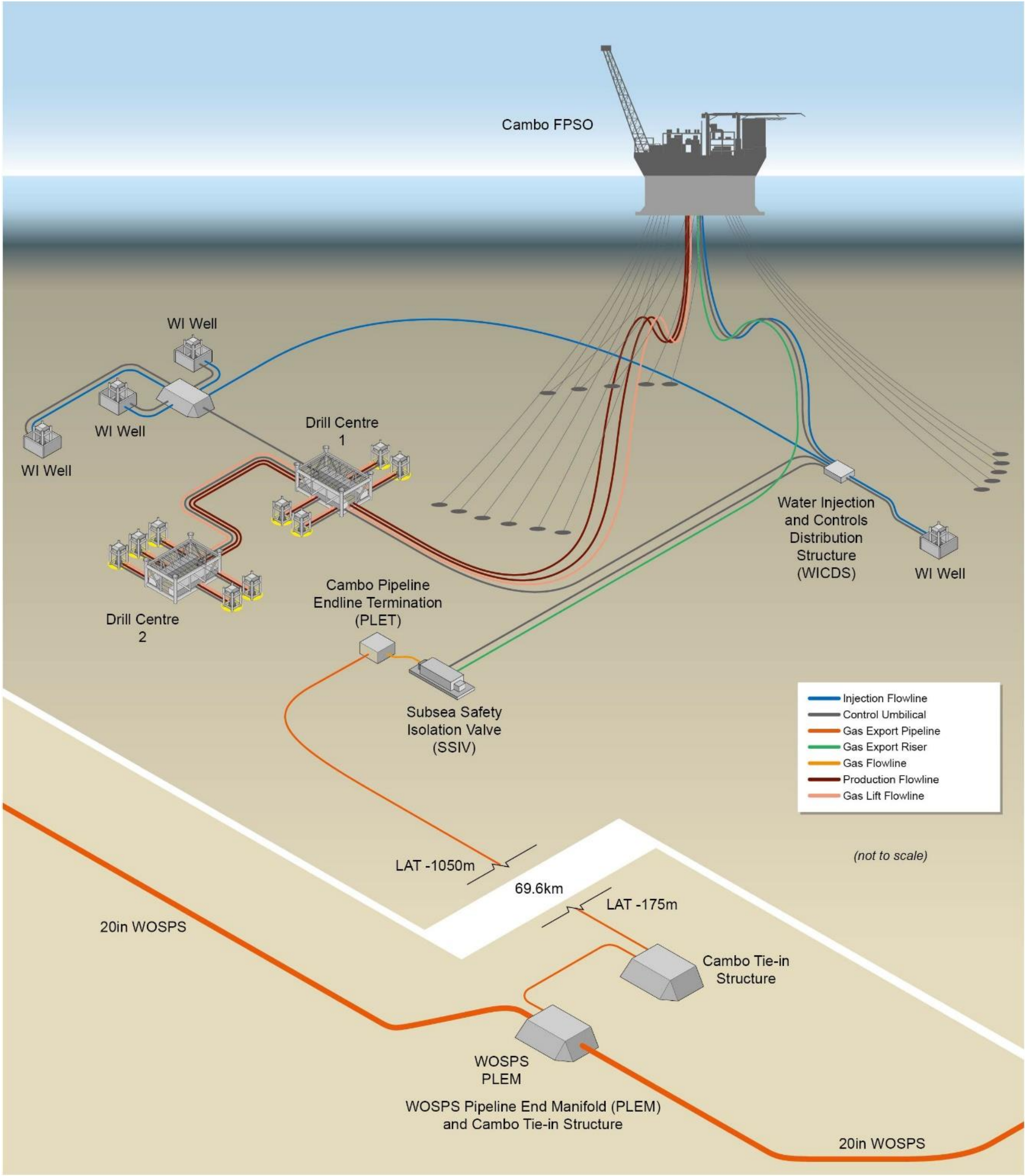
SICCAR POINT ENERGY

Cambo Oil Field, UKCS Blocks 204/4a, 204/5a, 204/9a and 204/10a

Environmental Impact Assessment (EIA)



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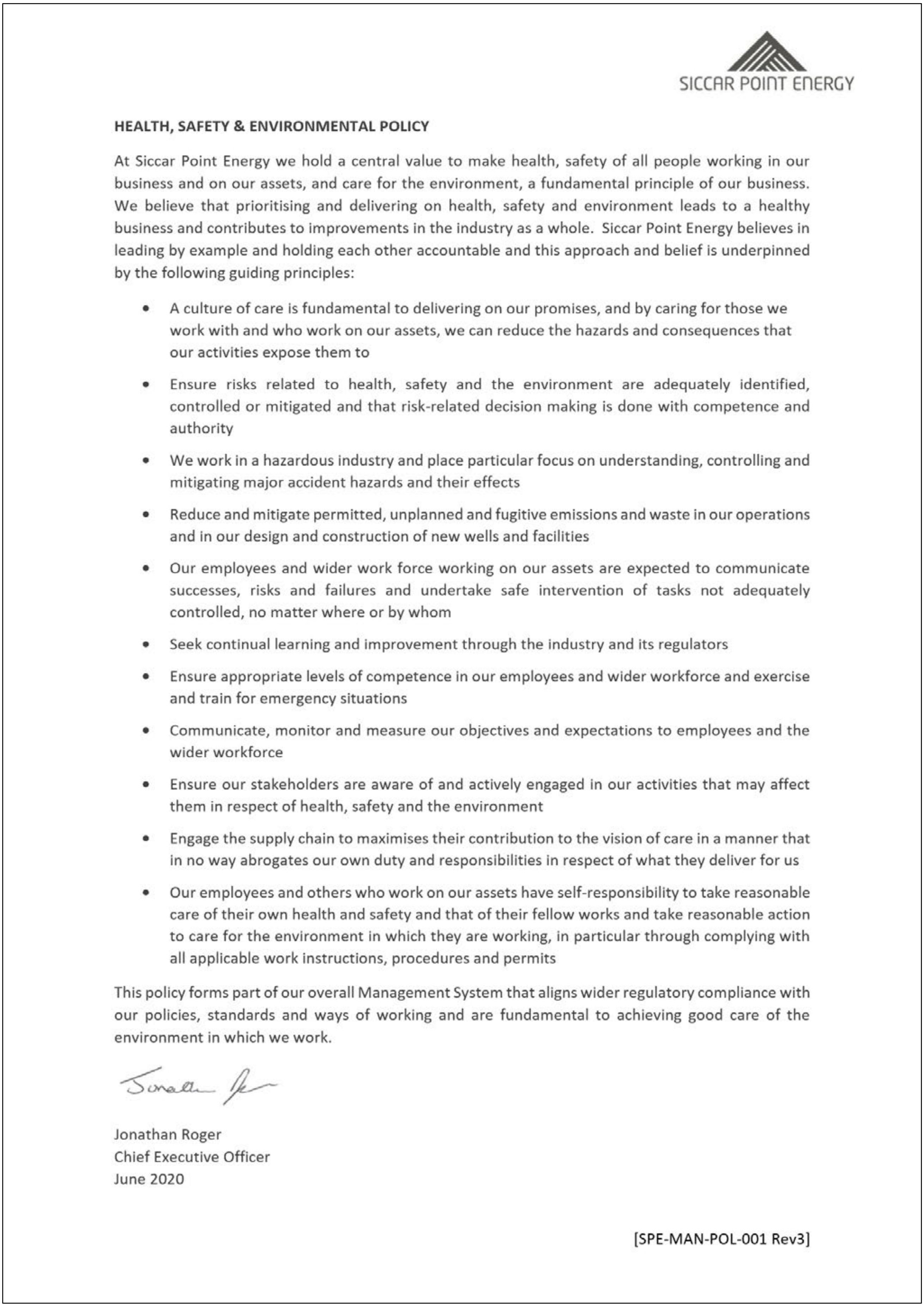

HEALTH, SAFETY & ENVIRONMENTAL POLICY

At Siccar Point Energy we hold a central value to make health, safety of all people working in our business and on our assets, and care for the environment, a fundamental principle of our business. We believe that prioritising and delivering on health, safety and environment leads to a healthy business and contributes to improvements in the industry as a whole. Siccar Point Energy believes in leading by example and holding each other accountable and this approach and belief is underpinned by the following guiding principles:

- A culture of care is fundamental to delivering on our promises, and by caring for those we work with and who work on our assets, we can reduce the hazards and consequences that our activities expose them to
- Ensure risks related to health, safety and the environment are adequately identified, controlled or mitigated and that risk-related decision making is done with competence and authority
- We work in a hazardous industry and place particular focus on understanding, controlling and mitigating major accident hazards and their effects
- Reduce and mitigate permitted, unplanned and fugitive emissions and waste in our operations and in our design and construction of new wells and facilities
- Our employees and wider work force working on our assets are expected to communicate successes, risks and failures and undertake safe intervention of tasks not adequately controlled, no matter where or by whom
- Seek continual learning and improvement through the industry and its regulators
- Ensure appropriate levels of competence in our employees and wider workforce and exercise and train for emergency situations
- Communicate, monitor and measure our objectives and expectations to employees and the wider workforce
- Ensure our stakeholders are aware of and actively engaged in our activities that may affect them in respect of health, safety and the environment
- Engage the supply chain to maximises their contribution to the vision of care in a manner that in no way abrogates our own duty and responsibilities in respect of what they deliver for us
- Our employees and others who work on our assets have self-responsibility to take reasonable care of their own health and safety and that of their fellow works and take reasonable action to care for the environment in which they are working, in particular through complying with all applicable work instructions, procedures and permits

This policy forms part of our overall Management System that aligns wider regulatory compliance with our policies, standards and ways of working and are fundamental to achieving good care of the environment in which we work.

Jonathan Roger
Chief Executive Officer
June 2020

[SPE-MAN-POL-001 Rev3]

ENVIRONMENTAL STATEMENT - SUBMISSION SUMMARY

THE OFFSHORE OIL AND GAS EXPLORATION, PRODUCTION, UNLOADING AND STORAGE (ENVIRONMENTAL IMPACT ASSESSMENT) REGULATIONS 2020

SUBMISSION OF AN ENVIRONMENTAL STATEMENT IN SUPPORT OF AN APPLICATION FOR THE CONSENT OF A PROJECT UNDER THE PETROLEUM ACT 1998 OR THE ENERGY ACT 2008

Section A: Administrative Information

A1 – Project Reference Number

Number D/4261/2021

A2 - Applicant Contact Details

Company name: Siccar Point Energy E&P Limited

Contact name: [redacted]

Contact title: [redacted]

A3 – ES Contact Details

Company name: As above

Contact name: [redacted]

Contact title: [redacted]

A4 – ES Preparation

Key expert staff involved in the preparation of the ES:

Name	Company	Title	Relevant Qualifications/Experience
[redacted]	Fugro GB Marine Limited	[redacted]	[redacted]
[redacted]	Fugro GB Marine Limited	[redacted]	[redacted]
[redacted]	Fugro GB Marine Limited	[redacted]	[redacted]
[redacted]	Siccar Point Energy E&P Limited	[redacted]	[redacted]
[redacted]	Siccar Point Energy E&P Limited	[redacted]	[redacted]

A5 - Licence Details

a) Licences covering proposed activities

Licence numbers: P1028 and P1189

b) Licensees and current equity

Company	Percentage Equity
Siccar Point Energy E&P Limited	70%
Shell U.K. Limited	30%

Section B: Project Information

B1 - Nature of Project

a) Name of the project: **Cambo Phase 1 Field Development**

b) Name of the ES: **As above**

c) Brief description of the project:

SPE plans to develop the Cambo field in order to produce the oil and gas contained in the reservoir. The field will be developed using a dedicated, moored Floating Production, Storage and Offloading (FPSO) vessel to produce hydrocarbons from two drill centres. Oil will be exported via shuttle tanker. Gas will be exported via a new gas export pipeline which will tie into the West of Shetland Pipeline System.

Offshore development activities are due to commence at the Cambo field in 2021, with first drilling operation in 2022. First oil is expected in 2025.

B2 - Project Location

a) Offshore location of the main project elements

Geodetic Datum: ED50, UTM zone 30, CM 3°E					
Oil Field	**UKCS Block**	**Easting [m]**	**Northing [m]**	**Latitude**	**Longitude**
Cambo FPSO	204/10a	439000.0	6742200.0	60° 48’ 32.606” N	004° 07’ 15.941” W
Cambo Gas Export Pipeline End Termination (PLET) (infield start of pipeline)	204/10a	438521.7	6742600.4	60°48'43.103" N	004°7'54.916" W
Cambo Gas Export Pipeline Termination – WOSPS Pipeline End Manifold (PLEM) (end)	205/21	455433.0	6683277.0	60° 16' 56.182" N	003° 48' 21. 094" W

Development of the Cambo oil field in Blocks 204/4a, 204/5a, 204/9a and 204/10a, in the west of Shetland region of the United Kingdom Continental Shelf (UKCS). The proposed infield development location is centred approximately 125 km to the west of the Shetland Islands, in a water depth of 1050 m to 1100 m. The scope of the development also includes an export pipeline route extending 70 km to the southeast of the Cambo field, and will terminate at the West of Shetland Pipeline End Manifold tie-in.

B3 – Previous Applications

Name of project:

Cambo Phase 1 Field Development Environmental Statement.

Date of submission of ES:

29th October 2019.

Identification number of ES:

D/4240/2019.

Please note that Environmental Statement (ES) Ref. D/4240/2019 was previously submitted under the Offshore Petroleum Production and Pipelines (Assessment of Environmental Effects) Regulations 1999 (as amended) and was awaiting approval at the end of 2020. However, the ES was required to be resubmitted following the replacement of these Regulations by the Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020, and because the ES was not regarded as a transitional case under these Regulations.

TABLE OF CONTENTS

TABLE OF CONTENTS CONTINUED

TABLE OF CONTENTS CONTINUED

TABLE OF CONTENTS CONTINUED

TABLE OF CONTENTS CONTINUED

TABLE OF CONTENTS CONTINUED

APPENDICES

Non-Technical Summary

NON-TECHNICAL SUMMARY

This environmental statement presents the findings of the environmental impact assessment conducted by Siccar Point Energy E&P Limited (SPE) for the development of the Cambo oil field in Blocks 204/4a, 204/5a, 204/9a and 204/10a, in the West of Shetland region of the United Kingdom Continental Shelf (UKCS). The proposed infield development location is centred approximately 125 km to the west of the Shetland Islands, in a water depth of 1,050 m to 1,100 m (Figure 1). The purpose of this environmental statement is to provide an assessment of the potential environmental effects that may arise from the proposed drilling, installation and production operations and to identify measures which will be put in place to minimise these effects.

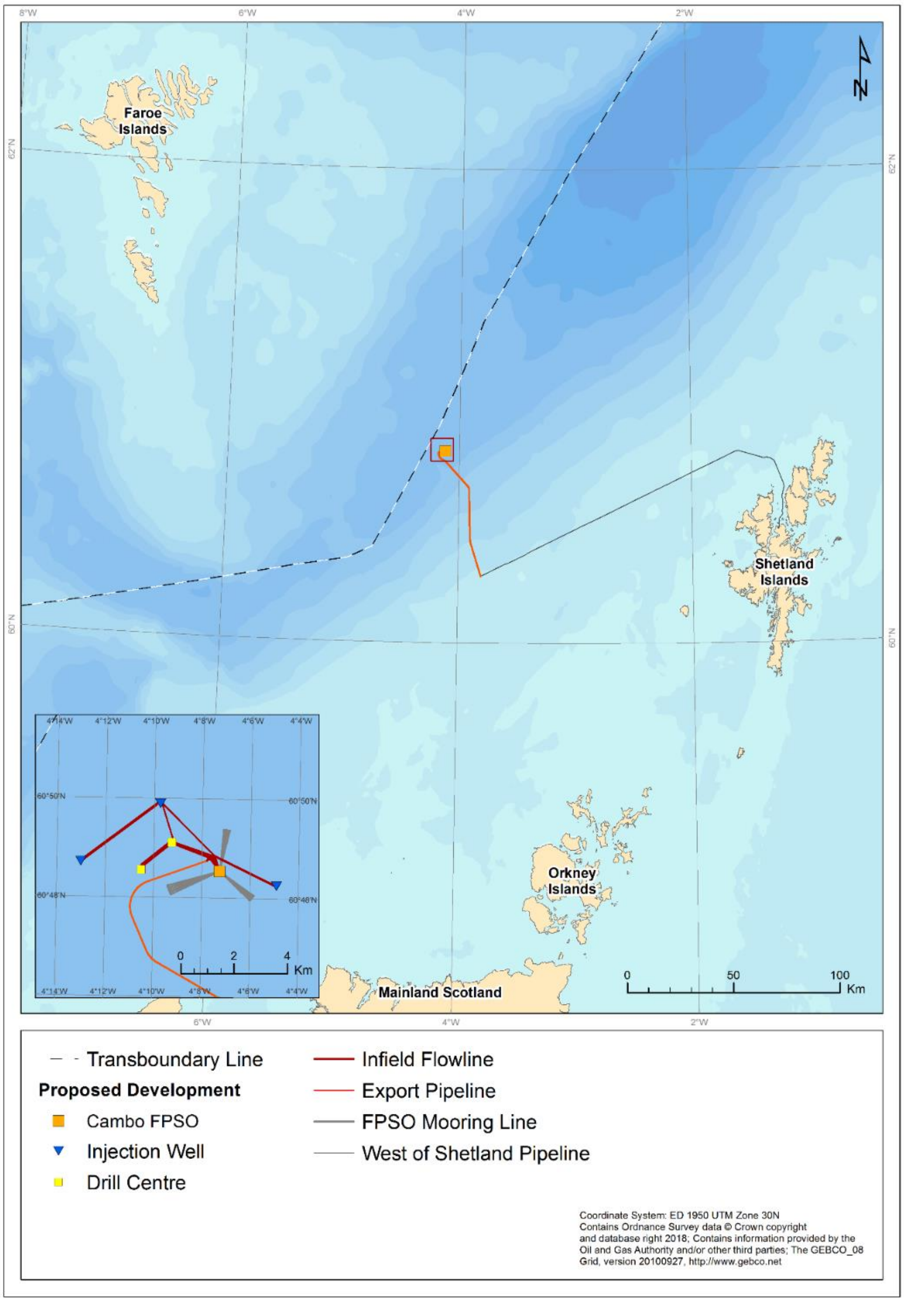

Figure 1: Location of the Proposed Cambo Field Development

The Environmental Impact Assessment Process and Environmental Management

Offshore oil and gas activities can involve a number of environmental interactions and impacts due, for example, to operational emissions and discharges and general disturbance. The objective of the Environmental Impact Assessment process is to incorporate environmental considerations into the project planning and design activities, to ensure that best environmental practice is followed and ultimately to achieve a high standard of environmental performance. The process also provides for the potential concerns of stakeholders to be identified and addressed, as far as possible, at an early stage. In addition, it ensures that the planned activities are compliant with legislative requirements and SPE's own management procedures.

All project activities are carried out in accordance with SPE's Health, Safety & Environmental (HSE) Policy. The HSE Policy forms part of the company's overall Management System and aligns wider regulatory compliance with its own policies, standards and ways of working, in order to achieve good care of the environment. The environmental performance of any third parties contracted to support SPE activities will be controlled under the auspices of this Policy.

SPE reviews the impact all activities may have on the environment and ensures that all environmental risks are adequately identified, controlled or mitigated to an acceptable level by way of formal assessment.

SPE proposes to appoint a third party 'Well Operator' to drill the wells and prepare them for production. Another third party 'Installation Operator' will be appointed to operate the proposed Cambo Field Development on behalf of SPE.

All operational activities undertaken on behalf of SPE will be managed under the appointed Installation/Well Operator's Environmental Management System. Third parties will need to demonstrate to SPE that an Environmental Management System certified (and verified by an external verification company) to the International Standard for Environmental Management Systems, ISO 14001:2015, is in place and implemented.

Specific environmental management activities relating to operational activities will be taken forward in an Environmental Management Plan which will incorporate the mitigation, control and monitoring measures identified in this environmental statement as well as the responsibilities for implementation.

The Proposed Operations

The proposed Cambo field development comprises a Floating Production, Storage and Offloading vessel (FPSO), two subsea drill centres with nine production wells in total, four water injection wells and a gas export pipeline. Hydrocarbons will be produced from the two drill centres into the FPSO. Onboard the FPSO the produce oil and gas will be separated and the oil stored onboard the FPSO. The FPSO will be periodically visited by a shuttle tanker to take off the oil. The produced gas will be used to power the equipment onboard the FPSO, with the remainder of the gas being exported via a 70 km pipeline into the West of Shetland Pipeline System. The wells will be drilled using a Mobile Operated Drilling Unit (MODU). Once the Cambo reservoir starts producing water along with the oil and gas this water will be separated out as well and cleaned-up to contain less than 15 mg/l of oil (on a monthly average basis), before being discharged overboard.

SPE is currently planning to commence offshore development activities at the Cambo field in 2021, with first drilling operation in 2022. First oil is expected in 2025. At present, it is anticipated that this development will be in production until 2050.

Option Selection

Developing the Cambo Field Development will support the objectives of the UK's current energy policy, as set out in the Oil and Gas Authority (OGA) document, The Maximising Economic Recovery Strategy for the UK. The strategy's oil and gas objectives aim to ensure the UK secures a resilient and diverse energy supply, in both the domestic and international markets, and maximises the economic recovery of the UK's existing reserves as part of the wider energy strategy.

Whilst not developing the Cambo Field would avoid any potential for environmental impact, it would prevent the production of oil and natural gas from the Cambo field that would help to meet the UK's energy needs and would not provide any economic benefit.

Various options for the field development were evaluated in terms of technical feasibility, environmental impact, health and safety, reputation and cost. The environmental assessment process was initiated early in the planning stage to support the option selection process, and actively drive mitigation measures, where certain impacts could not be avoided.

A detailed option selection process has been conducted throughout the Cambo project, and the main considerations relating to environmental impacts are summarised below.

Field Development Concept

A number of scenarios for field development have been considered for the Cambo field, including:

- Early Production System;
- Full Field Standalone Development;
- Hub Development;
- Full Stream Tie-Back;
- Long Range Tie-Back to Shallow Water Platform;
- Phased Development.

Due to the water depth at the Cambo field (approximately 1,100 m), areal extent of the field and the low well density and shallow nature of the Cambo reservoir, all concepts were centred on a wet subsea production system with surface processing facilities. The conclusions from the evaluation showed that while all options were technically feasible, a phased development on a standalone basis was preferred based on the following key decision criteria:

- Improved confidence/understanding of the Cambo reservoir, deliverability and recoverable resources through the successful drilling and test of the Cambo 204/10a-5Y well;
- More substantive initial phasing supports incorporation of features to reduce environmental impact;
- Phasing allows managed development of the full field/optimisation of field infrastructure and environmental footprint.

This set out the base case for the remainder of the option selection process.

Drilling and Well Design

The proposed Development facilities will not have any drilling capability and therefore a MODU will be required to drill the wells. Due to the water depth, floating MODUs are the only feasible option. Furthermore, a Dynamically Positioned (DP) floating MODU (as opposed to wire/chain moored) can be positioned more readily between the various drilling locations at the field and reduces the potential environmental impacts from anchors. The nature of the drilling programme is such that MODU moves will be frequent. Two MODU types considered were a DP semi-submersible drilling rig or a DP drill ship.

The key criteria considered when reviewing the type of MODU to use included:

- Deepwater capability;
- Favourable motion characteristics under harsh weather conditions West of Shetland and likely weather uptime;
- Operational efficiency in subsea completions and subsea tree installations.

Assessment concluded that the semi-submersible hull design had significant benefits as it offered a greater stability/improved vessel motion response to Cambo field metocean conditions, resulting in higher uptime/reduced risk of frequent disconnection compared to ship-shaped MODUs. This was supported by other operator experiences in deployment of DP drill ships at the Rosebank field and other west of Shetland locations.

Two options were identified for drilling fluids:

1) Water Based Mud (WBM) with treated cuttings disposal to sea;
2) Low Toxicity Oil Based Mud (LTOBM) with either skip and ship to shore or offshore clean-up/disposal to sea.

The drilling fluid design will follow Option 1, the concept proven in Cambo offset wells. The use of WBM has been very successful in meeting drilling objectives while providing the benefit of lower environmental risk as a consequence of reduced cuttings handling, treatment and transportation requirements.

Reservoir Management

Four options were considered for the depletion strategy for Cambo:

1. Natural depletion;
2. Water injection;
3. Gas injection;
4. Enhanced oil recovery.

Based on the goal of maximizing economic oil recovery, water injection (Option 2) is the preferred depletion strategy.

Produced Water Management

Produced water comprises Cambo formation water plus gradually increasing quantities of injection water over the life of field. A range of options were considered for the management of production and the disposal of produced water, summarised as follows:

- Minimisation of produced water production during operations;

- Produced Water Reinjection (PWRI) to producing formations;
- Produced water injection into a non-producing formation via disposal well(s);
- Treatment and overboard discharge to sea.

Two options for produced water management were taken forward for further assessment for Cambo; produced water re-injection (PWRI) into the Cambo producing formation (Option 1) and produced water disposal to sea (Option 2). Both options were assessed, applying the principles of BAT/BEP and considering technical viability and risk. Based on the assessment, Option 2 - produced water clean-up and discharge to sea has been selected for the development based on the following main factors:

1. Reservoir Souring;
2. Reservoir Injectivity.

Given its relative low temperature, the Cambo reservoir conditions are favourable to Sulphate Reducing Bacteria (SRB) activity. The reservoir fluids, whilst initially ‘sweet’, are expected to ‘sour’ with Hydrogen Sulphide (H_2S) generation resulting from water injection activity This would be significantly exacerbated by injecting produced water back into the reservoir, and hence the selected option is to clean the produced water to less than 15 mg/l oil content and discharge it sea.

The Cambo reservoir is characterised by relatively weak, unconsolidated rock. As a consequence, downhole sand control and stringent adherence to water injection specifications are required to maintain injectivity and reduce the risk of out of zone injection. Therefore, in order to maintain injectivity and hence pressure support, it is preferred to inject filtered and treated seawater to reduce otherwise likely permeability impairment and poor operability of produced water re-injection systems (by sand/fines and/or residual oil in injected produced water).

To reduce the potential for H_2S production in the reservoir any seawater must be treated before being injected into the wells. The three options considered were:

1. Continuous biocide injection;
2. Low sulphate seawater injection;
3. Nitrate injection.

Due to the reservoir characteristics, neither continuous biocide injection nor nitrate injection were considered technically viable. Continuous biocide injection is not a proven technology in a sandstone reservoir such as that found in the Cambo field and nitrate injection was rejected as it was not proven technology at the low Cambo reservoir temperatures. Low sulphate seawater injection (Option 2) was therefore selected as the souring control measure.

Host Facilities

Due to the water depth at the Cambo field, host options focussed on permanently-moored floating systems. Fixed structures (e.g. compliant tower or similar) at the Cambo field location were discounted given the water depth and environmental conditions in the area. To date no such platforms have been deployed at these water depths and in comparable metocean conditions. Non-permanently moored floating options e.g. units operating with dynamic positioning were also ruled out for safety and reliability reasons.

Several floating concepts were considered for the proposed Development:

1. A semi-submersible platform;

2. A Floating Production Storage and Offloading (FPSO) vessel;
3. Single Point Anchor Reservoir (SPAR) platform;
4. A Tension Leg Platform (TLP).

Each concept was examined to determine its suitability for the development.

Option 2: FPSO, was selected on the basis that this is a well-proven concept already delivered into the West of Shetland area on the UKCS.

The large areal extent and relatively shallow depth of the Cambo reservoir is such that it is not possible to fully develop the field from a single drill centre. When considering which subsea system to deploy at the Cambo field, SPE considered three principle options:

1. Individual well tie-backs to the host facilities;
2. Close-clustered wells and subsea manifolds;
3. Subsea templates.

A subsea manifold (at each drill centre) is a structure consisting of pipework and valves designed to transfer oil and gas from individual well into a pipeline or flowline. A subsea template is a larger, heavier steel structure which is used as a base for various subsea structures such as wells, subsea trees and manifolds. All options were considered to be viable for the proposed Development. However, Option 2 (manifolds), was selected on the following basis:

- Clustered wells/subsea manifolds are well suited to a field like Cambo where flexibility in well tophole locations is required to maintain ease of drilling, management of collision risk and ensure optimum well placement;
- Ease of fabrication and hence the ability to take account of design changes later in design and/or field life;
- Drilling programme decoupled from subsea structure delivery;
- Well proven concept West of Shetland.

The FPSO design and selection process covered the full range of hull forms including redeployment, hull conversion and new-build options. When compared to alternative ship-shaped options, a new build Sevan-type cylindrical hull unit was selected based on its suitability for a harsh environment, cost and schedule opportunities and simplification of mooring and fluids transfer arrangements.

The majority of the atmospheric emissions from an offshore oil and gas installation come from the need to maintain a reliable power supply for production, maintenance of safety/life support and environmental protection systems.

Seven principle power supply options for the proposed Cambo facility were considered with the above in mind:

1. Onshore power generation from non-renewable sources and import from shore;
2. Onshore power generation via renewable sources and power import via cable from shore;
3. Offshore renewable energy;
4. Offshore generation by a third party with cable import to Cambo;
5. Combined Cycle gas turbines;
6. Local host facility gas turbines – conventional offshore power generation using gas turbines and produced gas from the Cambo field;
7. Local host facility gas turbines with local Carbon Capture and Storage (CCS).

Each concept was examined to determine its suitability for the proposed Development, with Option 6 selected as the only technically and economically viable option, currently available.

Oil and Gas Export

Oil export via shuttle tanker was selected based on lack of existing oil export infrastructure in the area and flow assurance issues associated with dry oil export from Cambo.

In terms of oil offloading to shuttle tanker, tandem offloading was selected as the lowest risk and complexity option.

The following options were considered for disposal of hydrocarbon gas produced in excess of fuel requirements for Cambo:

1. Pipeline export to shore for processing/distribution;
2. Offshore sale to third party – sale of excess produced gas to other nearby fields that may be gas deficient;
3. Gas to Products – processing of gas to alternative liquid gas/other products;
4. Gas to Power – offshore power generation and export to other users;
5. Gas reinjection to a non-producing horizon;
6. Operational flaring.

Option 1, gas export by pipeline to shore was selected, allowing SPE to bring the modest volumes of Cambo produced gas to market. The gas export pipeline would also provide a source (through import from the host pipeline system) of fuel gas to support initial start-up and to provide efficient recovery from production shutdown/blowdown. The availability of import gas is particularly important once Cambo production has declined such that the field becomes fuel gas deficient. The latter two points will help to minimise reliance on liquid fuel import and consumption.

Key environmental considerations considered during the route selection process included the geometric features associated with all routes; the primary feature being the Continental Shelf to the Faroe-Shetland basin, soils, flora/fauna, existing pipelines/cables and approaches to the tie-in points. In addition, installation of the export pipeline considered specific aspects and areas of potential risk, including environmental issues (pipeline route options cross the Faroe-Shetland Sponge Belt Nature Conservation Marine Protected Area (NCMPA)).

A pipeline via the West of Shetland Pipeline System (WOSPS) Pipeline End Manifold (PLEM) was found to represent the most suitable host for the Cambo gas export pipeline system. This option represents one of the shortest pipeline routes and is one of the simplest to execute as there is a tie-in point available and the water depth is within diver limits.

Protection of the pipeline to mitigate against upheaval buckling and reduce any potential risk from fishing gear interaction, including interaction loads, may be provided by:

1. Mechanical trenching/backfilling;
2. Jetting and/or;
3. Rock dumping.

Protection for pipelines under 16" NB (Nominal Bore) is typically provided by trenching below the seabed, either with a mechanical plough and backfilled, or with a jet trencher. The complex nature of the seabed in the proposed locations make decisions on trenching equipment difficult with the available information.

It is recognised that trenching with mechanical ploughs towed behind a support vessel presents challenges in deeper water. Due to the long catenary lengths required (circa 3 times water depth) control of the plough velocity may become the limiting factor. With surging, uplift and trim becoming issues detracting from a quality trench. Using the plough in deeper water may be possible with suitable conditions, these being, homogeneous soil conditions, straight sections and boulder free.

Given these parameters, it may be likely that a mechanical plough will not be suitable for the deeper sections of the route. It is therefore assumed that the pipeline will only be trenched in water depths of less than 600 m or less. However, there may be a requirement to extend the trenched section of the pipeline to a water depth of 800 m, depending on the outcome of a trenching assessment and fisheries risk assessment to assess the minimum safe trenching requirement for the pipeline. Survey data will determine trenching capabilities once soils data and bathymetry are defined.

Tracked jetting machines may be deployed in the water depths being considered. However, suitable soils conditions are required if a jetting machine is to be successfully utilised.

Where trenching may encounter harder soils and fails to meet required trench depth, some rock dumping may be required to provide the pipeline with adequate protection from trawling activities.

It is assumed that mattress protection will be used at the PLEM tie-in structure at WOSPS.

The Local Environment

Information about the environment at the Cambo Field Development and its surroundings was collated to allow an assessment of those features that might be affected by the proposed operations, or which may influence the impact of any of these operations. The key sensitivities of the areas are summarised below.

Environmental Surveys Relevant to the Proposed Cambo Field Development

Numerous environmental surveys have been conducted in Quadrants 204 and 205, and in the surrounding quadrants, over the past 23 years (Figure 2 and Figure 3). These surveys provide useful information on the seabed sediments and the animals living in and on the seabed (benthos) in the area, including any potentially sensitive features that could be classified as Annex I habitats, under the EU Habitats Directive, such as biogenic reefs and deep-sea sponge aggregations. Particular attention is given to the assessment of impacts on these potential Annex I habitats, due to their conservation importance.

Physical Environment

The proposed Cambo Field Development is located in the Faroe-Shetland Channel, a deepwater channel in the north-east Atlantic which runs between the Faroe and the Shetland Islands. The proposed Cambo Field Development Footprint is situated at water depths of between 1,050 m in the southeast to 1,100 m in the northwest within the Faroe-Shetland Channel, with the Gas Export Pipeline route situated at water depths of 1,085 m to 190 m.

The ocean current regime in the Faroe-Shetland Channel is very complex due to the bathymetry of the area, the interaction of a number of different water masses, and seasonal variability in water flows. On a broadscale, cold, dense water from the Arctic flows south-west along the bottom of the channel, whilst warmer water from the Atlantic flows over the top to the north-east. Winds in the area are variable throughout the year, and blow from any direction, although they most frequently originate from the west and south-west.

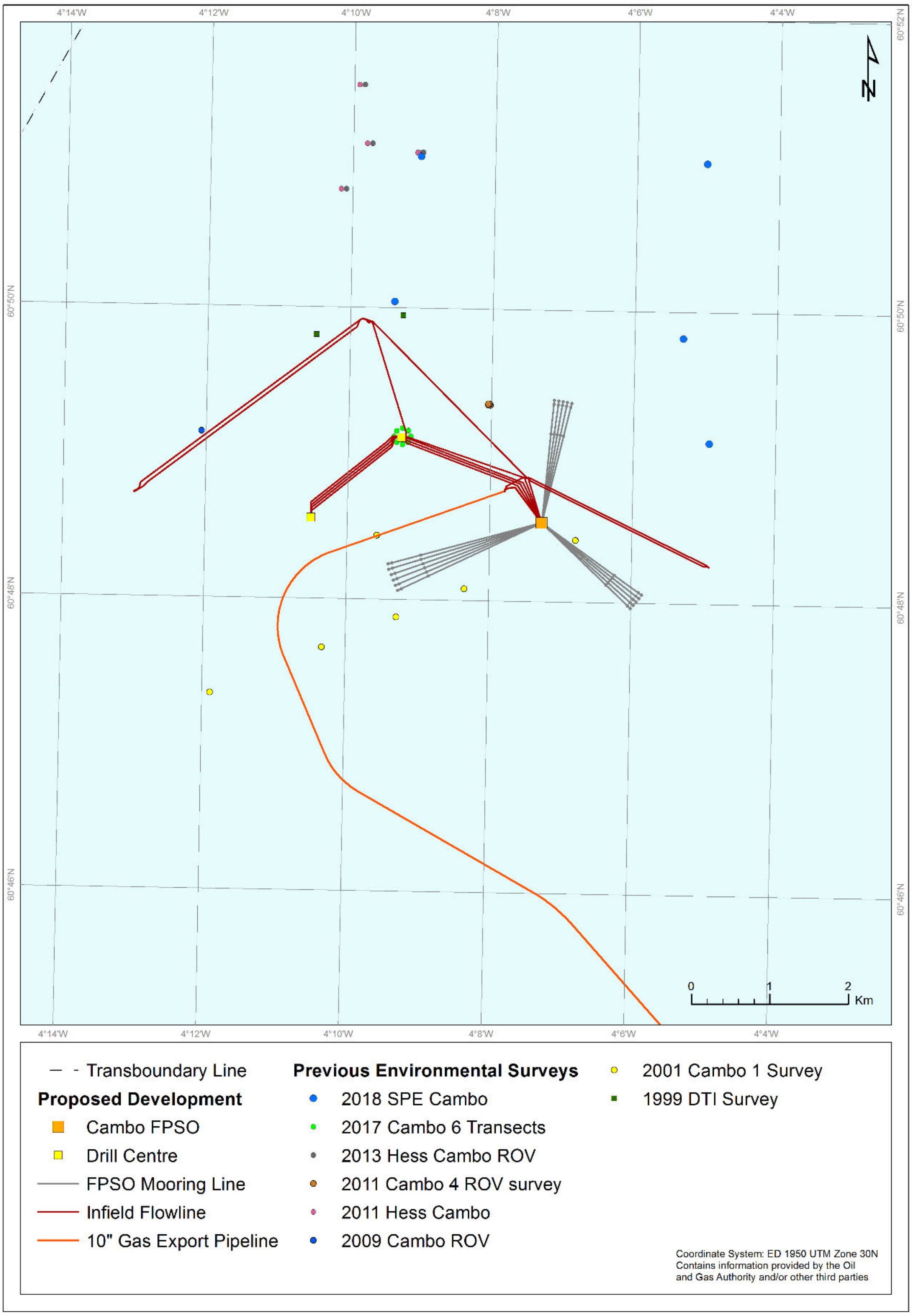

Figure 2: Environmental Survey Locations Relevant to the Proposed Development Footprint

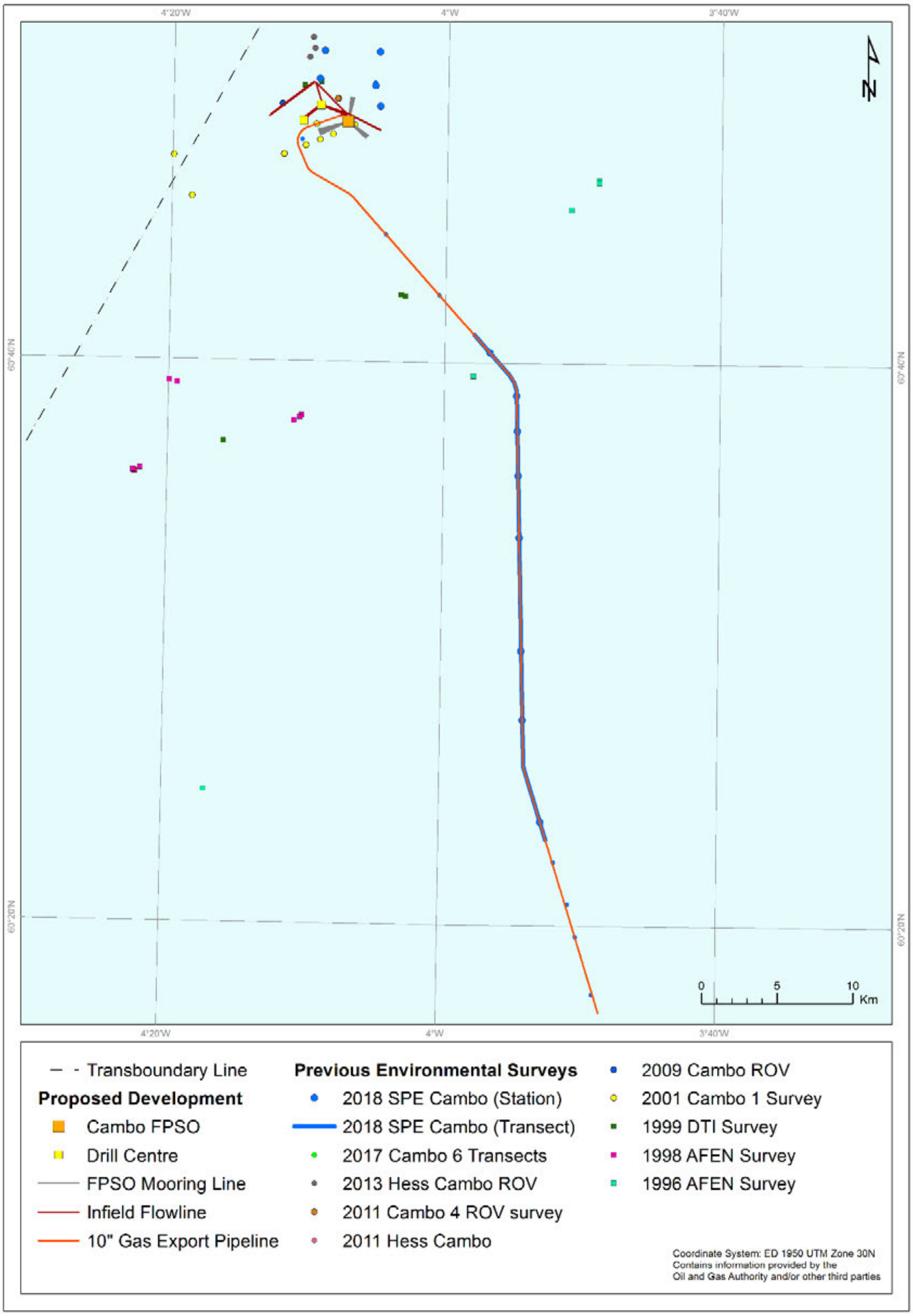

Figure 3: Previous Environmental Survey Locations Relevant to the Proposed Development

Seabed sediments show a general decrease in grain size with increasing water depth, from mixed sand and gravel in the upper continental slope to mud in the deeper basins of the Faroe Shetland Channel. This was confirmed the survey data, which show deep-sea muddy sand and deep-sea mixed substrata together with patches of boulders on the deep-sea bed with the sediments becoming coarser, more sandy sediments further along the gas pipeline export route when gradually moving up the continental slope.

Biological Environment

Benthos

Benthos is the term used for animals and plants associated with the seabed, although plants are generally limited by their light requirement to depths of less than 50 m. Benthos consists mainly of animals that burrow into the sediment or form tubes in it (known as infauna). Other species which live on the seabed, or attached to rocks or to other biota, are known as epifauna. Soft sediments such as those encountered around Cambo Field and the pipeline route are typically characterised by infaunal communities.

The various surveys undertaken in and around the Cambo Field and along the gas export pipeline route show that the local benthos is made up of large numbers of polychaetes (bristle worms), with Arthropoda (crabs and lobster type animals) having the greatest diversity. The surveys also identified a variety of epifauna communities comprising large numbers of brittle stars along with club sponges, burrowing anemones, a type of carnivorous sponge and tube living polychaetes.

The gas export pipeline traverses the Faroe-Shetland Sponge Belt Nature Conservation Marine Protected Area north to south. This protected area has been designated for its ability to support deep-sea sponge aggregations and ocean quahog aggregations. However, the gas export pipeline route survey through the Faroe-Shetland Sponge Belt Nature Conservation Marine Protected Area did not reveal any significant sponge assemblages or ocean quahog aggregations. Coverage of sponges was typically recorded as <5% with some instances of coverage reaching 5% to 10% only.

As sediments became finer, the characterising macrobenthic species changed from suspension-feeding to deposit feeding forms. Community diversity declined with depth beyond a peak at approximately 400 m (the depth experiencing the greatest range in water temperature). Below 700 m, macrobenthic abundance and diversity were generally low, due to the influence of cold Arctic waters. In the upper- to mid-slope (approximately 200 m to 500 m water depth) the fauna of the finer sediment areas are generally dominated by burrowing heart urchins.

Plankton

Plankton consists of organisms that drift with the ocean currents and can be divided into phytoplankton (plants) and zooplankton (animals). During spring, an increase in day length and temperature, coupled with the supply of nutrients released during winter mixing of the water column, results in the rapid growth of the phytoplankton population. This phytoplankton bloom is closely followed by an increase in the zooplankton population, as they feed on the increased phytoplankton population. Subsequently, phytoplankton levels drop throughout the summer months, as the nutrients in the surface waters become depleted and as a result of the zooplankton grazing on them. A second smaller phytoplankton bloom occurs in autumn, but is less pronounced in the open waters West of Shetland than in other areas, such as the North Sea.

Fish and Shellfish

Fish communities in the Faroe-Shetland Channel can be broadly split in three vertical zones, which are based on differences in temperature and food availability. The upper slope zone extends from the shelf edge (around 200 m) to approximately 500 m. The fish community of this area includes rabbit fish, redfish and blue whiting.

Between 500 m and 1,000 m lies the transition zone. The sharp temperature gradient in the transition zone supports an unusual fish assemblage dominated by cold water species such as arctic skate and Greenland halibut. Other species that live in this zone include deepwater demersal species such as redfish and roughhead grenadier.

Below 1,000 m, bottom temperatures are generally less than or equal to 0°C. This deepwater environment supports comparatively few demersal fish species. The sparse fauna present at these depths includes Arctic skate, rockling, Greenland halibut and deepwater species of eelpout.

There are no spawning grounds which fall directly within the Development Footprint. However, predicted spawning grounds for blue whiting are found in the vicinity. The proposed gas export pipeline route will pass through predicted spawning grounds for Norway pout and sandeel. These spawning grounds are all located in slightly shallower waters depths than those present at the Development Footprint location, along the continental slopes on either side of the Faroe-Shetland Channel.

The Development Footprint is also host to a year-round high intensity nursery grounds for blue whiting. The proposed gas export pipeline route passes through predicted nursery grounds for blue whiting, Norway pout, herring, monkfish, hake, ling, mackerel, sandeel, spurdog, and whiting. These nursery areas are also located in slightly shallower waters, along the continental slopes and form part of large continuous swathes of habitat over which nursery grounds are found.

Many of the fish species which have been identified within or in the vicinity of the proposed development have been designated as Priority Marine Features which are considered to be of conservation importance in Scotland's seas. These include monkfish, blue ling, Greenland halibut, ling, blue whiting, Atlantic herring, Atlantic mackerel, Norway pout, sandeels, spurdog and whiting.

Many of shark and ray species (basking, leafscale gulper and porbeagle sharks; sandy ray and Portuguese and spiny dogfish) which have been identified within or in the vicinity of the proposed development have been designated as Priority Marine Features.

Marine Mammals

All whales, dolphins and porpoises that occur in UK waters are protected under the EU Habitats Directive, which makes it an offence to deliberately capture, kill or recklessly disturb them. Species which regularly occur in the Faroe-Shetland Channel include, Atlantic white sided dolphin, killer whale, long-finned pilot whale and sperm whale. Harbour porpoise, common, Risso's and white-beaked dolphin and Northern bottlenose, fin, sei and minke whales are also recorded to a lesser extent, while some species of baleen whale such as blue and humpback are occasionally observed. Blue, fin, sei and sperm whales, are thought to use the Faroe-Shetland Channel as a migratory pathway, swimming through the area to summer feeding grounds in the north, before returning to more southern overwintering and breeding grounds. Many of the whales and dolphin species which have been identified within or in the vicinity of the proposed Cambo Field Development have been designated as Priority Marine Features, these include, Atlantic white-sided, white-beaked and Risso's dolphins, fin, killer, long-finned pilot and sperm whales.

Two species of seal are resident in Scottish waters, the common and the grey seal. These animals are most commonly found in coastal waters shallower than 200 m and are present in internationally important numbers around Shetland. Both species are only rarely sighted in the deeper parts of the Faroe-Shetland Channel, including around the Cambo Field location. Both the common and grey seal have been designated as Priority Marine Features in Scottish waters.

Hooded seals however, do prefer deeper waters and can be found in the Faroe-Shetland Channel area, although, numbers on the whole are low.

Seabirds

The Orkney, Shetland and Faroe Islands and their surrounding waters are sites of major international importance for the seabird colonies they support. The offshore seabirds include members of several families, most notably the petrels and shearwaters, gannets, gulls, skuas and auks. These birds breed on the coasts of the UK, with some feeding far offshore. The Faroe-Shetland Channel is within the maximum foraging range for some species during breeding.

In the winter months, birds become less attached to their nesting sites and range considerable distances in search of food. Seabirds are present throughout the year in the Faroe-Shetland Channel, with mostly low to moderate densities found in the proposed development area.

Coastal Habitats

Coastal habitats are described in this ES, to help assess the potential impacts of a large hydrocarbon spill. As such, not only the relevant parts of the UK coastline have been described below, but also the main coastal characteristics of the Faroe Islands, Norway and Iceland.

The nearest UK land mass to the proposed Cambo Field Development are the Shetland and Orkney Islands. The Development Footprint lies approximately 125 km West of the Shetland Islands and 177 km from the Orkney Islands. At its closest approach, the proposed Pipeline route lies approximately 100 km from the closest point on the Shetland Islands and 120 km on the Orkney Islands.

Shetland is an archipelago consisting of numerous islands with extensive and complex coastlines supporting a range of different habitat types. The majority of the Shetland coastline is characterised by either sea cliffs or exposed rocky shores consisting of bedrock platforms and boulders. The coastline of the Orkney archipelago is more diverse than that of Shetland and is generally characterised by a low profile and gentle gradient. However, exposed steep sandstone cliffs and stacks dominate the Atlantic coast of the largest Islands, the Mainland, and the Island of Hoy.

The north coast of mainland Scotland predominantly feature steep-sided cliffs with headlands, caves, geos (an inlet, a gully or a narrow and deep cleft in the face of a cliff), blowholes and stacks cut into granite, sandstone and limestone.

The Faroe Islands lie around 146 km northwest of the proposed Development Footprint. The north and west of the archipelago are characterised by sea cliffs, accompanied by small islands, stacks and skerries. The eastern coast is gently sloping, and more sheltered environments with sandy beaches are found here, particularly within the many fjords found on this coast.

The nearest landfall on the Norwegian coast to the proposed Development Footprint location is approximately 475 km to the east. The western coastline of Norway is primarily characterised by a network of deep, steep sided fjords, dotted by numerous small, rocky islands and islets.

The nearest landfall on the Icelandic coast is approximately 650 km to the northwest of the proposed Cambo Field Development. Active volcanism has resulted in some areas in lava fields which run straight to the sea, forming a hard, bare rock pavement which slopes towards the coast. In other areas, the volcanic rock has been eroded by glacial action into deep fjords. Extensive gravel beds are present in the south of the island. These have been reworked via current action to create spits and barrier islands. Extensive mud flats and saltmarshes have developed on the lee side of these barriers.

Protected Sites and Sensitive Habitats

There are numerous protected sites along the coastlines of the Shetland and Orkney Islands. These include internationally designated Ramsar Sites (internationally important wetlands of importance, especially for waterfowl), Special Protection Areas (SPAs) and Important Bird Areas (IBAs) (protecting rare and vulnerable species of wild birds), and Special Areas of Conservation (SACs) (EC Directive (92/43/EEC) for the Conservation of Natural Habitats and Wild Flora and Fauna 1992 (The Habitats Directive)). There are also numerous nationally designated sites, including Sites of Special Scientific Interest (SSSIs) (Figure 4).

The Shetland and Orkney Islands possess many habitats that are either of major conservation importance in themselves or for the species they support. As such, many sites are afforded protection under both statutory and non-statutory conservation designations. The Shetland and Orkney Islands are of international ornithological significance, particularly as seabird breeding sites. There are also areas of protection that can be found along the Norwegian and Icelandic coasts.

There are also marine designated sites such as NCMPA in Scottish waters, a few of which are located around the proposed Cambo Field Development and Gas Export Pipeline route (Figure 5). The closest Nature Conservation Marine Protected Area to the proposed Development Footprint is the Faroe-Shetland Sponge Belt which lies 35 km to the southeast. The proposed gas export pipeline passes through the southwest portion of the NCMPA.

The closest Special Area of Conservation (SAC) is the Wyville-Thomson Ridge SAC located approximately 86 km to the southwest of the proposed Pipeline route. The Seas off Foula is one of the locations selected as a proposed SPA (pSPA) and lies 42 km to the southeast of the Pipeline Route. In addition to these protected areas, the JNCC has identified areas where Annex I habitats may be present. Of the three habitat types most likely to occur in UK offshore waters (reefs, sandbanks and pockmarks), reefs are most common in the Faroe Shetland Channel.

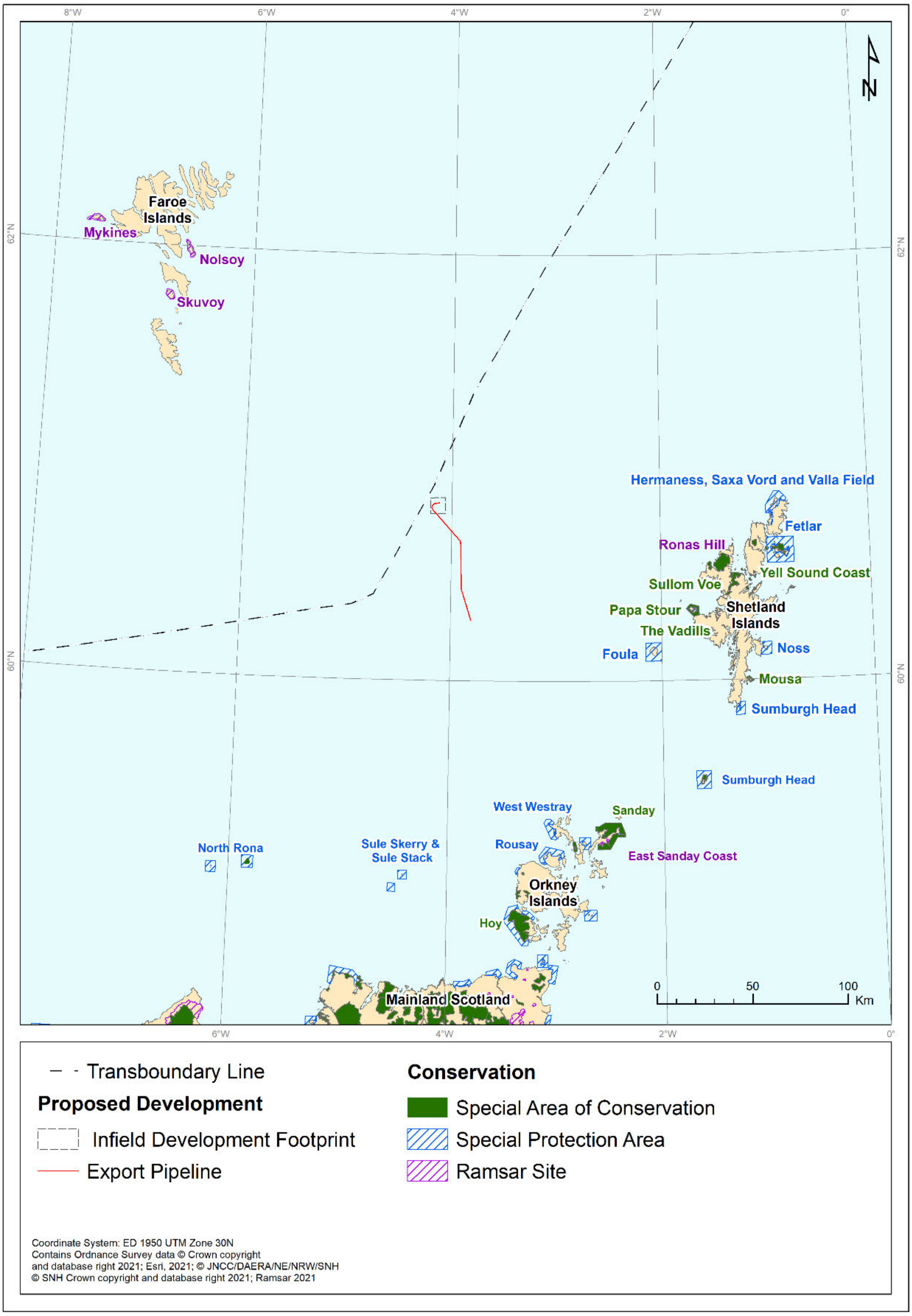

Figure 4: Coastal Conservation Areas

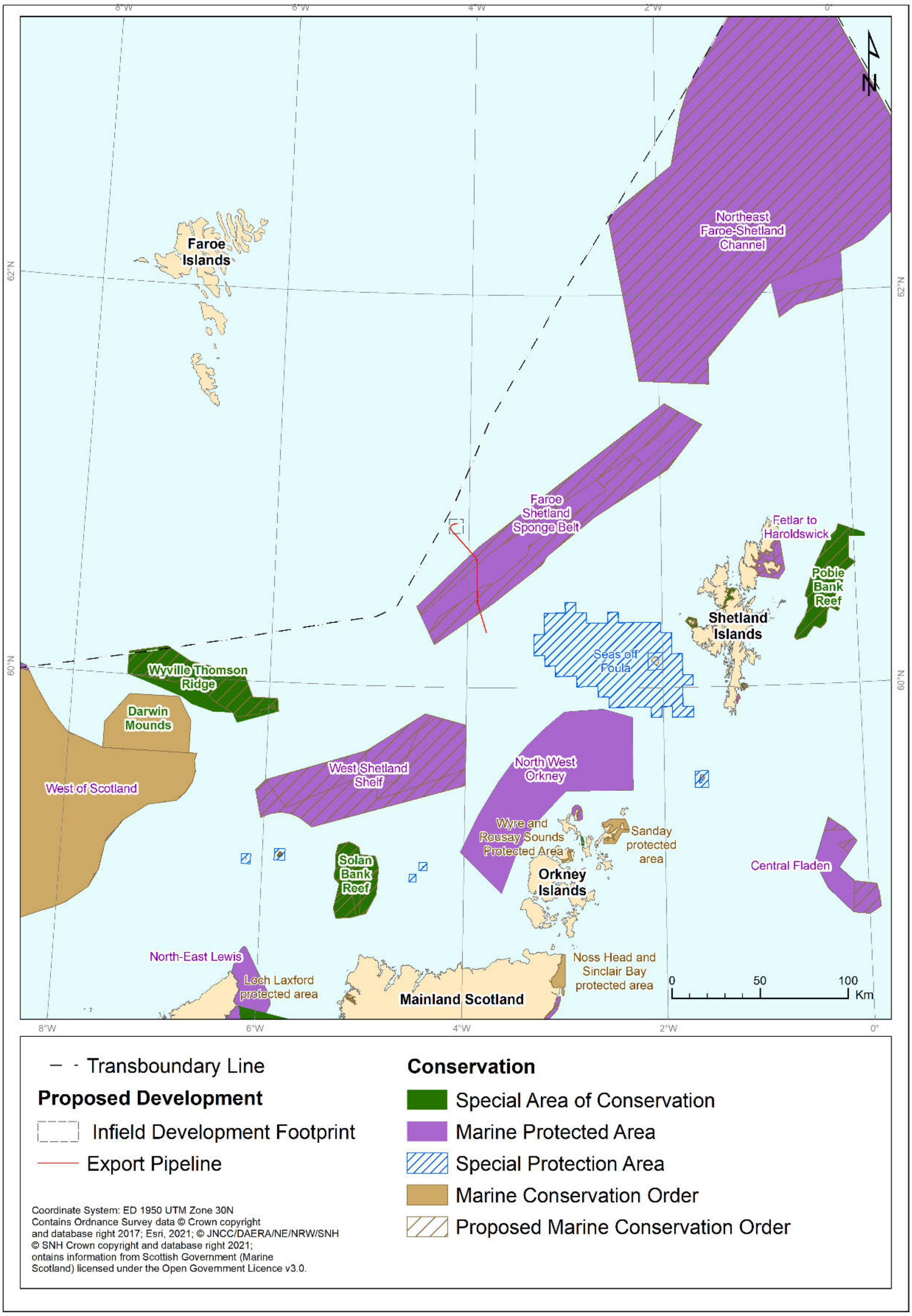

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Figure 5: Offshore Conservation Areas

Other Users of the Sea

Although fishing effort on the continental shelf to the West of Shetland is quite high and the fishing industry is important to the economy of the Shetland Islands, fishing activity in the deep waters around the proposed Cambo Field Development location can be considered low. A mixed demersal (i.e. living in or near the seabed) fishery operates year-round and across the entire west of Shetland shelf area. Shellfish and herring fisheries are found close to shore. Other pelagic (i.e. living in the water column) fisheries are seasonal and restricted to areas of the continental shelf break and beyond. Landings of pelagic fish species are highly variable. The deep waters to the West of Shetland support a deep-water fishery for species such as blue ling, round-nose grenadier, orange roughy, black-scabbard fish and a number of deepwater sharks. The deepwater fishery has little economic significance to the UK fishing industry as a whole.

The end of the proposed pipeline route passes through a moderate to high level of intensity for demersal static and mobile gear, located over the continental shelf. A fishing intensity study showed that that the main type of fishing activity around the area of the pipeline route is demersal fishing comprising saithe, hake, monkfish, ling, cod and haddock.

The waters of the West of Shetland region are relatively undeveloped in terms of oil and gas infrastructure, in comparison with the neighbouring northern North Sea. The BP operated Alligin, Loyal, Schiehallion and Foinaven fields are located approximately 54 km to the south of the proposed Development Footprint. Various oil fields in the development stage, including Rosebank, are also located in the wider area around the proposed Cambo Field Development location.

The Faroe-Shetland Channel experiences very low densities of shipping traffic. A vessel traffic study was commissioned in 2017 within the Cambo area (Block 204/10). This study identified nine shipping routes which would pass within 18.5 km (10 nm) of the Cambo Field Development location. It was estimated that these routes were used by a total of 302 vessels each year, corresponding to an average of one vessel per day.

No practice and exercise areas (PEXA) have been highlighted in the vicinity of the proposed Cambo Field Development.

The Faroese Telecom’s SHEFA-2 subsea cable passes within 20 km to the northeast of the Development Footprint. The closest subsea cable to the proposed pipeline route is the telecommunications line between Schiehallion and Claire, which runs alongside WOSPS at the end of the proposed pipeline route.

Assessment of Potential Impacts

To determine the activities associated with the proposed drilling and installation operations at the proposed Cambo Development which could have a significant impact on the environment, SPE has undertaken the following scoping activities:

- Informal scoping consultation with the statutory consultees and other stakeholders;
- An Environmental Issues Identification (ENVID) workshop by members of the project team;
- Consideration of national policies and guidance, including the Scottish National Marine Plan (NMP) policies relating to the potential impacts from oil and gas activity, the assessment of the sensitive features of the local environment and corresponding relevant pressures from the

proposed development based on Feature Activity Sensitivity Tool (FEAST) and the JNCC's formal conservation advice for the Faroe-Shetland Sponge Belt NCMPA.

The scoping activities identified all potentially significant concerns associated with the proposed Development, which were taken forward for to be fully assessed in the ES and helped guide mitigation measures incorporated into the project planning in order to eliminate or reduce the potential environmental impacts. The key concerns relating to the proposed Cambo Field Development are addressed under the following headings:

- Physical Presence;
- Atmospheric Emissions;
- Drilling Discharges;
- Production Discharges;
- Underwater Noise Generation and Wildlife Disturbance;
- Waste Management;
- Accidental Events.

Physical Presence

The first 24.6 km length of pipeline between the proposed field and the 800 m depth contour, will be laid on top of the seabed. This distance may be extended to 39.6 km at the 600 m depth contour, pending the results of the trenching assessment and fisheries risk assessment which will be undertaken to assess the minimum safe trenching requirement for this section of the pipeline. The remaining 45 km of pipeline above the 800 m depth contour (or 30 km above the 600 m depth contour) and to the West of Shetland Pipeline End Manifold will be trenched and buried to a target depth of 1.5 m below the seabed to avoid potential interaction with other users of the sea, for example fishing trawlers. Burial will be achieved by laying the pipeline into a trench using a remotely operated jet trenching tool. This is expected to disturb up to 33,750 m^2 of seabed if trenching takes place from the 800 m water depth contour. If the target trench depth cannot be achieved then those parts of the pipeline may be protected by rock placement to create a protective rock berm. The placement of rock material on the seabed has the potential to affect local bottom current flows to due altered seabed bathymetry which may increase erosion of the adjacent sediment creating localised scour depressions. The worst-case seabed area affected by the proposed gas export pipeline would be 61,858 m^2.

It is currently planned that all other subsea infrastructure will be installed on the seabed under gravity i.e. using the weight of the structure to partially penetrate the seabed sediment. However, depending on the results of a geotechnical survey some structures may require suction piles to complete the installation.

There are no protected or sensitive habitats or species associated with the proposed location of the FPSO site and any infield infrastructure and so significant adverse effects on nature conservation are not expected in this regard. Any effects on local seabed communities will be very small in size and will last for the duration of the development, for as long as the infrastructure remains in place. Impacts will cease on decommissioning when any infield infrastructure placed upon the seabed will be removed, after which the seabed communities are expected to recover to baseline conditions over time.

However, the proposed gas export pipeline will traverse the Faroe-Shetland Sponge Belt Nature Conservation Marine Protected Area (MPA) resulting in a small reduction of the available benthic habitat (i.e. habitat 'take'), benthic habitat disturbance and alteration and temporary deposition of sediment plumes. This MPA has been designated for a number of habitats and species of conservation value, including ocean quahogs and large sponge aggregations. However, sponge coverage along the entire pipeline route was found to be very low (between 5% and 10%).

The spatial extent of the predicted effects of the pipeline installation and operation will be very small within the context of the Nature Conservation Marine Protected Area and with respect to habitat disturbance and plume deposition, will be very short term lasting for the duration of the pipeline laying only. Effects of habitat take and habitat alteration will last for as long as the infrastructure remains in place. A Comparative Assessment will be undertaken to assess all potential decommissioning options available for the gas export pipeline at the time, including complete recovery of the pipeline as well as leaving sections of the pipeline in-situ. In conclusion therefore, effects of the physical presence of the proposed export pipeline on high value receptors will be long term, but will be highly localised and will have no significant effects on the conservation objectives of the NCMPA.

The proposed location of the FPSO site and subsea infield infrastructure is not associated with significant fishing or other shipping activity and so is unlikely to displace or interfere with fishing, shipping and navigation. Some temporary exclusion from fishing grounds around the immediate area of the pipelaying vessel may occur during pipe laying during the pipe laying operation, estimated to be 23 days. Also, the pipe laying vessel will be continuously moving along the pipeline route and so long-term obstruction and exclusion at any one location will not occur. Effects on fishing, shipping and navigation due to the physical presence of the proposed Development are therefore considered very small and thus insignificant.

Mitigation

Safe working distances will be imposed during installation activities and 500 m safety zones will be put in place around the drilling rig, FPSO and infield infrastructure. The 500 m safety zones will be enforced during operations by a dedicated Emergency Response and Rescue Vessel (ERRV).

All construction vessels will be highly visible and display the appropriate light or daytime signals to warn other sea users of the presence and their activities. When installed, the FPSO will also be highly visible and be in full compliance with the necessary Class and UKCS legal requirements for identification, lighting and sound signals to alert all approaching vessels of its presence

A Vessel Traffic Study (VTS) was carried out within the Cambo area (Block 204/10) and a further VTS will be undertaken as part of the permitting application process to support a Consent to Locate application, before drilling and installation operations commence.

A Notice to Mariners will be posted prior to the FPSO and MODU moving onto location, ensuring that all vessels, including fishing vessels, will be aware of its presence in advance and for the duration of operations. In addition, Kingfisher will be notified of the exact location of the FPSO and MODU activities and the planned installation operations allowing inclusion in their fortnightly bulletin to fishing vessels. The Hydrographic Office will also be notified as to the location of the FPSO and the gas export pipeline so that these can be marked on navigational charts.

Atmospheric Emissions

Generation of power onboard the MODU*,* FPSO, all support vessels and aircraft will result in the emissions of various combustion gases. During the production phase additional atmospheric emissions will be generated from:

- Fuel consumption by the FPSO, MODU, installation vessels, support vessels and helicopters;
- Non-routine flaring and venting operations.

All these emissions will contribute to local and global environmental effects. At a local level, such impacts are mitigated by health and safety measures in place to control emissions onboard the vessels, as well as by the dispersive nature of the offshore environment (i.e. the wind and weather conditions).

Emissions will also contribute to global environmental issues such as climate change. The most commonly used general indicator of atmospheric emissions is the global warming potential (GWP), expressed in tonnes of carbon dioxide (CO_2) equivalents. The GWP can be used to estimate the potential future impacts of gaseous emissions upon the climate system.

