Knarr Gas Pipeline Decommissioning Environmental Appraisal

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1. Abbreviations and Executive Summary

1.1. Abbreviations

BEIS	UK Department of Business, Energy & Industrial Strategy, now DESNZ
CA	Comparative Assessment
CoP	Cessation of Production
DESNZ	Department for Energy Security and Net Zero
DP	Decommissioning Program
EA	Environmental Appraisal
FLAGS	Far North Liquids and Associated Gas System
FPSO	Floating production, storage and offloading vessel
GRP	Glas fibre reinforced protection
IA	Impact Assessment
IOP	Institute of Petroleum
JNCC	Joint Nature Conservation Committee
KGP	Knarr Gas Pipeline
LCV	Light Construction Vessel
LPP	Layer polypropylene
MFE	Mass Flow Excavator
NCS	Norwegian Continental Shelf
NNS	Northern North Sea
NPD	Norwegian Petroleum Directorate
NSTA	North Sea Transition Authority
OGA	Oil and Gas Authority
OPRED	Offshore Petroleum Regulator for Environment and Decommissioning
OSPAR	Oslo and Paris Convention
PLEM	Pipeline end manifold
PLET	Pipeline end template
SSIV	Subsea Isolation Valve

ToP	Top of pipe
UKCS	United Kingdom Continental Shelf

1.2. Executive Summary

The 12" Knarr Gas Pipeline (KGP) is operated by Gassco AS on behalf of the pipeline Joint Venture owners, and the pipeline passes through the Norwegian Continental Shelf to the UK Continental Shelf. Production from the Knarr Field started in 2015 and cessation of production (CoP) occurred on 1st of May 2022.

The complete decommissioning of the KGP and associated facilities will occur in three phases. Phases 1 and 2 form the current decommissioning programme (DP) planned for completion in 2024-2026. Phase 3 will occur after cessation of production (CoP) of the FLAGS pipeline, currently anticipated to be in 25-30 years' time, and will be the subject of a future, separate DP.

Although this Environmental Appraisal covers all three phases of decommissioning, all Phase 3 decommissioning options, the CA, and this EA will be completely re-assessed in line with UK and international regulations and guidance in place at the time of submission of the DP for Phase 3.

The three decommissioning phases are:

1. Following CoP of the Knarr Field. The KGP was isolated at the Knarr Tee and PLEM from downstream infrastructure, a pigging spread was installed at the Knarr PLEM, and the KGP was flushed and cleaned back to the Knarr FPSO. Phase 1 was performed from 1st - 18th of May 2022 from Knarr Field CoP to FPSO sail-away respectively. This phase was completed under the PWR submitted by Gassco AS on 29/04/2021.
2. A minor section of the spool #7 will physically be cut and disconnected from PLEM, retrieved, and transported to shore (Norway). This is scheduled to be completed before December 2026 and most likely during Q3/Q4 2024.
3. At FLAGS CoP: Pipe Spool #8 and all GRP covers would be removed at the same time as the PLEM. Due to the proximity of UKCS subsea infrastructure, the Knarr Tee and Knarr PLEM, to the operational FLAGS gas pipeline, the removal of these items will be undertaken when the FLAGS gas pipeline enters CoP. This will eliminate risks attendant with removal works near live, hydrocarbon containing infrastructure.

A first DP for the Knarr facilities in the UK sector covers phases 1 and 2. A second, separate DP will be submitted for Phase 3 once FLAGS has reached CoP, in addition to a re-assessment of this EA and the supporting CA. The KGP Environmental Appraisal assesses the environmental impacts associated with all phases of decommissioning.

Decommissioning of offshore oil and gas facilities can have short-term and long-term impacts on the environment and on society. Environmental impacts can result from the hydrocarbons contained within the facilities and other issues such as hazardous substances, waste production and energy consumption. Long-term societal impacts to fishing and shipping are possible due to restrictions caused by any oil and gas facilities

that are left in the sea. Impacts onshore are possible due to onshore dismantling activities creating dust, noise, and traffic.

This Environmental Appraisal report focusses on the UKCS components of the KGP Decommissioning Project, and:

- Describes the nature and current condition, in the UK sector, of the Knarr Gas Pipeline and associated infrastructure, such as PLEM, concrete mattresses, GRP covers and pipeline crossings.
- Discusses regulatory requirements and stakeholder consultation.
- Describes the sensitivity of the surrounding environment.
- Assesses the potential environmental impacts of the preferred decommissioning option.

This report concludes that the preferred decommissioning options, with the implementation of appropriate management measures, have only negligible or small localised environmental and social impacts, in both the short and long term.

2. Introduction

The Knarr Gas Pipeline is being decommissioned. This report describes the nature and current condition of the Knarr Gas Pipeline and associated infrastructure in the UK sector, the sensitivity of the surrounding environment, the feasible decommissioning options and the reasons behind the selection of the preferred decommissioning option. This report then considers the environmental impacts of the preferred decommissioning options, and the management measures necessary to ensure environmental impacts are managed appropriately.

The complete decommissioning of the KGP and associated facilities will occur in three phases. Phases 1 and 2 form the current decommissioning programme (DP) planned for completion in 2024-2026. Phase 3 will occur after cessation of production (CoP) of the FLAGS pipeline, currently anticipated to be in 25-30 years' time, and will be the subject of a future, separate DP.

Although this Environmental Appraisal covers all three phases of decommissioning, all Phase 3 decommissioning options, the CA, and this EA will be completely re-assessed in line with UK and international regulations and guidance in place at the time of submission of the DP for Phase 3.

2.1. Knarr Field Description

The Knarr Field is located in Block 34/3 of the Norwegian Continental Shelf (NCS) in the northern North Sea, 50 kilometres northeast of the Snorre field. The Knarr Field is approximately 50 km from the UK-Norway median line (Figure 1) at a water depth of approximately 410 m.

The Knarr Field comprises 2 subsea well templates (in water depth of approximately 410 m) connected to a floating production, storage and offloading vessel (FPSO), with shuttle tankers for oil export. Rich Gas is exported from the Knarr FPSO in the Norwegian sector to the UK via the Knarr Gas Pipeline (KGP), which passes through NCS to enter the UK Continental Shelf (UKCS) and connects to the Far North Liquids and Associated Gas System (FLAGS) pipeline. Gas presents much lower risks to the marine environment than oil.

The KGP was installed in 2013, and field production started in 2015.

Cessation of production (CoP) on the Knarr field occurred on 1st of May 2022 and FPSO sail away was on 18th of May 2022.

Figure 1 The Knarr Field and Knarr Gas Export Pipeline

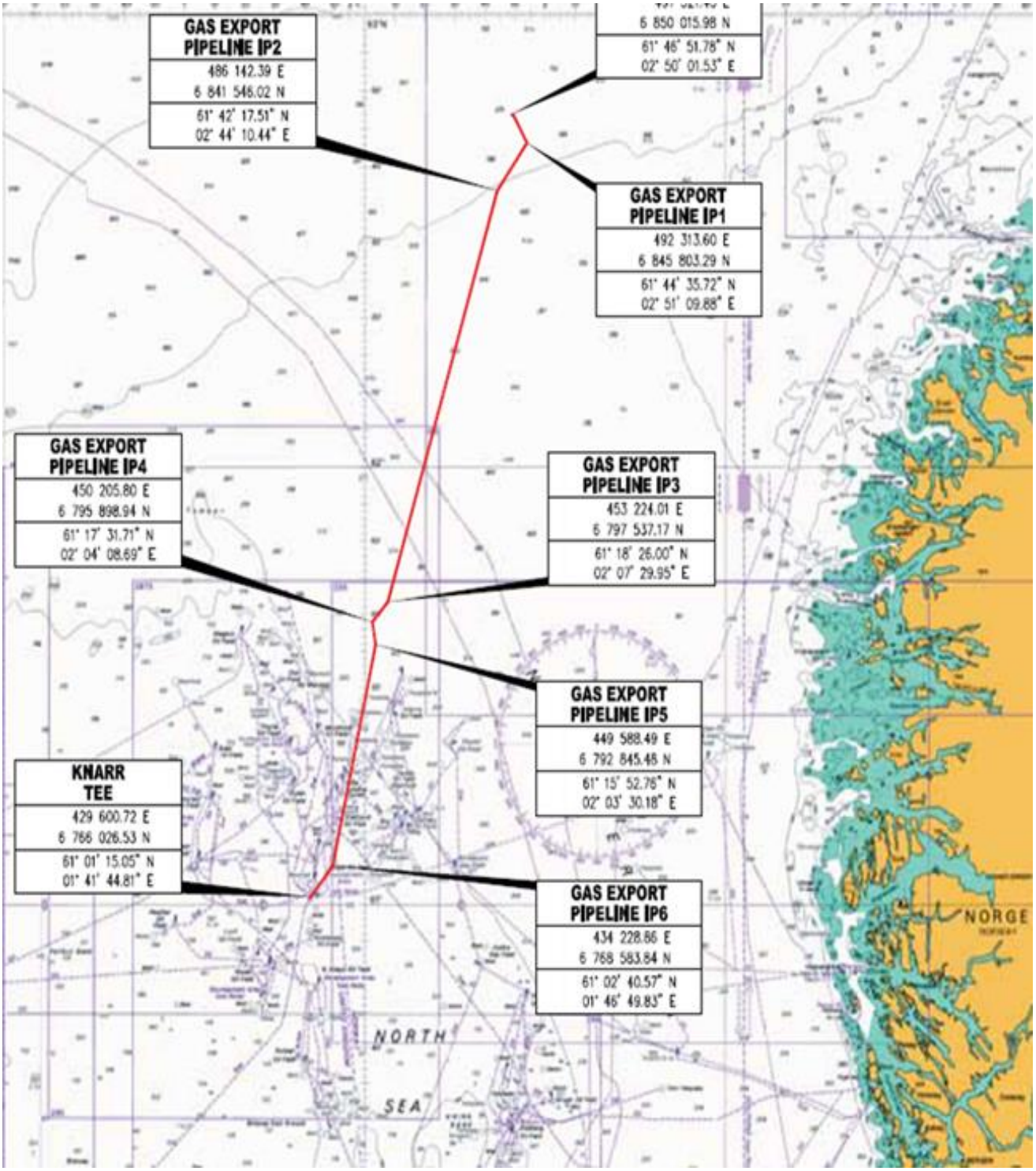

Figure 2 Coordinates of Knarr Gas Pipeline route from NCS to UKCS

The Knarr FPSO flexible riser was connected to a Subsea Isolation Valve (SSIV) inside the Knarr FPSO safety zone on the NCS (safety zone terminated after FPSO sail away). A rigid spool mated the SSIV structure with the main Pipeline End Termination (PLET). The main length of KGP route (approximately 105.7 km) consists of 12" rigid pipeline which connects (on UKCS) to the Knarr Pipeline End Manifold (PLEM) and Knarr Tee through a series of 12" rigid spools. The final tie-in from the Knarr Tee to FLAGS is through a single 16" rigid spool. 11.6 km of the KGP extends into the UKCS (Block 211/29 and 211/30).

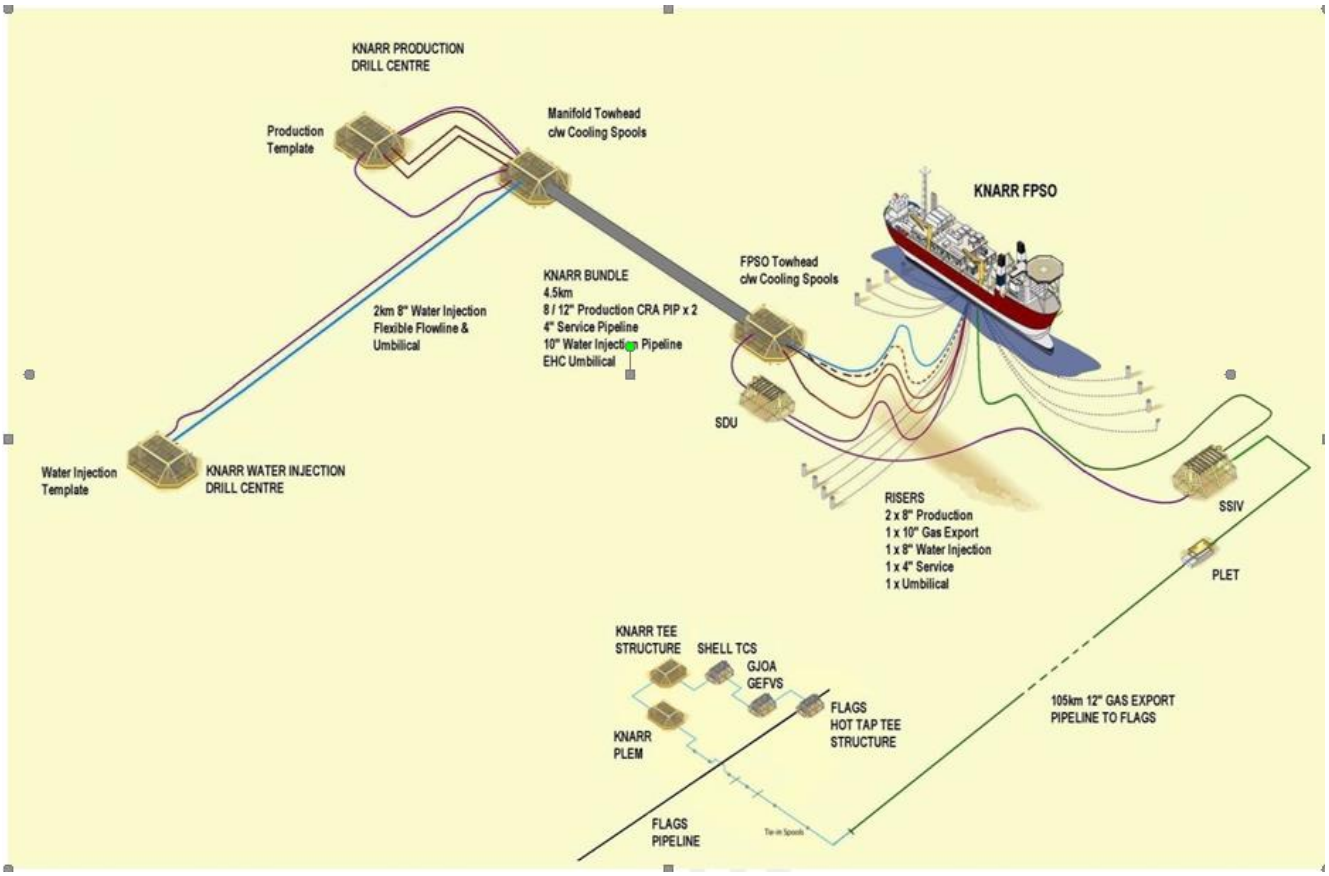

Figure 3 Knarr Field Layout

As illustrated in Figure 4, the Knarr Field is operated by A/S Norske Shell; the 12" KGP (PL3039) is operated by Gassco AS on behalf of the pipeline Joint Venture (JV) owners (A/S Norske Shell, INPEX Idemitsu Petroleum Norge AS, Wintershall DEA Norge AS). The KGP enters the UKCS to join the Knarr Tee structure before entering the FLAGS system, operated by Shell UK.

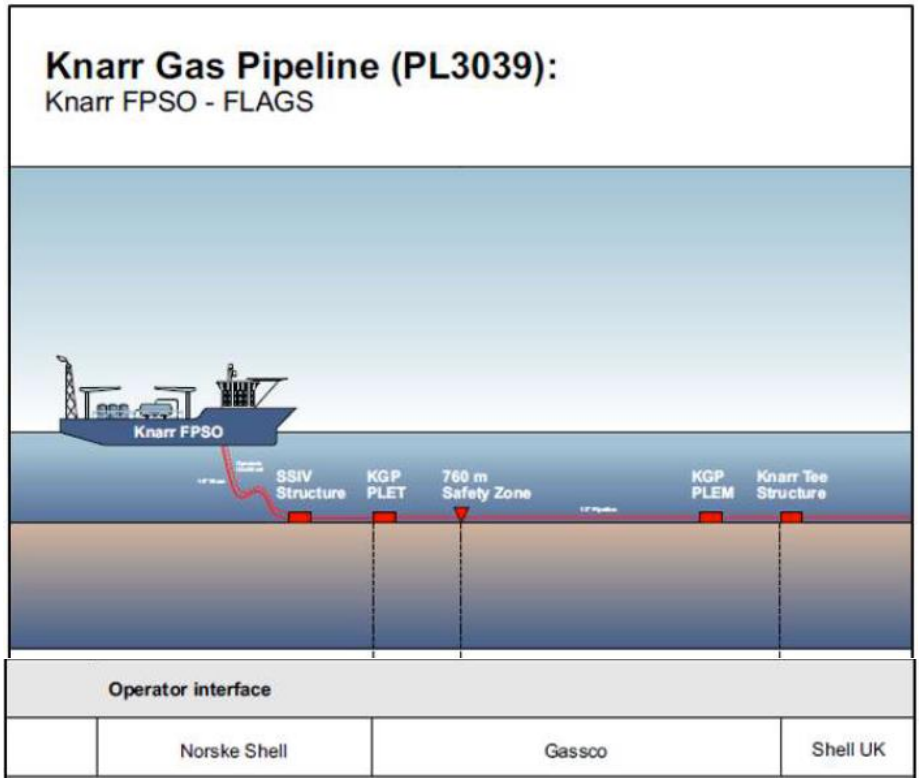

Figure 4 FPSO, Knarr Gas Pipeline and Operator Interface

2.2. Knarr Field Decommissioning Project

Production from the Knarr field started in 2015 and cessation of production (CoP) occurred on 1st of May 2022 and the FPSO sail away date was 18th May 2022.

A notification from A/S Norske Shell as Knarr Field operator regarding initiation of a Knarr Decommissioning Plan was received by Gassco AS as KGP Operator in late December 2018. The Knarr FPSO was the only user of the KGP. Gassco AS initiated planning according to Norwegian Petroleum Act section 5-1 which states a decommissioning plan shall be submitted at the earliest of 5 years, but at the latest 2 years prior to the time when the use of a facility is expected to be terminated permanently.

In the Norwegian sector, Decommissioning Plans for the Knarr field and KGP were prepared based on the requirements of the Oslo Paris (OSPAR) Convention and Norwegian Petroleum law, by A/S Norske Shell and Gassco AS respectively. As part of this, A/S Norske Shell and Gassco AS developed separate Impact Assessment (IA) reports and issued for consultation (3 months consultation period) [1]. These IAs were completed before the decommissioning program was submitted for approval to the Norwegian Ministry of Petroleum and Energy in early 2020.

As 11.6 km of the KGP infrastructure extends into the UKCS, additional requirements of the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED) and

North Sea Transition Authority (NSTA) also need to be addressed. This report comprises one component of the necessary documentation required by OPRED, the UK regulator.

2.3. Knarr Gas Pipeline in brief

The KGP is 12" in diameter and 105.7 kilometers long, and passes through the NCS to enter UKCS, where it connects to the FLAGS pipeline. 11.6 km of the KGP is in the UKCS, all of which is laid on the seabed and is covered by rock. Approximately 30% of the KGP on the UK side passes through the Brent Field.

The UKCS components for the KGP Decommissioning Project which are the subject of this EA, comprise:

- 11.6 km of the 12" KGP
- 8 Pipeline Spools
- 4 Pipeline crossings
- Knarr PLEM
- 22 Concrete mattresses at 3 of the pipeline crossings
- GRP covers
- Debris in close proximity to the pipeline.

2.4. Objective and Scope of Environmental Appraisal

Decommissioning of offshore oil and gas facilities can have short-term and long-term impacts on the environment and on society. Environmental impacts can result from the hydrocarbons contained within the facilities and other issues such as hazardous substances, waste production and energy consumption. Long-term societal impacts to fishing and shipping are possible due to restrictions caused by any oil and gas facilities that are left in the sea. Impacts onshore are possible due to onshore dismantling activities creating dust, noise and traffic.

It is therefore important to carry out an EA to ensure that environmental and social impacts are identified so that they can be managed effectively.

The KGP Decommissioning project has infrastructure in in both the Norway and UK sectors of the North Sea, and the focus of this EA is on the UKCS components of the KGP Decommissioning Project. The location of the UK/Norwegian median line transition point for the KGP is Latitude 61°06'07.23" N, Longitude 01°51'09.21" E.

