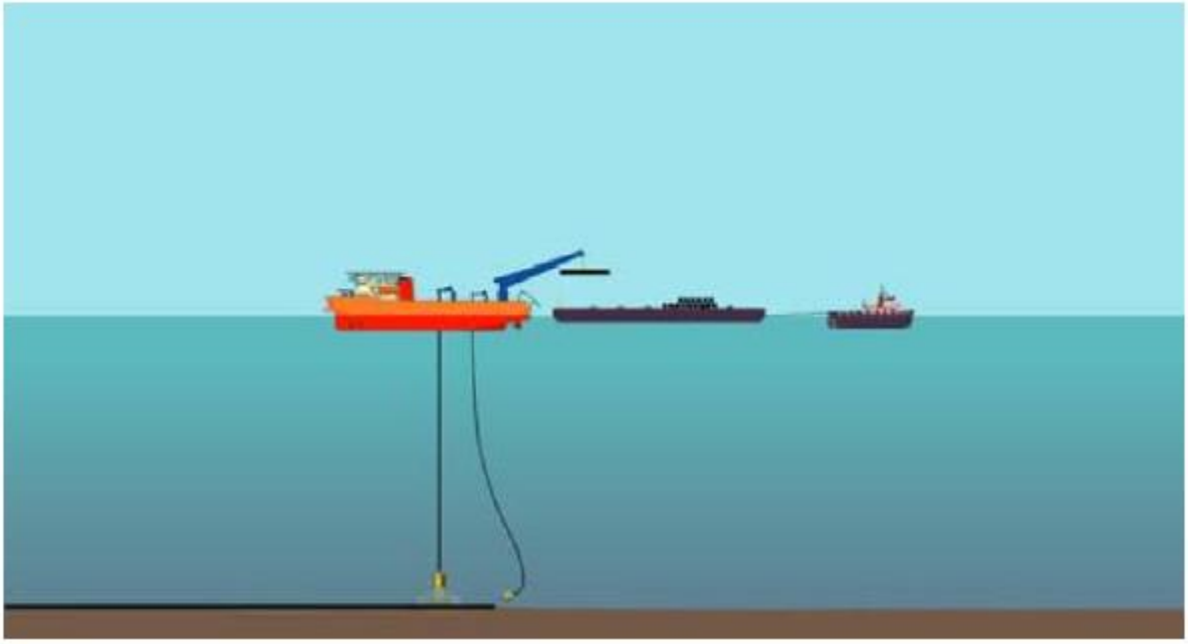


Figure 4-1 – Cut and Lift Pipeline Removal Illustration

4.2.2. Reverse Reel

Reverse reeling of the buried pipelines or umbilicals would potentially require them to first be un-trenched and de-watered to reduce the submerged unit weight. The pipeline or umbilical ends would then need to be cut or disconnected and then the reeling vessel would connect to and recover the end using the A&R (abandonment and recovery) winch until the tensioner could grip and proceed to pull the pipeline or umbilical on to the vessel. The pipeline or umbilical would then need to be connected to the main reel, so that the vessel could proceed to reel on. The pipeline or umbilical would then be transported to shore for disposal or recycling.

4.2.3. Reverse S-lay

Reverse S-lay is a potentially feasible option to recover pipelines. Reverse S-lay is the reversal of the common S-lay installation technique, which generally consists of a pipeline lay vessel or barge equipped with a stinger and tensioner and then the line pipe is welded together on the vessel, prior to being laid onto the seabed, which is controlled by the applied tension to the pipeline.

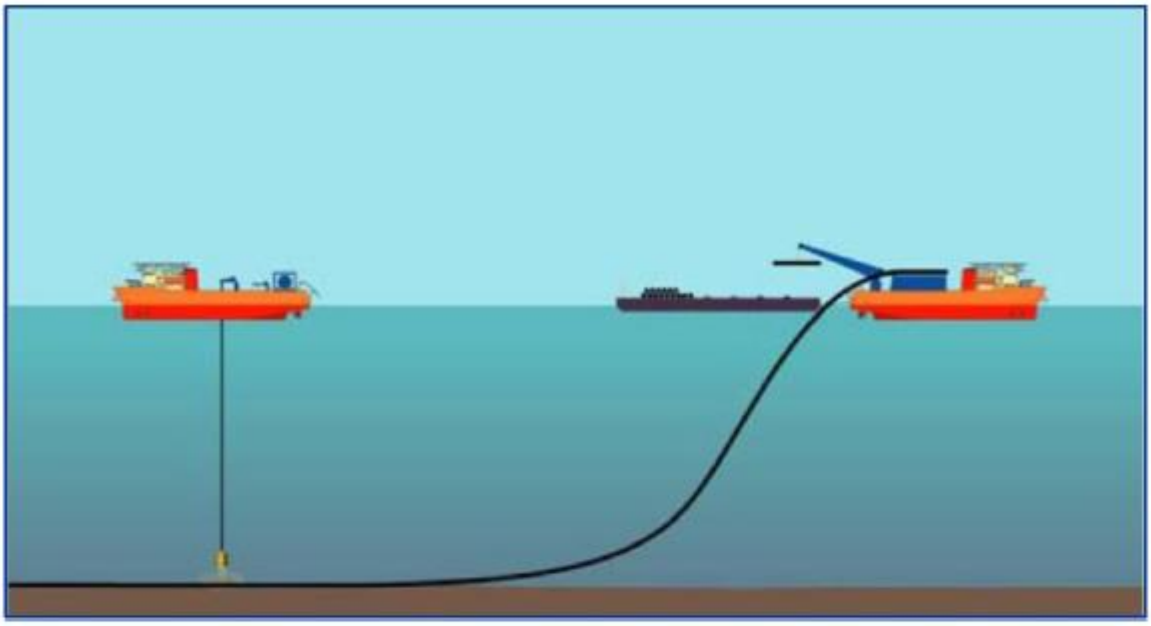


Figure 4-2 – Reverse S-lay Illustration

For the removal process the tensioner would be used to recover the pipeline from the seabed and then it would be cut to manageable lengths on the vessel and transported back to shore.

The pipeline would need to be un-trenched to perform this method of recovery. In addition, it would be prudent to dewater the pipeline (air filled or nitrogen purged) to reduce the equivalent weight of the pipeline and hence reduce the required tension. A summary of the reverse S-lay methodology is set out in Figure 4-2.

4.3. Leave In-situ

4.3.1. Pipelines (No remediation)

This option consists of leaving the pipeline or umbilical in-situ with no further remediation, however the pipeline ends may be cut and buried or cut and rock covered.

4.3.2. Pipelines (Re-trench)

Re-trenching pipelines or umbilicals is an option where lines are subject to increased risk from snagging or becoming unstable (e.g. buoyant pipelines or free spanning pipelines) due to a reduction in the burial depth or cover. The retrenching of a pipeline or umbilical can be performed by a jet trencher, plough or mass flow excavator. Re-trenching on areas with remedial rock may need the rock removed prior to trenching, depending on the rock grade.

4.3.3. Localised Cut and Lift

For localised exposures or areas of low cover, localised cut and lift operations can be used, which would be executed in a similar manner to that shown in section 4.2.1.

4.3.4. Pipelines (Remedial Rock Cover)

Remedial rock cover involves either blanket or locally placing rock at specific locations to increase the cover on the pipeline to reduce the risk of snagging or it affecting other users of the sea. Due to the water depth at Kingfisher (approx. 114m) a fall pipe vessel, shown in Figure 4-3, would be the most likely method for additional rock cover.