It is estimated that the MODU will consume 28,614 tonnes of diesel being used for power generation during drilling and completion operations. The global warming potential for the MODU and all support vessels which will be used during the drilling operations is estimated to be 133,175 tonnes of carbon dioxide (CO_2) equivalents. CO_2 equivalents are a unit of measurement for climate change potential, which enables various different emission gases to be compared in one single unit.

During the installation of the pipeline the pipelay vessel will consume an estimated 460 tonnes of diesel. Fuel consumption by the trenching vessel during trenching operations is estimated to be 216 tonnes of diesel with the dive support vessel consuming 520 tonnes of diesel. The Remotely Operated Vehicle Support Vessel installation vessel will use an estimated 800 tonnes of diesel fuel during installation and inspection operations. The global warming potential for these activities is estimated to be 7,208 tonnes of CO_2 equivalents.

During the installation of the Subsea Production System/Subsea Umbilicals, Risers, and Flowlines, the installation vessel will consume an estimated 2,640 tonnes of diesel. Helicopter support operations will consume 18 tonnes of helifuel during the installation period. The Remotely Operated Vehicle Support Vessel installation vessel will use an estimated 1,470 tonnes of diesel fuel during installation and hook-up of the FPSO moorings. The global warming potential for these activities is estimated to be 18,586 tonnes of CO_2 equivalents.

Based on the current engineering designs for the FPSO, the estimated global warming potential generated by the FPSO during operations from fuel gas use, flaring and diesel use, over the life of the field is estimated to be 3,451,597 tonnes of CO_2 equivalents. This is predicted as the worst-case scenario and does not take into account any potential future mitigation measures that may be introduced over the life of field, such as electrification of the Cambo FPSO, in support of the overall government aim of net zero by 2050.

In 2018, a total of 18.3 million tonnes of CO_2 equivalent were released from upstream oil and gas operations on the UKCS, equating to 4% of the total UK GHG emissions. Compared to this value, the combined average annual GWP generated by operations at the proposed Development, including flaring (i.e. 134,280 tonnes of CO_2 equivalents per year on average over the life of field) would account for less than 0.73%, a minor proportion of overall annual exploration and production operations undertaken on the UKCS. In this context, the atmospheric emissions generated during the proposed operations are not considered to be significant. However, it is acknowledged that the UK Government has set a target to reduce industry-wide GHG emissions to net zero by 2050, and SPE is committed to contribute towards this target, where it can. For example, although neither technically nor economically viable from the outset at the start of production, the FPSO has been designed to accommodate the installation of a future electrical infrastructure to facilitate electrical power import and eventual replacement (in whole or in part) of the proposed gas-turbine driven power and heat generation system. SPE and the Cambo Joint Venture have been instrumental in the establishment of a West of Shetland electrification workgroup to explore opportunities to address the challenges of electrification through collaboration with other West of Shetland upstream oil and gas Operators and stakeholders. SPE is also a member of the steering committee of Project ORION, an initiative established by the Oil and Gas Technology Centre, Shetland Islands Council and others with a number of strategic priorities, including support to net zero ambitions through electrification of oil and gas assets.

Localised impacts from combustion and flaring emissions at the Cambo Field are considered to be negligible, and therefore not significant. Whilst emissions from the proposed operations have the potential to combine with those from local low-density shipping, and the limited oil and gas infrastructure in the West of Shetland region, this is not expected to increase any local impacts significantly. The proposed operations are therefore not expected to have any significant cumulative effects in combination with other local sources of emissions. Local wind conditions may result in the transboundary transport of atmospheric emissions generated at the proposed Cambo Field Development location. However, as the quantities involved are minimal in relation to national scale emissions and of a relative short duration, the resulting incremental effects of transboundary emissions on other nation's total emissions levels are not expected to be detectable.

Mitigation

All Cambo development facilities will be selected and designed such that, as far as is reasonably practicable, Greenhouse Gas (GHG) emissions are minimised. All processing facilities on the FPSO will be designed to operate without the need for routine flaring of hydrocarbons for operational purposes. All associated gas from the various separation stages shall be recovered through compression onboard the FPSO. Combustion equipment shall use Best Available Techniques (BAT) to limit emissions, including the use of dual fuel units that are gas fuel Dry low NO_x (DLE)/liquid fuel Lean Direct Injection (LDI) equipped.

All equipment will be well maintained according to a strict maintenance regime; including regular monitoring and inspections to ensure an effective maintenance regime is in place. The maintenance regime will ensure all equipment will operate at optimum efficiency, and therefore minimise the overall fuel consumption. The combustion plants onboard the MODU and FPSO, will be built to modern emission standards and be fuel efficient. Low sulphur fuels according to International Maritime Organisation (IMO) requirements will be used. Fuel gas imported from the West of Shetland Pipeline System will also help to minimise diesel consumption, when the Cambo Field itself will no longer produce enough gas for power generation. When scheduling the drilling operations, optimising fuel use has been considered, including batch drilling of the wells, for example, to minimise fuel use.

The atmospheric emissions from the MODU and the FPSO will be reported under Environmental Emissions Monitoring System.

Drilling Discharges

During the drilling operations associated with the proposed Development, various discharges will be made both directly onto the seabed and at the sea surface. These discharges have the potential to affect the marine environment through both chemical and physical mechanisms. The extent of these discharges has been quantified and the significance of their associated effects assessed.

The drilling discharges from the proposed drilling operations associated with the proposed Development have the potential to cause moderate effects in the immediate vicinity of the well locations, primarily through physical changes to the seabed.

Effects of Water Based Mud and cuttings discharges on the benthic environment are related to the total quantity discharged and the energy regime encountered at the discharge site, particularly the currents close to the seabed itself. Based on these factors, the discharge of cuttings, mud and cement at the Cambo wells have the potential to cause a localised impact to the benthic environment, primarily through direct physical changes to the seabed.

There is a preference to use CAN-ductors (a prefabricated tophole well section) on all wells, which will remove the requirement to drill the tophole section of the well. However, for any wells where the use of the CAN-ductor proves to be not suitable, conventional tophole sections will be drilled by the MODU instead. Hence, for the purposes of assessing the effects of drilling discharges, the larger volume of the discharges of drilling all wells with conventional tophole sections has been assessed, to represent the potential worst-case discharge scenario.

This impact section is based on a worst-case modelling exercise that assumes all tophole sections are drilled. However, wherever technically feasible, CAN-ductors will be used, potentially reducing the overall extent, thickness and impact of drill cuttings.

Evidence from long-term monitoring at other wells drilled West of Shetland indicate that recovery of megafaunal assemblages in the wider area will be noticeable after a few years, but that full recovery of megafaunal assemblages in areas directly affected by cuttings will be slower and may take >10 years.

As a conservative estimate, it is expected that all benthos will be lost within the area with cuttings deposits >50 mm. Beyond this immediate area of effect, survival rates will increase with decreasing cutting deposition thickness. The cuttings dispersion modelling indicates that the area in which all benthos is expected to be lost, represents a very small fraction of the available local habitat in the wider project area.

In addition, no species or habitats of conservation interest have been previously identified in immediate area around the proposed well location. Seabeds covered with Water Based Mud contaminated drilling discharges generally have a good potential for recovery, over time.

The magnitude of effect in this small area is considered to be moderate, and receptor value is assessed as 'low', and therefore the effect is considered to be not significant.

The impacts from discharges of cuttings and muds from the sea surface are expected to have only a minor effect. This is largely attributable to the fact that any cuttings and mud discharged at the sea surface and will become widely dispersed as they settle through the water column and will form a patchy very thin layer with a maximum deposition thickness of 0.1 mm. Impacts from these discharges can therefore be considered minor to negligible and thus insignificant.

Mitigation

All chemicals used for the drilling operations are regulated under the Offshore Chemicals Regulations 2002 (as amended), which aims to replace chemicals with poor environmental characteristics by more environmentally friendly chemicals. Selection of all chemicals that may be used in drilling operations and subsequent production phase will be based upon both their technical specifications and their environmental performance. The use of all chemicals will be minimised, where practicable.

For cement discharges, the amount discharged onto the seabed during installation of the top section casing will be minimised by visual monitoring of the operation by a Remotely Operated Vehicle. Once returns are observed, pumping will be stopped in order to minimise discharged volume.

A closed mud circulation system (i.e. shale shakers) will be used for the 17½" and 12¼" sections, so the returned drilling fluids can be reconditioned and reused, thus minimising the quantity of drill fluids and chemicals to be discharged. In addition, the drilling mud and cuttings discharged from the drilling rig will be discharged close to the sea surface, allowing dilution and dispersion over a large area and thereby minimising the overall environmental impact.

Any cuttings contaminated with liquid from the payzone (i.e. the reservoir section of the well, where the hydrocarbons enter the wellbore) will be treated in the same way as uncontaminated cuttings, i.e. using the shale shakers to ensure that as much mud and oil as possible is retained in the circulating system. As such, this treatment will result in some oil from the reservoir being incorporated into the mud system which will ultimately be discharged. However, this discharge would take place over a longer period rather than the batch discharge of the cuttings and will be considerably diluted by the drilling fluid prior to discharge, both of which will assist dispersion and breakdown of the condensate in the water column. This potential discharge will be included within the OPPC permit.

The oil content of payzone cuttings will be measured onboard the drilling rig, and a number of samples will also be returned to shore for further analysis and verification. If the oil concentration on cuttings exceeds the limits described in the OPPC permit, cuttings discharge will be ceased, and cuttings collected onboard the drilling rig and shipped back to shore for appropriate disposal. However, previous drilling activity experience monitoring oil on cuttings indicates that this is unlikely.

With regard to chemical discharge, only Water Based Muds will be used and the selection of all chemical additives will be conducted with reference to the CEFAS templates to ensure the most environmentally benign chemicals will be chosen wherever technically possible. Finally, the actual mud and chemical usage will be monitored during drilling operations and subsequently reported to OPRED.

Produced Water Discharge

Produced water will be cleaned up and discharged to sea, due to its potential to 'sour' the reservoir fluids and other potential water injection issues due to the weak rock formations at Cambo. The treatment process will be designed to treat 100% of the anticipated water production and reduce the residual dispersed oil content in the produced water to a target concentration of 15 mg/l or less (measured on a monthly average basis) before being discharged to sea.

Numerical modelling was undertaken to determine the fate and dispersion of produced water following discharge to sea and to inform assessment of potential environmental impacts. How the produced water plume will disperse is dependent on factors such as temperature, ambient current conditions, and depth of release.

Under typical conditions the desired dilution factor of 400 is achieved within 500 m for all simulations suggesting that the Risk Based Approach (RBA) threshold for produced water is likely to be met at the proposed Cambo Field Development. Any environmental effects of produced water discharged at the proposed Cambo Field Development are therefore likely to be limited to the area within 500 m from the discharge location under typical conditions or within 888.9 m under a worst-case scenario, although ultimately this can only be definitively confirmed once the constituents of the produced water at Cambo are known and are demonstrated to have a Predicted Environmental Concentration (PEC) ratio to Predicted No Effect Concentration (PNEC) of ≤1.

Significant interaction with seabed sediments and communities are highly unlikely due to the rapid dilution rates within receiving waters and the buoyant nature of the plumes so that they will remain near the sea surface. Other oil and gas facilities are located far beyond the point at which plumes are diluted to below RBA threshold such that potential mixing of respective plumes and potential synergistic effects are highly unlikely to occur. Consequently, significant effects on the interests of the Faroe-Shetland Sponge Belt NCMPA are not forecast to occur and associated conservation objectives are not expected to be significantly affected. Significant effects of the discharge of produced water on benthic and water column communities either alone or cumulatively with other discharges in the region are not expected.

Mitigation

No significant effects on benthic communities or nature conservation interests are predicted due to the proposed produced water discharges, and mitigation is thus not considered as being required, although the following observations are provided:

- Reducing the discharge temperature to 45˚C will ensure the RBA dilution rates of 400 at 500 m from the discharge is met under all meteorological conditions, and therefore SPE will ensure the discharge temperature will be 45˚C (or less) to further improve initial dilution rates;
- A downward orientation of the discharge will increase the horizontal distance travelled during the near-field propagation stage and further improves predicted dilution factors, and hence an angled discharge port will be used.

Underwater Noise and Wildlife Disturbance

Man-made underwater noise has the potential to impact marine animals. During the drilling operations at Cambo, noise will be generated by the MODU, its support vessels (i.e. the standby vessel and supply vessels), and by helicopters. Additional (shipping) noise will be generated by the vessels used for the installation of the FPSO and its associated subsea infrastructure, as well as during the installation of the export pipeline. During the operational life of the field, the main sources of underwater noise will be from the FPSO and its associated support vessels and the shuttle tankers visiting periodically to offload the crude oil.

Therefore, the two main underwater sound sources to be assessed were engine/propeller/thruster noise from the FPSO, its support vessels and shuttle tankers, and the piling noise associated with subsea infrastructure installation.

All types of MODU generate low-frequency noises, which are, to some extent, transferred into the water column. Shipping is a major contributor to noise in the oceans, especially at low frequencies. During the production phase, shuttle tankers will periodically visit the FPSO to offload the crude oil. Noise will also be produced during piling operations.

The introduction of additional noise into the marine environment could potentially interfere with the animals' ability to determine the presence of other individuals, predators, prey and underwater features and obstructions. This increase in noise could therefore cause short term behavioural changes and, in more extreme cases, cause auditory damage. In addition to marine mammals, underwater sound may also cause behavioural changes in other animals such as fish and diving seabirds.

Anthropogenic noise from shipping and existing oil and gas installations, is currently believed to be the main source of anthropogenic background noise in the area of the proposed Cambo Field Development. The addition of (mainly) low frequency noise generated by the MODU and subsequently by the FPSO and their support vessels will add to the overall anthropogenic footprint in the area. No good practice guidelines exist in the UK for drilling or production activities since these are thought to be of low concern in terms of disturbance to cetaceans. Consequently, these are not expected to cause any significant impacts on marine mammals potentially present in this area.

In addition, the planned piling operations may cause avoidance responses and other, more subtle, behavioural reactions in marine mammals within a few kilometres of the piling operations. However, given the short duration of such operations (1 day), any such effects are expected to be transient and are therefore also not considered likely to be significant.

Mitigation

The amount of underwater sound generated during drilling operations will be kept to a minimum where possible. The main priority will be to minimise the time over which sound energy is emitted into the marine environment during the proposed piling operations (1 day).

The planned piling operations will be conducted in accordance with the JNCC Protocol for minimising risk of injury to marine mammals from piling noise, at all times. This will include the use of a trained Marine Mammal Observer (MMO) to undertake cetacean monitoring duties before any piling operations commence and the use of “soft start” procedures.

Throughout the proposed Development, logistics will be optimised to minimise unnecessary or low payload helicopter flights and vessel sailings.

Waste Management

Several different waste streams will be generated throughout the development’s lifespan. Waste management will be undertaken in compliance with current environmental legislation and in line with the waste hierarchy. The management of offshore waste generated on the UKCS is strictly regulated and the UK has well-established infrastructure in place to manage this waste effectively. Therefore, no significant impacts are anticipated.

Accidental Events

Oil Spill

The risk of an accidental hydrocarbon spillage to sea is often one of the main environmental concerns associated with oil-industry activities. Spilled oil at sea can have a number of environmental and economic impacts, the most conspicuous of which are on seabirds and coastal areas. The actual impacts depend on many factors, including the volume and type of hydrocarbon spilled, the sea and weather conditions at the time of the spill, and the oil spill response.

The risk of a large-scale hydrocarbon spill during drilling operations or during the subsequent production phase of the proposed Cambo Field Development is very low.

Oil spill modelling shows that a large spill, such as from a well blow-out or a complete loss of inventory from the FPSO, would, under the majority of meteorological circumstances, drift northeast of the proposed well location. A large oil spill would have the potential to reach the coasts of Shetland, Orkney, Faroe Islands or Norway, and during spring and summer time there would be a small probability of oil beaching on the north coast of mainland Scotland and the Isle of Lewis as well. These conclusions are based on modelling results that assume no intervention in the slick. In practice oil spill response resources would be mobilised immediately if a spill occurred. It would be a priority for SPE and the Installation/Well Operator to attempt to ensure no spilled oil would impact the coastline and, therefore, all appropriate oil spill response techniques would be employed in the event of a spillage moving towards the shore.

It should be noted that these potential impacts would only occur under extreme circumstances in the event of a very large oil spill. Historic data on oil spills from oil and gas installation operating on the UKCS show that there has only been one crude oil spill of such a large size (112 tonnes) in the period 1990 to 2019. This spill happened in 1990. Historic data suggest small spills of less than 1 tonne represent the most likely spill scenarios.

Throughout the life of field, the focus will be on the prevention of oil spills. Stringent safety and operational procedures will be adhered to throughout the operations. Procedures will be in place to ensure that immediate and appropriate action is taken in the event of any hydrocarbon spillage, minimising any impact to the marine environment. Ultimately, the type and size of spill, along with the meteorological and oceanographic conditions at the time of the spill, will dictate which resources are most suitable for the spill event.

With the measures in place to prevent an oil spill incident from happening and the oil spill contingency planning and response resources available to the Well Operator/Installation Operator in the event of a large oil spill event, the residual environmental risk posed by the proposed Cambo Field Development is judged to be reduced to an acceptable level.

Catastrophic Loss of the FPSO, MODU, a Vessel or the Helicopter

Under extreme circumstances, the FPSO, MODU, a support vessel or a helicopter may sink. These events are extremely rare and happen so infrequently that no reliable statistics could be obtained to quantify them. There are mitigation measures in place for preventing such as event.

In the event of the loss of the FPSO, the MODU, a support vessel or a helicopter, it would be unlikely that the vessel or aircraft would be salvageable in this deepwater environment and, therefore, would most probably remain on the seabed as a wreck. Attempts would be made to salvage any remaining hydrocarbons and other potentially harmful products onboard the vessel/aircraft, although it should be noted that, in practice, these types of operations are prone to causing pollution incidents. The wreck would be marked on navigational charts to prevent the snagging of fishing nets and other towed equipment. In general, the presence of wrecks on the seabed is not considered to have any long lasting negative environmental effects. Therefore, given the remote chance of such an event happening due to appropriate mitigation measures in place, and minimal negative long-term environmental impacts, the residual impact of a loss of rig is considered to be insignificant.

Mitigation

In order to prevent an oil spill occurring, stringent safety and operational procedures will be followed at all times. Specific mitigation measures include:

- The Installation/Well Operator will fully assess the competence and experience of all contractors, and the suitability of all equipment to operate in the West of Shetland area. All offshore personnel will be appropriately trained, experienced and certified to carry out their specific duties. The crew of the FPSO and the MODU will also undergo environmental awareness and safety training;
- A thorough and formal peer-review approach will be used to review all critical elements of the well designs and the execution of drilling and abandoning the well. In addition, the well designs will be independently reviewed by a Well Examiner. The Well Examiner will also monitor the actual construction and any modifications to the wells. Any change or deviation to the drilling programme, the subsurface parameters for the well design, or the well construction itself, will be subject to a formal management of change process;
- Well control procedures will be in place, to prevent uncontrolled well flow to the surface and a full risk assessment will be performed as part of the planning phase of each well. Data on well pressure will be monitored throughout the drilling operations;
- A blow-out preventer (BOP) will be put in place. In addition to the standard control systems, the BOP typically has several other backup emergency control systems;
- The BOP will be independently inspected and verified periodically. Regular testing of the BOP and its back up systems takes place onboard the MODU, typically at 7 and 21 day intervals;
- Vessel audits will be performed to confirm sea worthiness of supply vessels and shuttle tankers, and only DP vessels will be used. Bunkering and offloading operations will only take place in suitable weather conditions, and with a dedicated and continuous watch posted at both ends of the fuel/offloading hose. All hoses used during bunkering/offloading will be segmented with pressure valves that will close automatically in the event of a drop in pressure. The bunkering/offloading hoses will be stored on reels, to prevent wear and damage. These hoses will be visually inspected and their connections tested prior to every loading operation. Bunkering/offloading procedures will be followed throughout all bunkering/offloading operations;
- The FPSO will be designed with double bottom/doubled-sided hull. In addition, the cargo tanks will be configured with ballast tanks on the outside;
- All equipment used on the FPSO and the MODU will have safety measures built in to minimise the risks of any hydrocarbon spillage. For example, the FPSO and the MODU will have open and closed drain systems in place that will route any operational spills onboard the FPSO or MODU to the slop tanks where they can be contained and recovered. There are also a number of spill kits available to deal with (smaller) spillages. All supply vessels will operate via DP;
- Use of ROV to identify the source of subsea spill. If at any time the safety of the MODU becomes compromised, the first priority will be to close the BOP, disconnect the MODU from the well, and move off location. The BOP is designed as fail safe closed, ROV and acoustic overrides are available should this not work correctly. The ROV can be deployed to verify the BOP is properly closed;
- A contingency stock of cement and barite will be kept onboard the MODU;
- In the event of a subsea blow-out, whereby the BOP has failed and oil is freely flowing into the sea, the possibility of fitting a temporary capping device to the well will be considered;
- SPE is a member of Oil Spill Response Ltd (OSRL), which allows SPE access to the OSPRAG (the Oil Spill Prevention and Response Advisory Group) Capping Device;
- In the extremely unlikely event where a blow-out situation occurred and all options to kill the well failed, the only remaining option to bring the well back under control to stop the spill may be to

drill a relief well. Siccar Point Energy and the Well Operator will comply with the Oil and Gas UK "Guidelines on Relief Well Planning – Subsea Wells";

- Planning for the relief well will include a review of the original well design and the reasons for the uncontrolled well blow-out, allowing any required changes to well design, equipment and operating procedures to be implemented. Preparation of equipment, procedures and consent applications will all be conducted in parallel with the activities required to gain access to a suitable replacement drilling unit;
- Several alternative relief well locations around the Cambo Field will be identified in the Relief Well Plan;
- If a large well control incident were to occur, it would be a priority to avoid spilled hydrocarbons impacting the coastline and, therefore, all available and suitable oil spill response techniques would be employed in the event of a spillage moving towards the shore;
- The FPSO's Installation Operator and the MODU's Well Operator will have an Oil Pollution Emergency Plan (OPEP)/Temporary Operations Oil Pollution Emergency Plan (TOOPEP) in place, respectively. The OPEP/TOOPEP will conform to the Merchant Shipping (Oil Pollution, Preparedness, Response and Co-operation Convention) (Amendment) Regulations 2015 and the Offshore Installations (Emergency Pollution Control) Regulations 2002. The OPEP/TOOPEP will fully consider the specific oil spill response requirements for Cambo;
- Specific members of the FPSO/MODU and standby vessel crew will have undertaken OPEP level oil spill response training. The Offshore Installation Manager (OIM) and the Installation/Well Operator offshore representatives will have undertaken the OPRED course for On-Scene Commander (OPEP Level 1);
- As a minimum, the OPEP/TOOPEP will be distributed to personnel with designated duties in the event that an oil spill response is required, and to the regulatory authorities and statutory consultees. On receipt of the OPEP/TOOPEP, personnel will undergo awareness training in oil spill response prior to the commencement of drilling operations;
- The FPSO and MODU will regularly undertake training exercises, including vessel-based oil spill response exercises for the crew and an Offshore TOOPEP Exercise while on site. Similar offshore exercises will be held periodically for the FPSO's OPEP, once it is in operation;
- External oil spill response training will be organised for key onshore personnel, in line with the OPRED requirements and the internal requirements of environmental training and continual improvement in the Well Operator's Management Systems. Relevant SPE and Installation/Well Operator Duty Managers will, as a minimum, have undertaken the OPRED course, Corporate Management oil spill response awareness (OPEP Level 2). SPE is a member of Oil Spill Response Ltd (OSRL), with activation rights being provided to the Installation/Well Operator. A response advisor with OPEP Level 4 training would also be provided by OSRL;
- Desktop exercises will be undertaken prior to commencement of operations to test the effectiveness of the oil pollution emergency plan;
- The most appropriate response to a hydrocarbon spill from the planned drilling operations will be determined by oil type, logistics and prevailing physical conditions. A precise response strategy can only be decided at the time of the spill. Oil spill response personnel must be prepared to adapt their actions as the spill develops as changes in both the prevailing conditions and the oil properties dictate;
- It is proposed that, in the event of a crude or diesel spill incident, the principal response strategy will be the monitoring and surveillance of the slick, where evaporation and natural dispersion will be the principle mechanisms for removal of oil from the sea surface;
- A standby vessel will be on site at all times during drilling and production operations through the life of the proposed Development. In the early stages of an incident, the slick may be monitored by this onsite standby vessel, provided it can still meet its safety function. For larger, ongoing spills,

aircraft may be mobilised to undertake aerial surveillance. However, in the short term, aerial surveillance may be undertaken by the helicopter contractor;

- A contract with OSRL will be put in place, allowing the rapid deployment of a dedicated aerial surveillance aircraft;
- Tracking and monitoring of the spilled oil would commence as soon as possible after the incident has occurred and continue for the duration of the response;
- To aid natural dispersion of a large oil spill, or when sensitive receptors such as flocks of seabirds are at risk, Siccar Point Energy will consider applying chemical dispersants;
- The use of chemical dispersants may therefore be considered for oil spills which are observed to not disperse naturally. The decision to use chemical dispersants will always need to consider its positive benefits against any resulting impacts in the water column;
- Booms may be used to contain a large slick on the sea surface, concentrating the oil for recovery by skimmers;
- Once the coastal sensitivities under immediate threat have been identified, coastal protection resources will be deployed to protect priority areas. Although Siccar Point Energy and the Installation/Well Operator will provide all necessary assistance as required, all shoreline protection strategies will be determined by the local authority in consultation with their environmental advisors;
- Every effort will be made to clean-up up any oil that reaches the shoreline.
- If a spill does reach the shoreline, aerial surveillance will be used to gain a broad overview of where it has beached, while vehicles or vessels will be used to make a more detailed, shore specific assessment. Through OSRL, stretches of shoreline will be surveyed, recording the type of shoreline (sediment type, slope, exposure etc), its use (tourism, recreation, etc), and any environmental sensitivities (protected areas, seal breeding sites, otter holts, etc), as well as the severity of any oiling (mobile oil, surface or subsurface oil, stranded oil, sheen etc). Information on access arrangements, parking and storage arrangements, and proximity to other facilities will also be recorded. This information will be used to determine where to focus the clean-up effort by making the optimum use of the available clean-up resources;
- With all required assistance and information provided by SPE and the Installation/Well Operator, the strategy for shoreline clean-up ultimately will be directed by the affected local authorities. Adequately trained personnel and clean-up equipment will be made available to assist any clean-up operations, through OSRL;
- SPE will ensure that it has sufficient finances and insurance in place to cover the cost of responding to a large oil spill.

Overall Conclusions

The only potential significant impact identified in the environmental impact assessment is that of a large-scale oil spill. However, the probability of such a spill is very low and mitigation and management procedures will be in place to prevent this from happening, as well as adequate resources to deal with any such spill should it occur.

The drilling discharges have the potential to cause moderate effects in the immediate vicinity of the well locations through physical changes to the seabed. The discharge of the drill cuttings, drilling mud and cement have the potential to cause localised impacts to the benthic environment. Where possible, CAN-ductors will be used to help reduce the overall extent and thickness of the drill cuttings. Recovery in the wider area is likely within a few years but the area with direct impact would be slower however, the area with a direct impact is relatively small and therefore the effect is not significant.

If rock dump will be required for small pipeline sections that cannot by buried to adequate depths below the seabed, the rocks will likely remain on the seabed resulting in a permanent effect. Physical change (to another seabed type) is classified by both the FEAST tool and by the Advice on Operations (AoO) as a pressure to which deep-sea sponge aggregations, ocean quahog aggregations and offshore sands and gravels features are sensitive. However, the rock protection material on the seabed within the boundaries of the Faroe-Shetland Sponge Belt NCMPA will only take up 0.022 km^2, which is a very small fraction (0.0004%) of the total area of the NCMPA. While some individual specimens of ocean quahog and/or sponges may be affected within the direct footprint of rock placement, significant effects at the population level are unlikely. Consequently, the site's nature conservation objectives will not be significantly affected in this regard.

All other impacts identified in the ES covering the drilling, installation and production phases of the Cambo Field Development are expected to only have localised impacts with good recovery potential over time.

Overall, it is concluded that the environmental impacts of the proposed Cambo Field Development will not incur any significant long-lasting environmental effects.

Section 1

Introduction

1 INTRODUCTION

This Environmental Statement (ES) presents the findings of the Environmental Impact Assessment (EIA) conducted by Siccar Point Energy E&P Limited (SPE) for the Development of the Cambo Oil Field in Blocks 204/4a, 204/5a, 204/9a and 204/10a, in the West of Shetland region of the United Kingdom Continental Shelf (UKCS). The proposed infield development location is centred approximately 125 km to the West of the Shetland Islands, in a water depth of approximately 1,050 m to 1,100 m (Figure 1.1). The scope of the development also includes a gas export pipeline extending 70 km to the southeast of the Cambo field, to the West of Shetland Pipeline System (WOSPS). The purpose of this ES is to provide an assessment of the potential environmental effects that may arise from the proposed Cambo Phase 1 Field Development (also referred to in this ES as the proposed Development/proposed Cambo Field Development) and to identify the measures which will be put in place to minimise these effects.

This ES has been produced in accordance with the Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020 and associated guidelines. It also addresses issues and mitigation associated with the Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001 (as amended), the Offshore Chemicals Regulations 2002 and the Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005 (as amended), as well as other relevant legislation.

It is proposed that an Installation Operator and Well Operator will be appointed to operate the proposed Development on behalf of SPE.

The introductory sections explain the background and purpose of the proposed development and describe the EIA process. The underlying regulatory and other environmental requirements are also outlined.

1.1 Background to the Proposed Cambo Field Development

UKCS Blocks 204/4a, 204/5a, 204/9a and 204/10a are within Licence areas P1189 and P1028, for which SPE is the Licence Operator (70% equity). The other co-venturer is Shell UK Limited (30% equity). Licence P1028 was awarded during the 19th Round of Offshore Licensing in 2001, whilst Licence P1189 was awarded during the 22nd Round of Offshore Licensing in 2004.

An overview of the history of the Cambo oil field from its discovery in 2002, to the latest well drilled in 2018, is provided in Table 1.1.

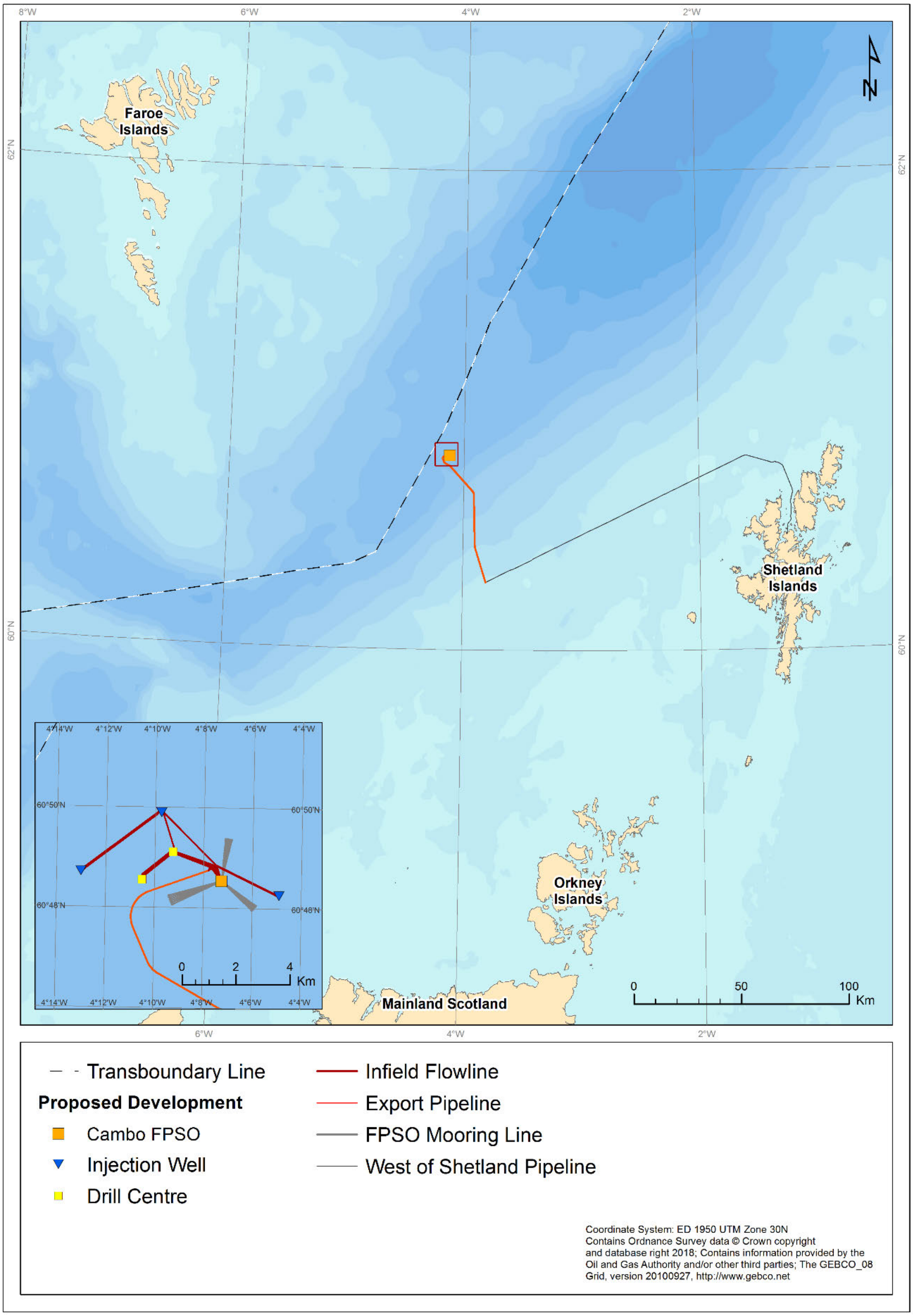
Table 1.1: History of the Cambo Field

Well Name	Spud Date	Operator	Well Type and Target	Status	May also be Referred to in this ES as:
204/10-1	2002	Hess	Exploration well. Drilled to appraise the Hildasay sands.	Plugged and Abandoned	Cambo 1
204/10-2	2004	Hess	Exploration well. Drilled to appraise the Hildasay sands.	Plugged and Abandoned	Lindisfarne
204/10a-3	2009	Hess	Exploration well. Drilled to appraise the Hildasay sands and to test the presence of pre- and intra-basalt sand potential.	Plugged and Abandoned	Cambo 3
204/10a-4, 204/10a-4Z	2011	Chevron	Appraisal well. Drilled to confirm the amount of commercial reserves in the Hildasay H30 sands. Side track (204/10a-4Z) completed ready for testing.	Plugged and Abandoned	Cambo 4
204/5a-1	2013	Chevron	Appraisal well. Drilled to further evaluate the structure, extent and hydrocarbon bearing potential of the Colsay reservoir.	Plugged and Abandoned	Cambo 5
204/10a-5, 204/10a-5Z, 204/10a-5Y	2018	SPE	Appraisal well. Drilled to reduce remaining subsurface uncertainties, to allow core and reservoir fluids to be tested for system design input/validation. Horizontal side-track (204/10a-5Y) was tested and flowed.	Suspended as future producer	Cambo 5Y

SPE now plans to develop the Cambo field in order to produce the oil and gas contained in the reservoir. The field will be developed using a dedicated, moored Floating Production, Storage and Offloading vessel (FPSO) to produce hydrocarbons from two drill centres. Oil will be exported via shuttle tanker, whilst gas will be exported via pipeline to the WOSPS.

The Cambo field is expected to produce oil and gas for approximately 25 years. Based on the best estimates available to date, the field is expected to produce a total (average annual rate) of 8,490 m^3/d of oil and 850,000 Sm^3/d of gas per day during peak production. SPE is currently planning to commence offshore development activities at the Cambo field in 2021, with first drilling operation in 2022. First oil is expected in 2025. A full description of the planned development and production operations is provided in Section 3.

This ES has been prepared in support of the Cambo Field Development Plan (FDP).



Coordinate System: ED 1950 UTM Zone 30N
Contains Ordnance Survey data © Crown copyright
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Oil and Gas Authority and/or other third parties; The GEBCO_08
Grid, version 20100927, http://www.gebco.net

Figure 1.1: Location of the Proposed Cambo Field Development

1.2 Legislative Framework

The proposed Field Development lies outwith UK territorial waters (i.e. greater than 12 nm from land). The majority of the activities undertaken will therefore be governed under the current legislation regarding offshore oil and gas activities. The main legislation applicable to the proposed Cambo Field Development is summarised in Appendix 1 together with the relevant consents, authorisations and exemptions that are required. An overview of the key legislation is provided below.

1.2.1 The Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020

These regulations replace The Offshore Petroleum Production and Pipelines (Assessment of Environmental Effects) Regulations 1999 (as amended) and implement the requirements of EC Directive 2011/92/EC (the EIA Directive) for offshore oil and gas operations in the UK. The EC Directive 2011/92/EU revokes the 85/337/EEC and its amendments 97/11/EC, 2003/35/EC and 2009/31/EC. These regulations require that an EIA must be undertaken for an offshore development considered to fall within the scope of a Schedule 1 project and that a public consultation document (the ES) is submitted to the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED) and made available to any interested party for comment prior to approval by the Secretary of State (SoS). OPRED has prepared guidance notes on the new regulations, issued in December 2020, which detail the information the ES must contain. Essentially the document must describe the proposed project and identify any impacts it is likely to have on the receiving environment, together with any measures to reduce the significance of any impacts. No consent in respect of an activity will be granted until the SoS is satisfied with the environmental information provided and that there will be no significant effect on the environment.

The Offshore Petroleum and Pipelines (Environmental Impact Assessment and other Miscellaneous Provisions) (Amendment) Regulations 2017 came into force on 16 May 2017. These regulations transpose the requirements of Directive 2014/52/EU into the EIA regulations. Directive 2014/52/EU amends the EIA Directive.

1.2.2 Offshore Chemicals Regulations 2002 (as amended)

The Offshore Chemicals (Pollution Prevention and Control) Regulations 2002 (as amended) have been developed in response to the Harmonised Mandatory Control System (HMCS) introduced by the Oslo and Paris Commission (OSPAR). The regulations stipulate that operators must hold a permit to use and discharge chemicals offshore. This permit must be in place before commencement of drilling and production operations. An application for the approval of a permit for the use and discharge of chemicals is made electronically to OPRED through a Chemical Permit-Subsidiary Application Template (CP-SAT) submission. These applications are made using the online OPRED Portal Environmental Tracking System (PETS), and this shall contain:

- A description of the offshore source on or from which the offshore chemical is to be used or discharged, and the location of the offshore source in the relevant area;
- A description of the proposed technology and other techniques for preventing or, where this is not possible, reducing the use or discharge of the offshore chemical from the offshore source;
- A description of the measures planned to monitor the use or discharge of chemicals;
- An assessment of the risk of damage to the environment from the use and discharge of the offshore chemicals proposed.

Chemical permits require reporting of actual chemical use and discharges on the Environmental and Emissions Monitoring System (EEMS).

1.2.3 The Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005 (as amended)

These regulations, generally referred to as the OPPC Regulations, introduced a permitting system for oil discharges to the sea.

The OPPC Regulations also amend the Offshore Chemicals Regulations 2002 to increase the powers of OPRED inspectors to investigate non-compliances and risk of significant pollution from chemical discharges, including the issue of prohibition or enforcement notices.

In 2011, amendments were made to the OPPC Regulations to align them with amendments made to the Offshore Chemicals Regulations (as described in Section 1.2.2). The amendments make it unlawful to unintentionally release oil into the offshore environment. The amendments also update the definition of a “discharge” as an intentional emission of oil. All oily discharges must be in accordance with the terms and conditions of an OPPC permit.

At Cambo the discharge of any drill cuttings contaminated with reservoir hydrocarbons will be subject to an OPPC permit. During the production phase, OPPC permits will be required for the discharges contaminated with reservoir hydrocarbons, such as produced water, produced sand and scale, for example.

1.2.4 The Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001 (as amended)

These regulations, which were amended in 2007 (Section 1.2.5), seek to ensure that oil and gas activities on the UKCS are carried out in a manner that is consistent with the requirements of the Habitats Directive (92/43/EEC).

These regulations are designed to ensure that the integrity of either a Special Area of Conservation (SAC) or a Special Protection Area (SPA) is not significantly affected by activities occurring either within or outside those sites. Any plan or project which either alone or in combination with other plans or projects would be likely to have a significant effect on a site must be subject to an appropriate assessment of its implications for a site’s conservation objectives. Such a plan or project may only be agreed after ascertaining that it will not adversely affect the integrity of a SAC or SPA unless there are imperative reasons of overriding public interest for carrying out such a plan or project.

1.2.5 Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007 (as amended)

These regulations make provision for implementing the Birds Directive (79/409/EEC) and Habitats Directive in relation to marine areas where the UK has jurisdiction beyond its territorial sea, i.e. everywhere on the UKCS outside the 12 nm zone. The regulations make provision for the selection, registration and notification of sites in the offshore marine area (European Offshore Marine Sites) and for the management of these sites. Competent authorities are required to ensure that steps are taken to avoid the disturbance of species and deterioration of habitats in respect to the offshore marine sites and that any significant effects are considered before authorisation of certain plans or projects. Provisions are also in place for issuing of licences for certain activities and for undertaking monitoring and surveillance of offshore marine sites.

These regulations also make it an offence to deliberately disturb wild animals of a European Protected Species (EPS), in such a way as to significantly affect the ability of any significant group of animals to survive or breed, or the local distribution or abundance of that species. If appropriate, a Wildlife Disturbance Licence may be required.

These regulations were amended in April 2010, altering the transposition of the Wild Birds and Habitats Directives. Draft guidance notes on ‘The protection of marine European Protected Species from injury and disturbance’ are available on request from the Joint Nature Conservation Committee (JNCC, 2010).

1.2.6 The Conservation (Natural Habitats, &c.) (EU Exit) (Scotland) (Amendment) Regulations 2019

Due to the UK’s exit from the European Union (EU), legislative amendments have been undertaken with respect to some of the main pieces of legislation that afford protection to particular habitats and species in this country. These are the Conservation (Natural Habitats, &c.) Regulations 1994, the Conservation of Habitats and Species Regulations 2017, the Conservation of Offshore Marine Habitats and Species Regulations 2017 and the Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001, known collectively as “the Habitats Regulations”, as well as The Wildlife and Countryside Act 1981.

In Scotland, these changes are enacted through The Conservation (Natural Habitats, &c.) (EU Exit) (Scotland) (Amendment) Regulations 2019, which seek to ensure that Scotland maintains the standards required by the EU Habitats and Wild Birds Directives, commonly referred to collectively as “the EU Nature Directives”, which set out rules for the protection and management of certain habitats and species and all wild bird species to ensure their conservation in the long term.

For Scotland and the rest of the UK, the Habitats Regulations continue to remain in force, including the general provisions for the protection of European sites and the procedural requirements to undertake Habitats Regulations Appraisal (HRA) to assess the implications of plans or projects for European sites.

1.2.7 Petroleum Act 1998 (as amended)

The Petroleum Act 1998 establishes the regulatory regime applying to oil and gas exploration and production in the UK (other than onshore in Northern Ireland). The Petroleum Act (as amended) vests all rights to the nation’s petroleum resources in the Crown but allows licences to be granted that confer exclusive rights to ‘search and bore for and get’ petroleum on the UKCS. The vast majority of offshore energy activities relating to oil and gas exploration and production are controlled under the Petroleum Act 1998 (as amended) and the Energy Act 2008 (as amended) or are exempted under the Marine Licensing (Exempted Activities) Order 2011 (as amended).

1.2.8 The Energy Act 2008 (as amended)

The Energy Act 2008, as amended in 2016, makes provisions for the decommissioning of offshore oil and gas installations. Part III of the Energy Act 2008 amends Part 4 of the Petroleum Act 1998 and contains provisions to enable the Secretary of State to make all relevant parties liable for the decommissioning of an installation or pipeline; provide powers to require decommissioning security at any time during the life of the installation and powers to protect the funds put aside for decommissioning in case of insolvency of the relevant party. Section 314 of the Marine and Coastal Access Act 2009, described in Section 1.2.12, creates a new part of the Energy Act 2008, Part 4A, which includes for Consent to Locate (CtL) provision.

1.2.9 The Offshore Combustion Installations (Pollution Prevention and Control) Regulations 2013 (as amended)

These regulations implement the provisions of the European Union (EU) Integrated Pollution Prevention and Control Directive (IPPC) (Directive 2008/1/EC) for offshore oil and gas installations and apply to those structures where combustion plant has a thermal input greater than 50 MW(th). In order to help prevent or reduce atmospheric emissions, the regulations require that a permit be obtained for the installation. In order to receive a permit, the operator must demonstrate that a BAT (Best Available Techniques) assessment has been conducted to ensure that the atmospheric emissions generated by the installation have been reduced as much as practically possible. Consideration should also be given to environmental quality standards, energy efficiency and waste minimisation. Adequate capacity for monitoring and analysis of emissions is required.

Once consent is granted, the permit holder is required to monitor and report emissions to demonstrate compliance with the permit conditions.

1.2.10 The Greenhouse Gas Emissions Trading Scheme Order 2020

Under these regulations, any combustion installation with a thermal input greater than 20 MW(th) (except in installations for the incineration of hazardous or municipal waste) must make an application for a greenhouse gas (GHG) emissions permit. Permits include a requirement to surrender allowances to OPRED that are equal to the total emissions of carbon dioxide from the installation in each calendar year. The holders of permits may buy and/or sell such allowances under the trading scheme.

1.2.11 The Offshore Installations (Offshore Safety Directive (Safety Cases etc.) Regulations 2015

The Offshore Installation (Offshore Safety Directive) (Safety Case etc.) Regulations 2015 came into force on the 19 July 2015 replacing the 2005 Safety Case Regulations. The 2015 regulations apply to all oil and gas operations in UK waters and implement the EC Directive on safety of offshore oil and gas operations 2013/30/EU. The EU has put in place a set of rules to help prevent accidents, as well as respond promptly and efficiently should one occur. The 2015 regulations provide for the preparation of safety cases for offshore installations and the notification of specified activities.

1.2.12 UK Marine and Coastal Access Act 2009

The UK Marine and Coastal Access Act 2009 provides a legal mechanism for improved management and protection of the marine and coastal environment, with particular relevance to biodiversity and nature conservation. This legislation makes provision for the designation of Marine Protected Areas (MPA) in UK offshore waters.

1.2.13 Marine Strategy Framework Directive

The aim of the European Union's Marine Strategy Framework Directive (MSFD) (2008/56/EC) is to protect the marine environment across Europe more effectively. The Marine Directive was adopted by the EU on 15 July 2008 and transposed into Scottish legislation by the Marine (Scotland) Act 2010. The Directive requires Member States to prepare national strategies to manage their seas to achieve Good Environmental Status (GES) by 2020. The MSFD outlines the following 11 high level descriptors of GES in Annex I of the Directive. The proposed Cambo Field Development is aligned with these descriptors, where applicable.

1) Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions;
2) Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems;
3) Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock;
4) All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity;
5) Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters;
6) Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected;
7) Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems;
8) Concentrations of contaminants are at levels not giving rise to pollution effects;
9) Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards;
10) Properties and quantities of marine litter do not cause harm to the coastal and marine environment;

11) Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.

1.2.14 The Scottish National Marine Plan

EU Directive 2014/89/EU introduced a framework for maritime spatial planning, with the aim to promote the sustainable development of marine areas and the sustainable use of marine resources. In accordance with this Directive, the Scottish National Marine Plan (NMP) was published in March 2015. The Scottish NMP sets out strategic policies for the sustainable development of Scotland's marine resources through informing and guiding regulation, management, use and protection of the Marine Plan areas. SPE will ensure compliance with all the NMP policies throughout the proposed Field Development. Section 5.3.1 summarises the general and oil and gas specific policies and objectives which are of relevance to the proposed Field Development.

1.2.15 The Climate Change Act 2008

The Climate Change Act (2008) establishes a legally binding target for the UK to reduce greenhouse gas emissions by at least 80% by 2050 from 1990 levels. The 2008 Act requires that the UK Government set five-yearly carbon budgets which limit greenhouse gas emissions from all sources, excluding international aviation and shipping. In 2019 this target was revised with the UK planning to reduce all greenhouse gas emissions to net zero by 2050.

1.2.16 UK Energy White Paper 2020

The White Paper sets out the UK Government's long-term vision for the energy system with the goal of achieving net-zero emissions by 2050. The oil and gas industry is acknowledged to play a critical role in maintaining the country's energy security, supports approximately 147,000 jobs and is a major contributor to the economy. The Oil & Gas Authority (OGA) estimates that there are still 10 to 20 billion barrels of oil remaining in the UKCS. Projections for demand for oil and gas, whilst reduced, is forecast to continue for decades to come.

To reduce the emission of greenhouse gases from offshore oil and gas operations the White Paper makes a number of commitments to make the UKCS a net zero basin by 2050. Commitments include reducing and ultimately eliminating flaring and venting operations, repurposing of existing infrastructure to support clean energy technologies, review and support the functions of industry regulators, support the supply chain in securing low carbon export opportunities in overseas markets and agree a 'North Sea Transition Deal' to support and promote the move away from oil and gas production.

Whilst these measures are ongoing, the White Paper also commits to ensuring a secure and resilient supply of fossil fuels during the transition to net zero emissions.

1.3 Environmental Impact Assessment (EIA) Process

Offshore oil and gas activities can involve a number of environmental interactions and impacts due, for example, to operational emissions and discharges and general disturbance. The objective of the EIA process is to incorporate environmental considerations into the project planning and design activities, to ensure that best environmental practice is followed and ultimately to achieve a high standard of environmental performance. The process also provides for the potential concerns of stakeholders to be identified and addressed, as far as possible, at an early stage. In addition, it ensures that the planned activities are compliant with legislative requirements and SPE's own management procedures (Section 1.4). The main elements of the EIA process followed are outlined below.

1.3.1 Information Gathering

Information was gathered on the natural and the socio-economic environment in the vicinity of the proposed Development, and potential sensitivities identified. Information was also gathered on the proposed operations, including the alternative options considered, and on relevant environmental legislation.

1.3.2 Commissioning Specialist Studies

Numerous environmental surveys have been conducted in Quadrant 204 and surrounding quadrants over the past 23 years, as discussed in Section 4.1.1. The most recent survey was commissioned by SPE in 2018 which included a cross transect of the Faroe-Shetland Sponge Belt Nature Conservation Marine Protected Area (NCMPA). As part of the EIA process, SPE has also commissioned a fisheries intensity study (Xodus, 2019) for the area around the proposed infield development location and export pipeline route. In addition, the following modelling studies were undertaken: drill cuttings dispersion modelling, produced water dispersion modelling (Fugro, 2019) and oil spill modelling (OSRL, 2020a and OSRL, 2020b) to cover the worst-case spill scenarios which have been identified.

1.3.3 Identification Potential Environmental Effects

A core element of the EIA process is the identification of all environmental effects associated with proposed project activities which may have a 'potentially significant' impact. This process is called 'scoping'.

SPE prepared an early consultation document which was sent to key stakeholders (statutory and non-statutory) to invite a dialogue early on in the project. This was followed up by a number of meetings during which any concerns raised were noted, so that they could be addressed fully in the ES.

In parallel to this process, SPE undertook an internal scoping exercise by means of an Environmental Issues Identification (ENVID) workshop. During the ENVID all proposed development operations were listed that may interact with the environment. These activities are termed 'environmental aspects'. The source and pathway of each environmental aspect was defined, and the receptor identified. All aspects identified were then scored against the environmental receptors to determine whether their impact would require further detailed assessment and appropriate mitigation in the ES. Section 5 of this ES details all scoping activities undertaken as part of this EIA and summarises the results of the scoping process.

1.3.4 Assessment of Potentially Significant Environmental Effects

Those environmental aspects that were scoped in for detailed assessment were then assessed systematically to ensure that all potential impacts of the project were considered transparently and in the same way.

The assessment of each aspect involved describing the concern, describing and quantifying its potential effects, recognising any gaps in understanding and explaining how these are dealt with, and defining measures that have been taken to mitigate the potential effect. Section 6 of this ES describes the process used to assess potential environmental effects.

1.3.5 Development of Mitigation Measures

Identifying and assessing potential impacts and mitigating their significance is an iterative process conducted throughout the project. Mitigation measures were explored throughout the assessment process in order to eliminate or reduce the significance of the identified environmental impacts. Mitigation measures adopted are described in each of the individual impact sections (Section 7 to Section 13) and have been summarised in the Commitments Register (Appendix 2).

1.3.6 Reporting of the Outcome of the Process by Means of the Publicly Reviewed ES

This ES reports the findings of the EIA process and explains how the conclusions have been reached. The intention has been to present the information in such a way to allow readers to form their own opinion on the acceptability of the residual levels of impact associated with the project. The ES covers:

- Non-Technical Summary;
- The reasons for the proposed Field Development and the nature and role of the EIA process (Section 1);
- A description of the option selection process for the proposed operations (Section 2);
- A description of the proposed operations (Section 3);
- A description of the environment in the vicinity of the proposed development (Section 4);
- The methods used to identify the environmental concerns associated with the programme (Section 5);

- The methods used to assess the potential environmental effects associated with the programme (Section 6);
- A detailed assessment of each concern, including any potential cumulative and transboundary impacts, and mitigation measures (Section 7 to Section 13);
- Conclusions (Section 14);
- Several Appendices, including a commitments register, a summary of relevant environmental legislation, ENVID matrices, scoping consultee responses and other scoping results and the production forecast.

Formal consultation takes place following submission of the ES, which is subject to public review.

1.4 Environmental Management

All SPE activities are carried out in accordance with SPE's Health, Safety & Environmental (HSE) Policy. A copy of the HSE Policy is provided in the inside cover of this Environmental Statement. SPE's HSE Policy forms part of the company's overall Management System and aligns wider regulatory compliance with SPE's policies, standards and ways of working, in order to achieve good care of the environment. The environmental performance of any third parties contracted to support SPE activities will be controlled under the auspices of this Policy, via appropriate interface documentation.

SPE reviews the impact all activities may have on the environment and ensures that all environmental risks are adequately identified, controlled or mitigated to an acceptable level by way of formal assessment. Risk related decision making is carried out with competence and authority. Seasonal variation in the distribution and vulnerability of species and features, such as seabirds and marine mammals, is considered in the planning of all work programmes. SPE has a strong understanding of required environmental provisions for UKCS licensees, including compliance with standards such as the National Marine Plan, as well as environmental consenting requirements.

1.4.1 Environmental Management During Operation of the proposed Cambo Field Development

As Licence Operator SPE relies on outsourced primary services to directly support its activities. As stated in Section 1.1, SPE propose to appoint an Installation Operator and Well Operator to operate the proposed Cambo Field Development on their behalf, in line with the Offshore Installation (Offshore Safety Directive) (Safety Case etc) Regulations 2015 (OSDR 15). Any applications to appoint an Installation Operator and Well Operator will be subject to approval from the OGA. As Licence Operator SPE will ensure that any potential operators *"have the capacity to meet the OSD [Offshore Safety Directive] requirements in relation to the particular offshore operations, duties and responsibilities relevant to the appointments, and must take all reasonable steps to ensure that the appointed operators satisfy those requirements"* (BEIS/HSE, Undated).

SPE must ensure that any third parties appointed to work on SPE's behalf fulfil requirements as detailed in the Offshore Installations (Offshore Safety Directive (OSD)) (Safety Case etc) Regulations 2015[1]. Environmental management is inextricably linked to requirements of the OSD and is often referred to in the context of the operator's safety and environmental management system (SEMS).

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[1] These Regulations implement the requirements of the Offshore Safety Directive (OSD) (Directive 2013/30/EU);

With specific reference to environmental management, operatorship appointments are subject to evidence of the following environmental provisions being in place:

- Environmental Policies;
- Understanding of statutory environmental provisions and roles and responsibilities in relation to environmental management;
- Have an environmental management system or a commitment to have such a system in place prior to undertaking offshore activities. All Well and Installation Operators are required to have an Environmental Management System (EMS) that fulfils the requirements of BEIS EMS Guidance (BEIS, 2014) and that of OSPAR Recommendation 2003/5[2].

With this operating model, all operational activity undertaken on behalf of SPE will be managed under the appointed Installation/Well Operator's EMS.

As part of this assurance process, third parties will need to demonstrate to SPE:

- That any operational activity will be conducted in accordance with the company's (i.e. Contractor's) Environmental Policy;
- That an EMS certified (and verified by an external verification company) to the International Standard for Environmental Management Systems, ISO14001:2015, is in place and implemented;
- That they have extensive knowledge of UKCS environmental consenting requirements;
- A history of compliance with environmental legislation.

Third parties will also be subject to audit by SPE. Key areas of consideration during the audit will include:

- Environmental policies and overall management arrangements, including the status of EMS certification where applicable;
- Mechanisms for the identification of environmental issues and legislation and the undertaking of risk assessments;
- Arrangements for staff training and competence assurance;
- 'Shipboard' oil pollution and emergency arrangements, including Safety Case;
- Hazardous substance handling and storage procedures;
- Arrangements for legal compliance evaluation e.g. drainage discharge monitoring;
- Waste management practices and procedures, including associated onshore issues;
- Controls on key emissions to water and air;
- Mechanisms for the achievement of continuous improvement in performance.

Specific environmental management activities relating to operational activities will be taken forward in an Environmental Management Plan (EMP) which will incorporate the mitigation, control and monitoring measures identified in this environmental statement as well as the responsibilities for implementation. The EMPs for drilling and production operations will be prepared by the appointed Well Operator and Installation Operator, respectively, nearer to the start of the operations.

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[2] OSPAR Recommendation 2003/5 promotes the use and implementation of Environmental Management Systems (EMS) by the Offshore Industry.

Section 2

Options Selection

2. OPTION SELECTION

This section of the Environmental Statement (ES) describes the main alternatives considered for the proposed Cambo Field Development during the early Assess and Select (concept) and Define (Front End Engineering Design, FEED) stages of the SPE field development and opportunity maturation process. This process is illustrated in Figure 2.1.

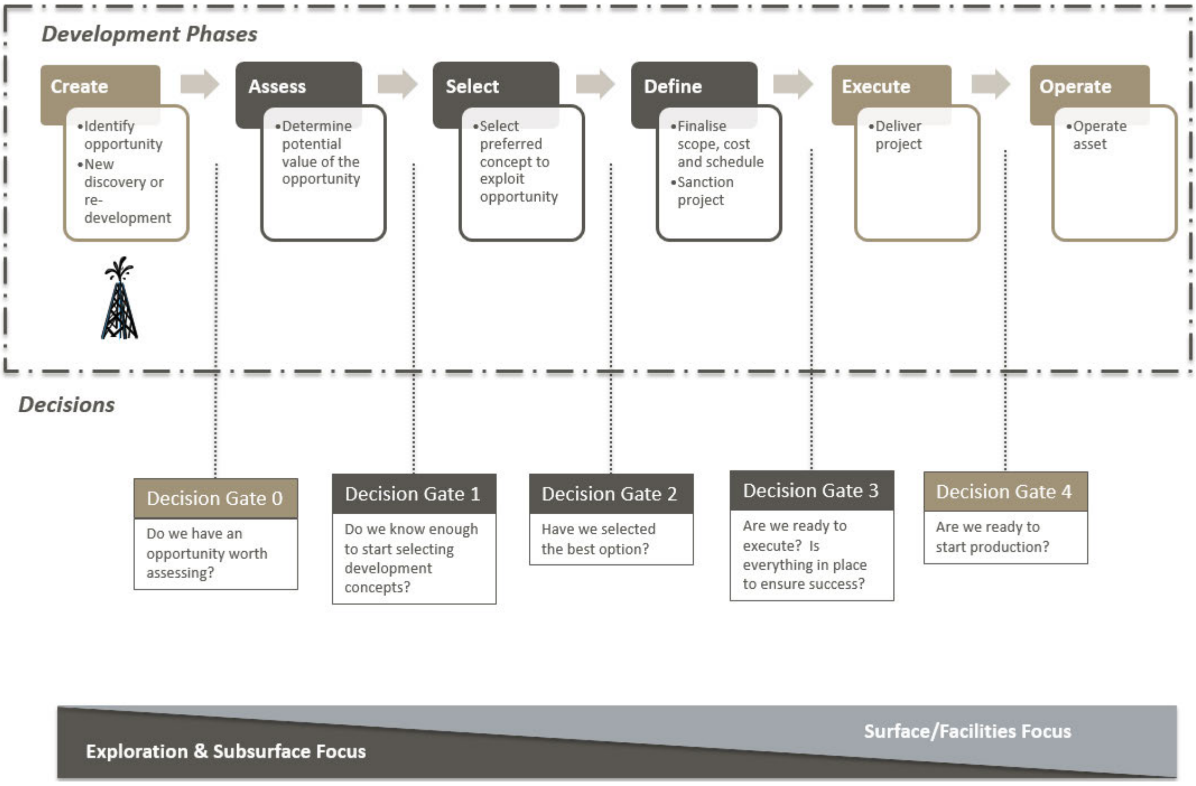


Figure 2.1: SPE Field Development Process

2.1 Introduction

Under the EIA Directive (2011/92/EU) (as amended by Directive 2014/52/EU) a developer is required to provide *“a description of the reasonable alternatives studied by the developer, which are relevant to the project and its specific characteristics, and an indication of the main reasons for the option chosen, taking into account the effects of the project on the environment”*.

In December 2020, BEIS OPRED produced Guidance Notes on the Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020. The guidelines stipulate that the ES should *“describe the main alternatives to the proposed project that have been considered, and clearly describe the advantages and disadvantages of each option and the associated environmental implications. The main reasons for selection of the preferred option should be summarised, taking particular account of the environmental issues. Other factors influencing the final choice should also be recorded, e.g. feasibility including technical constraints and cost effective issues relating to each option. If a formal option appraisal system has been used, it should be described and the relevant decision factors identified.*

Where appropriate, consideration should always be given to alternative sites (including pipeline routes), alternative timing, alternative construction methods, alternative plant and equipment and *alternative operating practices. Wherever possible, OPRED would always encourage the use of existing infrastructure, and if there is existing infrastructure available but its use is not the selected option then a robust justification should be provided. The consideration of alternatives may also be relevant for the drilling of a well and details of the decision-making process should be included, e.g. alternative sites, alternative rig types, alternative timing, slim hole, horizontal or extended reach technologies, alternative drilling muds and alternative cuttings treatment and disposal options.*

Where final option selection has not been made before the submission of the ES, it is acceptable for more than one option to be presented in the assessment. However, sufficient detail must be provided to permit a full assessment of each option."

2.1.1 Planning the Proposed Cambo Field Development - Background

Prior to SPE's acquisition of the Cambo Licences in Q1 2017 a number of scenarios for field development had been considered for the Cambo field (by previous operators), based on appraisal data available and analyses at that time. Concepts considered for full field development included:

Option 1: A Floating Production Facility on a Cambo Full Field Development Standalone Basis

Based on a deepwater floating host at the Cambo field in 1,100 m water depth, processing only the Cambo fluids (Figure 2.2). The host would process well stream fluids with oil and gas export. Floating production options included:

- Floating production, storage and offloading (FPSO);
- Semi-submersible platform;
- Tension-leg platform (TLP);
- Single point anchor reservoir (SPAR) platform.

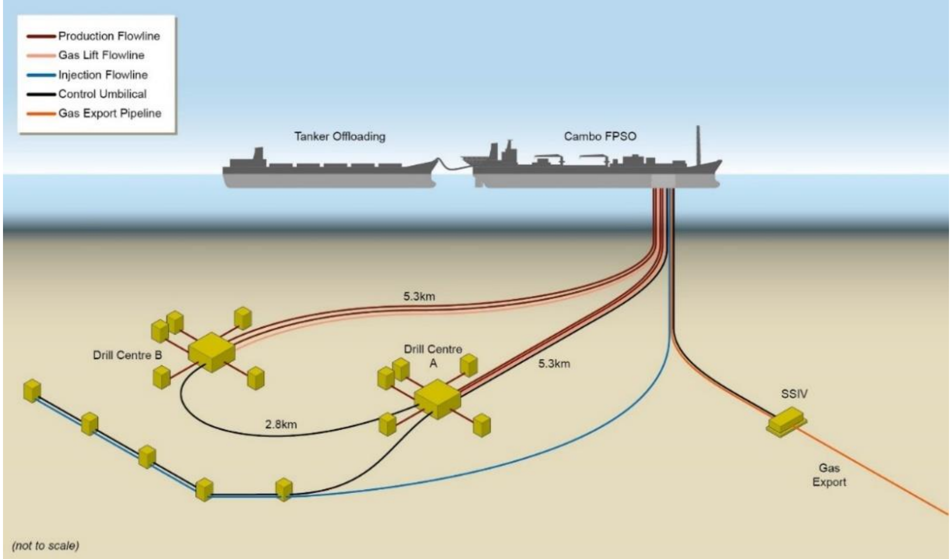


Figure 2.2: Floating Production Facility on a Cambo Full Field Development Standalone Basis

Option 2: A Larger Hub for Potential Tie-back of Other Nearby Gas Discoveries and Prospects

Similar to the full field development standalone option with the addition of the subsea tie-backs to a host facility at Cambo. Host topsides with additional inlet reception, gas processing and compression, hydrate management (MEG injection, reception and reclamation) facilities to accommodate tie-back fluids processing (Figure 2.3).

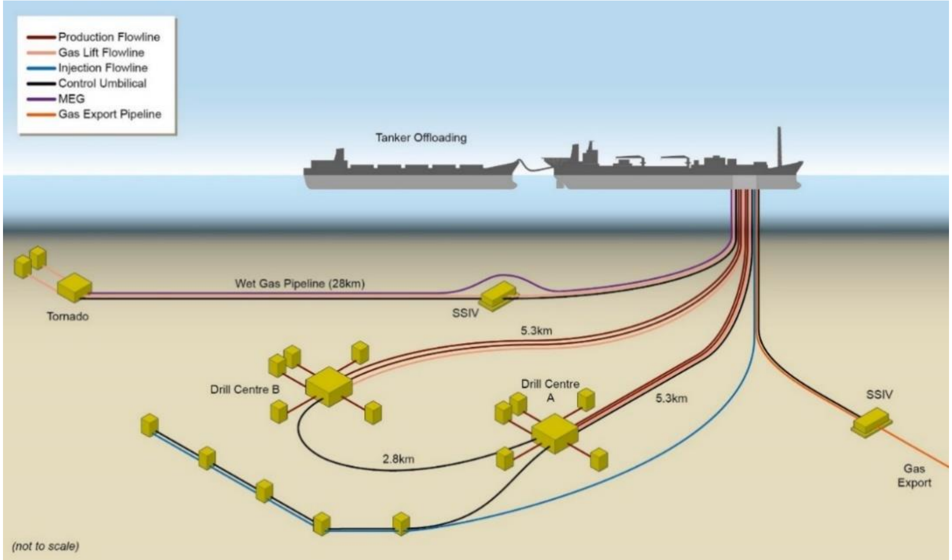


Figure 2.3: Larger Hub for Potential Tie-back of Other Nearby Gas Discoveries and Prospects

Option 3: Subsea Tie-back to an Existing Host
Co-development of Cambo as a subsea tie-back to an existing host facility e.g. the proposed Rosebank FPSO development, approximately 40 km north of Cambo (Figure 2.4). Subsea multiphase (combined oil, gas and water) pumping to transfer the Cambo wellstream fluids to the Rosebank FPSO. All processing and export functions carried out on the Rosebank FPSO using common facilities with increased capacity. Power, chemicals and control provided by the Rosebank FPSO to the Cambo field.

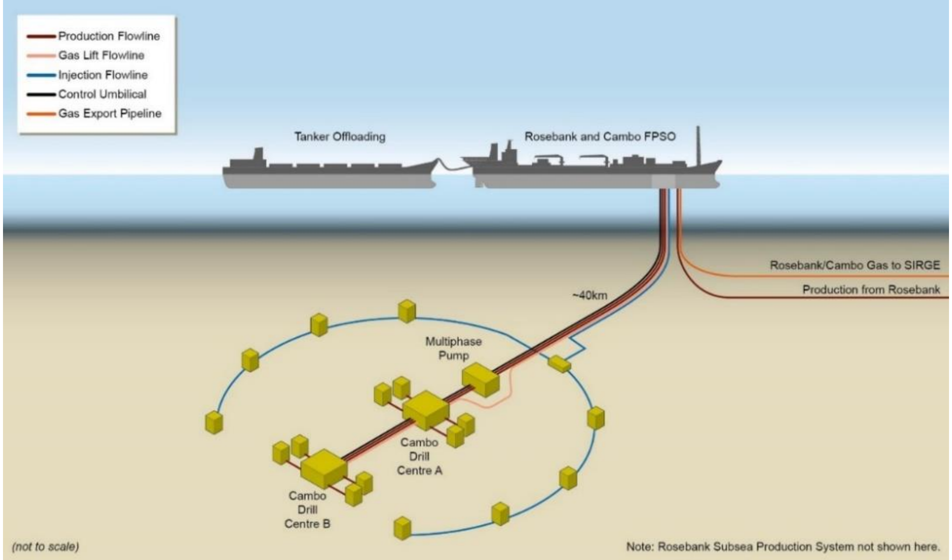


Figure 2.4: Subsea Tie-back to an Existing Host

Option 4: A Shallow Water Platform Allowing Potential Tie-back of Cambo and Other Discoveries, Prospects or Other Third-Party Fields in the Area
Similar to the Cambo Hub, premised on co-development of the Cambo field with other regional resources. The host in this case is located 80 km south east of Cambo in shallow water, enabling the

use of a fixed substructure (Figure 2.5). This development concept requires subsea separation and/or pumping of the liquids to enable fluids to flow to the shallow water location with substantial power transfer from the host.