As per DESNZ expectations, this Environmental Appraisal provides an assessment of the potential environmental impacts of the selected decommissioning option. The Comparative Assessment considered the impacts related to the alternative decommissioning options.

2.5. Report Structure

This report describes:

- The KGP and associated infrastructure that are planned for decommissioning, such as concrete mattresses, spools, PLEM and GRP covers.
- The relevant regulatory requirements
- The environmental baseline
- The decommissioning options considered, and the preferred decommissioning options.
- The impact assessment methodology, impact assessment results, and proposed mitigation.

3. Regulatory requirements

The KGP Decommissioning Project is subject to the requirements of international treaties, and UK and EU legislation.

The Offshore Petroleum Regulator for Environment and Decommissioning (OPRED) which sits within the Department for Energy Security and Net Zero (DESNZ) is the UK competent authority[1] and provides guidance about the regulatory requirements (including international requirements) for decommissioning of UK offshore pipelines and subsea structures.

3.1. OSPAR Convention

OSPAR Decision 98/3 [2] is an international framework that mandates the decommissioning of offshore oil and gas facilities in the northeast Atlantic, including the North Sea. OPRED Guidance Notes on the *Decommissioning of Offshore Oil and Gas Installations and Pipelines 2018* [3] state that OSPAR Decision 98/3 does not apply to pipelines and there are no international guidelines specifically on pipeline decommissioning. Hence, pipelines are considered on a case-by-case basis, informed in the UK by conducting a Comparative Assessment of the disposal options.

Table 1 shows the decommissioning options which can be considered for subsea structures that are located on the UKCS, such as the PLEM, as per OSPAR requirements.

Table 1: Possible Disposal Options for Subsea Categories of Offshore Installations (not applicable for pipelines) [2]

Installation	Weight (tonnes)	Complete Removal to Land	Partial Removal to Land	Leave Wholly in Place	Re-use	Disposal at Sea
Subsea structures	Any	Yes	No	No	Yes	No

3.2. UK and EU Regulations

Petroleum Act 1998

The decommissioning of offshore oil and gas installations and pipelines on the UKCS is controlled through the Petroleum Act 1998 (as amended by the Energy Act 2008), including preparation, submission and approval to OPRED of a decommissioning programme before decommissioning can take place.

The Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020 no 1497

These regulations implement for offshore oil and gas operations in the UK the requirements of European Directive EIA directive, and replaced The Offshore Petroleum Production and Pipelines (Assessment of Environmental Effects) (Amendment) Regulations 1999 (as amended 2007). OPRED Guidance Notes [3] section 12 state a decommissioning programme needs to be supported by an Environmental Appraisal

[1] Competent Authority is the authority responsible for determining all permit/licence applications

(EA). The EA should assess the impact of the project on the environment and include information on the energy balance and emissions of the options considered.

Other Relevant Environmental Legislation

The OPRED Guidance Notes [3] state that operators must apply for appropriate environmental consents, permits and licences before undertaking the activities proposed in the Decommissioning Programme:

- Consents to use or discharge chemicals under the **Offshore Chemicals Regulations 2002 (as amended 2011)**
- Marine licence that involves deposits (e.g. of stabilisation or protection equipment), removals or seabed disturbance resulting from decommissioning activities (e.g. dredging, water jetting etc.) under the **Marine and Coastal Access Act 2009 (Amendment) Regulations 2011**
- Licences under the **Waste Management Licensing Regulations.** For example, any decommissioning waste brought onshore to the UK would need to go to a facility with an appropriate waste management licence to store and handle the waste.

3.2.1. Protected sites

The **Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001 (as amended)** apply the European Commission Habitats Directive and Wild Birds Directive in relation to oil and gas plans, projects and decommissioning proposals. The Directives aim to protect and ensure the biodiversity of certain habitats, areas and species by designating protected sites termed Special Areas of Conservation (SACs) and Special Protection Areas (SPAs). The regulations apply to decommissioning proposals and in the light of the information provided in this EA, DESNZ in consultation with the JNCC and/or the Nature Conservation bodies will decide whether the proposals are likely to have a significant effect on the habitats and species covered by the regulations. An EA for a decommissioning programme is required to identify any habitats and species relevant to the study area which are protected under the regulations, and to demonstrate that the protected sites are not significantly affected by the decommissioning programme. But the regulations do not apply to artificial habitats created by the offshore infrastructure, and it is not necessary to justify the removal of structures colonised by protected or rare species.

3.2.2. Guidance Notes

OPRED Guidance Notes [3] require a comparative assessment where all feasible decommissioning options for UK pipelines are considered and compared. The Comparative Assessment should demonstrate a balanced judgement of technical and engineering aspects, safety, marine impacts, environmental emissions and energy use, use of natural resources, physical impacts, and societal and economic impacts. Guidance states:

- Where rock cover 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 cover and the pipeline will remain in place. Small diameter pipelines (including flexible flowlines and umbilicals) which are neither trenched nor buried should normally be entirely removed.
- Stabilisation features, such as mattresses or grout bags, which have been installed to protect pipelines during their operational life should be removed, and if the

operator considers this is not the optimal solution, they must provide evidence through a comparative assessment. Discussions with DESNZ suggest that their policy on buried mattresses (with poly-binding) is currently under review and hence they currently examine on a case by case basis. But as the KGP mattresses are buried under rock, DESNZ are currently inclined to allow the mattresses to be left in situ, as this may be the most practical solution with the least environmental impact (however this policy may change in the future).

- Instances where pipelines could be decommissioned in situ. For example, pipelines that are adequately buried or trenched or which are expected to self-bury could be considered as candidates for in situ decommissioning. It is expected that burial to a minimum depth of 0.6 meters above the top of the pipeline will be necessary in most cases.
- That appropriate surveys should be undertaken to identify and recover any debris located on the seabed which has arisen from the decommissioning operation or from past development and production activity. Debris survey and removal is required along a 100m corridor (50 m either side) of a decommissioned pipeline over its whole length.

4. Stakeholder Consultation

The KGP decommissioning project recognises the importance of involving stakeholders, because of their interest and specialist expertise. Stakeholders have been consulted as follows during the development of the environmental appraisal, the comparative assessment and the decommissioning programme on the UKCS.

Table 2: Key Stakeholder Engagement Activities

Party engaged	Date	Details
BEIS OPRED	4 April 2019	Meeting with the BEIS OPRED Offshore Decommissioning Unit (ODU) to discuss the proposed decommissioning project to clarify BEIS requirements. BEIS confirmed that • All 3 deliverables (DP, CA and EA) were required • After internal BEIS review, the 3 documents would be sent (by OPRED) for 30 day consultation period, plus would be sent to statutory consultees • Qualitative CA would be sufficient. It was agreed to have a follow-up meeting (see below).
Oil and Gas Authority (OGA)	4 April 2019	Meeting with OGA, who have a focus on cost effectiveness in decommissioning. It was agreed that there was little scope for reducing decommissioning costs owing to the small size of KGP on UKCS.
BEIS OPRED	31 October 2019	Second meeting with BEIS OPRED to provide an update on the progress and status of the DP, CA and EA and associated timescales, and capture any BEIS comments or concerns.
Fishermen's Organisations	31 January 2020	The draft CA was sent to the following fishermen's organisations for early information/review: • Scottish Fishermen's Federation • The National Federation of Fishermen's Organisations • The Northern Irish Fish Producers Organisation • Global Marine Systems Ltd.

5. Project Description

This section:

- considers alternative uses of the KGP after decommissioning
- describes the KGP infrastructure to be decommissioned in the UKCS sector
- describes the feasible decommissioning options considered in the comparative assessment
- describes the preferred decommissioning methods, and the activities involved.

5.1. Alternative use of KGP

Gassco AS has a mandate under the Norwegian Petroleum Regulation Section 66A to assess gas transportation needs on the NCS from an overall perspective. Under this mandate, Gassco AS looked into the possible re-use of the KGP by other fields, as the KGP, PLET and the PLEM were designed for sour service environment for 20 years lifetime.

Gassco AS performed an area assessment to investigate potential for further utilization of the KGP after decommissioning. The assessment was based on information received from operators in the area and in dialogue with the Norwegian regulator, NPD. The study did not identify any new fields, discoveries or projects which could benefit from reuse of the KGP in the NCS. As only a small proportion of the KGP (<11%) is located on the UKCS, such a conclusion is considered to remain valid. The issue was discussed in a meeting with the UK Oil and Gas Authority (OGA) and no reuse potential was identified.

5.2. Description of KGP infrastructure

5.2.1. Knarr Gas Pipe

Rich gas was exported from the Knarr FPSO via the KGP, which passes through NCS to enter UKCS, and connects to the FLAGS pipeline.

The 105.7 km 12” KGP is a steel rigid pipeline which connects, on the UKCS side, to the Knarr PLEM and Knarr Tee through a series of 12” rigid spools before feeding into FLAGS.

Table 3 provides some details about the KGP.

The downstream end of the KGP is at the flange into the Knarr Tee of the 12” tie-in spool downstream of the PLEM.

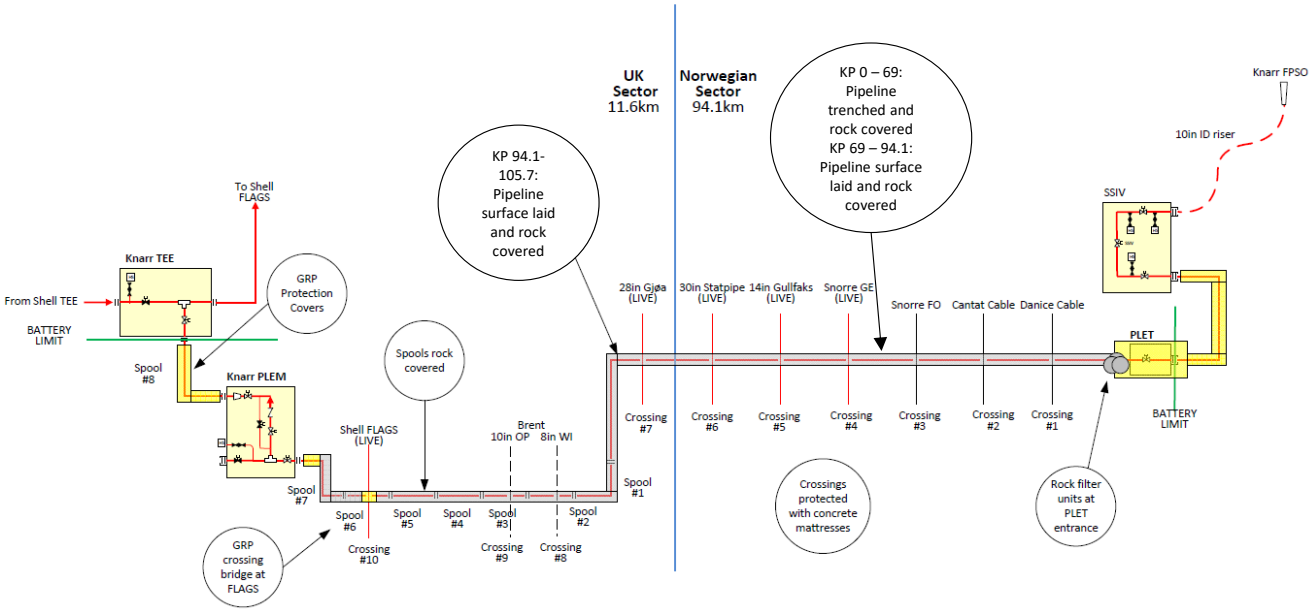

Figure 5 Knarr Gas Pipeline and Pipeline Crossings (Crossings 7 – 10 in UKCS) [47]

Table 3 Features of the 12" KGP

Feature	Detail	Comments
Length (km)	105.7 including spools	11.6 km of the pipeline is in UKCS. In the UKCS, the pipeline is surface laid with rock cover. Pipeline has no concrete cap.
Inner Diameter (inch)	12	
Outer Diameter (inch)	13	Wall thickness generally 12.7mm, 13mm in certain areas.
Depth max (m)	411	Maximum depth at start of pipeline in NCS
Depth Min (m)	137	All of the KGP on UKCS is at water depth of approximately 140 m.
Material	DNV HFI 450 SFD	Steel
Coating (mm)	3LPP* 3 mm thick (min)	• Base coat: fusion bonded epoxy primer • Intermediate: polymeric adhesive • Top coat: polypropylene • Heat shrink sleeves were selected for the field joint coating • KGP has no concrete coating, as it is either trenched with natural backfill (NCS) or rock covered (UKCS)
Steel in UKCS (t)	1,139	Approximate weight for the 11.6 km KGP on UKCS only, plus 1 tonne of anodes. The entire KGP is approximately 10,381 tonnes steel.
Plastic in UKCS (t)	32	This is the weight of the polypropylene coating, including spools.

*3LPP – 3-layer polypropylene

The water depth varies along the length of the KGP, as it moves from the NCS to the UKCS (Figure 6). From KP 0.15 to KP 69 (NCS) the KGP is trenched with natural cover. In 2016/2017 an additional rock cover campaign was performed to give necessary cover in the area KP 40 - KP 69 based on trawl activity mapping of the area showing trawling in an area where little trawling was assumed during design. From KP 69 the pipeline is

laid on the seabed with rock cover (0.6m of ToP) to prevent fishing gear interaction. All spools between the PLEM and the KGP to the point of full trench depth are rock covered.

The KGP enters the UK sector at KP 94,1 and between KP 94,1-105,7 the pipeline is completely rock covered, has no free spans, and is at a water depth of approximately 140 m.

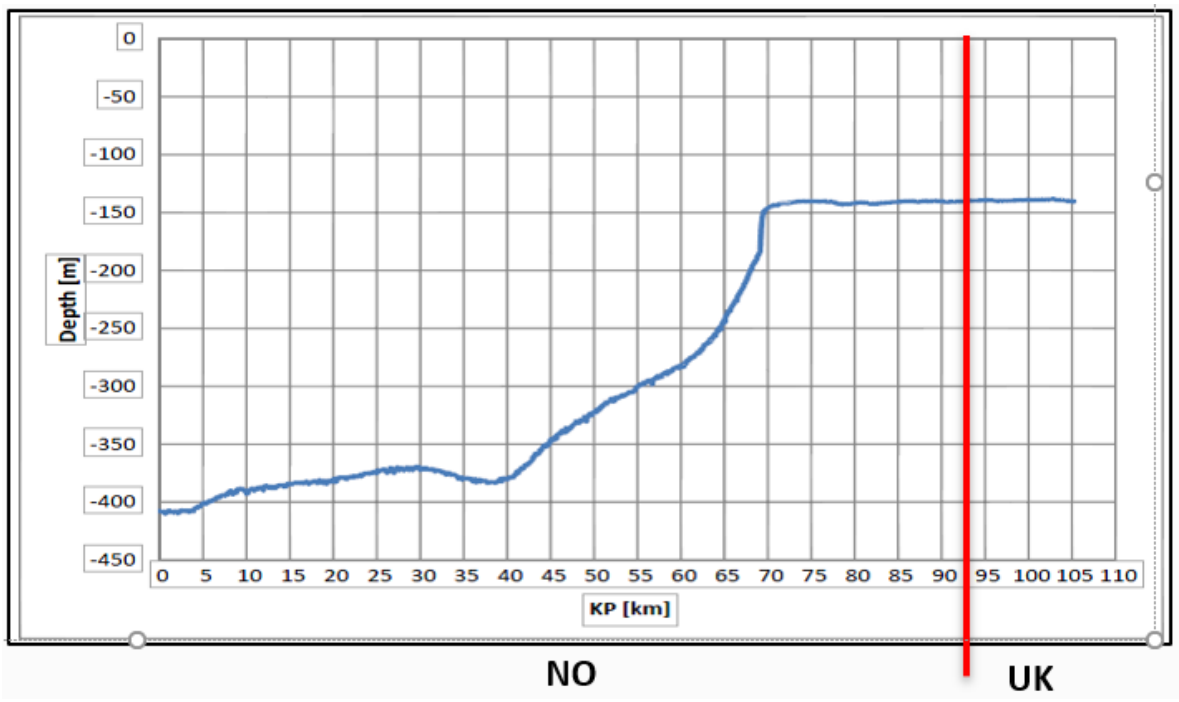

Figure 6 KGP pipeline sections at different water depths

5.2.2. PLEM

The KGP UKCS PLEM (Figure 7) is about 10 metres long, weighs approximately 91.4 tonnes (excluding entrance and exit GRP covers, which weigh 22.6 tonnes) and is located at KP 105.640 to KP 105.650. The 2018 survey report [4] found the PLEM to be in good overall condition.

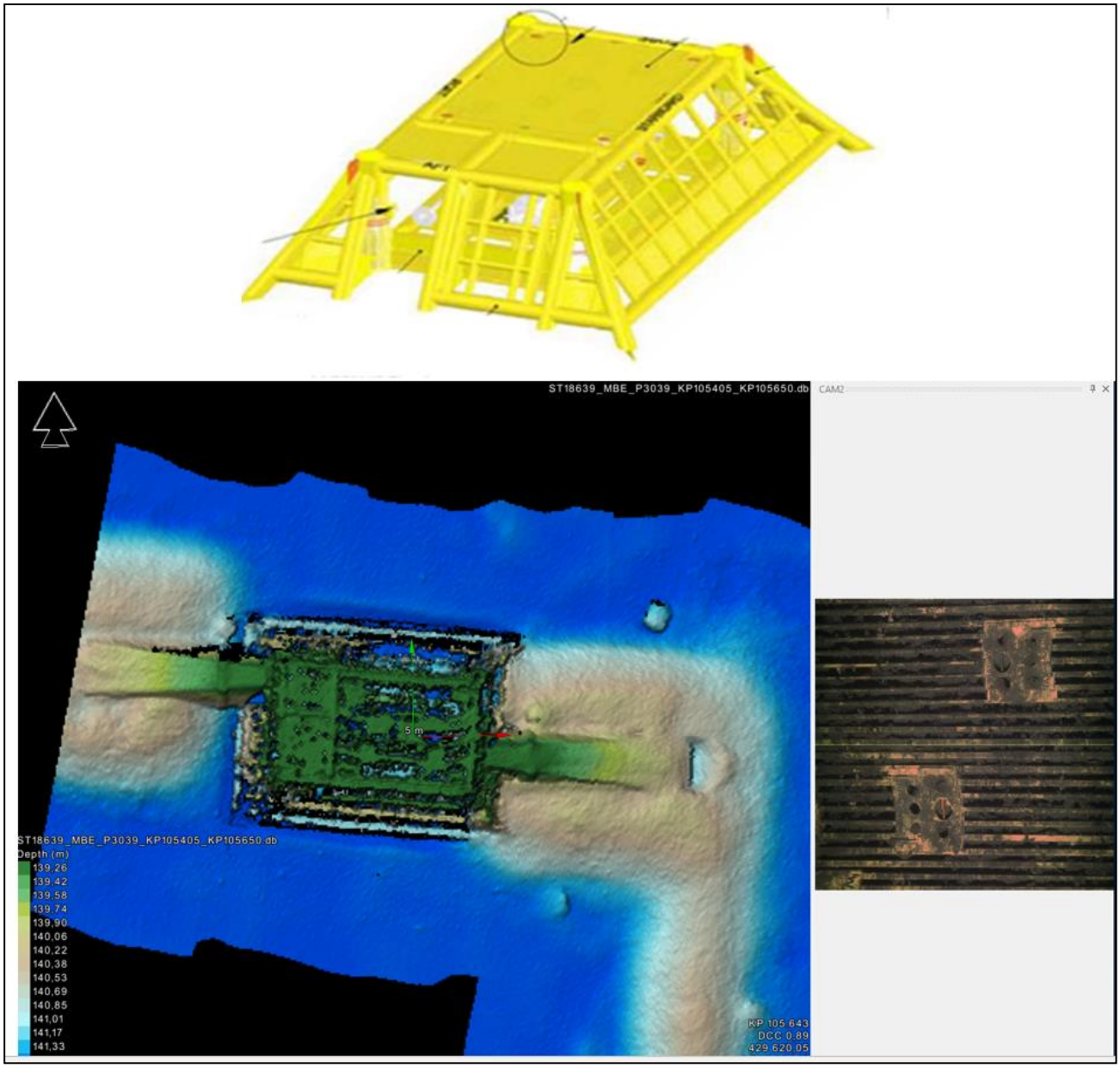

Figure 7 PLEM image from the 2018 survey

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Figure 8 Knarr Tee (left) and PLEM (right), showing rock cover and GRP covers

5.2.3. Spools and GRP cover

The KGP connects to the PLEM and Knarr Tee (in UKCS) through eight 12” rigid steel pipe spools as illustrated in the figure below.