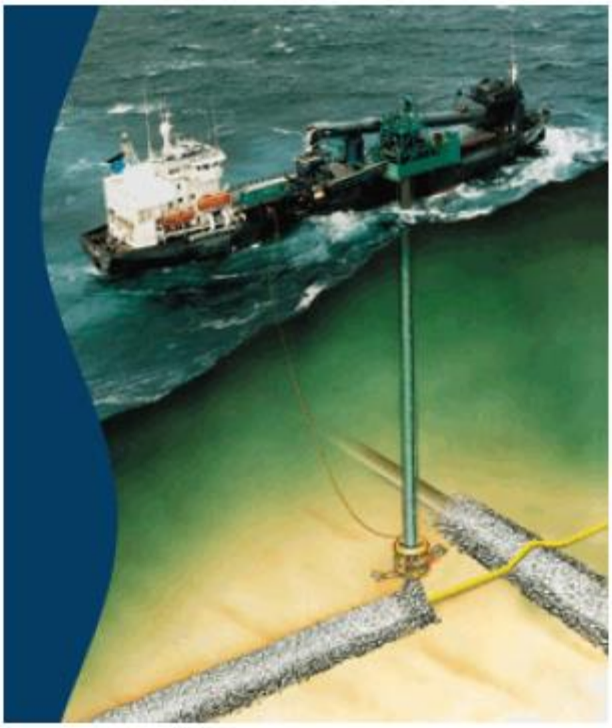


Figure 4-3 – Remedial Rock Cover Installation Illustration

5. Comparative Assessment Results

5.1. Initial Decommissioning Options Screening and Grouping

A number of stakeholder engagements took place during the initial screening phase to further understand and clarify each stakeholder's concerns and views regarding the decommissioning of the Kingfisher Field.

Internal workshops to screen the options were held by Shell in Q1 2018 utilising information from both internal and external survey data gathered over the life of the field. The workshops enabled the project team to identify and define credible options for each scope, assessing what data gaps existed for each option and defining whether any studies were required to inform the comparative assessment workshop.

During the initial screening workshop, the credible options for each grouping was assessed against the five CA criteria identified in Section 3.3 and, as appropriate, decommissioning recommendations identified.

In addition, the pipelines were grouped, where applicable, for the purposes of the comparative assessment workshop. A summary of the grouping and options assessed for each scope is shown in Table 5-1.

Details of the conclusions for each scope and group are contained within the following sections.

Scope	Description	Decommissioning Options
1, 3, 4	Scopes 1, 3 and 4 will be covered by a separate Decommissioning Programme and Comparative Assessment	
2	Surface-laid lines outside Brae Bravo 500m Zone (PL1488, PL1489, PLU1490, ~~PL N/A~~, PL1497, PL1498, PL1499, PL1500, PL1501, PL1502, PLU1491, PLU1492, PLU1493, PLU1494, PLU1495, PLU1496)	~~Decommission in situ~~ ~~Blanket rock cover~~ Total removal
5	Pipeline ends at manifold (PL1488 & PL1489)	Decommission in situ ~~Blanket rock cover~~ ~~Total removal~~
6	Trenched and buried sections (PL1488, PL1489, PLU1490)	Decommission in situ ~~Total removal~~
7	Umbilical end at manifold (PLU1490)	~~Decommission in situ~~ ~~Blanket rock cover~~ Total removal

Table 5-1 – Summary of Decommissioning Options and Grouping

Notes:

Options with a strikethrough (e.g. ~~Decommission in-situ~~) were deselected during initial screening.

5.2. Scope 2 – Surface Laid Lines Outside Brae Bravo 500m Zone

This scope includes the surface-laid sections of the manifold umbilical (PLU1490) and both 10" production lines (PL1488 and PL1489) at the Kingfisher Manifold; and the tie-in spools and jumpers between the Kingfisher Manifold and six Kingfisher wellheads (PL1497, PL1498, PL1499, PL1500, PL1501, PL1502, PLU1491, PLU1492, PLU1493, PLU1494, PLU1495, PLU1496). Most of the surface laid sections are covered by mattresses. The stabilisation features associated with this scope were included within the CA.

Scope 2 infrastructure adjacent to the Kingfisher Manifold and wellheads is shown in Figure 5-1.

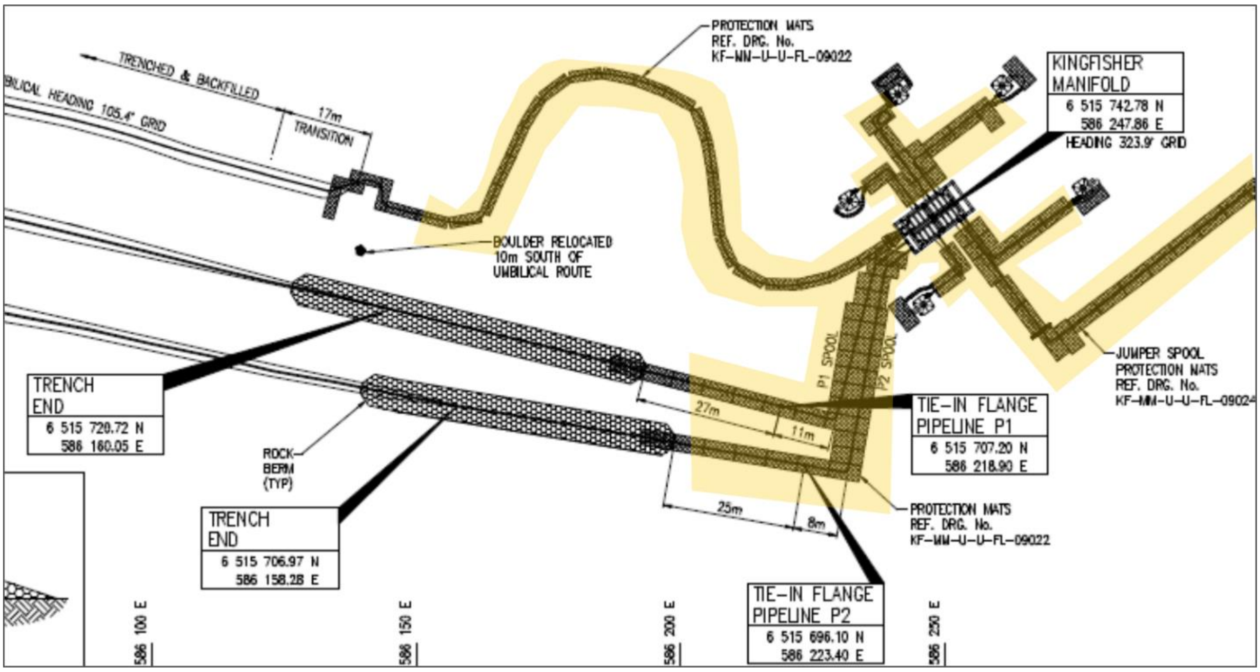


Figure 5-1 – Scope 2 at Kingfisher Manifold and Wellheads (highlighted)

Three credible options were identified for this infrastructure:

- Total removal
- Decommission in situ
- Blanket rock cover and decommission in situ

The three credible options were reviewed against the five CA criteria of safety, environment, technical, societal and economic impacts.

In terms of safety impact, decommissioning the spools and jumpers in situ was deemed to leave an unacceptable safety risk to future users of the sea as the infrastructure would present a snagging risk in open water. This option was therefore discounted.

Total removal is in line with both the regulatory expectation and stakeholder preference for clear seabed on conclusion of decommissioning activities. All pipelines, umbilicals and spools associated with this scope are surface-laid, with the mattresses broadly accessible and expected to be in good condition given the age of the field. Therefore, whilst representing a comparatively higher safety risk to project personnel offshore than blanket rock cover, total removal would not impose any unusual safety risks. Further, blanket rock cover would reduce the legacy safety risk of snagging by other users of the sea compared with decommissioning in situ, however it would represent a comparatively higher risk than total removal.