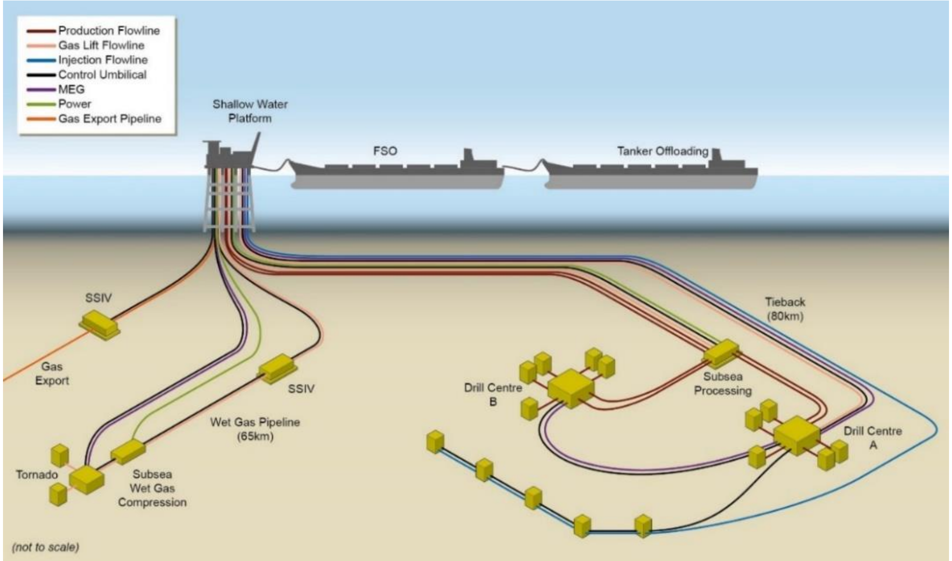


Figure 2.5: Shallow Water Platform allowing Cambo and other 3rd Party Tie-backs

Option 5: Standalone Early Production System and Phased Field Development
Similar to the Cambo standalone concept with variation on scope, commitment and timing of distinct development phases (Figure 2.6).

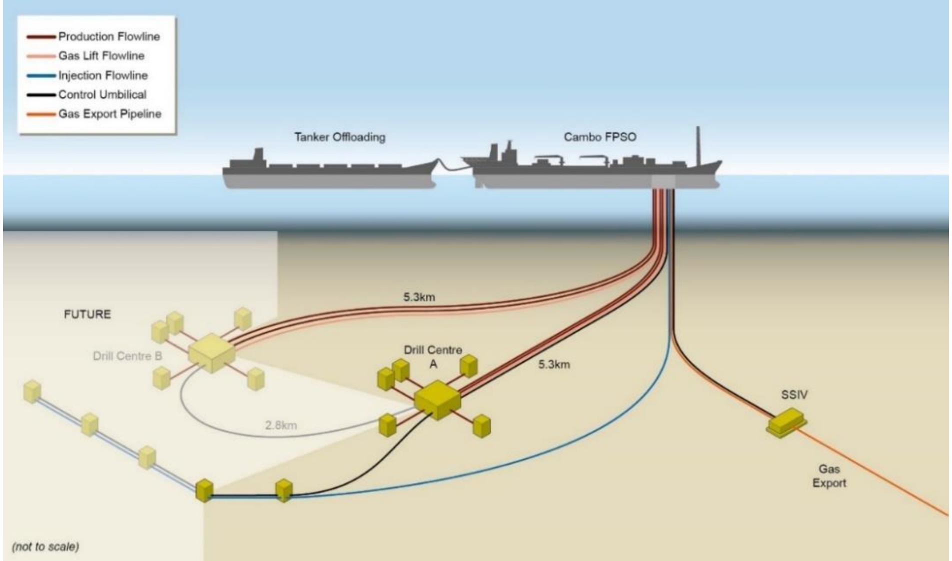


Figure 2.6: *S*tandalone Early Production System and Phased Field Development

Following completion of a 2015 work programme, the licence operator at the time concluded that a standalone EPS approach to the Cambo development was preferred to mitigate subsurface risk and allow the appraisal of the full field and other opportunities to follow. EPS planning was underway when SPE became licence operator of the Cambo field.

In order to comprehensively test the conclusions drawn by previous licence operators, SPE revisited the development options for the Cambo field to identify and re-evaluate all credible concepts and approaches to the development. Initial SPE work focussed on subsurface studies and the need for further appraisal to reduce remaining subsurface uncertainty and inform development concept selection.

A further appraisal well (204/10a-5) was drilled in 2018. The main objective of this well was to perform a well test to obtain information on well deliverability and connected volumes, to de-risk concerns around reservoir connectivity.

The well encountered oil-bearing Hildasay H50/H40/H30 sands that were cored. The subsequent horizontal side-track (204/10a-5Y) was completed and tested in the H50 reservoir unit. The well flowed naturally for 10 days at rates of circa 795 m3/day (5,000 bpd) of dry oil, recovering approximately 7,472.4 m3 (47,000 bbls) oil over the test period. All test objectives were met, and a high-quality data set acquired. Analysis established reservoir continuity and confirmed that the Hildasay reservoir in Cambo comprises excellent quality sands.

The positive test results and enhanced data set subsequently formed the basis for further field development planning and option selection, as described in the following sections.

2.1.2 Option Screening and Selection Process

Having a common understanding and alignment amongst project teams, management, joint venture partners, and other key stakeholders on strategic project issues is key to ensuring that the field development opportunity is appropriately framed, and key value drivers and critical success factors are established. This ensures that decision criteria for the selection of alternatives are agreed and established early in the project life cycle i.e. Assess and Select Phases (see Figure 2.1).

2.1.3 SPE Value Drivers and Decision Criteria

There are a number of areas that have potential to add value to the project, including schedule, overall development cost, project scope and facilities design and build quality. These so-called ‘Value Drivers’ provide focus for the project team and establish the basis for prioritising activities and developing optimal solutions. Making decisions that offer the best overall outcome and ensure environmental and economic sustainability are essential for the project. As such, SPE developed decision criteria and identified critical success factors (those issues to consider and manage to ensure a successful project outcome) to aid decision-making (Table 2.1).

Table 2.1: SPE Decision Criteria and Cambo Development Project Goals and Value Drivers

Decision Criteria	Project Goals	Risks/Opportunities to Consider
Health, safety and environment	▪ Industry-leading HSE practices; ▪ Minimising environmental impacts.	▪ Scale and likelihood of hazards/management options; ▪ Inherently safe design; ▪ Environmental impact; net zero obligations and opportunities.
Cost and value	▪ Economically attractive solution; ▪ Delivery of project to schedule and budget promise; ▪ Targeted provisions and investment for further development phases.	▪ Cost and schedule estimates/risks, opportunities and uncertainties; ▪ Maximising Economic Recovery Strategy for the UK (MER UK); ▪ Reserves recovery; ▪ Balance against CAPEX goals.
Technical	▪ Industry leading outturn performance in design; ▪ Improved understanding of Cambo reservoir; ▪ Maximising economic hydrocarbon recovery; ▪ Appropriate infrastructure choices for subsequent phases.	▪ Design simplicity; ▪ Robust front-end loading ▪ Technology stretch; ▪ Track record in deep water, harsh environment; ▪ Flexibility; ▪ Subsurface uncertainty.
Deliverability	▪ Industry-leading project outturn performance.	▪ Acceptability to regulators (OGA, BEIS, HSE) and other stakeholders; ▪ Alignment with OGA strategies (MER UK and net zero); ▪ Partner alignment; ▪ Deliverability of sanctionable FDP; ▪ Market conditions/schedule risk; ▪ Execution risk; weather windows.
Operability	▪ Competitive outturn performance in operation; ▪ Delivery of project functional objectives.	▪ O&M philosophies; ▪ Training/sparing; ▪ Production and operating efficiency; ▪ Human factors.

The list of decision criteria is not exhaustive.

A crucial element within the criteria and the decision-making process has been consideration of potential environmental impact and the environmental sensitivities within the Cambo area.

2.1.4 Other Factors Influencing Concept Selection

In addition to the value drivers mentioned above, there are a number of other critical success factors that have influenced concept selection for the proposed Cambo Field Development. These factors are supporting objectives or activities that will support the value drivers – if managed well, these will assist the project in achieving its goals, but conversely if poorly managed will erode value; the key factors are illustrated in Figure 2.2.

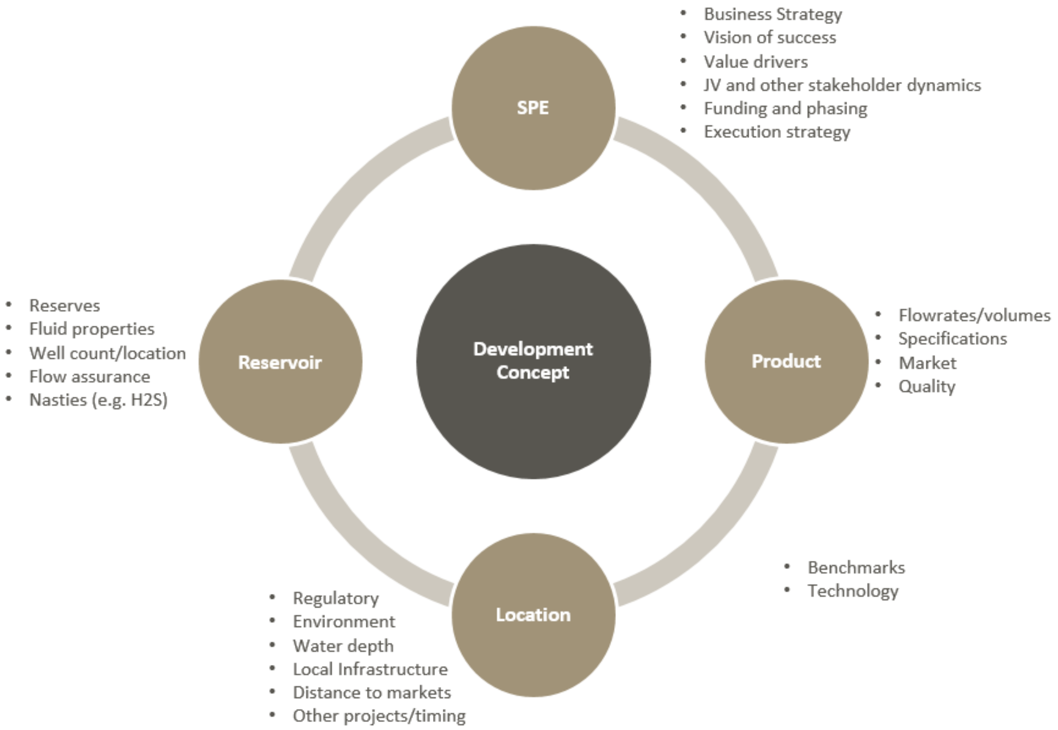


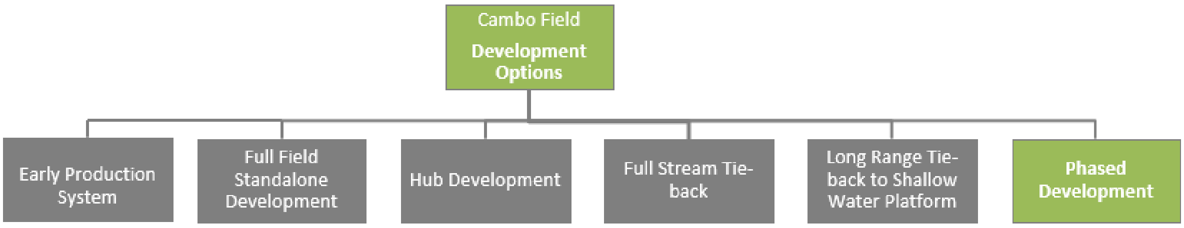
Figure 2.7: Key Factors Influencing Concept Selection

2.2 Option Identification and Selection

The following sections detail the basic development concepts and development component sub-options considered for the Cambo field.

Flow diagrams for each of the key decisions and elements of the project have been provided for ease of reference. Green boxes indicate which decisions have been taken.

2.2.1 Field Development Concept



This section summarises the range of highest-level field development concept options considered by previous operators and subsequently re-evaluated by SPE.

Due to the water depth at the Cambo field (approximately 1,100 m), areal extent of the field and the low well density/shallow nature of the Cambo reservoir (circa 2,400 m True Vertical Depth Subsea (TVDSS)), all concepts were centred on a wet tree/subsea production system (SPS) with surface processing facilities.

The conclusions from the evaluation showed that while all options were technically feasible, a phased development on a standalone basis was preferred. The key factors supporting the decision were:

- Improved confidence/understanding of the Cambo reservoir, deliverability and recoverable resources through the successful drilling and test of the Cambo 204/10a-5Y well;
- More substantive initial phasing supports incorporation of features to reduce environmental impact;
- Phasing allows managed development of the full field/optimisation of field infrastructure and environmental footprint.

Table 2.2 summarises the rationale for rejection of the alternatives based on the project decision criteria outlined in Section 2.1.

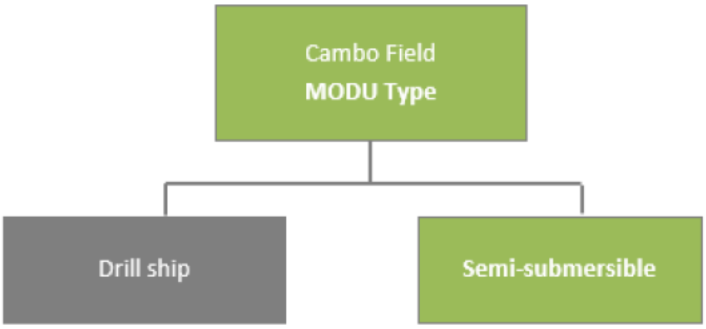
Table 2.2*:* Rationale Summary for Rejection of Field Development Concept Alternatives

Rejected Option	Positive Aspects	Rationale for Rejection
Full field standalone development	▪ Economy of scale - potential overall capital expenditure efficiency improvement over phased development.	▪ Large areal extent of the Cambo reservoir. Some remaining subsurface uncertainty in areas of the Cambo reservoir beyond existing well control; ▪ Does not facilitate further appraisal of the Cambo reservoir and optimisation of plans for subsequent phases; ▪ High initial CAPEX and long schedule to first production; ▪ Large initial environmental footprint.
Hub development	▪ Infrastructure enabler to unlock development of other discoveries and prospects.	▪ Uncertainty of probability/timing of development of nearby discoveries and prospects; ▪ High initial CAPEX and uncertain timeline for development; ▪ Flow assurance associated with long tie-back of gas resources to Cambo location.
Full stream tie-back to existing host	▪ Low capital expenditure and schedule opportunities. ▪ Inherent safe design. ▪ Efficient use of existing infrastructure; reduced environmental footprint.	▪ No local infrastructure; lack of availability of a suitable existing host to accommodate Cambo; ▪ Uncertainty over timing of other prospective area developments (e.g. Rosebank); ▪ Flow assurance (wax and hydrate management) associated with Cambo fluids and long tie-back to existing facilities.
Long range tie-back to shallow water platform	▪ Technical risk associated with floating system in harsh, deep water environment removed.	▪ No suitable existing shallow water host platforms nearby; ▪ High CAPEX for new-build shallow water host option; ▪ Flow assurance (wax and hydrate management) associated with Cambo fluids and long tie-back to existing facilities.
Standalone Early Production System	▪ Lowest cost exposure in event of poor reservoir outcome. ▪ Schedule opportunity through redeployment of existing assets with modest conversion scope.	▪ Greater confidence in Cambo reservoir supports more substantial first phase development; ▪ Lack of suitable host options available for an Early Production System at acceptable technical risk/CAPEX level; ▪ Poor environmental performance – Early Production System would not support gas disposal options other than routine flaring.

✓ **Development Concept Decision:** Phased Development

2.2.2 Drilling/Wells

2.2.2.1 Mobile Offshore Drilling Unit (MODU) Type



The proposed Development facilities will not have any drilling capability and therefore a Mobile Offshore Drilling Unit (MODU) is required. Due to the water depth, floating MODUs are the only feasible option. Furthermore, a dynamically positioned (DP) floating MODU (as opposed to wire/chain moored) can be positioned more readily between the various drilling locations at the field and reduces the potential environmental impacts from anchors. The nature of the drilling programme is such that MODU moves will be frequent.

Two MODU types considered were:

1. A DP semi-submersible;
2. A DP drill ship.

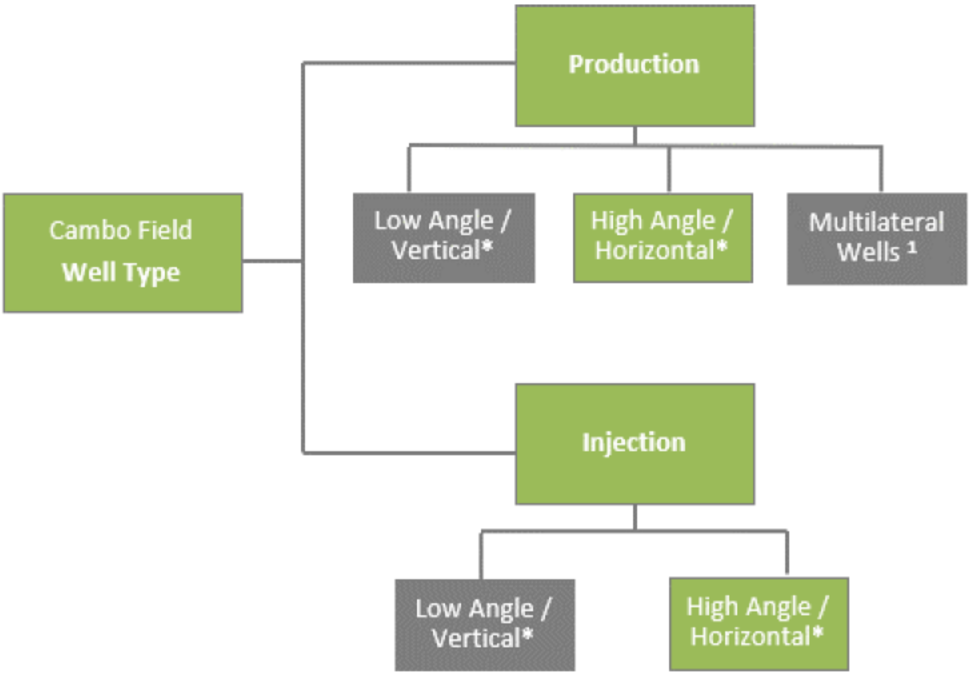
The key criteria considered when reviewing the type of MODU to use included:

- Deepwater capability;
- Favourable motion characteristics under harsh weather conditions west of Shetland and likely weather uptime;
- Operational efficiency in subsea completions and subsea tree installations.

Assessment concluded that whilst drill ships offer favourable mobility, transit speed and deck load capacity, these positive aspects are outweighed by the greater stability/improved vessel motion response of the semi-submersible hull design to Cambo field metocean conditions, resulting in higher uptime/reduced risk of frequent disconnection. This was supported by other operator experiences in deployment of DP drill ships at the Rosebank field and other west of Shetland locations.

✓ **MODU Type Decision:** DP Semi-submersible

2.2.2.2 Well Type



** Single producing bore*

¹ Two or more producing bores / reservoir sections

Production Wells

Three well types were considered for the oil producers:

1. Low angle;
2. High angle/horizontal;
3. Multilateral wells, which would have two or more producing bores.

The proposed Development well construction objective is to achieve maximum reservoir recovery from the simplest well design.

One advantage of multilateral wells (i.e. those with multiple branches from the same well bore) is that they can produce from multiple reservoir sections within the same well, which might reduce the required well count and the construction costs of the upper hole sections. However, the multilateral design itself introduces extra complications and risks for a successful completion, can compromise well locations and can reduce production rates.

Multilateral wells are not expected to be cost efficient for Cambo and their use has been rejected for this development.

High angle or horizontal producers are needed to achieve attractive production rates. Given the shallow depth and stratigraphy of the reservoir, long high angle horizontal reservoir sections maximise recovery and limit the required well count (thereby minimising potential environmental impacts of drilling and production operations e.g. drill cuttings disposal, energy and resource use etc.).

The horizontal 2018 appraisal well proved the feasibility of drilling such wells in the Hildasay sands.

✓ **Production Well Type Decision:** Dedicated, High Angle Wells

Injection Wells

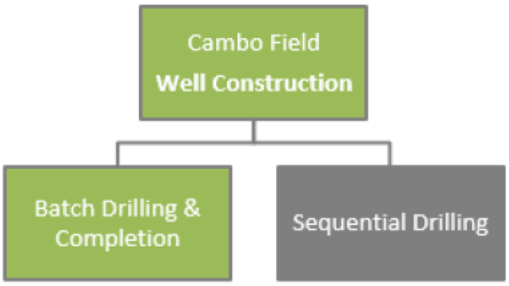
The extent of any aquifer is uncertain and Cambo will be developed using peripheral water injection to provide pressure support and to sweep oil to the production wells. Two water injectors will be available at first oil with an additional two water injectors included in development plans should they be needed to effectively develop the field.

The initial injection wells will be dedicated to individual reservoir units, with decisions on future injection well type to be determined based on observed well performance. This approach ensures injection into each reservoir unit and offers improved reservoir monitoring / data acquisition.

The wells will be high angle single bore wells in order to maximise injectivity and prevent the risk of loss of containment (out of zone injection).

✓ **Injection Well Type Decision:** Dedicated, High Angle Wells

2.2.2.3 Well Construction



Two well construction alternatives were considered for delivery of the wells:

1) Batch drilling and completion - drill the upper sections of several wells first, before re-entering each at later dates to drill and complete the remaining lower sections;
2) Sequential drilling - drill and complete one well at a time.

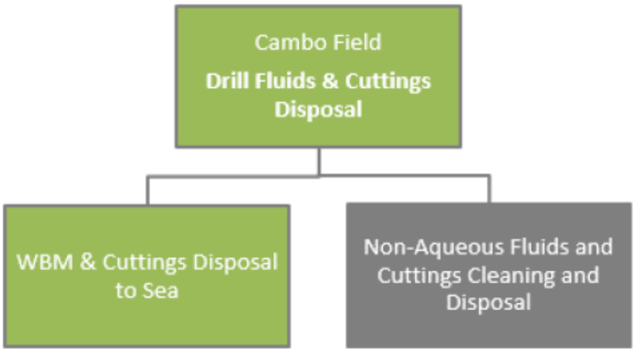
The option selected was batch drilling and completion. This decision was primarily driven by the efficiencies gained through batch operations and the benefit it provides in scheduling operations during the winter months, which see particularly harsh weather conditions at the Cambo area.

The top-hole conductor section of the well will either be drilled conventionally with a 36" × 30" conductor then cemented in place or this will be replaced with a suction piled CAN-ductor with an integrated wellhead housing and conductor extension joint.

The well sequence will be optimised and Blowout Preventer (BOP) Hopping utilised to reduce the risk of environmental impact by limiting the frequency of disconnecting the marine riser due to weather conditions.

✓ **Well Construction Decision:** Batch Drilling and Completion

2.2.2.4 Drill Fluids and Cuttings Disposal



Two options were identified:

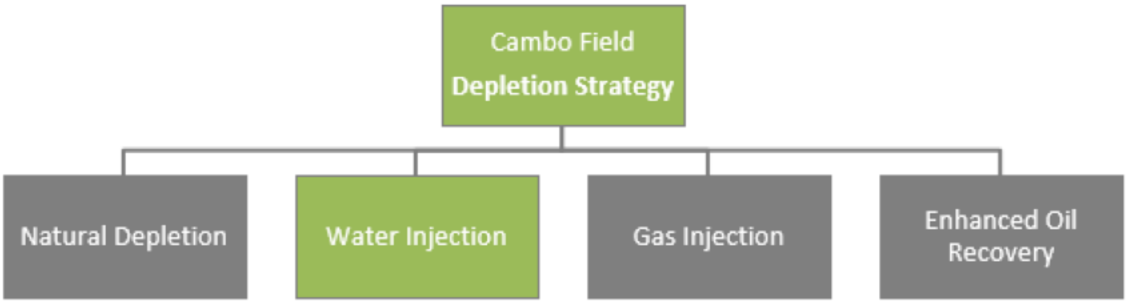
1) Water based mud (WBM) with treated cuttings disposal to sea; and
2) Low toxicity oil-based mud (LTOBM) with either skip and ship to shore or offshore clean-up/disposal to sea.

The drilling fluid design will follow Option 1, the concept proven in Cambo offset wells. The use of WBM has been very successful in meeting drilling objectives while providing the benefit of lower environmental risk as a consequence of reduced cuttings handling, treatment and transportation requirements.

✓ **Drill Fluids and Cuttings Disposal Decision:** WBM and Cuttings Disposal to Sea

2.2.3 Reservoir Management

2.2.3.1 Depletion Strategy



Four options were considered for the depletion strategy for Cambo:

1. Natural depletion;
2. Water injection;
3. Gas injection; and
4. Enhanced oil recovery.

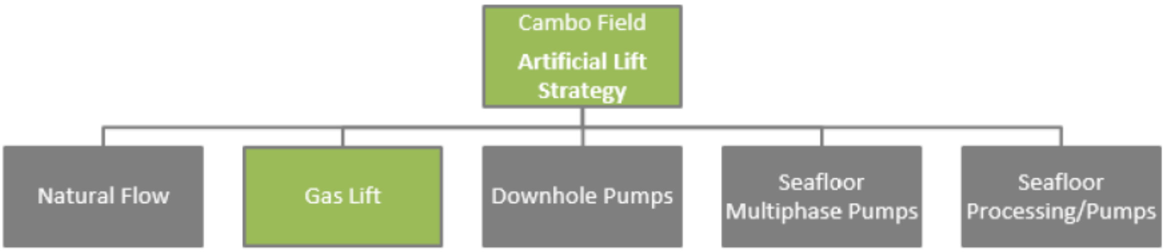
Based on the goal of maximizing economic oil recovery, water injection (Option 2) is the preferred depletion strategy. Table 2.3 summarises the rationale for rejection of the alternatives:

Table 2.3: Rationale Summary for Reservoir Depletion Strategy

Rejected Option-	Positive Aspects	Rationale for Rejection
Natural depletion/ aquifer support	▪ Lower capital expenditure.	▪ The extent of any Cambo aquifer is uncertain and cannot be guaranteed to provide adequate pressure support for the predicted reservoir withdrawals.
Gas injection	▪ Potentially lower capital expenditure. Reduced environmental impact if not exporting via new pipeline infrastructure.	▪ Cambo is structurally flat and gas injection is predicted to have an adverse impact on oil recovery, with gas very quickly breaking through to producing wells unless injected at some distance from the producers.
Enhanced Oil Recovery (EOR)	▪ Potential increase in oil recovery.	▪ Already favourable mobility; ▪ Most polymer waterflood type schemes have been undertaken in reservoirs with significantly heavier and more viscous oil (> 10 cP at reservoir conditions); ▪ Limited well stock (Polymer waterflooding would lower water injection rates); ▪ Limited field life and unfavourable timescales for implementation of EOR and its economics.

✓ **Depletion Strategy Decision:** Water Injection

2.2.3.2 Artificial Lift Strategy



Artificial lift is needed to sustain attractive production rates at higher water cuts given the low reservoir pressure regime. The artificial lift methods considered were:

1. None - natural flow;
2. Gas lift;
3. Downhole pumps;
4. Flowing wells with seafloor multiphase pumps;
5. Flowing wells with seafloor gas/liquid separation with and without liquid boosting.

Gas lift (Option 2) is preferred, being a well proven form of artificial lift as used in other West of Shetland subsea developments, involving a simple completion design and having a low installation and operations risk, avoiding the need for potentially frequent costly interventions to replace pumps. Gas lift is relatively insensitive to variations in fluid properties, gas to oil ratio (GOR) and sand production.

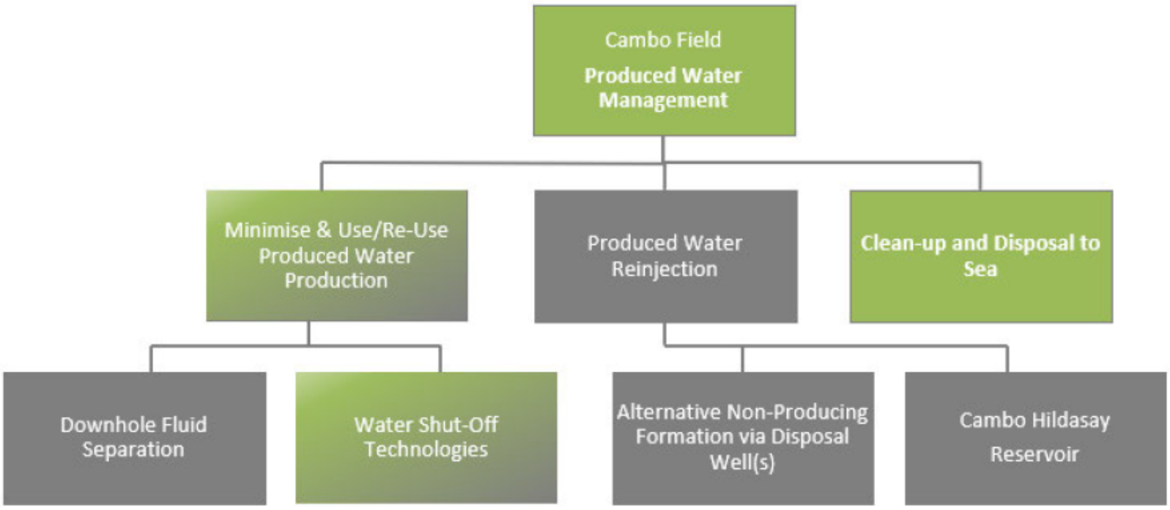
Table 2.4 below summarises the rationale for rejection of the alternatives:

Table 2.4: Rationale Summary for Artificial Lift Strategy

Rejected Options	Positive Aspects	Rationale for Rejection
Natural flow	- Simple well design; - Reduced facilities complexity and cost.	- Whilst Cambo wells are expected to be able to flow naturally, reservoir pressure is too low to sustain attractive production rates at higher water cuts and to kick-off wet wells after shutdowns (or after completion).
Downhole pumps	- Higher production rate potential per well.	- Higher downhole and topsides/FPSO interface complexity; - High cost of workover in event of downhole pump failure; - Sand production.
Seafloor multiphase pumps	- Reduced backpressure on wells; improved production opportunity; - Improved flow assurance potential; - Capital expenditure reduction opportunity through simplified SURF scope.	- Limited experience in successful deployment/operation in deepwater harsh environments; - High cost of intervention in event of multiphase pump failure; - Sand production.
Seafloor processing/pumps	- Reduced backpressure on wells; improved production opportunity; - Improved flow assurance potential; - Capital expenditure reduction opportunity through simplified Subsea Umbilical Riser and Flowline (SURF) scope.	- As for seafloor multiphase pumping.

✓ **Artificial Lift Strategy Decision:** Gas Lift

2.2.3.3 Produced Water Management



The produced water at Cambo comprises formation water plus gradually increasing quantities of injection water over the life of field. A range of options were considered for the management of production and the disposal of produced water, summarised as follows:

- Minimisation of produced water production during operations;
- Produced Water Reinjection (PWRI) to producing formations;
- Produced water injection into a non-producing formation via disposal well(s);
- Treatment and overboard discharge to sea.

Minimisation of Produced Water Production from Cambo Wells

This could be achieved through two means:

- Water shut-off techniques;
- Downhole separation.

There will be limited scope to manage water production from the Cambo producers by water shut-off or other downhole means.

The Cambo producers are high angle/horizontal wells targeting clean, relatively thin (low tens of metres thick) homogeneous sands. The Cambo sands are weak, and sand control is required in the wells in order to limit sand production into the wellbore and solids transport to the subsea pipelines and surface facilities or sand fill of the wellbore, restricting or preventing production. Producers will be competed with alternate path open-hole gravel packs to provide this sand control. The particle size distribution (PSD) of the Cambo sand has been measured by both sieve and laser diffraction techniques. The PSD, in conjunction with industry standard criteria, has been used to select the most appropriate sand control method. Sand retention testing has also been carried out on the mesh of premium screens which indicated unacceptable levels of plugging and thus the use of standalone screens has been rejected. Whilst the sand control should limit sand production, a certain degree of sand production is still expected. Levels have been estimated based on a plastic radius calculated from the mechanical properties of the formation, the in-situ stress and drawdown, giving a sand rate of up to between 5.7 and 20 mg/l (2 and 7 lbs per 1000 bbls). These levels of sand production are consistent with analogue fields.

The Cambo reservoir sands are relatively flat, in a low dip structure, and displacing injection water will quickly move to the producing section. Without suitable thick non-reservoir (e.g. shale) intervals and/or blank pipe within the lower completion, the options to mechanically shut-off water are limited and are likely to be quickly bypassed by the water in the reservoir. Given the deepwater environment at Cambo, the cost of any well intervention will be high, making it more difficult to justify speculative well interventions. An evaluation of alternative inflow control devices, such as Autonomous Inflow Control Devices (AICDs), indicated negligible benefit in terms of oil production. AICDs are also incompatible with the preferred choice of sand control using alternate path open-hole gravel packing. Whilst offering some benefits in terms of reducing water, similar as for water shut-off, it is expected that water would quickly bypass any individual AICDs which are restricting water inflow. AICDs and other inflow control devices also introduce an additional pressure loss, which would lower production rates.

Downhole separation of hydrocarbons and formation water could be achieved through the inclusion of a hydrocylone stage as part of an electrical submersible pump (ESP) assembly. The separated formation water could then be routed to a disposal formation beneath the produced formation, whilst the remaining reservoir fluids are routed to surface. However, downhole separation as a means of produced water management was discounted as a viable option for the following reasons:

- ESPs were not selected as the optimal artificial lift technique for Cambo Phase 1;
- The weak nature of the Cambo formation means that some solids production is expected. Injecting such solids into a disposal formation, will drastically reduce injectivity limiting the ability to dispose of produced water and increasing the risk of out of zone injection;
- Downhole separation suffers from a lack of track record and industry experience;
- Expected high installation and operating costs (assuming pump failure).

Produced Water Injection into a Non-producing Formation Via Disposal Well(s)

This option was reviewed and discounted on the basis of the following:

- Subsurface risks:
    - Uncertainty in the lateral extent and quality of disposal horizons and ability of injection water/pressure to leak off over time. Core water flooding measurements indicate that there will be permeability impairment and a loss of injectivity with PWRI (from solids carryover and oil), even in the excellent quality (Darcy permeability) sands seen in the Cambo Hildasay and as expected to be present in overlying sands. The quality of the deeper Colsay sands is also expected to be good based on the limited data available from the 204/10a-3 well and other wells along the Corona Ridge. However, the Colsay sands at Cambo would need appraisal in order to better delineate the extent of and quality of the sands and to ensure that possible future development of the oil lying in these sands is not jeopardised;
    - Increased risk of loss of containment if injecting into a shallower sand, especially given the expectation of this horizon containing weak sands (weaker than the Cambo Hildasay reservoir). Fracture modelling of vertical water injectors, indicates that at the disposal rates required (i.e. the produced water volumes of up to 12,719 m^3 (80,000 bbls/d)), that there would most likely be a loss of containment, unless drilling multiple or high angle/horizontal disposal wells, the latter maybe only deferring the loss of containment.
- Additional project costs as a standalone injection system (for PWRI) would be required in addition to the seawater injection system (sized to meet Cambo voidage replacement requirements since PWRI would not contribute to reservoir pressure support and sweep). The cost of installing dedicated disposal infrastructure and the drilling of multiple disposal wells would also be prohibitively expensive. (Drilling into the Colsay, were this to be identified as a possible disposal horizon, would require the drilling of deeper wells, penetrating basalt layers, adding to the duration and cost of drilling the disposal wells).

Options Carried Forward from Initial Screening

Subsequently, two options for produced water management were taken forward for further assessment for Cambo; produced water re-injection (PWRI) into the Cambo producing formation (Option 1) and produced water disposal to sea (Option 2). Both options were assessed, applying the principles of BAT/BEP and considering technical viability and risk. Based on the assessment, Option 2 - produced water clean-up and discharge to sea has been selected for the development.

The criteria against which the decision was made included consideration of Cambo fluid and reservoir properties, environmental impact, safety, production risk and commercial issues in relation to product specifications from the Cambo field. In summary, the rationale for selecting this option is based on two key factors: 1. propensity for/consequences of Cambo reservoir souring and 2. reservoir injectivity issues:

1. Propensity for/Consequences of Cambo Reservoir Souring

Studies indicate that, given its relative low temperature, the Cambo reservoir conditions are favourable to Sulphate Reducing Bacteria (SRB) activity. The reservoir fluids, whilst initially sweet, are expected to sour with Hydrogen Sulphide (H_2S) generation resulting from water injection activity (identified as a requirement for the development as noted in Section 2.2.3.1). SRB growth and respiration will be controlled by the presence of sulphate, a carbon (or nutrient) source such as Volatile Fatty Acids (VFAs) within the reservoir. Cambo formation water contains Volatile Fatty Acids which provides a nutrient for SRB activity and H_2S generation.

Modelling indicates that combined seawater (SW) and produced water re-injection (PWRI) results in an order of magnitude increase in souring and H_2S generation in comparison to seawater injection alone (OilPlus, 2019). The primary causes of this are introduction of VFA in the injected water, and the increasing effect of biofilm sulphide generation mechanism resulting in H_2S generation around the injection wells near the wellbore (and transported through the reservoir). The OilPLus modelling study considered injection of a combined mix of produced water/seawater and seawater alone, performance sensitivities to various key parameters such as nutrient levels, reservoir temperature, well spacing, etc. The modelled base case predictions give a maximum concentration of H_2S in gas of 1,366 ppm for a mix of PWRI and seawater versus 69 ppm for seawater injection alone. Significant H_2S of tens of ppm in gas occurs within the first few years of production for both PWRI and seawater injection.

The levels predicted with commingled SW/PWRI have significant implications for wells, risers and other facilities integrity management/materials selection. Personnel safety risk through exposure to more elevated levels of H_2S is also increased. In addition to these aspects, the 'Fate of Produced Gas' methodology proposed for the proposed Development is gas export, in order to minimise environmental impact of operations and avoid reliance on operational flaring. The preferred export route is to the West of Shetland Pipeline System (WOSPS) (Section 2.2.5.10). The proposed Development is restricted to a low gas export H_2S specification for entry to WOSPS due to the lack of available capacity in onshore H_2S removal/gas sweetening, and this requires offshore gas sweetening (even for the selected seawater injection only case). At the higher predicted H_2S levels predicted with commingled SW/PWRI, this presents practical design and operational challenges and high operating cost risk.

The proposed gas sweetening methodology selected is solid bed adsorption. Whilst 100% efficient, adsorption beds are only suitable for relatively low H_2S loadings as the volume of media required is directly proportional to the H_2S loading and the frequency of media changeout. At high H_2S loadings the volume of media required becomes impractical (space and weight) unless a very frequent media changeout is adopted. Solid adsorbent beds are therefore only typically used for polishing applications where the outlet specification is very low. As an example, the solid adsorbent beds for seawater proposed for Cambo are specified based on design gas rates with 20 ppm H_2S loading and a changeout frequency of once per year. This results in the following vessel sizes and weights:

- 34 m^3 bed volume
- Bed dimensions: 2.8 m (Internal Diameter) × 6.8 m (Tan/Tan dimension)
- Skid dimensions: 7.4 m × 6 m × 9.4 m
- Operating weight per bed: 137 tonnes

With re-injection of Produced Water, rather than seawater, the H_2S loadings may increase to peak levels of 1,366 ppm. This level of H_2S would make the solid bed size impractical unless a very frequent media changeout is adopted which is not considered acceptable from an operations perspective.

Assessment of measures to manage reservoir souring risk and consequences outlined above have been identified and assessed, including injection water treatment or in situ (reservoir) treatments individually or in combination. Table 2.5 below summarises the outcomes of the assessment of the various techniques.

Table 2.5*: Assessment of Reservoir Souring Management Techniques*

Rejected Options	Positives	Negatives
Biocide Dosing into Injection Water	Common first treatment strategy for microbial control in injection water.	Not fully effective for PWRI due to the organic content of produced water - often consumed readily. Use generally limited to cleaner seawater injection systems.
Free Radical Generator (FRG) Dosing	Highly effective biocide - promising emerging technique.	Relatively novel and not fully proven/adopted by industry.
Nitrate Dosing into Injection Water	Established SRB activity can be controlled by the injection of nitrate. Some evidence of effectiveness of technique e.g. Schiehallion.	High carbon availability in the injection and formation water increases the degree of nitrate dosing required, with resulting impact on OPEX. Not expected to be effective at Cambo reservoir temperature of 61ºC.
Injection Water Sulphate Removal	Low sulphate injection water reduces barite scaling risk.	Sulphate removal reduces the concentration of sulphate in the injection water but does not eliminate it completely - sulphate removal processes are still able to reduce low amounts of sulphate injected to generate some sulphide in the presence of nutrients. Sulphate concentration of Cambo produced water is low in comparison to seawater at circa 15 mg/l. Modelling indicated only marginal reduction in souring tendency at sulphate concentrations in injection water from 100mg/l to 40mg, and so reduction below this low level in produced water/SRU for PWRI was not considered to be of benefit. Sulphate removal systems in upstream offshore oil and gas applications generally utilise membrane nanofiltration - required pre-treatment very challenging with produced water reinjection systems, requiring significant filtration with potential for high membrane turnover due to fouling by residual oils, waxes, solids etc.
Injection Water Nutrient Removal	Refer to separate Table 2.6**:** below.	

Table 2.6 summarises considerations and options for treatment of Cambo produced water where the primary objective is to reduce or remove VFA, the main source of nutrients for SRB activity/reservoir souring through PWRI on Cambo. Other secondary nutrients (extra carbon sources, biodegraded crude oil, nitrogen and phosphorus) are not explicitly considered, although the techniques may in some cases also remove these components.

Table 2.6: **Injection Water Nutrient Removal Techniques**

Rejected Options	Positives	Negatives
Precipitation		Solid waste generated. No known applications in offshore produced water treatment.
Multi-stage Flash Distillation		High energy demand and capital costs. No known applications in offshore produced water treatment.
Membrane Separation	Common technique for water purification. Relatively compact technology for offshore applications where weight / space are constrained.	No evidence found of application or effectiveness of nanofiltration for removal of highly soluble, low MW VFA in upstream offshore environment. Not proven for complex high-volume flow waste water streams. Significant pre-treatment requirements to prevent fouling/high turnover of required nanofiltration membranes.
Reverse Osmosis (RO)	Common technique for water purification. Can remove almost all contaminants.	No evidence found of application or effectiveness of RO for removal of VFA from produced water in upstream offshore environment. High pressure/energy requirements. Only trace amounts of contaminants can foul RO membranes.
Electrodialysis		Difficult process to scale up. Energy intensive. Prone to fouling. No known applications in offshore produced water treatment.
Ion Exchange		High resin costs and energy demand for resin regeneration. Low adsorption capacity.
Adsorption	Well established technique for produced water treatment.	High retention time/low capacity, high adsorbent costs, energy demand for adsorbent regeneration.
Oxidation		High energy inputs for ozone system; oil may foul catalyst; may produce sludge and toxic residues; requires some pre- treatment of produced water stream.
Biological		Not suitable for offshore application - large, heavy process with long residence times.
Solvent Extraction		No known applications in offshore produced water treatment at scale required for Cambo.
Macro Porous Polymer Extraction (MPPE)	Effective technique for BTEX (Benzene, Toluene, Ethylbenzene and Xylene) and polycyclic aromatics (PAHs etc.).	Not effective for organic acids/VFA separation.

The overview above shows that it is technically possible to filter and treat produced water to remove residual produced solids and dispersed oil in order to mitigate against souring risk. However, the additional treatment package weight and layout requirements plus higher capital and operating costs to achieve and maintain the same or a similar standard to treated seawater (in terms of residual oil, SRB nutrient content, low solids loading and particulate size) are significant. In addition, the required space to accommodate this very sizeable equipment would be a particular challenge on the FPSO.

It should also be noted that depending on treatment type selection, filtration and treatment to manage fouling and operability aspects may not necessarily address potential souring risk as a consequence of produced water reinjection (with the key contributor to increased levels of souring being the introduction of water-soluble nutrients (VFA) in the produced water).

SPE and its Cambo partner Shell have direct experience of an analogous reservoir with PWRI causing major operational challenges, equipment damage including multiple subsea chokes, and injector sand face plugging from carryover and re-injection of fines. The alternate path open-hole gravel packs completions in the producer wells will not completely mitigate the production of fines.

In summary, for the PWRI case, no reliable and cost-effective means of suitably managing souring risk were identified.

Assessment of options to manage reservoir souring risk for the SW-only injection case selected for Cambo are outlined in Section 2.2.3.4.

2. Reservoir Injectivity

The Cambo reservoir is characterised by relatively weak, unconsolidated rock. As a consequence, downhole sand control and stringent adherence to water injection specifications are required to maintain injectivity and reduce the risk of out of zone injection (OOZI).

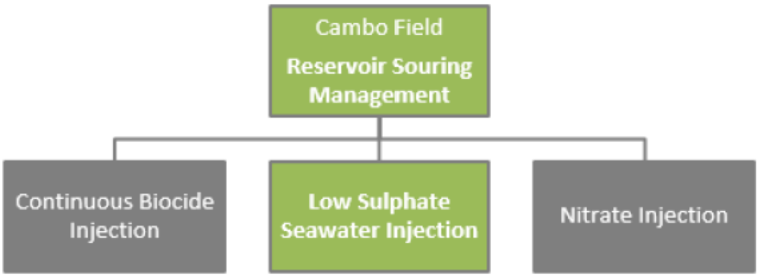
The presence of solids and oil in injection water will have an adverse impact on well injectivity from plugging, as commonly observed in oil fields. This effect has been confirmed by core flooding tests performing on Cambo core material, injecting water with a solids loading of 30 mg/l and a range of particle sizes (7.5 mg/l of each of 3, 5, 10 and 25 microns) and in some tests with the addition of 30 ppm oil droplets. In all cases there was a loss of injectivity. The planned sand control should contain larger sand particles but will still allow for the production of fines. As seen in other fields, these finer particles are expected to carry through the separators and be re-injected with PWRI. Fine filtered sea water will be delivered to the wells with a much lower solids loading of only very small particles of less than 5 microns. The coreflood tests indicated a loss of injectivity of 69 to 78% over short durations of hours for the above solids loading. This permeability impairment would be expected to increase further over time and the likelihood of longer-term impairment is in excess of 95%. Coreflood tests with smaller particles of < 5 microns gave reduced impairment of only 23 to 46%.

Such degradation in well injectivity is commonly observed with PWRI, as per offset fields such as Schiehallion. Severe loss of injectivity leading to the loss of wells has occurred in some analogue fields. Any significant reduction of injectivity would lead to major production deferrals with loss of reservoir pressure and/or the need to drill replacement water injectors or increase the injector count to maintain water injection rates and voidage replacement.

Therefore, in order to maintain injectivity and hence pressure support, it is preferred to inject filtered and treated seawater to reduce otherwise likely permeability impairment and poor operability of PWRI systems (by sand/fines and/or residual oil in injected produced water).

✓ **Produced Water Management Decision:** Clean-up and Disposal to Sea

2.2.3.4 *Reservoir Souring Management*



As noted in previous Section 2.2.3.3, as a result of the relatively low temperature of the Cambo reservoir it is expected that the introduction of sulphate via injected sea water will cause reservoir souring through generation of H_2S by SRB. The consequences are also summarised in Section 2.2.3.3.

To reduce the potential for H_2S production in the reservoir, any seawater must be treated before being injected into the wells. The three options considered were:

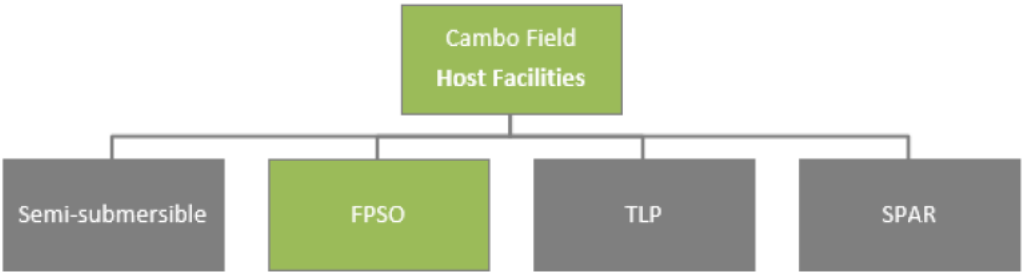
1. Continuous biocide injection;
2. Low sulphate seawater injection; and
3. Nitrate injection.

Due to the reservoir characteristics, neither continuous biocide injection nor nitrate injection were considered technically viable. Continuous biocide injection is not a proven technology in a sandstone reservoir such as that found in the Cambo field and nitrate injection was rejected as it was not proven technology at the low Cambo reservoir temperatures. Although these were the primary reasons for rejecting these options, SPE also noted there were other potential environmental impacts from these processes which would have required careful consideration.

Low sulphate seawater injection (Option 2) was therefore selected as the souring control measure. The sulphate content of the injected seawater will be reduced through the use of a sulphate removal unit (SRU).

✓ **Reservoir Souring Management Decision:** Low Sulphate Seawater Injection

2.2.4 Host Facilities



Due to the water depth at the Cambo field, host options focussed on permanently-moored floating systems. Fixed structures (e.g. compliant tower or similar) at the Cambo field location were discounted given the water depth and environmental conditions in the area. To date no such platforms have been deployed at these water depths and in comparable metocean conditions. Non-permanently moored floating options e.g. units operating with dynamic positioning were also ruled out for safety and reliability reasons.

Several floating concepts were considered for the proposed Development:

1. A semi-submersible platform;
2. A floating production storage and offloading (FPSO) vessel;
3. Single point anchor reservoir (SPAR) platform; and
4. A tension leg platform (TLP).

Each concept was examined to determine its suitability for the development.

Option 2: FPSO, was selected on the basis that this is a well-proven concept already delivered into the West of Shetland area on the UKCS. Other key factors supporting the decision were:

- Potential cost and schedule opportunities through redeployment of an existing FPSO or conversion of an existing hull;
- Low complexity and cost decommissioning.

Table 2.7 summarises the rationale for rejection of the alternatives.

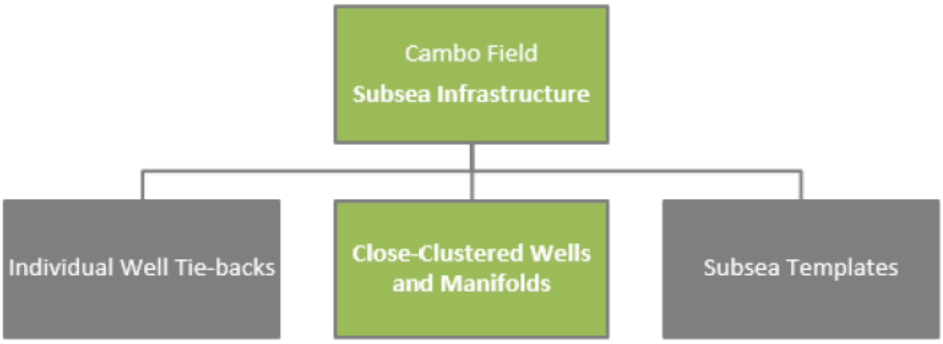
Table 2.7*:* Rationale Summary for Host Facility Options

Rejected Options	Positive Aspects	Rationale for Rejection
Semi-submersible	▪ Potential improvement in safety gradient - cargo inventory not stored on facility.	▪ No oil storage. Would require dedicated floating storage unit (FSU), subsea storage or new local oil export infrastructure; ▪ Oil export via pipeline not cost-effective and challenging from a flow assurance perspective (wax); ▪ Environmental impact of a new pipeline to host platform or to the Shetland Islands.
SPAR	▪ Potential dry-tree solution. ▪ Favourable motion characteristics in harsh environment.	▪ Not suitable for full integration before field installation – topsides and hull mated on or near location leading to increased installation risk; ▪ Higher sensitivity to payload variation than FPSO and semi-submersible options; ▪ High intrinsic cost due to proprietary design and complex project execution.
TLP	▪ Potential dry-tree solution. ▪ Favourable motion characteristics in harsh environment.	▪ Oil storage - FSU or oil pipeline required (refer to semi-submersible platform option); ▪ Installation risk in harsh west of Shetland environment; ▪ Harsh environment and water depth at upper end of concept capability created challenges for tendon design and increased risk.

✓ **Host Facilities Decision:** FPSO with Shuttle Tanker Oil Offtake

2.2.5 Facilities Design

2.2.5.1 Subsea Infrastructure



The large areal extent and relatively shallow depth of the Cambo reservoir is such that it is not possible to fully develop the field from a single drill centre. When considering which subsea system to deploy at the Cambo field, SPE considered three principle options:

1. Individual well tie-backs to the host facilities;
2. Close-clustered wells and subsea manifolds;
3. Subsea templates.

A subsea manifold (at each drill centre) is a structure consisting of pipework and valves designed to transfer oil and gas from individual well into a pipeline or flowline. A subsea template is a larger, heavier steel structure which is used as a base for various subsea structures such as wells, subsea trees and manifolds. All options were considered to be viable for the proposed Development. However, Option 2 (manifolds), was selected on the following basis:

- Clustered wells/subsea manifolds are well suited to a field like Cambo where flexibility in well tophole locations is required to maintain ease of drilling, management of collision risk and ensure optimum well placement;
- Ease of fabrication and hence the ability to take account of design changes later in design and/or field life;
- Drilling programme decoupled from subsea structure delivery;
- Well proven concept West of Shetland.

Table 2.8 below summarises the rationale for rejection of the alternatives.

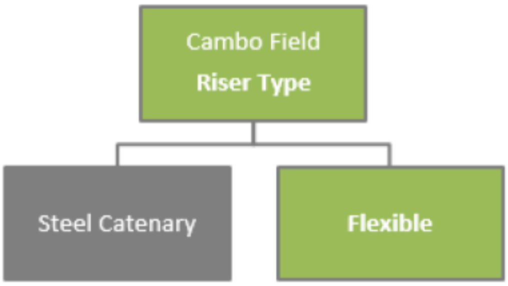
Table 2.8*:* Rationale Summary for Subsea Infrastructure Options

Rejected Options	Positive Aspects	Rationale for Rejection
Individual Well Tie-backs	▪ None identified.	▪ Largest environmental footprint – multiple flowlines from individual wells; ▪ Added host facility riser loads; ▪ Flow assurance challenges associated with individual well flowlines.
Subsea Templates	▪ No hydrate and other flow assurance issues associated with well jumper management;	▪ Higher complexity/heavier structures – increased fabrication and installation risk; ▪ Drilling programme coupled to structure delivery schedule – risk of impact on programme in event of delivery delay; ▪ Reduced flexibility in selection of tophole locations.

Rejected Options	Positive Aspects	Rationale for Rejection
	▪ Fewer leak paths and smaller subsea installation scope.	

✓ **Subsea Infrastructure Decision:** Close-clustered Wells and Subsea Manifolds

2.2.5.2 Riser Type Selection



SPE considered two options for the risers:

1. Steel catenary risers;
2. Flexible risers.

Despite higher materials costs, flexible risers were selected over steel catenary on the following basis:

- Higher host vessel loads due to heavier pipe;
- Larger seabed footprint due to a longer layback distance from riser hang-off to touch down point;
- Higher installation cost.

The selected flexible riser (Option 2) configuration is restrained lazy wave, as illustrated in Figure 2.3.

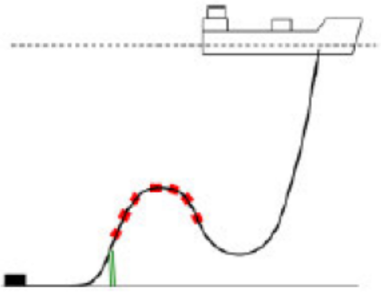
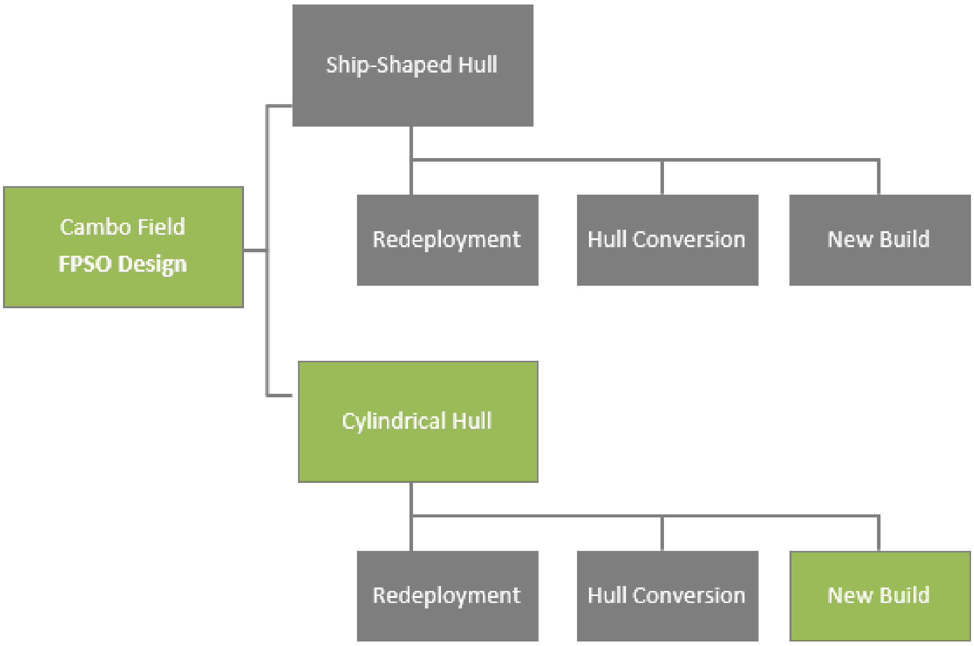


Figure 2.3: Restrained Lazy Wave Riser Configuration

A restrained lazy wave configuration improves upon other configurations through the addition of a tether to the riser touchdown point on the seabed. This restricts vertical orientations due to buoyancy changes and minimises the transverse motion which restricts the use of risers of some other configurations.

✓ **Riser Type Decision:** Flexible, Restrained Lazy Wave

2.2.5.3 FPSO Hull Type



The FPSO design and selection process covered the full range of hull forms including redeployment, hull conversion and new-build options. When compared to alternative ship-shaped options, a new build Sevan-type cylindrical hull unit was selected based on its suitability for a harsh environment, cost and schedule opportunities and simplification of mooring and fluids transfer arrangements.

The new build cylindrical shaped FPSO will be moored with a 3-cluster lower chain and polyester rope mooring arrangements given the environmental conditions, water depth and mooring loads. The use of sonar reflectors on the mooring lines was considered, but dismissed for the following reasons:

- No fishing activity occurs in the location around the FPSO (See Section 4.6.1);
- As a result of the line movements in storms, steel/aluminium reflectors may damage the polyester fibres, which will reduce the capacity of the lines. In addition, reflector connecting wire may get entangled with the potential for damaging lines.
- The mooring lines (and subsea infrastructure) will be marked on new revisions of Admiralty charts and marked on Kingfisher/FishSafe sites.

Table 2.9 summarises the rationale for rejection of the FPSO alternatives.

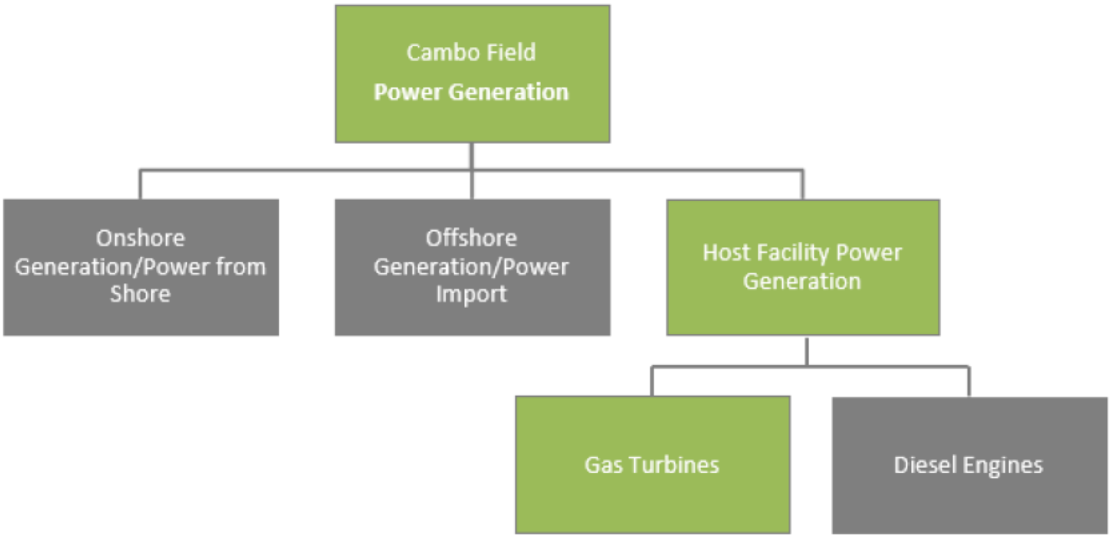
Table 2.9: Rationale Summary for FPSO Options

Rejected Option		Positive Aspects	Rationale for Rejection
Ship-shaped	Hull conversion	▪ Potentially greater equipment footprint and weight capacity. Potentially wider range of contractors capable of delivery of ship-shaped units. ▪ Environmental benefit of re-use/recycle of existing unit.	▪ Limited hulls available with sufficient strength and fatigue capacity for operation in west of Shetland environment; ▪ Only suitable hulls identified have already been in service for many years – significant cost, schedule, execution and operational longevity risk; ▪ May require active station-keeping (common to all ship-shaped options) and added thruster fuel consumption.
	New build	▪ As for hull conversion (excluding final bullet).	▪ Proven concept but high CAPEX/lengthy schedule; ▪ Complex fluids transfer system design.
	Redeployment	▪ As for hull conversion. ▪ Environmental benefit of re-use/recycle of existing unit.	▪ Very limited pool of technically viable units available; ▪ A suitable commercial model could not be agreed.
Cylindrical	Redeployment	▪ As for new build cylindrical option. ▪ Environmental benefit of re-use/recycle of existing unit.	▪ No suitable redeployment candidates identified.
	Hull Conversion	▪ As for new build cylindrical option. ▪ Environmental benefit of re-use/recycle of existing unit.	▪ No suitable hull conversion candidates identified.

✓ **FPSO Hull Type Decision:** New Build Cylindrical Hull

2.2.5.4 Main Power Generation

Primary Power Source



The majority of the atmospheric emissions from an offshore oil and gas installation come from the need to maintain a reliable power supply for production, maintenance of safety/life support and environmental protection systems.

Seven principle power supply options for the proposed Cambo facility were considered with the above in mind:

1. Onshore power generation via non-renewable sources and power import via cable from shore;
2. Onshore power generation via renewable sources and power import via cable from shore;
3. Offshore renewable energy;
4. Offshore generation by a third party with cable import to Cambo;
5. Combined cycle gas turbines;
6. Local host facility gas turbines – conventional offshore power generation using gas turbines and produced gas from the Cambo field.
7. Local host facility gas turbines with local Carbon Capture and Storage (CCS)

Each concept was examined to determine its suitability for the proposed Development. Table 2.10 summarises the rationale for rejection of the alternatives, with further commentary added on Option 2 in subsequent text.

Table 2.10*: Rationale Summary for Power Generation Options*

Power Supply Concept	Positive Aspects	Negatives
Onshore power generation from non-renewable sources and import from shore	▪ Reduced offshore GHG emissions from Cambo; ▪ Increase in surplus gas export to WOSPS.	▪ Insufficient electrical power generation capacity on the Shetland Islands to meet Cambo power/heat demands; ▪ No credible routes identified to establishing other sources of onshore, non-renewable power for export to Cambo. Environmental benefits over local non-renewable generation via Cambo produced gas also unclear; ▪ Potential environmental impacts from onshore works and cable laying from shore; ▪ Subsea electrical cable technology not yet qualified for water depth at Cambo.
Onshore power generation from renewable sources and import from shore	▪ Delivery of Viking Wind Farm and Shetland HVDC Interconnector projects provides a potential source of power for Cambo from a renewable source; ▪ Reduced offshore GHG emissions from Cambo; ▪ Increase in surplus gas export to WOSPS.	▪ Onshore power connection infrastructure timeframe is not aligned with the Cambo development programme schedule. First renewable power from Shetland expected to be available from 2027 at the earliest – Cambo first oil targeted end 2025; ▪ Potential environmental impacts from Cambo onshore works and cable laying from shore; ▪ Subsea electrical cable technology not yet qualified for water depth at Cambo; ▪ Full electrification of Cambo from shore on a stand-alone basis not economically viable.
Offshore renewable energy	▪ Reduced GHG emissions from Cambo; ▪ Increase in surplus gas export to WOSPS.	▪ Floating offshore wind turbines would be required at Cambo given the water depth. This technology is not yet proven for such a location and there are no existing or planned offshore renewable energy developments in this area; ▪ Marine renewable energy converters not technically mature at scale required for Cambo power needs; ▪ Back-up generation capacity required to address intermittency of renewable power sources. Potential challenges with balancing power sources;

Power Supply Concept	Positive Aspects	Negatives
		▪ Subsea electrical cable technology not yet qualified for water depth at Cambo.
Offshore power generation and power import	▪ Utilisation of spare capacity from existing offshore power generators; ▪ Reduced GHG emissions from Cambo.	▪ No identifiable options for import from existing facilities or new renewable/other offshore energy projects with timing and capacity to meet Cambo power needs.
Combined Cycle Gas Turbines	▪ Higher efficiency than conventional open-cycle gas turbines; reduced fuel consumption and GHG emissions	▪ Although the technology may reduce the amount of fuel gas required, there remains a requirement for investment in gas turbines; ▪ The efficiency of the secondary power recovery system did not justify the additional cost; ▪ Limited offshore experience; space and weight impact.
Local host facility gas turbines	▪ Conventional, well-proven and reliable power generation source; ▪ Heat can be recovered from exhaust gases to meet process heating requirements.	▪ High GHG emissions.
Local host facility gas turbines with local CCS	▪ Local CCS reduces environmental impact of local non-renewable power generation.	▪ Technologies more suited to onshore deployment. Compact local CCS technologies of size/weight suitable for offshore deployment not yet technically mature; ▪ High CCS system energy requirements offset emissions reduction potential; ▪ No obvious suitable CCS reservoir in the vicinity of the Cambo Field – storage potential, seal and local structure challenges.

Assessment of Options 2 and 3, electrification via onshore or offshore power generation/import from renewable sources, concluded that neither were viable for the Cambo development alone on the grounds noted in the table above. However, given the importance of electrification of upstream oil and gas assets to the delivery of the OGA strategy and achievement of net zero goals, opportunities to address the challenges of these options through collaboration with other operators in the West of Shetland area were identified. Subsequently, a West of Shetland Operator Electrification Workgroup was established in early 2021 together with Equinor and BP (as operators of the Rosebank and Clair developments, respectively).

Work to date supports the view that there is potential for collaboration, although significant technical, commercial and regulatory challenges remain to be addressed. Timelines for other development projects also remain uncertain and do not align with the Cambo development programme. However, to retain optionality and the potential to improve emissions performance of the Cambo asset in operation, the facilities will be designed to facilitate potential future electrification (either from on or offshore renewable sources) if and when these challenges are suitably addressed.

Specifically, provisions are being made in the FPSO design for potential future installation of a power import connection and required electrical infrastructure for power conditioning and distribution. The selection of a cylindrical-hull FPSO for Cambo is a significant enabler to potential future electrification, as the technical and execution complexities of electrification of a conventional ship-shaped FPSO (e.g. feasibility of high voltage/large power load transfer through an internal turret mooring system) are avoided.