Seven of the spools are upstream of the PLEM, with one spool located between PLEM and Knarr Tee structure. The wall thickness of the spools is 12.7 mm, and they are coated with 3 mm of 3LPP. Table 4 summarises the spool features.

34 drop bags with rock with a total estimated weight of 70 tonnes will be used to stabilize one of the GRPs as part of the Phase 2 activities. The empty bags will be recovered to deck.

Spools and GRP cover

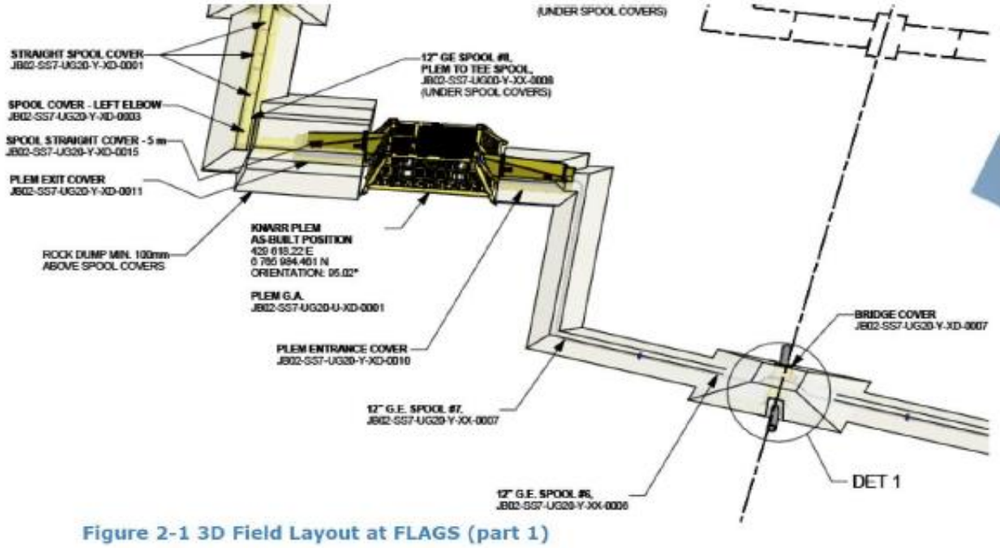

Figure 2-1 3D Field Layout at FLAGS (part 1)

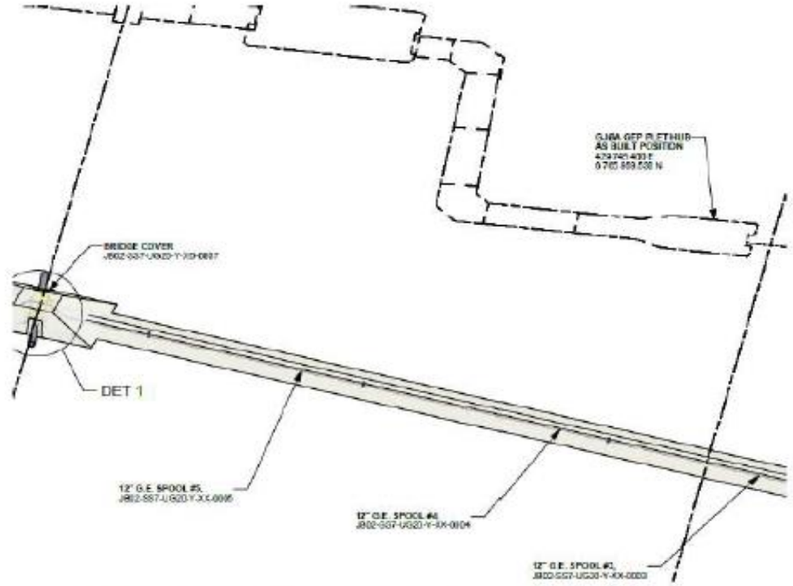

Figure 2-2 3D Field Layout at FLAGS (part 2)

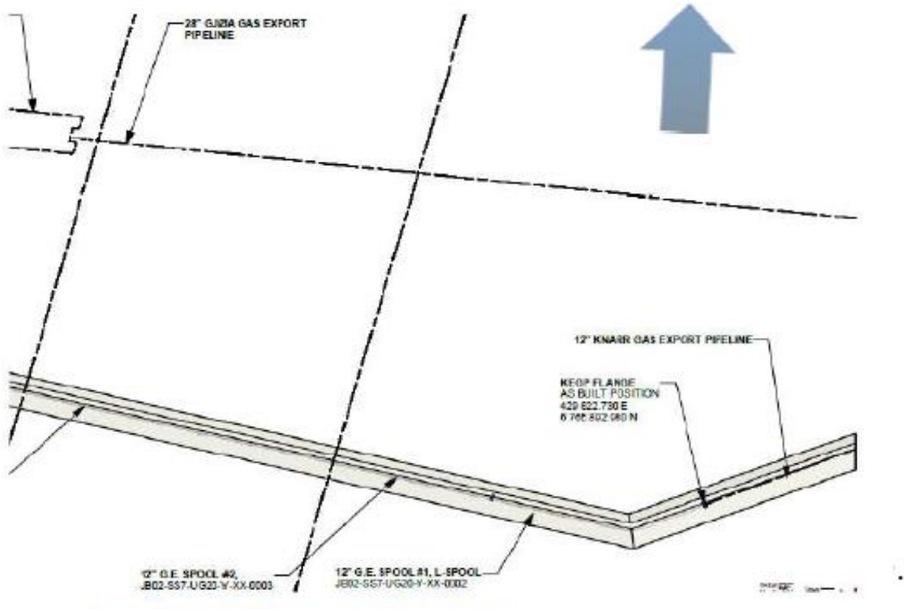

Figure 2-3 3D Field Layout at FLAGS (part 3)

Figure 9 Spools and GRP covers in the KGP UKCS

Table 4 Spools 1 – 8 & GRP Details

Spool #	Weight (t)	Interface and cover
1	4	L-type spool, interface between Spool 2 & KGP. Swivel flange at each end. Rock cover
2	4.1	I-type spool, connected by flanged connection and rock cover
3	4.1	I-type spool, connected by flanged connection and rock cover
4	4.0	I-type spool, connected by flanged connection and rock cover
5	3.6	I-type spool, connected by flanged connection and rock cover
6	4	I-type spool, connected by flanged connection and rock cover
6 (crossing)	3.8	GRP cover over FLAGS 36" gas export pipeline (crossing 10)
7	5.7	Z-type spool, interface between Spool 6 & PLEM. Swivel flange at PLEM end & weld neck at other end. Rock cover.
8	5.9	L-type spool, located between PLEM and Knarr Tee structure, fitted with swivel flange at each end. Protected by GRP cover (see below).
8 Cover #1	2,8	Spool 8 GRP straight cover #1
8 Cover #3	3.1	Spool 8 GRP Left elbow cover #3
8 Cover #15	2.4	Spool 8 GRP straight cover #15

The 2018 KGP survey [4] shows the 12” spools (either buried by GRP protection, or rock covered, or both) to be in good condition with no debris, significant recent scars or evidence of other third-party threats. Figure 10 shows some details of the GRP cover at the PLEM exit, and at pipe crossing 10 (see 5.2.4).

GRP cover

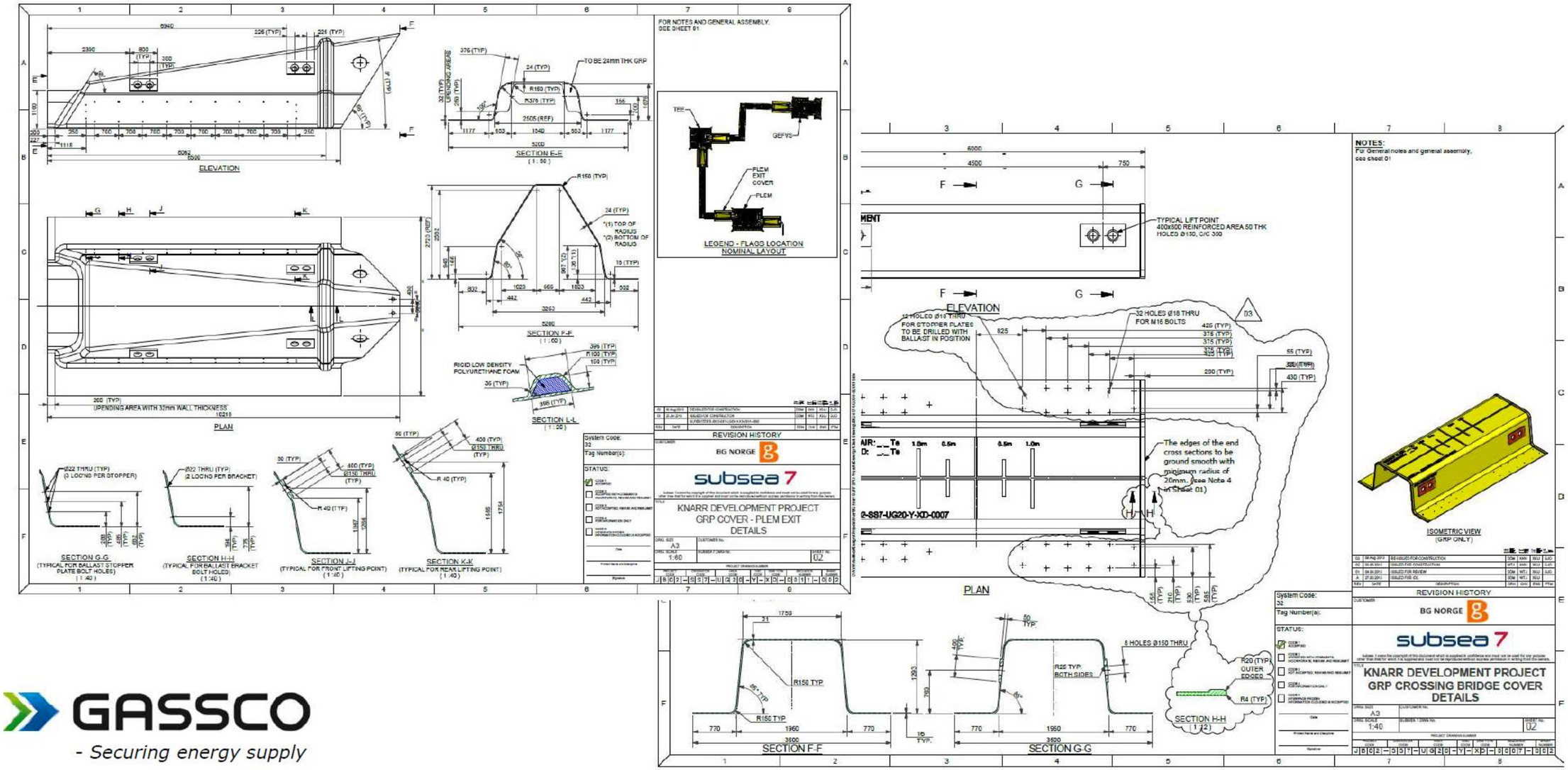

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Figure 10 GRP Cover

5.2.4. Pipeline Crossings and Concrete Mattresses

Along the pipeline route to FLAGS, the KGP crosses the following 4 pipelines in the UK sector:

- Crossing 7: Gjøa 26" gas export pipeline (live).
- Crossing 8: Brent South 10" oil pipeline (no longer in operation).
- Crossing 9: Brent South 8" water injection line (no longer in operation).
- Crossing 10: FLAGS 36" gas export pipeline (live).

The KGP crosses over at all 4 pipeline crossings. A physical, vertical separation of 300 mm minimum is ensured between the KGP and the other pipeline at the crossings (whether originally exposed or buried) and with consideration to both short-term and long-term settlement at the crossings. The separation is provided at crossings 7, 8 and 9 by 300 mm thick flexible concrete mattresses as detailed in Table 5. There are no mattresses over the FLAGS 36" gas export pipeline (crossing 10), as separation is provided by GRP cover [5].

Table 5 Concrete mattresses located in KGP UKCS

		Concrete Mattresses					
Pipe crossings		No.	Dimensions (m)	Weight (t in air)	Submerged Weight (t)	Density (kg/m^3)	Additional Specs
7	Gjøa 26" gas export pipe	20	6x 3 x 0.3	9.6	5.9	2,400	20mm polyprop rope
8	Brent South 10” Oil Pipe	1	6x 3 x 0.3	9.6	5.9	2,400	20mm polyprop rope
9	Brent South 8” water inject	1	6 x 3 x 0.3	9.6	5.9	2,400	20 mm polyprop rope

The concrete mattresses in the FLAGS area were installed under the spools and rock covered post tie-in to cover all mattresses. The GRP cover at crossing 10 is also under rock cover. Latest survey 2018 [4] showed that all of these crossings are stable.

Figure 11 Photos from installation of concrete mattresses in the FLAGS area

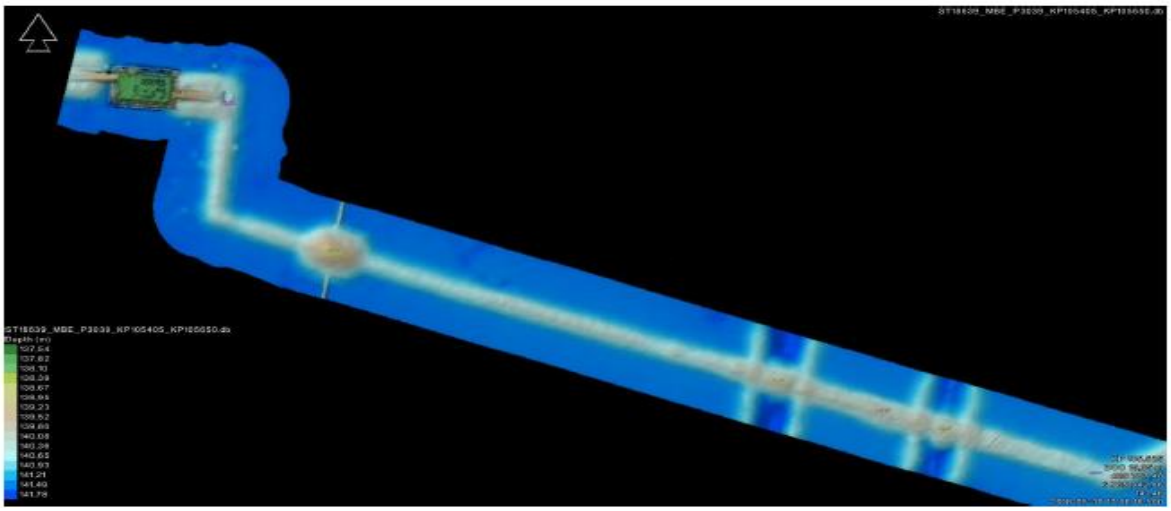


Figure 12 KGP showing PLEM, Pipeline Crossings & rock cover in UKCS, 2018 survey

5.2.5. Rock cover on UK sector

The entire length of the KGP on the UK sector is covered by rock. Approximately 97,000 Te of rock was installed as stabilisation and cover on the KGP in the UK sector. The rock is generally laid with a 1:3 slope and with a top of pipe average coverage of 0.58m (Figure 13). The installed rock size varies between 1-5" [6]. An as-laid survey was undertaken in 2015 [7], with later external inspections in October 2015, 2016, 2017 and 2018, which document sufficient coverage along the entire length of the pipeline.

The areas approaching the Knarr PLEM (GRP covers and spools) are all rock covered, apart from the entrance and exit GRP covers of the PLEM (Figure 14 and Figure 15), which are only partially covered with rock. About 54,000 Te of rock was installed in this area, covering the crossings, spools and PLEM [6].

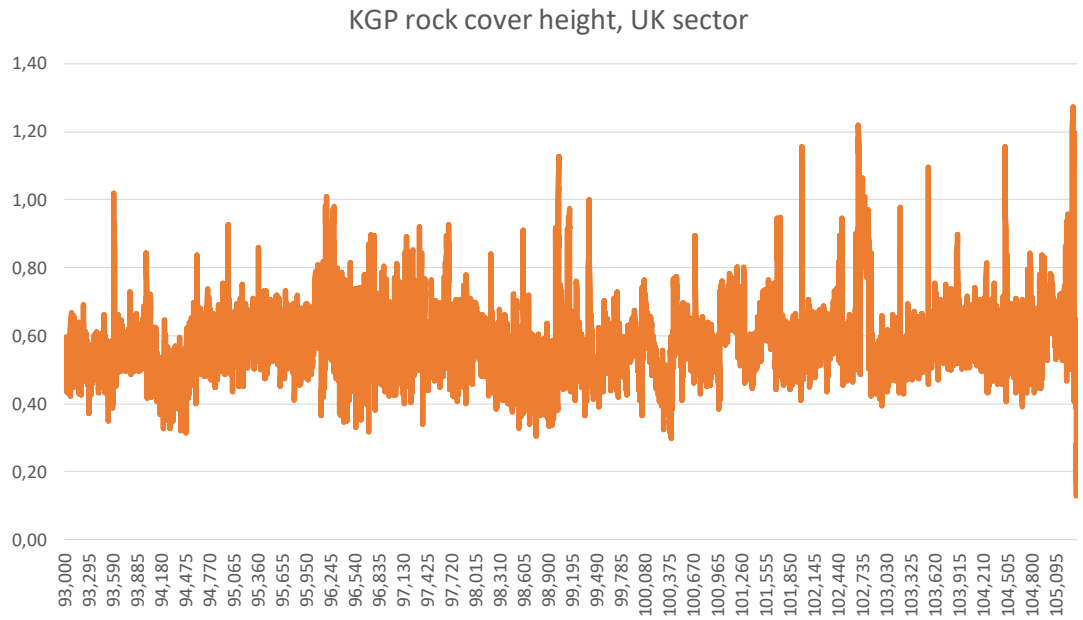


Figure 13 Rock Cover height above pipe (m), UK sector.

GASSCO

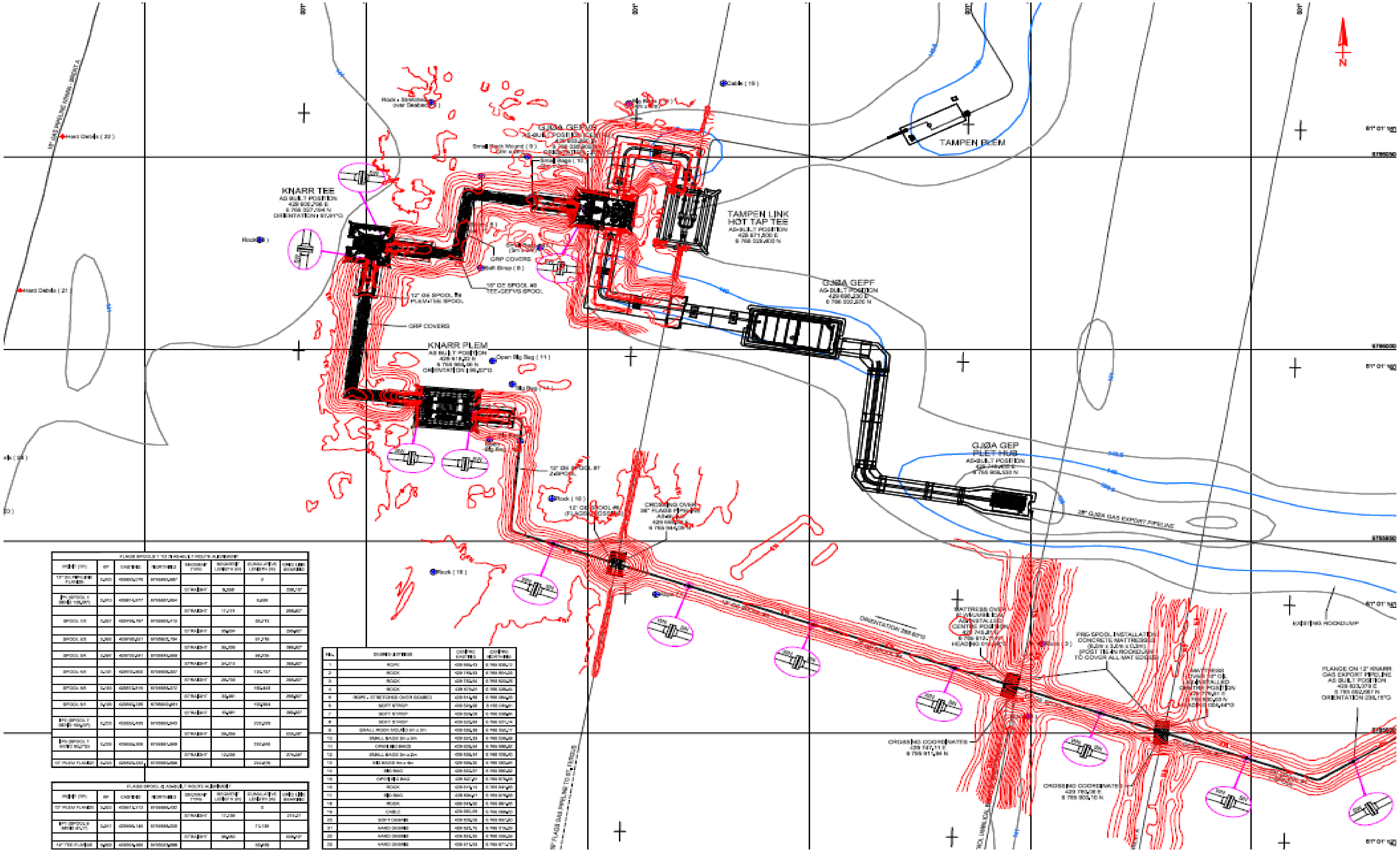


Figure 14 Area layout for the tie in of KGP to FLAGS.