For environmental impact, total removal would be less significant than blanket rock-cover. The latter would create seabed disturbance across a greater footprint in the short-term and have a comparatively higher long-term impact by introducing new and habitat-altering substrate

With each option representing a relatively short execution scope and employing well-known, commonly used technology, there is no comparable difference between the two remaining options in terms of technical impact.

Similarly, neither total removal nor blanket rock cover would have a significant societal impact. Resulting in a short offshore campaign and returning small volumes of waste to shore for recycling will have little or no effect on existing employment and supply chains.

In terms of cost, total removal will result in a higher execution cost than blanket rock cover; however the legacy cost of total removal is expected to be lower as fewer post-decommissioning surveys and/or remedial work is required to prove the seabed remains safe for other users of the sea.

Taking into account the above factors, *decommission in situ* was excluded due to the unacceptable safety risk; whilst total removal is preferable to blanket rock cover for this scope.

Following comments from OPRED during public consultation and to provide additional clarity of the assessment detailed above, a graphical representation of the Scope 2 assessment against the criteria outlined in Section 3 is provided in Table 5-2 overleaf.

Therefore, the recommended decommissioning solution to **remove all lines and exposed mattresses** was presented at the CA workshop. Removed infrastructure will be recovered to shore for recycling and disposal.

There were no objections to this proposal from the stakeholder consultees.

Criteria	Ref	Sub Criteria	Option A: Decommission in situ	Option B: Blanket rock cover	Option C: Total Removal Selected Option
Safety	1	Project risk to personnel - Offshore	g	g	a
	2	Project risk to other users of the sea	b	b	b
	3	Project risk to personnel - Onshore	b	b	b
	4	Potential of a high consequence event	b	b	b
	5	Residual risk to other users of the sea	r	a	g
Environment	6	Marine impact of operations	g	a	a
	7	Energy, emissions, resource consumption	b	b	b
	8	Impact of marine end points (legacy impact)	a	a	g
Technical	9	Risk of major project failure	b	b	b
	10	Technology demands / track record	b	b	b
Societal	11	Commercial impact on fisheries	b	b	b
	12	Socio-econ impact on communities and amenities	b	b	b
Economic	13	Cost	r	a	a
	14	Cost risk and uncertainty	a	g	g

Table 5-2 – Assessment Summary – Scope 2

Key for colour-blind readers: g – Green, a – Amber, r – Red, b – Blank / grey, i.e. no comparative difference between options

5.3. Scope 5 – Pipeline Ends at Manifold

Sections of both 10" production pipelines where they transition from their respective trenches until they exit the existing rock berm. This covers only the ends at the Kingfisher manifold. Sections are approximately 50m in length for each pipeline. Stabilisation features associated with these pipeline ends, i.e. mattresses and grout bags, were included within the CA.

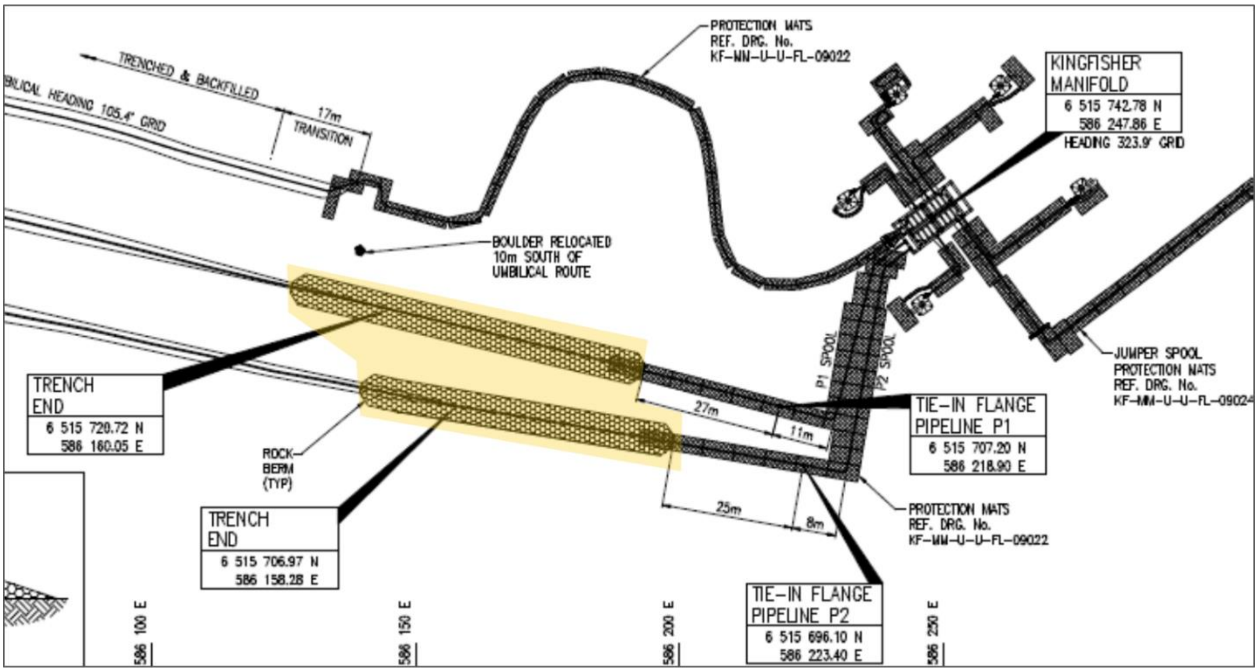


Figure 5-2 – Scope 5 at Kingfisher manifold (highlighted)

Both ends are completely covered by existing rock berms with no exposures, with a depth-of-rock cover between 0.3m and 1.2m. The depth-of-lowering within the trench should also be considered when assessing the likely snagging risk. Survey data shows total depth-of-lowering or cover varies between 0.4m and 1.4m. The OPRED Decommissioning Guidance Notes ([2] Section 10.19) state that "where rock-dump has previously been used to protect a pipeline it is recognised that removal of the pipeline is unlikely to be practicable and it is generally assumed that the rock-dump and the pipeline will remain in place. Where this occurs, it is expected that the rock-dump will remain undisturbed".

Three credible options were identified for these sections of pipeline:

- Total removal
- Decommission *in situ*
- Decommission *in situ* with additional rock cover

The three credible options were reviewed against the five CA criteria of safety, environment, technical, societal and economic impacts.

In terms of safety impact, total removal of the ends would represent the highest risk during execution due to requiring the longest offshore campaign although this risk would not be considered prohibitive. Decommissioning *in situ* would present the lowest risk during execution as there would be no offshore campaign at all.

Total removal would result in the dispersal of the existing rock-berm by any activity undertaken to de-bury the pipeline ends. This dispersal would result in an increased snagging risk to the fishing industry and therefore represents a comparatively larger risk than either of the decommissioning *in situ* options.

Further, dispersal of the existing rock-berm would result in a larger level of seabed disturbance and therefore short-term environmental impact than the other options. Of the remaining two options, decommissioning *in situ* with additional rock cover would have a comparatively greater short-term impact than simply decommissioning *in situ* due to the seabed disturbance of installing new rock.

Conversely, total removal would have the lowest long-term impact of the three options due to removing all installed material from the seabed. However, the impact of either decommission *in situ* option was considered to be negligible given the short sections of pipe being considered.

In terms of technical capability and taking into account the short sections considered, there is no significant difference between the three options.

Similarly, none of the three credible options would have a significant societal impact. Resulting in a short offshore campaign or returning small volumes of waste to shore for recycling will have little or no effect on existing employment and supply chains.