✓ **Power Generation Type Decision:** Conventional Local Power Generation via Gas Turbines; provision in facilities design for potential future electrification

Turbine Fuel Supply

The decision was made for the turbines to be all dual fuel (fuel gas or diesel). This option provides the project with the opportunity to improve on operational efficiency, and also improves greater flexibility, standardised equipment and redundancy for power generation start-up.

Consideration was given to single (gas) fuelled units which, whilst technically feasible, was not preferred for Cambo due to the lower availability and loss of flexibility in such units to accommodate transient events, such as recovery from unplanned shutdowns on the FPSO, interruptions to fuel gas import supply from WOSPS (planned or unplanned) or outages of the FPSO gas import or fuel gas systems. Furthermore, dual fuel units offer more flexibility during commissioning and periodic plant turnarounds.

Alternative low/no carbon fuels were considered (e.g. hydrogen blended with natural gas, ammonia or biofuels). However, these options were ruled out on technology maturity for offshore deployment and fuel supply logistics grounds.

Current Cambo production forecasts indicate that the field will become gas deficient in the future. Two options were considered to address future fuel gas deficiency.

1. Import gas from WOSPS;
2. Increase in the use of diesel fuel to supplement available fuel gas.

The decision was made to import gas from the WOSPS system. This option is better environmentally as fuel gas combustion generates lower emissions than equivalent diesel consumption. It is also the preferred option in terms of value, as diesel is higher cost.

✓ **Turbine Fuel Supply:** Dual fuel (Fuel Gas and Diesel)

Turbine Configuration

Careful selection of power generation configuration on the Cambo FPSO is essential for the provision of a secure, reliable and flexible power supply. Two options were considered:

1. N configuration to supply the defined load (i.e. installation of N turbines where N is the number of turbines required to meet the power output requirement) to provide the defined load;
2. N+1 configuration to supply the defined load (i.e. back-up is provided through provision of an additional turbine).

Option 1 reduces the number of installed turbines required to meet the power requirements, but the loss of one turbine could adversely impact on production and operating efficiency. An N+1 configuration (as per Option 2) is a common design concept which allows for maintenance and overhauls so that the required generation capacity is available the majority of the time.

✓ **Turbine Configuration:** N+1 turbines

Turbine Emissions Control

There are various techniques for reducing emissions from turbines, and these are generally described as wet or dry. Wet technologies involve the injection of water or steam and require installation of large purification systems and are not considered a viable option offshore. The project therefore considered the following three main options when considering turbine emissions control:

1. Install dry low NOx emissions (DLE) dual fuel turbines;
2. Install DLE turbines on fuel gas;
3. Install DLE-ready dual fuel turbines.

Industry experience to date in the use of DLE dual fuel turbines has been mixed, with reliability, operability issues and mechanical failure (e.g. combustor and exhaust collector failures) experienced. In addition, the mechanical and emissions performance of DLE turbines is dependent on load – high loads have resulted in satisfactory performance, but operation at lower loads has proved problematic. However, based on evaluation and engagement with power generation package vendors, dual fuel units have been selected that are gas fuel DLE/liquid fuel LDI (Lean Direct Injection) equipped (Option 2).

The key issues relating to DLE option, i.e. cost, performance and reliability on fuel gas have been addressed sufficiently to give confidence in this approach. Furthermore, LDI is an advancement in design to allow more operational flexibility in terms of liquid fuel quality for offshore applications (one of the key issues identified with the traditional dual fuel DLE approach) and therefore presents a lower risk compared to dual fuel DLE options. With the facility to import gas on Cambo, it is envisaged that the use of liquid fuel will be limited, thus minimising emissions, compared to traditional dual fuel DLE.

✓ **Turbine Emissions Control:** Gas fuel DLE/liquid fuel LDI

2.2.5.5 Major Drive Selection

FPSO host high pressure (HP) compression and water injection systems require significant power to operate. In terms of how these systems will be driven, SPE considered the following:

1. Gas turbine drives;
2. Electric motor drives.

Once it was established that there was sufficient gas turbine generator capacity to support Option 2, this option was selected as it provided several advantages over Option 1. This included increased reliability and savings in space, weight and cost, as well as representing best available technology (BAT).

Electric drive has significantly lower emissions and higher energy efficiency than is seen by direct drive and is the environmentally preferred option. In addition, electric drive is considered to be the inherently safer design option which, whilst higher CAPEX, does have an overall lower OPEX with reduced fuel demand by virtue of higher efficiency.

✓ **Major Drive Selection Decision:** Electric Motors

2.2.5.6 Produced Water Treatment

As noted in Section 2.2.3.3, the proposed produced water management plan is clean-up and disposal to sea, such that the identified Cambo reservoir souring and injectivity challenges can be mitigated.

Produced water separated from the 2^{nd} stage and coalescer stage of separation will be commingled and routed to a produced water treatment package prior to discharge.

The package will be designed to treat water production up to design capacity to a target residual dispersed oil in water specification of 15 mg/l or less (measured on a monthly average basis). Any instantaneous maximum concentration shall not exceed 100 mg/l. Whilst a higher residual oil in water specification would meet current UK statutory requirements for produced water discharge (at present a maximum monthly average of 30 mg/l), the lower target recognises that the OSPAR Recommendation 2001/1 for the Management of Produced Water from Offshore Installations requires that any plans to construct new offshore installations should take as a point of departure the reduction of discharges and, where appropriate, the achievement of zero discharges of oil in produced water into the sea.

The design capacity of the produced water treatment package has been set based on Cambo subsurface simulation and production profiles. Future development phase(s) will be managed within this capacity by optimising the well stock and where necessary shutting in high water cut wells.

The setting of a maximum monthly average of 15 mg/l has been informed by understanding of current performance of other offshore operations in the UKCS and further afield where disposal of produced water to sea is required, and in recognition of practical challenges identified in achieving zero discharge of oil in produced water offshore where produced water reinjection (or measures to avoid produced water production to surface) are not feasible. The approach to produced water treatment system design has however been to achieve as low a concentration as practicable in line with the principles of BAT, and balance between environmental performance and technical/cost aspects.

Laboratory test work has been completed to assess Cambo oil/water separation and emulsion formation and stability characteristics. In summary, the results indicated that good separation efficiency can be achieved, and the results have been utilised to determine the proposed produced water clean-up package configuration.

The treatment package consists of primary and secondary treatment stages, with deoiling hydrocyclones (primary stage) deployed in combination with gas flotation (secondary stage) to remove residual oil. Solids removal hydrocyclones are also proposed in order to protect the downstream equipment from the impact of sand/fines production carried through to the package. Recovered oil is pumped back to the separation train. In order to maximise the performance of the flotation unit it is also planned to inject deoiler and/or flocculant chemicals upstream of the unit. This will aid the coalescing of the oil droplets in the unit and improve performance.

The proposed produced water treatment package suppliers have confirmed that the proposed configuration will meet discharge specification requirements (15 mg/l) with the Cambo fluids.

Treated produced water will be cooled prior to discharge, as modelling work identified a material benefit in terms of plume dilution factor and reduction in extent of any environmental effects arising from produced water disposal. Other steps taken in this regard include optimising the disposal caisson dimensions and exit orientation from the FPSO.

Pressure drop and turbulence that create oil/water emulsions in the treatment system shall be minimised, where possible by the incorporation of low shear pumps and valves in the package design.

Consideration has been given to the use of tertiary/produced water polishing treatment to target further removal of dissolved hydrocarbon components and reduce oil-in-water concentration. Macro

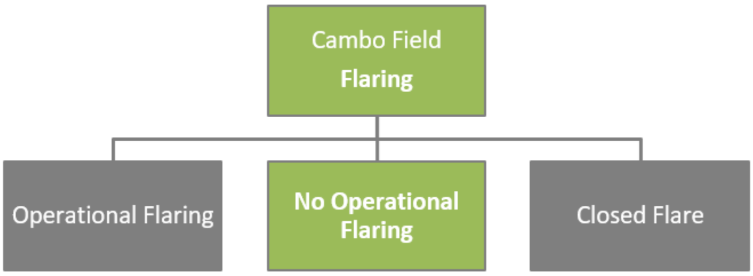
Porous Polymer Extraction (MPPE) and membrane technologies have been amongst the tertiary treatment options considered. However, the deployment of these technologies offshore on Cambo is not proposed given lack of track record in offshore applications at the scale required for the prevailing produced water production rates. The resulting package deck space and weight requirements, and increased utility/operations challenge to maintain performance of these tertiary systems, are considered to offset the potential incremental benefit in residual oil in water reduction.

However, some deck space and weight capacity will be reserved for the addition of future equipment, and this may include tertiary produced water treatment in case the monthly average oil in water concentration limit is reduced further in the future.

Produced water disposal metering will be implemented such that accurate measurement of the volume of produced water discharged can be achieved. In addition, residual oil in water measurement/sampling provisions shall conform to BEIS guidance on methodologies for sampling of produced water and other hydrocarbon discharges.

Certain process upsets or outages (e.g. slugging, loss of deoiler chemical injection, reduced hydrocyclone efficiency caused by blockages, etc.) may occasionally cause a temporary increase in the oil in water concentration. If, under these circumstances, the oil in water discharge specification cannot be met, the produced water can be routed to and stored in hull tanks for later processing and disposal overboard within the required specification. Should sufficient volume be unavailable for storage of produced water, the procedure will be to restrict or shut in production until the produced water is brought back into specification.

2.2.5.7 Flaring and Venting



Gas produced from Cambo in excess of requirements for fuel will be conditioned and exported to WOSPS. In addition, hydrocarbon vapour from the FPSO cargo storage system will be recovered and returned to the topsides process system via a vapour recovery system. However, there are a number of other low rate sources of hydrocarbons that may be routinely routed to the FPSO flare system.

SPE considered three options for flaring:

1. Operational flaring – open flare, with routine operational flaring of low rate and low-pressure sources of hydrocarbons;
2. No operational flaring – recovery of all sources of continuous operational flaring;
3. Closed flare – recovery of all sources of continuous operational flaring; HP and LP flare tips isolated in normal operations.

Option 3 requires interconnection between the FPSO flare and either dedicated recovery compression or vapour recovery/LP compression systems for collection and return of hydrocarbons from the flare to the process. HP and LP flares will typically be isolated by Fast Opening Valves (FOVs) and Bursting Discs (BDs) which will open in the event of a significant relief or blowdown event. The flare tips may be purged with nitrogen and feature ballistic or other pilot systems to ignite the flare when required.

In all options, non-routine flaring during plant upsets or readiness for full or partial plant shutdown (e.g. for maintenance) will still occur.

Each option was examined to determine its suitability. Option 1 was ruled out as the project is targeting a no operational flaring approach in line with OGA strategy and net zero expectations. Whilst Option 3 could be considered BAT, a number of challenges were identified in implementing a closed flare on Cambo:

- Not inherently safe design - introduction of complexity in the design of the primary FPSO safety system, and integration of safety and process systems;
- Concerns over reliability of the closed flare gas recovery system in operation/resulting increased maintenance and intervention requirements;
- Risk of unignited venting of gas (potentially with high H_2S content) in the event of failure of the flare ignition system on demand.

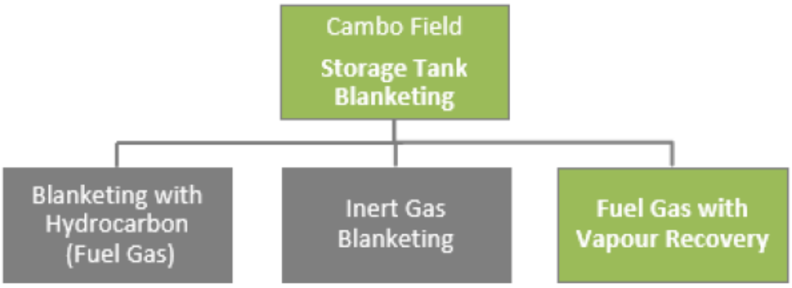
As a consequence, Option 2 has been selected. Routine operational flaring has been designed out through the following measures either being implemented or considered in the Cambo FPSO design:

- Use of inert gas (nitrogen) instead of hydrocarbon gas for:
  - Flare header/tip purging;
  - Compressor dry gas seals;
  - Utility system blanketing (e.g. heating and cooling medium expansion vessels);
- Recovery of low pressure hydrocarbon sources frequently routed to LP flare via the FPSO vapour recovery system, including produced water treatment/gas flotation system and TEG regeneration system;
- Specification of valves connected directly to the flare to minimise fugitive emissions;
- Flare wind shielding to improve flare pilot burner efficiency.

There will be no routine cold venting (discharge of unburnt hydrocarbons) from the Cambo facilities. Low volume, non-routine venting may be necessary from time to time in readiness for maintenance e.g. hydrocarbon freeing in preparation for cargo tank entry.

✓ **Flaring Decision:** No Operational Flaring

2.2.5.8 Cargo Storage Tank Blanketing



In order to prevent the build-up of a flammable mixture in the FPSO cargo oil tanks (COTs) during production operations, a positive pressure must be maintained to avoid air ingress. To achieve this, the COTs must therefore be blanketed with some form of non-oxygenated vapour. Further, vent gas from FPSO cargo tanks can present a significant source of volatile organic compounds (VOCs) including methane and is a potentially significant environmental impact.

SPE considered three options for cargo storage tank blanketing:

1. Blanketing with hydrocarbon (fuel) gas with displaced gas/vapour recovery back to the FPSO process;
2. Inert gas blanketing and discharge of displaced gas to LP flare; and
3. Inert gas blanketing and discharge of displaced gas to cold vent in a safe location.

Option 1 was chosen. Whilst not the most inherently safe or lowest complexity/CAPEX option, this is considered BAT, with no VOC or methane emissions in normal operation.

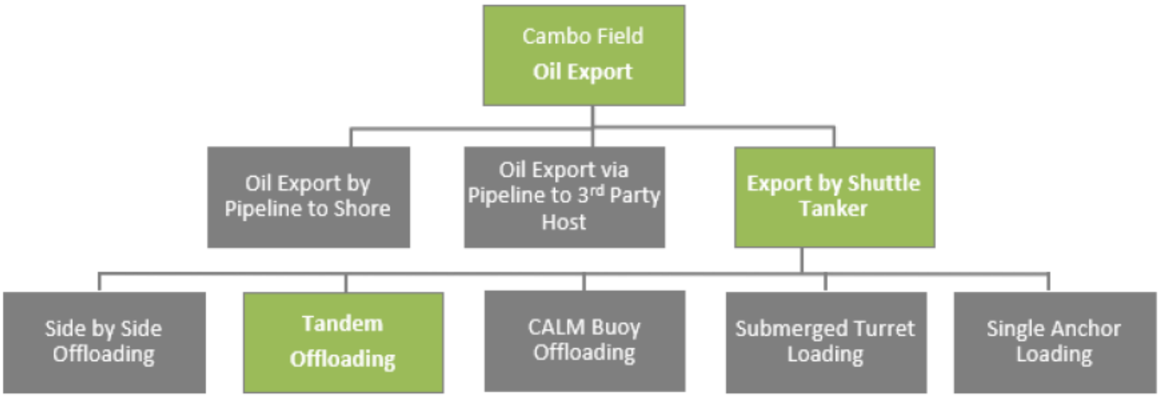
Table 2.11 summarises the rationale for rejection of the alternatives.

Table 2.11*: Rationale Summary for Cargo Storage Tank Blanketing Options*

Rejected Options	Positive Aspects	Rationale for Rejection
Inert gas blanketing/discharge to LP flare	▪ Lower complexity; inherently safe.	▪ VOC and methane emissions not minimised, but reduced through flaring rather than venting; ▪ Loss of oil over life of field due to evaporative losses; ▪ Inert Gas (IG) blanket more corrosive than hydrocarbon gas.
Inert gas blanketing and cold venting	▪ Lower complexity.	▪ High VOC and methane emissions; ▪ As above for evaporative losses and corrosivity.

✓ **Storage Tank Blanketing Decision:** Fuel Gas with Vapour Recovery

2.2.5.9 Oil Export

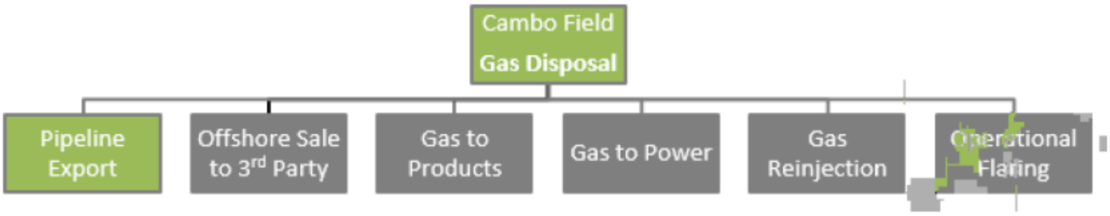


Oil export via shuttle tanker was selected based on lack of existing oil export infrastructure in the area and flow assurance issues associated with dry oil export from Cambo.

In terms of oil offloading to shuttle tanker, tandem offloading was selected as the lowest risk and complexity option. The presence of significant hydrocarbon storage inventories in the field and potential for loss of containment as a result of offloading hose failure or damage was recognised but was considered to be tolerable when compared with risks of more complex buoy options. Tandem offloading is also commonly conducted in other west of Shetland FPSO developments, with a range of North Sea tankers accessible for offloading operations.

✓ **Oil Export Decision:** Export by Shuttle Tanker with Tandem Offloading

2.2.5.10 Fate of Produced Gas



The following options were considered for disposal of hydrocarbon gas produced in excess of fuel requirements for Cambo:

1. Pipeline export to shore for processing/distribution;
2. Offshore sale to third party – sale of excess produced gas to other nearby fields that may be gas deficient;
3. Gas to Products – processing of gas to alternative liquid gas/other products;
4. Gas to Power – offshore power generation and export to other users;
5. Gas reinjection to a non-producing horizon; and
6. Operational flaring.

Option 1, gas export by pipeline to shore was selected, allowing SPE to bring the modest volumes of Cambo produced gas to market. The gas export pipeline would also provide a source (through import from the host pipeline system) of fuel gas to support initial start-up and to provide efficient recovery from production shutdown/blowdown. The availability of import gas is particularly important once Cambo production has declined such that the field becomes fuel gas deficient. The latter two points will help to minimise reliance on liquid fuel import and consumption.

The specifications and datasheets provided to vendors for relevant fuel gas users include composition data for the required range of design cases (including fuel import).

Table 2.12 summarises the rationale for rejection of the alternatives:

Table 2.12*: Rationale Summary for Produced Gas Options*

Rejected Option	Positive Aspects	Rationale for Rejection
Offshore sale to third party	▪ Reduced CAPEX.	▪ Challenged by lack of developed fields in vicinity of Cambo; ▪ Utilisation of excess gas dependent on third party requirements – current lack of demand.
Gas to products	▪ None identified.	▪ Major processing requirements offshore not justified by modest volumes of excess Cambo gas from Phase 1.
Gas to power	▪ None identified.	▪ No nearby power demand identified; ▪ Modest excess gas volumes limit power availability and justification for infrastructure to shore.
Gas reinjection	▪ Reduced capital expenditure in comparison to export pipeline solution.	▪ No suitable non-producing horizon identified; ▪ Risk of gas recycle to producing wells, utilising gas handling capacity and reducing production.
Operational flaring	▪ Low complexity and cost.	▪ Routine operational flaring Incompatible with SPE or Joint Venture (JV) partner philosophy for new field developments.

✓ **Fate of Produced Gas Philosophy Decision:** Gas Export by Pipeline to Shore

2.2.5.11 Gas Export Route Selection

SPE considered several possible tie-in options for a gas export pipeline route within a nominal 300 km radius from Cambo (Figure 2.4). The basic philosophy in identifying a suitable export route was to avoid the unnecessary proliferation of new pipeline infrastructure as far as practicable by identifying and considering the full range of existing host options.

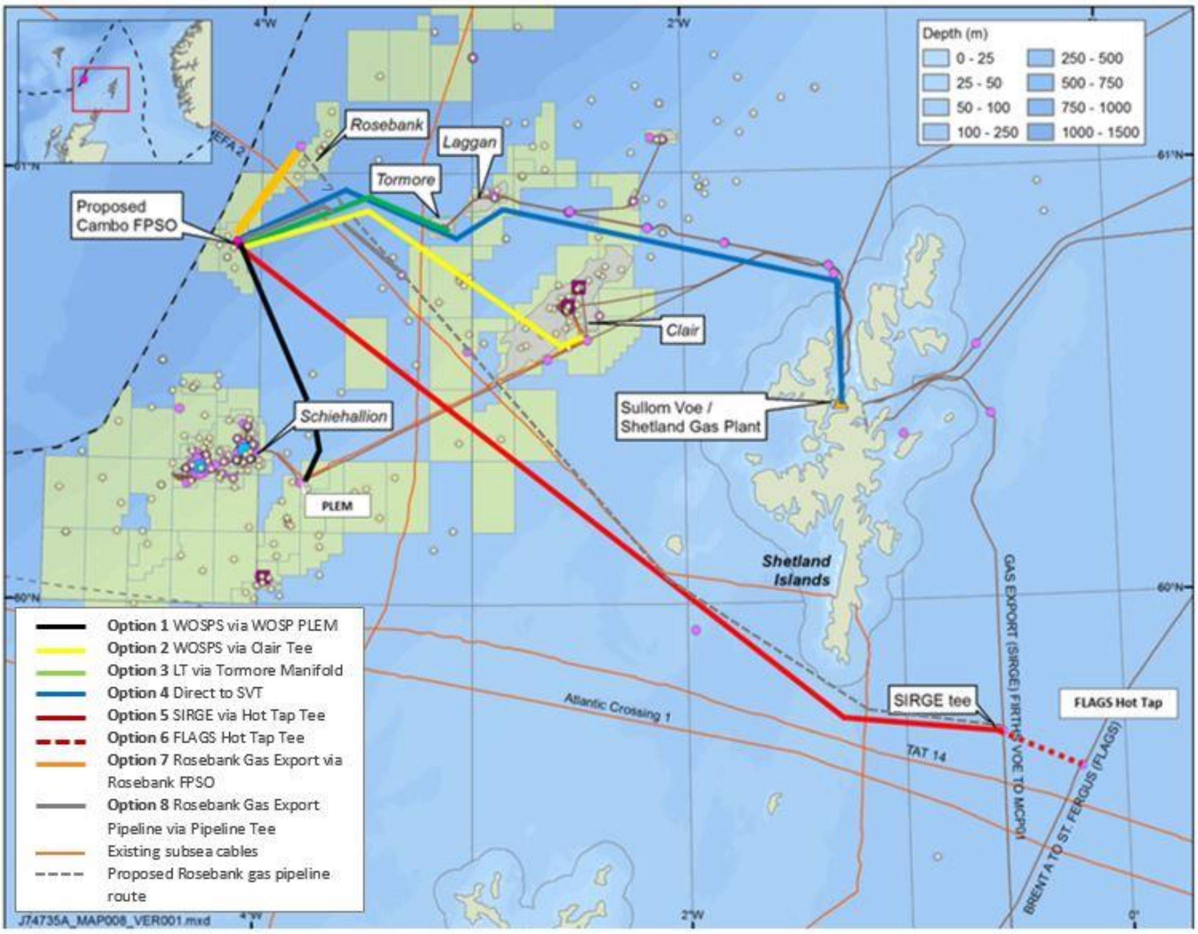


***Figure 2.8*: Gas Export Tie-in Options**

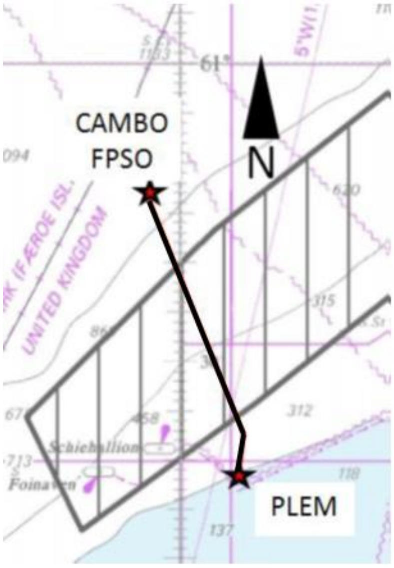
A screening exercise was undertaken to compare the options and test feasibility. Technical criteria considered when evaluating the options included, routing and installation, tie-in method, export host system, cost and long-term security of supply.

Key environmental considerations considered during the route selection process included the geometric features associated with all routes; the primary feature being the Continental Shelf to the Faroe-Shetland basin, soils, flora/fauna, existing pipelines/cables and approaches to the tie-in points. In addition, installation of the export pipeline considered specific aspects and areas of potential risk, including environmental issues (pipeline route options cross the Faroe-Shetland Sponge Belt Nature Conservation Marine Protected Area (NCMPA), see Section 4.5.2; also illustrated as a grey lined area in Figure 2.8), pipelay operations and trenching risks.

All route options were developed to cross the Continental Shelf at right angles to minimise their length within the NCMPA.

Based on infrastructure existing in the area, six initial tie-in options were identified for Cambo gas export (distances are based on the proposed routes from Cambo):

Option 1: West of Shetland Pipeline (WOSPS) via the WOSPS Pipeline End Manifold (PLEM) (65 km)



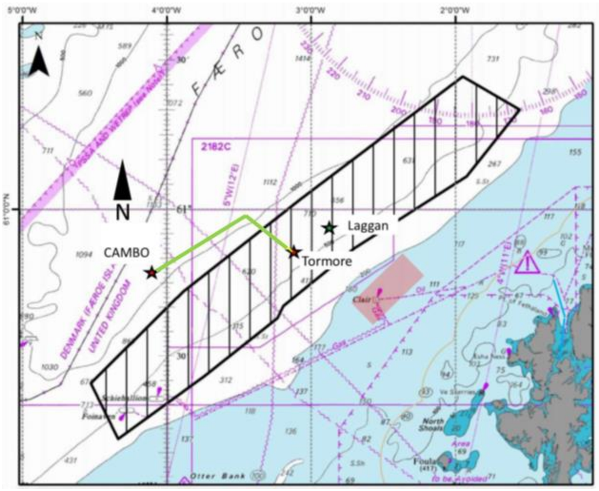
- This route involves short distances on the basin floor and on the Continental Shelf with most of the length being over the continental slope. A direct pipeline route would feature approximately 25 km on the floor of the Faroe/Shetland channel, after which the seafloor rises over approximately 40 km to the continental shelf at 200 m water depth;
- Relatively minor deviations to the route would be required to this host, primarily to avoid geometric features associated with the slope area. No major installation issues envisaged, and it is expected that the pipeline could be trenched up to 800 m water depth if required.

Option 2: WOSPS via Clair Tee (117 km)

- This route involves running the pipeline in a north easterly direction parallel to the ridge (and NCMPA) until a route at right angles to the slope can be reached (a straight-line route between Cambo and the Clair Tee would comprise a significantly larger portion of the NCMPA);
- The pipeline is assumed to be trenched and backfilled in shallow water location, over approximately 50 km. The risk of boulders and rock outcrops could require rock dump protection at some points along the route and in the Clair Tee area for fishing protection. Two cable crossings are associated with this route: Shetland – Faroe Communication Cable (SHEFA 2) and Faroe – Iceland Communication Cable (FARICE) cable, and a local crossing of a communications cable adjacent to the new tie-in structure.

Option 3: Laggan Tormore Pipeline via Tormore Manifold (65 km)

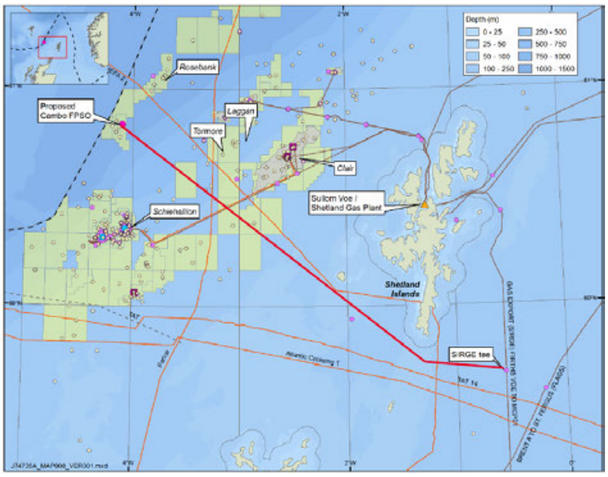
- This route involves crossing the NCMPA at a shallow angle and would have approximately 30 km of the line within the area, while also crossing the steepest part of the shelf at an oblique angle. The selected case assumes that the pipeline would be laid on the basin floor for approximately 40 km before turning south easterly towards Tormore, crossing the NCMPA and shelving region at right angles. This dog-leg route would add approximately 10 km to the route length. Two cable crossings are required on this route, the SHEFA2 and FARICE.



Option 4: Direct Sullom Voe Terminal (SVT) (190 km)

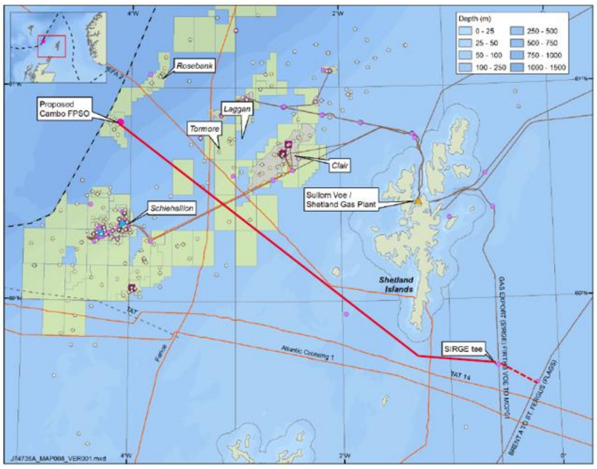
- This route features several obstacles that prevent a direct route. The major feature being the access route in through Yell Sound to the shore approach at Orka Voe;
- The pipeline would require an increase in concrete weight coat thickness in the shallower water depths/shore approach and its installation would comprise a significant increase in complexity when compared to other cases. In particular, the shore approach through Yell Sound would be difficult with potential significant environmental issues. A number of crossings would also be required on this route.

Option 5: Shetland Island Regional Gas Export System (SIRGE) pipeline via existing Hot Tap Tee (240 km)



- This route is the second furthest tie-in considered with a length of approximately 240 km. Three cable crossings would be required, FARICE, SHEFA 2, and SHEFA 2 (south of Shetland). A pipeline crossing would be needed at WOSPS. Crossing of the NCMPA would be almost at right angles minimising length within the area. Trenching and bury is assumed from approximately 300 m water depth to the host location (with crossings) a distance of some 190 km;
- The pipeline routes to the Far North Liquids and Associated Gas System (FLAGS) / SIRGE pass through a potential Special Protection Area (pSPA), "Seas off Foula" to the south west of Shetland, this area is related to seabird populations. Hard substrate is reported for areas south of the Shetland Island; this could prevent efficient trenching operations.

Option 6: FLAGS Hot Tap Tee (290 km)



- This route would involve three cable crossings: FARICE, SHEFA2 (adjacent to WOSPS) cable, and one, SHEFA2, south of Shetland. Crossing of the SIRGE pipeline would also be required. The pipeline would require trenching and burying in the shallower waters on the Continental Shelf, over a distance of approximately 240 km. Hard substrates to the south of Shetland may prevent trenching, potentially requiring rock dumping.

Although the Rosebank pipeline system is not expected to be in place in time for Cambo first oil, it was included within the list of potential options:

Option 7: Rosebank Gas Export Pipeline via Rosebank FPSO (35 km)

- This route would be along the floor of the Faroe- Shetland Channel in water depths of approximately 1,100 m. Crossing of the SHEFA2 communications cable would be required.

Option 8: Rosebank Gas Export Pipeline via Pre-Installed Pipeline Tee (95 km)

- This route would be along the floor of the Faroe-Shetland Channel for approximately 30 km in a north easterly direction, before taking a south easterly route to cross the NCMPA/shelf at right angles. Crossing of the SHEFA2 communications cable would be required.

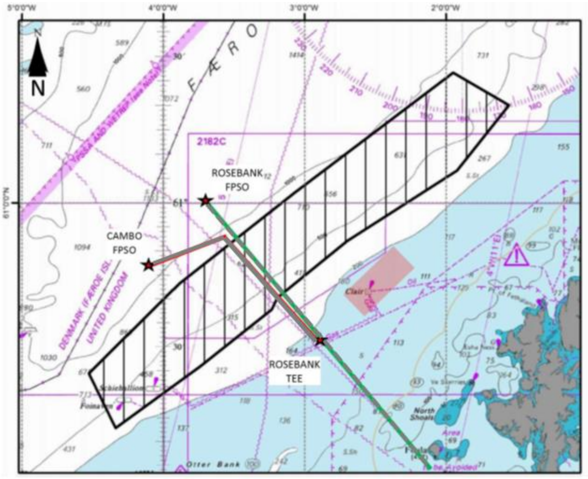


Table 2.13 summarises the results from the screening exercise, which resulted in these options being screened out.

Table 2.13*: Summary for Gas Export Route Selection*

Potential Gas Export Route	Rationale for Rejection
WOSPS via Clair Tee	▪ Longer pipeline than more direct route to the WOSPS PLEM at Schiehallion; ▪ Modest Cambo gas export rates do not require the additional capacity afforded by lower entry pressures possible at this entry point.
Laggan Tormore pipeline via Tormore manifold	▪ Multiphase system presents operational challenges for both gas export and future gas import; ▪ Uncertainty over longevity of Laggan Tormore system.
Direct to Sullom Voe Terminal	▪ High CAPEX and significant environmental impact; ▪ Technical challenges with other shore approaches through the Yell Sound.
Shetland Island regional gas export system (SIRGE) pipeline via existing Hot Tap Tee	▪ High CAPEX and significant environmental impact.
Rosebank options	▪ Timing of proposed Rosebank development uncertain.

A pipeline via the WOSPS PLEM (Option 1) represents the most suitable host for the Cambo gas export pipeline system. This option represents one of the shortest pipeline routes and is one of the simplest to execute as there is a tie-in point available and the water depth is within diver limits.

Detailed route survey results will determine the most suitable route over the Continental Shelf and Slope and through the NCMPA. However, it is proposed that relatively minor deviations to the route would be required to this host, primarily to avoid geometric and environmental features associated with the slope area.

Security of supply of import gas was one of the key decision criteria in selecting the WOSPS system as the gas export/import route for Cambo. Specific uncertainty was identified with respect to commercial arrangements for the continuation of sweetening facility operations due to the expiry of the Sullom Voe Terminal (SVT) agreements and the SVT Land Lease. Sweetening Facilities operator BP has advised SPE that the current operating agreements between the Sweetening Facilities and Sullom Voe Terminal (SVT) expire in August 2025. As Cambo first production is expected to be after this date, BP cannot enter into terms enabling Cambo access to the Sweetening Facilities until post-2025 arrangements with SVT have been put in place. BP issued a Letter of Comfort to Cambo in March 2021 confirming that:

- Continued long term operation of the Sweetening Facilities is critical to West of Shetlands gas export, including from BP's own fields;
- The Sweetening Facilities have adequate available capacity for Cambo's needs;
- BP has commenced discussions with SVT regarding continued operation of the Sweetening Facilities beyond August 2025, targeting resolution within 2022;
- BP will negotiate access terms with Cambo in good faith once post-2025 terms for Sweetening Facilities operation have been agreed with SVT.

In addition, it is noted that other long-life fields including the Clair Ridge and Quad 204 developments are reliant upon WOSPS and the sweetening facility, and some are expected to continue to require a gas export route or import gas source beyond 2045. Furthermore, other prospective West of Shetland developments including Equinor Rosebank have identified WOSPS as a prospective gas export route.

As such there is confidence that the necessary agreements will be extended or replaced to enable continued service, and that fuel import for Cambo can be secured over field life.

✓ **Fate of Produced Gas decision:** Gas Export by Pipeline to Shore

2.2.5.12 Export Pipeline Protection

Protection of the pipeline to mitigate against upheaval buckling and reduce any potential risk from fishing gear interaction, including interaction loads, may be provided by:

1. *Mechanical trenching/backfilling*
   This method works very well in stiffer soils giving good depth of lowering and the backfill process usually results in very good depth of cover which is particularly useful if upheaval buckling is a concern. Good backfill can result in a much lower remedial rock dumping requirement where there is a need to mitigate the potential for upheaval buckling of the pipeline e.g. for HP/HT systems.

2. *Jetting*
   This method is well suited to softer soils, particularly where the on-bottom weight of the much heavier ploughs used in mechanical trenching, cannot be supported. Often (though not always) jetting is matched with natural backfill, saving a run down the pipeline with a separate tool. Jet trenching does not involve any contact with the product, so is particularly suited to un-armoured cables/umbilicals or fibre optic lines. The deployed systems are smaller than mechanical ploughs, requiring smaller handling systems and potentially increased operational sea-states for launch and recovery and/or;

3. *Rock dumping*
   Provides very reliable protection to seabed infrastructure which is largely independent of the soil conditions. Can be very accurately placed on the seabed using fall pipe techniques even in very deep water.

Protection for pipelines under 16" NB (Nominal Bore) is typically provided by trenching below the seabed, either with a mechanical plough and backfilled, or with a jet trencher. The complex nature of the seabed in the proposed locations make decisions on trenching equipment difficult with the available information.

It is recognised that trenching with mechanical ploughs towed behind a support vessel presents challenges in deeper water. Due to the long catenary lengths required (circa 3 times water depth) control of the plough velocity may become the limiting factor. With surging, uplift and trim becoming issues detracting from a quality trench. Using the plough in deeper water may be possible with suitable conditions, these being, homogeneous soil conditions, straight sections and boulder free.

Given these parameters, it may be likely that a mechanical plough will not be suitable for the deeper sections of the route. It is therefore assumed that the pipeline will only be trenched in water depths of less than 800 m or less. Survey data will determine trenching capabilities once soils data and bathymetry are defined.

Tracked jetting machines may be deployed in the water depths being considered. However, suitable soils conditions are required if a jetting machine is to be successfully utilised.

Available survey information available suggests that jetting may be a viable option for the majority of the route although some areas may not be suitable and therefore require rock dump remediation. At tender stage, installation contractors will be required to carry out a full trenching assessment, specific to the machines they have available in-house (or on hire from third parties) and make an appropriate recommendation.

Where trenching may encounter harder soils and fails to meet required trench depth, some rock dumping may be required to provide the pipeline with adequate protection from trawling activities (see Section 3.8).

It is assumed that mattress protection will be used at the pipeline end manifold (PLEM) tie-in structure at WOSPS.

2.3 Summary

Given the detailed consideration that the options selection process has been through, the development design (detailed in Section 3 Project Description) is considered to present appropriate solutions for the location and environment.

It should be noted that mitigation has been applied where possible to the options selection process through the avoidance of specific sensitive receptors and the application of techniques for dealing with potential impacts.

Section 3

Project Description

3 PROJECT DESCRIPTION

This Section contains a detailed description of the selected options described in Section 2 of this Environmental Statement (ES).

3.1 Cambo Field Overview

The Cambo field is situated approximately 125 km to the West of the Shetland Islands in water depths of between 1,050 m to 1,100 m.

As mentioned in Section 1.1, a number of wells have been drilled to date on the Cambo structure. Well 204/10-1 (Cambo 1) was drilled in 2002, and oil and gas were discovered in late Palaeocene Hildasay Member sands of the Flett Formation. The reservoir has been subdivided into several units from the H10/H20 basal unit to the H70 uppermost part of the Hildasay Member. An overview of the stratigraphy of the Cambo Field is provided in Figure 3.3 in Section 3.5.2.

The next well was Lindisfarne (Well 204/10-2), which was drilled in 2004, 3.4 km southeast of Cambo 1. The primary targets for the Lindisfarne well were T38 to T40 aged pre- and intra-basalt sands, which at this crestal location were absent. However, an additional penetration of the Hildasay sands was made. The Hildasay H30 sand was thin but hydrocarbon bearing with good porosities (21% to 25%). The Lower Hildasay sand (H10/20) was also found to be hydrocarbon-bearing.

Well 204/10a-3 was drilled in June 2009 to appraise the Hildasay sands in a down-dip location and also to test the presence of pre- and intra-basalt sand potential. The Hildasay sands were water bearing and were of a thicker and better quality than anticipated. An additional thick Upper Hildasay sand (H40/50) was also encountered.

Well 204/10a-4 and its side-track well 4Z were drilled during the summer and autumn of 2011. This appraisal well was drilled to confirm the amount of commercial reserves in the Hildasay H30 unit, and to investigate if hydrocarbons were present in other sandstone formations at this location. The pilot well encountered oil bearing H70 to H40 units. The side-track was completed in the H30 unit ready for testing, but the onset of poor weather prevented the test from happening. While the well revealed the extent of hydrocarbons in the Hildasay formation, it failed to find sand or hydrocarbons in the Lower Colsay interval. The well was plugged and abandoned in July 2019.

Appraisal well 204/5a-1 was drilled in 2013 to further evaluate the structure, extent and hydrocarbon bearing potential of the Colsay reservoir, within the Cambo field.

Appraisal well 204/10a-5 was drilled in 2018 and encountered oil-bearing Hildasay sands in units H70, H50, H40 and H30, with gas present in the H10/20 unit. Two whole cores were cut in the H50, H40 and H30 Hildasay units. The subsequent horizontal side-track (204/10a-5Y) was tested and flowed naturally at 794.9 m^3 of oil per day (5,000 bopd). The well is currently suspended as a future producer.

3.2 Crude Characteristics and Production Rate Forecast

The oil present in the Hildasay reservoir is of varying quality due to a complex fill history.

Only the Hildasay H50/40 and H30 sands will initially be targeted during the proposed Cambo Field Development. Table 3.1 presents the main oil characteristics of the H50/40 and H30 fluids.

Table 3.1: Cambo Crude Oil Characteristics

Oil Characteristics	H50/40	H30
Specific gravity	916	905
Oil Gravity °API	22.8	24.6
GOR (scf / stb)	345	393
Pour point (°C)	-24	-21
Wax content (%)	8.4	10.4
Asphaltene content (%)	0.35	0.35
Viscosity (cP at reservoir conditions)	6.6	4.1

The proposed Development is expected to produce hydrocarbons for circa 25 years. Figure 3.1 presents the P_{10} (upper) anticipated production profile for Cambo with production efficiency factored in.

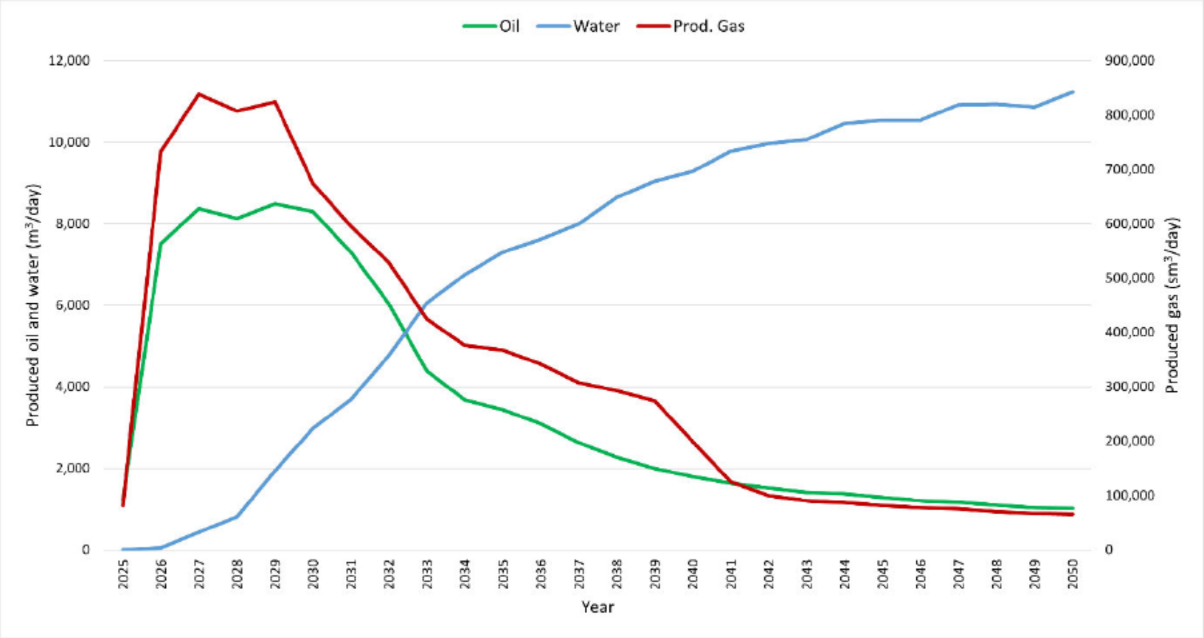


Figure 3.1: Production Profile of the Proposed Cambo Field Development

3.3 Project Overview and Schedule

As explained in Section 2.2.1, a phased development on a standalone basis is the preferred development option for the Cambo field. The first phase of the development will comprise nine production wells (this includes completion of the Cambo 204/10a-5Y well as a producer) and four water injection wells (Figure 3.2).

All reservoir fluids will be produced via subsea flowlines and processed onboard a Floating Production, Storage and Offloading vessel (FPSO). The liquid fraction of the produced hydrocarbons (oil), will be offloaded by oil tanker, with produced gas used as fuel onboard the FPSO. Gas produced in excess of fuel requirements will be exported by pipeline into the West of Shetland Pipeline System (WOSPS).

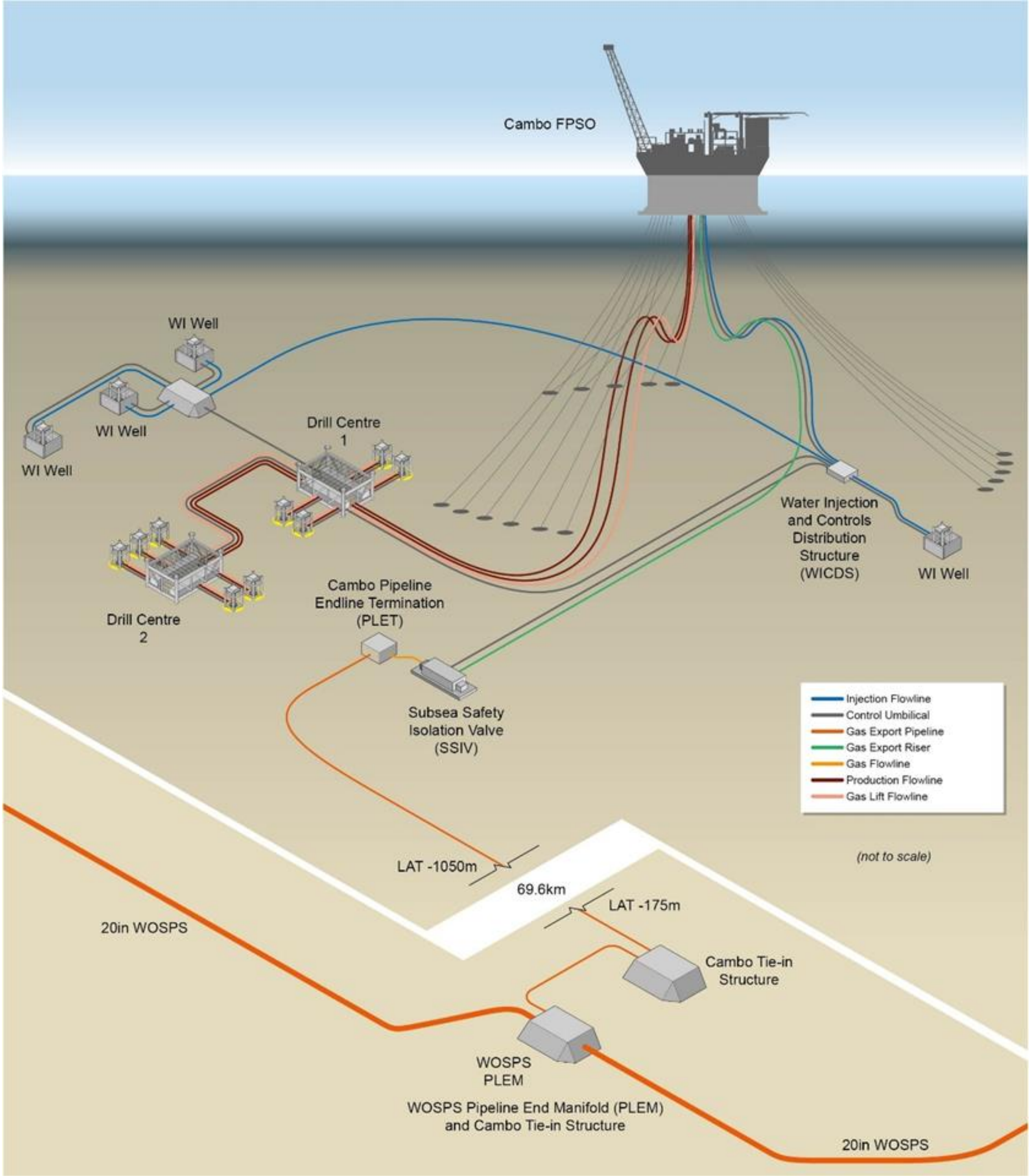


Figure 3.2: Overview of the Proposed Field Development Layout (indicative illustration - not to scale)

The Cambo project is currently in the Front End Engineering Design (FEED) phase of the project life cycle. The following sections provide a detailed description of the current base-case design for the project. Some of the aspects in this project description will be further refined during the detailed design phase and may therefore be subject to change. However, the design parameters presented are deemed realistic, yet conservative (i.e. worst-case) with regard to the potential environmental impacts, based on the current project understanding.

Table 3.2 provides an indicative overview of the proposed timeline for the drilling and installation phase of the proposed Cambo Field Development.

Subsea installation will be limited by the summer weather windows. It is anticipated that the FPSO hook-up, pipeline and field commissioning will take 4 to 6 months. First oil is expected in Q4, 2025.

Table 3.2: Indicative Timetable for the proposed Cambo Field Development

	2021		2022				2023				2024				2025			
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
CAN-ductor Installation	■			■														
Drilling and completions*				■	■	■	■	■	■									
Gas export pipeline installation												■	■					
SPS/SURF installation												■	■					
FPSO anchor installation												■	■					
FPSO mooring lines installation																■		
Xmas tree installation																■		
SPS/SURF completion and pre-commissioning																	■	
FPSO hook-up and commissioning																	■	■
First oil																		▨

* = 5 production wells (one of which was drilled in 2018 (204/10a-5Y)) and 2 water injection wells will be drilled for 1st oil with remaining wells (4 producers and 2 water injectors) drilled after this in 2026.

3.4 Subsequent Development Phases

The current development is predicated on development of the Cambo H50, H40 and H30 Hildasay units only, targeting the areas of highest confidence.

SPE has reviewed the reservoir development in the southern part of the field and has determined that a third drilling centre comprising five additional wells could be an economic additional phase of development that would target the additional resources present but not developed by the current two drill centre plan. As with the two drill centre case, the southern third drill centre would target the seismically imaged H50/40 channels and the extensive H30 sands. Decision-making in relation to any subsequent development phases will be determined by further assessment and informed by Phase 1 production experience and will be subject to separate development planning and environmental impact assessment.

3.5 Drilling Operations

Up to eight new production wells and four water injection wells will be drilled in the Cambo field. Additionally, the currently suspended Cambo 204/10a-5Y well (P2), drilled as an appraisal well in 2018, will also be completed for production, bringing the total number of production wells up to nine. A dynamically positioned (DP) semi-submersible Mobile Drilling Unit (MODU) will be used to drill and complete all new Cambo wells. The wells will be drilled using a combination of seawater and bentonite sweeps for the top holes, and all cuttings and muds will be discharged directly to the seabed after circulating through the well. Following this, a riser will be installed, so that cuttings and muds for the deeper sections of the well will be returned to the MODU. SPE plans to use water-based mud (WBM) for the lower sections of the well, and cuttings will be returned to the MODU before being discharged at the sea surface. The wells will be left suspended until the FPSO comes online in 2025. Once the wells are connected to the FPSO, clean-up will be completed before production commences. The well clean-up operations from the FPSO may require some flaring. By selecting a robust completion design and reliable components, planned interventions (i.e. operations within SPE’s control, such as production logging or water shut off) or workovers will be infrequent throughout the life of field, and none are currently planned.

Due to the soft upper seabed sediments in the Cambo area, SPE plans to use NeoDrill ‘Conductor Anchor Nodes’ (CAN-ductors) on all Cambo wells. A CAN-ductor was successfully used on the Cambo 204/10a-5Y well in 2018, increasing tophole wellbore stability and reducing overall drilling time. A subsequent geotechnical site survey in 2019 confirmed that seabed conditions at the Cambo 204/10a-5Y well are typical of the seabed conditions in the field development area and verified the suitability of the CAN-Ductor technology for the remaining Cambo wells. However, in case of any currently unforeseen circumstances preventing the use of CAN-Ductors for any of the proposed wells, conventional tophole sections will be drilled by the MODU instead. For the purposes of this ES, the slightly larger physical footprint of the CAN-ductor has been assessed in the physical impacts section as a worst case, whereas the assessment of drill cuttings discharges has been based on the worst-case scenario of drilling all wells with conventional tophole sections.

3.5.1 The Mobile Drilling Unit, Other Vessels and Helicopters

The MODU to be used to drill the Cambo wells has not yet been confirmed, however, is anticipated to be a semi-submersible drilling unit designed to operate in deepwater harsh environments, such as that present at the Cambo field.

Once on location, MODU station-keeping will be via a Dynamic Positioning (DP) system. The DP System comprises multiple azimuth thrusters, which are controlled by a computer determining the exact location of the MODU from DP pods (sensors) laid around the wellhead and attached to the MODU itself. The thrusters are activated automatically when necessary to maintain the vessel precisely on station.

A typical DP deepwater MODU will have an on-board fuel capacity around 3,500 m^3 and consumes an average of 45 m^3 (38 tonnes) of fuel per day while drilling.

In addition to the MODU itself, the drilling operations will require support vessels (supply vessels and a statutory standby vessel) and helicopter transfer of personnel to and from the MODU during the drilling period. Helicopters may also be used to supply the MODU with equipment at short notice and in the event of an emergency situation. It is estimated that there will be three scheduled helicopter visits to the rig per week. Otherwise, all transport of drilling equipment, supplies, water, fuel and food will be undertaken by supply vessels, which will also return waste and surplus equipment to shore.

A supply vessel will visit the MODU approximately twice per week from the supply base in Aberdeen. The standby vessel will be on station near the MODU throughout the drilling operations.

Table 3.3 and Table 3.4 show the estimated fuel consumption of the MODU and its associated support vessels and aircraft for the duration of the proposed drilling and completion operations with and without the use of CAN-ductors (see Section 3.5.2 for more information on CAN-ductors).

Table 3.3: Vessel Requirements for Drilling using CAN-ductors for all Wells and Installation of Xmas Trees

Activity	Vessel	Fuel Type	Consumption Rate	Duration	Total Fuel Consumption (tonnes)
Drilling wells (excluding tophole sections – Assumes CAN-Ductors are used on all wells)	DP MODU	Diesel	38 tonnes/day	704 days	26,752
Support Shipping (201 round trips)	Supply vessels	Diesel	8 tonnes/day	402 days	3,216
Support Shipping	Standby vessel	Diesel	1.5 tonnes/day	704 days	1,056
Installation of CAN-ductors	CSV	Diesel	22 tonnes/day	38 days	836
Installation of Xmas Trees	CSV	Diesel	22 tonnes/day	73 days	1,606
Total Diesel Consumption					**33,466**
Personnel transport (302 round trips)	Helicopter	Aviation fuel	3 tonnes / Return flight	302 flights	906

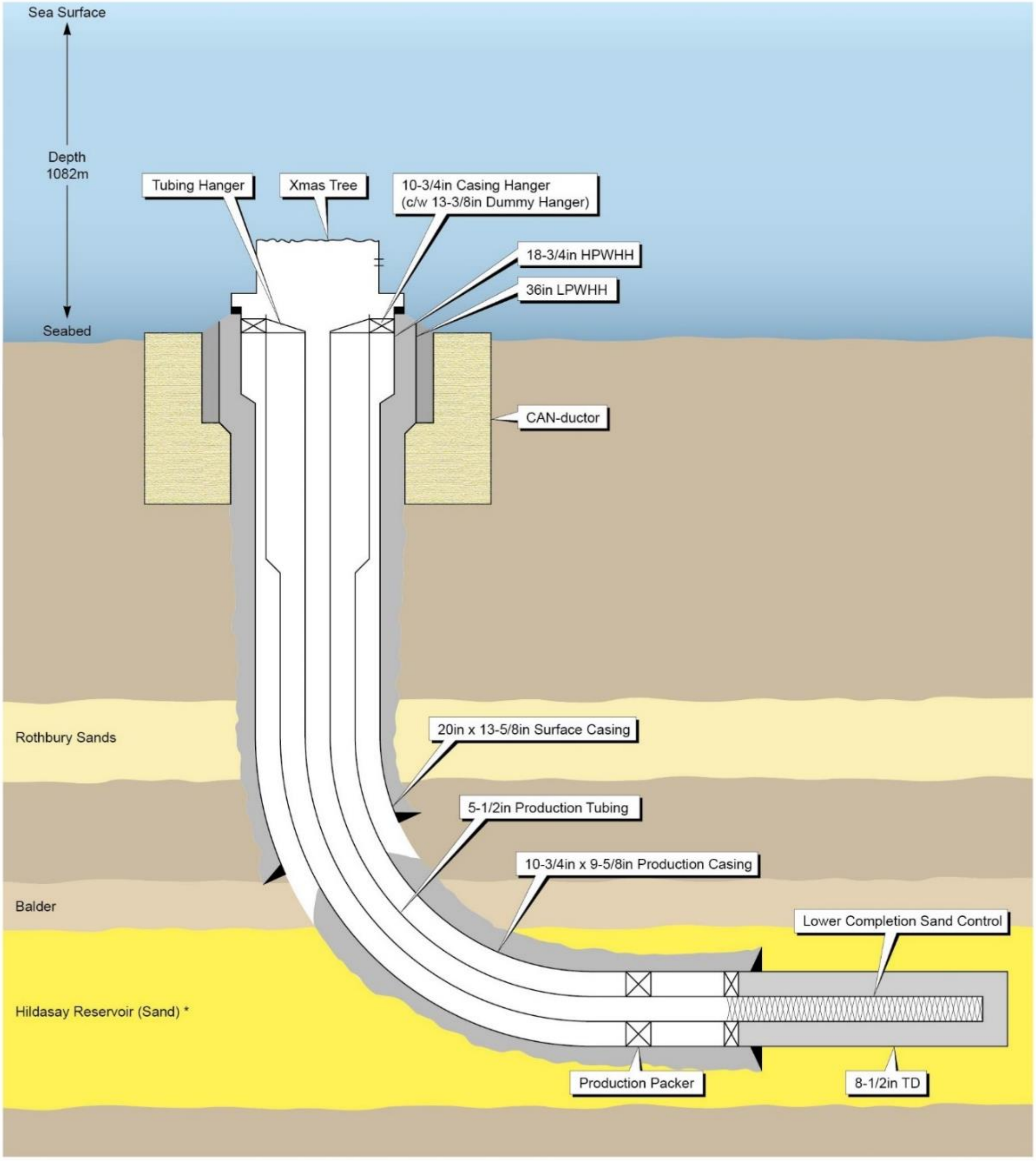
Table 3.4: Vessel Requirements During Conventional Drilling and Installation of Xmas Trees (No CAN-ductors)

Activity	Vessel	Fuel Type	Consumption Rate	Duration	Total Fuel Consumption (tonnes)
Drilling wells (including tophole sections)	DP MODU	Diesel	38 tonnes/day	753 days	28,614
Support Shipping (215 round trips)	Supply vessels	Diesel	8 tonnes/day	430 days	3,440
Support Shipping	Standby vessel	Diesel	1.5 tonnes/day	753 days	1,130
Installation of Xmas Trees	CSV	Diesel	22 tonnes/day	73 days	1,606
Total Diesel Consumption					**34,790**
Personnel transport (323 round trips)	Helicopter	Aviation fuel	3 tonnes / Return flight	323 flights	969

3.5.2 Well Engineering

All production wells will be of very similar design (Figure 3.3), comprising a single wellbore, with a long high angle/near horizontal reservoir sections to maximise production rates and limit the required well count. The proposed casing design for the Cambo development wells will follow a proven design that has been used on the previous Cambo wells. This design was used successfully on the recently drilled well 204/10a-5Y and is seen as the most efficient design to safely execute the well. The injection wells will follow a similar design to the production wells and will also be high angle single bore wells. Two water injectors will be available at first oil with an additional two water injectors included in development plans should they be needed to effectively develop the field.

A batch drilling and completion approach has been selected to drill the wells. This means that the tophole sections of the wells will be drilled in succession with a likely maximum of a batch of four wells at any one time. The deeper well sections that require a marine riser to be installed, can then be drilled efficiently with the Blowout Preventer (BOP) being hopped between wells. This approach will optimise operations and reduce the overall duration of the campaign.



* Cambo production wells will target sand units H30, H40 and H50 within the Hildasay Reservoir

(not to scale)

Figure 3.3: Well Design

As mentioned in Section 3.4, SPE plans to use CAN-ductors on Cambo wells. The CAN-ductor is a pre-rig stage well construction technology designed to replace a conventional tophole section and associated conductor (Figure 3.4). If used, the CAN-ductors will be pre-installed into the seabed before the drilling rig arrives.

The CAN-ductor is a specially designed cylindrical suction anchor containing an integrated continuous conductor pipe. The outer structure is approximately 17.5 m long, with a 6 m diameter and a surface area of 28.3 m^2. The CAN-ductors will be transported and installed from a high capacity construction support vessel (CSV) before the MODU arrives. The CAN-ductor is placed on the seabed via a crane and allowed to partly self-penetrate the seabed under its own weight. A pump, based on a remotely operated vehicle (ROV) is then connected to the CAN-ductor via a hot-stab. The ROV pumps water out of the can, creating negative pressure within it, sucking the remaining extent of the CAN-ductor into the seabed. Once the top of the CAN-ductor is no more than 1 m above the seabed, with the integrated conductor pipe projecting roughly 2 m above the sediment surface (Figure 3.5), the lifting gear is released by the ROV and recovered to the vessel. Deployment and seabed installation of the CAN-ductor is anticipated to take just over one day (1.1) per well, so, up to 14.3 days in total.

Figure 3.4: CAN-ductor for the Previously Drilled Cambo 5Y Well on the Quayside, Awaiting Deployment

Figure 3.5: CAN-ductor for the Previously Drilled Cambo 5Y Well Installed on the Seabed

The pre-drilling installation of the CAN-ductor effectively installs the initial tophole and conductor sections without the need for a MODU, providing support in soft seabed sediments as well as increased horizontal stability, verified load capacity and improved fatigue management. This removes the need for tophole drilling, conductor installation and subsequent cementing operations. Consequently, if CAN-ductors are used there will be no discharge of cuttings and excess cement at the seabed in relation to the first section of each well. The CAN-ductor must be installed well in advance of the actual drilling operations to allow surrounding sediments to re-stabilise, providing a structurally sound basis for installation of the BOP and running of other well structures.

If the wells are drilled conventionally (i.e. without CAN-ductor) however, then the first step in the sequence of activities will be to drill the 42" × 36" diameter top-hole section into the seabed, into which the 36" × 30" diameter conductor pipe is cemented. The second (17½") section will then be drilled through the conductor. A 13⅜" casing string with a high-pressure wellhead housing will then be installed inside the conductor to provide stability to the well and prevent the flow of fluids from the well into the surrounding formations. The casings of the two top-hole sections, firmly cemented into the borehole, will then provide a firm anchorage for the BOP, which will be installed on the drilling riser at the seabed. The drilling riser connects the well to the MODU, therefore providing a conduit to return the mud and cuttings from the deeper sections of the well back up to the MODU.

The deeper 12¼" and 8½" sections of the wells will then be drilled with the drilling fluids circulated back to the MODU. The wells will be completed and left ready for hook up, once the FPSO arrives.

3.5.3 Mud System and Cuttings Discharge

Drilling fluid (or drilling mud as it is commonly known) fulfils a number of functions, such as lubrication and cooling of the drill bit, suspension and transport of rock cuttings to the surface, and the provision of ‘weight’ (hydrostatic pressure) to counter-balance formation pressure. Drilling fluids can be categorised on the basis of their principal constituent (in the continuous phase). This continuous phase may be water, oil, synthetic oil or gas. The resulting drilling fluids are called water-based muds (WBMs), oil-based muds (OBMs), synthetic or pseudo-oil based muds (SBMs or POBMs) and foam muds, respectively. Depending upon the type of drilling fluid, the continuous phase may additionally contain dissolved organic and inorganic additives as well as finely divided suspended solids of various types. The type of drilling mud to be used generally depends on the downhole conditions in the well, both anticipated and those encountered in real-time, for which each of these mud types will have certain advantages and disadvantages. Where technically possible, WBMs are now most commonly used on the UKCS, although synthetic OBMs are also widely used for the deeper well sections, especially in deviated wells or those with challenging and unstable formations. The drilling fluid design for the Cambo wells will follow a proven concept as used in other wells (often referred to as ‘offset wells’) that have been drilled successfully in the area.

The mud system for the two top sections of the well (42" × 36" and 17½") will consist of seawater with high viscosity bentonite sweeps to clean out the borehole. Typically, an 8 m^3 (50 bbl) sweep for every 9 m to 14 m (30 ft to 45 ft) drilled is adequate for hole cleaning, but the frequency and volume of the sweeps will be determined by the hole conditions. The well will be displaced with bentonite mud during installation of the casings.

The deeper 12¼" and 8½" sections will be drilled after the BOP and the marine riser have been installed, using a full WBM system. The mud will be pumped down the drill string to the drill bit and then circulated back to the surface via the annulus (the space between the drill string and the wall of the bore hole), through the BOP stack and the drilling riser back to the MODU. Back onboard the MODU, the mud and cuttings from these sections will pass through a mud recovery system to recover as much of the drilling mud as possible. Once reconditioned, this mud will be used again, thereby minimising the amount of drilling mud used and eventually discharged. The remaining cleaned rock cuttings are discharged to sea from the rig.

It is proposed that all drill cuttings and associated WBM from the Cambo wells will be discharged to sea, which is general practice on the UKCS. An estimate of the quantity of cuttings generated and WBM used and discharged from the largest production well (P10) and the largest injector well (I7) is presented in Table 3.5 and Table 3.6. An overview of the estimated cuttings discharges for all wells is provided in Appendix 8. The overall combined amount of cuttings discharges from all 12 remaining wells to be drilled is 6,086 tonnes, if all wells are drilled with CAN-Ductors and 7,682 tonnes if all wells were to be drilled without any CAN-Ductors being used.

Table 3.5: Cuttings and WBM Volumes for the Largest Production Well (P10)

Section	Discharge Point	Section Length (m)	Section Volume (m^3)	Cuttings Generated (Tonnes)	WBM Discharged (Tonnes)
36"	Seabed	90	59	133	193
17½"	Seabed	641	99	224	399
12¼"	Surface	2062	157	353	1002
8½"	Surface	500	18	41	594
Total	-	3293	333	751	2188

Table 3.6: Cuttings and WBM Volumes for the Largest Injection Well (I7)

Section	Discharge Point	Section Length (m)	Section Volume (m^3)	Cuttings Generated (Tonnes)	WBM Discharged (Tonnes)
36"	Seabed	90	59	133	193
17½"	Seabed	628	97	219	399
12¼"	Surface	2,199	167	376	1,040
8½"	Surface	500	18	41	600
Total	-	3,417	341	769	2,232

3.5.4 Cementing Operations Chemicals

The casings used to prevent the well from collapsing will be cemented into place inside the borehole. Depending on whether a CAN-ductor is used, the cementing programme and associated discharges will be different for either option.

If a CAN-ductor is used, the conductor will already have been cemented into the CAN-ductor onshore, and hence there will be no offshore cementing discharges from the first tophole section. The 20" × 13⅜" casing will be cemented through the CAN-ductor. The cement will be pumped down the casing string and forced back up to the (seabed) surface through the annulus. This will typically lead to a certain amount of cement used being squeezed out of the top of the well and discharged to the seabed immediately around the well. For the 20" × 13⅜" casing it is critical to get cement back to the seabed for the structural integrity of the well. The slimhole nature of the Cambo well design (i.e. 17½" hole and primarily 13⅜" casing) allows for lower excess cement discharges from the smaller casing strings, as the washed out cement will be a smaller fraction of the overall volume. Therefore, 50% excess cement of the open hole volume for the conductor will be used to ensure that the space between the casing and the wellbore is completely filled with cement to ensure the integrity of the well. In theory, this could result in up to 22.7 m^3 (143 bbls) of cement slurry being discharged per well, containing approximately 12.6 tonnes of dry bulk cement. However, the actual amount discharged will be much smaller, as the actual wellbore diameter will be larger than the wellbore gauge diameter (i.e. the diameter of the size of the drill bit), due to hole wash out caused by the drilling muds. In fact, that is the reason why the excess cement is required.