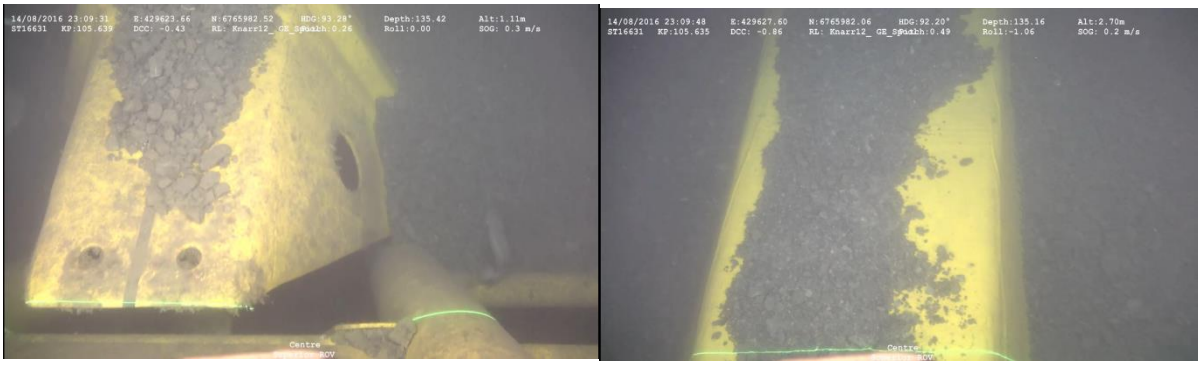


Figure 15 GRP covers close to the PLEM

5.2.5.1. Trawl Scars

The KGP survey in 2015 [7], identified extensive trawling, and trawl scars can be seen between KP 60 (NCS) to approximately KP 100 (UKCS) where the pipeline is surface laid with rock cover. Several external inspections have been performed in this area to monitor the development of the trawl scars to the rock protection. The pipeline coverage\protection is still considered as intact.

5.3. Feasible Decommissioning Options - Comparative Assessment

A Comparative Assessment (CA) was conducted [8] to examine feasible decommissioning options and facilitate decision-making for the KGP UKCS decommissioning programme. The CA did this by comparing alternative decommissioning options to understand the safety, environmental, technical, economical and societal risk associated with it, such that robust conclusions as to the preferred decommissioning option could be drawn.

A CA workshop was held on 20 May 2019 at Gassco AS offices in Bygnes, Norway to consider the most appropriate method of decommissioning the KGP UKCS infrastructure [8]. The approach was based on methodology as recommended in the Oil & Gas UK Guidelines [9].

The simplest CA methodology ("Evaluation Method A: Narrative + Red-Amber-Green", a mainly qualitative approach using relatively broad-brush comparisons across each decommissioning option) was applied. This was agreed with OPRED owing to the small scale of this decommissioning project, and because pipeline CA are generally accepted to be less comprehensive than more complex decommissioning projects involving structures such as jackets, GBS, etc.

An overview of the decommissioning options considered in the CA for the different parts of the KGP UKCS infrastructure is presented in Table 6.

Table 6 CA Decommissioning Options for KGP UKCS infrastructure

Infrastructure	Option A	Option B	Option C
11.6 km KGP	Decommission pipeline in situ, including pipeline crossing. As concrete mattresses are under rock cover at the pipeline crossings, so their fate is bound up with the pipeline crossings. √	Full removal of pipeline. The pipeline will be cut into a number of segments and lifted from the seabed to a vessel and taken to shore.	-
Phase 2; Pipe Spools #1-7, pipe crossings, mattresses, GRP cover (crossing 10)	Leave pipe spools #1-7, pipe crossings, and mattresses *in situ* under rock cover. Remove GRP cover at crossing 10. √	Remove Pipe Spools #1-7, GRP cover (at crossing 10) and mattresses, at the same time as KGP decommissioning & PLEM removal	Remove Pipe Spools #1-7, GRP cover (at crossing 10) and mattresses. Delay until after FLAGS cessation of production, and remove PLEM at same time
Phase 3; Pipe Spool #8 & GRP covers	Leave pipe spool #8 & GRP covers in situ.	Remove Pipe Spool #8 & GRP covers - at same time as KGP decommissioning & PLEM removal	Remove Pipe Spool #8 & GRP covers - delay until after FLAGS cessation of production & remove PLEM at same time √

√ denotes preferred option

The conclusion of the CA for the decommissioning of KGP UKCS infrastructure was the following preferred decommissioning options:

- Leave KGP in situ, under rock cover
- Leave Spools #1-7 and associated mattresses in situ, under rock cover
- Remove Pipe Spool #8 and associated GRP covers, and remove Knarr PLEM with associated GRP covers at same time. Delay removal until after FLAGS cessation of production. Remove Knarr PLEM/associated GRP covers at same time.
- Remove GRP cover at pipe crossing #10 and Knarr PLEM with associated GRP covers at same time. Delay removal until after FLAGS cessation of production. (This would mean that ultimately there would be no GRP covers on the KGP UKCS left in situ). Remove Knarr PLEM/associated GRP covers at same time.

Full details can be found in the CA report.

The above approach will mean that some infrastructure will remain in situ, while other infrastructure will be fully removed, as summarized in Table 7 below.

During planning for Phase 2 it has been decided to remove a small section of spool #7. The small spool section being removed during Phase 2 activities, will be taken to Norway for dismantling and recycling.

Table 7 Selected Decommissioning Options, Quantities of Materials and Destination (Phases 1-3)

Infrastructure	Preferred Decommissioning Option	Quantity of Material	
		Left in situ	Brought ashore
KGP	Leave pipe in situ, under 0.6 m rock cover	11.6 km of 12" pipeline Steel: 1,139 t Plastic: 31 t of 3LPP*	0
PLEM & in/out GRP covers	Complete removal	0	Steel: 91t Plastic: 22.6 t GRP covers
Concrete mattresses at pipe crossings	Leave concrete mattresses in situ under 0.6 m rock cover	22 mattresses in total, each mattress is 6m x 3m x 0.3m and weighs 9.6 t (in air). Total weight of mattress left in situ is 230.4 t (in air)	0
Spool #8 & GRP covers	Remove Pipe Spool #8 & GRP cover	0	Spool #8: 5.9 t GRP covers x 3: 11.1 t
Spools #1-7, and GRP cover at crossing 10.	Leave Spools #1-7 in situ, under rock cover. Remove GRP cover at crossing 10 (delay until after FLAGS cessation of production).	28.7 t steel ~1 t plastics (3LPP coating)	GRP cover: 3.8 t

*3LPP – 3-layer polypropylene coating

5.4. Activities during the Preferred Decommissioning Option

5.4.1. Cleaning

Under the terms of the PWR submitted by Gassco AS on 29/04/2021, Phase 1 of the decommissioning activities were carried out in May 2022.

The KGP was cleaned by pigging from Knarr PLEM (UK sector) towards Knarr FPSO (Norwegian sector) to displace any residual hydrocarbons and contaminants from the pipeline during decommissioning in May 2022. A 4 off pig train was propelled by filtered seawater from the PLEM to the Knarr FPSO. All piping between the Knarr Tee and the PLEM header was filled with 100% MEG and pressurized to 90 barg prior to pigging. After pigging, the Knarr PLEM main header was flushed with MEG and valves closed to provide additional barriers between KGP and FLAGS.

The cleaning process conformed to industry standards to ensure that the lines are adequately cleaned. Cleaning reduced the hydrocarbon content to as low as reasonably practical and complied with best available techniques and industry practice. Cleaning was managed environmentally under the relevant regulations (e.g., Offshore Chemical Regulations 2002, Offshore Petroleum Activities (Oil Pollution Prevention and Control, OPPC) Regulations 2005). A chemical permit and an OPPC permit were granted by DESNZ prior to execution of the cleaning activities.

5.4.2. Knarr Gas Pipeline activities

The KGP in UK sector is under rock cover and would be left *in situ,* hence there would be very few, if any, operations required, so very low vessel density, no lifting, no resources, etc. The KGP would remain connected to Spool #1, so not cutting required.

5.4.3. PLEM, spools & GRP covers – activities

Decommissioning activities would take place in three distinct time period phases, as described below, and therefore any potential environmental impacts to occur similarly. The first two phases involve only short duration, low complexity activity, with few operations, low vessel density, resources and (in the second phase) simple lifting to vessel, followed by bringing items to shore.

5.4.3.1. Activities at the time of KGP decommissioning (Phase 1)

After cleaning the KGP in May 2022 as described in Section 5.4.1, only a few activities were required at this time, and they were in proximity to the PLEM and Spool #8.

- The PLEM was (after cleaning) sealed off with a double barrier, by closing valves (by Remote Operated Vehicle, ROV) on both the upstream side of the PLEM, and at the downstream side at Knarr Tee. To access the valves, the GRP cover needed to be opened and small amounts of overburden soils and rock were relocated (estimated to 70 m^3) to nearby seabed. This was performed using a WROV operated standalone dredger for more controlled rock relocation due to the vicinity of live FLAGS.
- Spool #8 and the PLEM were filled with MEG to protect the Knarr Tee from seawater.

5.4.3.2. Phase 2 activities

As the KGP is required to be separated from the UK sector infrastructure, in Phase 2 Spool #7 will be disconnected upstream of the PLEM by cutting a small spool section using a subsea pipe cutter (either a WROV operated diamond wire cutter or hydraulic shearing tool). To access spool #7, the PLEM entrance cover will be removed temporarily (after removing any rocks via WROV dredger). The small spool section that is cut will be lifted to vessel, and the GRP cover re-installed for protection of cut spool ends.

Thus, there will be a small amount of dredging, cutting and lifting at this stage, and it will take place over a small area. The very small quantity of spool material generated (cut spool #7 section) will come to shore.

Figure 16 Example of Diamond Wire Cutter (left) and Hydraulic Shear Cutter (right)

5.4.3.3. Activities after FLAGS production has ceased, Phase 3

The PLEM, spool #8 and associated GRP covers, together with the GRP cover over crossing 10, will be removed at this stage.

This will first require the clearance of any residual quantities of rock cover/sediment on top of the GRP covers (worst case 1,200 m^3) using a WROV operated standalone dredge unit for up to 60 hours. The rock cover/sediment will be moved to an appropriate nearby seabed area. The work is governed under a marine licence.

The GRP covers at the entrance/exit of the PLEM, over Spool #8 and at Crossing 10 will then be recovered to deck using the vessel main crane. Lifting straps will be connected to lift points on the GRP covers using WROV.

The PLEM will thereafter be disconnected/cut from Spool #8, and the spool will be cut into manageable lengths and placed in a subsea basket for recovery to deck. The cutting will be performed using a subsea pipe cutter.

The piles securing the PLEM must be released or cut and removed. Piles are generally required cut 3 metres below the seabed in UKCS, which would require significant excavation if cutting from the outside. Therefore, an internal cutting tool is proposed. Prior to cutting, the soil plug within the pile will be removed using a standalone dredge unit with an additional high flow water jetting pump, and dispersed to sea.

The PLEM is assumed recovered fully assembled to deck using lifting spread, connecting crane tugs and tag lines (attached by WROV) as required for handling onto deck.

After removal activities are completed, exposed pipe ends on the seabed will be protected with rock placement (drop bags), installed with positioning assistance from WROV. The empty bags will be recovered to deck.

In summary, there will be some dredging, cutting and lifting at this stage, which will take place over a small area. The materials generated will come to shore.

5.4.3.4. Legacy Impacts

There is potential for environmental impact from the long-term eventual degradation of the KGP and the spools #1-7 that are left in situ.

5.4.4. Post Decommissioning surveys

As part of the KGP UKCS decommissioning, Gassco AS will remove and recover any significant oil and gas related seabed debris for onshore disposal or recycling in line with existing disposal methods. As per DESNZ Guidance notes, debris survey and removal are required along a 100m corridor (50 m either side) of a decommissioned pipeline over its whole length.

In addition to the as-left survey and debris removal as necessary after Phase 2, Gassco AS will conduct an appropriate post-decommissioning environmental seabed survey when Phase 3 decommissioning work has been completed, all oil and gas debris has been removed, and the final debris sweep has been successfully carried out.

A Close Out Report will be submitted to OPRED within 12 months after executing Phase 2 activities, and once a qualified body certifies that the seabed has been left in a condition that does not present a hazard to commercial fishing vessels.

The seabed survey strategy will be aligned with regulatory guidance and developed in consultation with regulator. Any survey or maintenance required between the time the KGP is decommissioned and FLAGS cessation of production, will be risk-based and agreed with OPRED.

A new Close Out Report will be submitted within 12 months after the completion of future DP works following FLAGS CoP.

5.4.5. Monitoring

Gassco AS will survey any infrastructure decommissioned in situ. In consultation with OPRED, the frequency and content of any long-term monitoring required will be determined through a risk-based approach.

6. Environmental Management

6.1. Introduction

The KGP UKCS decommissioning Project will be managed within the framework set by Gassco AS's governing document HSE Management [10]. Gassco AS is committed to conducting its activities in a manner that incorporates health, safety and environmental protection as core values and best practice. Gassco AS HSE&Q policy states '*company will conduct its operations without harm to the environment and in line with the principles for sustainable development. Gassco AS will also concentrate attention on efficiency, compliance with requirements in its framework documents and continuous improvement'*.

Gassco AS has an Environmental Management System (EMS) [11] which provides a framework for a systematic approach to identifying and managing the environmental risks associated with Gassco AS operations. The EMS is based on the principles specified in ISO 14001. Gassco AS provides training to ensure that personnel are competent to carry out their activities and where there are specific responsibilities for environmental protection, specific training is provided.

Gassco AS's environmental impact is continuously monitored, followed up, managed and results are included in monthly HSE reporting. Audits are conducted to satisfy both regulatory requirements including compliance with environmental consents, as well to identify progress/fulfilment of project objectives and commitments.

Emissions and discharges associated with the KGP UKCS decommissioning will be monitored.

6.2. Contractor Management

As contractor companies may undertake some of Gassco AS's decommissioning activities, the management of contractors will be undertaken by the Gassco AS Project Team. Standard procedures for operational control and hazard identification and management will be used. All contractors will be required to fulfil defined standards in management before they work with Gassco AS, and their performance in this area will be monitored and reviewed. Contractor competency, ensuring that the correct training and relevant qualifications have been achieved, will be verified during the assessment of tender documents. Gassco AS will carry out audits and second-party checks and Gassco AS will have contractor interface documents.

6.3. Onshore Site Management

The onshore dismantling yard location is yet to be confirmed and may be in Norway or UK. The selected site will have appropriate site management plans and the correct environmental permits necessary for the proposed dismantling operations to ensure dismantling operations minimise any potential impacts to the local community. Gassco AS will ensure that the selected onshore dismantling yard has procedures, plans and contractual agreements in place to account for (e.g.) noise management, odour management, formal community engagement and closeout of any outstanding issues and internal audits. Gassco AS will also perform HSE management site inspections during the onshore dismantling phase.

7. Environmental Baseline

7.1. Introduction

The chapter describes the environment baseline of the project area. Factors about the environment are described such as its nature, location, scale, condition, value, sensitivity and rarity. This helps to define an environmental baseline against which it is possible to assess the impact of the proposed operations.

7.2. Data Sources

The North Sea has been extensively studied, meaning that this report has been able to draw on a significant volume of published data. This is supplemented by:

- Surveys conducted for the Knarr Gas Pipeline (KGP). Although there has been no site-specific benthic sampling carried out specifically for the KGP on the UKCS, a number of inspections and surveys (see Table 8 and Figure 19) have been carried out and give a good indication of the pipeline and seabed conditions.

- Significant work conducted by Shell in assessing the environmental baseline for the decommissioning of the UK Brent Field [12]. This is a key study used to inform the environmental description for the KGP environmental baseline on the UK side because 3.6 km of the 12.5 km KGP that is on the UKCS actually pass through the Brent Field (Block 211/29 and 211/30) as shown in Figure 17 and Figure 18. Brent Alpha platform is the nearest platform to KGP and is located approximately 1.5 km north of the final tie-in to the Knarr Tee to FLAGS. Brent South is approximately 1 km south of the Knarr Tee. DNV GL considers the survey data from Brent Field data to be representative of the baseline for the whole length of KGP on the UKCS because the water depth and seabed conditions at the KGP outside of the Brent Field are similar to those within the Brent Field.

Figure 17 KGP (UK) going through the Brent Field.

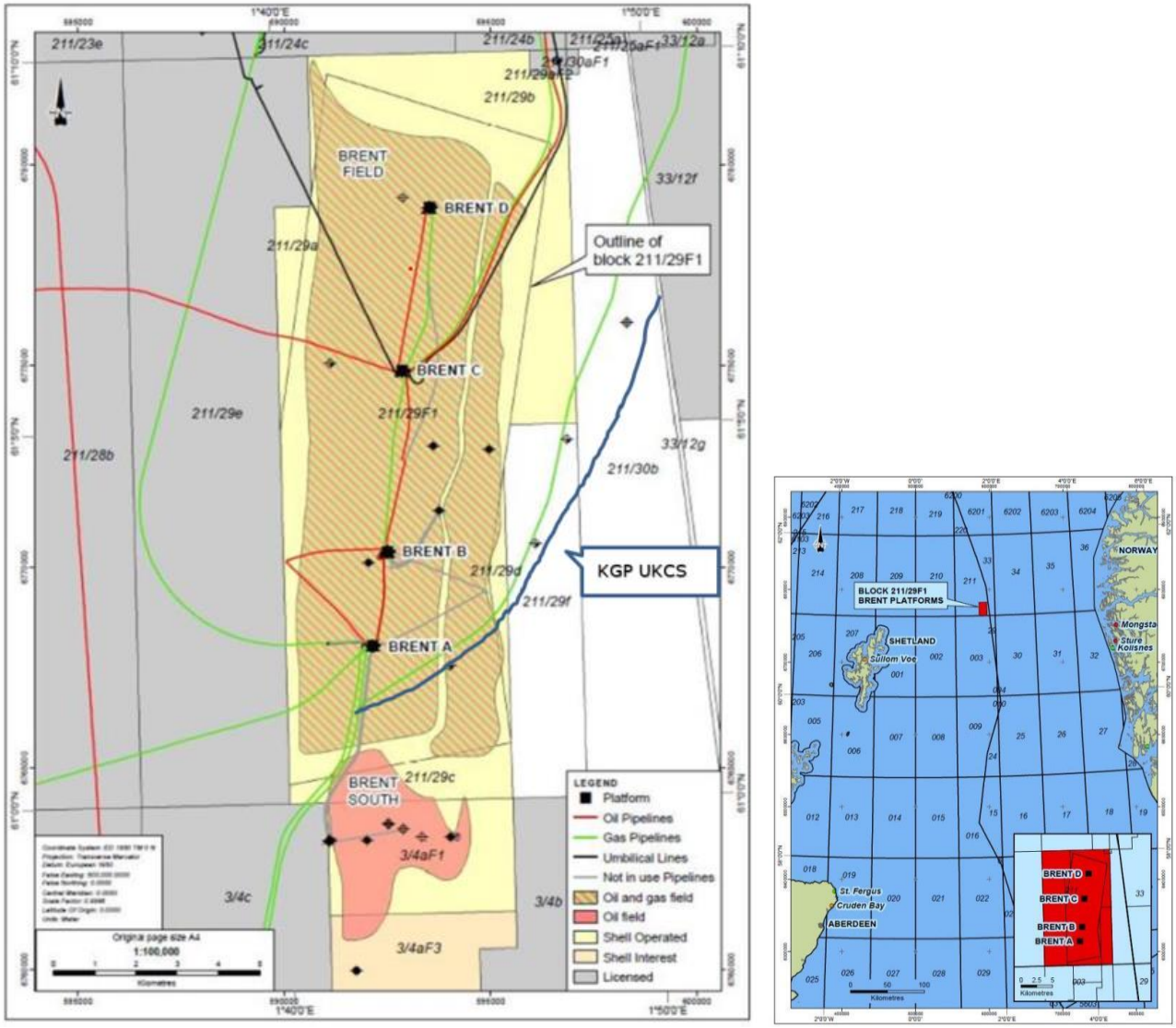


Figure 18 Location of 12.5 km KGP UKCS in relation to Brent Field [12].