In terms of cost, total removal will result in a higher execution cost than either decommissioning *in situ* or adding more rock. Further, as total removal would result in the dispersal of the existing rock-berm rather than retaining the existing stable rock berm, it would also result in an increased legacy monitoring cost to ensure the area remains safe for other users of the sea compared to the other two options

Taking into account the above factors, total removal was considered to be the least favourable option. 'Decommissioning *in situ*' and 'additional rock cover' were considered to be two variations of the same option, with both resulting in the pipeline sections and existing rock berm remaining in place. The only comparative impacts would result from the volume of additional rock required, if any, with a proportionate rise in environmental impact (both 'impact of operations' and 'legacy impact') and cost.

Following comments from OPRED during public consultation and to provide additional clarity of the assessment detailed above, a graphical representation of the Scope 5 assessment against the criteria outlined in Section 3 is provided in Table 5-3 overleaf.

Therefore, the recommended decommissioning solution to **decommission *in situ*** was presented at the CA workshop. The safety of the rock berm for future users of the sea is to be positively confirmed, where possible without the use of chain-mat over-trawling. This will include verifying the depth-of-cover and profile of the berm, likely to be performed by multi-beam sonar scanning. Any requirement to make this berm more suitable for future users of the sea will be completed using additional rock. Section 6.1.2 of the Kingfisher Environmental Appraisal outlines the reasonable worst-case assumptions for additional rock cover. The expectation is that the rock cover required for the pipeline ends is 20 tonnes in total, 10 tonnes per end.

There were no objections to this proposal from the stakeholder consultees.

Criteria	Ref	Sub Criteria	Option A: Total Removal	Option B: Decommission in situ Selected Option	Option C: Decommission in situ with additional rock cover
Safety	1	Project risk to personnel - Offshore	a	g	g
	2	Project risk to other users of the sea	b	b	b
	3	Project risk to personnel - Onshore	b	b	b
	4	Potential of a high consequence event	b	b	b
	5	Residual risk to other users of the sea	a	g	g
Environment	6	Marine impact of operations	a	g	a
	7	Energy, emissions, resource consumption	b	b	b
	8	Impact of marine end points (legacy impact)	a	g	g
Technical	9	Risk of major project failure	b	b	b
	10	Technology demands / track record	b	b	b
Societal	11	Commercial impact on fisheries	b	b	b
	12	Socio-econ impact on communities and amenities	b	b	b
Economic	13	Cost	a	g	g
	14	Cost risk and uncertainty	a	g	g

Table 5-3 – Assessment Summary – Scope 5

Key for colour-blind readers: g – Green, a – Amber, r – Red, b – Blank / grey, i.e. no comparative difference between options

5.4. Scope 6 – Trenched and Buried Sections

Sections of both the 10" production pipelines (PL1488 and PL1489) and the manifold umbilical (PLU1490) which are trenched and buried for approximately 9km between the boundary of the Brae Bravo 500m safety zone and the Kingfisher Manifold. This area includes the Miller pipeline crossing (Kingfisher lines are crossed) and where all three Kingfisher lines exit their respective trenches to cross the East Brae PMS Cable and Heimdal pipeline approximately 4.5km from the SSIV manifold. The stabilisation features associated with this scope, including the buried mattresses at the crossings, were included within the CA.

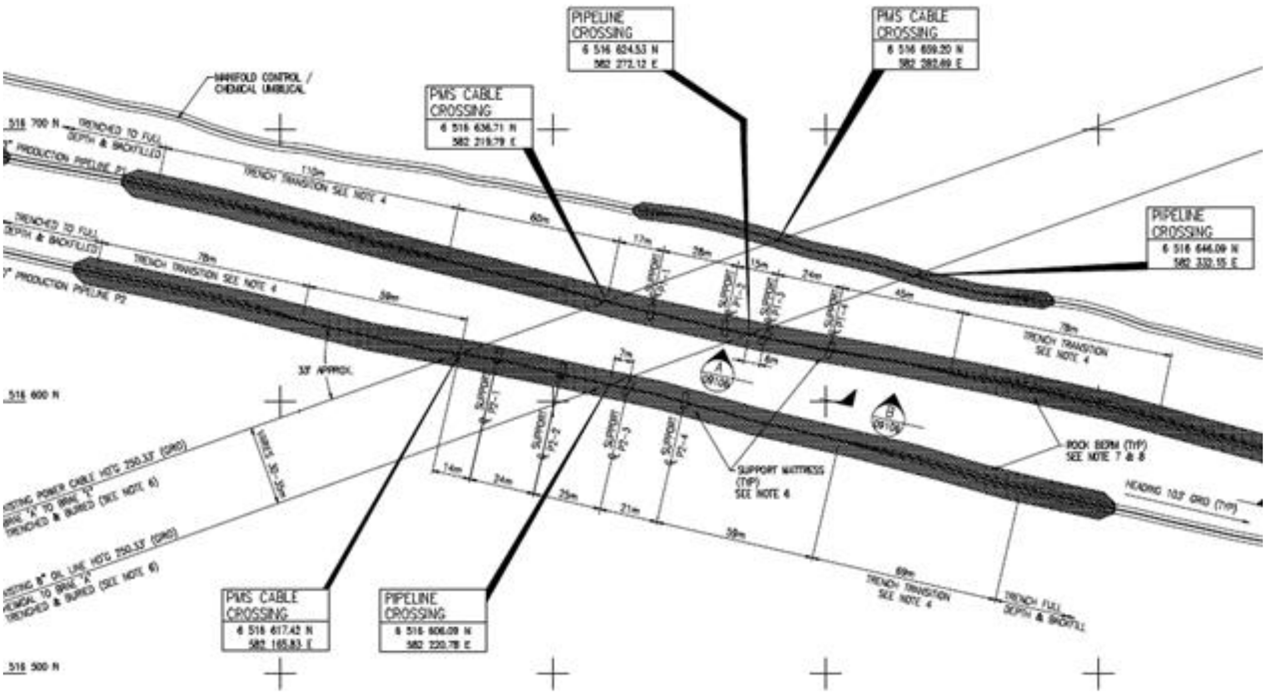


Figure 5-3 – Heimdal Crossing

These sections are trenched and buried to a depth-of-cover greater than 0.6m for more than 90% of their length (pre-rock cover data). Where the depth-of-cover achieved by the initial trenching following installation was lower than 0.6m, for example at the crossing of the Heimdal line and PMS Cable shown in Figure 5-3, the lines were subsequently covered with rock, see Figure 7-2. There are also small sections of rock cover, used to prevent upheaval buckling during operation. 70% of the section has depth-of-cover greater than 0.7m.

Section 10.12 of the OPRED Guidance Notes [2] states that "as a general guide… pipelines (inclusive of any "piggyback" lines and umbilicals that cannot be easily separated) may be candidates for *in-situ* decommissioning [if they] … are adequately buried and trenched and… are not subject to development of spans and expected to remain so." Depth-of-cover charts are shown in Appendix A of this document.

Two credible options were identified for these sections of pipeline:

- Decommission in situ
- Total removal

The two credible options were reviewed against the five CA criteria of safety, environment, technical, societal and economic impacts.

Total removal would require the pipelines to be de-buried and removed from their existing trench. This would require a significant offshore campaign and including a significant number of lifts. Therefore, decommissioning *in situ* represents an inherently safer option by eliminating potentially risky activities in an extensive offshore campaign.

Further, the act of de-burying the pipelines and umbilical would create significant seabed spoil on either side of the existing trenches. These spoils would represent a snagging risk to the fishing industry and a higher risk than decommissioning *in situ* which, considering the stable depth-of-cover shown for these lines, would result in a clear seabed. However, it is assumed that any resulting spoils that potentially pose a snagging hazard would be remediated following decommissioning activities in order to leave the seabed safe for other users of the sea.