On any well where a CAN-ductor cannot be used, the conductor will be cemented into the tophole section of the well. In this case an allowance will be made to pump up to 300% excess cement to allow for washout and cratering of the wellbore. However, a ROV will monitor the return flow at the seabed and all attempts will be made to identify returns and reduce the pumped slurry volume when possible and safe to do so. A dye will be added to the cement spacer to assist in visually identifying the returns from the wellhead in this case. At this point the remaining cement in the drill string will have to be circulated out, and it is estimated this may result in a discharge of 20.7 m^3 (130 bbls) of cement being discharged at the seabed per well. The cementing of the 20" × 13⅜" casings will be very similar to that of the CAN-ductor option, using 50% open hole excess cement, which will amount to a theoretical maximum of 20.4 m^3 (128.5 bbls) of mixed cement being discharged onto the seabed. However, as explained above, this will be significantly less in reality. Hence, up to 41.1 m^3 cement slurry (made up of 22.9 tonnes of dry bulk cement) may be discharged at the seabed per well.

The cementing of the 10¾" × 9⅝" casings for the deeper well sections will be engineered so that the cement will not reach to top of the casing, and thus no cement is expected to be returned to the surface from these sections. Hence, there is no planned discharge of any cement from this part of the cementing operations. The only potential discharge during this part of the cementing operations, would be from an unplanned vent, such as an aborted cement job due to technical or mechanical failures. If for any reason cement is circulated back to the MODU, it would need to be discharged to sea before it solidifies. No unmixed cement will be discharged overboard.

3.5.5 Chemical Additives used During Drilling Cementing Operations

The specific chemicals and additives used during drilling and cementing will be dependent upon the mud and cement composition, which in turn will be determined by the down-hole conditions encountered whilst drilling. All chemicals will be selected on their technical specifications but will also be assessed on their potential environmental impacts, using the regulatory Harmonised Offshore Chemical Notification System (HOCNS) incorporating the Chemical Hazard Assessment and Risk Management (CHARM) model, where applicable. Additional permitted chemical additives will be stored on the rig to deal with any contingencies such as a stuck drill pipe or loss of circulation. All chemicals to be used in the drilling of the Cambo wells will be detailed in a Chemical Permit Subsidiary Application Templates (CP-SATs), to be submitted via the Portal Environmental Tracking System (PETS) on the online UK Energy Portal, as part of the well consenting process.

During the drilling of the Cambo wells, waste will be generated both due to operational activities (e.g. cements and chemicals), and due to everyday running of the MODU (food waste, water, sewage). All hazardous and non-hazardous waste generated on the MODU and support vessels will be segregated, and either discharged in line with the requirements of the MARPOL Convention (where appropriate) or returned to shore and disposed of appropriately.

3.6 In-Field Subsea Infrastructure

The subsea infrastructure for the proposed Development comprises two drill centres (DCs) with four and five close-clustered production wells respectively, manifolded and tied back to an FPSO. Four water injection wells will be drilled on the flanks of the Field (see Figure 3.2).

3.6.1 Trees, Jumpers, Manifolds and Infield Flowlines

The subsea trees, jumpers, manifolds, gas export SSIV, infield flowlines, umbilicals and risers will be installed using heavy construction vessels with ROV capability.

Trees, Jumpers and Manifolds

Subsea xmas trees (a set of valves, spools and fittings connected to the top of a well) will be installed on the wellheads. Trees will be vertical type. The trees are the main barrier to the reservoir and provide the means for flow control and well entry. The production trees are provided with connections for production and lift gas. All wells will be provided with surface-controlled subsurface safety valves which will fail safe closed to isolate the reservoir in the event of an emergency.

Fishing intensity studies have indicated that there is no fishing activity in the Cambo in-field area. On this basis, and as exclusion zones will be established around the wells and in-field infrastructure, there are no wellhead protection structures planned. The xmas trees on top of the CAN-ductors will be 4.4 m × 2.8 m, 4.2 m high and weigh around 31 tonnes each (Figure 3.6).

Figure 3.6: Example of a Typical Xmas Tree

Flexible jumpers (i.e. short flexible flowline sections) will be installed to connect the wells to production and injection manifolds.

The two drill centre production manifolds will be 6-slot rectangular box-shaped structures of approximately 11.5 m long × 9.5 m wide (109.25 m^2), 7 m high and weighing 280 tonnes. Figure 3.7 shows an example of a typical manifold.

Both structures will be suction foundation or skirted mud mat-based, hence no piling operations will be required.

Figure 3.7: Example of a Typical Manifold on the Back of an Installation Vessel

A water injection and controls distribution structure (WICDS) will be installed to control the distribution of injection water to the wells, as well as to control the production and injection wells/manifolds and the SSIV (see Figure 3.2). An additional single 3-slot water injection manifold will be installed for the distribution of water injection to the westerly water injection wells. The distribution structure and injection manifold will also be box-shaped and are anticipated to be 13.5 m × 10 m (135 m^2) footprint and a height of 4 m, with a weight of around 100-150 tonnes.

Table 3.7 presents an overview of the physical footprint on the seabed of the production wells and their manifolds. The wellhead footprints are based on using CAN-ductors for all wells, resulting in the largest potential footprint. The footprint of a CAN-ductor with a 6 m diameter is 28.3 m^2, whereas the footprint on the seabed of a typical wellhead is around 0.7 m^2.

Table 3.7: Preliminary Locations and Seabed Footprints of Producing Well Infrastructure

Asset Type	Identifier (Well Number)	Drill Centre	UTM E [m]	UTM N [m]	Dimensions	Footprint on Seabed [m^2]
Wellhead/CAN-ductor	P1	1	437205	6743299	6 m (diameter)	28.3
Wellhead/CAN-ductor	P10	1	437205	6743274	6 m (diameter)	28.3
Wellhead/CAN-ductor	P2 (204/10a-5Y)	1	437230	6743299	6 m (diameter)	28.3
Wellhead/CAN-ductor	P22	1	437230	6743274	6 m (diameter)	28.3
Wellhead/CAN-ductor	P11	2	436075	6742225	6 m (diameter)	28.3
Wellhead/CAN-ductor	P20	2	436075	6742250	6 m (diameter)	28.3
Wellhead/CAN-ductor	P21	2	436050	6742250	6 m (diameter)	28.3
Wellhead/CAN-ductor	P3	2	436050	6742300	6 m (diameter)	28.3
Wellhead/CAN-ductor	P7	2	436075	6742300	6 m (diameter)	28.3
Drill centre manifold	DC1	1	437218	6743286	11.5 m × 9.5 m	109.25
Drill centre manifold	DC2	2	436063	6742275	11.5 m × 9.5 m	109.25
Total						473.2

Similarly, the physical footprint of the water injection wells is presented in Table 3.8.

Table 3.8: Location and Seabed Footprints of Water Injection Well Infrastructure

Asset Type	Identifier	UTM E [m]	UTM N [m]	Dimensions	Footprint on Seabed [m^2]
Wellhead/CAN-ductor	I1	436795	6744749	6 m (diameter)	28.3
Wellhead/CAN-ductor	I2	436780	6744769	6 m (diameter)	28.3
Wellhead/CAN-ductor	I5	433800	6742600	6 m (diameter)	28.3
Wellhead/CAN-ductor	I7	441130	6741630	6 m (diameter)	28.3
I1 and 2 Manifold	WI manifold	436788	6744759	13.5 m × 10 m	135.0
Water injection and controls distribution structure	WICDS			13.5 m × 10 m	135.0
Total					383.2

Infield Flowlines, Risers and Umbilicals

The manifolds in turn will be tied back to the FPSO via flexible flowlines and risers (i.e. flexible pipeline sections between the seabed and the FPSO). Power, controls and chemicals will be distributed to the subsea system via umbilicals (static seabed and dynamic riser sections).

The proposed riser configuration is a restrained lazy-wave layout (see Figure 2.3; Section 2.2.5.2), with buoyancy modules installed at the appropriate locations. Each individual riser and umbilical will be tethered to the seabed via hold down tether-clamp systems to reduce movement and fatigue in operation. The risers will be secured to the seabed using 4 m diameter suction cans of 8 m length.

Table 3.9 provides details and totals for the footprint for all in-field umbilicals, risers and flowlines and associated protection.

Table 3.9: Seabed Footprint of All Infield Umbilicals, Risers and Flowlines and Associated Protection

Line Type	Start Point	End Point	Length [m]	Installation Width [m]	Total [m^2]
Production jumpers	P3, P7, P11, P20, P21, P24	DC2	50 (6×)	0.203	60.9
Gas lift jumpers	P3, P7, P11, P20, P21, P24	DC2	50 (6×)	0.102	30.6
Control umbilicals	P3, P7, P11, P20, P21, P24	DC2	50 (6×)	0.102	30.6
Production flowline 1	DC2	DC1	1,600	0.356	569.6
Production flowline 2	DC2	DC1	1,622	0.356	577.4
Gas lift flowline	DC2	DC1	1,588	0.152	241.4
Control umbilical	DC2	DC1	1,572	0.152	238.9
Production jumpers	P1, P2 (204/10a-5Y), P10, P22	DC1	50 m (4×)	0.203	40.6
Production flowline 1	DC1	Touch down	1,653	0.356	588.5
Production flowline 2	DC1	Touch down	1,629	0.356	579.9
Gas lift jumpers	P1, P2 (204/10a-5Y), P10, P22	DC1	50 m (4×)	0.102	20.4
Gas lift flowline	DC1	Touch down	1,620	0.152	246.2
Control umbilical	P1, P2 (204/10a-5Y), P10, P22	DC1	50 m (4×)	0.102	20.4
Control umbilical	DC1	WICDS	2,210	0.102	225.4
Injection flowline	I1, I2	WI manifold	50 m (2×)	0.356	20.3
Injection flowline	I5	WI manifold	3,730	0.356	757.2
Injection flowline	WI manifold	WICDS	2,910	0.356	590.8
Injection flowline	I7	WICDS	2,590	0.356	525.8
Injection flowline	WICDS	Touch down	53	0.356	18.9
Control umbilical	I1, I2	WI manifold	50 m (2×)	0.076	7.6
Control umbilical	WI manifold	DC1	1,600	0.102	163.2
Control umbilical	WICDS	Touch down	53	0.152	8.1
Control umbilical	WICDS	SSIV	1,150	0.102	117.3
Gas export riser	SSIV	Touch down	100	0.356	35.6
Gas flowline	SSIV	PLET	150	0.305	45.8
Riser Suction Cans (16×)	Riser base	n/a	8	4	201.6
Total					5,963.0

3.6.2 Subsea Installation and Commissioning

Infield jumpers, flowlines and static umbilicals will be surface laid. The structures i.e. WICD, Manifolds, SSIV and PLET, are planned to be gravity-based, pending analysis of results from the geotechnical survey. If the survey results prove the gravity-based foundations unsuitable, then suction piles or skirted mud mat foundations may be used instead. No piling will be required, as the seabed is too soft for piling. Flowlines and umbilicals will be connected to the structures and trees via diverless horizontal connection systems operated by ROV. All connections will be subsequently leak tested and control and chemical injection systems function tested after hook-up to the FPSO.

Table 3.10 provides an overview of the estimated vessel requirements and durations with regard to the installation of the Subsea Production System / Subsea Umbilicals, Risers, and Flowlines (SPS/SURF) system.

Other SPS infrastructure associated with the gas export pipeline i.e. the Subsea Safety Isolation Valve (SSIV), Pipeline End Termination (PLET) structure and the Cambo Tie-In Structure (CTIS) are address in section 3.8.

Table 3.10: Vessel Requirements and Estimated Fuel Consumption during SPS/SURF Installation

Activity	Vessel	Fuel Type	Consumption Rate	Duration	Total Fuel Consumption (tonnes)
Installation of SPS/SURF system	ROVSV	Diesel	20 tonnes/ day	132 days	2640
Total Diesel Consumption					**2640**
Personnel transport (to and from FPSO)	Helicopter	Aviation fuel	3 tonnes/ Return flight	6 flights	18

3.6.3 Inspection and Maintenance

An integrity management system will be developed, and inspection programmes implemented for the subsea system. The inspection tasks for the subsea facilities shall be undertaken by an appropriate system capable of capturing the data required, this can include ROV or In-line Inspection systems. Inspection programmes shall be developed to cover all elements of the subsea system. The inspection programmes shall be based on three levels of inspection: general visual inspection, close visual inspection and detailed inspection. Inspections will be undertaken at a frequency determined by the integrity management system, with the necessary corrective maintenance performed if defects are identified.

In general, the subsea equipment is designed for the field life time such that no maintenance subsea is required. One exception would be for cleaning of marine growth/fouling from equipment and calcareous deposits around couplings/connections if this was found to be required.

3.7 Floating Production, Storage and Offloading (FPSO)

3.7.1 FPSO Concept

The general arrangements onboard the Sevan-type cylindrical hull FPSO comprise fluids reception, processing, metering, utility and offloading facilities, plus power, controls, communications and chemicals for delivery to the wells.

Primary process and utility systems are located on a mega module structure integrated with the hull on the main deck. Helideck, oil offloading, flare, turbine exhaust and other systems are configured and oriented to ensure operations are not unduly restricted by weather conditions.

As the unit does not weather-vane, fluids and utility transfer to/from the vessel is relatively simple in comparison to a conventional turret moored FPSO. Risers and umbilicals are routed to the topsides via I-tubes located within the hull structure.

The unit features 14 dedicated hull cargo tanks with a total product storage volume of circa 103,342 m^3 (650,000 bbls), excluding two slops tanks. Hydraulic-driven pumps will be installed in each of the cargo tanks.

The principle FPSO dimensions of the cylindrical Sevan FPSO are as shown in Table 3.11.

Table 3.11: Dimensions of cylindrical Sevan FPSO

Dimension	Value
Diameter at water line	84 m
Main deck diameter	94 m
Depth (from main deck to bottom of Sevan)	38 m
Loaded draught	27 m

A large bulwark will protect the main and process decks against green water (i.e. solid masses of seawater flooding the main deck of ships in heavy weather). The bulwark is an open wave breaking design to ensure sufficient natural ventilation under the process deck level. Above process deck level it is of solid construction. As the bulwark will allow water to pass through at the main deck level, a 1.25 m high water stopper will be installed 9 m from the deck edge. No equipment will be located outside of the water stopper. The design of the bulwark has been designed to withstand 1 year, 10-year, 100-year (Ultimate Limit State (ULS)) and 10,000-year (Accidental Limit State (ALS)) conditions, as validated by numerical modelling.

3.7.2 Mooring and Installation

The FPSO will be located at 60° 48’ 32.606" N, 004° 07’ 15.941" W. The proposed anchor pattern, riser, injector line and umbilical layout, is illustrated in Figure 3.8.

The FPSO will be permanently moored via a total of 16 mooring lines in a 3-cluster configuration (2 bundles with 5 mooring lines each, and 1 bundle of 6 mooring lines). The anchor chains and polyester rope lines will run from the FPSO to a series of new suction anchors on the seabed.

The mooring and riser systems are designed to withstand all anticipated environmental conditions for the life of field, including 1000-year wind and current events as per industry standards, negating the requirement for riser self-sealing, quick release mechanisms.

Installation of the FPSO will involve the connection of mooring lines followed by pull-in of the risers and umbilicals.

The local water depth and the lazy-wave design of the risers precludes the water injection and controls distribution structure and gas export SSIV to be located within the FPSO's nominal 500 m zone, as show in Figure 3.8. However, as they are within the FPSO anchor pattern, a separate 500 m zone specifically for these structures is not anticipated.

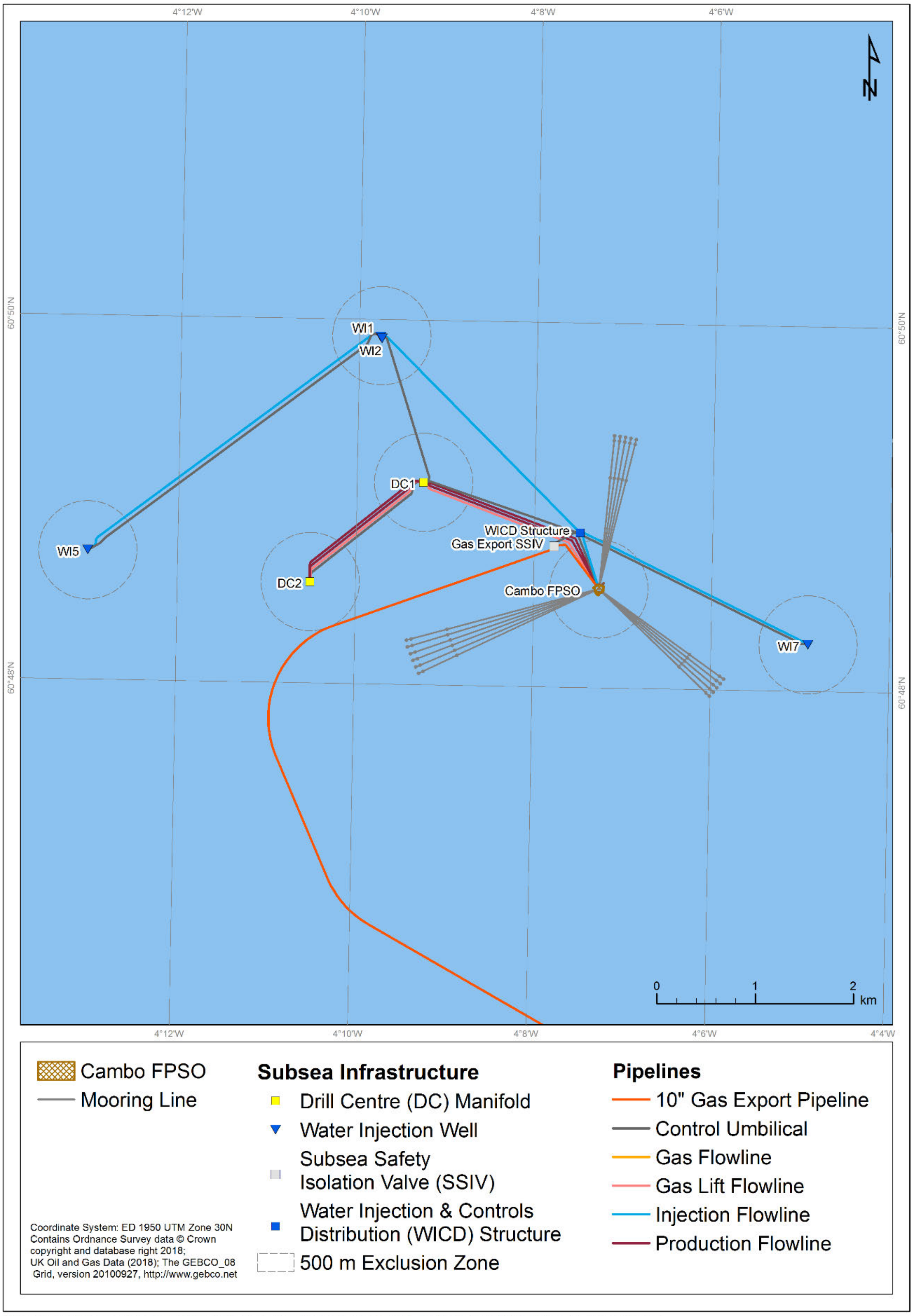


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Figure 3.8: Anchor Pattern, Riser, Injector Line and Umbilical Layout for the FPSO

3.7.3 Design Parameters

The design parameters for the FPSO are based on the anticipated maximum production profile presented in Section 3.2. The annualised maximum anticipated production rates are 8,490 m^3/day of oil, 838,829 Sm^3/day of gas and 11,232 m^3/day of water. The production facilities capacities design parameters are summarised in Table 3.12.

Table 3.12: Design Parameters for Production Facilities Onboard the FPSO

Parameter	Value (Metric)	Value
Oil	9,539 m^3/day	60,000 bbls/day
Produced water	12,719 m^3/day	80,000 bbls/day
Total liquids	15,899 m^3/day	100,000 bbls/day
Water injection	15,899 m^3/day	100,000 bbls/day
Gas compression [total]	1,699,011 m^3/day	60 MMscf/d
Gas Export	991,090 m^3/day	35 MMscf/d

3.7.4 Facilities Overview

Produced hydrocarbons will be processed onboard the FPSO, with the produced oil being exported via shuttle tanker. Produced gas will be used to meet the FPSO’s power requirements. It is estimated that up to 207,644 m^3/day (7.33 MMscf/day) produced gas will be required for fuel onboard the FPSO. Any excess produced gas will be conditioned for export via the new pipeline which ties in to the West of Shetland Pipeline System (WOSPS).

Figure 3.9 provides a simplified overview of the process facilities for the proposed Development. Please note that gas from the produced water treatment process is no longer routed to the LP Flare but is now routed to vapour recovery.

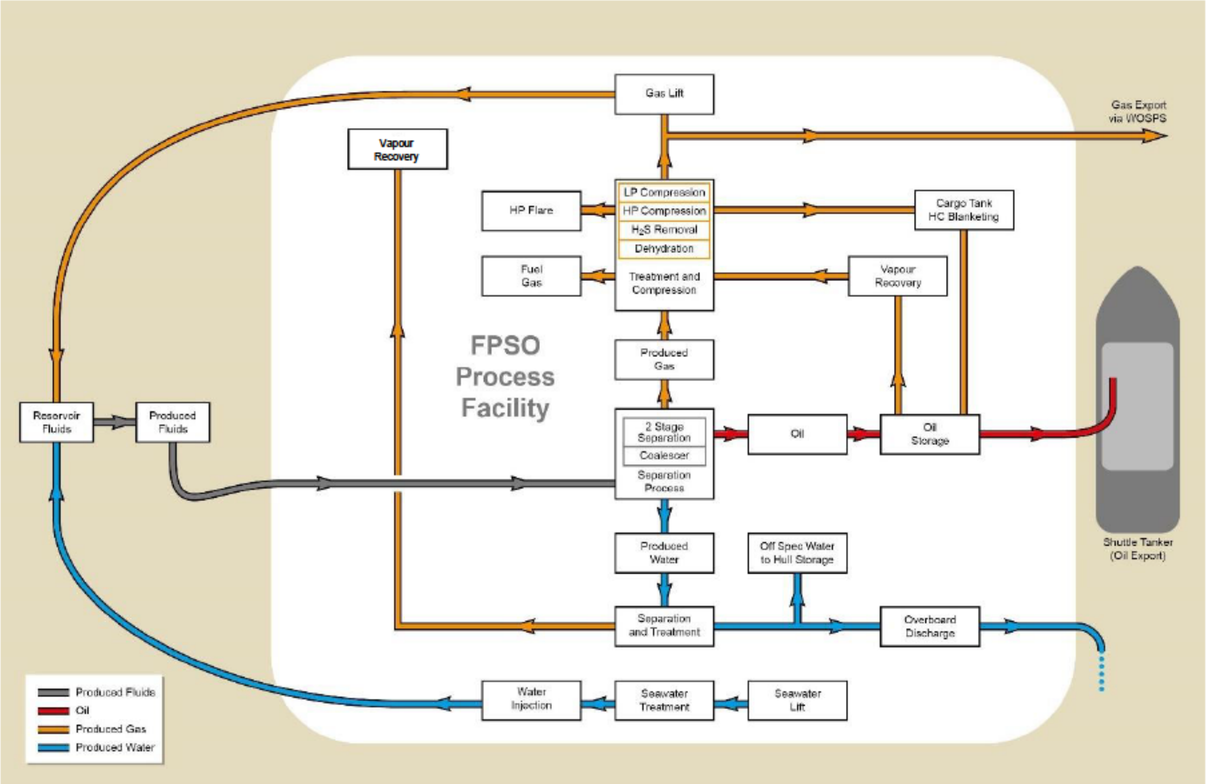

Figure 3.9: Cambo Process Facilities Overview

The general layout of the FPSO is presented in Figure 3.10.

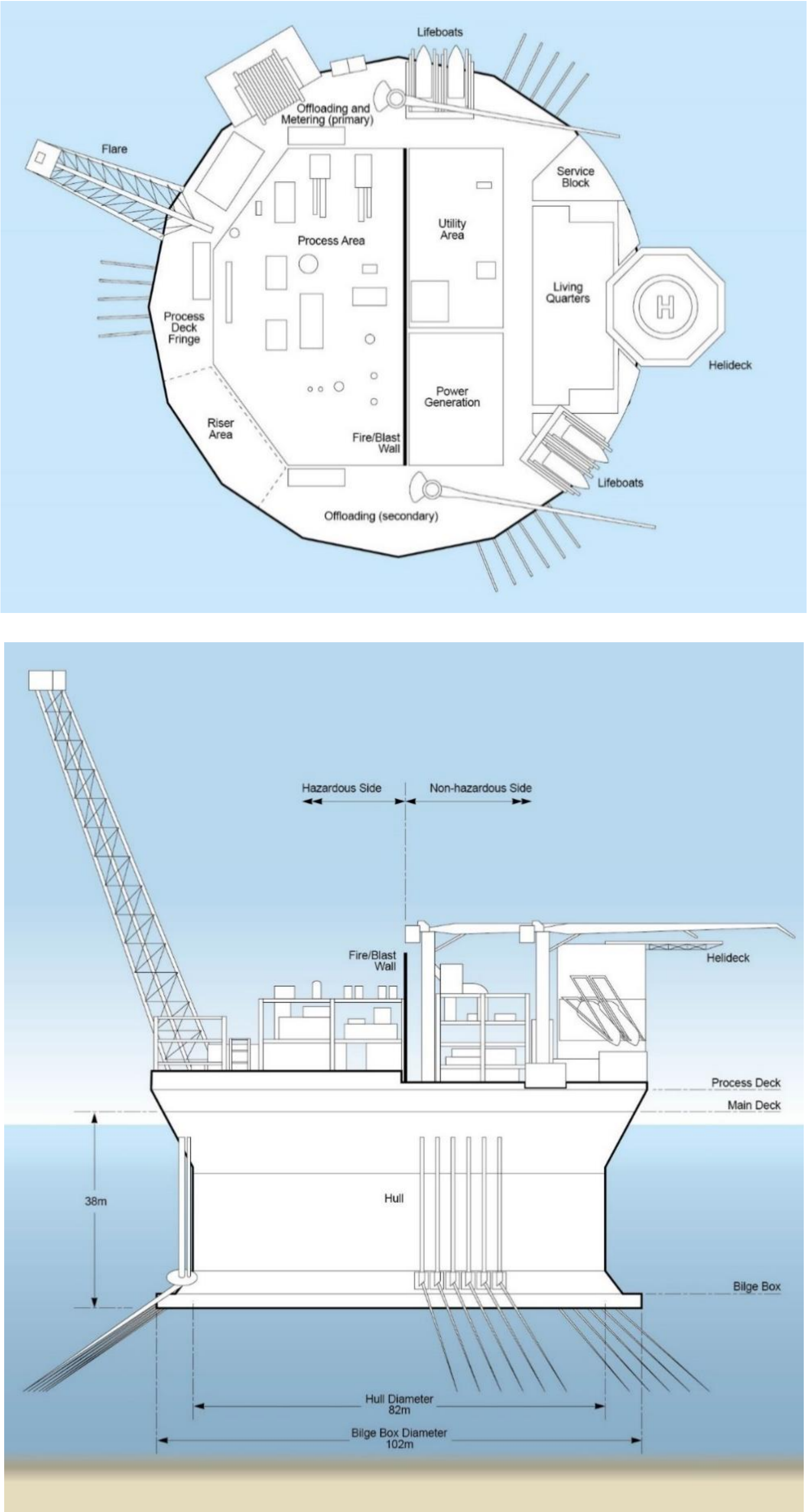

Figure 3.10: Cambo FPSO General Arrangements

3.7.5 Oil Processing

The produced reservoir fluids will be routed via production risers and the manifolds to the main separation process train onboard the FPSO (Figure 3.11).

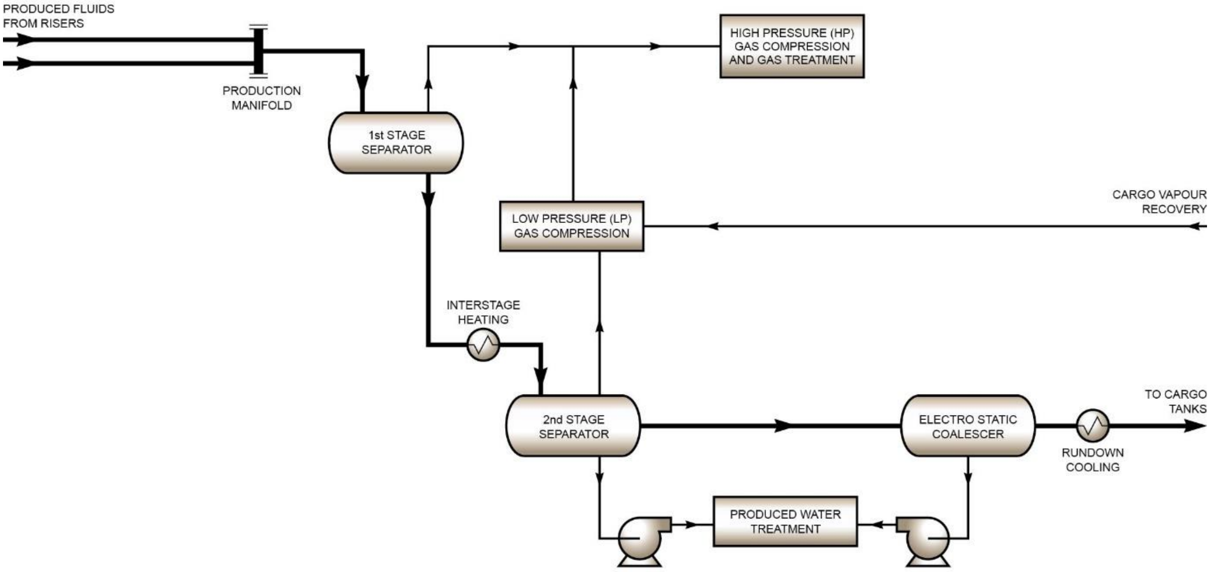

Figure 3.11: Simplified Schematic of the Oil Process System

The oil processing facilities are configured as a single processing train designed to process 100% of production capacity.

Once onboard the FPSO, the produced fluids are received in the 1st stage separator. The vessel separator will operate at circa 10 barg as a two-phase separator, with separated gas routed to High Pressure (HP) compression. The temperature of the produced fluids coming onboard the FPSO is dependent on the prevailing production rates and thus will be variable over field life.

The produced oil and water will be heated to up to 90°C and routed into the three-phase 2nd stage separator. The produced oil from the 1st and 2nd stage separator will then be routed to the electrostatic coalescer for removal of further entrained produced water.

Provisions will be made at the inlet of the 1st and 2nd stage separator to receive off-spec oil pumped from storage.

The three-phase 2nd stage separator will operate at up to 92°C and low pressure (LP), typically 1 to 2 barg, to reduce product vapour pressure to specification for rundown into the FPSO cargo system. Any gas recovered at this stage of the process will be routed to LP compression.

From the 2nd stage separator, the produced oil, along with any remaining oil/water emulsion, flows to the electrostatic coalescer where these emulsions are broken. Free water collected in the electrostatic coalescer is pumped back to the produced water system. Dry oil (with a base sediment and water content (BS&W) of 0.5% or less) from the electrostatic coalescer is then cooled via cross-exchange with 2nd stage separator inlet fluids in a heat exchanger prior to entry into the cargo tanks.

Newly completed wells will be brought on line and flow back cleaned up through a single production flowline to the FPSO. Clean-up fluids will be degassed prior to being routed to the slop tanks in the hull. Degassed well fluids in the slop tank will be treated and separated before being introduced back into the process train.

3.7.6 Gas Processing

Figure 3.12 provides an overview of the gas process system. Gas metering points for the gas process system are provided at the following points:

- Gas outlet of 1st and 2nd Stage Separators;
- Gas Lift (total, also measured subsea at individual wells);
- Fuel Gas (total plus individual Gas Turbine Generators);
- Export/Import Gas.

In addition to these gas metering points, the flare system will also be metered.

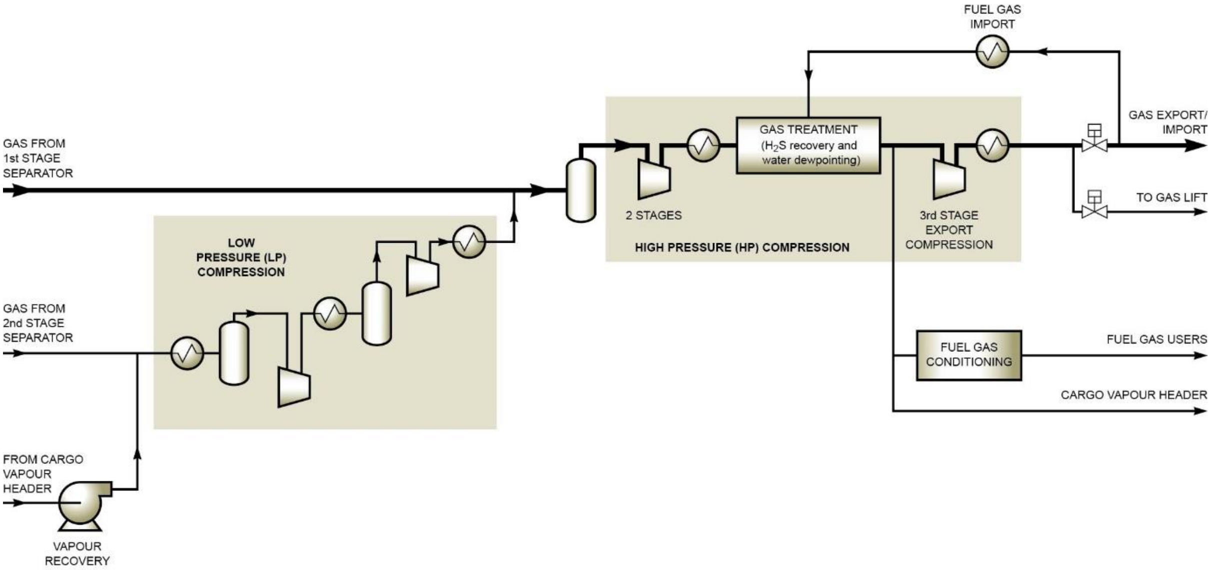

Figure 3.12: Simplified Schematic of the Gas Process System

Low Pressure (LP) Compression

The LP gas compression system consists of a two-stage dry screw compressor with fixed speed motor. Offgas from 2nd stage separation, plus cargo tank gas from the FPSO vapour recovery system, will be routed to the LP compressor suction scrubber and compressed to circa 10 barg and commingled with the gas stream from the 1st stage separator. Gas from LP compression will be routed to HP compression.

High Pressure (HP) Compression

The HP compression system is a 1 × 100% three-stage centrifugal compressor train with dedicated coolers and scrubbers and an HP compressor skid with variable speed electric motor driving the compressor stages.

The gas is cooled to 35 °C in the 1st Stage HP suction cooler and routed via 1st stage HP suction scrubbers to the 1st and 2nd stages of HP compression. From the 2nd stage discharge, gas is routed to gas dehydration and gas sweetening packages operating at circa 90 barg (pending final compressor selection). Fuel gas is taken from downstream gas treatment, before the remaining gas flow is routed to the 3rd stage HP Compressor. Downstream of the 3rd stage HP gas aftercooler, gas is distributed to the lift gas and export risers as required.

Gas Treatment

The gas treatment system consists of gas dehydration and H_2S removal. The gas enters the H_2S removal package where two adsorption beds are used to decrease the H_2S content in gas export to less than 2 kg per day to comply with the Cambo H_2S content specification for entry to WOSPS.

The solid adsorbent beds have been specified with a media change out frequency of once per year based on an H_2S loading of 20 ppm_v (1st Stage Separator vapour outlet). This represents a 100% design margin over the peak H_2S levels predicted by reservoir souring studies.

The adsorption beds are specified in a lead-lag configuration. An H_2S analyser will be provided between the two beds which will detect when the lead bed media is spent. At this point the first lead bed will be isolated and the media changed out. The second lag bed will continue to operate during this period and will then be designated the lead bed. This alternation of lead-lag bed will continue and ensure that the facility can operate uninterrupted during media changeout without any flaring of gas or impact on export specification.

In the event that higher H_2S levels are encountered than currently anticipated, it is intended to employ H_2S scavenging to ensure that the H_2S loading of the solid adsorbent bed remains at 20 ppm_v. This will ensure the solid adsorbent beds continue to operate with the same changeout frequency and that they carry out the final H_2S removal to achieve the specification for entry to WOSPS.

Gas from the H_2S removal package is dehydrated in the Tri-Ethylene Glycol (TEG) dehydration unit to meet the gas export water content specification of 24 kg per million standard cubic metres.

3.7.7 Produced Water Treatment

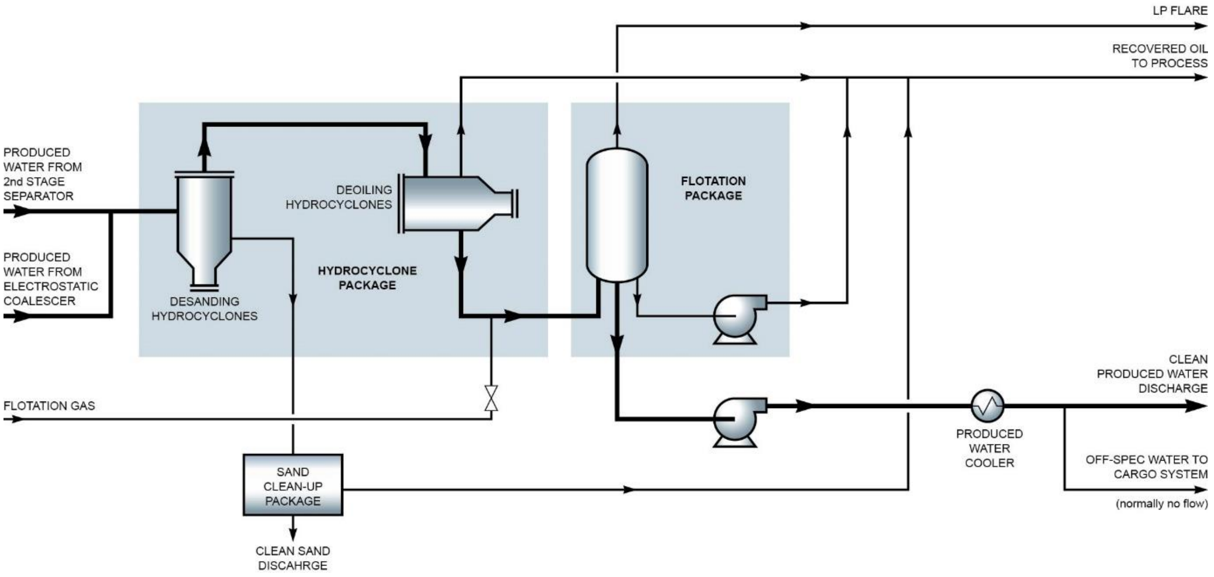

Figure 3.13: Simplified Schematic of the Produced Water Treatment System

As illustrated in Figure 3.13 produced water will be treated and discharged to sea under normal operations, as re-injecting produced water has the potential to sour the gas in the reservoir and will present injectivity issues (see Section 2.2.3.3.). The produced water treatment system is designed to reduce the oil content in the produced water to a target of ≤15 ppm oil in water (monthly average) prior to overboard disposal. De-oiler and/or flocculant chemicals will be injected upstream of the Flotation Unit. This will aid the coalescing of the oil droplets in the unit and improve performance. The chemical selection will be subject to laboratory review and confirmation in the field.

The produced water treatment system has a capacity of 12,719 m^3 per day (80,000 bbls/day) and will remove oil from produced water in two stages by using hydrocyclones, followed by a Compact Flotation Unit (CFU).

Water from the 2nd stage separator and other separation vessels will be routed to a low pressure produced water collection vessel for oil skimming before being pumped to the produced water hydrocyclones. Approximately 2% of the oily water fed to the hydrocyclones will be rejected and the remainder routed to the CFU. The CFU reduces the entrained oil content further and the cleaned water is routed to produced water transfer pumps. From here, the water is pumped through produced water coolers and routed overboard at 45°C or less. An on-line oil in water analyser will be located downstream of the Produced Water Discharge Cooler at the final point of discharge.

Oil skimmed from the CFU will be returned to the produced water collection vessel and from there it will be transferred to either the 2nd stage separator or off-spec tanks.

If oil in water specification cannot be met, produced water can be routed to and stored in hull tanks for later processing and disposal overboard within the required specification. Should sufficient volume be unavailable for storage of produced water, the procedure will be to restrict or shut in production until the produced water is brought back into specification.

3.7.8 Flaring and Venting

The flare system will be segregated into HP and LP flare systems with dedicated flare knock out drums, knock out drum pumps and flare stacks. The flare system will be designed to safely handle gas releases under the following circumstances:

- Start-up conditions when the compression train, H_2S removal and gas dehydration must be brought online and stabilised;
- Relief device discharges to protect equipment and/or systems from over pressure caused by process upsets;
- Emergency flaring caused by depressurisation of systems due to fire or gas detection.

During any of these non-routine operations the flare gas will flow through the flare knock-out drums to remove any liquid before it is combusted. The flare systems will be metered so any flared gas can be monitored.

All processing facilities on the FPSO will be designed to operate without the need for routine flaring of hydrocarbons for operational purposes through the implementation of the following measures:

- Recovery of low pressure hydrocarbon sources frequently routed to LP flare via the FPSO vapour recovery system, including produced water treatment/gas flotation system and TEG regeneration system;
- Use of inert gas (nitrogen) instead of hydrocarbon gas for:
  - Flare header/tip purging;
  - Compressor dry gas seals;

  - Utility system blanketing (e.g. heating and cooling medium expansion vessels);
- Specification of valves connected directly to the flare to minimise fugitive emissions;
- Flare wind shielding to improve flare pilot burner efficiency.

Fuel gas will be used for the pilots, with nitrogen for purging the flare headers and major subheaders and the flare stack.

There also will be no routine venting of unburnt hydrocarbons. Venting from cargo tanks will normally be recovered by vapour recovery blowers and routed to LP compression.

3.7.9 Sand Production and Disposal

The Cambo reservoir formations comprise weak sands and sand control is essential to prevent massive sand production. Currently it is planned to complete the production wells using alternate path open hole gravel pack (AP OHGP) as used for the test of well 204/10a-5Y. Alternatives including alpha/beta gravel packs, Baker Hughes General Electric’s (BHGE’s) GeoFORM ™ or the use of standalone screens (SAS), are being assessed as alternatives to AP OHGP.

Water injection wells will be completed with stand-alone screens (SAS) to prevent sand production during possible temporary flow back or cross-flow when wells are shut-in.

Sand produced to the surface will be recovered from the process system at the following locations:

- Vessels in the separation train (online Tore system or equivalent);
- Desanding Hydrocyclones in the Produced Water Treatment package.

The sand removed from the above sources will be transferred to a Sand Clean-up Vessel via the Sand Slurry Pumps. The Sand Clean-up Vessel consists of an inlet hydrocyclone and a sand collection chamber. As the sand slurry enters the unit it passes through the hydrocyclone section with any oil/water rejected to the 2nd Stage Separator. The washed sand will pass through the hydrocyclone and collect in the base of the Sand Clean-up Vessel. Prior to discharge overboard the sand from the base of the Sand Clean-up Vessel will be washed with treated Produced Water.

Produced Water is supplied to the base of the vessel to create a sand slurry, which is then re-circulated back to the inlet of the Sand Clean-up Vessel and through the hydrocyclone section where further oil/water is removed. This washing of sand with Produced Water will continue until samples show that the sand particles contain ≤ 1% by weight of oil. At this point the sand slurry will be routed overboard. The washing and overboard disposal of sand is expected to be a batch process, which operates intermittently.

3.7.10 Oil Storage and Offloading

The cargo handling system consists of 14 cargo tanks and 2 slop tanks (Figure 3.14). The cargo handling system is designed to permit loading of cargo oil from the topsides into cargo tanks while also simultaneously offloading from other cargo tanks or performing crude oil washing or transferring from one tank to another. Cargo storage volume is approximately 103,342 m^3 (650,000 bbls).

Each cargo tank will have submersible cargo pumps installed for the discharge of oil from the tanks. Oil export pipework will route cargo from the tanks to an export hose reel. Connection of the FPSO to the shuttle tanker will be via flexible offloading hose.

Oil will be exported from the FPSO via tandem offloading to a dynamically positioned bow-loading export shuttle tanker. The offloading system is designed to offload a full cargo parcel within a 24-hour period.

At peak production rate, the offloading frequency of the FPSO for an expected offload tanker volume of 79,494 m^3 (500,000 bbls) will be one every 7-8 day (depending on the operational buffer of tank volume prior to the start of offloading). As production declines in later field life, the offload frequency will decrease gradually over time.

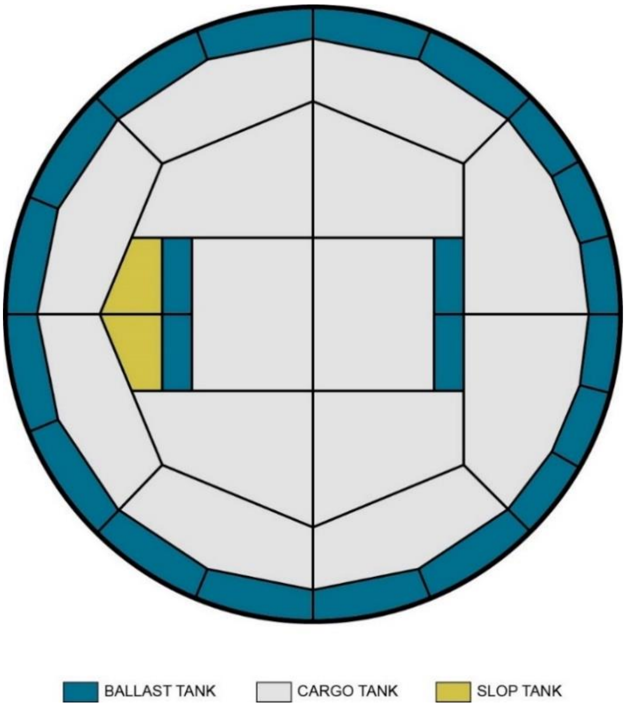

Figure 3.14: Cylindrical Hull FPSO Tank Plan

Each of the outer cargo tanks will have its own hydraulic driven cargo pump with a capacity of approximately 750 m^3/h.

During offloading, 6 to 7 pumps will run simultaneously giving an offloading rate of 5,000 m^3/h.

There will be a common Hydraulic Power Unit (HPU) for all the cargo and slop pumps in addition to the ballast pumps. All pumps driven by the HPU will have variable speed, regulated by the pressure and valves in the hydraulic system.

The FPSO will be equipped with a tandem offloading system for off-take of oil to tanker. The location of the Offloading station has been developed with cognisance of the metocean data to provide the optimal offloading availability. When the offloading hose is securely connected to the shuttle tanker's bow loading manifold, the systems at the FPSO and shuttle tanker are prepared for transfer of cargo. The cargo transfer operation is controlled from the central control room on the FPSO.

The offloading hose will be suspended in a U-configuration during operation, and length is selected to ensure a suitable catenary with the selected separation from the FPSO.

3.7.11 Utility Systems

Seawater Treatment and Injection

Treated seawater will be injected into the reservoir for reservoir pressure support and improved sweep. Seawater treatment begins with coarse and fine filtration, followed by sulphate removal for souring and scale management purposes and deaeration. The sulphate content of the injected seawater will be reduced to circa 100 mg/l for souring and scale management purposes. Seawater will be de-aerated to reduce the oxygen content to ≤ 10 ppb.

Up to 15,899 m^3 (100,000 bbls/day) of treated seawater permeate will be generated by the sulphate removal package.

Figure 3.15 provides an overview of the seawater treatment and injection process. The water injection pump system consists of three centrifugal pumps, directly driven by electric motors. Under normal load the pumps will operate at 50% capacity, providing flexibility to inject water at increased rates for a limited period to recover reservoir pressure after a short shutdown of the injection system. Two 100% booster pumps maintain the required suction pressure on the injection pumps.

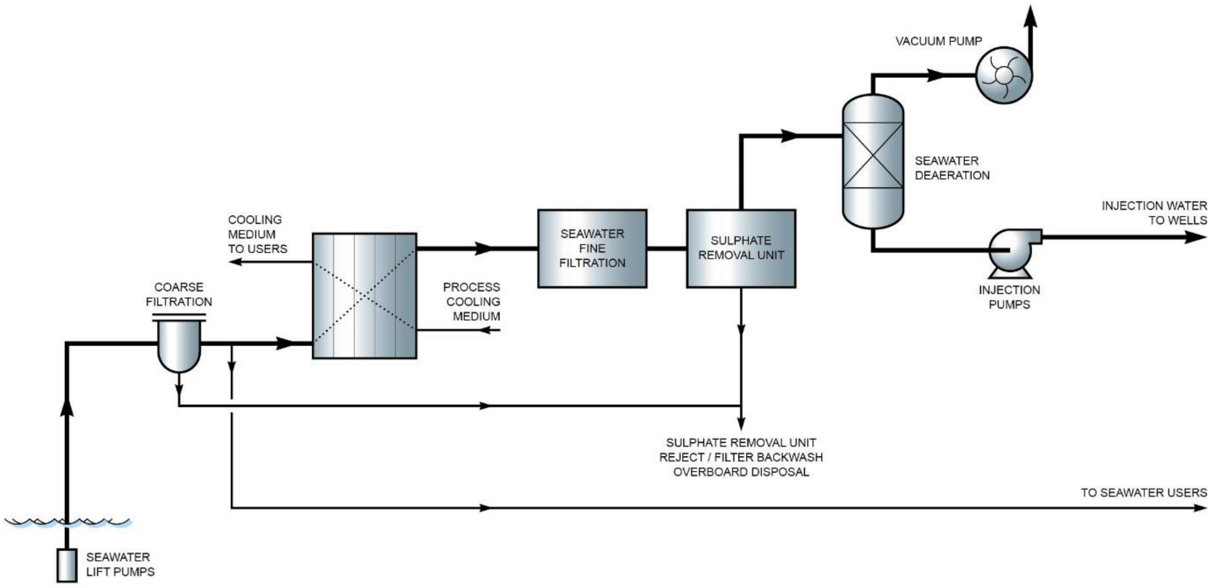

Figure 3.15: Simplified Schematic of the Seawater Treatment and Injection System

Power Generation

The FPSO will be provided with power generation capacity as shown in Table 3.13. Each main generator will be coupled with a 11-kV electric generator with nameplate rating of no less than that of the turbine. Under normal operations, electric power will be supplied from electric generators powered by dual fuel, i.e. dry low NO_x emissions (DLE)/liquid fuel ‘lean direct injection’ (LDI) turbines.

The Cambo FPSO will be designed to facilitate potential future electrification from renewable energy sources.

Waste heat from the turbines will be used to provide process heating requirements through the installation of Waste Heat Recovery Units (WHRUs).

Table 3.13: Cambo FPSO Power Generation

Power Generation	Main	Emergency
Type	Gas turbine dual fuel (gas fuel DLE/liquid fuel LDI)	Diesel
Site Rated power	21.0 MW each	2.5 MW
No. of units	3 × 50%	1

One emergency diesel generator is used to provide emergency power for emergency safety systems, maintaining life support facilities and black-start facilities.

Chemical Injection

Chemical storage and injection systems will be provided for topsides facilities (process and utilities) onboard the FPSO, as well as for the subsea production systems. Where the quantity of chemical consumed is less than 2 m^3 over 30 days, storage tanks will be portable feed type tanks. Methanol will have dedicated storage tanks in the hull. Chemical storage tanks will be sized for 21 days consumption.

Chemical injection facilities will be provided at various locations in the production system. Subsea and topsides equipment will be designed so that controlled distribution of chemicals to each well is achieved in order to protect the subsea trees and subsea pipelines and ultimately the whole production process.

To prevent chemical contamination of the open drains, the chemical storage areas (tote tank area and chemical injection package area) are bunded with normally closed valves on each of the bund deck drain outlets. Each bund is sized to hold the largest tank volume in case of leakage and has two valves, one with a permanent connection to the open drain system, and one to allow drainage to a portable tote tank. The valve to the open drain system will normally be open to drain rainwater but will be closed before maintenance or filling of the chemical injection tanks.

Non-compatible chemicals can form slurries or solids and create problems if they are drained into the same system. In case of non-compatible chemicals, the bunds will be divided to ensure that non-compatible chemicals are not mixed. The dividing bunds will be lower than the outer bunds to ensure overflow of liquids from a small compartment to the entire bund in case of tank leakage.

Drainage System

The FPSO drainage system will consist of closed and open drains, hull open drains, sewage drains and drains from the helideck.

Hazardous liquids from the topsides process system i.e. pressure vessels and piping, will be collected through a completely closed drains system with liquids routed to a closed containment vessel. Separated gas will be routed to the LP flare, with liquids routed back to the process system (Figure 3.16)

Liquids such as rain or washdown water, that may contain small quantities of oil, will be collected through the topsides open drains system which will be segregated as hazardous and non-hazardous as appropriate. The hazardous open drains system will collect oily waste water from process areas and any other areas likely to contain hydrocarbons. Oily waste water will be routed to the drain and slop treatment unit located in the hull. This is a centrifuge type treatment unit that will clean the oily water to a level of 15 mg/l oil-in-water, before being discharged overboard. On occasions when this required specification is not met, the water will be routed back to the drain and slops treatment unit. Separated oil from the process will be routed to the slops tanks, where it can be recovered as cargo product. Separated solids are periodically disposed of via a tote tank. Any liquids in the slop tanks will undergo further processing and separation before being discharged overboard; discharge overboard will only occur if the target of 15 mg/l (through dedicated monitoring) is met. Figure 3.16 show the location of the two oil and water analysers. Additional manual sampling points are located adjacent to the on-line analyser to allow manual sampling/analysis at each of the following locations:

- Discharge line overboard from Non-Hazardous Open Drains Tank;
- Discharge line overboard from Hazardous Open Drains Tank;
- Discharge line overboard from Drain and Slops Treatment Unit.

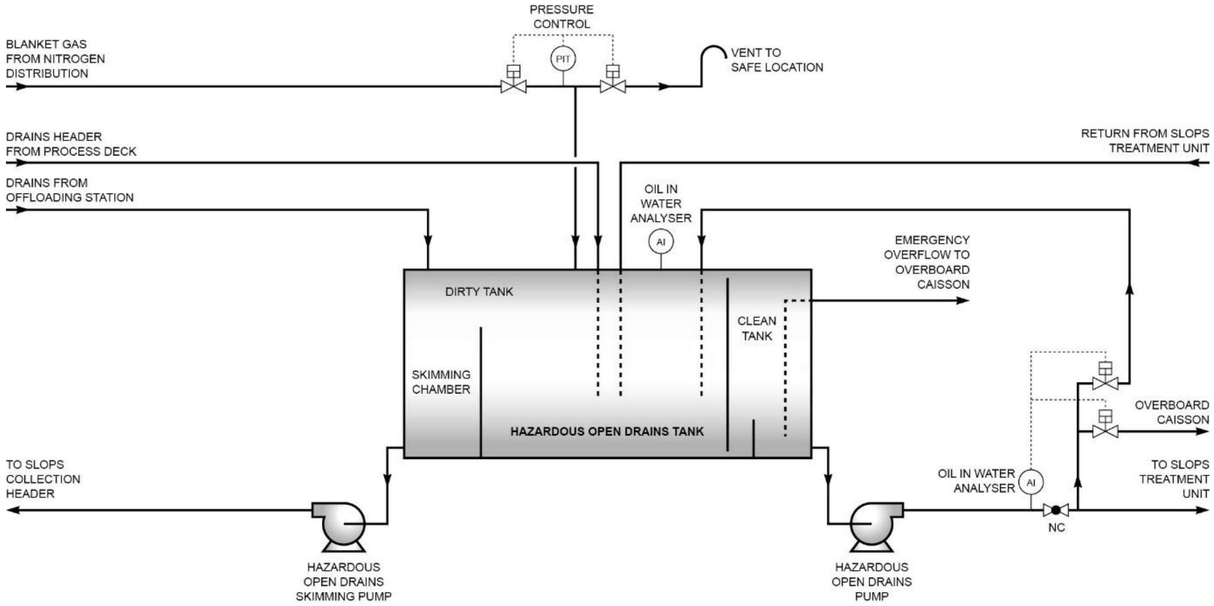

Figure 3.16: Simplified Schematic of the Hazardous Open Drains System

The non-hazardous open drains system will collect waste water from process areas designed as non-hazardous. Liquid in these drains will be routed to a collection tank where potential contaminants e.g. grease, lube-oil, hydraulic oil etc., will be removed and the remaining liquid routed to the slop tanks.

The hull open drains system will also be segregated as hazardous and non-hazardous and will capture leaks from, for example, void spaces, helideck, machinery spaces, main deck and hose reel off-loading area. Liquids from the hazardous open drains will be routed via the topsides hazardous open drains system into the separation vessel. Liquids in the non-hazardous drains will be routed via the topsides non-hazardous open drains collection tank and onward to the slop tanks. The helideck will have an independent drains system to address any potential helicopter fuel releases. Storage tanks for aviation fuel will be bunded and drains routed to the hazardous open drains system. Rainwater will be routed overboard.

Water effluent from sinks, showers, laundry and kitchen/canteen (also referred to as grey water) and effluent from toilets (also referred to as blackwater) will be treated and disposed of through an independent sewage drains system. All effluent will be routed to a sewage treatment package which will ensure that regulatory requirements are met before being discharged overboard (the discharge caisson will be located away from the seawater intake). During times when the sewage treatment plant is unavailable, e.g. due to maintenance, the effluent will be macerated and disinfected until such time that the treatment package is operational again.

3.7.12 Fuel Use

Produced gas will be used to meet a significant amount of the FPSO power requirements. Based on the current project design, SPE expects that the use of fuel gas is expected to peak at 171,870 m^3/day (131.8 tonnes/day) or 62.7 million m^3 (48,091 tonnes) per year in 2029. Fuel gas demand remains relatively flat throughout the life of field at an average of around 125.1 tonnes/day, as power is still required for gas lift and water injection purposes. The fuel usage values presented here, and throughout the remainder of the ES are SPEs best estimates based on current project design parameters, including vendor data and benchmark data from similar operating assets on the UKCS.

In addition to the produced gas, the FPSO will also use up to 1.3 tonnes of marine diesel per day, giving a total of 119.6 tonnes per year for the first year (92 days) of production, followed by 474.5 tonnes per year for the years 2026 to 2050. This level of diesel usage is based on an assumed number of plant re-starts per year with main power generation on diesel (if, for example, fuel gas import was not available), plus a further additional allowance for consumption by the following non-routine diesel consumers:

- Inert Gas Generation for cargo tank blanketing;
- Emergency power generation;
- Firewater pump drives;
- Totally Enclosed Motor Propelled Survival Craft (TEMPSC).

3.7.13 Commissioning and Start-up

There are three main phases to commissioning and start-up; onshore commissioning and performance testing; offshore hook-up and commissioning; start-up. To minimise offshore commissioning activities, the Project aims to maximise as far as practicable the onshore commissioning of process, utility and marine systems.

The FPSO will be moored to the seabed using suction pile anchors, which are the conventional mooring standard solution for deep-water soft soils (Lloyds Register, 2019). These piles are initially allowed to penetrate into the seabed under self-weight before water is pumped from the top of the pile to create a differential pressure which results in additional penetration force driving the anchor piles into the seabed. The suction pile anchors will be 7.5 m in diameter and up to 32 m long.

Table 3.14 provides the total seabed footprint of the FPSO mooring system. Once the anchors piles are in place, the movement of the anchor lines on the seabed will be minimal. The anchor line arrangement will comprise short sections of chain (150 m) lying on the seabed, at each anchor pile. The remainder of the anchor lines consist of polyester ropes, which will be suspended in the water column.

As a worst-case estimate, it is expected that a maximum 120 m length of chain will raise and lower on the seabed during extreme weather events. Lateral movement of the anchor lines during their installation and hook up, as well as later on during bad weather events will be restricted to a maximum distance of 5 m on either side of each anchor chain. Consequently, based on a maximum of 16 anchor lines being deployed in total, this would potentially result in an overall area of 19,200 m^2 of seabed being periodically disturbed throughout the life of the field.

Table 3.14: Total mooring footprint for the FPSO

FPSO Type	Suction Pile Diameter	Individual Anchor Pile Footprint	Number of Anchor Piles/Lines	Length of Anchor Lines	Seabed Disturbance Footprint for Anchor Lines	Total Footprint
Sevan	7.5 m	44.2 m^2	16	2,513	19,200 m^2	19,907.2 m^2

Table 3.15 provides an overview of the estimated vessel requirements and durations associated with to the installation of the mobilisation and hook up of the FPSO.

Table 3.15: Vessel Requirements and Estimated Fuel Consumption during FPSO installation

Activity	Vessel	Fuel Type	Consumption Rate	Duration	Total Fuel Consumption (tonnes)
Mobilisation and hook up of FPSO moorings	ROVSV	Diesel	20 tonnes/day	51 days	1,020
Support shipping (3 ×)	Tow tugs	Diesel	3×35 tonnes/day	14 days	1,470

3.7.14 Waste Management

In line with the current EU & UK Directives on waste management, SPE and the Installation Operator will ensure that:

- All waste is correctly segregated to ensure recycling/reuse objectives and onward transport to shore requirements can be met;
- Appropriate authorisations and placards are displayed onboard the FPSO;
- No overboard disposal of garbage;
- All waste is contained and secured in such a way so as to prevent loss overboard;
- Waste minimisation and recycling/reuse/recovery of waste is encouraged, as far as possible;
- Transfer Notes and Consignment Notes are retained, as required.

3.7.15 Inspection and Maintenance

During the Execution phase of the Cambo project, a Computerised Maintenance Management System (CMMS) for the FPSO will be developed.

The Safety and Environmentally Critical Elements (SECEs), as will be defined in the development Safety Case, will be translated into a suite of performance standards which, in turn, will define the SECE maintenance requirements and will form the examination and verification scheme.

The CMMS will be populated utilising the SECE maintenance requirements, together with production critical and other maintenance requirements, as appropriate. Planned maintenance turnarounds (TARs) will be scheduled on a regular basis.

3.8 Gas Export Pipeline and Associated Subsea Infrastructure

The Gas Export Pipeline (GEP) will be carbon steel, uninsulated and without concrete weight coating, as the concept design study shows that given the relative small diameter of the GEP (10"), it will be stable on the seabed (i.e. will be negatively buoyant). The GEP will be reel-laid from a pipelay vessel and will take 23 days to complete. The new 69.6 km long GEP (Figure 3.17) will transport the produced gas at Cambo to shore via a new tie in structure connected to the existing WOSPS Pipeline End Manifold (PLEM). The installation and tie in of the new structure will be accomplished by divers working at 175 m water depth.

To protect the pipeline from any potential trawling or other mechanical impacts, a remotely operated jet trenching vehicle will be used to trench approximately 30 km of pipeline from the 600 m water depth contour line to the WOSPS PLEM location. However, there may be a requirement to extend the trenched section of the pipeline to a water depth of 800 m. Whereas the pipeline route survey (MMT,2019) showed that trawl marks were only evident at depths of around 600 m and above (MMT, 2019), the Protection Philosophy Document, which sets out the requirements for the gas export pipeline system, indicated that bottom trawling in the area may take place to a depth of 760 m. Bottom trawling in waters deeper than 800 m is prohibited in international waters of the Northeast Atlantic under Regulation (EU) 2016/2336. Therefore, a trenching assessment and fisheries risk assessment will be undertaken to assess the minimum safe trenching requirement for the pipeline section between 600 m and 800 m water depth, during the detailed design phase of the pipeline. For the purposes of this EIA it has been assumed that 45 km of pipeline may be trenched, between the 800 m water depth and the WOSPS PLEM, as a worst-case estimate for trenching and potential rock dump operations. To ensure adequate protection for the pipeline, the trench will be at least 1.5 m deep. The jet trenching will be undertaken in a single passage, moving along the route on tracks straddling the pre-layed pipeline and jet cutting the sides of the trench. Additional jets fluidise the spoil and the pipeline's own weight allows the pipe to settle into the trench. Due to the nature of the soils, the vast majority of the fluidised spoil will fall back on top of pipe, naturally backfilling the line and negating the need for mechanical backfilling. It is anticipated that the trench will backfill immediately due to the unconsolidated nature of the sediment. The width of the trench generated by the jetting will be approximately 0.75 m. Deposition of sediment outwith the footprint of the trench will be minimal. Hence, it is estimated that an overall area of 33,750 m^2 will be disturbed as a result of the trenching operations.

Based on the current soils data available, jet trenching is the preferred solution to install the pipeline. Analysis of recent geotechnical survey data will be used to confirm the local soil conditions along the pipeline route. As a contingency, for where trenching may encounter harder soils and fails to meet required trench depth, some rock dumping may be required to provide the pipeline with adequate protection from trawling activities.

Where rock dump will be required, a DP flexible fallpipe vessel will be used to place the rocks on top of the pipeline. The rock protection material, typically 10 cm (4") in diameter, will form a berm of approximately 4 to 5 metres wide and 1 m in height. It is not possible to state where the locations will be or exactly how much rock will be required until detailed soil investigations / analyses are completed. However, for the purposes of assessing the impacts in this ES, it has been assumed that up to 40,000 tonnes of rock dump may be required (based on the full capacity of two load outs of a large rock dump vessel). Based on a typical rock profile for a 10" pipe this would allow for a total overall length of 7 km of pipeline being rock dumped covering a seabed area of up to 35,000 m^2, which, at present, is considered the worst-case scenario, based on providing pipeline protection to a water depth of up to 800 m. The option for potentially rock dumping part(s) of the pipeline has been included as a contingency measure, in case the 'as installed' surveys show any part(s) along the trenched and buried part of the pipeline that has/have not been backfilled adequately back to seabed level. It is intended to keep remedial rock dumping to an absolute minimum. No rock dump will be undertaken within areas of offshore subtidal sands and gravels, unless strictly required to mitigate against potential upheaval buckling of the pipeline. Concrete mattresses will be used to protect the rigid spool pieces from the Cambo pipeline to tie-in structure and tie-in structure to the WOSPS PLEM. Rock dump will not take place on top of mattresses.

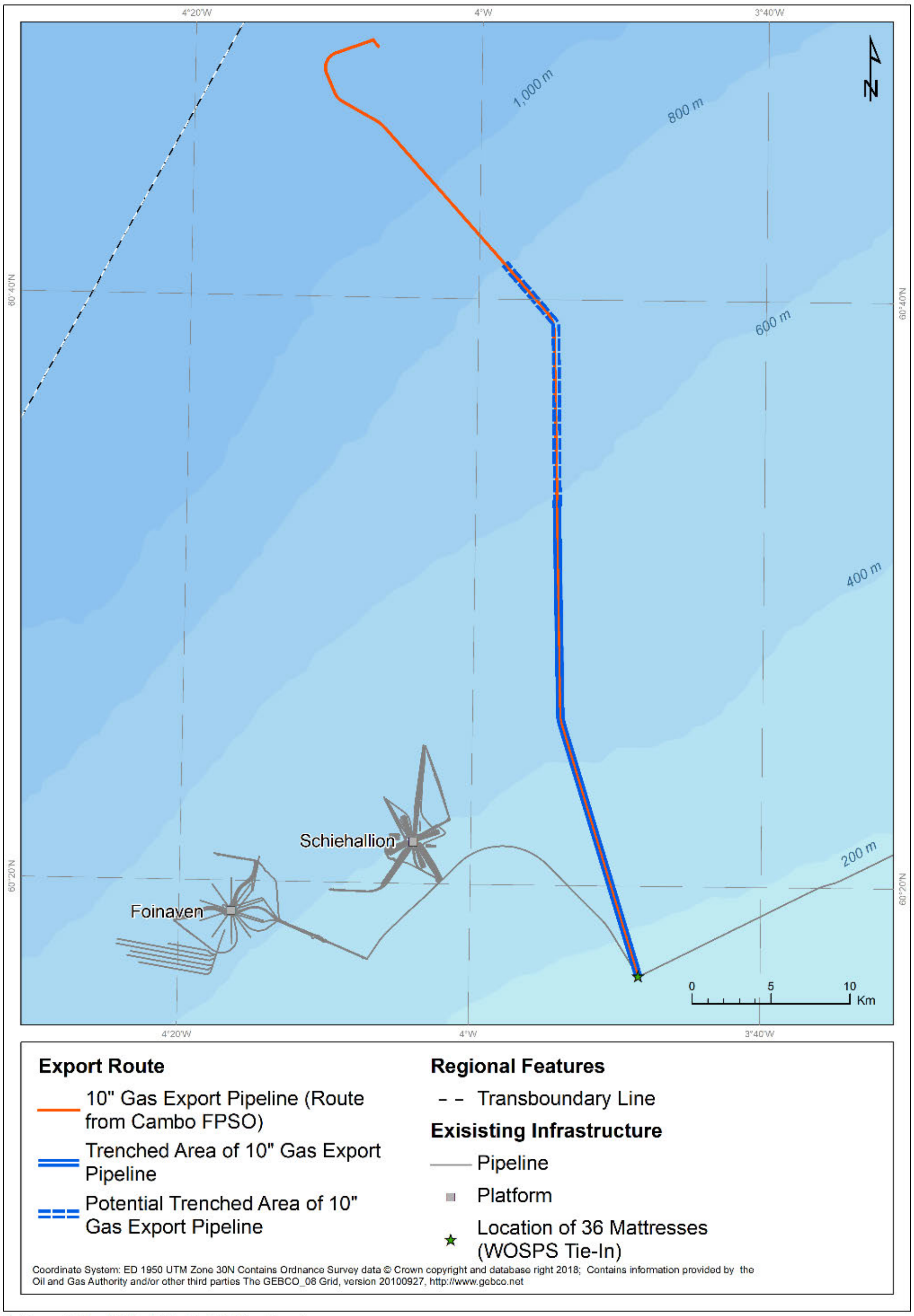

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Figure 3.17 Cambo Gas Export Pipeline Route

Table 3.16 provides the locations and footprints of all other infrastructure associated with the export pipeline. Although the final foundation designs and installation methods for these are still being designed, it is currently anticipated that the Cambo Tie-in Structure (CTIS) will be installed with driven piles, and the subsea isolation valve (SSIV) will rest on mudmats. The foundation design for the Cambo Pipeline End Termination (PLET) is presently anticipated to be a gravity-based structure.