Table 8 External inspections in the vicinity of the KGP UKCS.

Survey	Details
External inspection March 2015 [7]	The entire KGP was externally inspected in March 2015 as part of the pre-operational preparations. The pipeline was buried to approximately 98.5 %. Six minor free spans were observed but all in the Norway sector. No findings indicated any hazards or unforeseen exposed pipe.
External inspection October 2015	The entire KGP was externally inspected in October 2015. Nineteen free span sections were observed. All free spans were observed in trenched areas in Norway sector. No damage or significant debris was observed. The main seabed features observed were areas of trawl scars. The 12'' spools and PLEM were found in good condition.
External inspection 2016	The entire KGP was externally inspected in 2016 including video of the PLEM area. Seabed scars occurred extensively throughout the majority of the surveyed section and many of these features indicated recent trawling activity. However, the pipeline was either predominantly buried within a trench or gravel covered throughout and no pipeline coating damage was observed within these areas. The FLAGS area with Knarr 12'' spools, PLEM and Tee spool are in good condition with no hazardous items of debris, significant recent scars or evidence of other third-party threats.
External inspection 2017	The KGP was externally inspected between KP70-105 in 2017 with focus on pipeline trawling and trawl scars in the rock berm. Seabed scars occurred extensively throughout the majority of the surveyed section and many of these features indicated recent trawling activity. However, the pipeline was gravel covered throughout these areas and there was no indirect evidence of possible impact damage.
External inspection 2018 [4]	The entire KGP was externally inspected in 2018. Seabed scars occurred extensively throughout the area with rock berm, and many of these features indicated recent trawling activity. However, the pipeline was gravel covered throughout these areas and there was no indirect evidence of possible impact damage. The FLAGS area with Knarr 12'' spools, PLEM and Tee spool are in good condition with no debris, significant recent scars or evidence of other third-party threats.

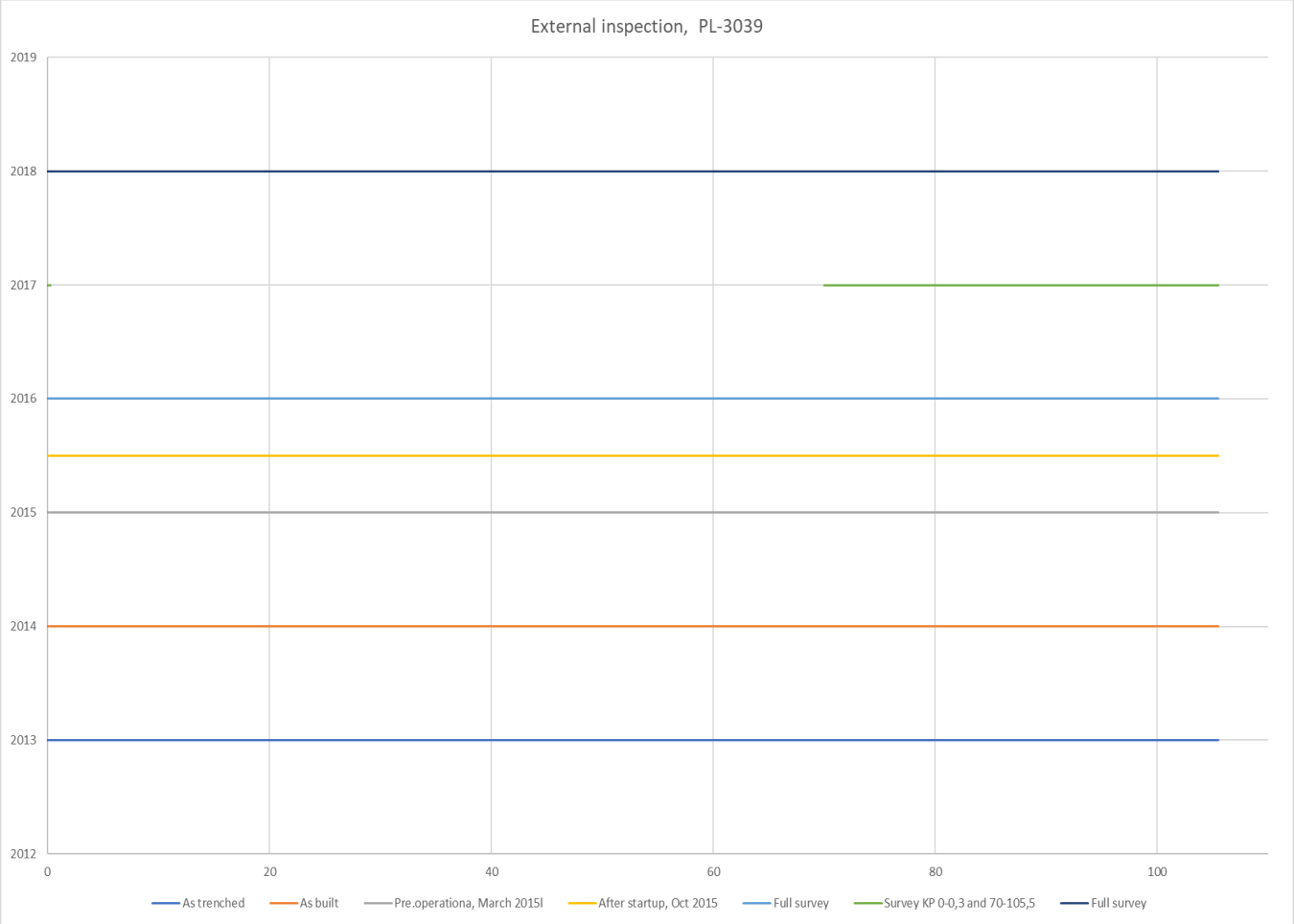


Figure 19 Overview of external inspections on Knarr Gas Pipeline

7.3. Physical Environment

7.3.1. Weather

The North Sea weather is characterised by large variations in wind speed and direction, lots of cloud cover, and relatively high rainfall. Weather patterns are variable throughout the year.

Winds speeds greater than 28m/s mainly occur during winter, while wind speeds during summer are usually lower, ranging between 5-14 m/s, and the dominant wind direction originates mainly from the south and south-west [12].

7.3.2. Water Currents and Wave Height

The major water masses in the North Sea are shown in Figure 20, and are important as they influence biological productivity, and the movement of plankton. The UK KGP is located in an area influenced by the Northern North Sea water mass. Atlantic Water enters the North Sea from Shetland and via the Fair Isle Channel, driving an anti-clockwise circulation in the central North Sea.

The Scottish National Marine Plan [13] reports for the KGP UKCS area show:

- Mean spring tidal range is between 1.1 – 2 m.
- Annual mean significant wave height is 2.4 – 2.7 m.

The prevailing seabed currents in the project area run in a north-south direction. The severe gales and storms that can commonly occur in this area result in variable, wind-driven surface currents and oscillatory currents at the seabed [12].

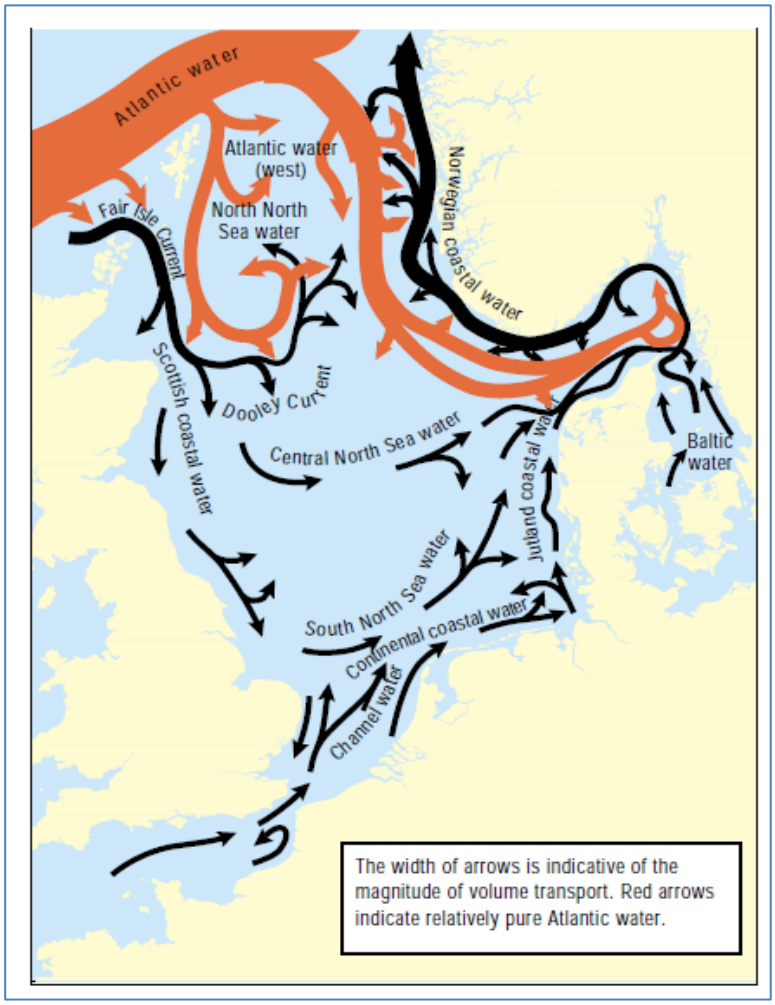


Figure 20 General Near-surface Water Circulation in UKCS [14].

7.3.3. Water Temperature and Salinity

Water masses in most of the North Sea are vertically well-mixed, and water temperature remains uniform throughout the water column during winter (average of 7.75°C at sea surface, 7.25°C at seabed). During spring, a vertical temperature gradient develops, which separates the warmer, lighter surface layers (average 13.5°C) from the colder, heavier, deeper layers (average 8°C) [12]. The surface salinity is approximately 35 parts per thousand.

7.3.4. Water Depth and Seabed Sediment

Water depth in the UK northern North Sea varies between 50 m and 200 m [14]. Water depths around the Brent Field range between 138–145 m and the seabed is relatively flat. As can be seen in Figure 21, the pipe is ~140 m below sea level for its entire length in UK waters.

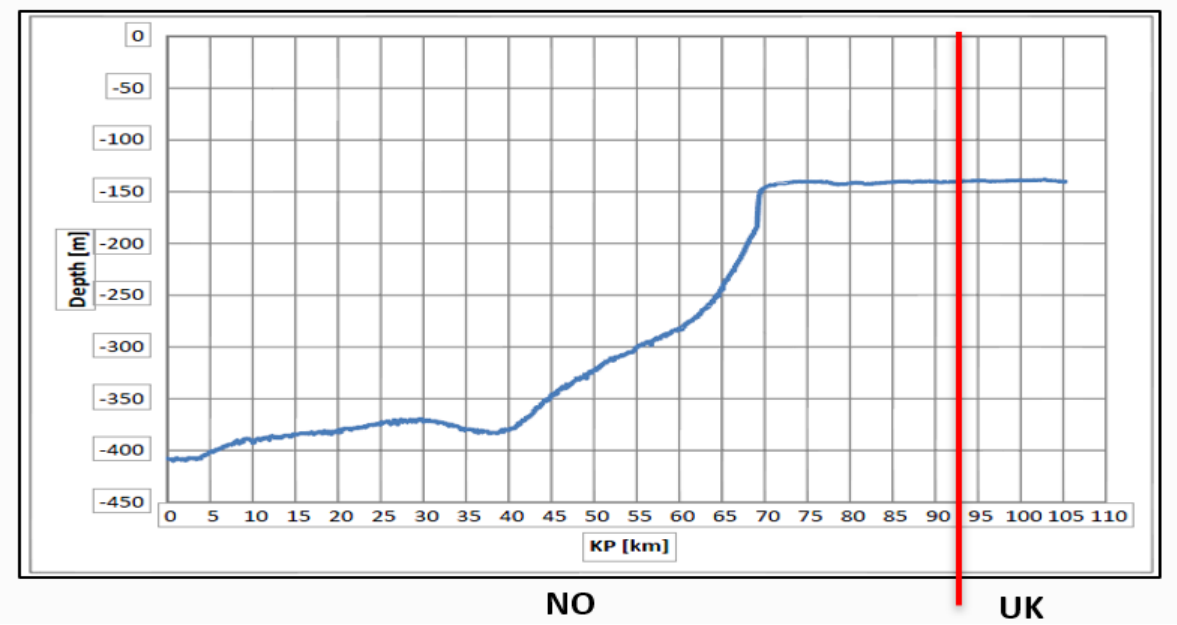


Figure 21 Depth of KGP below sea level, Norwegian and UK side

Sediments at the Brent Field consist of moderately well sorted, fine to very fine sands, which contain a relatively low proportion of organic matter and coarse material, with moderate amounts of fine and shelly material. This implies that generally the sediments at the project area are not characteristic of those prone to adsorbing hydrocarbons or heavy metals [12].

7.3.5. Seabed Features

In the 2015 pipeline survey [7], there were no boulders and pockmarks identified. Two elongated objects were identified as debris (KP 103.036 and KP 100.304) and were more than 20 m from the pipeline. In the 2018 pipeline survey for the KGP [4] there was no debris identified on UKCS apart from some big bags.

7.4. Biological Environment

7.4.1. Plankton

The planktonic community is made up of microscopic animals (zooplankton) and plants (phytoplankton) that drift with the tides, currents and thermal stratification within the water column [15]. Most phytoplankton are in the top 20 m of the water column as they require light for photosynthesis [16], while zooplankton can go deeper.

Plankton forms the base of the marine ecosystem chain and many species (e.g. birds, fish and cetaceans) are dependent on them, hence the distribution of plankton can directly influence the distribution of other marine species. The composition of planktonic communities is variable temporally, depending on the circulation patterns of water masses, the season and nutrient availability.

The phytoplankton community in the NNS is dominated by the dinoflagellate genus *Ceratium spp.,* and phytoplankton in the area generally exhibit an increase in productivity in summer before a decline in November. In the North Sea, a bloom of

phytoplankton occurs every spring, often followed by a smaller bloom in the autumn, although blooms also occur at other times [17].

Zooplankton (multicellular herbivorous and carnivorous organisms) in the NNS comprise coastal, mixed water and oceanic species. Zooplankton species in the NNS are dominated by the *Calanoid copepods*, and krill is also abundant throughout the North Sea and is a primary food source for some fish and whales [16].

Plankton in the North Sea has been monitored over the last 80 years, and there has been a sharp decline in dinoflagellates in the North Sea over the last decade, due largely to a dramatically reduced abundance of *Neoceratium spp*., although there were signs of recovery between 2012-2013 [16].

Planktonic organisms are potentially vulnerable to accidental oil spills and chemical discharges, although they may be able to recover quickly from localised pollution incidents through the continual exchange of individuals with surrounding waters and short reproductive cycle [15]. Secondary effects to organisms which depend on plankton as a food source (e.g. commercial fish and marine mammals) could be affected by a change in plankton communities.

7.4.2. Benthic Fauna

Benthic fauna are species that live either in the seabed sediment (infauna) or on its surface (epifauna). Benthic communities in this region of the NNS are diverse and abundant and include species typical of the deep water and soft fine sediments. There do not appear to be any benthic species listed for their conservation value in this part of the NNS; the characteristic infaunal species include the polychaetes (tube worms) *Myriochele spp. Owenia fusiformis*, and *Thyasira spp* [18].

Benthic communities at the Brent Field (KGP crosses in the Brent Field and is located 1.5 km south of Brent Alpha and 1 km north of Brent South), were analysed in surveys below [12]:

- In 2007, 237 adult taxa and 30 juvenile taxa were recorded in the 18 samples from 9 stations at the four Brent platforms and Brent South. 49% of the adult individuals consisted of polychaete annelids, 24% were crustaceans, 18% molluscs and 4% echinoderms. The most abundant species were the polychaete annelids *Paraphinome jefferysii, Owenia fuciformis* and *Capitella capitate*. None of the species identified was of statutory conservation significance, as defined within the EU Habitats Directive.
- A 2015 benthic survey collected further samples from each of the four Brent platforms and at Brent South. The survey identified a typical North Sea benthic community, largely dominated by polychaetes and bivalve molluscs. More than 500 m from the Brent Field platforms, the benthic fauna was generally considered background for the East of Shetland Basin and wider NNS area.

7.4.3. Fish and Shellfish

Decommissioning oil and gas infrastructure can potentially impact fish populations by, for example, underwater noise, hydrocarbon or chemical discharges, or sediment disturbance. Conversely, some fish species may congregate around offshore structures and pipelines, which may provide a habitat (positive).

Fish are an important food source for seabirds, marine mammals and other fish species, and can be broadly classified as shown in Table 9. In the North Sea there is a total

record of 330 species of fish, but it is estimated that fewer than 20 species constitute over 95% of the total fish biomass. The proportion of large fish (body length >40cm) by weight in the region was estimated at 22% in 2014. It was reported that fish species diversity is not as great in the central and northern North Sea as in the southern North Sea [16].

Table 9 Fish Species in North Sea [16].

Pelagic	Swim in mid-water, occur in shoals, and often migrate to different sea areas between seasons. Includes herring, mackerel, blue whiting and sprat
Demersal	Live on or near the seabed. Includes cod, haddock, plaice, sandeel, sole, monkfish & whiting
Shellfish	Comprise demersal (bottom-dwelling) molluscs and crustaceans, e.g. mussels, shrimps, crabs, Nephrops norvegicus (Norway lobster), and scallops.

Several kilometres of the KGP passes through the Brent Field. Fish are most vulnerable to disturbance and pollution during the egg and juvenile stages of their lifecycle, and the project area is located within spawning and nursery grounds used by several species, as shown in Table 10. Although for many fish species, spawning grounds are dynamic and are rarely fixed in one location from year to year. Nurseries are used throughout the year, potentially making it impossible to avoid an operational period coinciding with the presence of juvenile fish.

Table 10 Spawning and Nursery Times of Fish in vicinity of Brent Field [19,20,12].

Species	J	F	M	A	M	J	J	A	S	O	N	D	
Anglerfish													
Blue whiting													
Cod		*	*										
European hake													
Haddock		*	*	*									
Herring													
Ling													
Mackerel													
Norway pout		*	*										
Saithe	*	*											
Sandeel													
Spurdog													
Whiting													

Spawning period | * Peak spawning period | Nursery/Juveniles

Note: Nursery cells highlighted in light blue indicate these fish species using the area around the Brent Field as rearing grounds. White cells indicate no spawning or nursery grounds.

Demersal species are particularly vulnerable to any sediment disruption. Pelagic spawners are generally not as vulnerable to activities that disturb the seabed.

Photos from external inspections show fish along the rock cover, Figure 22.

Figure 22 Examples of fish seen along the KGP (saithe and ling).

7.4.4. Seabirds

'Seabirds' depend wholly or mainly on the marine environment, and much of the coastline and offshore waters of the North Sea are internationally important breeding and feeding habitats for seabirds. In general, offshore areas contain peak numbers of seabirds following the breeding season and through winter, with birds tending to forage closer to coastal breeding colonies in spring and early summer.

Seven million seabirds breed regularly every year in UK and around mainland North Sea coastlines, as detailed in Table 11.