The de-burying activities and resulting seabed disturbance across 9km of each line would also cause much greater short-term environmental impact than decommissioning *in situ*. Conversely, total removal would have the lowest long-term impact of the two options due to removing all installed material from the seabed.

In terms of technical impact, total removal carries significantly more technical risk than decommissioning *in situ*. Decommissioning *in situ* requires minimal operational effort and all anticipated activities (over-trawl, survey and mitigating rock-cover) would utilise standard technologies that have an existing track record and high confidence in their success. In contrast, the technical success of removing the pipelines and umbilicals is not certain with little track-record on the UKCS and could result in the need to mobilise additional tooling or vessels.

Total removal would have a greater societal impact than decommissioning *in situ*, both positively and negatively. With each pipeline and umbilical being returned to shore for dismantling, there would be an increase in volume of work for the decommissioning supply chain. This would be offset by potential for increased odour pollution from returned material and increased use of landfill for non-recyclable items such as concrete mattresses or plastics. However, for both positive and negative effects, the impact was considered to be minimal – with the existing supply chain capable of meeting the demand adequately.

Finally, total removal would have a significantly higher operational cost than decommissioning *in situ* with significantly more offshore vessel days. Further, as the pipelines and umbilical are trenched and buried with stable depth-of-cover, there is no expectation that future monitoring costs for decommissioning *in situ* would be higher than total removal. Indeed, with the de-burying of the pipelines and umbilical likely to create extensive seabed disturbance, it is possible that total removal would require more future monitoring than decommissioning *in situ*.

Taking into account the above factors, total removal was considered to be the least favourable option.

Following comments from OPRED during public consultation and to provide additional clarity of the assessment detailed above, a graphical representation of the Scope 6 assessment against the criteria outlined in Section 3 is provided in Table 5-4 overleaf.

Therefore, to the recommended decommissioning solution to **decommission *in situ*** was presented at the CA workshop. The pipelines and umbilicals in this area are either adequately trenched and buried or are adequately rock-covered. Decommissioning *in situ* achieves clear seabed with the exception of the rock-covered crossings, which due to the depth of rock cover will also be decommissioned *in situ* at this time. The decommissioning of the crossings will be revisited when the owners of the third party crossed lines have received approval for their decommissioning proposals from OPRED. At that time, we will discuss and agree appropriate decommissioning with OPRED

There were no objections to this proposal from the stakeholder consultees

Criteria	Ref	Sub Criteria	Option A: Decommission in situ Selected Option	Option B: Total Removal
Safety	1	Project risk to personnel - Offshore	g	a
	2	Project risk to other users of the sea	b	b
	3	Project risk to personnel - Onshore	b	b
	4	Potential of a high consequence event	b	b
	5	Residual risk to other users of the sea	g	g
Environment	6	Marine impact of operations	g	r
	7	Energy, emissions, resource consumption	b	b
	8	Impact of marine end points (legacy impact)	a	g
Technical	9	Risk of major project failure	g	r
	10	Technology demands / track record	b	b
Societal	11	Commercial impact on fisheries	b	b
	12	Socio-econ impact on communities and amenities		g
Economic	13	Cost	g	r
	14	Cost risk and uncertainty	g	a

Table 5-4 – Assessment Summary – Scope 6

Key for colour-blind readers: g – Green, a – Amber, r – Red, b – Blank / grey, i.e. no comparative difference between options

5.5. Scope 7 – Umbilical End transition at Manifold

Section of the manifold umbilical (PLU1490) from the Kingfisher manifold to where the umbilical achieves depth-of-cover of 0.6m within its trench. This section is currently protected by concrete mattresses. The stabilisation features associated with this scope were included within the CA.

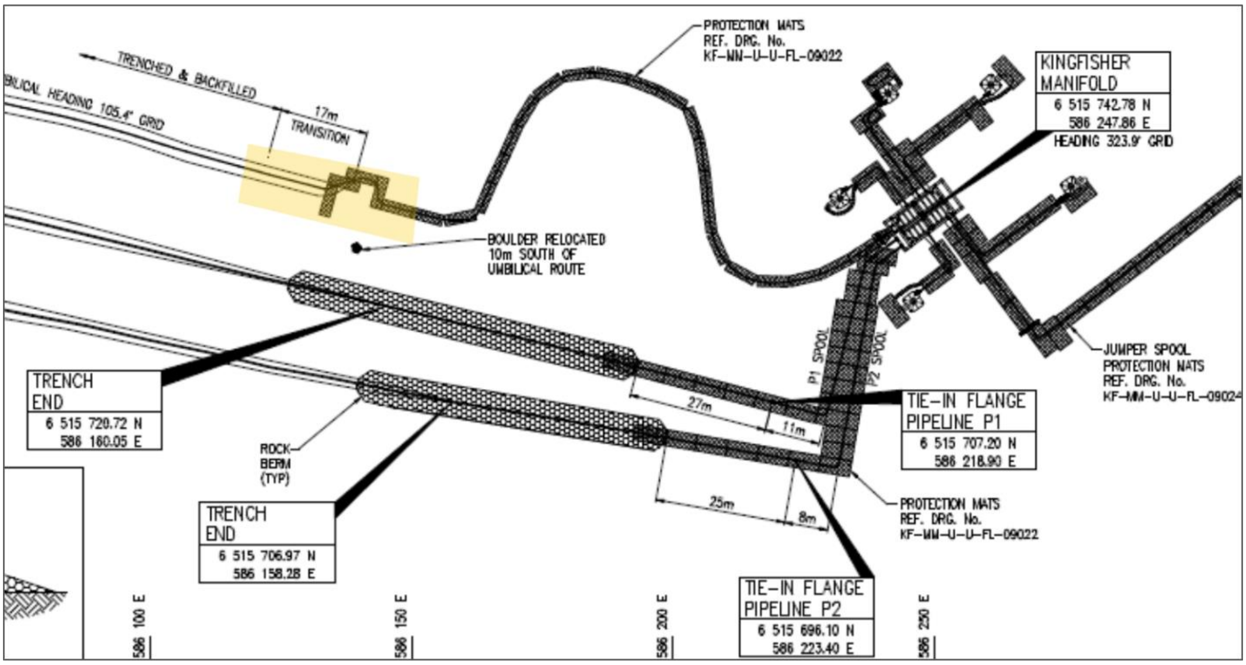


Figure 5-4 – Scope 7 at Kingfisher manifold (highlighted)

Three credible options were identified for this infrastructure:

- Total removal
- Decommission in situ
- Blanket rock cover and decommission in situ

The three credible options were reviewed against the five CA criteria of safety, environment, technical, societal and economic impacts.

In terms of safety impact, decommissioning this section of umbilical *in situ* was deemed to leave an unacceptable safety risk to future users of the sea as the infrastructure would present a snagging risk in open water. This option was therefore discounted.

Total removal is in line with both the regulatory expectation and stakeholder preference for clear seabed on conclusion of decommissioning activities. The umbilical and mattresses in this scope are broadly accessible and expected to be in good condition given the age of the field. Therefore, whilst representing a comparatively higher safety risk to project personnel offshore than blanket rock cover, total removal would not impose any unusual safety risks. Further, whilst blanket rock cover would reduce the legacy safety risk of snagging by other users of the sea compared with decommissioning *in situ*, the resulting rock-berm would also present a comparatively higher future risk than total removal, albeit a minor one.