Table 3.16: Location and Seabed Footprints of Remaining SPS Infrastructure

Asset Type	Identifier	UTM E [m]	UTM N [m]	Footprint of Asset and Protective Structure [m^2]	Total [m^2]
Subsea isolation valve	SSIV	438 370	6 742 758	10 m × 4 m	40
Cambo pipeline end termination	PLET	438 320	6 742 698	8 m × 4 m	32
Cambo tie-in structure	CTIS	455 432	6 683 280	14 m × 10 m	140
Concrete mattresses protecting the two rigid spool pieces tying in the CTIS to the pipeline end and the PLEM	-	tbc	tbc	6 m × 3 m (36×)	648
Total					860

The CTIS will have four piles of 0.61 m (24") diameter × 12 m long. A dedicated pile driveability analysis has not been undertaken for the proposed tie-in structure, however, the piled foundations for the nearby WOSPS PLEM provide evidence that driveability should not pose a significant risk at this location (Lloyds Register, 2019). The existing WOSPS PLEM made use of an IHC S280 hammer, which is a typical hammer size for this type of construction activity. An average blow count of 509 blows / pile was recorded and this should be considered typical for the new structure piling i.e. a total blow count in the region of 2,050 is anticipated.

Table 3.17 provides an overview of the estimated vessel requirements and durations associated with to the installation of the mobilisation and hook up of the FPSO.

Table 3.17: Vessel Requirements and Estimated Fuel Consumption During Installation of the Gas Export Pipeline

Activity	Vessel	Fuel Type	Consumption Rate	Duration	Total Fuel Consumption (tonnes)
Installing gas export pipeline	Pipelay vessel	Diesel	20 tonnes/day	23 days	460
ROV and survey support	ROVSV	Diesel	16 tonnes/day	50 days	800
Pipeline tie-ins and testing	DSV	Diesel	20 tonnes/day	26 days	520
Trenching	TSV	Diesel	12 tonnes/day	18 days	216
Total Diesel Consumption					1,996

3.9 Decommissioning

The infrastructure associated with the proposed Cambo Field Development will be decommissioned when operations are no longer economically viable and opportunities for potential hub operations have been exhausted.

All decommissioning operations will be undertaken in accordance with UK Government legislation and international agreements in force at the end of field life. In the UK, decommissioning is controlled through the Petroleum Act 1998, as amended by the Energy Act 1998. The UK's international obligations on decommissioning are governed principally by the 1992 Convention for the Protection of the Marine Environment of the North East Atlantic (OSPAR Convention).

Wells will be decommissioned in accordance with the prevailing Oil & Gas Authority (OGA) guidelines. The selection of an FPSO allows it to be towed away and the current plan is to fully recover all infield flowlines and any other surface laid infrastructure or deposits at the time of decommissioning. The decommissioning of the gas export pipeline will be subject to a comparative assessment, which will assess all potential decommissioning options available at the time, including complete recovery of the pipeline, as well as leaving (parts of) the pipeline in-situ. All decommissioning activities will be undertaken in compliance with regulatory requirements in force at the time of decommissioning and in consultation with regulators and other stakeholders.

The main considerations of the decommissioning process will be navigational safety, the prevention of marine pollution and prevention of damage to the marine environment. The ultimate intention is to leave the seabed development area in the condition that it will pose no harm to the marine environment.

Prior to the decommissioning process, re-use and recycling alternatives will be considered where feasible. In advance of the decommissioning process, an inventory of all project equipment will be made and an examination for further reuse will be carried out. Pre-decommissioning surveys will be carried out to establish the environmental baseline before decommissioning. The precise decommissioning methodology will depend upon operating conditions. Discussion on what may be required in an individual case will be held with the Department for Business Enterprise and Industrial Strategy (BEIS) Offshore Decommissioning Unit before commencing.

Section 4

Environmental Description

4 ENVIRONMENTAL DESCRIPTION

Information about the local environment at the proposed Cambo Field Development and its surrounding area has been collated to allow an assessment of those features that might be affected by the proposed activities or may influence the behaviour of potential contaminants.

The proposed development is situated in United Kingdom Continental Shelf (UKCS) Blocks 204/4a, 204/5a, 204/9a and 204/10a, approximately 125 km to the west of the Shetland Islands and adjacent to the UK/Faroe Island transboundary line. The centre location of the development is 60^o 48’ 32.606” N, 004^o 07’ 15.941” W. The Faroe Islands lie 146 km northwest from the proposed Development Footprint location (Figure 4.1). The proposed Cambo Gas Export Pipeline route passes through UKCS Blocks 205/11, 204/15, 205/16 and 205/21 terminating at the West of Shetland Pipeline (WOSPS) Pipeline End Manifold (PLEM) tie-in (60° 16' 56.182" N, 003° 48' 21.094" W).

4.1 Data Sources

Information on the proposed development has been gathered from a wide range of sources. Existing data has been sourced from publicly available national and regional datasets, as well as from published journals. Information on seabed features, sediment types, seabed habitats and benthic species has been sourced from regional and site-specific surveys that have been carried out in the area around the proposed development.

4.1.1 Environmental Surveys Relevant to the Proposed Cambo Field Development

Numerous environmental surveys have been conducted in Quadrants 204 and 205, and in the surrounding quadrants, over the past 23 years (Figure 4.3 and Figure 4.4). These surveys provide useful information on the seabed sediments and benthos in the area, including any potentially sensitive features that could be classified as Annex I habitats, such as biogenic reefs and deep-sea sponge aggregations.

The most recent survey was conducted in August 2018 (MMT, 2019). This survey comprised the proposed Cambo Field Development Footprint and the proposed Cambo Gas Export Pipeline (GEP) route (also referred to in this ES as the proposed Pipeline route). A detailed review of the survey data was undertaken to assess the potential for the sensitive habitats “stony reefs” and “deep-sea sponge aggregations” (Fugro, 2020).

The environmental baseline survey and habitat assessment used continuous high-resolution colour still images mounted on the ROV to acquire seabed data together with seabed sampling using a dual Van Veen grab for grab sampling. A total of eight still image ROV transects and 13 grab sample sites were selected for sampling in field. An additional 32 km long imagery transect, with one short cross transect, was surveyed along a section of the pipeline route located within the Faroe-Shetland Sponge Belt Nature Conservation Marine Protected Area (NCMPA). The geophysical data acquired was used to identify areas of interest along the proposed Pipeline route, which were then investigated further. Along the proposed Pipeline route eight environmental sampling stations and fifteen habitat assessment camera visual imaging stations were acquired, eight of which were within the Faroe-Shetland Sponge Belt NCMPA. Figure 4.2 provides an overview of environmental sampling along the proposed GEP route and in the FPSO site survey area. The geophysical and environmental data was combined and used as the basis for the European Union Nature Information System (EUNIS) habitat classification and assessments for potential areas of species conservation.

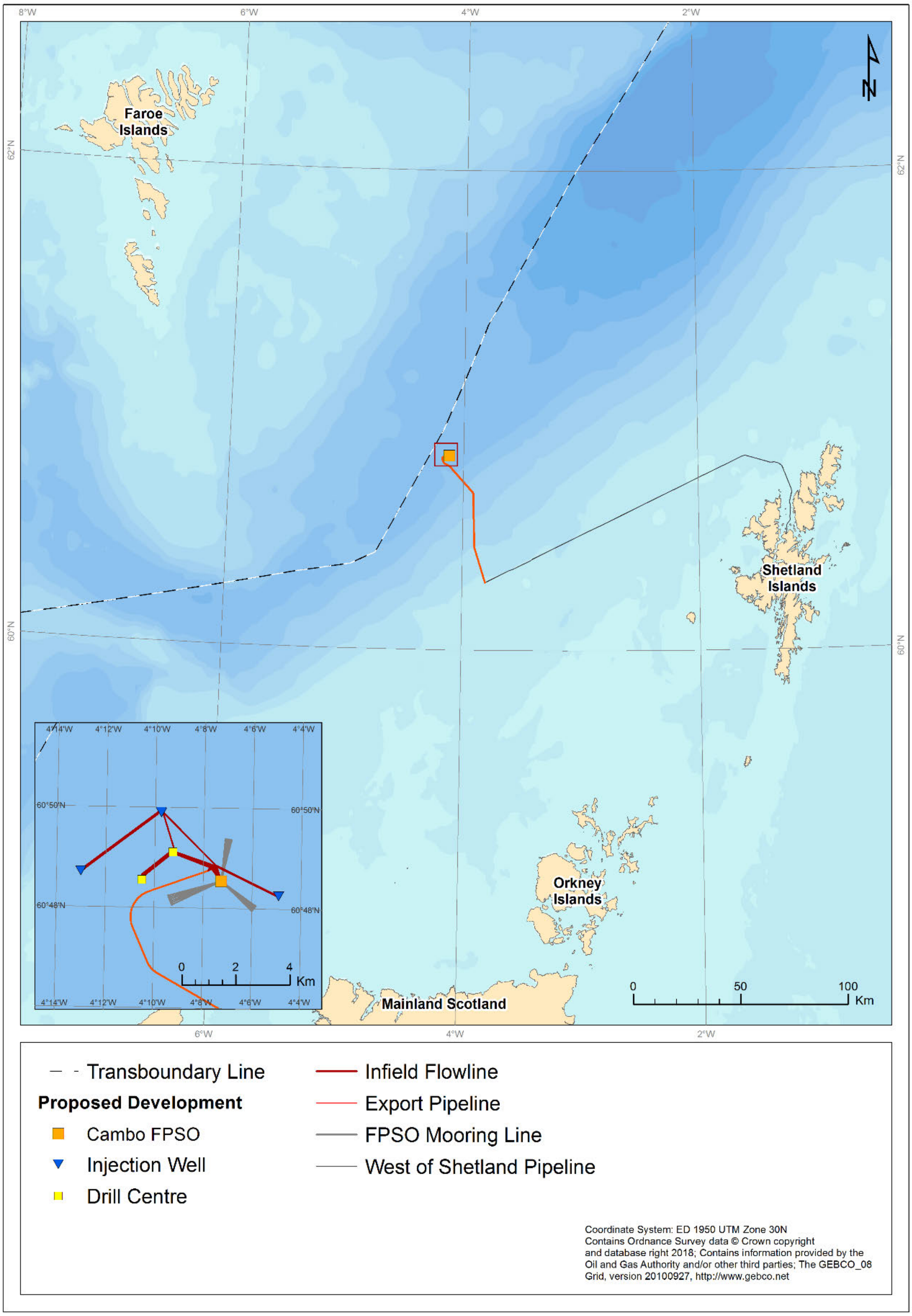

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Figure 4.1: Location of the Proposed Cambo Field Development

In 2017 a habitat assessment within Block 204/10a within the vicinity of well 204/10a-5 location was undertaken. The survey was carried out using a remotely operated vehicle (ROV) capturing video footage and digital stills along eight 100 m transects centred on the proposed drilling location (Fugro, 2017).

An environmental survey was conducted at Well 204/5a-1 (Cambo 5) in 2011. Bathymetric and side scan sonar (SSS) data were gathered from a 2 × 2 km survey grid. Four geotechnical core samples were taken from a 200 m radius around the well location, to aid in geophysical interpretation of sediment types from the side scan data. The side scan and bathymetry data were then used to select four stations within a 1 km radius of the well location for investigation via seabed photography (Fugro, 2011a). Stations were chosen to characterise the general sediments in the area and of an area of coarser sediment. A ROV survey was also conducted as part of a pre and post drilling habitat assessment at Cambo 5 in 2013 (Fugro, 2013).

A ROV based habitat assessment was carried out at Well 204/10a-4 (Cambo 4) in 2011. Digital stills were taken of the seabed at approximately 10 m intervals along four transects (southwest, southeast, northwest and northeast) from the well centre to identify if any areas of reef or other Annex I habitats were present (Fugro, 2011b).

A ROV survey of the Cambo 3 well location (204/10a-3) was undertaken by the SERPENT project in July 2009. Data from eight video transects were used to analyse the seabed and habitats around the immediate well location. Additionally, two sediment cores were taken for chemical and biological analysis (SERPENT, 2009).

In 2001 a rig site and environmental survey was conducted around the original Cambo well location, Well 204/10-1 (Gardline, 2002). This survey investigated the seabed using analogue survey techniques such as echo sounders and SSS equipment as well as grab sampling and seabed photography at nine stations.

The results of the local surveys described above are further supported by regional surveys that have taken place in the West Shetland and Faroe-Shetland Channel region. These include several broad scale surveys and studies conducted by the Atlantic Frontier Environmental Network (AFEN) in 1996 and 1998 (AFEN, 2000) and the Department of Trade and Industry (DTI) survey of the former White Zone in 1999 for Strategic Environmental Assessment (SEA) 1 (DTI, 2000). This work sought to characterise the seabed habitats and communities in the region by using a combination of analogue survey techniques (such as side-scan sonar and a multi-beam echo sounder) subsequently ground-truthed by digital stills camera/video systems and grab sampling (Figure 4.3).

The locations of all the relevant site and regional sampling stations in relation to the proposed development are presented in Figure 4.3 and Figure 4.4, with further survey details summarised in Table 4.1.

The results of the environmental survey and habitat assessment are presented where relevant in Sections 4.2.4 (Seabed Features), 4.5.2 (Seabed Sediments), 4.3.1 (Benthos) and 4.2.5 (Offshore Conservation Areas).

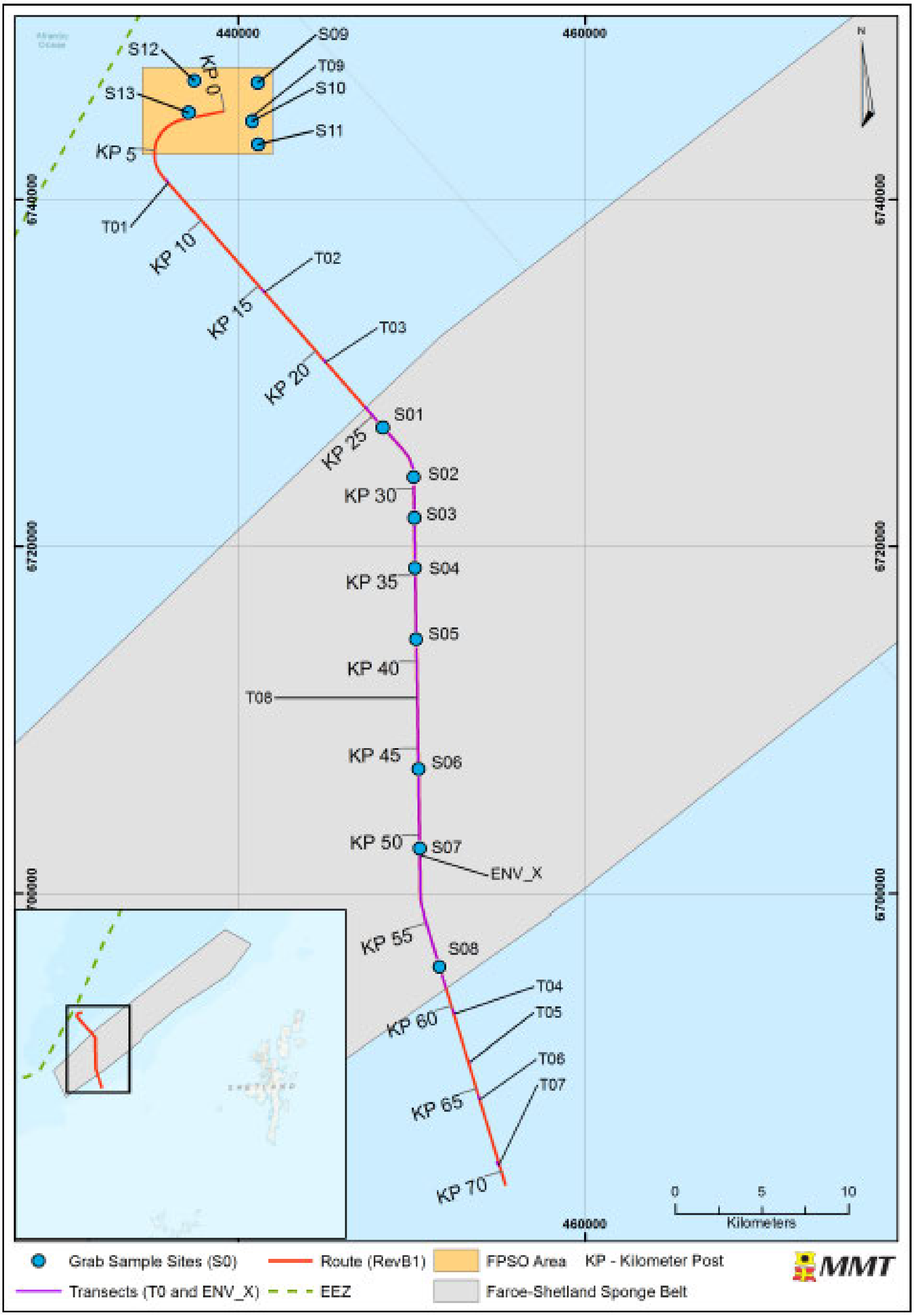

Figure 4.2: Overview of 2018 Environmental Sampling along the Proposed GEP Route and FPSO Site Survey Area

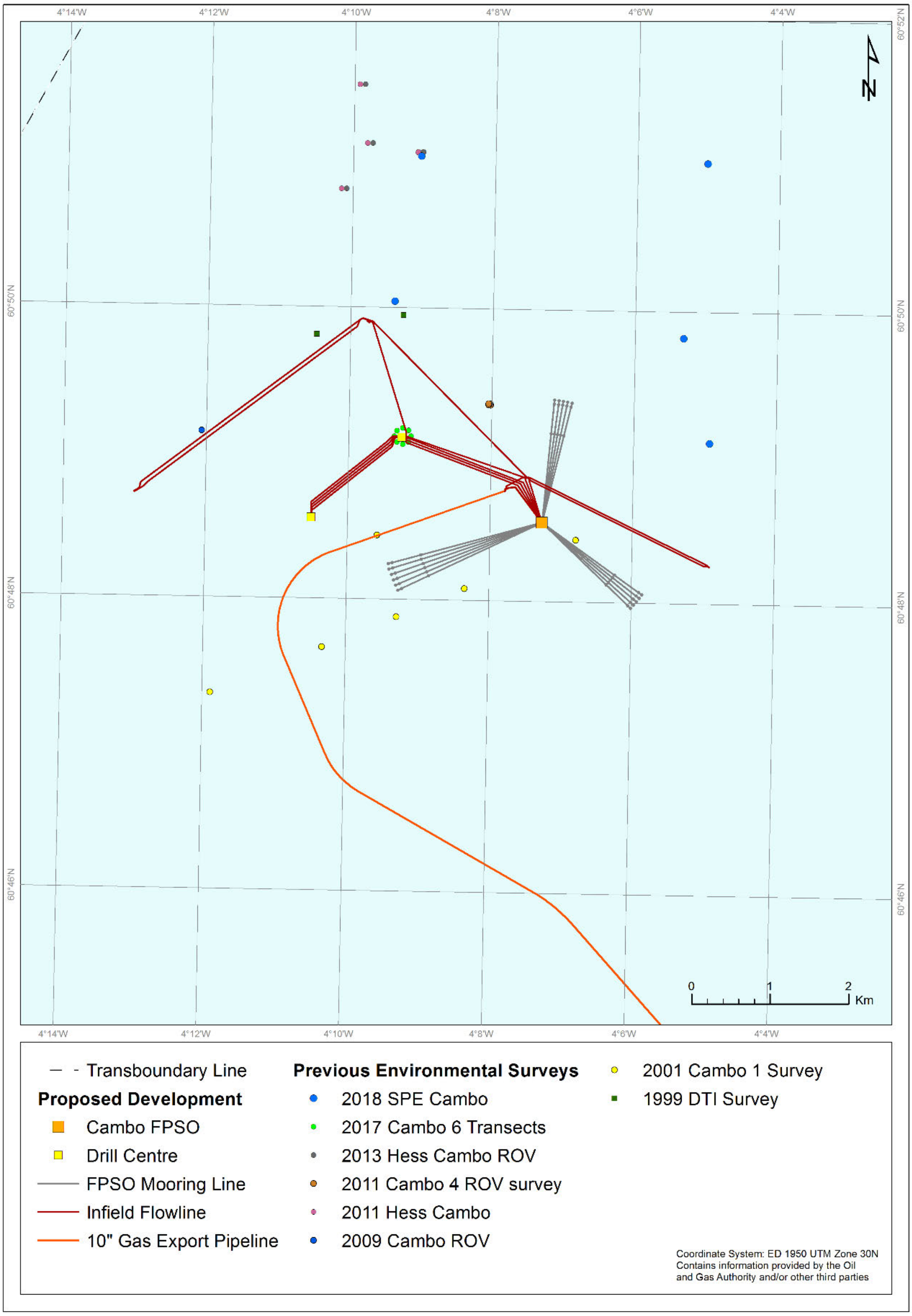

Figure 4.3: Previous Environmental Survey Locations Relevant to the Proposed Development Footprint

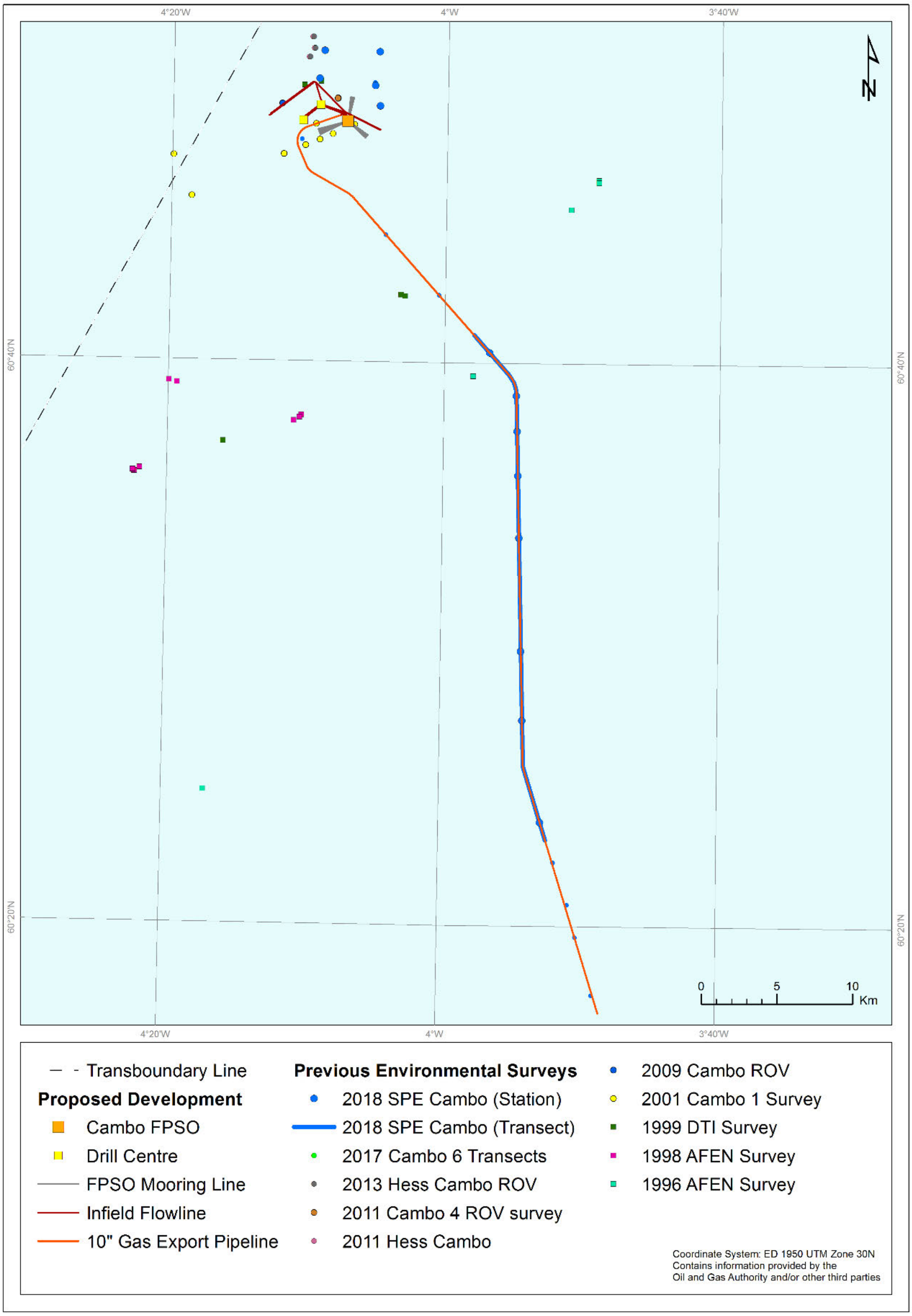

Figure 4.4: Previous Environmental Survey Locations Relevant to the Proposed Development

Table 4.1: Summary of Survey Information

Survey Commissioned By	Year	Name	Quadrant/Block/Licence Area	Survey Details
AFEN	1996	-	204	Broadscale regional survey that characterised the seabed habitats and communities in the region. Utilised analogue survey techniques and ground-truthed via digital stills, video systems and grab sampling.
AFEN	1998	-		Broadscale regional survey that characterised the seabed habitats and communities in the region. Utilised analogue survey techniques and ground-truthed via digital stills, video systems and grab sampling
DTI	1999	-	204	Broadscale regional survey that characterised the seabed habitats and communities in the region. Utilised analogue survey techniques and ground-truthed via digital stills, video systems and grab sampling.
HESS	2001	Cambo	204/10	Rig site and environmental survey for the original Cambo well location (well 204/10-1). Utilised analogue survey techniques and ground-truthed via digital stills and grab sampling
HESS	2009	Cambo	204/10	ROV survey of the Cambo 3 well location. Eight video transects were used to analyse the seabed and habitats around the well location. Sediment cores were also taken for chemical and biological analysis.
HESS	2011	Cambo	204/5	Environmental survey of well 205/5a-1. Data gathered included bathymetric, side scan sonar (SSS), seabed photography and geotechnical core samples.
HESS	2011	Cambo	204/10	Pre- and post-drill habitat assessment for well 204/10a-4. An ROV survey collected digital stills along four transects located southwest, southeast, northwest and northeast rom the well centre. The assessment aimed to identify any reefs or annex 1 habitats.
Chevron	2013	Cambo	204/6	Pre- and post-drill habitat assessment at Cambo 5 via ROV survey. Digital still photography and video footage was used for the assessment.
Siccar Point Energy	2017	Cambo	204/10	Habitat assessment in the vicinity of well 204/10a-5 using an ROV to capture digital stills and video footage along eight 100 m transects centred on the proposed drilling location.
Siccar Point Energy	2018	Cambo	204/4,204/5,204/9,204/10 and 204/5 to 205/21	Environmental baseline survey and habitat assessment using an ROV to capture digital stills along eight transects, with one cross transect to target the Faroe-Shetland Sponge Belt MPA. Thirteen grab sampling locations were used for sediment sampling. Geophysical data acquired was used to identify areas of interest along the pipeline route.

4.2 Physical Environment

4.2.1 Hydrography

The proposed Cambo Field Development is located in the Faroe-Shetland Channel, a deepwater channel in the north-east Atlantic which runs between the Faroe and the Shetland Islands (Figure 4.5). The ocean current regime in the Faroe-Shetland Channel is complex due to the bathymetry of the area, the interaction of a number of different water masses, and seasonal variability in water flows. On a broad scale, cold dense bottom water from the Arctic Basin flows southwest along the channel floor, whilst warmer, Atlantic water flows over the top of it to the northeast (Metoc, 2002). In total, five distinct water masses are present in the channel, each of which may be described in relation to their geographical position and vertical distribution in the water column (Figure 4.5).

The proposed Cambo Field Development Footprint is situated at water depths of between 1,050 m in the southeast to 1,100 m in the northwest within the Faroe-Shetland Channel, with the Gas Export Pipeline route situated at water depths of 1,085 m to 190 m (Figure 4.1).

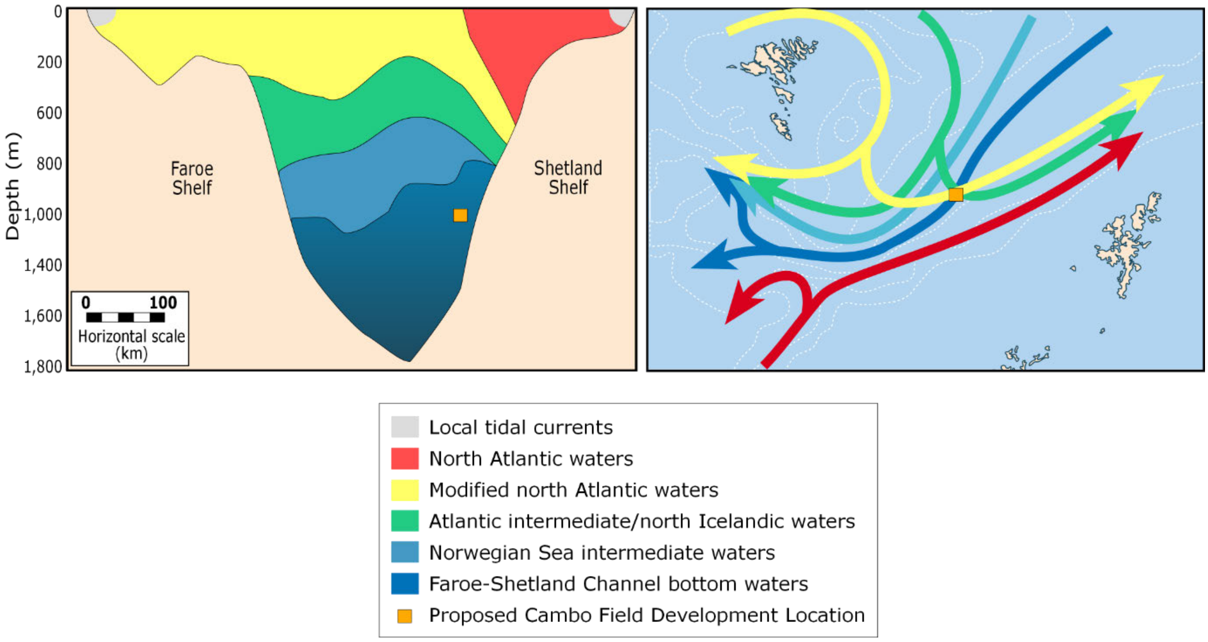

Figure 4.5: Water Masses and Ocean Current Circulation in the Faroe-Shetland Channel
Sources: Fiskirannsóknarstovan, 1995; GEM, 2001.

Two slow moving deepwater masses originate from Arctic waters and travel southward through the Faroe-Shetland channel towards the Wyville-Thomson Ridge. The Faroe-Shetland Channel bottom waters occur below 800 m on the Faroe shelf side and below 600 m on the Shetland shelf side of the channel, flowing to the southwest along the channel floor. The Norwegian Sea Intermediate Waters occur just above these, at depths of around 600 m to 800 m. This water layer becomes shallower towards the Scottish slope and is often absent from this side of the channel (DECC, 2016). The net flow of the Norwegian Sea Intermediate Waters in the channel is also to the southwest (Turrell et al, 1999).

The Atlantic intermediate/north Icelandic waters occur from approximately 400 m to 600 m depth. These waters enter the Faroe-Shetland Channel from the north and split to form two flows, with one moving northeast and one southwest along the channel (Turrell et al, 1999). In the region of the proposed development, these waters flow in a northeasterly direction (Figure 4.5).

Two bodies of water from the North Atlantic form the dominant surface currents in the region of the proposed development. These surface waters are limited to a depth of around 400 m. North Atlantic waters originate from the south and enter the Faroe-Shetland Channel over the Wyville-Thomson Ridge. These surface waters flow to the northeast through the channel, confined to the eastern (Scottish) slope (Debes, 2000; DECC, 2016). Modified North Atlantic waters flow to the north around the Faroe Islands, splitting into two currents, one flowing to the west and one to the northeast along the Faroese side of the Channel. The surface currents originate from more southerly, Atlantic waters and so are relatively warm.

Net flow of surface waters in the Faroe-Shetland Channel is to the northeast. Currents are strongest along the upper continental slope, where they average around 0. 3 m/s. The mean velocity of the shelf edge current is approximately 0. 4 m/s towards the northeast, and in the lower water mass 0. 15 m/s towards the southwest (Saunders, 1990). Measured near-bottom current velocities indicate peak currents over 0.75 m/s on the upper continental slope to the West of Shetland (DECC, 2016).

The depths at which different water bodies occur are variable and are influenced by seasonal, yearly and decadal fluctuations in temperature and salinity (Turrell et al, 1999). Eddies frequently develop in the surface waters of the channel. These may be warmer or colder than the surrounding water, and tend to last for several days (Metoc, 2002). Internal waves can form at the interface between layers and may result in seabed surges and incursions of cold water to shallower regions (Metoc, 2002).

Analysis of wave height and direction for the area around the proposed Cambo Field Development indicates that waves most frequently originate from the west and southwest (Figure 4.6).

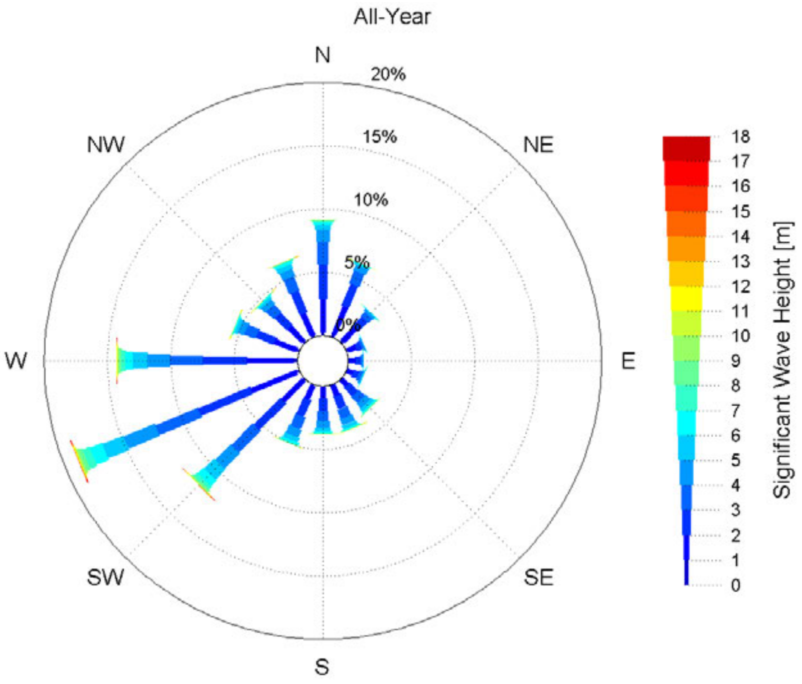

Figure 4.6: Percentage Occurrence of Total Significant Wave Height and Mean Wave Direction at the Proposed Cambo Field Development Annually

Source: Fugro, 2018.

These wave directions are consistent with findings outlined in PhyseE (2018). Mean significant wave heights were found to be between 1 and 4 m. Higher waves occur more frequently during the winter months, with occasional wave heights reaching over 17 m (Fugro, 2018). The 100-year maximum significant wave height at the proposed development area was found to be between 32.3 (PhysE, 2018) and 33 m (Fugro, 2018).

A permanent thermocline is present in the Faroe-Shetland channel. The thermocline occurs at the boundary between the cold Arctic bottom waters, and the warmer North Atlantic waters which flow over them at a depth of around 400 m to 600 m (Debes, 2000; SERPENT, 2009). Temperatures in the cold, dense bottom currents are typically below 0°C and can be as low as -1.5°C (Larsen et al, 2016). The temperature then quickly rises at the level of the thermocline, so that intermediate waters fluctuate within the range 3.0 to 4.5°C (Heath and Jónasdóttir, 1999). Sea surface temperatures in the Faroe-Shetland Channel vary seasonally from a minimum of 5.5°C to a maximum of 11.4°C (Larsen et al, 2016). A shallower thermocline may also develop in the surface waters during the spring and summer to depths of between 20 m and 50 m, depending on wind conditions (Debes, 2000).

Both surface waters, the North Atlantic Water and Modified North Atlantic Water, are the most saline water layers in the Faroe-Shetland Channel, transferring salt from the Atlantic through the channel to the Nordic seas (Berx, 2012). Salinity decreases with increasing water depth and density.

Mean surface salinities in the area around the proposed development location were found to be 35.30% in the winter and 35.20% during the summer months (BODC, 1998). Mean bottom salinities in the area were found to be 35.10% in the winter and 35.25% during the summer (BODC, 1998). Recent studies have found that temperature and salinity of the surface waters of the Faroe–Shetland Channel have generally increased over the past two decades (Larsen et al., 2016). In the deep layers of the Faroe-Shetland Channel (800 m) temperatures have shown an increase since 2000, with salinities showing a slow decline, which has now thought to have stabilised (Larsen et al., 2016).

4.2.2 Meteorology

The proposed development region has a generally mild, maritime climate resulting from prevailing south-westerly winds and the warming influence of the Atlantic Continental Slope current (DTI, 2003). The area around the proposed development experiences frequent low cloud with periods of extensive rain and drizzle. The presence of sea fog is more common in the summer, with gales occurring during the winter months (DTI, 2003).

Figure 4.7 represents the seasonal wind regime for the area around the proposed Cambo Field Development. Offshore winds may blow from any direction. However, analysis of the windroses indicates that the winds are most frequently from the southwest and are least likely to originate in the east. Mean wind speeds were found to be between 7 and 11 m/s. Stronger winds occur more frequently during the autumn and winter months, with wind speeds occasionally reaching over 34 m/s (Fugro, 2018). The 100-year extreme wind speed at the proposed development area, represented as a 3-second gust speed at 10 m above sea level, was found to be 47.9 m/s (Fugro, 2018), but could be as much as 56.3 m/s (PhysE, 2018).

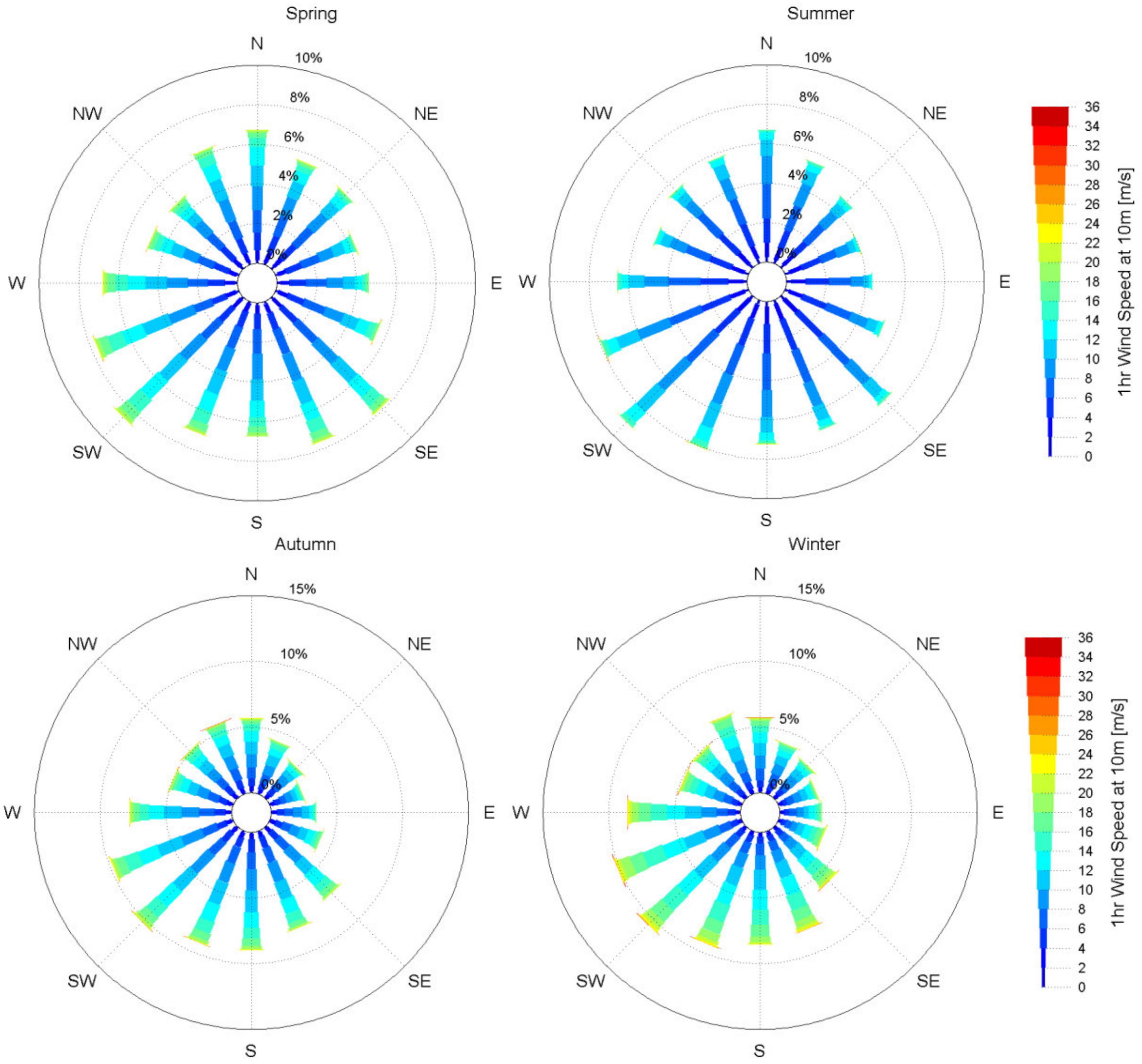

Figure 4.7: Windroses for the Area Around the Proposed Cambo Field Development
Source: Fugro, 2018.

4.2.3 Bathymetry

The Faroe-Shetland Channel is a deep topographical feature, which is bordered to the southeast by the West Shetland Continental Shelf, to the northwest by the Faroe Shelf and to the southwest by the Wyville Thompson Ridge. The bathymetry within the proposed Development Footprint varies from approximately 1,050 m in the southeast to over 1,100 m in the northwest within the Faroe-Shetland Channel. Water depth along the proposed pipeline route varies between 1,050 m to 190 m (Figure 4.8). The seabed slope gradient across the proposed Development Footprint is generally less than 2° in the southeast and less than 1° across the rest of the area. Isolated gradients of up to 5° are present in the central and southeasterly regions, which are associated with debris fan deposits.

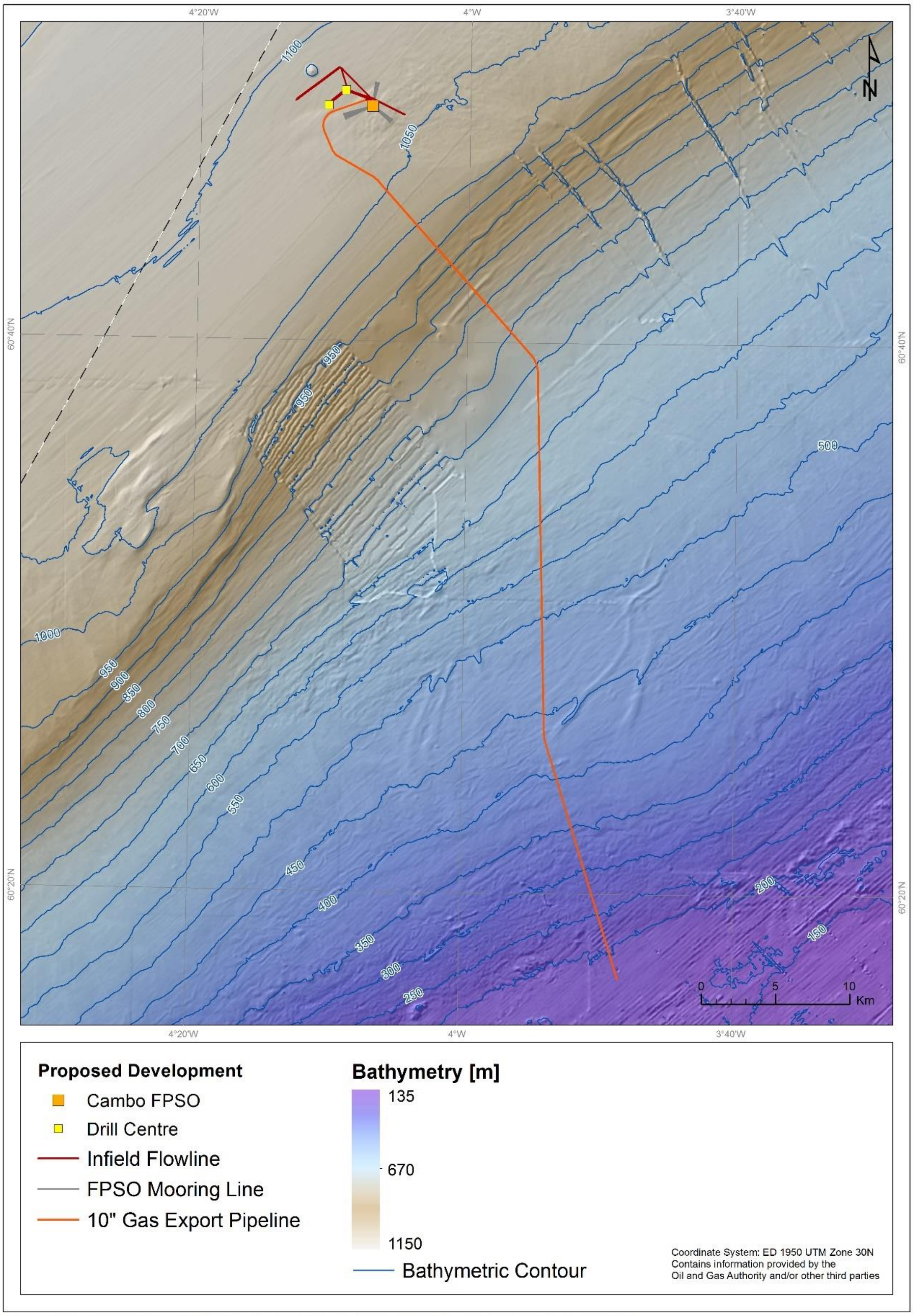

Figure 4.8: Bathymetry Within the Cambo Field Development

4.2.4 Seabed Features

Iceberg plough marks are a common feature along the edge of the West Shetland Continental Shelf. These generally consist of raised ridges separated by a central depression, resulting from the grounding of floating icebergs during the last glacial period (Masson, 2001). Typical plough marks can be several tens to a few hundred metres in width, with coarse gravel substrate in the ridges and finer grained material in the depressions. The Faroe-Shetland Sponge Belt NCMPA, located 12 km from the proposed Development Footprint and transited by the proposed Pipeline route, was designated amongst other features, for the presence of iceberg plough marks (JNCC, 2020a). Debris fans are present at the base of the continental slope. These are also relicts from the last glacial period and one has been found radiating across the Faroe-Shetland Channel towards the Cambo field. The distal end of this debris fan was present across the central, east and southeast of the Development Footprint. The Pipeline route heads west before bearing west-southwest and south to avoid the distal end of the debris fan deposit. The seabed elsewhere across the Faroe-Shetland Channel area is relatively smooth and featureless. Figure 4.9 shows the location of these features in the wider Cambo area.

Numerous other glacial features, such as drop-stones and scouring, are found throughout the wider area. Seabed depressions and sediment mounds are also prevalent and are thought to have formed due to the action of strong bottom currents known to exist in the area. This is supported by data from previous environmental surveys around UKCS Quadrant 204 (Fugro, 2011a; Fugro, 2011b; Lloyd’s Register, 2018a).

4.2.5 Seabed Sediments

The distribution of seabed sediments across the wider region of the proposed Cambo Field Development is presented in Figure 4.10.

The sediments in the region were shaped during the last glacial period, during which there were high sediment deposition rates, in contrast to the low sediment input and deposition rates that feature today. Seabed sediments show a general decrease in grain size with increasing water depth, from mixed sand and gravel in the upper continental slope to mud in the deeper basins of the Faroe-Shetland Channel (Masson et al., 2003).

Regional survey work conducted to the West of Shetland observed that the superficial seabed sediments of the continental slope were mostly sands with some gravel and mud, and typically form a layer of 5 to more than 20 cm thickness. The proportion of fine sediment grains (mud) generally increases with water depth; sediments in the deepest areas, below approximately 800 m, contain a significant mud fraction, and muddy sands and pebbly muddy sands dominate (AFEN, 2000). As the Faroe-Shetland Channel narrows towards the southwest, the seafloor may be characterised as gravelly sand with cobbles and boulders, indicative of an increased current flow regime and near-seafloor base rocks (Bett, 2000). The outer continental shelf consists of gravel overlain by mobile sand bedforms and iceberg plough marks (Masson et al., 2003). Figure 4.10 shows that the seabed sediments of the proposed Development Footprint comprise slightly gravelly sandy mud, with the Cambo Gas Export Pipeline Route traversing slight gravelly muddy sand, gravelly muddy sand, gravelly sand, muddy sandy gravel and sandy gravel on route to the WOSPS PLEM (Marine Scotland, 2021).

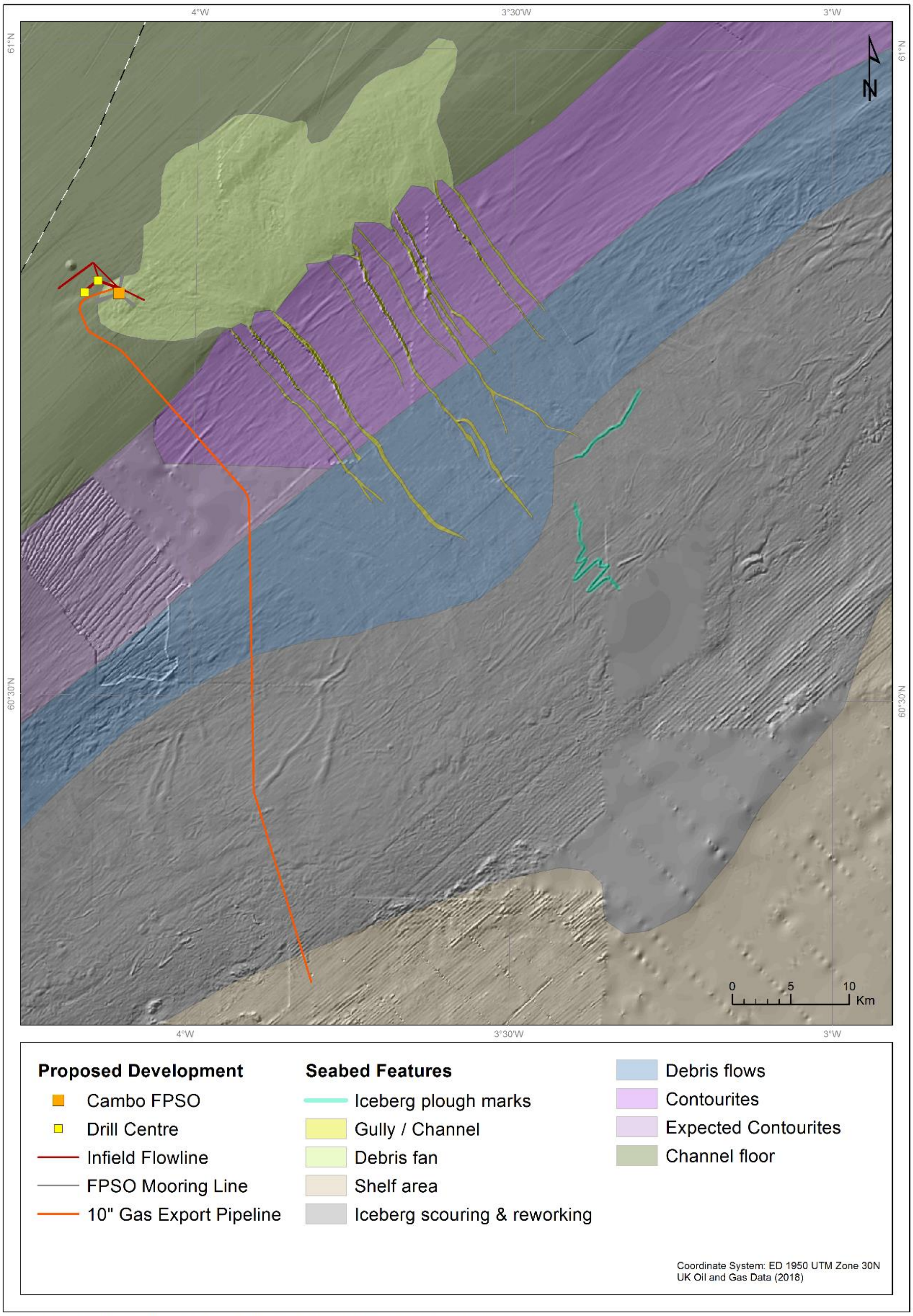

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Figure 4.9: Seabed Features

Source: Lloyd's Register, 2018a.

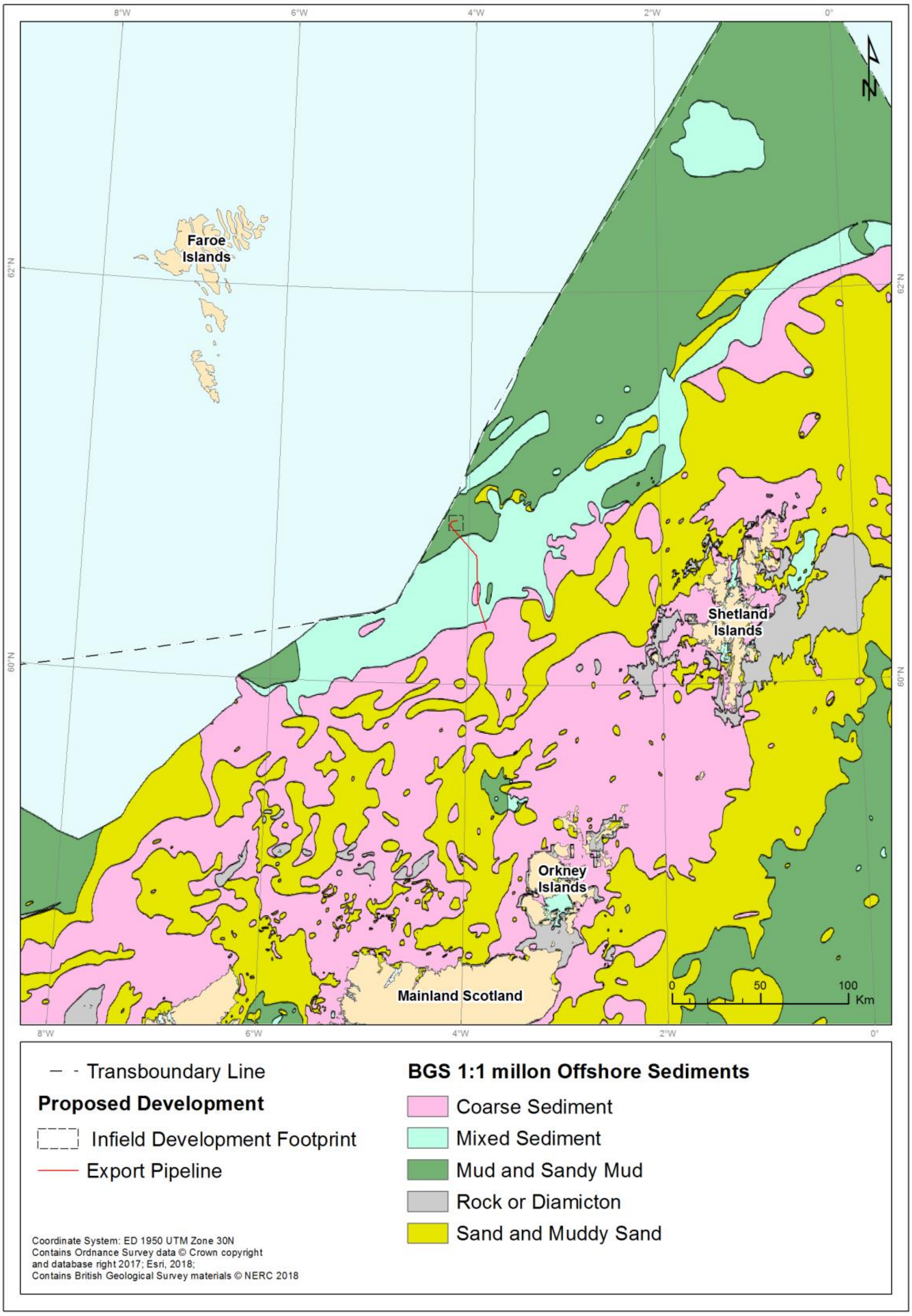

Figure 4.10: Seabed Sediments

Sources: BGS NERC, 2018; Marine Scotland, 2021.

Site surveys carried out for previous wells in the Cambo field have produced an extensive baseline of environmental information in the immediate area (see Table 4.1).

The most recent survey to have been undertaken (MMT, 2019) classified three EUNIS deep-sea habitats within and around the proposed FPSO site. These included deep-sea muddy sand and deep-sea mixed substrata together with patches of boulders on the deep-sea bed which constituted potential low graded stony reefs in places. The distribution of the three characterising seabed habitats within and around the proposed FPSO site are presented in Figure 4.11.

To the south of the proposed FPSO site and along northern sections of the proposed Cambo Gas Export Pipeline route, deep-sea mixed substrata and deep-sea muddy sand sediments continued to dominate the seabed and slope areas to a point approximately equivalent to the northern boundary of the Faroe-Shetland Sponge Belt NCMPA (Figure 4.12).

Within the boundary of the NCMPA, the dominant sediment types along the proposed pipeline route are deep-sea muddy sand and deep-sea sand (Figure 4.13). These sediment types are associated with important habitats including the Scottish Priority Marine Feature (PMF) habitat ‘burrowed mud’, which comprises the OSPAR habitat ‘sea-pens and burrowing megafauna’. A short section of potential Annex I (EC Habitats Directive) stony reef habitat was also identified along the proposed pipeline route albeit classified as low grade (MMT, 2019 and Fugro, 2020).

The central section of the proposed the pipeline route within the Faroe-Shetland Sponge Belt NCMPA coincides with deep-sea mixed substrata with patches of the deep-sea sand together with deep circalittoral coarse sediment (Figure 4.14). The latter sediment type was noted to be representative of the Scottish PMF habitat ‘offshore sands and gravels’ (MMT, 2019).

Deep circalittoral coarse sediment (representative of ‘offshore sands and gravels’ PMF) continues to be the dominant sediment type along the proposed pipeline route as it exits the NCMPA and to the point at which is connects to the WOSP. A patch of coarser sediment material, including boulders and cobbles and classified as boulders on the deep seabed, is present along this section of the proposed pipeline route and may be an artefact of an iceberg plough mark (MMT, 2019) (Figure 4.15).

These findings are in line with the previous survey findings in the area that also recorded the presence of soft sediments with varying proportions of cobbles, boulders and gravel (Fugro, 2018; Fugro, 2011; Fugro, 2011b; SERPENT, 2009; Gardline, 2001).

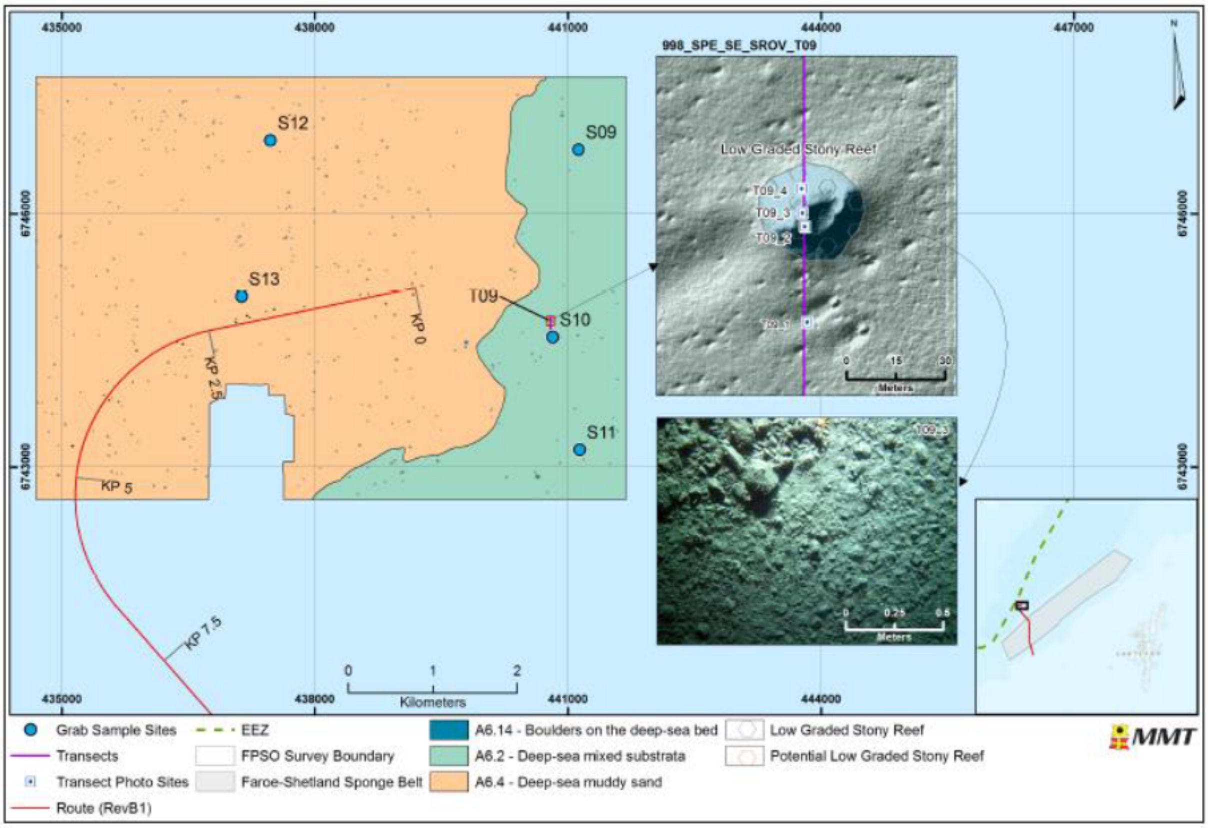

Figure 4.11: Distribution of EUNIS Classified Habitats Within the FPSO Site Survey Area

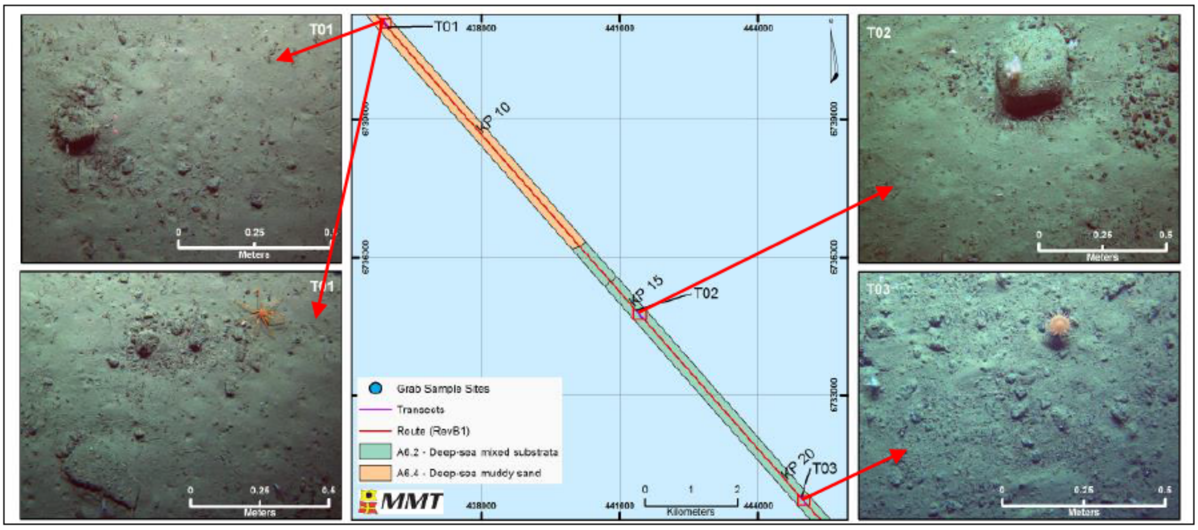

Figure 4.12: EUNIS Classified Habitats, Transects and Images from the Northern Part of the Export Route

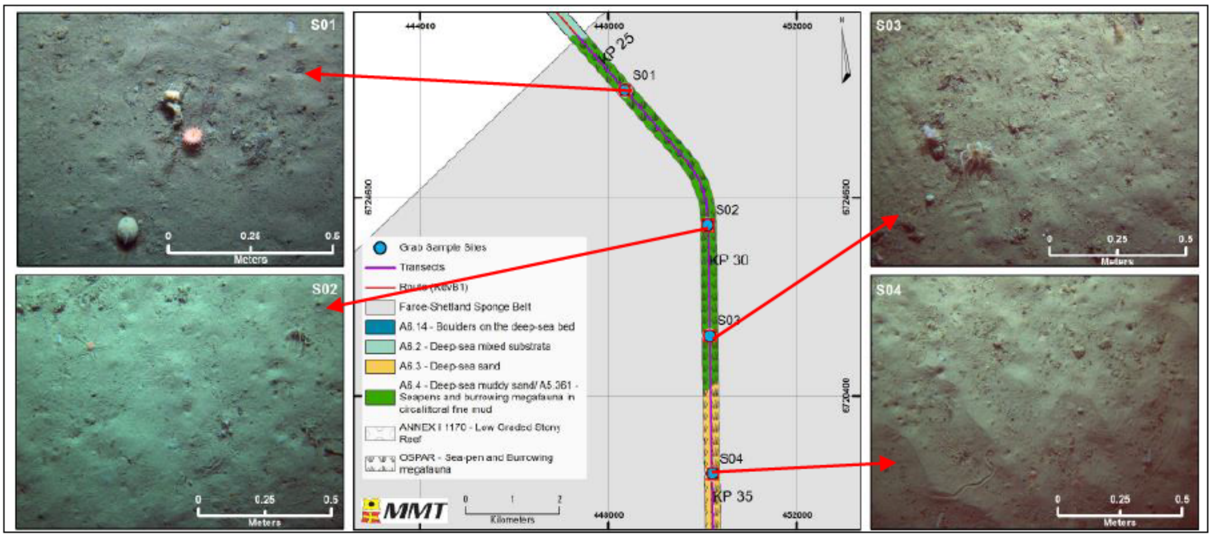

Figure 4.13: EUNIS Classified Habitats, Transects and Images from the Northern and Central Part of the Export Route

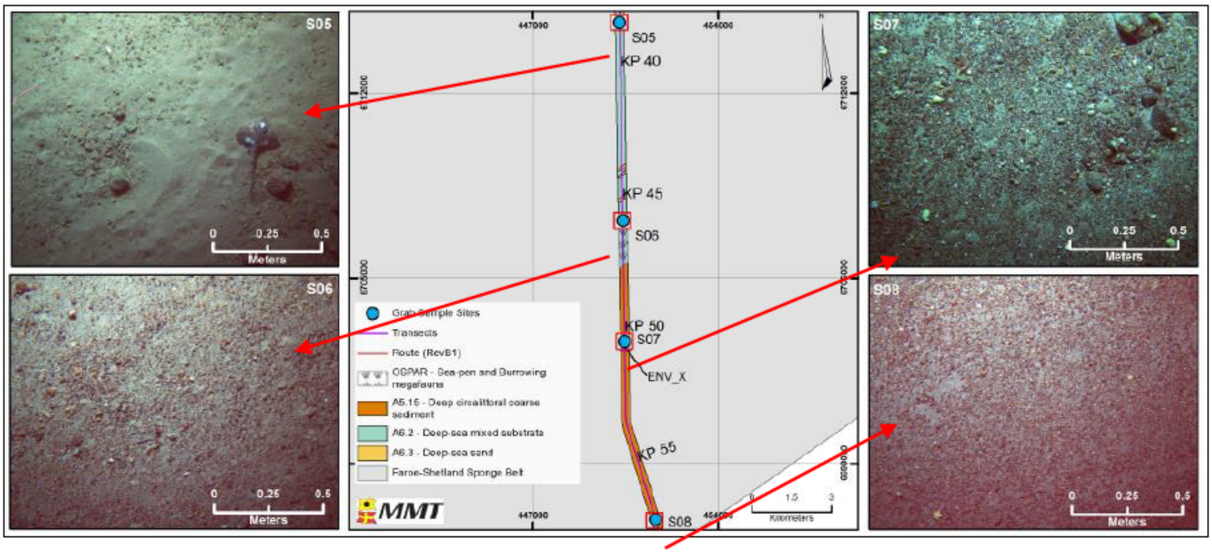

Figure 4.14: EUNIS Classified Habitats, Transects and Images from the Central Part of the Export Route

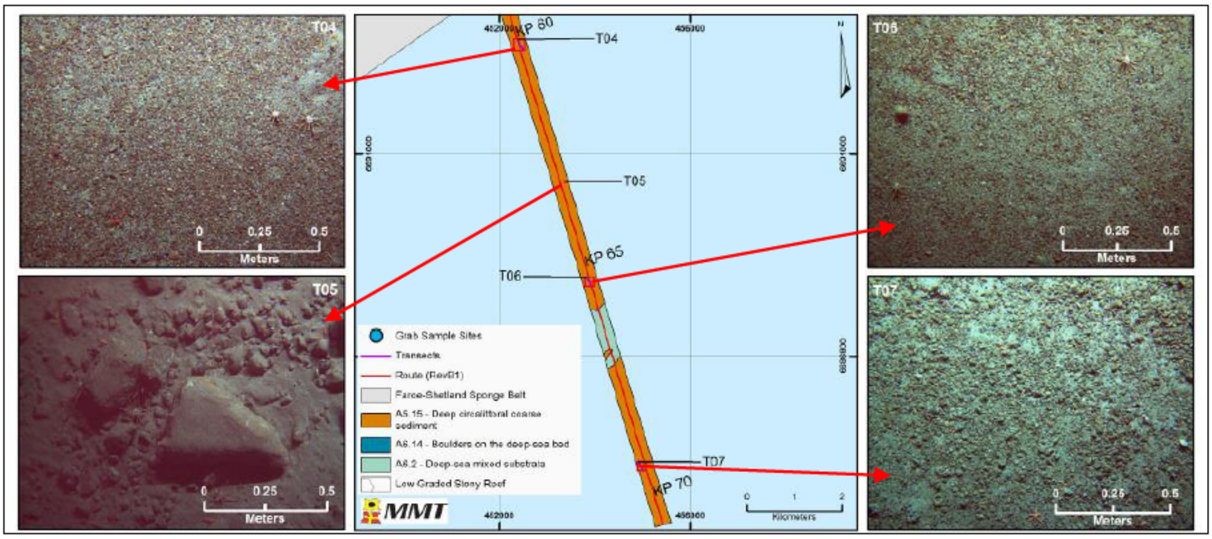

Figure 4.15: EUNIS Classified Habitats, Transects and Images from the Southern Part of the Export Route

Sediment Chemistry

Sediment chemistry data for the proposed site and local surrounds are presented in Table 4.2.