Table 11 Seabird species in UK and North Sea coastline [16].

Species	Types of species
Petrel	Fulmar, Manx shearwater, Storm Petrel, Leach's Petrel
Cormorant	Cormorant, Shag
Gannet	Northern gannet
Skua	Great skua, Arctic skua
Gull	Herring gull, Common gull, Black-headed gull, Lesser black-backed gull, Great black-backed gull, Kittiwake
Tern	Sandwich tern, Roseate tern, Common tern, Arctic tern, Little tern
Auk	Guillemot, Razorbill, Black guillemot, Puffin

Seabirds are not normally affected by routine offshore oil and gas operations, but are susceptible to oil spills, as they are particularly sensitive to the effects of oil pollution, which can result in mass mortality owing to oil ingestion and plumage contamination. Seabirds populations may also suffer long-term impacts of reduced population size following an acute incident, mainly due to their low annual reproductive output, which means that a reduced population has a longer recovery time [21]. The vulnerability of seabirds to oil spills varies with species and time of year, with peaks in late summer after breeding when the birds disperse into the North Sea, and during the winter with the arrival of over-wintering birds.

In addition:

- Birds that feed, swim and dive on the sea surface are more vulnerable, e.g. auks, diving ducks, many terns and gulls, grebes, cormorants and gannets.
- Guillemots, razorbills and puffins moult their flight feathers after the breeding season (July-August) and are unable to fly for 2-7 weeks. They spend this flightless period at sea, where they are safe from terrestrial predators; and are then most vulnerable to oil pollution.
- Fulmar and gulls, due to their aerial habits, large populations and widespread distribution are the least vulnerable to oil pollution.

The KGP passes through the Brent Field in Block 211/29. The overall vulnerability of seabirds to oil pollution at the Brent Field is shown in the JNCC block-specific vulnerability data (Table 12) and overall it is "low", although some specific months (e.g.) July and November are "high".

Table 12 Vulnerability of Seabirds to Oil Pollution in the Brent Field Area [21,12].

Block	J	F	M	A	M	J	J	A	S	O	N	D	All
211/29	3	3	4	4	4	4	2	4	3	3	2	4	4

KEY

1	Very High Vulnerability
2	High Vulnerability
3	Moderate Vulnerability
4	Low Vulnerability
	No data

7.4.5. Marine mammals

Marine mammals include whales, dolphins and porpoises (cetaceans) and seals (pinnipeds). They can be impacted by offshore oil and gas activities as they are vulnerable to underwater noise, injury from collisions with vessels, oil spills or chemical discharges, and effects on availability of prey [22].

Annex IV of the European Commission Habitats Directive (92/43/EEC) protects *cetaceans* from any deliberate disturbance, particularly during the periods of breeding and migration. The availability of prey (fish, plankton and cephalopods) influences cetacean distribution [16], and 28 cetacean species have been recorded in UK waters and 11 species occur regularly. The KGP passes through the Brent Field, in the vicinity of which the following have been recorded: harbour porpoise, killer whale, minke whale, sperm whale, white beaked dolphin and white-sided dolphin. The majority of sightings of cetaceans occurred between May–August, although a few sightings of harbour porpoise, sperm whale and white-beaked dolphins have also occurred during autumn and winter. Table 13 provides seasonal data on the densities of cetacean species found in the Brent Field and surrounding quadrants; the density is predominantly 'low'.

Both grey and harbour *seals* breed in the UK, with harbour seals pupping in June/July and grey seals pupping between October and December. Seals are more likely to be seen in coastal areas than in areas around the KGP.

The harbour seal is widespread along the east coast of Scotland; estimated numbers in the UK are approximately 32,600 animals in 2015-2017, with the majority (82%) in Scotland. Seal tracking studies from the Moray Firth indicate that harbour seals generally forage within 40–50 km of their haul-out sites; their distribution far out at sea is constrained by their need to return periodically to land.

The grey seal in UK waters was approximately 150,000 in 2017 with approximately 70,000 seals associated with breeding colonies in the North Sea. More than 88% of the UK population breed in Scotland. Grey seal foraging movements are either long distance trips from one haul-out site to another or local repeated trips to discrete offshore areas [23].

Table 13 Seasonal Sightings of Cetaceans in Vicinity of Brent Field [12].

Species	J	F	M	A	M	J	J	A	S	O	N	D
Harbour porpoise		L		L	L	L	L	L	L			L
Killer whale					M	M		L				
Minke whale					L		L					
Sperm whale					L	L	L	L	L	L		
White-beaked dolphin		M	M			L	L					
Atlantic white-sided dolphin					L	L						

KEY	
	No animals / no data
	0.01-0.09 animals/km
	0.10-0.19 animals/km
	0.20-0.49 animals/km
	>0.5 animals/km
	Sightings within Quadrants 211 and 3
	Sightings in surrounding Quadrants

Note: Quadrant 211 and surrounding quadrants. As marine mammals are wide ranging, Quadrant 211 and surrounding quadrants are used as a reference to get an indication of their potential presence in the area.

7.4.6. Marine Reptile

The leatherback turtle has been recorded in UK and Irish waters, with 451 sightings recorded between 1950-2000 (95% reported between June and October), although most sightings were in west UK or west/south Ireland [24].

7.4.7. Marine growth

Gassco AS has some photos from the visual inspections of the KGP in August 2016, and it shows there is limited marine growth on equipment and rock cover, as shown in Figure 23.

Figure 23 Limited marine growth on the PLEM structure and associated rock cover.

7.5. Environmentally Protected Areas

7.5.1. Special Areas of Conservation

The UK has designated Special Areas of Conservation (SACs) or Sites of Community Importance (SCI) to protect habitat or specific species of European importance, as listed in Annex I of the EU Habitats Directive (92/409/EEC).

DNV GL has not identified any SAC in proximity to the UK section of the KGP, and the closest SCI (the Pobie Bank Reef) is more than 90 km away (Figure 24). Pobie bank is considered an SCI is due to its extensive community of encrusting and robust sponges and bryozoans. There are no known sandbanks, reefs (bedrock, stony, biogenic), submarine structures made by leaking gases and submerged sea caves in the UKCS project area to be considered for SAC selection.

7.5.2. Marine Protected Areas

Marine Scotland has put forward areas for designation as Nature Conservation Marine Protected Areas (NCMPAs) under the Marine (Scotland) Act (2010). The Marine Management Organisation put forward areas with features of conservation importance for designation as Marine Conservation Zones (MCZs) under the UK Marine and Coastal Access Act (2009).

The closest Marine protected area to the UK KGP project is the NE Faroe Shetland Channel NCMPA, but it is located approximately 110 km to the north-west. The site

features deep-sea sponge aggregations, offshore deep-sea muds, offshore sub-tidal sands and gravels, continental slope and features of geological importance.

7.5.3. Brent Field surveys

Shell surveyed the Brent Field, including a debris and habitat survey, and no environmentally sensitive habitats were identified within the survey area (15 km x 4 km covering the Brent Field and the four Brent platforms). In addition, no pockmarks or naturally occurring reef structures were identified [12].

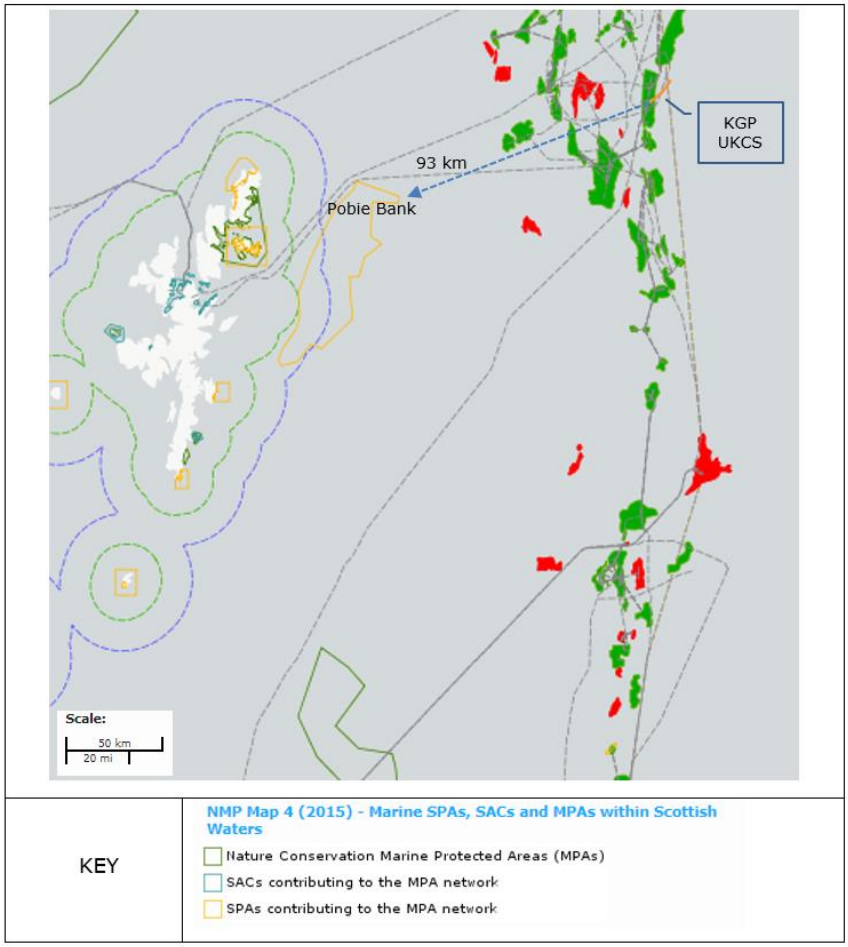


Figure 24 Conservation designation in the vicinity of the UK KGP project [13].

7.5.4. Annex II Species

Four species listed in Annex II (species requiring designation of SAC) of the Habitats Directive are known to occur in significant numbers in UK waters (see Table 14 below), but no offshore SACs have yet been designated in the vicinity of the KGP works for these species. Additionally, coastal SACs have been identified for the bottlenose dolphin, and a JNCC study [25] considered that no suitable SACs in UK offshore waters can be identified for the bottlenose dolphin.

An on-going study by JNCC is examining whether any SACs for grey or common seals may be identified in offshore waters (currently only coastal SACs have been identified) [26]. Both grey and harbour seals are unlikely to be present in any significant numbers in the project area due to the distance from shore.

The only species listed on Annex II likely to occur in the vicinity of the project area with any regularity is the harbour porpoise (low numbers have been recorded, see Table 13). The harbour porpoise is the most common cetacean in UK waters, being widely distributed and abundant, both inshore and offshore. Due to the wide geographical distribution and the lack of knowledge with regards to their feeding and breeding habitats, there has been difficulty in selecting sites essential for their life and reproduction.

Table 14: Species listed in Annex II.

	Species
1	Grey seal
2	Harbour seal
3	Bottlenose dolphin
4	Harbour porpoise

7.5.5. The Scottish national marine plan

The Scottish national marine plan for offshore waters was launched in 2015 under the Marine and Coastal Access Act 2009, to ensure sustainable use of the marine environment and its resources.

The plan is pointing at two key pressures; climate change contributed by human activity, and fishing impact on the seabed. It is further acknowledged that impacts of pressures like marine litter and noise are not well known. KGP equipment with a potential littering potential, e.g., GRP covers, will ultimately be removed to shore for waste management. Noise by vessel activities has been addressed and found to be within normal acceptable levels.

7.6. Socio-Economic Environment

7.6.1. Commercial fisheries

The North Sea is an important fishing ground for demersal, pelagic, and shellfish species. Fisheries activity is based on data from International Council for the Exploration of the Seas (ICES), provided by Marine Scotland. ICES collate fisheries information for individual rectangles, or geographic areas, measuring 30 nm by 30 nm, which equates to an area of approximately 3,080 km2.

The KGP on the UKCS is located in rectangle 51F1/4, and passes through the Brent Field, connecting with the FLAGS pipeline ~1.5 km south of Brent Alpha platform (see Figure 25).

Pelagic species are fished using techniques that do not interact with the seabed, whereas demersal and shellfish species are generally fished on or near the seabed and there is therefore the potential for fishing gear to interact with structures on the seabed.

April and May are the busiest months for fishing vessel activity in ICES rectangle 51F1 and equates to about one fishing vessel every other day in the vicinity of the Brent Field [12]. Fishing intensity in the KGP UKCS area from 2007-2015 ranges between 5-20 vessel monitoring system (VMS) tracks as shown in Figure 26. Figure 27 gives the

fishing intensity for the entire KGP (including UK) in the years 2014 and 2015, and shows that most activity is on the Norwegian side [27]. Analysis of bottom trawling statistics over this 2-year period on the UK side shows the number of passes totals 118, i.e. 59 per year or 5 per km pipeline per year. The 2016 data presented in Figure 28 also shows the vast majority of trawling to be on the Norwegian side, and trawling on UK side to have reduced since 2014/2015 [27].

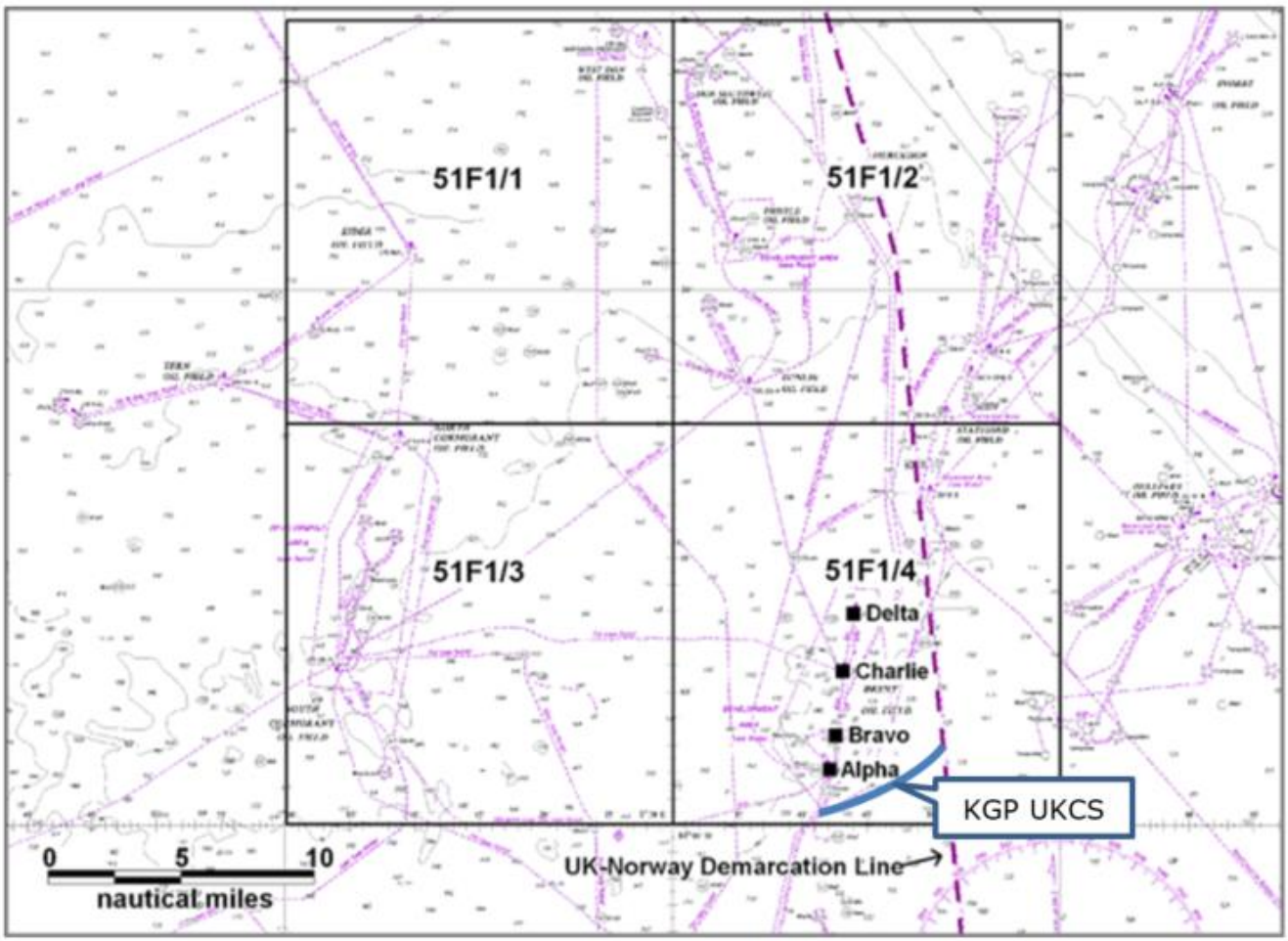


Figure 25 Location of UK KGP in relation to rectangle 51F1 & Brent Field [12,28].

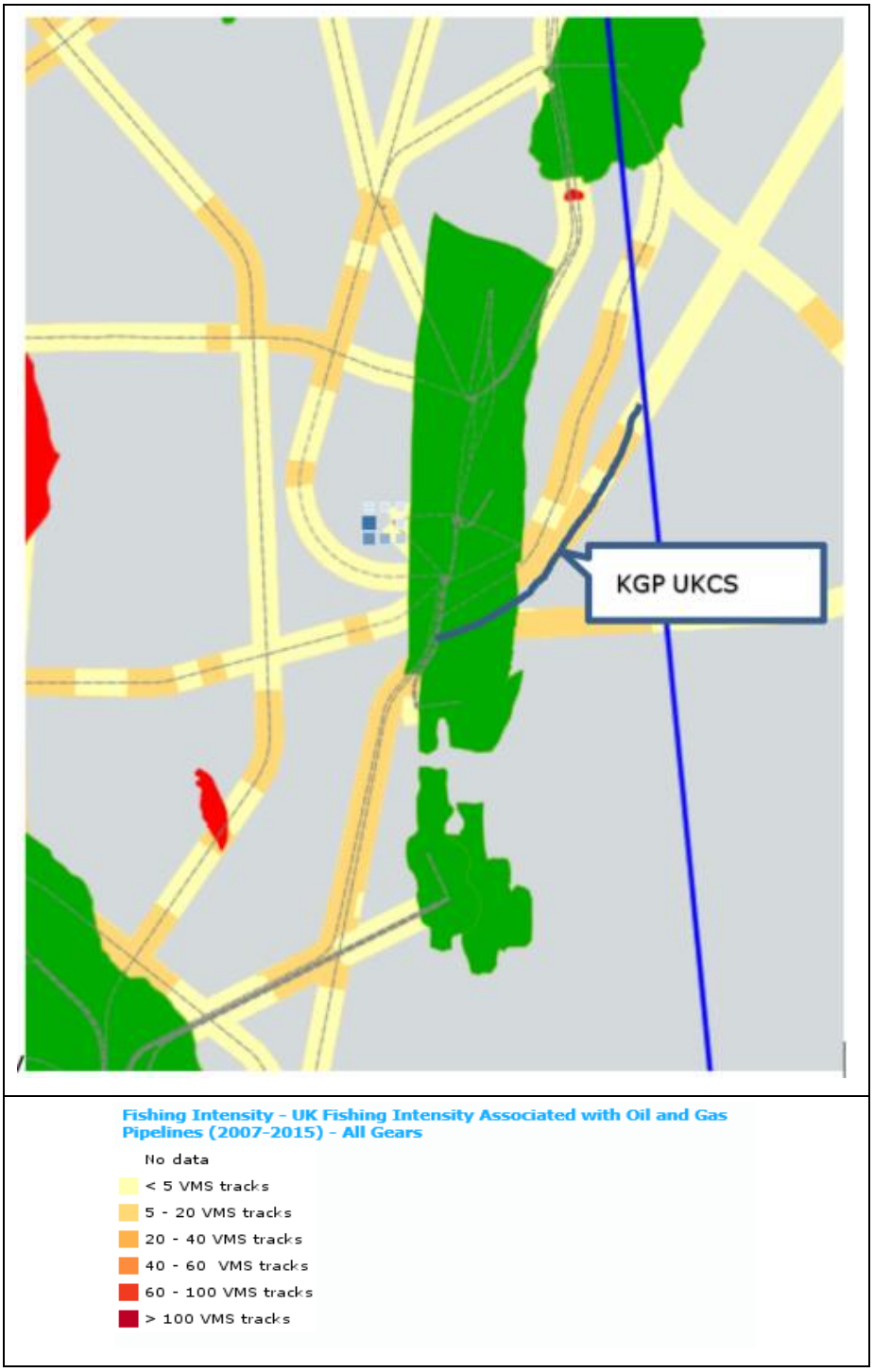


Figure 26 Fishing Intensity in KGP UKCS area [13].