For environmental impact, total removal would be less significant than blanket rock-cover. The latter would create seabed disturbance across a greater footprint in the short-term and have a comparatively higher long-term impact by introducing new and habitat-altering substrate

With each option representing a relatively short execution scope and employing well-known, commonly used technology, there is no comparable difference between the two remaining options in terms of technical impact.

Similarly, neither total removal or blanket rock cover would have a significant societal impact. Resulting in a short offshore campaign and returning small volumes of waste to shore for recycling will have little or no effect on existing employment and supply chains.

In terms of cost, total removal will result in a higher execution cost than blanket rock cover; however the legacy cost of total removal is expected to be lower as fewer post-decommissioning surveys and/or remedial work is required to prove the seabed remains safe for other users of the sea.

Taking into account the above factors, decommission in situ was excluded due to the unacceptable safety risk; whilst total removal is preferable to blanket rock cover for this scope.

Following comments from OPRED during public consultation and to provide additional clarity of the assessment detailed above, a graphical representation of the Scope 7 assessment against the criteria outlined in Section 3 is provided in Table 5-5 overleaf.

Therefore, the recommended decommissioning solution is to **recover the concrete mattresses, cut the umbilical and either lower the umbilical end by fluidising the soil or excavate the surrounding soil and making the cut at a point where the umbilical has reached 0.6m depth of lowering. Any section of umbilical not buried to a depth-of-cover of at least 0.6m would be recovered to shore for recycling and disposal**. Approximately 10 tonnes of additional rock cover will likely be required to cover the cut end to mean seabed level as an additional mitigation against future snagging risk. Removed infrastructure will be returned to shore for recycling and disposal.

There were no objections to this proposal from the stakeholder consultees.

Criteria	Ref	Sub Criteria	Option A: Total Removal Selected Option	Option B: Decommission in situ	Option C: Blanket rock cover and decommission in situ
Safety	1	Project risk to personnel - Offshore	a	g	a
	2	Project risk to other users of the sea	b	b	b
	3	Project risk to personnel - Onshore	b	b	b
	4	Potential of a high consequence event	b	b	b
	5	Residual risk to other users of the sea	g	r	a
Environment	6	Marine impact of operations	a	g	a
	7	Energy, emissions, resource consumption	b	b	b
	8	Impact of marine end points (legacy impact)	g	a	a
Technical	9	Risk of major project failure	b	b	b
	10	Technology demands / track record	b	b	b
Societal	11	Commercial impact on fisheries	b	b	b
	12	Socio-econ impact on communities and amenities	b	b	b
Economic	13	Cost	g	a	g
	14	Cost risk and uncertainty	b	b	b

Table 5-5 – Assessment Summary – Scope 7

Key for colour-blind readers: g – Green, a – Amber, r – Red, b – Blank / grey, i.e. no comparative difference between options

6. References

[1] Kingfisher Decommissioning Programmes Part 1, KDP-PT-S-AA-8203-00001

[2] BEIS OPRED Guidance Notes: Decommissioning of Offshore Oil and Gas Installations and Pipelines, November 2018

[3] Oil and Gas UK, Guidelines for Comparative Assessment in Decommissioning Programmes, 2015

7. Appendix A: Pipeline Burial Depth Summary

7.1. General

The burial depth of the pipelines and umbilicals is important information when considering leaving pipelines or umbilicals in-situ or removal. The as-built data and alignment sheets for the Kingfisher pipelines have been assessed and the operational survey data has been assessed to determine the pipelines' burial depth. The following sections present graphical summaries of the Kingfisher pipeline data.

7.2. Pipeline Burial Depth Definition

The definitions of burial depth that are being reported, generally there are two definitions for burial depth; depth of lowering and depth of cover, which are both illustrated in the figure below. The depth of cover is the conventional definition of burial depth, which is the depth of backfill or rock on top of the pipeline or umbilical. The depth of lowering is the depth of the top of the pipeline or umbilical below the natural mean seabed level. The natural mean seabed level is ignoring any berms to the sides of the trench.

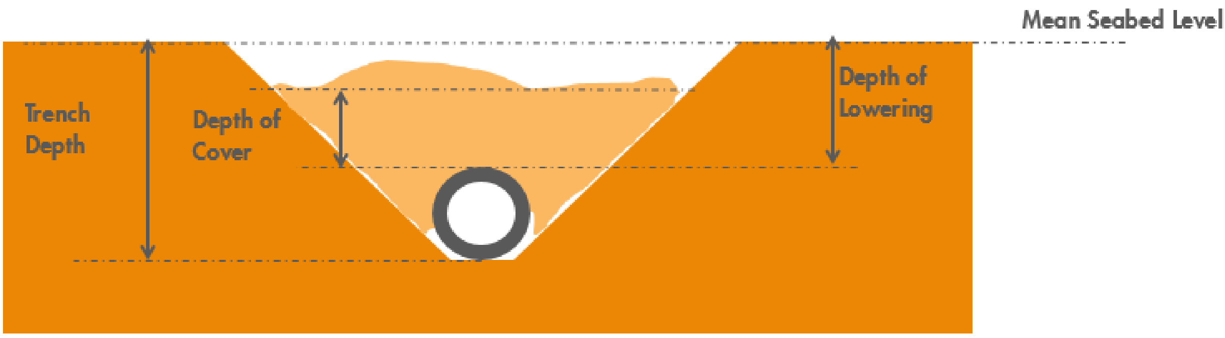


Figure 7-1 – Burial depth definition

7.3. Pipelines

N0510 As Rockdumped Survey (1997)

Pipeline Crossing KPs 4.5 – 5.0 Post Rockdumping Operations

- Illustrates rock dump coverage of the Heimdal 8" condensate crossing
- N0510, N0509 and the N0889 are laid on top of the Heimdal line
- Heimdal 8" condensate line is operational
- See detailed drawings of depth of rock dump cover below