Table 4.2: Sediment Chemistry

Survey	Level	THC	Ba	TBa	Cd	Cr	Cu	Pb	Zn
Cambo UKCS 204/10 (Gardline, 2001)	Maximum	3.5	291	315	<1	72	25	93	57
	Minimum	1.6	245	262	<1	41	12	9	32
	Mean	2.49	284	288	0	51	17	20	43
Site Specific Survey (MMT, 2019)	Maximum	7.51	402	-	0.2	42.4	17.3	10.2	42.7
	Minimum	1.97	272	-	0	22.5	8	6.7	21.3
	Mean	3.85	327.9	-	0.1	33.9	11.9	8.2	30.8
CEFAS Action Levels (AL)	AL 1	-	-	-	0.4	40	40	50	130
	AL 2	-	-	-	5	400	400	500	800
AFEN 1996	-	0.5-11.2	84-546	-	BD[1]	11-71	4-35.5	2-39.3	11-88
AFEN 1998	-	1.0-6.5	188-824	-	BD[1]	21-86	5-37	3-14	22-68
SEA4 (DTI, 2003)	-	0.8-11	208-349	-	BD[1]	10-35	2-39	3-20	15-76

🟦	> CEFAS Action level 1	■	> CEFAS Action Level 2	🟨	> UKOOA (2001) Mean	🟩	> UKOOA (2001) 95th Percentile

[1] BD = Below Detecting limit

Previous sampling surveys in the area recorded generally low levels of sediment contamination with mean concentrations of chemicals generally synonymous with background concentrations for this region of the Northeast Atlantic. Copper (Cu) and Zinc (Zn) were at levels above the UKOOA 95th percentile while Chromium (Cr) and Lead (Pb) levels exceeded CEFAS Action I guidelines. The level of total petroleum hydrocarbons (TPH) and polyaromatic hydrocarbons (PAH) however remained low and the proportion of different components generally indicated biogenic origin.

The site-specific sampling conducted recently across the proposed FPSO site and throughout the proposed gas export pipeline (MMT, 2019) recorded sediment metal concentrations at lower levels compared to those recorded in 2001 (Gardline, 2001). Values were either consistent with the ranges measured during surveys of the wider west of Shetland region or close to background concentrations in the OSPAR Northeast Atlantic region where these were available (Table 4.2).

4.3 Biological Environment

4.3.1 Benthos

Benthos is the term used for animals and plants associated with the seabed, although plants are generally limited by their light requirement to depths of less than 50 m. Benthos consists mainly of animals that burrow into the sediment or form tubes in it (known as infauna). Other species which live on the seabed, or attached to rocks or to other biota, are known as epifauna. In general, the main influences on benthic communities are water depth and sediment type although other factors such as sediment stability and temperature, as well as human influences, such as demersal fishing, also play important roles in determining species community distribution and composition.

For the infauna, large numbers of Annelida (segmented worms) were found with Arthropoda having the greatest diversity. The polychaete (bristle worm) *Paramphinome jeffreysii* dominated the samples followed by lower numbers of the sipunculid worm (unsegmented marine worm) *Nephasoma* sp. This survey also identified a variety of epifauna communities at the sampling stations. Large numbers of brittle stars Ophiuroidea, were recorded along with club sponges *Chondrocladia* sp., burrowing anemones Ceriantharia, flesh eating poriferan *Cladorhiza* sp and *Asbestopluma* sp., and tube living polychaete. A breakdown of the fauna present is displayed in Figure 4.16 and Figure 4.17.

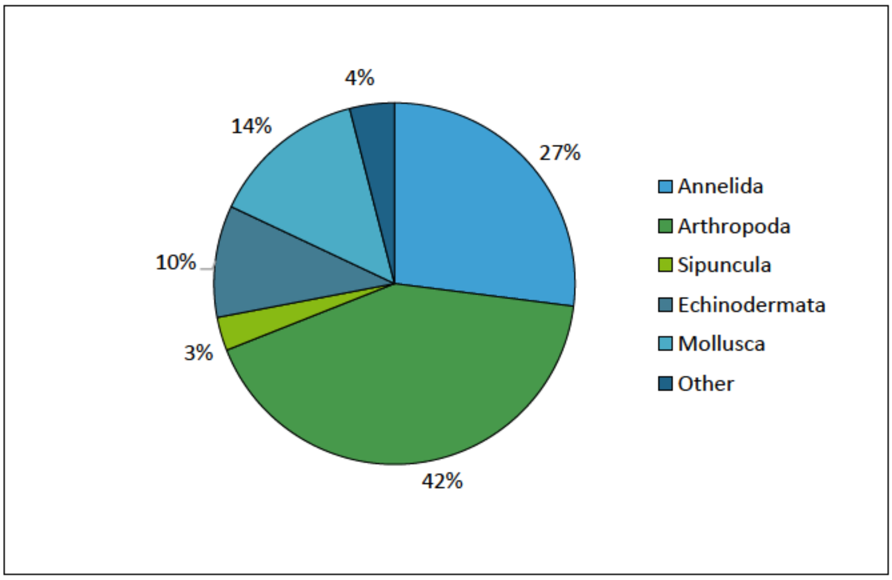

Figure 4.16: Diversity of Non-colonial Fauna in Grab Samples

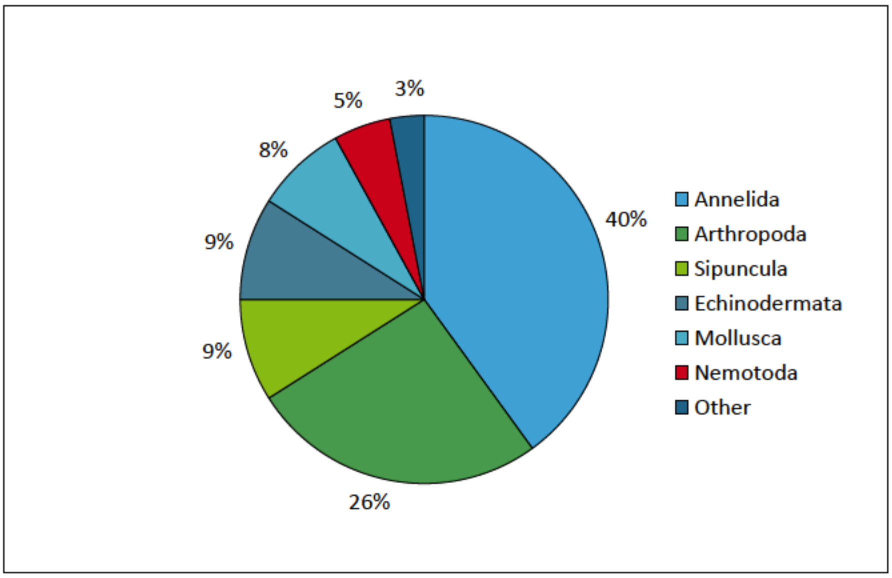

Figure 4.17: Abundance of Non-colonial Fauna in Grab Samples

Source: MMT, 2019.

The proposed Cambo FPSO site is located 12 km north of the Faroe-Shetland Sponge Belt NCMPA and will include a gas export pipeline which will traverse the site from north to south to connect with the WOSP. This NCMPA has been designated due to, amongst other features, deep-sea sponge aggregations and ocean quahog aggregations (JNCC, 2021, b and c; Section 4.5.2). Deep-sea sponge aggregations are strongly influenced by the wide depth range from the upper continental slope to the depths of the channel and associated environmental conditions. A dynamic mixing zone where warmer Atlantic waters flow over cooler Arctic waters is present, creating limits to species distribution. The continental slope plays an important role in funnelling ocean currents that bring valuable food and nutrients to the region. For example, at depths of 400 m to 600 m, the combination of seabed sediment and plentiful supply of nutrients create ideal conditions for the establishment of deep-sea sponges (DECC, 2016), however, these aggregations have been reported at depths up to 1,300 m (Bett and Rice, 1992). The ocean quahog (*Arctica islandica*) is a long-lived species which is found buried in sandy and muddy sediments ranging from the low intertidal zone down to 400 m (OSPAR, 2009; Section 4.5.2).

Deep-sea sponge aggregations and ocean quahogs have been included on the OSPAR list of threatened and/or declining species and habitats (OSPAR, 2018a), and as a Scottish PMF (NatureScot, 2021).

The 32 km seabed video tow (undertaken in 2018) along the proposed route of the Gas Export Pipeline through the Faroe-Shetland Sponge Belt NCMPA did not reveal any significant sponge assemblages. Coverage of sponges was typically recorded as <5% with some instances of coverage reaching 5% to 10% only. No deep-sea sponge aggregations (defined as sponge coverage >10%) for which the Faroe-Shetland Sponge Belt NCMPA is designated, were identified during the survey. No Boreal Ostur sponge aggregations which are characteristic of the Faroe-Shetland Channel were recorded within the study area. Figure 4.18 and Figure 4.19 present the distribution of sponges along the proposed gas export pipeline.

Current observations are consistent with those from previous environmental surveys conducted within wider area. Fugro (Fugro, 2017) reported a low abundance of benthic epifauna, including starfish, sun stars, feather stars, brittle stars, shrimp, sea spiders, whelk and faunal tubes during a

Remotely Operated Vehicle (ROV) survey in Block 204/10a. Soft corals, sea fans, sponges, sea anemones, stalked hydroid and faunal turf on areas were also recorded where hard substratum was available for attachment.

The environmental survey conducted within Block 204/5a for the Cambo 5 well described the density and diversity of epifauna seen in the seabed photographs as generally low, which concurs with the findings of regional surveys in this area (AFEN, 2000; DTI, 2000). Visible epifauna included sea spiders, starfish, burrowing anemones, burrowing hexacorals, sponges, small soft corals and bryozoans (Fugro, 2011a). Infaunal polychaete tubes were also frequently recorded (Fugro, 2011a). The ROV habitat assessment carried out for Cambo 4 supported the findings of the Cambo 5 survey with the main species recorded as burrowing anemones, *sabellid* polychaetes, sponges, soft corals and sea spiders (Fugro, 2011b). The Cambo 1 environmental survey observed similar species with the most common species being tube building polychaetes (Gardline, 2001).

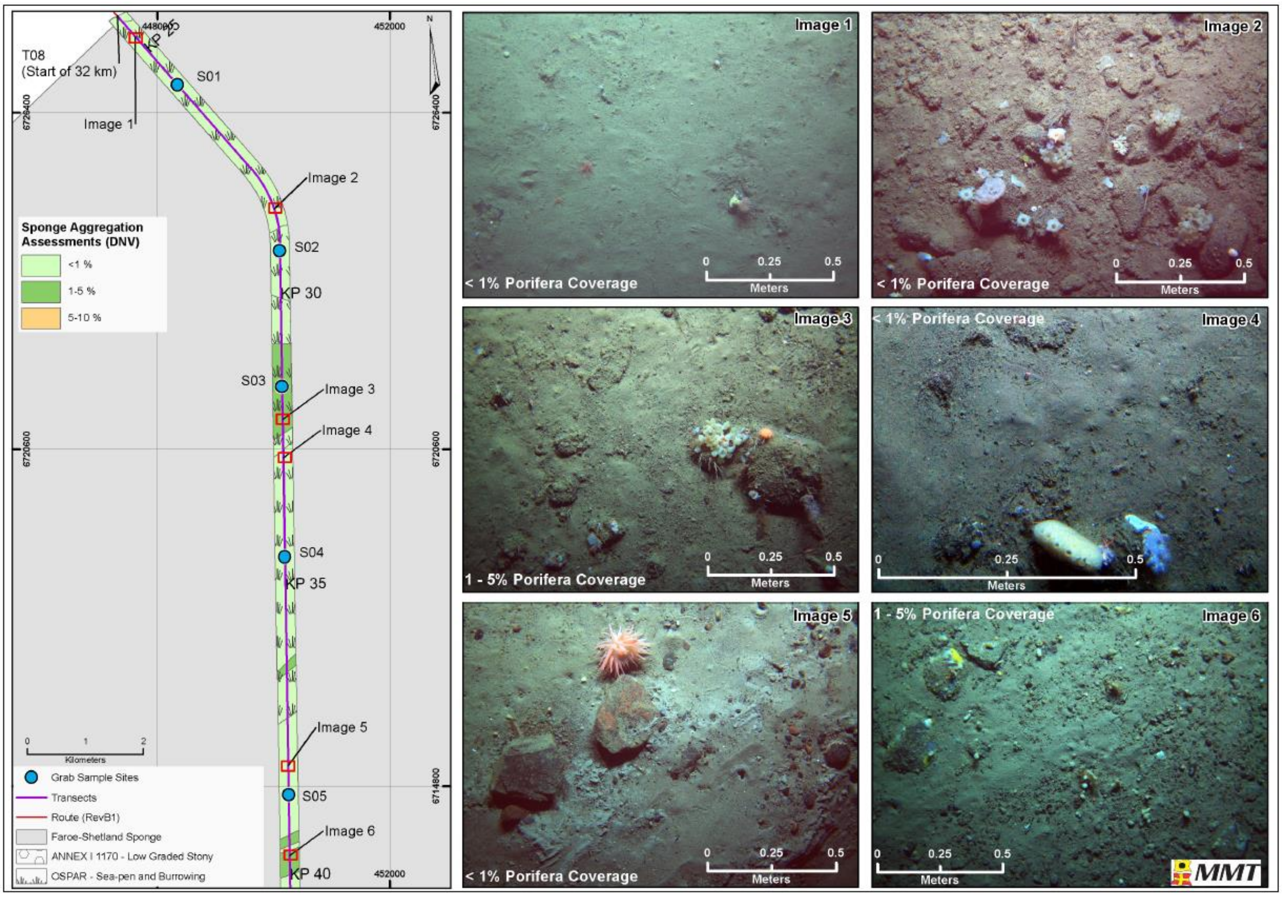

Figure 4.18: Overview of the Sponge Aggregations Along the Northern Section of the Sponge Belt (Northern Section of the Proposed Pipeline Route)

Source: MMT, 2019.

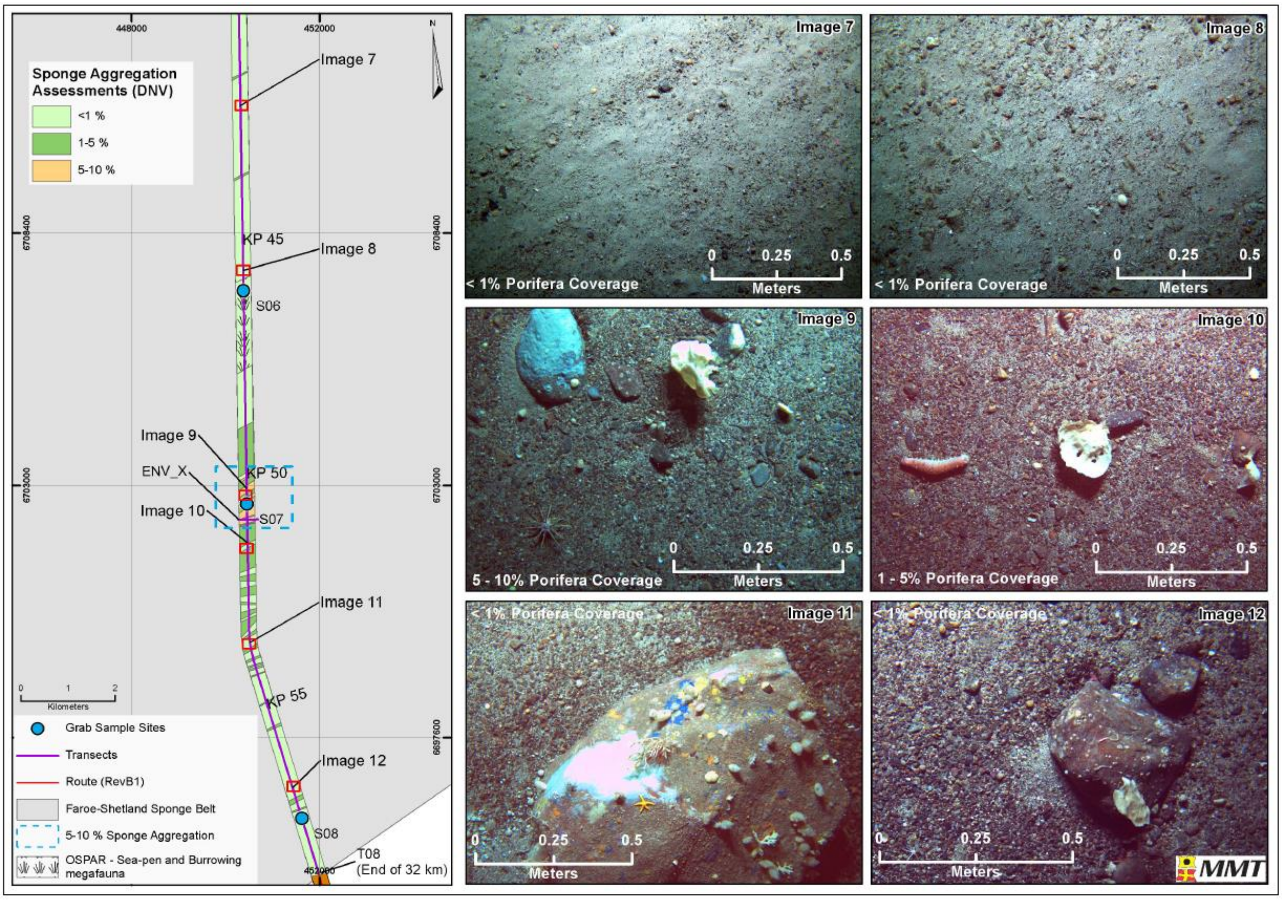

Figure 4.19: Overview of the Sponge Aggregations Along the Southern Section of the Sponge Belt (Southern Section of the Proposed Pipeline Route)

Source: MMT, 2019.

The 2017 Habitat Assessment classified the habitat throughout the survey area as the EUNIS biotope complex ‘deep circalittorial mixed sediment’ (Fugro, 2017). This biotope complex is described as highly diverse, with a high number of infaunal polychaete and bivalve species (EUNIS, 2017). Animal communities in this habitat are closely related to offshore gravels. This was again consistent with previous environmental surveys conducted within the Cambo field area.

Regional scale surveillance of the continental slope to the West of Shetland observed that the habitats and associated benthic communities varied strongly in relation to water depth, with a series of broad zones recorded (Bett, 2000). Variation in the benthos was also observed within each zone in relation to changes in sediment type. In general, macrobenthic communities were dominated by polychaete worms, with macrobenthic abundances peaking at approximately 700 m (Bett, 2000). As sediments became finer, the characterising macrobenthic species changed from suspension-feeding to deposit-feeding forms. Community diversity declined with depth beyond a peak at approximately 400 m (the depth experiencing the greatest range in water temperature) (Bett, 2003). Below 700 m, macrobenthic abundance and diversity were generally low, due to the influence of cold Arctic waters.

The upper- to mid-slope (approximately 200 m to 500 m water depth) is characterised by the presence of “iceberg ploughmarks”. Over time, these features, generally between 10 m and 200 m wide (SOC, 2000), have been partially infilled by finer sediments. This process has created a complex mosaic of seabed habitats alternating between areas of coarse (cobbles and boulders) and fine sediment (Bett, 2003). The megafauna of the finer sediment areas are generally dominated by burrowing heart urchins. Areas of boulders and cobbles can be extensive and support diverse epifaunal communities. These communities are characterised by cidarid (pencil-spined) urchins, squat lobsters and encrusting filter-feeding epifauna such as sponges, bryozoans and keel worms (AFEN, 2000). Deep sea sponge aggregations can be found in this region, mainly on the shelf break near the Faroe Islands and on the slope of the banks on the Faroe-Shetland Channel between 400 and 600 m depth, but becoming dominant at 450 m (known as the Faroe-Shetland Sponge Belt). These sponge aggregations typically occur in water temperatures greater than 5°C, although the Faroe-Shetland Sponge Belt may represent an extreme form of this habitat, being exposed to occasional subzero temperatures (OSPAR, 2010).

At depths of approximately 900 m, near the bottom of the slope, SSS surveys recorded a zone of low reflectivity corresponding to the presence of sandy “contourite” deposits. Contourites are sedimentary deposits produced by deepwater currents near the bottom of continental slopes. The contourite area at the base of the West Shetland Continental Shelf slope supported an abundance of surface-dwelling acorn worms (Bett, 2000). Acorn worms are deposit or suspension feeding species which typically adopt a burrowing lifestyle. Sea pens and sea spiders were also common in this zone.

4.3.2 Plankton

Plankton consists of microscopic plants (phytoplankton) and animals (zooplankton), including the larval stages of fish and many bottom living animals which drift with the ocean currents. The abundance of plankton is strongly influenced by factors such as water depth, tidal mixing and temperature stratification which determine the vertical stability of the water column; whilst the distribution of species is affected by salinity, temperature, water flow and the presence of local benthic communities.

During spring, an increase in day length and temperature, coupled with the supply of nutrients released during winter mixing of the water column, results in the rapid growth of the phytoplankton population. This phytoplankton bloom is followed by a similarly rapid increase in the zooplankton population, which prey upon phytoplankton. In the Northeast Atlantic, this plankton bloom tends to occur around May (Debes, 2000). Phytoplankton levels drop as the nutrients in the surface waters become depleted and as a result of zooplankton grazing. A secondary phytoplankton bloom occurs in autumn but is less pronounced in the open waters West of Shetland than in the North Sea (ERT, 2000). Diatoms of the genera *Chaetoceros* and *Thalassiosira*, and dinoflagellates of the genus *Ceratium* are the dominant phytoplankton forms in this region of the Northeast Atlantic. *Thalassiosira* species are more abundant in the West of Shetland area than in the North Sea (Johns and Wooton, 2003).

The zooplankton in the Faroe-Shetland Channel exhibit seasonal and geographical variation in abundance and distribution, to which the over-wintering of animals and food availability are closely linked. Zooplankton distribution is also strongly influenced by the complex hydrodynamic current system present in the area. These currents transport high abundances of copepods (notably *Calanus finmarchicus* and *Calanus helgolandicus*) into the area from the Norwegian Sea and the Faroe Shelf (Johns and Wootton, 2003). Currents in the area also produce large upwellings, leading to increased numbers of krill, upon which many fish, seabird and cetacean species feed, and provide migratory routes and nursery areas for planktonic juvenile fish. Krill abundance in the area is steadily decreasing over time (Johns and Wootton, 2003). The zooplankton in this area also includes the larval stages of fish and benthic invertebrates (meroplankton). Soft bodied zooplankton such as salps may also be abundant, particularly after phytoplankton blooms (Johns and Wootton, 2003).

4.3.3 Fish and Shellfish

Fish Distribution

There is comparatively little published information on the biology and distribution of fish populations in the Faroe-Shetland Channel. Much of the data available on the distribution and abundance of fish species in the area comes from commercial fisheries catches and, as such, most of the information presented here is concentrated on commercially significant species. The Faroe-Shetland Channel to the West of Shetland supports a deepwater fishery for species such as blue ling, round-nose grenadier, orange roughy, black-scabbard fish and a number of deepwater sharks (Barreto et al, 2017).

Data gathered from commercial fish catches and routine fish surveys in the area suggest that there is a vertical zonation of demersal fish communities in the Faroe-Shetland Channel (Figure 4.20). This zonation is maintained by a number of environmental influences, particularly variation in water temperature and food availability. Three broad zones have been identified in relation to temperature and water masses beyond the continental shelf on the Scottish side of the Faroe-Shetland Channel (Gordon, 2003). In simple terms, the upper slope zone extends from the shelf edge (around 200 m) to approximately 500 m and is characterised by the presence of warm Atlantic derived water. The fish community of this area includes rabbitfish (chimaeras), redfish (*Sebastes* spp.), bluemouth and blue whiting (Gordon and Swan, 1997).

Beyond 500 m in depth, water temperatures decline rapidly as warm Atlantic water meets with cold Norwegian Sea water; this region of rapid temperature change is known as the transition zone. The sharp temperature gradient supports an unusual fish assemblage dominated by cold water species such as Arctic skate, roughhead grenadier, blue ling, tusk, redfish and Greenland halibut. A number of unidentified species have also been recorded in this zone (Gordon, 2003). Fisheries landings data confirm the presence of deepwater demersal species such as redfish and Greenland halibut from the waters around the proposed Development Footprint (Scottish Government, 2017a). Dulvey et al (2008) have documented that coldwater species such as monkfish and megrim are moving into deeper waters as a result of ocean warming, which has increased numbers in waters deeper than 500 m.

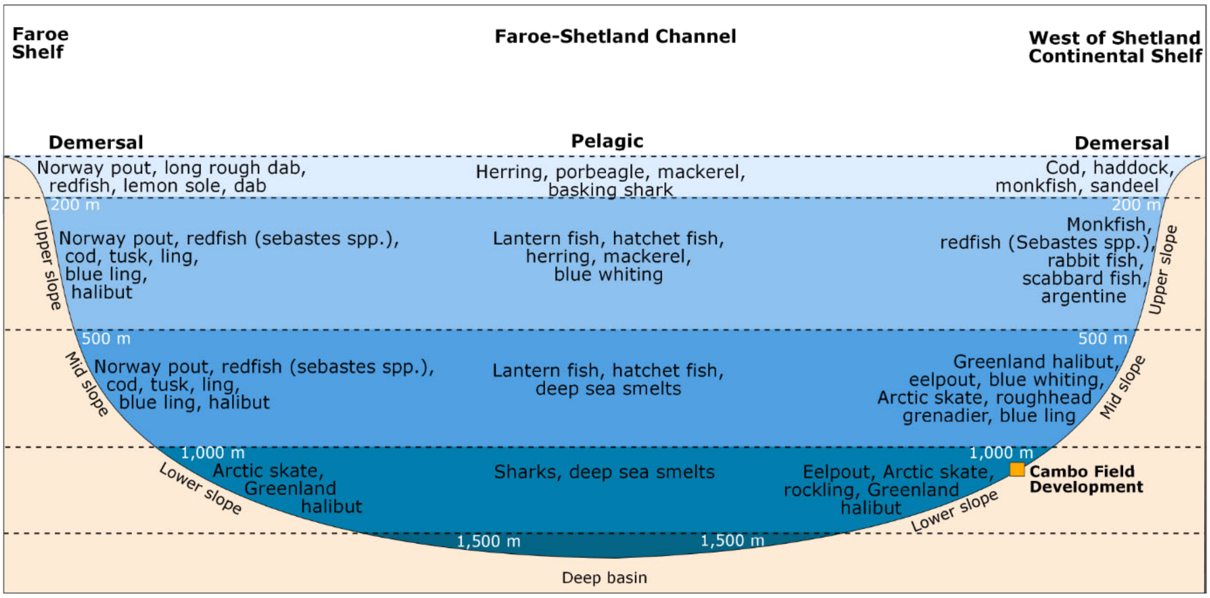

Figure 4.20: Zonation of Pelagic and Demersal Fish Assemblage in the Faroe-Shetland Channel

Sources: ERT, 2000; Gordon and Hunter, 1994; Gordon, 2003.

Below 1,000 m (the proposed Development Footprint depth is 1,050 m to 1,100 m), bottom temperatures are generally less than 0°C and the water mass present is confluent with cold Norwegian Sea water. This deep-water environment supports comparatively few demersal fish species which are commercially exploited (Gordon et al, 1994). The sparse fauna present includes Arctic skate, rockling, Greenland halibut and deepwater species of eelpout (DTI, 2003).

The distribution of pelagic fish species is similarly influenced by changes in water temperature and food supply. They are often found in large shoals, and typically undergo extensive migrations between feeding, spawning and overwintering grounds. Shoaling pelagic fish, including blue whiting and mackerel (Pinnegar, et al, 2010). Little is known about mesopelagic species, some of which can be very abundant, and it is thought that the dominant fish species to the west of the UK are the light-emitting lantern-fish and the pearlside (Pinnegar et al. 2010, DECC, 2016). The snipe-eel, dragonfish and lantern-fish have been reported in mid-water surveys, and it is thought that some of these species have extended their range around the UK. Large ocean wanderers such as the dealfish and the bony fish oarfish, have occasionally been washed up on UK coasts (Pinnegar et al. 2010).

Spawning and Nursery Grounds

Extensive survey programmes have been used to predict the broad distribution of spawning grounds for a range of commercially important fish and shellfish species in UK waters (Coull et al, 1998). For many of these species, this has been supplemented by more recent data collation and review by Centre for Environment, Fisheries and Aquaculture Science (CEFAS) (Ellis et al, 2012) and Marine Scotland (Aires et al, 2014), the latter with specific reference to the distribution of juvenile individuals. Spawning areas are not rigidly fixed, changing with the prevailing environmental conditions. Therefore, the distribution of spawning grounds given here is based on current knowledge but may be subject to change.

There are no spawning grounds which fall directly within the Development Footprint. However, predicted spawning grounds for blue whiting are found in the vicinity (Figure 4.21; Coull et al., 1998; Ellis et al., 2012). The proposed Pipeline route will pass through predicted spawning grounds for Norway pout and sandeel (Figure 4.21; Coull et al., 1998; Ellis et al., 2012). These spawning grounds are all located in slightly shallower waters depths than those present at the Development Footprint location, along the continental slopes on either side of the Faroe-Shetland Channel. However, both blue whiting and Norway pout have been known to spawn at depths similar to that found in the area of the proposed Development Footprint. The majority of species show spawning activity between November and June, although several spawn over a longer period. Peak spawning for blue whiting occurs between April and May (Ellis et al., 2012).

Most fish species release large numbers of eggs directly into the water column. Their spawning grounds cover extensive areas, leaving them less vulnerable to disturbance from point sources. However, some species, including sandeels, lay eggs directly on or within the seabed, and so are more susceptible to benthic disturbance. Sandeels deposit their eggs on sandy sediments, and once hatched the larvae will drift with the currents for several weeks, after which they settle in areas of sandy seabed. This dependence on sand means that the distribution of juvenile and adult sandeels is restricted by the patchiness of their preferred habitat, leaving the species particularly susceptible to impacts resulting from physical disturbance of the seabed. Sandeels spawn between November and February (Ellis et al., 2012).

The developing eggs, larvae and juveniles of blue whiting drift and migrate through the Faroe-Shetland Channel to the Norwegian Sea, at a depth of around 300 m to 400 m (Hatun et al, 2007). A return migration to the breeding grounds then occurs in November and December (Jákupsstovu, 1996).

These species spawn between January and May, with peak spawning activity occurring between February and May.

Norway pout spawn in the water column were the eggs and larvae are dispersed by currents. Spawning occurs between January and March mainly over the deeper parts of the northern North Sea (>100 m), with a peak in spawning occurring between March and April (IUCN, 2018).

Known spawning grounds for other commercially important species, such as halibut, Greenland halibut, ling, blue ling, tusk (or torsk), monkfish and redfish (*Sebastes* spp), which are present in the area of the proposed Development Footprint location as adults, have been recorded in the wider region. However, whether some of these also breed in the Faroe-Shetland Channel in the vicinity of the proposed development is not known. Many of these species have slow growth rates, late onset of sexual maturity and low fecundity, making them vulnerable to over-exploitation.

Monkfish are very important to the Scottish fleet with its value representing 6% of the total value of Scottish landings in 2016 (Scottish Government, 2017a). Adult monkfish make seasonal migrations to winter deepwater spawning grounds, with spawning occurring at depths of 150 m to 900 m during November to April (Hislop et al., 2001). Monkfish eggs are released in a large ribbon of jelly which float on the surface, hatching during February to April (Priede, 2018).

Studies have found that blue ling form spawning aggregations in the along the continental slope northwest of Scotland during February to June, peaking in March and May (Large et al., 2010), and that there are regional migrations to these spawning areas, nursery area are however unknown (Priede, 2018).

Halibut form seasonal spawning aggregations at depths of 700 m to 1000 m during January to April, spawning grounds have been identified to the south of the Faroe Islands. It is estimated that each female produces 0.5 to 7 million eggs (Haug and Gulliksen, 1988). Juvenile halibut live in shallower in-shore nursery grounds for the first years and gradually migrate to deeper waters (Haug, 1990).

Greenland halibut spawning occurs on the continental slope at 450 m to 1100 m depth during November to January, with females producing 200,000 to 230,000 eggs. However, studies have failed to identify spawning grounds or the evidence of nursery grounds within the proposed Cambo Field Development and the wider area (Priede, 2018).

Once spawning has taken place, fish hatch quickly from their eggs and many remain in the water column as larvae. The dispersal of fish eggs and larvae is largely dependent upon water circulation patterns. However, as the fish develop they tend to concentrate in localised nursery areas, either within the water column or on the seabed, where feeding opportunities and protection from predators are optimal. The prevailing water temperature and availability of food can alter the position of nursery grounds from year to year.

The Development Footprint is also host to a year-round high intensity nursery grounds for blue whiting. The proposed Pipeline route passes through predicted nursery grounds for blue whiting, Norway pout, herring, monkfish, hake, ling, mackerel, sandeel, spurdog, and whiting (Ellis et al., 2012; Coull et al., 1998; Figure 4.21). These nursery areas are all located in slightly shallower waters, along the continental slopes and form part of large continuous swathes of habitat over which nursery grounds are found. As stated above, Marine Scotland have published a report which provides modelled spatial representations of the predicted distribution of 0 age group fish (fish in the first year of their life) aggregations. These modelled representations are provided in Figure 4.21. Although not all species were included in the study and the results stop at the shelf edge, a review of the associated report indicates that there is a low probability of the proposed development being utilised by blue whiting, haddock, Norway pout, herring, cod, hake, monkfish and whiting (Aires et al., 2014), which is consistent with the data presented in Figure 4.21.

Information on deepwater fish spawning and nursery grounds is limited. However, as they often have a high age of maturation and the sparsity of life in the deep sea requires adult fish to aggregate at certain sites to spawn, usually around seamounts (DECC, 2016), such as the orange roughy (Priede, 2018).

Many of the fish species which have been identified within or in the vicinity of the proposed development have been designated as PMF which are considered to be of conservation importance in Scotland's seas (NatureScot, 2021). These include monkfish, blue ling, Greenland halibut, ling, blue whiting, Atlantic herring, Atlantic mackerel, Norway pout, sandeels, spurdog and whiting. Some of the species designated as PMF have been included as a significant proportion of their population occur or have a functional role in Scotland's seas, not necessarily due to whether they are under threat or in decline.

Sharks, Skates and Rays

There are a number of pelagic shark species found in the waters around the British Isles, several of which occur in the Faroe-Shetland Channel. The porbeagle occurs in the waters around Shetland and is thought to be present all year round in deepwater off the Faroe Islands (Gordon, 2003; Marine Scotland, 2021). Blue sharks are known to follow the North Atlantic Drift through the Faroe–Shetland Channel towards the Norwegian Sea (Kohler et al, 2002). Thresher sharks have also been recorded in these waters but only in low numbers (Muus and Dahlstrøm, 1985). The porbeagle, blue and thresher shark feed on pelagic herring and mackerel shoals and are regular, though not abundant, visitors to these northern latitudes during summer months (Muus and Dahlstrøm; 1985).

The basking shark is widely distributed throughout the waters of the UK west coast, including the Faroe-Shetland Channel. Basking shark sightings are most frequent between April and September (Chambers and Solandt, 2005). Basking sharks spend most of their time on the continental shelf, traveling widely between areas of high productivity, characterised by tidal fronts and fronts associated with the shelf break. This behaviour may explain variations in public sightings (Sims et al., 2005).

Data are limited, but a study of deepwater fish stocks to the West of Scotland indicates the potential presence of deepwater sharks of the family Squalidae in the Faroe-Shetland Channel (Gordon and Hunter, 1994). Despite this, the colder waters of the region support fewer deepwater demersal shark species than the warmer waters to the south of the Wyville-Thomson Ridge (Gordon and Swann, 1997; Gordon, 2003). The distribution of the leafscale gulper shark and spiny and Portuguese dogfish in Scottish waters overlaps with the Development Footprint (Marine Scotland, 2021).

The velvet bellied shark is probably the most abundant deepwater shark present along the (shallower) part of the Pipeline Route and is found in upper slope waters down to about 500 m (Gordon, 2003; Gordon and Hunter, 1994). In addition, blackmouth dogfish have been recorded in the Faroe-Shetland Channel down to 400 m (Gordon, 2003; Gordon et al, 1994). These shark species are of no commercial value.

The Arctic skate is one of the most abundant fish species in the deepwaters of the Faroe-Shetland Channel; it is found from about 600 m down to depths less than 1,500 m. This species forms a portion of discarded by-catch from the deep-sea fishery (Fowler et al, 2004). The sandy ray occurs at depths from 70 m to 275 m, within the depth range of the end of the Pipeline Route, within the northwest of Scotland (Scottish Government, 2018).

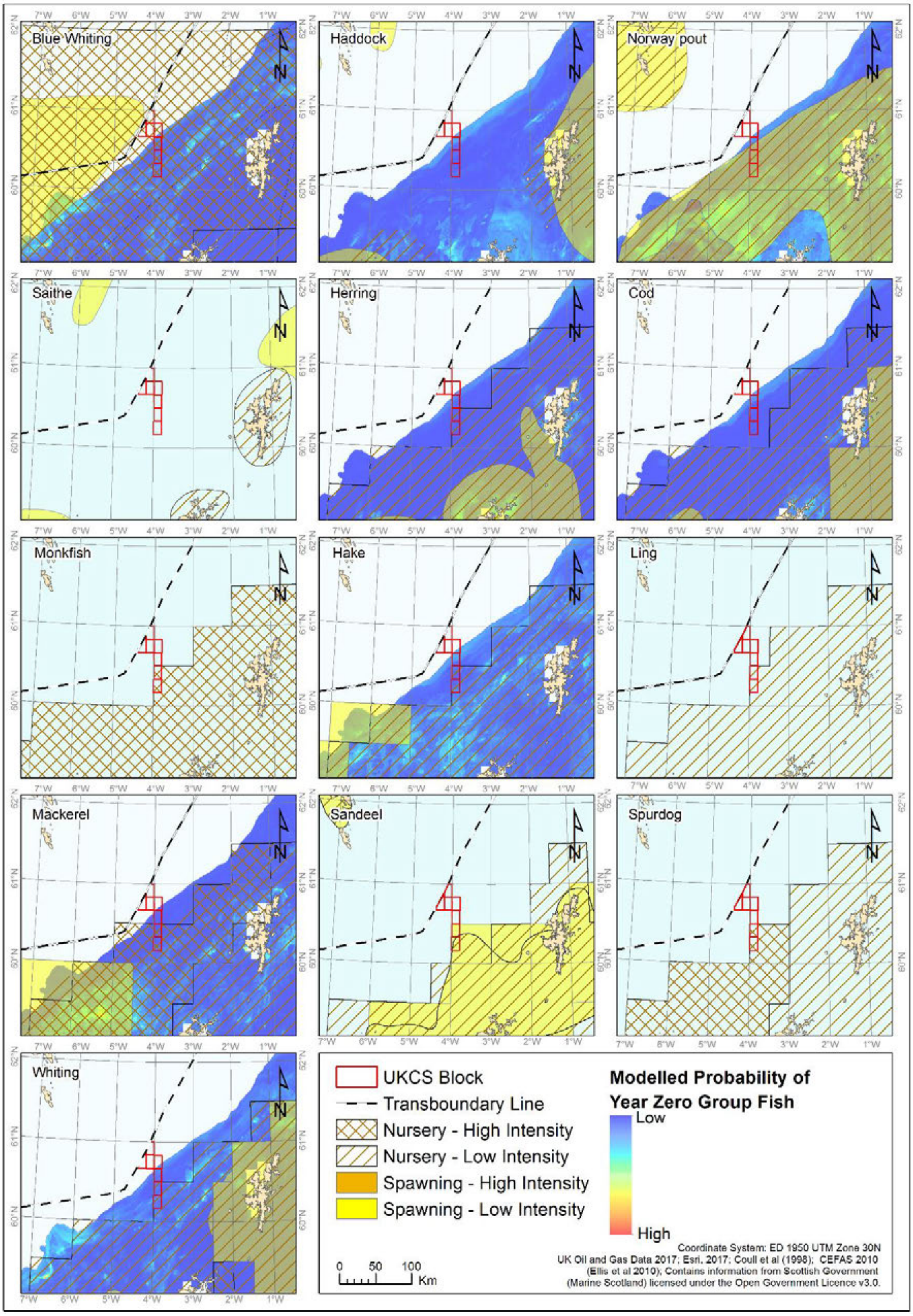

Figure 4.21: Commercially Important Fish Spawning, Nursery Grounds and Year Zero Group Fish in the Vicinity of the Proposed Cambo Field Development

Sources: Coull et al., 1998. Ellis et al., 2012, Aires et al., 2014.

The proposed Cambo Field Development is within a wider area known to be used by spiny dogfish, Portuguese dogfish, sandy ray, basking, leafscale gulper and porbeagle sharks. However, only catches of the spiny dogfish have been recorded within the area. Marine Scotland have mapped areas which are thought to be used by these species. However, these areas are vast, with all waters surrounding Scotland being considered as areas of known use.

Many of shark and ray species (basking, leafscale gulper and porbeagle sharks; sandy ray and Portuguese and spiny dogfish) which have been identified within or in the vicinity of the proposed development have been designated as PMFs (NatureScot, 2021). These species have also been included on the OSPAR list of threatened and/or declining species and habitats (OSPAR, 2018a).

Cephalopods

There are a number of cephalopod species found in the waters around the British Isles, among the most frequently recorded species within the Faroe-Shetland Channel are the long-finned squid, the short-finned squid and spoonarm octopuses (DECC, 2016). Other species may occasionally be encountered in the region. The deepwater octopuses are widespread throughout the deep, cold waters of the North Atlantic, down to depths of 2,500m. However, little is known about the ecology of these predatory species.

Cephalopods are short-lived molluscs, characterised by rapid growth rates, and are important predators and prey in oceanic and coastal environments. Cephalopods are frequently seen as a major dietary component for many marine mammals. The long-finned squid is the main cephalopod species of economic importance within the Faroe-Shetland Channel (Pierce et al,2003). However, the amount landed from the area round the proposed development is very small (Scottish Government, 2017a).

4.3.4 Marine Mammals

Whales, Dolphins and Porpoises

All cetaceans that occur in UK waters are protected under the EU Habitats Directive, which makes it an offence to deliberately capture, kill or recklessly disturb cetaceans. All cetacean species are listed on Annex IV. Bottlenose dolphin and harbour porpoise are also listed on Annex II (Marine Scotland, 2018a; JNCC, Undated a).

The waters of Faroe-Shetland Channel support a number of important and diverse populations of marine mammals, whose distribution is governed primarily by water depth and availability of preferred food sources. A confluence of ocean currents results in upwelling waters rich in food, enabling several species to live in the area throughout the year. Species which regularly occur in the Faroe-Shetland Channel include, Atlantic white sided dolphin, killer whale, long-finned pilot whale and sperm whale. Harbour porpoise, common, Risso's and white-beaked dolphin and Northern bottlenose, fin, sei and minke whales are also recorded to a lesser extent, while some species of baleen whale such as blue and humpback are occasionally observed (DECC, 2016). Cetaceans, including blue, fin, sei and sperm whales, are thought to use the Faroe-Shetland Channel as a migratory pathway, swimming through the area to summer feeding grounds in the north, before returning to more southern overwintering and breeding grounds (Marine Scotland, 2021; Reid et al, 2003).

Cetaceans can be very difficult to view at sea and can only be detected during the very short amount of time they spend on the surface. Visual surveys can only be conducted reliably in conditions of good visibility, during daylight hours, and in a limited range of sea states. This is especially limiting during the autumn and winter seasons, due to the poor weather conditions and reduced daylight hours. Many species, however, make loud and distinctive vocalisations and can often be detected more readily using passive acoustic systems, rather than by visual means. For this reason, passive acoustic techniques are being increasingly used in cetacean survey work, enhancing the information available on cetacean distribution.

The distribution of cetaceans within the Faroe-Shetland Channel are summarised in Table 4.3.

Table 4.3: Distribution and Abundance of Whales, Dolphins and Porpoises in the Faroe-Shetland Channel

Species	Cetacean Distribution and Abundance
Harbour porpoise	The harbour porpoise is common in shelf waters, with fewer records from deeper waters such as those around the proposed development. They have been observed in the Faroe-Shetland Channel and may be more abundant in deepwater than surveys suggest, as they are difficult to detect in rough sea states. They have been recorded within the wider area, most frequently observed between April to September. This opportunistic feeder feeds mainly on fish found on or near to the seabed.
Risso's dolphin	Risso's dolphins form groups of up to approximately ten individuals. Although often regarded as an offshore species preferring deeper continental slope waters, most sightings around Scotland have occurred over the shelf. Sightings in deep waters are generally between July and December. There have been no recorded sightings in the vicinity of the proposed development, although they have been observed in low to moderate numbers within the wider area.
White-beaked dolphin	Widely distributed on the continental shelf to the West of Shetland and Orkney but is rare in deeper waters such as those around the Development Footprint. Most frequently observed between June and October in UK waters. Generally found in groups of less than ten individuals, although they have been observed in larger aggregations.
White-sided dolphin	This species is often recorded in the deeper reaches of the Faroe-Shetland Channel, and is regularly sighted in large pods numbering in the tens to hundreds. White-sided dolphins are seen year-round in the Faroe-Shetland Channel with spring and autumn peaks. They have been sighted in high numbers close to the proposed development.
Common Dolphin	This species is an occasional summer visitor to the Faroe-Shetland Channel. It is thought that their presence in the Channel results from following squid, their preferred food source.
Minke whale	Most sightings of minke whales occur within the 200 m depth contour but there have been sightings in the Faroe-Shetland Channel. This species is resident in UK shelf waters, with peak sightings occurring from May to October. These whales are generally seen in pairs but can form aggregations of up to 15 individuals.
Sperm whale	Found on and beyond the continental shelf break and may be present all year round. The highest densities are observed in deeper waters and they have been sighted in low numbers in the waters adjacent to the Development Footprint during the summer months. The species can be seen in groups of tens of individuals. Evidence suggests that only males migrate to northern latitudes to feed, therefore it is assumed that the channel is a migratory route for some of the population.
Killer whale	This species appears to be present in the Faroe-Shetland Channel all year round but sightings increase during summer. The majority of sightings have been in the wider area around the proposed development, with occasional sightings around the Faroe Islands. The majority of UK sightings have been of individuals or groups of less than eight animals.
Long-finned pilot whale	Most long-finned pilot whale sightings occur along the shelf break and in the deeper waters of the Faroe-Shetland Channel. Sightings peak during the summer, especially July and August. Surveys to the north and West of Scotland have recorded an average pod size of just over ten. The species has been observed in low numbers in the area around the proposed development.
Northern Bottlenose whale	This beaked whale has been recorded throughout much of the Faroe-Shetland Channel, with the channel representing an important part of their habitat. However, sightings of the species are low. The species are thought to migrate north through the channel in spring returning in the autumn.
Fin whale	Fin whales are mainly seen in deeper waters off the continental shelf edge. Most sightings occur between May and October, although passive acoustic monitoring has shown the whales to be present year-round. Observed in relatively high numbers (four to five individuals) between May and October in the area around the Development Footprint.
Blue whale	This is a very rare species, although acoustic monitoring has shown that individuals do occur in the deepwater of the Channel during autumn and spring. Most sightings occur from July to October, and most acoustic detections take place during November and December, coinciding with breeding season.
Sei whale	Sei whales migrate between summer northern feeding grounds and lower latitude overwintering grounds. They arrive in Scottish waters between April and July, leaving late august and September. This species is observed in numbers of four to five individuals. Peak sightings occur between May and October in the area around the proposed Development Footprint.
Humpback whale	Considered relatively rare, humpback whales have been regularly reported from recent sightings and acoustic detections within the Channel. There have been few sightings along the shelf break, with most during summer but they may be present in the region all year round. Generally seen singly or in pairs, rarely exceed groups of four or five. They migrate annually from high latitude, cold water, feeding grounds in summer to low-latitude, warm water, breeding grounds in winter.

Sources: BODC, 1998; Bloch et al. , 2000; Hammond et al. , 2003; JNCC, 2021; Marine Scotland, 2021; Moscrop and Swift, 1999; Pollock et al, 2000, Reid et al. , 2003; Swift et al. , 2002; Taylor and Reid, 2001; DECC, 2016; Charif and Clark, 2000; Hammond et al, 2017; NPWS, 2009.

The information in Table 4.3 describes the distribution and movement of cetaceans throughout the Faroe- Shetland Channel and adjacent shelf waters. A seismic survey undertaken in the Cambo Field in 2014 documented the presence of killer, long-finned pilot, minke and fin whales (Figure 4.22).

Killer whale

Fin whale

Long-finned pilot whale

Minke whale

Figure 4.22: Photographs of Cetaceans Identified Within the Cambo Field During 2014 Seismic Survey

Source: RPS, 2014.

Table 4.4 summarises cetaceans which have been observed directly within the vicinity of Development Footprint and Pipeline Route.

Table 4.4: Distribution of Cetaceans in the Vicinity of the Proposed Cambo Field Development

		Cetacean Presence											
		J	F	M	A	M	J	J	A	S	O	N	D
Development Footprint	Long-finned pilot whale			H			▨	L	▨	▨	▨		▨
	Killer whale					H	▨	▨	▨	▨	▨		▨
	White-sided dolphin						M	▨	H	▨	▨		▨
	Fin whale					H	H	H	H	H	H		
	Sei whale					VH	VH	VH	VH	VH	VH		
	Humpback Whale					M	M	M	M	M	M		
	Sperm whale					L	L	L	L	L	L		
Pipeline Route	Killer whale	▨	▨	▨	▨	L	▨	▨	▨	▨	▨	▨	▨
	White-beaked dolphin	▨	▨	▨	▨	▨	▨	▨	▨	L	▨	▨	▨
	White-sided dolphin	▨	▨	▨	▨	▨	▨	▨	L	▨	▨	▨	▨
	Risso's Dolphin	▨	▨	▨	▨	▨	▨	▨	▨	L	▨	▨	▨

	No Data	▨	**No Animals**	L	**Low**	M	**Moderate**	H	**High**	VH	**Very High**

Source: BODC, 1998

Information on the feeding ecology of cetaceans in UK waters is limited, with information primarily drawn from analysis of the stomach contents of stranded or bycaught individuals, to a lesser degree from stable isotopic analyses of predator and prey tissues and from direct observations (DECC, 2016). The harbour porpoise is thought to be an opportunistic feeder, feeding mainly on fish found on or near to the seabed. The diet of the common dolphins includes a variety of fish and squid, with main dominant species varying with the seasons and region. White-beaked dolphins have been recorded taking whiting and other gadoids, sandeels, herring and octopus. Atlantic white-sided dolphins are thought to consume a diet of pelagic species such as herring and mackerel and squid. Killer whales have a diverse diet predating on seals and pelagic species. Risso's dolphins, long-finned pilot, sperm and bottlenose whales are generally thought to feed on cephalopods (Hammond et al., 2003; DECC, 2016). Minke whales feed on a variety of fish, with sandeels thought to be an important prey species, together with herring, haddock and cod. The diet of fin, sei and humpback whales is unknown however, it is thought to be composed of planktonic crustaceans and small schooling fish such as herring. The diet of the blue whales is composed of krill and copepods.

Many of the cetacean species which have been identified within or in the vicinity of the proposed Cambo Field Development have been designated as PMFs. These include, Atlantic white-sided, white-beaked and Risso's dolphins, fin, killer, long-finned pilot and sperm whales (NatureScot, 2021).

Seals

Two species of seal, common and grey, are resident in Scottish waters. These animals are typically found in coastal waters shallower than 200 m and are present in internationally important numbers around Shetland and Orkney. The grey and common seal are listed under Annex II of the EU Habitats Directive (JNCC, Undated a).

Grey Seal

Approximately 38% of the global grey seal population breed in the UK. Of these, 84% breed in Scotland (SCOS, 2019). They use outlying islands and remote coastlines as moulting, pupping and general haul-out sites. A number of grey seal haul out and breeding sites are distributed around the Shetland and Orkney Islands (Marine Scotland, 2021).

Grey seals spend a high proportion of their time ashore during their pupping and moulting seasons (Hammond et al., 2001). Grey seals pup from September to late November and then moult from December to April (SCOS, 2019). Satellite tracking has shown that grey seal foraging trips can extend several hundred kilometres offshore. However, most foraging tends to occur within 100 km of a haul out site and individual seals based at a particular haul-out site will often make repeated trips to the same offshore locations using prominent corridors (SCOS, 2019; Jones et al, 2015). Grey seals are generalist feeders, with diets primarily comprising sandeels, gadoids and flatfish. It is estimated that grey seals spent 12% of their time at distances greater than 50 km from the coast (Jones et al, 2015). This is also demonstrated by the estimated at-sea usage data presented by the Sea Mammal Research Unit (SMRU) maps for grey seal movements (Figure 4.23, SMRU and Marine Scotland, 2017) which illustrates the predicted average number of grey seals in each 5 km × 5 km grid cell at any point in time. Grey seals are not expected to be encountered within the proposed development location.

Most notably, the Island of Foula and its colony of grey seals is the closest sea haul-out location to the proposed development. The Orkney Islands support the second largest breeding colony for grey seals in the UK at the Faray and Holm of Faray Islands in the northern part of Orkney.

Common Seal

The UK is home to approximately 30% of the European population of common seals (SCOS, 2019). Haul out, breeding and moulting sites are typically situated in sheltered estuaries and on sandbanks but they also use rocky areas. Common seals are widely distributed around the west coast of Scotland and throughout the Hebrides and Northern Isles with east coast concentrations located in the Moray Firth (SCOS, 2019). Sanday SAC (Special Area of Conservation) in the northeast of the Orkney archipelago, is the most important site for common seals on the islands and supports the largest group of common seals at any site in Scotland.

Common seals spend a high proportion of time ashore during the pupping and moulting seasons from June to August (SCOS, 2019). During the pupping season hauled-out groups tend to be smaller and more dispersed (Duck, 2007). In contrast to grey seals, common seal pups are capable of swimming almost immediately after birth (SCOS, 2019).

Common seals tagged on Orkney and Shetland have been occasionally recorded in deeper water beyond the shelf edge northwest of Scotland, including the Faroe-Shetland Channel (Hammond et al. 2003); however, their presence in this area is very limited (DECC, 2016). Telemetry studies have observed that foraging trips are generally within 40 to 50 km of haul out sites. Although longer trips of over 200 km were observed, these were between haul out sites on Orkney and Shetland, rather than to offshore foraging areas (SMRU, 2013). Common seals have a varied diet comprising sandeels, gadoids, herring, sprat, flatfish, octopus and squid. It is estimated that common seals spend only 3% of their time at greater distances than 50 km form the coast (Jones et al, 2015). This is also demonstrated by estimated at-sea usage data presented by SMRU maps for common seal movements (Figure 4.23, SMRU and Marine Scotland. 2017) which illustrates the predicted average number of common seals in each 5 km × 5 km grid cell at any point in time. Likewise, as with grey seals, common seals were rarely sighted in the deeper waters of the Faroe-Shetland Channel during the JNCC Seabirds at Sea Team (SAST) surveys (Pollock et al., 2000).

There has been a significant decline in common seal populations recorded on Orkney in recent years with similar patterns recorded to a lesser extent in populations elsewhere such as the Moray Firth and the east coast of Scotland (Jones et al, 2015; SCOS, 2019). This may be related to interactions with grey seals and exposure to toxins from harmful algae (SCOS, 2019).

Both the common and grey seal have been designated as PMFs in Scottish waters (NatureScot, 2021).

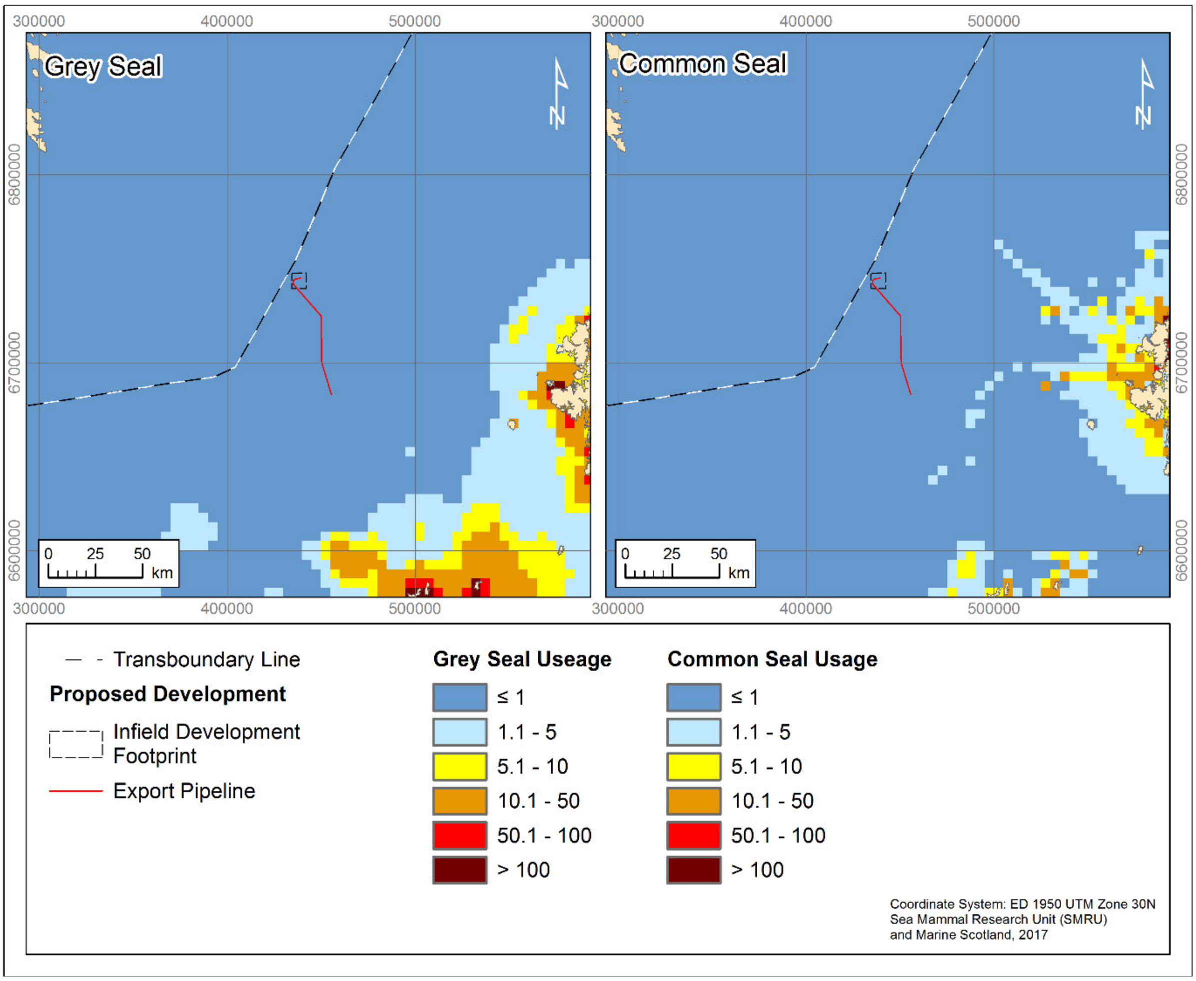

Figure 4.23: At-Sea Usage of Grey and Common Seals in the Vicinity of the Proposed Cambo Field Development

Sources: Sea Mammal Research Unit (SMRU); Marine Scotland, 2017.

Hooded Seals

Hooded seals regularly visit the waters West of Shetland in autumn and winter (Pollock et al., 2000). This species prefers deepwater, making repeated dives to depths of over 1,000 m, and sightings have been predominantly in the deep Faroe Shetland Channel (Bloch et al., 2000). Satellite telemetry data show that a proportion of the stock moves down to forage in the Faroe-Shetland Channel, mainly foraging over deep water (Hammond et al., 2003). Hooded seals are thought to feed primarily on demersal prey such as Greenland halibut, redfish and cod (Hammill, et al., 1997). Hooded seal numbers found in the Faroe-Shetland Channel area as a whole are low (Pollock et al., 2000).

4.3.5 Otters

The common otter is a semi-aquatic mammal, which utilises both inland freshwater and coastal areas. It is estimated that around half of the Scottish otter population uses shallow marine areas to feed. These animals, however, only use a relatively narrow strip of sea, extending to around 80 m from land (Kruuk, 2006). Within this zone, they show preferences for areas of bedrock or cobbles and boulders, foraging in areas with a dense covering of seaweed. Foraging ranges can be as little as 4 km to 5 km of coastline due to the productive inshore waters provide so much fish and crustacean prey (SNH, 2015).

A series of surveys undertaken by the Vincent Wildlife Trust, examined the distribution and status of otters in Scotland (Green and Green, 1997; Findlay et al, 2015). These surveys demonstrated that this animal had strongholds in the Highlands, the Hebrides, and Shetland Islands, but had undergone a decline in the central belt and parts of southeast Scotland. Since 2003, Scottish Natural Heritage (SNH) has continued to collect data on the distribution of otters and examine trends in their abundance (Strachan, 2007; Findlay et al, 2015). The otter population on the Shetland Isles is recognised as being exceptional in terms of the high density of animals and their signs.

Areas of the Yell Sound, on the northern coast of Shetland, are believed to support more than 2% of the entire UK otter population (JNCC, 2021). This region is characterised by low-lying peaty coastlines with large numbers of otter holts and easy access to freshwater. The adjacent marine areas have extensive seaweed beds which they use for foraging. Otters are afforded protection under the EC Habitats Directive, and this site has been designated as a SAC, primarily for its otter population (Section 4.5.1). Otters are also UK Biodiversity Action Plan (UKBAP) priority species and PMF. Otters are also known to occur along the shores of Sullom Voe, and in the large firths which dissect the island of Yell (Strachan, 2007; Shetland Islands Council, 2015). Shetland otters are morphologically and genetically distinct from those found on the mainland and are, therefore, considered to be of special importance in a UK context. The offshore location of the proposed Cambo Field Development makes it unlikely that any otters will be present within the development area.

4.3.6 Seabirds

Abundance and Distribution

The Orkney, Shetland and Faroe Islands and their surrounding waters are sites of major international importance for the seabird colonies they support. The offshore seabirds include members of several families, most notably the petrels and shearwaters, gannets, gulls, skuas and auks. These birds breed on the coasts of the UK, with some feeding far offshore. The Faroe-Shetland Channel is within the maximum foraging range for some species during breeding. However, it is thought that the area is too far for most species to visit during this time, the area is most likely to be used by non-breeders (DECC, 2016). Birds will generally move through the Faroe-Shetland Channel in autumn on passage to winter breeding grounds, or in spring on route to breeding colonies (DECC, 2016). In the winter months, birds become less attached to their nesting sites and range considerable distances in search of food. Seabirds are present throughout the year in the Faroe-Shetland Channel, with mostly low to moderate densities found in the proposed development area (Table 4.5). However, some species, e.g. fulmar occur in high densities in the proposed development area at certain times of the year (BODC, 1998; Kober et al, 2010)). Offshore surveys suggest that the area is of particular importance for a variety of seabirds during the autumn and winter periods, with overall densities decreasing offshore during summer (Table 4.5).