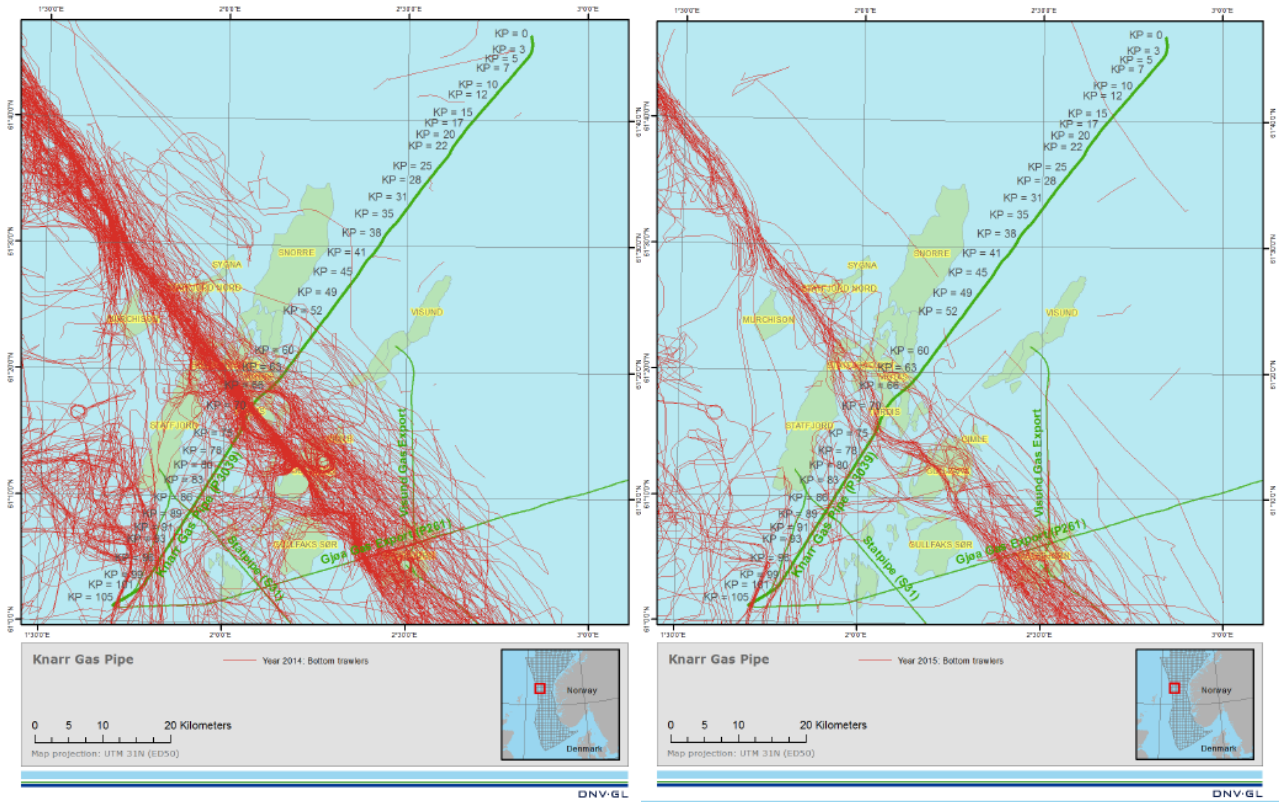


Figure 27 Trawl activity over KGP in 2014-2015 [27].

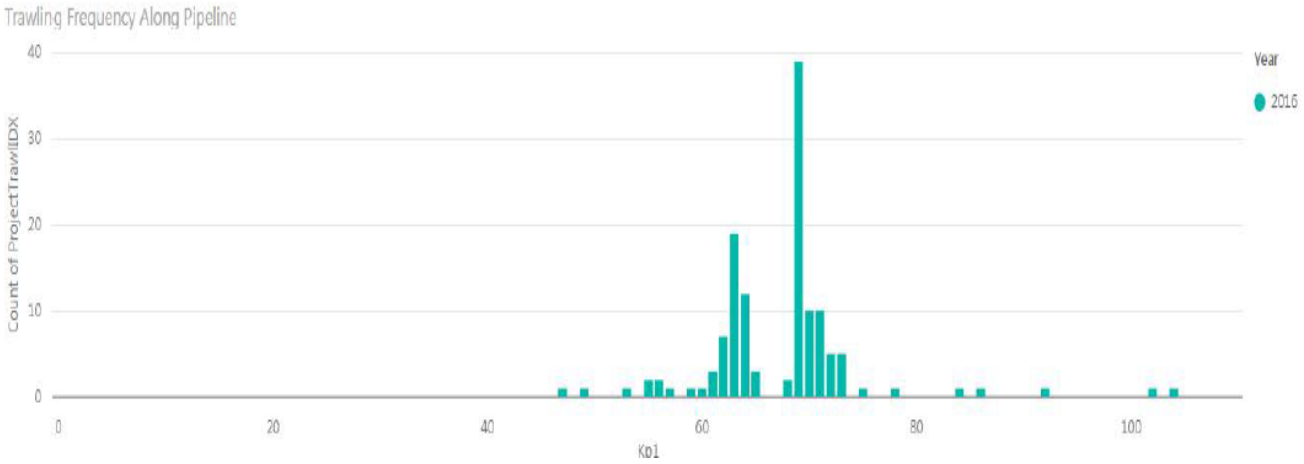


Figure 28 Trawling crossings/km in 2016 (8-month period) along the KGP pipeline [29]

Commercial fisheries statistics between 2000-2022 are summarised for rectangle 51F1 in Table 15, based on statistics from Marine Scotland [12, 18]:

- The total value of the catch was approximately £86 million, with an annual average of ~£3.7 million, and annual average weight of ~5,300 tonnes.
- The annual average catch in recent years is much lower than a decade ago.

- There are substantial year-to-year fluctuations in the weight and value of the catch, mainly because of available quotas and international fisheries agreements.

Table 15 Summary of Reported Catches in Rectangle 51F1 between 2000-2022 [12,28]

Year	Days Effort (Fished)	Live Weight (tonnes)	Value (£)
2000	1,142	22,602	9,625,166
2001	1,311	16,278	8,908,296
2002	1,090	19,287	10,757,250
2003	840	13,236	6,695,900
2004	458	10,120	6,958,058
2005	233	1,307	1,026,564
2006	182	4,018	3,200,928
2007	223	7,157	5,374,435
2008	237	10,826	11,400,099
2009	233	3,207	3,753,504
2010	158	1,036	1,119,618
2011	117	490	740,786
2012	90	361	556,236
2013	182	1094	1,422,491
2014	100	2067	1,748,346
2015	100	1933	1,562,931
2016	62	482	709,983
2017	75	545	825,765
2018	112	848	1,385,005
2019	167	1088	1,914,732
2020	115	636	993,474
2021	251	1896	2,985,678
2022	NA	1329	2,407,225
Total	**7,478**	**121,843**	**86,072,470**

Predictions of the future mackerel and demersal fishery in the Brent area (KGP goes through the Brent Field) indicate the value of approximately £5 million pa and £2 million pa respectively [12], which is similar to 2000-2009 average. No significant increase in fishing effort, number of vessels or fishermen is expected owing to significant improvements in catching technology.

7.6.2. Shipping activity

The KGP passes through the Brent Field. There are 24 shipping routes trafficked by an estimated 686 ships per year passing within 10 nm of the Brent Field [12]. This corresponds to an average of 1 to 2 vessels per day. There is limited international shipping traffic in the area and the majority of vessels are offshore and standby support

vessels given the high concentration of oil and gas developments. Shipping density is considered 'low' in the KGP UKCS area.

7.6.3. Oil and gas activities

The UK KGP is located within an area of major offshore oil and gas development and infrastructure. There are several oil and gas field developments close to the project area (Figure 1), as follows:

UK KGP passes through the Brent Field

Statfjord (~15 km), Murchison (~35 km) and Dunlin (~20 km) north of KGP Tee with FLAGS.

Cormorant (~30 km) and Hutton (~15 km) to the west of KGP Tee with FLAGS.

Lyell (~27 km) and Ninian (~17 km) to the south-west of KGP Tee with FLAGS

Strathspey (~2 km) to the south of KGP Tee with FLAGS.

7.7. Summary of Environmental Sensitivities

Table 16 Summary of Environmental Sensitivities in the Vicinity of the KGP UKCS.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Habitats Directive: Annex I Habitats There are no known Annex I habitats in the project area											
Habitats Directive: Annex II Species The only species listed on Annex II likely to occur in the vicinity of the project area with any regularity is the harbour porpoise (low numbers have been recorded)											
Benthic Fauna Benthic communities in the project area are similar to those found throughout the NNS. There do not appear to be any benthic species listed for their conservation value; the characteristic infaunal species is polychaetes (tube worms)											
Plankton The plankton in the KGP UKCS area is typical of the NNS.											
Finfish and Shellfish Project area is located in spawning grounds for cod, haddock, Norway pout, saithe, sandeel and whiting, & in nursery grounds for anglerfish, blue whiting, European hake, haddock, herring, ling, mackerel, Norway pout, sandeel, spur dog & whiting											
Marine Mammals The main marine mammal species occurring in the project area are harbour porpoise, killer whale, minke whale, sperm whale, white beaked dolphin and white-sided dolphin. The majority of sightings have taken place during the spring and summer											
Seabirds The overall vulnerability of seabirds to oil pollution in the project area is "low" (but "high" in July and November).											
Fisheries The relative value of demersal species in the project area is "moderate", while the relative value for shellfish species is "low". Relative fishing effort for demersal species is "low".											
Shipping Shipping density in the project area ranges from "low" to "very low" density.											

KEY:	
	Very High sensitivity
	High sensitivity
	Moderate sensitivity
	Low sensitivity
	Not surveyed/ No data

8. DNV Assessment methodology

This EA examines the effects of the activities during decommissioning the Knarr infrastructure in the UKCS, as well as considering any potential long-term legacy effects on the environment and society from anything left in situ. This is aligned with the expectations set out in the OPRED Guidance Notes [3]. The identification and assessment of the impacts includes positive and negative effects, and both long-term and short-term effects.

The assessment is conducted by considering the sensitivity of the area in which the activity occurs ("value" or "sensitivity"), combined with the size of the effect, to arrive at the total impact. This produces an impact matrix, to help make it easier to visualize impacts and distinguish important impacts from those less important.

The step-by-step evaluation is as follows:

1. General description of the area

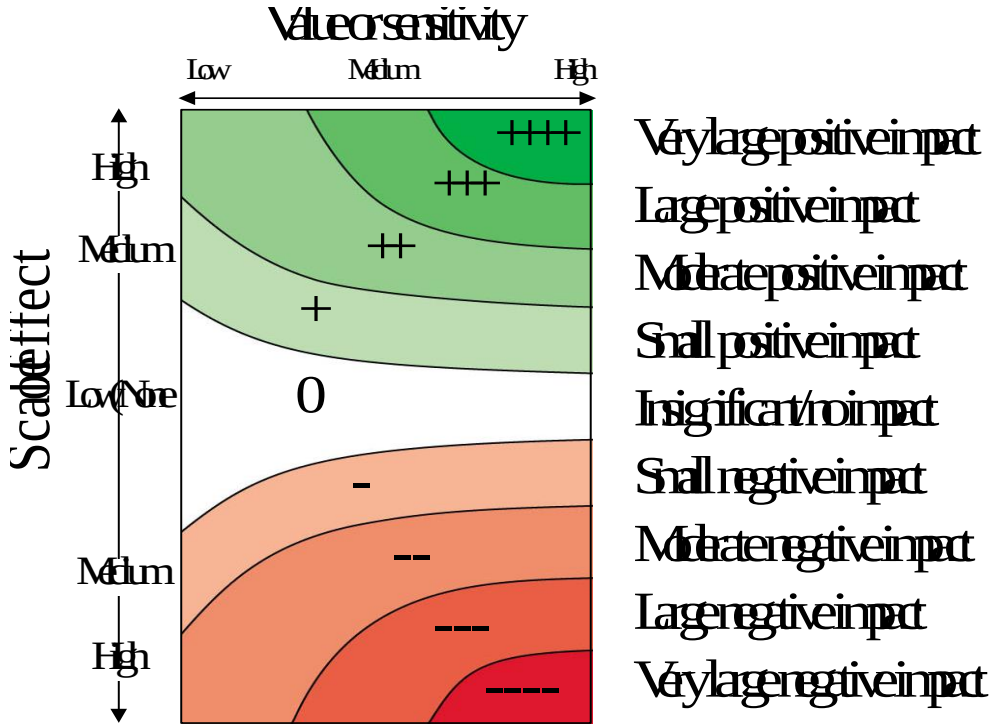
The value or sensitivity of an area is evaluated objectively, based on information compiled in the baseline study (Section 7).

2. Description of the extent of effect

The extent of the effect from the planned activity should be based on scientific documentation or, if not available, based on expert evaluations. The scale of this effect can range from very negative to very positive.

3. Establishing total impact

By combining 1) and 2) in the impact matrix, the total impact can be identified, which can range from a very large negative impact to a very positive impact.



By using this method, the same magnitude of effect may then give a different impact depending on the sensitivity of the impacted environment.

The impact is evaluated qualitatively in some cases, particularly where no criteria was available. In these cases, DNV made professional judgement, for example by comparison against benchmarks.

The following aspects are examined:

Table 17 Environmental Topics

Environmental & Socioeconomic Impacts	
Energy	This environmental appraisal calculates the energy and emissions to air during decommissioning based on a guideline published by the Institute of Petroleum [31]. The basis for calculations is the type and duration of operations/vessels, and applying standard calculation factors. The method takes a life-cycle perspective, including removal, dismantling and material handling until final disposal of the material. The method includes replacement energy if recyclable materials are not recycled. Data is based on Knarr-specific studies, plus lessons learned from actual projects.
Air Emissions	Direct emissions to air from decommissioning activities
Marine environment	Planned discharges to sea (and land) during the decommissioning include: • Pipe cleaning before removal / disposal • Treatment of water flows at land dismantling plants Impact assessment is done by studying the relevant emissions (type, amount, duration, toxicity, etc.) to the receiving environment (the water in the Knarr area has good circulation and good quality). Some decommissioning activities may involve physical interventions (e.g. dredging and/or moving/establishing rock cover. These activities can result in physical consequences such as covering of seabed with mud (cover and termination of local benthic fauna). Noise related to vessel activities, cutting and lifting may affect environmental receptors as fish and marine mammals.
Local communities	Relevant issues related to demolition plant activities include: • Noise related to vessel activities, lifting, cutting and material / waste handling • Dust Escape from dismantling activities • Odor associated with marine fouling degradation • Visual disturbance. It is not clear which onshore facility will be used, consequently, the impact assessments are made on a general basis. But the dismantling facility will be licensed, will discharge within permit conditions and will be monitored.
Waste management & resource use	The principles of the waste hierarchy are used for waste management. The purpose is to ensure the best environmental solution through optimized disposal solutions for the various waste streams, and verification of disposal.
Littering	Assessment of litter is limited to considering materials left behind.
Fisheries	Impact on fishing is assessed based on the type and extent of fishing; catch statistics and vessel tracking are used as the basis for the assessments.
Ship traffic	The effects of the decommissioning work upon ship traffic
Employment	Decommissioning works offer employment opportunities.

As per DESNZ guidance notes [3], there is "no expectation to assess all the options considered in the CA, or to assess the impact of accidental events. Under the Petroleum

Act 1998 there is a more straightforward requirement to undertake an assessment of the potential environmental impacts of the proposed decommissioning proposals".

9. Assessment of Environmental Impacts

9.1. Energy and Air Emissions (E&E)

This sub-section considers the energy consumption and emissions to air related to decommissioning and end disposal of the KGP and associated structures (Phases 1-3). Estimations are made for the preferred decommissioning option, and are based on the following approach and assumptions:

- Material inventory breakdown of the KGP pipeline and associated structures (PLEM, GRPs) from as-built documentation
- Vessel spread and duration of decommissioning activities from a KGP Decommissioning study [30]
- Daily fuel consumption, energy and emissions factors for vessels and material processing from Institute of Petroleum guidelines [31], and vessel specific / updated data as applicable.

Based on previous decommissioning projects, it is generally acknowledged that E&E estimates performed during the planning phase has an uncertainty range of 30-40% [32, 33], related to uncertainty of actual vessels being applied, weather conditions, etc.

9.1.1. Materials disposal

The recommended disposal solution implies that the PLEM structure, all GRP covers and spool #8 eventually will be recovered to shore. Removal of these facilities will be postponed and aligned with future FLAGS cessation of production, however the time aspect is not considered in this E&E assessment, but it is clear from Section 5.4 that most decommissioning activities – and hence most of the energy and emissions – will occur after FLAGS is decommissioned. Materials for disposal in place and removal to shore will be as per the table below. About 10% of the materials will be taken to shore for further material management (generally material recycling).

Table 18 Materials inventory KGP and associated facilities (tonnes)

KGP materials	Steel			Aluminium	Plastics	
End-disposal	KGP	PLEM	Spools	Anodes	KGP coating	GRPs
Remove to shore		91	6.2		0.2	37.5
Disposal in place	1,139		29.4	1	32	0
Sum	1265.6			1	69.5	

9.1.2. Decommissioning activities

The main decommissioning activities are:

- Cleaning the KGP pipeline
- Preparation for removal
- Removal and disposal work
- Post-disposal surveying and verification

These activities will be executed applying different maritime vessels for the offshore work and material deconstruction, transport and recycling activities onshore. Such activities require energy, normally fossil fuels (marine diesel) provide the energy source.

Cleaning of the pipeline was performed by pigging trains. A light construction vessel (LCV, *Edda Fauna*) was employed near the PLEM location to perform the pigging. The total duration of the cleaning activity was estimated to 13 days with the LCV on location. Since this vessel was located in UK waters (the pigs were driven towards Knarr FPSO located in Norway) the emissions are included in this E&E. Fuel consumption related to cleaning is about 45 percent of the overall fuel consumed by maritime vessels.

Vessels will further support activities on disconnection and preparing for removal of PLEM, GRPs and spool #8, and to install rock protection post removal (for which a licence will be obtained). An as-left survey will be executed, and a limited over-trawlability trial focussed on the small area of interest may be undertaken (as there are no key environmental sensitivities and the area involved is small). Whether an over-trawl operation is appropriate, or an alternative method employed, will be discussed and agreed with OPRED. The duration of the preparatory work and removal offshore was estimated to be about 20 days, including mob/demob and transit. Vessel activity related to monitoring between Phase 2 and 3 and post-decom surveys is not clarified hence not included in the overview.

Table 19 Vessel activities and duration

Vessel category	Activity	Duration
Light construction vessel	Cleaning	13
Multi construction vessel	Preparatory work, removal, rock installation	19
Trawler	Over-trawlability test	3
Survey vessel	As-left survey	3

9.1.3. E&E estimate

Energy consumption can be estimated based on the material inventory and vessel spread/duration factors as presented above.

The direct energy consumption is mainly related to marine operations (51%), with a limited amount related to material handling and recycling processes (2%). 47% of the overall energy balance is "replacement energy", energy to produce a similar amount of metals from ore from a life cycle perspective to replace materials left in situ [31].