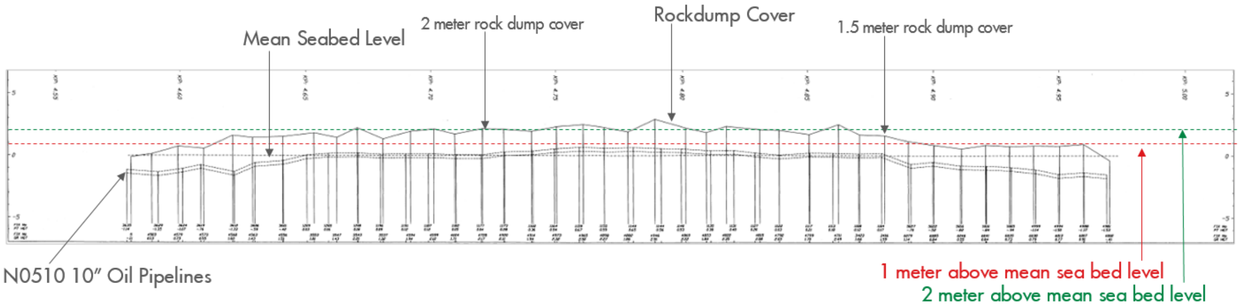


Figure 7-2 – Heimdal Crossing Depth of Rock Cover

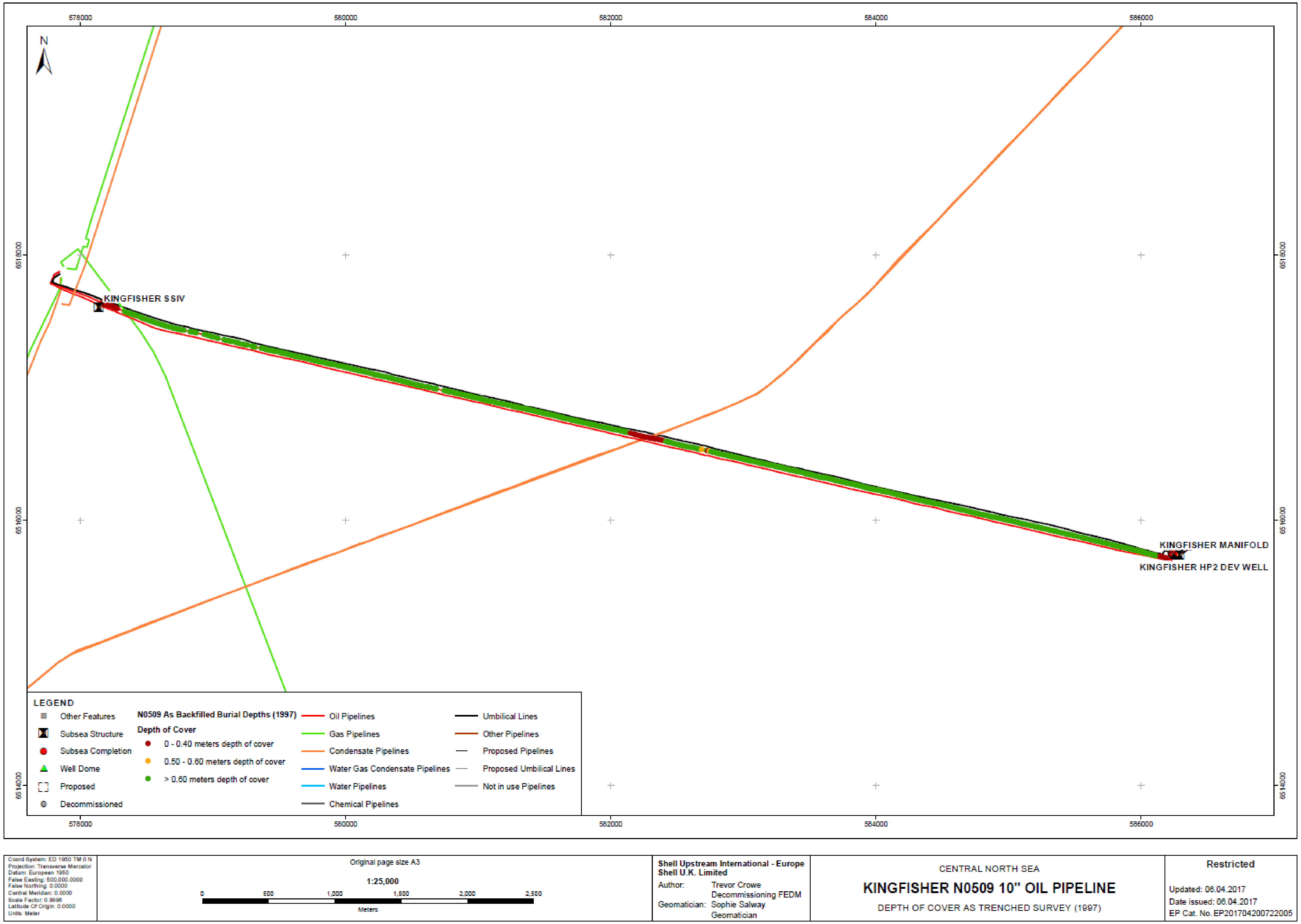


Figure 7-3 – Kingfisher Production Pipeline Survey Results Summary (N0509 / PL1488)

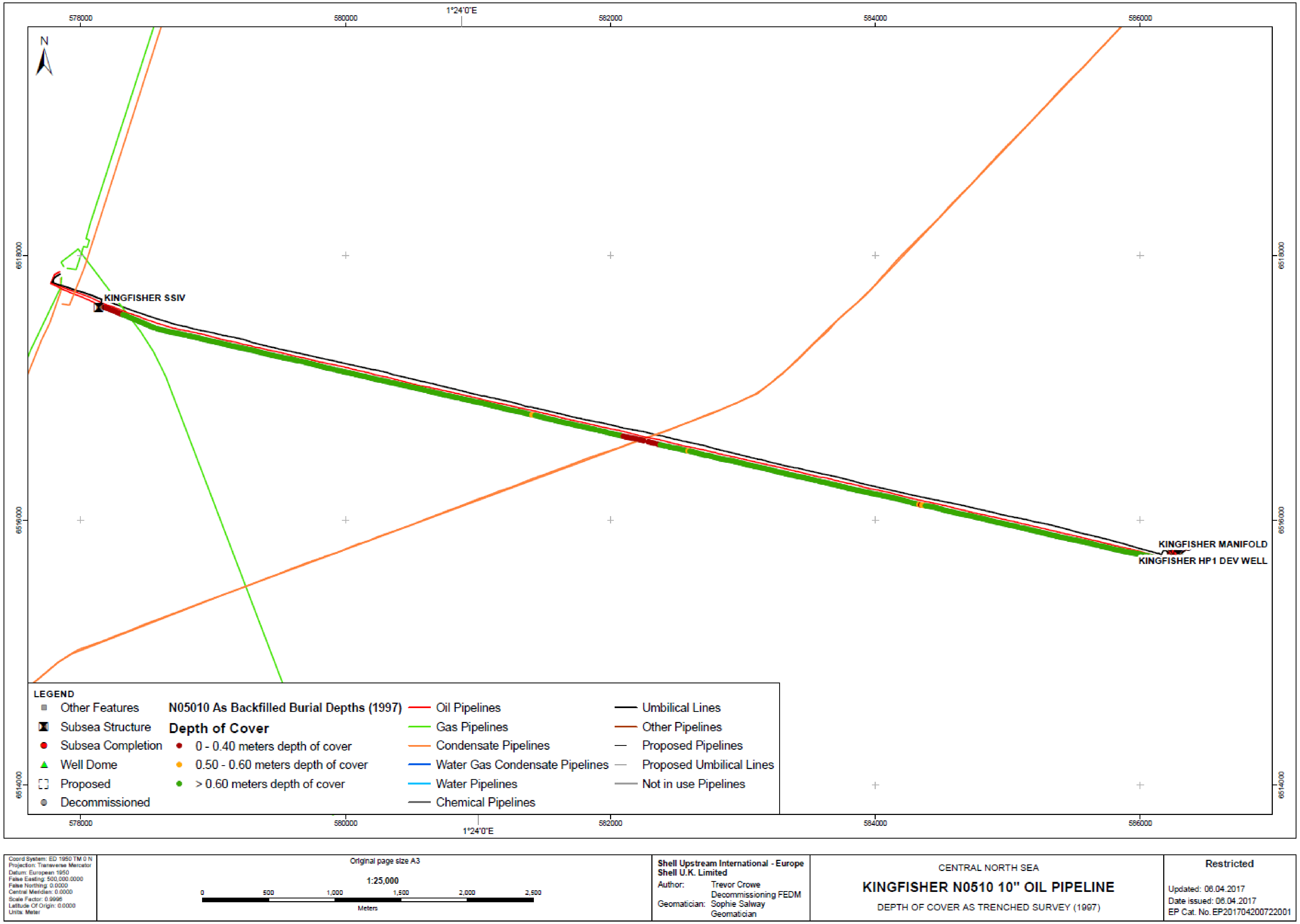


Figure 7-4 – Kingfisher Production Pipeline Survey Results Summary (N0510 / PL1489)

7.4. Manifold Umbilical

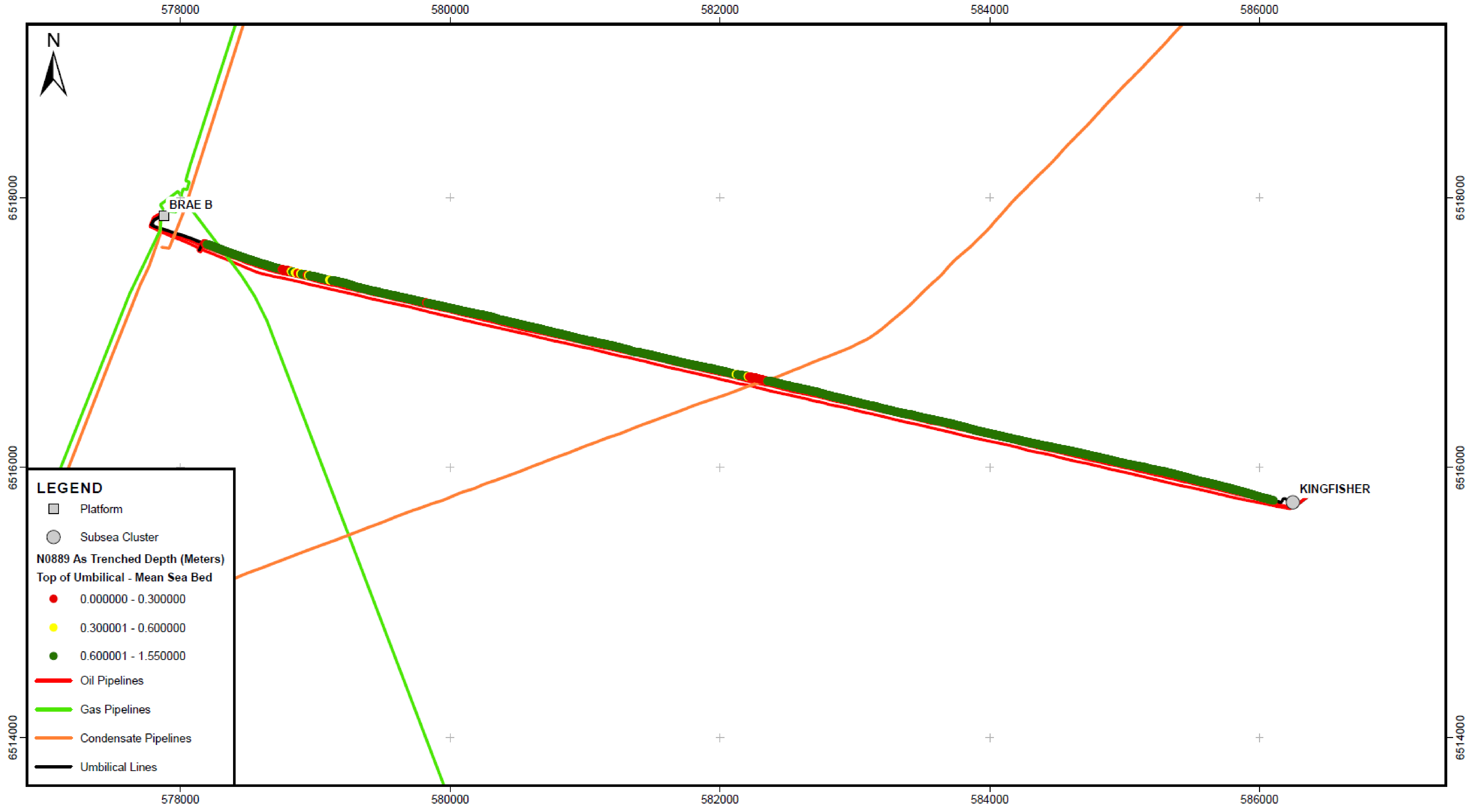


Figure 7-5 – Kingfisher Manifold Umbilical Survey Results Summary (N0889 / PLU1490)

8. Appendix D: Comparative Assessment Groupings (Schematic)

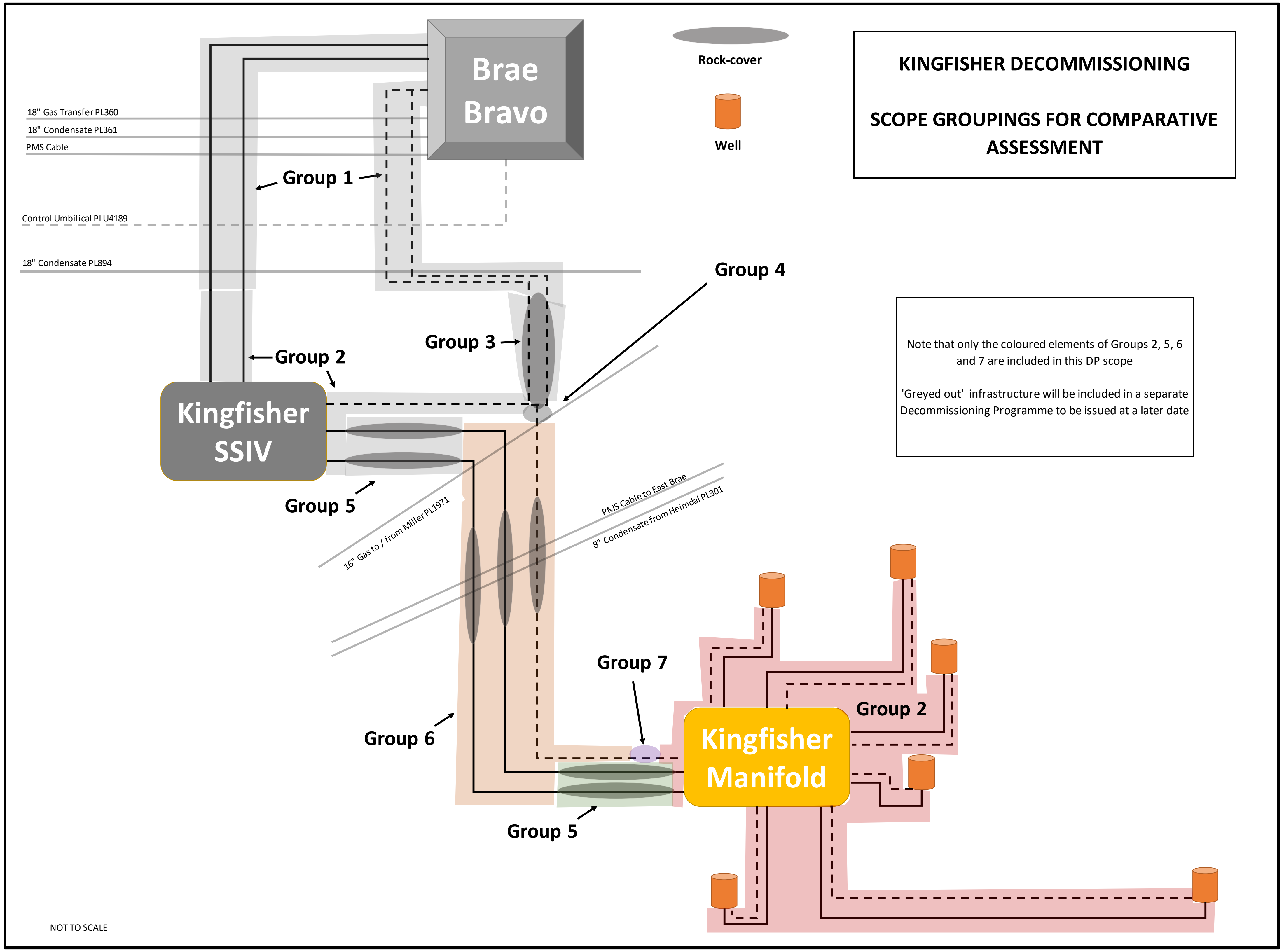


Figure 8-1 – Comparative Assessment Groupings Schematic