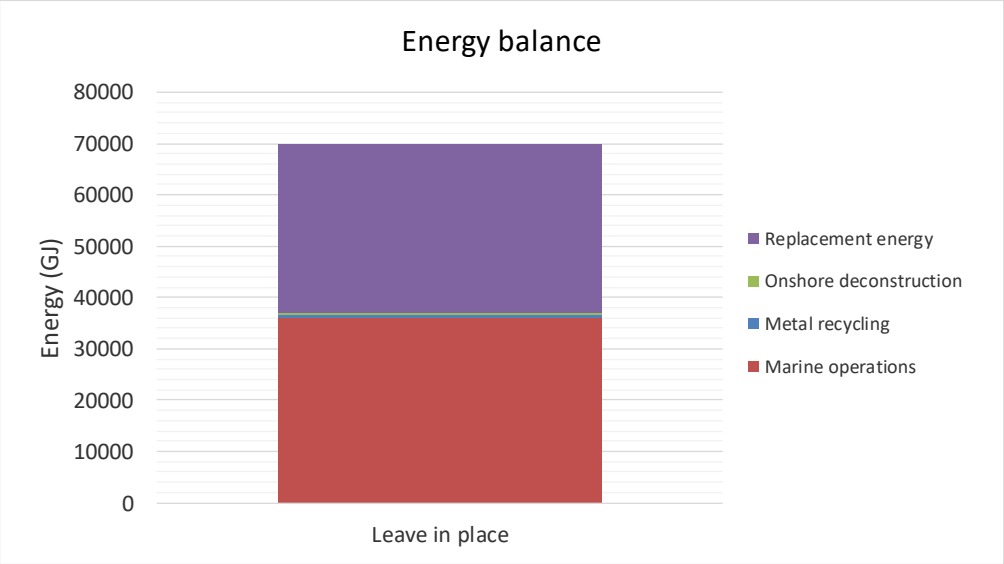


Figure 29 Energy balance for KGP decommissioning and end-disposal

Emissions to air are estimated for the direct energy consumption only (i.e. excluding the "replacement factor" part of the energy balance), as a best basis for assessing potential impacts. Fossil fuel will be the main energy source for the marine operations and part of the generic energy mix also for the metal processing. The main source of emissions to air is from the marine vessels' engines. An emissions estimate is presented in Table 20 based on standard emission factors [31] for generic activities and vessel specific factors for "Edda Fauna".

Table 20 KGP decommissioning and end-disposal – emissions to air

	CO_2	NO_X	SO_2
Marine operations	2634	77	2,2
Metal recycling	42	0,2	0,1
Onshore deconstruction	5	0,1	0,0

9.1.4. Environmental impacts

CO_2 emissions contribute to the global warming potential, however the KGP decommissioning contribution will be insignificant (cf. terminology in the assessment method, section 8) owing to the small scale of the activities, contributing approximately 2,700 tonnes. For comparison annual CO_2 (equivalent) emissions from UK oil & gas activities is about 15.7 million tonnes [34].

NO_X emissions can contribute to global warming potential (nitrous oxide), and nitrogen oxide may increase ozone which can potentially cause damage to crops/vegetation. The contribution from KGP decommissioning (77 tonnes) is insignificant (i.e., marginal vs. UK oil and gas industry emission at ca. 60,000 tonnes/year [34], and the distance to shore further prevents potential effects on vegetation.

SO_X emissions contribute to acidification/acid rain, however contribution from KGP decommissioning (ca. 2 tonnes) and distance to shore reduce the impact potential significantly. For comparison ca. 3,000 tonnes/year from UK oil & gas in 2017. Marine

vessels operating in the North Sea are required to use low sulphur fuel as per IMO requirements, hence the SO_X emission estimate provided is considered conservative.

In summary, the environmental impacts of energy and emissions from the decommissioning activities are insignificant.

9.2. Marine Environment

9.2.1. Cleaning KGP, Phase 1

Cleaning of the pipeline as part of decommissioning activities was by pigging (see Section 5.4.1) and the waste stream was managed at the Knarr FPSO on the NCS and be subject to Norwegian regulatory requirements. There was no discharges to sea on UKCS during cleaning. Gassco AS obtained the necessary permits from UK authorities for cleaning activities.

9.2.2. Marine & Physical Impacts from Decommissioning Activities, Phase 2 and 3

As described in Section 5.4.3, after CoP the decommissioning of the KGP will involve the relocation of small amounts of overburden soils and rock in a small area around Spool #7/PLEM (performed using a subsea dredger, for more controlled rock relocation due to the vicinity of live FLAGS). There will be a very small amount of dredging, cutting and lifting at this stage, and the very small quantity of spool material generated will need to come to shore.

Later once FLAGS has been decommissioned, the majority of the decommissioning activities will take place, when the PLEM, spool #8 and all the GRP covers will be recovered. This will require the clearance of residual quantities of rock cover/sediment (worst case 1,200 m^3) on top of the GRP covers using a WROV operated standalone dredge unit. The GRP covers will then be lifted by vessel main crane. The PLEM will thereafter be disconnected/cut from Spool #8, and the spool cut into manageable lengths for recovery to deck. The cutting will be performed using a subsea pipe cutter, and may result in small volumes of glycol being released to the sea when cutting spool #8; the necessary licence will be obtained from OPRED, and any chemicals used will be CEFAS registered. The piles securing the PLEM will be cut using an internal cutting tool (prior to cutting, the soil plug within the pile will be removed using a standalone dredge unit and a high flow water jetting pump). The PLEM will then be lifted to deck and brought to shore.

The above activities, particularly the dredging, will result in swirling and resuspension of sediment, and re-sedimentation, covering any immovable immobile organisms. But as detailed in Section 7, in this part of the NNS on the UKCS:

- there do not appear to be any benthic species listed for their conservation value; characteristic infaunal species include polychaetes (tube worms)
- DNV did not identify any environmentally sensitive habitats in proximity to the KGP, with the closest protected area more than 90 km away.
- Sediments consist of moderately well sorted, fine to very fine sands, which contain a relatively low proportion of organic matter and coarse material, with moderate amounts of fine and shelly material. This implies that generally the sediments at the project area are not characteristic of those prone to adsorbing hydrocarbons or heavy metals.

Because the decommissioning activities are relatively minor in nature, the disturbed sediment is uncontaminated, and the receiving environment is not particularly sensitive, the resulting environmental impact is anticipated to be small (cf. terminology in the assessment method, section 8), localised and temporary in nature.

9.2.3. Long term legacy impacts

There are potential long-term environmental impacts that can result from the 11.6 km of KGP being left in situ on UKCS, once the pipe degrades in the distant future.

The magnitude of scale, deposits and hydrocarbon residues in gas pipelines is generally less than in oil pipelines [35], however some deposits should be expected for KGP. The Knarr gas composition includes some mercury. A mercury cleaning arrangement with filter was commissioned at the Knarr FPSO in March 2018 and is currently removing 60-70%. Some mercury has however entered KGP during the years in operation, some will have passed through the system with the gas, some may have adhered to the pipe wall, some bound chemically to corrosion products, while some may have accumulated in the steel (chemical reaction with irreversible bindings at normal temperatures [36]).

The magnitude of mercury accumulation in the KGP steel pipe is very uncertain and is not possible to measure while the pipeline is still in operation. Literature refers to measurements and studies where mercury mainly adsorbes to the steel wall and binds chemically to corrosion products, as HgS (which requires the presence of H_2S in gas, and which is limited for Knarr gas). To a minor extent only will mercury diffuse into and/or be chemically bound to the actual steel [37].

Based on actual mercury concentrations in the Knarr gas and exported gas, a maximum 20 kg mercury is estimated to have entered the KGP over its lifetime. Literature suggests that 10-40% may have passed through the system, the remaining in general deposited and some possibly accumulated in the steel – divided over the 105.7 km long pipeline. Conservatively estimated, and with an even distribution in the steel, full accumulation in the steel pipe corresponds to a mercury concentration in the magnitude of 0.8-2.6 mg/kg. In practice, less mercury will have accumulated as some mercury will have passed through the system and/or deposited in the pipeline, as mentioned above. For comparison, the normal background level of mercury in North Sea sediments is 0.05 mg/kg [38] and the EU limit for mercury to be classified as a hazardous waste is 2500 mg/kg [39]. Some of the deposited mercury will be removed during the pigging operation, while some will likely remain adhered to the steel wall or accumulated in the steel pipe.

In the long term the steel will be subject to corrosion processes and the mercury is expected to form part of the corrosion products (see below). Since the pipeline is entirely buried/rock covered, no exposure of mercury to the biotic environment is expected.

For in situ disposal of KGP the pipeline will be subject to a long-term degradation process. This process is normally very slow and depends on different factors, mainly depending on characteristics of the actual materials and the in situ environmental characteristics. Normally the sacrificial anodes will degrade first, followed by corrosion of steel on any exposed areas, and finally corrosion of the entire steel pipeline. Generic corrosion rate for unpainted steel exposed to seawater without cathodic protection is in

the magnitude of 0.1-0.15 mm/year. With active cathodic protection the rate can be assumed to less than 0.01 mm/year for areas exposed to seawater.

Further degradation of the pipeline beyond the degradation of the sacrificial anodes depends on the condition of the coating (2-4 mm polypropylene layer). Polypropylene is a persistent plastic product, and direct effects on the marine environment is not expected from slow erosion/degradation of such. The degradation products will however contribute to the creation of micro plastic, which is a global environmental issue. The contribution from KGP will however be negligible in such context, as the pipeline is buried/cover.

Following the long-term degradation of the pipeline, metal products will be deposited and/or dissolved to local sediment and/or water, depending on degree of exposure and/or coverage [40]. Trace metals in sacrificial anodes are primarily considered having potential for toxicological effects on marine organisms [41]. The KGP anodes are made of aluminum with 2-3% zinc and insignificant concentrations of trace metals. Diffusion/leakage of metal from the pipelines is expected to continue over a period for several hundred to possibly thousands of years [42], until the pipeline is completely degraded. For a buried pipeline the degradation process will be very slow.

The KGP on the UKCS is rock covered, hence isolated from the external biotic environment. Metal products will thus mainly be trapped in local sediments rather than exposed to the marine environment, being dissolved into the water masses and spread.

With reference to the terminology in the assessment method, section 8, the long term legacy impacts are considered small.

9.3. Waste

The materials inventory provided in Table 7 shows that the materials that will come to shore are approximately 97 t of steel and 37.5 t of GRP covers; this represents approximately 8.5% of the total inventory of the UKCS KGP facilities (1,566 t, including concrete mattresses). The remainder of the facilities will be left in situ.

The steel is of standard quality and will be easy to recycle (re-melt). Parts of the spools removed to shore may contain minor amounts of mercury. Mercury levels will be measured, and waste management solutions will be developed in accordance with regulatory requirements.

GRP fiberglass covers will, if possible, be reused, and if not, then they will be used either in energy recovery (the organic part will combust), or cut and milled up and included in cement production (reduces need for lime, sand and aluminum oxide (Holcim, 2010).

Owing to the small volumes involved, there is only an insignificant to small environmental benefit from recycling the waste (cf. terminology in the assessment method, section 8).

9.4. Littering

As part of the decommissioning programme, surveys and verification will be undertaken to ensure that the area is cleared. The surveys will be conducted to identify and recover

any debris located on the seabed which resulted either from the decommissioning operations or from past development and production activities. Debris survey and removal will take place along a 100m corridor (50 m either side) of the KGP decommissioned pipeline over its whole length on the UKCS. The KGP pipeline and spools left behind will be under rock cover. Therefore, there will be no littering – no impact cf. terminology in the assessment method, section 8.

10. Assessment of Societal Impacts

10.1. Fishing Vessels

Any assessment upon fishing vessels needs to consider the baseline. As mentioned in Section 7.6.1, most fishing activity along the KGP is on the Norwegian side. Analysis of bottom trawling statistics over a 2-year period on the UK side shows the number of passes is only about one per week over the whole 11.6 km of the KGP on the UKCS. The 2016 data presented in Figure 28 also shows the vast majority of trawling to be on the Norwegian side, and trawling on UK side to have reduced since 2014/2015.

There will be a small amount of vessel activity during the decommissioning, as described in Section 9, which will require 1 to 2 vessels in the area. The duration of the cleaning, preparatory work and removal offshore is short and is estimated to be about 32 vessel-days in total in the UKCS, including mob/demob and transit. The short-term effects on fishing from the limited vessel activity are thus negligible.

The PLEM, Spool #8 and all the GRP covers will be removed, and hence do not present a threat on fishing.

Exposed pipelines that remain in situ can potentially cause problems for bottom trawl fishing by sliding trawl doors out of position and/or being hooked [43, 44, 45], especially at low crossing angles [46]. However, the KGP left in situ on UKCS is fully covered by rock and thus does not affect bottom trawl fishing. Rock fillings can also cause disadvantages for some types of bottom trawl fishing [47] but are generally preferred to exposed pipelines. As the steel in the KGP breaks down, it will be protected by the overcoating and it is not considered likely that pipe fragments will be exposed. The abandonment of a fully buried / covered KGP is therefore considered not to pose significant problems for the practice of bottom trawling, either in the short or long term, i.e., insignificant (cf. terminology in the assessment method, section 8).

10.2. Shipping

There will only be a small amount of vessel activity during the decommissioning, as described in Section 9, which will require 1 to 2 vessels in the area. The duration of the cleaning, preparatory work and removal offshore is short and is estimated to be about 32 vessel-days in total in the UKCS, including mob/demob and transit. The short-term effects on shipping from the limited vessel activity are thus negligible, particularly as there is generally little passing ship traffic in the area. And after decommissioning is complete, there are very few activities, thus no impact to ship traffic (cf. terminology in the assessment method, section 8).

10.3. Local communities

The amount of equipment to be removed, divided and sorted ashore is very minor (~134 tonnes in total) and very limited compared to (e.g.) a decommissioning project for fixed steel installations with large deck systems. Activity on land is therefore similarly limited both in scope and duration. Additionally, the onshore facility will be subject to environmental permit conditions and to operational procedures.

Consequently, potential negative effects onshore such as increased traffic congestion, odour, dust, noise are considered insignificant (cf. terminology in the assessment method, section 8).

10.4. Employment

There will only be a small amount of vessel activity in the UKCS during the decommissioning for a short period of time (~32 vessel-days). Additionally, the amount of equipment to be removed, divided and sorted ashore is very minor (~134 tonnes in total).

Thus, the effects both through direct employment and the effects of local business activity are correspondingly insignificant (cf. terminology in the assessment method, section 8).

11. Impact Summary

11.1. Summary of Impacts

In Sections 9 and 10, the environmental and societal consequences of the preferred decommissioning option have been considered and assessed.

The figure below provides an illustrative view of the overall impacts of the preferred decommissioning option. It shows that the preferred decommissioning option has only negligible or small localised environmental and social impacts, in both the short and long term.

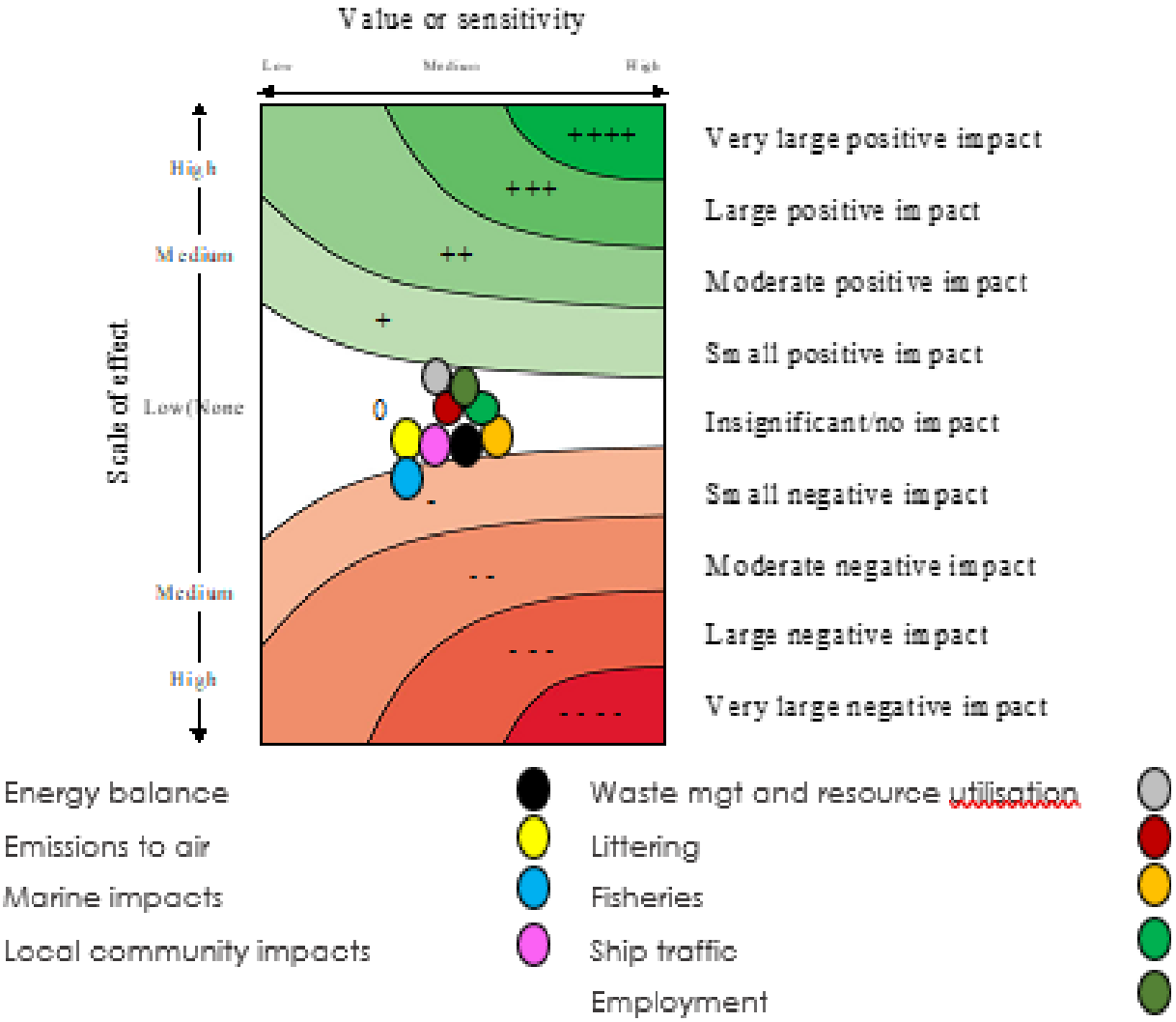


Figure 30 Summary of Impacts – preferred decommissioning option

It should be noted that most decommissioning activity will be delayed until the nearby FLAGS pipeline is decommissioned, as this will eliminate risks attendant with removal works near live, hydrocarbon containing infrastructure. As such, the decommissioning of the Knarr Gas Pipeline and associated facilities will occur in three phases:

1. Phase 1; following cessation of production (CoP) on the Knarr field. This involved isolation of the KGP at the Knarr Tee and PLEM from downstream infrastructure, the installation of a pigging spread at the Knarr PLEM and cleaning and flushing of the KGP back to the Knarr FPSO. *Phase 1 was* performed from 1st (CoP) to 18th (FPSO sail away) of May 2022. This phase was completed under PWR submitted by Gassco AS on 29/04/2021.

2. Phase 2; a minor section of the spool #7 will physically be cut and disconnected from PLEM, retrieved and transported to shore (Norway). This is scheduled to be completed before Q4 2025.

3. Phase 3; At FLAGS cessation of production: Pipe Spool #8 & all GRP covers would be removed at the same time as the PLEM.

A first Decommissioning Programme (DP) for the Knarr facilities in the UK sector covers phases 1 and 2, and a second DP will be submitted for phase 3. This Environmental Appraisal assesses the environmental impacts associated with both phases of decommissioning. It concludes that the three decommissioning phases will have only negligible or small localized impacts.

To the best of our knowledge there is no major large-scale projects or any other industry nearby and given the small nature of Phase II works there is no cumulative impacts.

11.2. Remedial measures

In the planning and implementation of the removal of the PLEM, Spool #8 and the GRP covers on the UKCS, efforts will be made to coordinate removal activities to help achieve shorter duration of maritime activities, and thus reduced emissions and cost savings.

After removing these items, final verification and inspection will be carried out to ensure they are in accordance with plans, commitments and regulatory requirements.

Additionally, methods will be studied to ensure that as much as possible of any adsorbed and corrosion linked mercury in the KGP system is removed and handled. And when handling and managing Spools #7 and #8 and the PLEM, there will be focus on the possible presence of mercury. This will be clarified (mercury levels will be checked) before any hot work is started onshore, in order to avoid any harmful mercury vapours to air (potentially a human health issue). Waste and any contaminated equipment will be disposed of in accordance with the waste regulations.

11.3. Post Decommissioning Surveys and Monitoring

A post decommissioning survey will be undertaken after this DP, during the time period until the next DP following FLAGS CoP, and after the future DP for removal of the PLEM. Details on surveys and post decommissioning monitoring are further addressed in sections 5.4.4 and 5.4.5.

Agreements will be entered into with licensees for pipelines over which KGP crosses, to ensure a future-oriented and lasting final disposal, and to avoid unforeseen future costs. Agreements will also be concluded with Shell UK Ltd, for any KGP decommissioning activities related to the operational FLAGS pipeline.

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