Table 4.5: Density of Seabirds in the Vicinity of the proposed Cambo Field Development

	Seabird Presence												
	J	F	M	A	M	J	J	A	S	O	N	D	
Fulmar	L	L	M	L	H	M	M	M	VH	M	M	L	Fulmar are the most abundant and widespread species in the proposed development area. During breeding season, Mar to July, moderate to high densities of fulmar have been observed over deepwaters and the shelf break. Birds disperse more widely into offshore waters in the autumn and winter.
Gannet	L	▨	L	L	L	L	L	L	L	L	L	▨	The gannet species is widespread throughout the region but has higher densities in shelf areas. This species becomes less common in winter months as the majority of immature birds migrate south. Birds return north to breed during the spring.
Sooty shearwater	▨	▨	▨	▨	▨	▨	▨	L	M	M	▨		From June to November the sooty shearwater migrates from eastern America to the Atlantic. The species cross the deep-waters to reach feeding grounds on the continental shelf.
Manx shearwater	▨	▨	▨	▨	▨	▨	L	L	▨	▨	▨	▨	Between June and August, Manx shearwaters penetrated northeastwards along the Faroe-Shetland Channel and east towards Shetland and Orkney. Sightings here are thought to relate to immature non-breeding birds.
Arctic skua	▨	▨	▨	▨	▨	M	L	L	▨	▨	▨	▨	Densities of Arctic skua are highest when the species returns from overwintering in the south during May. Breeding takes place during June to August with higher densities inshore.
European storm petrel	▨	▨	▨	▨	▨	M	L	M	L	▨	▨	▨	The regional population of this species is generally widespread during June and July, with the highest numbers sighted over the shelf break and deeper water of the Faroe-Shetland Channel during July. The species migrates south over the winter months.
Great skua	▨	▨	L	L	M	M	L	L	M	▨	▨	▨	The Great skua is widespread at low densities during the summer months, becoming widely dispersed from August to October.
Leach's storm petrel	▨	▨	▨	▨	▨	▨	▨	L	▨	▨	▨	▨	A highly aerial species which has a widespread distribution West of Shetland, but is usually sighted over deeper waters of the Faroe-Shetland Channel in the summer, prior to departing to winter areas in the tropics.
Lesser black-backed gull	▨	▨	L	H	M	L	L	L	▨	▨	▨	▨	In Scotland, lesser black-backed gulls migrate south for the winter. During the summer months the species is widespread at low densities. During the rest of the year the species are generally present in inshore waters.
Herring gull	▨	▨	▨	▨	▨	L	▨	L	▨	L	L	▨	Herring gulls are primarily coastal, especially during the breeding season. Migrant birds arrive during September and October, leaving in March and April to wintering areas offshore west and north of Shetland.
Great black-backed gull	▨	▨	▨	L	▨	▨	▨	L	▨	L	L	▨	The great black-backed gull is widely dispersed in the autumn, with abundance generally increasing between January to April. During the breeding season birds stay close to breeding colonies.
Common Gull	▨	▨	▨	▨	▨	▨	▨	▨	M	▨	▨	▨	Common gulls are recoded in small numbers throughout the year in inshore waters off the West of Scotland. Numbers recoded over the Faroe-Shetland channel in summer may reflect birds migrating from Norway.
Kittiwake	M	L	M	L	M	M	M	L	H	L	M	L	Kittiwakes are the most abundant and widespread gull species. During the breeding season birds remain near their colonies with non-breeding birds found in the offshore area.
Glaucous gull	H	▨	▨	▨	▨	▨	▨	▨	▨	M	H	▨	The glaucous gull is a winter visitor occurring from October to April. Birds are generally concentrated over the Faroe-Shetland Channel.
Iceland gull	L	L	L	L							L	L	The Iceland gull is a regular, but scarce, winter visitor from Greenland, the main wintering is Iceland. There have been a small number of sightings between November and March.
Arctic tern	▨	▨	▨	▨	H	▨	L	▨	▨	▨	▨	▨	Densities are highest in the inshore waters around Orkney and Shetland, during breeding season from May to July. Distribution is patchy in deeper waters but birds have been recorded returning to more northerly colonies in May.
Little Auk	▨	▨	▨	▨	▨	▨	▨	▨	L	▨	L	▨	Low densities were recorded in the Faroe-Shetland Channel from September to December. Little Auks are most common in December as this is a major wintering ground for this species.
Guillemot		▨	L	L	L	L	L	L	M	L	L	▨	The guillemot is the most abundant auk species found West of Shetland. The species prefer waters less than 100 m deep, but are also found in low densities in the Faroe-Shetland Channel.
Razorbill	▨	▨	▨	▨	L	▨	L	▨	L	▨	▨	▨	Razorbills are primarily a shelf species. There are localised areas of low densities have been recorded beyond the shelf break.
Puffin	▨	L	L	L	L	H	L	L	L	L	▨	▨	Non-breeding puffin are found offshore in deeper areas during the breeding season whilst adults congregate in colonies. Puffins are most widespread in deep-waters during August and September, with low densities during the winter.

	No Data	▨	**No Animals**	L	**Low**	M	**Moderate**	H	**High**	VH	**Very high**

Sources: BODC, 1998; Pollock et at, 2000; DTI, 2000; Kober et al, 2010.

During the breeding season, generally between March and June, large numbers of seabirds congregate in coastal breeding colonies. Numerous breeding sites are present along the coastline of the Orkney and Shetland Islands for guillemot, Arctic tern, common tern, great skua, kittiwake, fulmar, puffin, European storm-petrel, razorbill, shag, gannet, cormorant, black-headed gull, common gull, lesser-black backed gull, herring gull, great black backed gull and Arctic skua (JNCC, 2021; Birdlife International, 2018; Magic, 2018; Kober et al 2010). Data from the JNCC indicate that Scottish breeding populations of razorbill, Arctic tern, guillemot, black-headed gull and northern gannets have grown between 2000 and 2014, whilst breeding colonies for several other species, including, fulmar and kittiwakes, were found to be in decline over the same period (JNCC, 2015). Notable seabird breeding sites around the Faroe-Shetland Channel include Foula, Sumburgh Head and Hermaness, Sax Vord and Valla on the Shetland Islands and West Westray and Calf of Eday on the Orkney Islands (JNCC, 2021). Kober et al (2010 and 2012) show that the great skua is abundant in the area just west of Shetland during the breeding season.

The island of Foula, designated as a Special Protection Area (SPA), regularly supports populations of Arctic tern which are of European importance, Leach's storm-petrel and red-throated diver as well as migratory species such as great skua, puffin and guillemot. The waters around Foula have been selected as a proposed SPA to protect the adjacent marine foraging area and the prey on which the seabirds of Foula depend. Foula is located 136 km from the proposed Cambo Field Development.

The Faroe Islands also have 19 Important Bird Areas (IBA) including Vidoy, Fugloy, Nólsoy, and Lítla Dímun along the east coasts (Birdlife International, 2018). With Norway designating four IBAs along its southwest coast (Birdlife International, 2018).

4.4 Coastal Habitats

Oil spill modelling has been conducted to inform the assessment of potential impacts from hydrocarbon spills associated with the proposed Cambo Field Development (see Section 13). This modelling indicates that under typical climactic conditions, a hydrocarbon spill could reach the coastlines of the Scottish mainland, Shetland Islands, Orkney Islands, Faroe Islands, Norway and Iceland. The characteristic coastal habitats encountered in the areas identified are discussed below.

4.4.1 Shetland and Orkney Islands

The nearest UK land mass to the proposed Cambo Field Development are the Shetland and Orkney Islands. The Development Footprint lies approximately 125 km West of the Shetland Islands and 177 km from the Orkney Islands. At its closest approach, the proposed Pipeline route lies approximately 100 km from the closest point on the Shetland Islands and 120 km on the Orkney Islands. Both the Orkney and Shetland islands are archipelagos consisting of numerous islands with extensive and complex coastlines supporting a range of different habitat types.

Rocky Habitats (including Shingle Beaches)

Rocky shores are formed from hard substrates and can include different habitat types such as bedrock platforms, boulder fields, rock pools and cliffs. Sea cliffs are steep rock faces formed by erosion but they can show great diversity of form, from very tall vertical or near-vertical cliff faces, through long, steep slopes with a vertical face restricted to the base, to low cliffs above intertidal rock platforms (Dargie, 1997).

The majority of the Shetland coastline is characterised by either sea cliffs which have little or no intertidal zone or exposed rocky shores consisting of bedrock platforms and boulders (MAGIC, 2018). Cliffed coastlines on Shetland primarily consist of tall vertical cliffs although steep headlands, caves, arches and stacks are present too (Dargie, 1997). Sea cliffs are extensively distributed throughout the Shetland Islands but are slightly more prevalent on the western side of the mainland. The coastlines of the three largest northern islands of Unst, Yell and Fetlar all primarily consist of sea cliffs. High levels of exposure mean that the reduced intertidal areas present are typically characterised by attached invertebrate species such as barnacles and mussels. Sea cliffs also provide critically important habitats for seabird breeding colonies (Section 4.3.6).

Rocky shores support a range of sessile and mobile epifauna and seaweed communities varying in structure in relation to both biological and physical factors, particularly the gradient of the shore and the level of wave energy exposure. Over all, seaweed communities become more dominant with increasing shelter from wave energy. On Shetland, sheltered rocky shore areas are generally dominated by the egg wrack, *Ascophyllum nodosum* and other brown seaweeds. Very exposed areas are dominated by barnacles, limpets and mussels (Howson, 1998).

The coastline of the Orkney archipelago is more diverse than that of Shetland and is generally characterised by a low profile and gentle gradient. However, exposed steep sandstone cliffs and stacks dominate the Atlantic coast of the largest Islands, the Mainland, and the island of Hoy. Smaller lengths of cliff habitats are also distributed around to the north and south of the Island.

Although relatively sheltered from wave and wind exposure, the enclosed waters of Scapa Flow are largely surrounded by bedrock and rocky shorelines (Magic, 2018). The islands and skerries within the Pentland Firth to the south are also fringed by cliffs and rocky shoreline. As with Shetland, the sheltered rocky shore areas around Orkney are dominated by brown seaweed communities, accounting for just under half of all the Orkney coastline, giving way to more invertebrate dominated communities as the wave environment becomes more exposed (Howson, 1998).

Shingle features are formed from the accumulations of pebbles ranging from 2 mm to 20 cm in diameter. Shingle is generally deposited as fringing beaches running along a coastline or as forelands, spits and barriers formed by opposing wave actions. If the shingle is stable enough it can provide a foundation for plant communities to develop, further stabilising the habitat. Vegetated shingle is characterised by rare, specialised plant species adapted to the exposed, low nutrient conditions. Shingle also provides important habitat for ground-nesting seabirds and terrestrial invertebrates.

Small areas of vegetated shingle beaches, sometimes backed by coastal lagoons, are found on Shetland, particularly in the voes and firths of the northwest mainland and Yell. This represents less than 0.5% of the total Shetland coastline. As much of the shingle is heavily exposed, the associated plant communities are sparse except for in the sheltered part of voes and other features. The more extensive areas of shingle provide some locally important breeding areas for Arctic terns and ringed plovers (Randall, 1997). There are also considerable lengths of shingle on Orkney including spits and barrier beaches formed from the local red sandstone. Shingle on Orkney provides breeding habitats for fulmars along with Arctic and common terns (Randall, 1997). Some of these shingle barriers form coastal lagoons. Overall the shingle habitat represents 2.5% of the total Orkney coastline.

Sedimentary Habitats (Sandy and Muddy Shores Including Saltmarshes)

Sandy shorelines comprise beaches formed from loosely accumulated sandy, gravelly or shelly sediments. Sediment characteristics vary with exposure to wave energy and other physical features. Muddy beaches, comprised of finer, more closely associated sediments, are only found in areas with calm wave conditions. As with offshore benthic habitats, the intertidal zone of sedimentary shores are primarily colonised by burrowing infaunal communities, including polychaete worms such as lugworms and ragworms and bivalve molluscs such as cockles and razorshells. These communities provide an important food resource for other organisms, particularly juvenile fish and waterbirds.

On both mainland Shetland and the surrounding islands, the extent of cliffs and rocky areas is broken up by a series of bays, inlets and sounds. These areas are sheltered from wave and wind exposure to some extent and sedimentary shores are relatively common within them. Although gravelly, sandy and muddy areas are all found at various points on the coastline, sedimentary shores on Shetland typically consist of coarse sands and gravels reflecting the historical geological conditions (University of Aberdeen and Hartley Anderson, 2003). Intertidal benthic communities in coarser, shelly sediments are characterised by the bivalve *Macoma balthica* along with the polychaetes *Fabricia sabella* and *Tubificoides benedeni*. Finer sediments typically support the bivalves *Macoma balthica* and *Crenella decussata*, the polychaete *Travisia forbesii* and the isopod crustacean *Eurydice pulchra* (Irving, 1997a).

Soft sediment areas are, overall, rare on the Shetland Islands, with sandy beaches making up less than 5% of the total coastline (Gammack and Richardson, 1980). There are no major rivers on Shetland and therefore significant areas of estuarine sand or mud flats are also uncommon. Some of the bays around the Shetland Islands are also backed by sand dune systems and machair (sandy grassland) although sand dunes are limited in number and extent due to the lack of sand supply.

On the main island of Orkney, away from the exposed high energy environment on the Atlantic coast, there are numerous sandy shores backed by dunes and machair. In general, the group of islands to the north of the mainland have complex coastlines of rocky headlands and shallow sheltered bays supporting stable, sandy shores. In particular, the island of Sanday supports notable sandy beach areas especially on its southern side. This coastline consists of extensive sandy bays backed by dune and machair systems including two large intertidal sheltered embayments (Murray et al, 1999). These form two of the four small estuarine areas found on Orkney, three of which are located around Sanday at Cata Sand, Kettleloft Bay and Otterswick. The estuaries support sand and shingle tidal flats with small areas of mudflats in the most sheltered inner parts (Davidson, 1997).

Some areas of gravel, along with muddy shores are also present in very sheltered inlets and embayments within Scapa Flow. The sedimentary areas around Orkney typically consist of “clean” sediments (low organic content) and support intertidal benthic communities dominated by amphipod crustaceans and polychaete worms such as the sand mason worm, *Lanice conchilega* (Howson, 1998; Irving, 1997b).

In the most sheltered of intertidal areas, where very fine sediments accumulate, saltmarshes may be found. The accumulation of sediments allows the colonisation of plants, which in turn accelerates the deposition of sediments, raising and stabilising the marsh areas. Saltmarshes provide essential habitats for migratory and overwintering birds. On Shetland, saltmarshes are found mainly at the heads of voes and other inlets, covering approximately 0.2% (2.5 km) of the available coastline (Hill, 1997a). Most saltmarsh areas are found on mainland Shetland, but there are a few sites on Unst and Yell.

Small patches of saltmarsh habitats are also distributed around the Orkney Islands in very sheltered areas, although this amounts to less than 1% (3.5 km) of the total Orkney coastline (Hill, 1997b). Saltmarshes are concentrated in the sheltered bays and strands of Scapa Flow (particularly on Hoy), the northeast coast of Mainland and Sanday.

Voes, Houbs and Vadills

As mentioned above, the Shetland coast is indented by a series of features, including inlets known locally as “voes”. Voes are narrow, steep-sided sea inlets formed from river valleys flooded by historical sea level rise, similar to fjords or sea lochs. These features are found frequently along the coastline of the mainland and the surrounding islands. Voes support a range of habitat types along their length. Near the sea they typically support exposed, steep bedrock shores and cliffs, generally followed by more gentle and sheltered bedrock and boulder areas. Sedimentary shores are found at the heads of voes. The heads of voes can also support unusual brackish lagoon systems known as known as ‘houbs’ - pools with a shingle ridge across the mouth and ‘vadills’ - bays with narrow rocky entrances (Barnes and Bamber, 1997). Voes, houbs and vadills provide sheltered habitats, with the seabed grading from rock to coarse shelly sand to mud.

4.4.2 UK Mainland

The north coast of mainland Scotland, along with the coast of Moray and Aberdeenshire, predominantly feature steep-sided cliffs with headlands, caves, geos (an inlet, a gully or a narrow and deep cleft in the face of a cliff), blowholes and stacks cut into granite, sandstone and limestone (BGS, 1996; Dargie, 1996). These areas are high energy environments exposed to the full force of climatic and tidal influences from storms in the North Sea and Atlantic Ocean resulting in rocky shorelines. Sediment accretion is therefore only seen in the more sheltered inlets around the Kyle of Durness and Kyle of Tongue, which feature sandy beaches with shallow sand flats exposed at low tide.

The Inner Moray Firth is less exposed, but with tidal effects that have transported shingle and sandy sediments to form banks on both coasts of the Firth (BGS, 1996). The sheltered inlets of the Dornoch Firth, Cromarty Firth and the Inner Moray Firth are lower energy environments where sand and shingle spits and barriers can form, with extensive intertidal sand flats, backed in some places by mudflats and saltmarshes.

The cliffs along the Aberdeenshire coastline are interspersed with more sheltered areas where sandy beaches are present, backed by extensive sand dune systems and machair. A few very small mud flats and saltmarshes are also present along the Grampian coast (Hill, 1996).

4.4.3 Faroe Islands

The Faroe Islands lie around 146 km northwest of the proposed Development Footprint. They comprise 18 major islands, divided by a series of northwest to southeast running channels and fjords. The steeply dipping strata of the volcanic rock which forms the islands has created two different types of coastal habitat across the islands (Johansen and Olafsson, 1989). The north and west of the archipelago are characterised by sea cliffs of up to 750 m in height, accompanied by small islands, stacks and skerries. These regions are characterised by exposed, high energy rocky shores with little intertidal zone. In contrast, much of the eastern coast is gently sloping, and more sheltered environments with sandy beaches are found here, particularly within the many fjords found on this coast. The only sand dunes on the archipelago are found at Sandur in the south (Johansen and Olafsson, 1989).

4.4.4 Norway

The nearest landfall on the Norwegian coast to the proposed Development Footprint location is approximately 475 km to the east. The western coastline of Norway is primarily characterised by a network of deep, steep sided fjords, dotted by numerous small, rocky islands and islets. Coastal habitats are therefore dominated by steep cliffs falling straight into deep-water with no significant intertidal zone and by rocky shores (Norwegian Environment Agency, 2017). Sand and mud habitats are restricted to sheltered areas away from strong tides. Sandy beaches also fringe some of the coastal islands, particularly in the northern part of the country. Mudflats and saltmarshes are very limited and are restricted to inner reaches of the fjords (Marthinsen et al, 1992).

4.4.5 Iceland

The coastline of Iceland is diverse. Active volcanism has resulted in some areas in lava fields which run straight to the sea, forming a hard, bare rock pavement which slopes towards the coast. In other areas, the volcanic rock has been eroded by glacial action into deep fjords, which indent the coastline around the country, and form steep cliffs and rocky shores, with little intertidal zone (AMS, 1952). Numerous rocky islands are also present. Glacial meltwater rivers and streams transport large amounts of sediment to the coast, and so sedimentary coastlines are also common around Iceland. Direct glacial outwash has resulted in extensive gravel beds, particularly in the south of the island (AMS, 1952). These have been reworked via current action to create spits and barrier islands. Extensive mud flats and saltmarshes have developed on the lee side of these barriers, and in the sheltered inner parts of fjords. Sandy beaches are present in smaller fjords where wave action is more severe. In general, low energy, sedimentary habitats are present in the south, west and far northeast of the island, whilst cliffs and rocky shores are most prevalent along the east coast (AMS, 1952). The nearest landfall on the Icelandic coast is approximately 650 km to the northwest of the proposed Cambo Field Development.

4.5 Protected Sites and Sensitive Habitats

4.5.1 Coastal Conservation Areas

There are numerous protected sites along the coastlines of the Shetland and Orkney Islands, which are located adjacent to the proposed development (Figure 4.24). These include internationally designated Ramsar Sites (internationally important wetlands of importance, especially for waterfowl), Special Protection Areas (SPAs) and IBAs (protecting rare and vulnerable species of wild birds), and SACs (EC Directive (92/43/EEC) for the Conservation of Natural Habitats and Wild Flora and Fauna 1992 (The Habitats Directive)). There are also numerous nationally designated sites, including Sites of Special Scientific Interest (SSSIs).

The Shetland and Orkney Islands possess many habitats that are either of major conservation importance in themselves or for the species they support. As such, many sites are afforded protection under both statutory and non-statutory conservation designations. The Shetland and Orkney Islands are of international ornithological significance, particularly as seabird breeding sites, and as such many coastal sites on the islands are designated as SPAs and IBAs (Figure 4.24). Ronas Hill – North Roe and Tingon on Shetland and the East Sanday Coast on Orkney are also classified as a Ramsar sites (Marine Scotland, 2021; Ramsar, 2018). Hermaness, Saxa vord and Valla Field is designated as a SPA for its breeding populations of red-throated diver, gannet, great skua and puffin. The island of Foula was also designated as a SPA for its breeding populations of Arctic tern, Leach’s storm-petrel, red-throated diver, great skua, guillemot, puffin and shags, together with its seabird assemblage of international importance (JNCC, 2021). Inshore waters adjacent to seabird colonies are used heavily by seabirds during the breeding season; this has been reflected in the recent seaward extension to breeding colony SPAs. Several SPAs around the Shetland Islands have been extended by up to 2 km (JNCC, 2021). Some SPAs on the islands have also been selected for the presence of rare divers and overwintering waders which are concentrated near to shore or on the shoreline.

There are also a number of SAC designated for habitats and species on the Shetland and Orkney Islands (Figure 4.24). Important habitats designated as SACs include the extensive sea cliffs at Hoy on Orkney, shallow inlets and bays found in Sullom Voe, coastal lagoons in Vadills and reefs and submerged or partially submerged sea caves of Papa Stour on the Shetland Islands (JNCC, 2021). SACs have been established for the major common seal breeding sites at Sanday on Orkney and in the Yell Sound and Mousa on Shetland as well as for the second largest grey seal colony in the UK at the islands of Faray and Holm of Faray on Shetland (JNCC, 2017). The Yell Sound coast is also designated due to its otter population.

Numerous Sites of Special Scientific Interest (SSSI), the UK's main national nature conservation designation, have also been designated throughout the Shetland Islands. Non-statutory sites include several sites owned or managed by the Royal Society for the Protection of Birds (RSPB) and the Scottish Wildlife Trust (RSPB, 2018; Scottish Wildlife Trust, 2018).

There are three Ramsar sites, Mykines, Nolsoy and Skuvoy, all designated as important bird areas and 19 IBAs designated along the coast of the Faroe Islands (Ramsar, 2018; Birdlife International, 2018).

A number of candidate Emerald Network areas of special conservation interest have been designated along the Norwegian coastline for vulnerable or rare habitats and species (Norwegian Environment Agency, 2018). There are also four Ramsar sites and four IBAs designated along the southwest coast of Norway (Ramsar, 2018; Birdlife International, 2018).

The coastline of Iceland supports 94 IBAs and two Ramsar sites, Andakill and Grunnaf Jordur, both located on the west coast of Iceland (Ramsar, 2018; Birdlife International, 2018).

4.5.2 Offshore Conservation Areas

The Marine (Scotland) Act 2010 and the UK Marine and Coastal Access Act 2009 provide the powers for Scottish Ministers to designate Nature Conservation Marine Protected Area (NCMPA) in Scottish waters.

Figure 4.25 illustrates the offshore conservation sites located around the proposed Cambo Field Development and Gas Export Pipeline route.

The closest NCMPA to the proposed Development Footprint is the Faroe-Shetland Sponge Belt which lies 16 km to the southeast at the closest point. The proposed pipeline passes through the southwest portion of the NCMPA for 34.6 km. This NCMPA has been designated for its deep-sea sponge aggregations, offshore subtidal sands and gravels, ocean quahog aggregations, continental slope, wide range of features representative of the West Shetland Margin palaeo-depositional, Miller Slide and Pilot Whale Diapirs Key Geodiversity Areas and sand wave fields, and sediment wave fields representative of the West Shetland Margin contourite deposits Key Geodiversity Area (JNCC, 2021; Figure 4.18 and Figure 4.19).

The proposed Pipeline route will traverse through the Faroe-Shetland Sponge Belt NCMPA on route to the WOSPS PLEM. Figure 4.26 illustrates the offshore protected habitats present within the Faroe-Shetland Sponge Belt NCMPA in relation to the proposed pipeline route. This figure shows that the proposed pipeline route will pass through an area of encrusted sponge dominated aggregations.

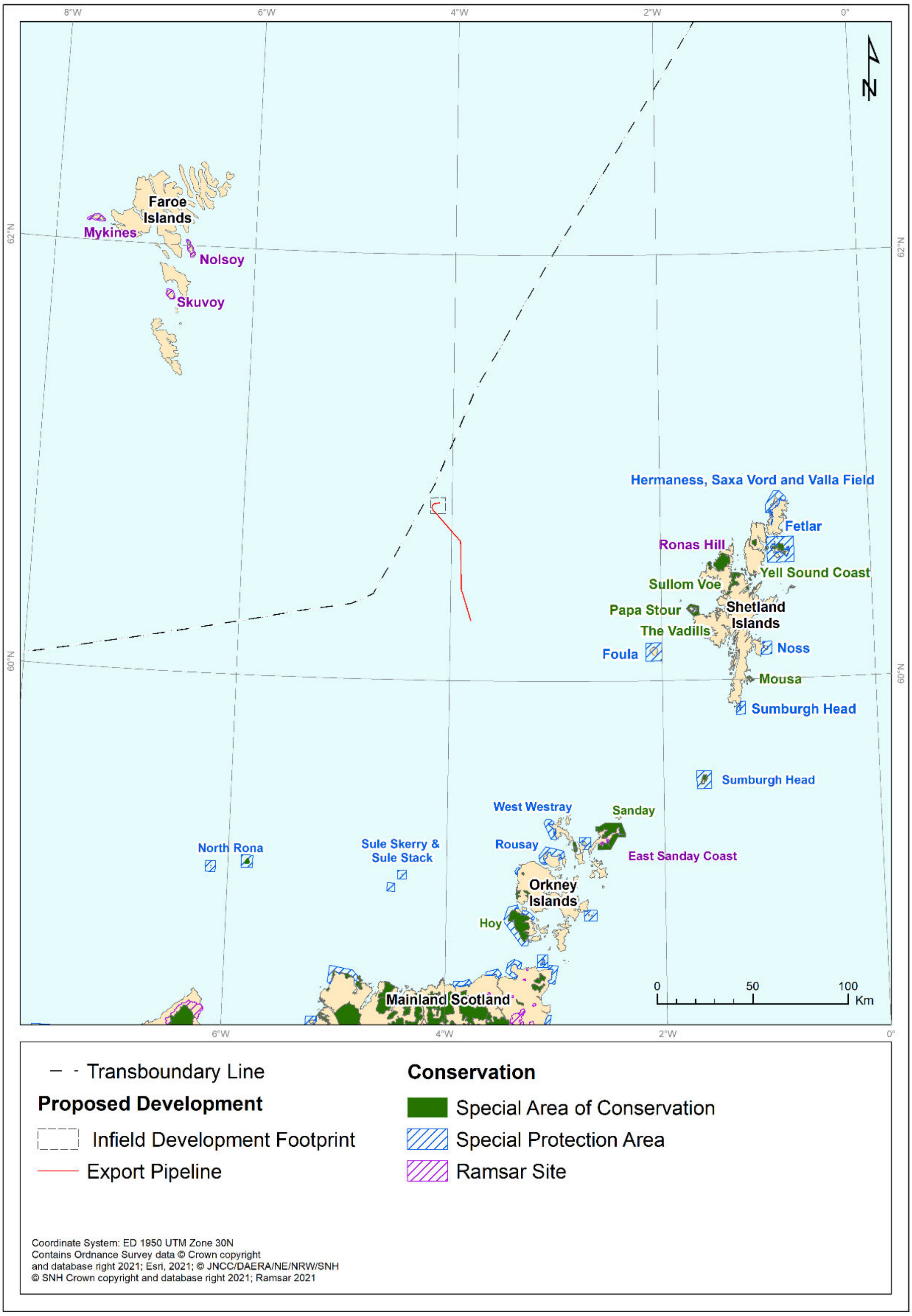

Figure 4.24: Coastal Conservation Areas

Sources: JNCC, 2021; NatureScot, 2021.

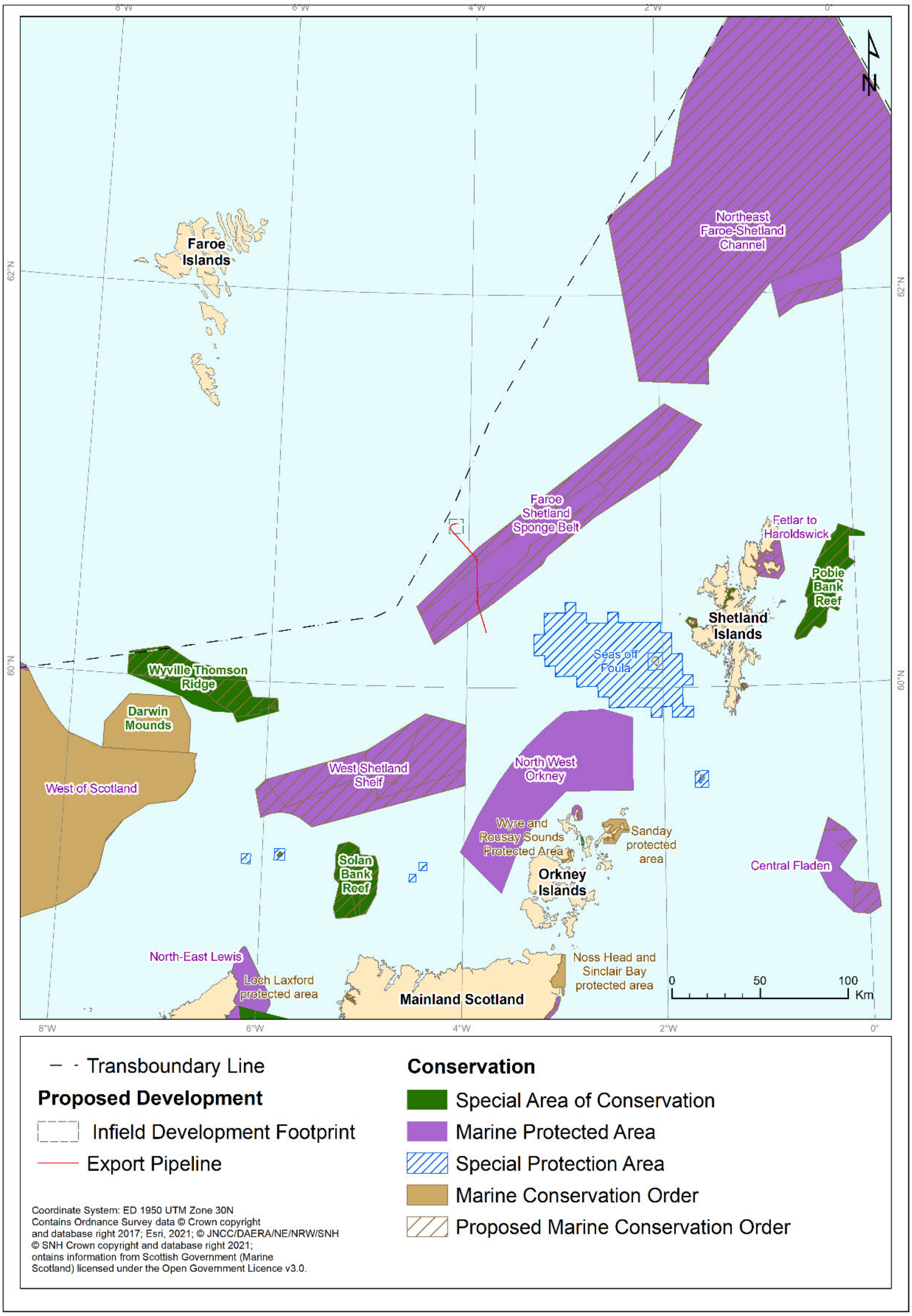

Figure 4.25: Offshore Conservation Areas

Sources: JNCC, 2021; NatureScot, 2021, Marine Scotland, 2021.

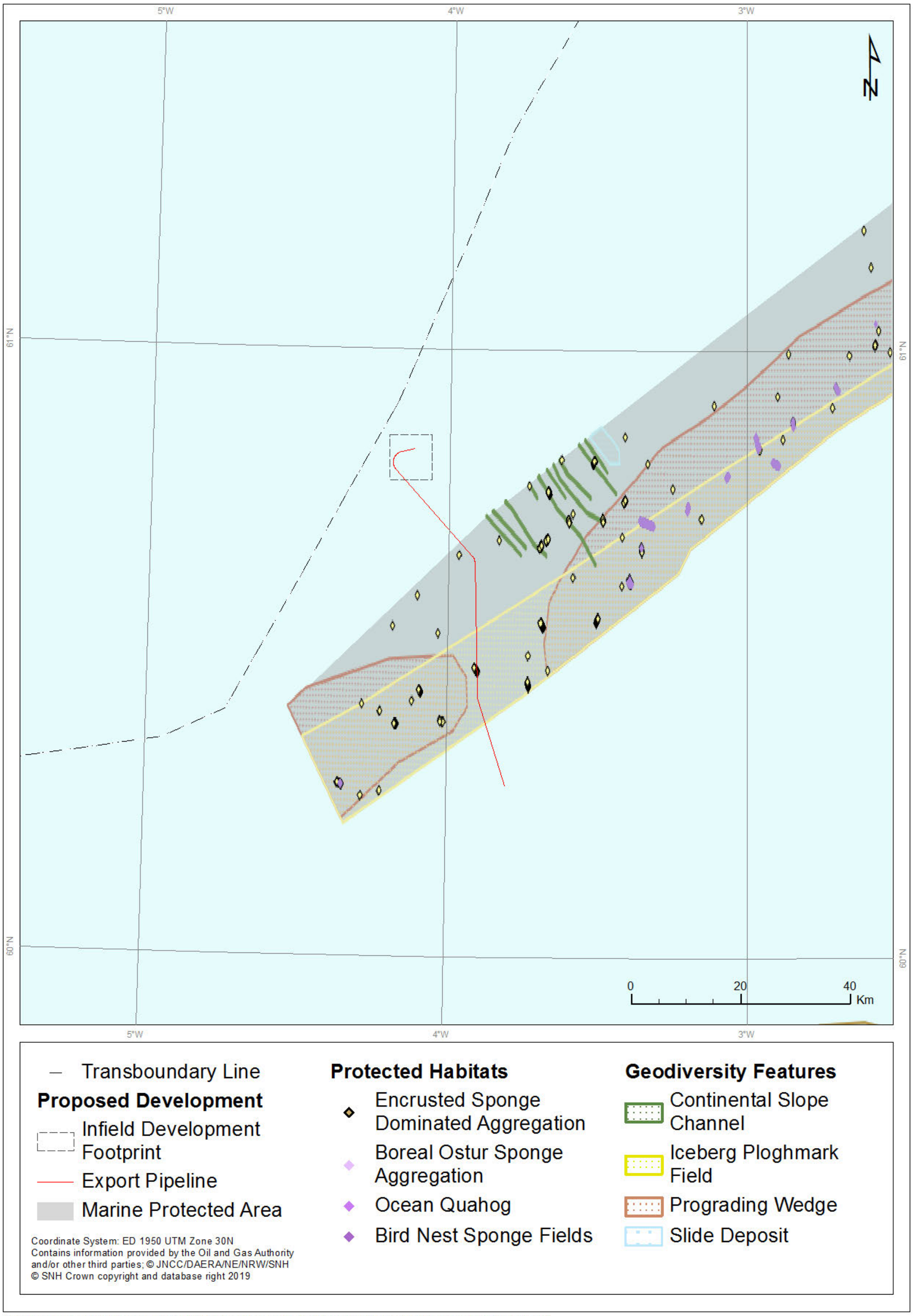

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Figure 4.26: Offshore Protected Habitats and Geodiversity Features
Sources: JNCC, 2021; NatureScot, 2021.

At its closest point, the proposed Pipeline route is located approximately 110 km and 140 km south from the West Shetland Shelf NCMPA and North-West Orkney NCMPA, respectively. The West Shetland Shelf NCMPA was designated for its offshore subtidal sand and gravel habitat which provides conditions for a diverse range of animals to live in and on the seabed (JNCC, 2021). The North-West Orkney NCMPA was designated for its sand banks, sand wave fields and sediment wave fields representative of the Fair Isle Strait Marine Process Bedforms Key Geodiversity Area and sandeels (JNCC, 2021).

The Fetlar to Haroldswick NCMPA located 280 km southeast of the Development Footprint and 262 km from the Pipeline Route, was designated for its aggregation of black guillemots, Marine geomorphology of the Scottish shelf seabed, circalittoral sand and coarse sediment communities, horse mussel beds, kelp and seaweed communities on sublittoral sediment, maerl beds and shallow tide-swept coarse sands with burrowing bivalves (NatureScot, 2021).

The conservation objective for these NCMPAs is to conserve the deep-sea sponge aggregations and other protected habitats in a favourable condition. The UK Marine and Coastal Access Act 2009 also requires fisheries management measures to be taken to ensure that achievement of the conservation objectives of the offshore NCMPA's are met. The Faroe-Shetland Sponge Belt NCMPA proposed fisheries management measures include the prohibition of beam and bottom trawling, dredging and the use of seine nets in areas where the designated features are more sensitive to this fishing method. This prohibition is also the case for the use of gillnets and entangling nets, hooks and lines, and pots and traps in order to protect deep-sea sponge aggregations (Scottish Government, 2017b).

NCMPAs have been selected to protect a range of PMFs, these features incorporate habitats and species included on the OSPAR list of threatened and/or declining species and habitats (OSPAR, 2018a), in addition to those included in the UKBAP Priority List, and the Scottish Biodiversity List. PMFs most relevant for the proposed Cambo Field Development are habitat PMFs, offshore subtidal sands and gravels and deep-sea sponge aggregations and species PMF ocean quahog aggregations (NatureScot, 2021).

Deep-sea sponge aggregations are generally found at depths of 400 m to 600 m, where a combination of seabed type and a plentiful supply of nutrients in the NCMPAs are ideal for the establishment of deep sea sponges (JNCC, 2020a), although they have been reported at depths up to 1,300 m (Bett and Rice, 1992). These aggregations have been reported at depths within the depth range of the proposed Cambo Field Development. The 2017 habitat assessment did identify the presence of sponges; however, no areas were found to constitute the OSPAR habitat, deep-sea sponge aggregations (Fugro, 2017), this is supported by the Cambo 5 survey which found no evidence of deep sponge aggregations (Fugro, 2011a). Imagery analysis from the 2018 export pipeline route survey, which crosses the Faroe-Shetland sponge belt, also concluded that no areas could be classified as "Deep-sea Sponge Aggregations" (i.e. areas with a sponge coverage of greater than 10%) (MMT, 2019). The export route generally had low sponge coverage of less than five percent and only four separate sections of the transect had a sponge coverage of between five and ten percent.

JNCC has derived three criteria for assessing whether a habitat qualifies as an OSPAR "deep-sea sponge aggregation" as detailed in Henry and Roberts, 2014. These qualifying criteria consider sponge density, habitat and ecological function. A detailed review was undertaken of the still images and video footage from the 2018 pipeline route survey to assess whether any deep sponge aggregations observed along transect TR8 of the survey, which run through the Faroe-Shetland Sponge Belt NCMPA did meet the OSPAR requirements to be considered as "deep-sea sponge aggregations (Fugro, 2020).

All areas assessed were classified as not fulfilling the criteria of the OSPAR habitat ‘Deep-sea sponge aggregations’. Sponges recorded were generally small or encrusting. No large structural geodiid sponges were recorded. The review noted that, along this particular transect, a total of 15 areas met the criteria for density and ecological function, but not for the habitat function. Where density and ecological function were scored, the sponges were associated with isolated cobbles and boulders and were constrained to an area less than 25 m^2. The review identified that whilst ecological function was scored for each of these fifteen areas, any elevation in species diversity was generally associated with an isolated cobble or boulder. Additionally, many of the taxa associated with the sponges were also identified on the surrounding seabed indicating that their presence was not conditional on the presence of sponges, thus not meeting the habitat function criteria.

In five areas, densities of sponges greater than 0.5 per m^2 were identified in an area greater than 25 m^2. However, none of these areas fulfilled the criteria for habitat or ecological function. No areas of seabed reviewed from survey transect TR08 met the criteria for all three categories, density, habitat and ecological function (Fugro, 2020). Given these findings, it is considered that there are no significant deep-sea sponge aggregations along the route of the proposed pipeline.

The ocean quahog (*Arctica islandica*) is a long-lived species which is found buried in sandy and muddy sediments ranging from the low intertidal zone down to 400 m (OSPAR, 2009). Ocean quahog aggregations are found within the Faroe-Shetland Sponge Belt NCMPA, which the proposed pipeline route traverses. This species is generally found to depths of 400 m, a depth experienced along some of the proposed pipeline route, however is far shallower than the depths experienced at the Development Footprint. The 2017 and 2018 habitat assessment within the proposed Development Footprint identified no sensitive species (Fugro, 2017; MMT, 2019). Due to the depths experienced along the Pipeline Route, ocean quahogs may be present.

The Breisunddjupet OSPAR MPA is located within Norwegian waters, approximately 560 km to the east of the Development Footprint, have been designated for cold-water coral *Lophelia pertusa* reefs (OSPAR, 2018b).

Offshore SACs are designated to protect fully marine habitats situated beyond the 12 nautical mile (nm) limit of UK territorial waters. The Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001 (as amended) apply the requirements of the European Habitats Directive and Wild Birds Directive to oil and gas activities on the entire UKCS, including within the 12 nm territorial limit. Annex I of the Habitats Directive lists three habitat types that are most likely to occur in offshore waters and be eligible for designation as offshore SAC:

- Submarine structures made by leaking gases (pockmarks);
- Reefs (bedrock, stony or biogenic);
- Sandbanks that are slightly covered by water all the time.

Consequently, the proposed Cambo Field Development is surrounded by a range of offshore protected areas has been designated at European level for these important habitats. The closest offshore SAC to the proposed development Wyville-Thomson Ridge SAC is located approximately 86 km to the southwest of the proposed Pipeline route and encompasses rock and stony reefs supporting a variety of sponges, cup and soft corals; brachiopods; bryozoans; dense beds of featherstars and brittlestars; sea urchins, sea cucumbers and sea spiders (JNCC, 2021).

The Darwin Mounds SAC located approximately 114 km to the southwest of the proposed pipeline route, was designated for its Annex I reef habitat (JNCC, 2021). The Darwin Mounds is an extensive area of sandy mounds formed by seabed fluid expulsion, each of which is capped with multiple thickets of the cold-water coral *Lophelia pertusa* (JNCC, 2021).

The Pobie Bank Reef SAC located approximately 226 km to the southeast of the proposed pipeline route, was designated for its Annex I reef habitat (JNCC, 2021). The stony and bedrock reef of the SAC provides a habitat to an extensive community of encrusting and robust sponges and bryozoans, which are found throughout the site (JNCC, 2021).

As all the SAC described above are located 86 km or more from the Cambo Field Development. At present, there are no designated Annex I habitats in the vicinity of the Cambo Field Development.

As part of the SPA selection process, the JNCC and SNH have identified possible marine SPAs for seabirds in offshore waters around the UK. The Seas off Foula is one of the locations selected as a proposed SPA (pSPA). The Seas off Foula pSPA covers an area of 3,412km^2 around the northwest of the island and is 42 km to the southeast of the Pipeline Route. This island hosts more than 190,000 breeding seabirds which are already protected on land and in the waters immediately surrounding the island by the existing Foula SPA. The proposed Seas off Foula SPA will complement the existing protection and ensure that the adjacent marine foraging area and the prey on which the seabirds depend are equally protected (JNCC, 2021).

In addition to these protected areas, the JNCC has identified areas where Annex I habitats may be present. Of the three habitat types most likely to occur in UK offshore waters (reefs, sandbanks and pockmarks), reefs are most common in the Faroe Shetland Channel. The 2018 site and export pipeline survey identified Annex I (1170) Low Graded Stony Reefs along transect TR08, which surveyed the export pipeline. The 2017 habitat assessment in Block 204/10a found that hard surfaces were colonised by faunal turf. However, due to the low diversity and density of other epifauna this was deemed ‘not a reef’ (Fugro, 2017). These results were supported by the Cambo 5 environmental and ROV surveys (Fugro, 2011a; Fugro, 2013) and regional studies (Bett, 2000), with no corals capable of biogenic reef formation being encountered. Sparse cobbles and boulders were encountered throughout the Cambo 5 survey area, but not at a sufficient density to warrant assessment as an Annex I stony reef habitat, based on JNCC preliminary reef characteristics (Fugro, 2011a). The Cambo 4 ROV survey also classified the entire survey area as having low reef potential and no reef forming species were present. Soft corals and sponges were present but in very low densities (Fugro, 2011b). The Fugro (2020) review of the 2018 geophysical survey data and seabed imagery assessed the potential for the presence of Annex I stone reef habitats along transect TR08. The data indicated the presence of a clear mound and an area of high reflectivity both of which coincided with the seabed imagery, indicating areas of seabed classified as an Annex I low graded stony reef covering an area of approximately 76 m^2.

4.6 Other Users of the Sea

4.6.1 Commercial Fisheries

The Faroe-Shetland Channel, to the West of the Shetland islands, supports a deepwater fishery for species such as blue ling, round-nose grenadier, orange roughy, black-scabbard fish and a number of deepwater sharks (Barreto et al, 2017). The deepwater fishery has little economic significance to the UK fishing industry as a whole (Barreto et al, 2017). The consensus of the International Council for the Exploration of the Sea (ICES) is that many of the deepwater fish stocks have declined and are now outside safe biological limits. Some species declines have been halted, but there is presently no sign of recovery (Barreto et al., 2017).

Fishing effort on the continental shelf to the north and northwest of Shetland is relatively high, with the fishing industry an important contributor to the economies of the Shetland and Orkney Islands. The mixed demersal fishery operates year-round and across the entire shelf area and to the northwest of the Shetland Islands. Herring fisheries operate in more inshore areas, whilst other pelagic fisheries are very seasonal and restricted to areas of the continental shelf break and beyond. Shellfish fisheries also operate in more inshore areas.

For fisheries statistics purposes, the northeast Atlantic is divided into rectangles by the ICES. The proposed Development Footprint lies within ICES rectangle 50E5, with the proposed Pipeline route traversing ICES rectangles 50E6 and 49E6. Data is currently unavailable for ICES rectangle 50E5. It should be noted that recent landings data is currently only made publicly available if over five vessels were active in a particular ICES area. This means that the data presented here may be an underestimation of the actual overall fishing effort, tonnes of fish landed and/or sales value in this area (Scottish Government, 2020a and Marine Scotland, 2021). In order to gain understanding of the overall fishing effort within the wider area of the proposed Cambo Field Development and proposed pipeline route, analysis of commercial fishing has been conducted using ICES rectangle 51E6, 50E6, 49E4, 49E5 and 49E6, the rectangles surrounding the proposed development, allowing for a more reasonable comparison. Information on ICES rectangle 51E5 were unavailable or disclosive, due to the reason previously stated.

Maps of fishing intensity amalgamating vessel monitoring systems (VMS) during the period 2009-2013 show that ICES rectangle 50E5 (Development Footprint) is outwith the data available for demersal static fishing. Demersal mobile fishing within the proposed Development Footprint has a low level of intensity (Kafas et al, 2012). The end of the proposed pipeline route passes through a moderate to high level of intensity for demersal static and mobile gear, located over the continental shelf (Figure 4.27; Kafas et al, 2012).

A recent survey of fishing vessels in the vicinity of the proposed development was carried out to assess the number of vessels engaging in fishing activities around or within the development. It recorded 31 vessels throughout the duration of the survey. The study concluded that no fishing vessels were engaging in fishing activities within 10nm of the proposed development and that all vessels were on passage. The majority of vessels were recorded passing northwest to southeast (Anatec, 2019).

A fishing intensity study (Xodus, 2019) which focused on the pipeline route was also undertaken. The study was undertaken using Automatic Identification System and publicly available VMS data. This study showed that the highest density of fishing activity along the pipeline route occurs at the southern end of the pipeline in approximately 183 m to 313 m water depth, but that vessels tracked as crossing the pipeline route fell by 40% between 2016 and 2018. 14% of the fishing vessel crossing over the pipeline route where through the Faroe Shetland Sponge NCMPA. The study showed that the main type of fishing activity around the area of the pipeline route is demersal fishing, with long liners (34.5%) and gill netters (22.5%) being the most used vessel type.

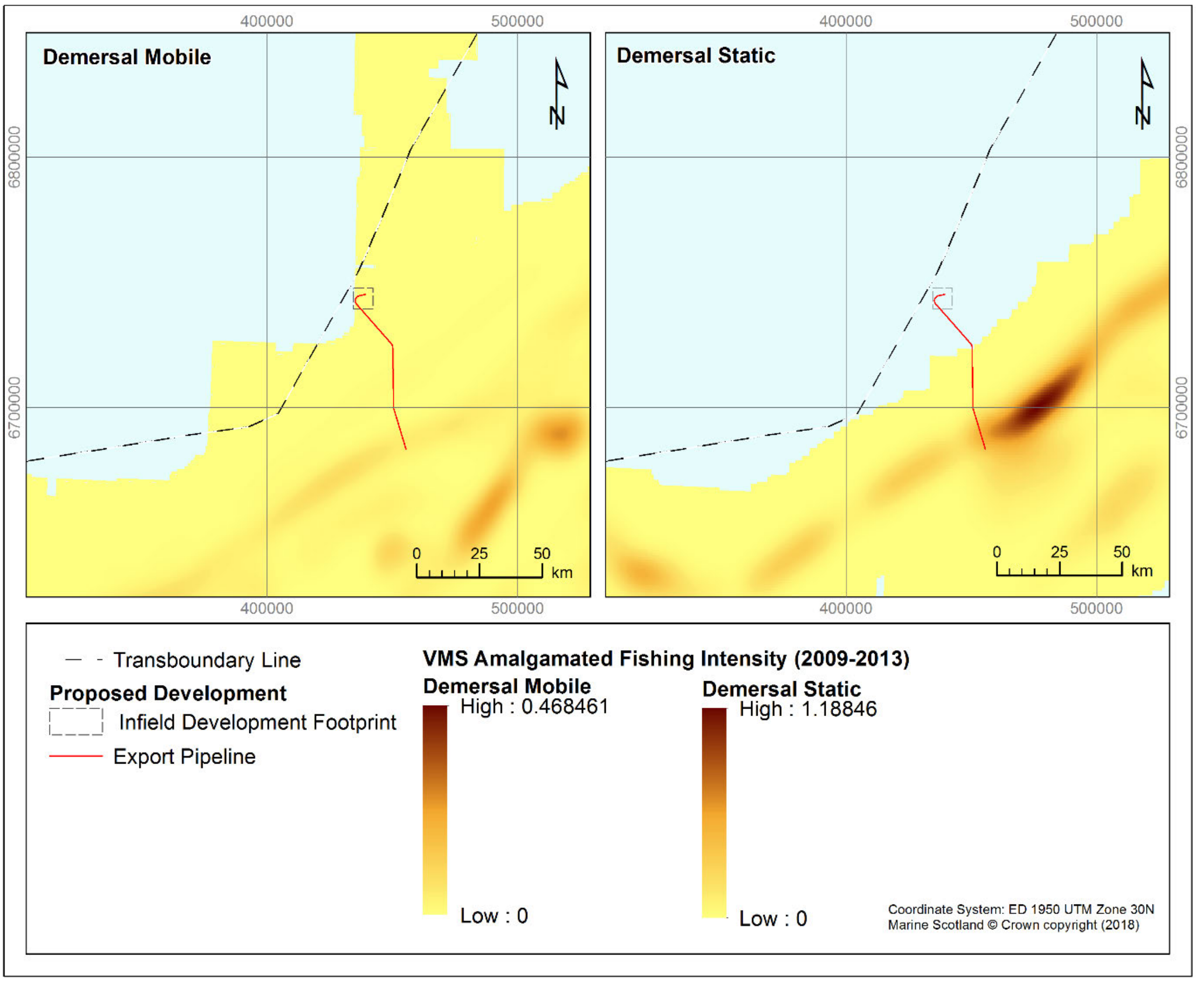

Figure 4.27: Fishing Intensity in the Vicinity of the Cambo Field Development

Source: Kaftas et al., 2012.

Consultation with the Scottish Fishermen's Federation (SFF) confirmed that fishing activity in the direct vicinity of the proposed Cambo Field Development will be limited and will not impact on the Scottish demersal fleet (SFF, pers comm, 2018). Under Regulation (EU) 2016/2336, bottom trawling in waters deeper than 800 m is prohibited in international waters of the Northeast Atlantic. Fishing activity from foreign fishing fleets include Spanish, French, German and Faroese vessels which can fish at depths greater than 800 m. Foreign vessels working at these depths and greater are targeting specific species which are of little commercial value to the Scottish fleet (with the exception of monkfish) (SFF, pers comm, 2018). Data from 2012 show that foreign vessel were actively fishing for less than one week within ICES rectangle 50E5 (Development Footprint location), up to six months along the Pipeline Route (ICES rectangle 50E6) and for over six months within ICES 49E6 (end of Pipeline Route, WOSPS PLEM location) (Marine Scotland, 2021). Data from vessel activity logs taken during the drilling of Appraisal well 204/10a-5 in the Cambo Field between May and August 2018, identified 39 fishing vessels within the area over this time period (Anatec, 2018).

ICES catch data (ICES, 2020) from 2013-2018 for ICES division 27.4a (Shetland area) were interrogated to further understand the fishing activity and species caught in the wider area of the Cambo Development Footprint area for landings in other European countries. The data across all years shows that the species with the highest recorded landings (tonnes per live weight (TLW), in this instance landings of over 10,000 tonnes were used) is Atlantic herring and Atlantic mackerel which were primarily landed in Norway and Denmark. The highest landings for herring being between 116,455 TLW and 152,410 TLW across 2013-2018, and for mackerel being between 35,948 TLW and 135,569 TLW across the same time period. Figure 4.28 and Figure 4.29 shows the fish species with the highest landings across 2013-2018 per country. Other species caught with a landings weight of over 10,000 TLW included horse mackerel, Norway pout, pollock, sandeels and blue whiting.

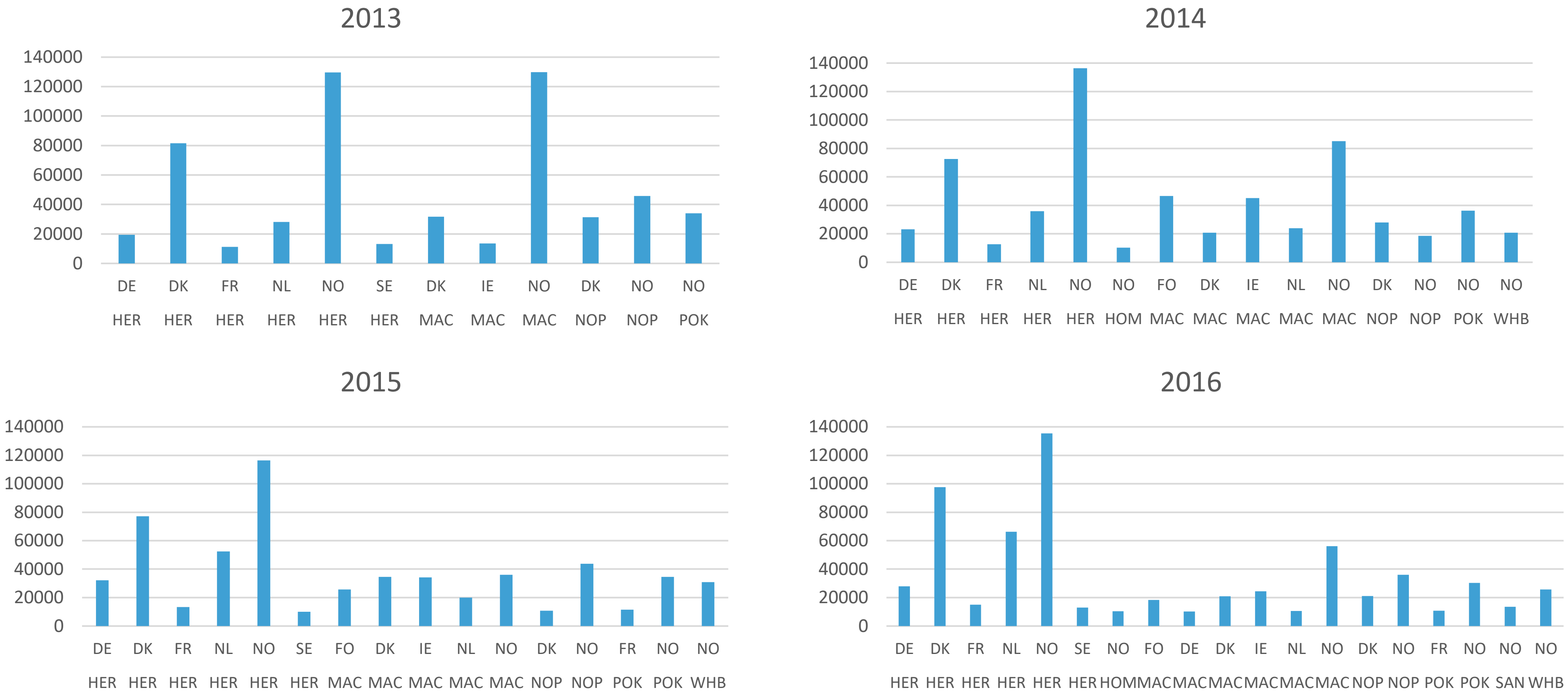

Figure 4.28: Fish Landings in Tonnes Per Species per Country Excluding UK for ICES Rectangle 27.4a across 2013-2016

Source: ICES, 2020.

Key:

HER	Herring	**HOM**	Atlantic horse mackerel	**MAC**	Atlantic mackerel	**NOP**	Norway pout	**POK**	Pollock	**SAN**	Sandeels	**WHB**	Blue whiting		
DE	Germany	**DK**	Denmark	**FO**	Faeroe Islands	**FR**	France	**IE**	Ireland	**NL**	Netherlands	**NO**	Norway	**SE**	Sweden

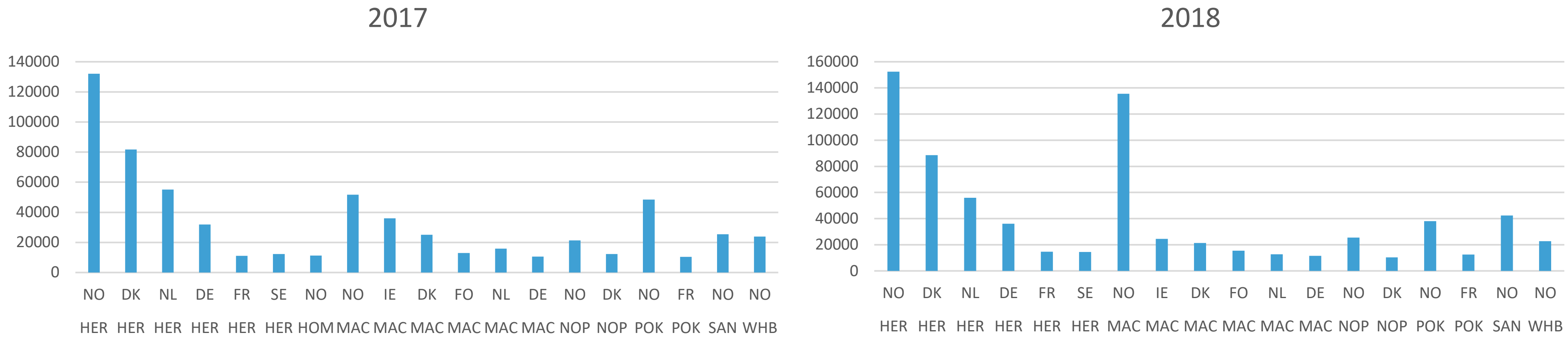

Figure 4.29: Fish Landings in Tonnes Per Species per Country Excluding UK for ICES Rectangle 27.4a across 2017-2018

Source: ICES, 2020.

Key:													
HER	Herring	**HER**	Herring	**HER**	Herring	**HER**	Herring	**HER**	Herring	**HER**	Herring		
DE	Germany	**DK**	Denmark	**FO**	Faeroe Islands	**FR**	France	**IE**	Ireland	**NL**	Netherlands	**NO**	Norway

Figure 4.30 to Figure 4.32 illustrate fisheries landings data, sales value and effort within rectangles 51E6, 50E5, 50E6, 49E4, 49E5 and 49E6 between 2015 and 2019. Figure 4.30 illustrates the landings data for all three species types, the data shows that the majority of landings from the area around the Cambo Field Development were demersal species with far fewer pelagic and shellfish species caught although increases in pelagic landings were noted in 2017 and 2019 largely within 49E6. Figure 4.30 also shows an increase in landings with distance to the continental shelf (Marine Scotland, 2021). Landings data for ICES rectangles 51E6, 50E5 and 49E4 were either no data or data which could not be disclosed. The same was true for pelagic data in 50E6, 49E6 and 49E5 in 2015 and 50E6 in 2016. The total landings of all three species types within the study area between 2015 and 2019 was over 49,500 tonnes, landings per year were relatively constant between the 5 years of review (Scottish Government, 2020a).

Figure 4.31 illustrates the annual sales value of each species within each ICES rectangle. Sales values are strongly correlated with landings, therefore a similar trend occurs with demersal species dominance in value and decreasing sales value with distance from the continental shelf (Scottish Government, 2020a). Like landings, sales value for 51E6, 50E5 and 49E4 were either no data or data which could not be disclosed. The same was true for pelagic data in 50E6, 49E6 and 49E5 in 2015 and 50E6 in 2016. The total sales value of all three species within the study area between 2015 and 2019 was over £87 million. Total sales value per year was relatively constant across the 5 years of review however there was a spike in value in 2019 attributed to the increased landings of pelagic species that year as described above.

Figure 4.32 illustrates the effort in days by UK vessels over 10 m in length using passive, pelagic active or demersal active gears within each ICES rectangle. Like landings and sale value, much of the data could not be disclosed. However, the data available does show the dominance of demersal active gear use, which corresponds to the dominance of demersal landings within the area, as well as passive gear which targets pelagic and demersal species. The total effort of all three types of gears within the study area between 2015 and 2019 was 5,805 days, effort per year was relatively constant between the five years of review although effort for passive gears tended to vary frequently each year (Marine Scotland, 2021). Figure 4.33 illustrates the average effort for different gear types (passive, pelagic active and demersal active) within the proposed development location. As previously discussed, these figures also show low average effort in the deeper channel waters, with an increase in average effort for both passive and active demersal gears increase over the continental shelf, towards the end of the Pipeline route (Scottish Government, 2020b).

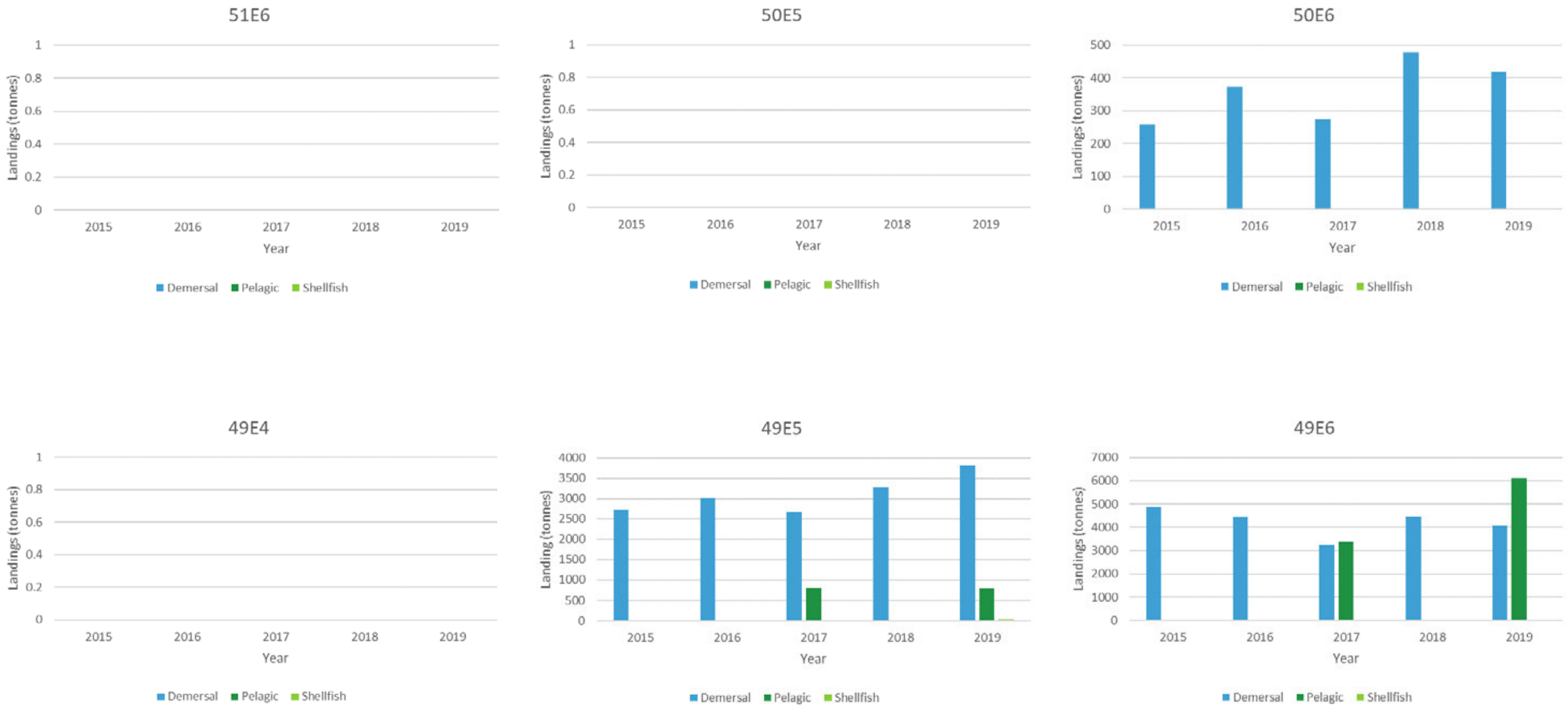

Figure 4.30: Landings (Tonnes) for the Area Around the Proposed Cambo Field Development between 2015 and 2019

Source: Scottish Government, 2020a.

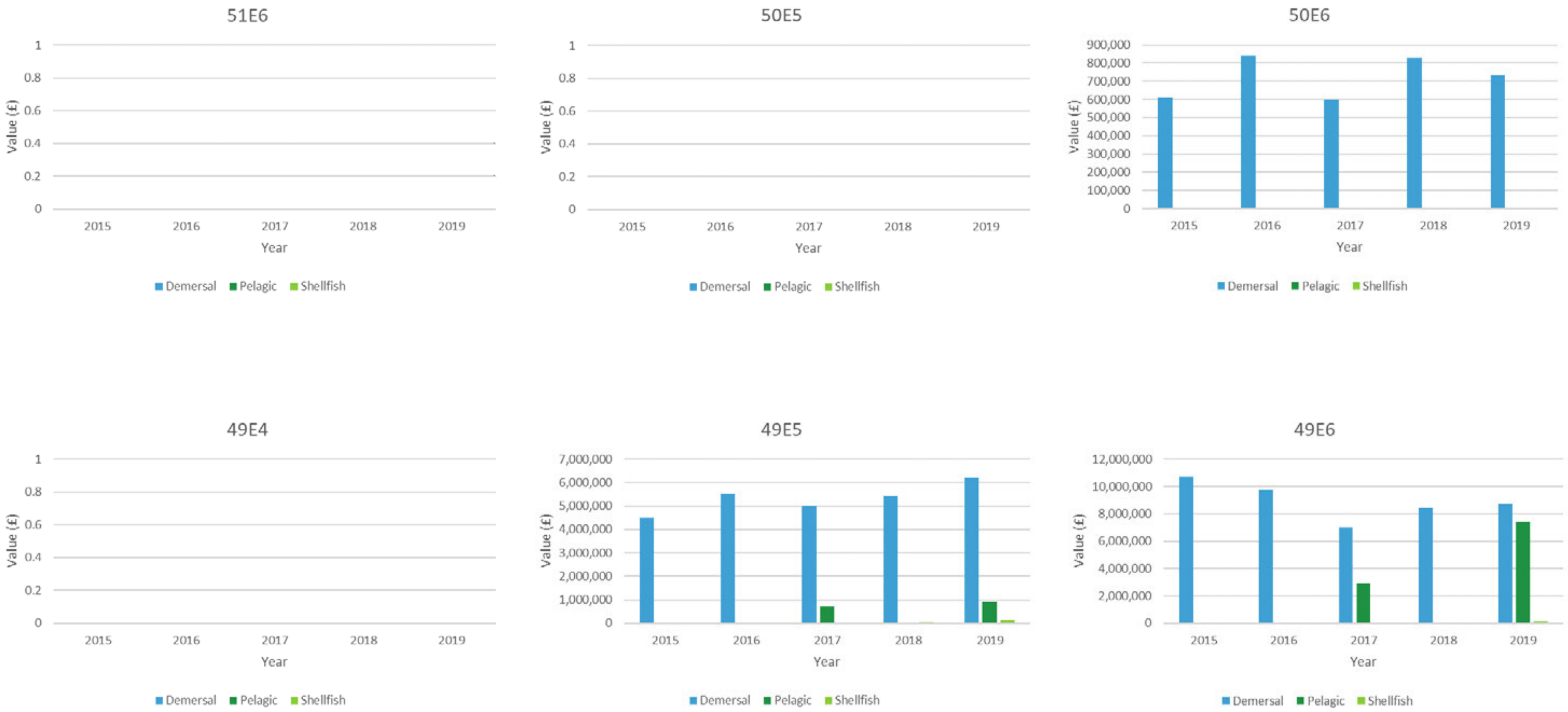

Figure 4.31: Sales Value (£) for Fish Landings in the Area Around the Proposed Cambo Field Development Between 2015 and 2019

Source: Scottish Government, 2020a.

Figure 4.32: Effort (Days) for Different Gear Types Used in the Area Around the Proposed Cambo Field Development Between 2015 and 2019

Source: Marine Scotland, 2021.

Figure 4.33: Average Effort (days) for Different Gear Types in the Area Around the Proposed Cambo Field Development Between 2015 and 2019

Source: Marine Scotland, 2021.

Demersal Fisheries

The main demersal species caught within ICES rectangles 51E6, 50E5, 50E6, 49E4, 49E5 and 49E6 between 2015 and 2019 were gadoids such as saithe, hake, monkfish, ling, cod and haddock. Deepwater species, such as Greenland halibut and redfishes have also been landed from the area (Scottish Government, 2020a). Figure 4.34 illustrates that average demersal landings and sales value decrease with distance going down the continental shelf.

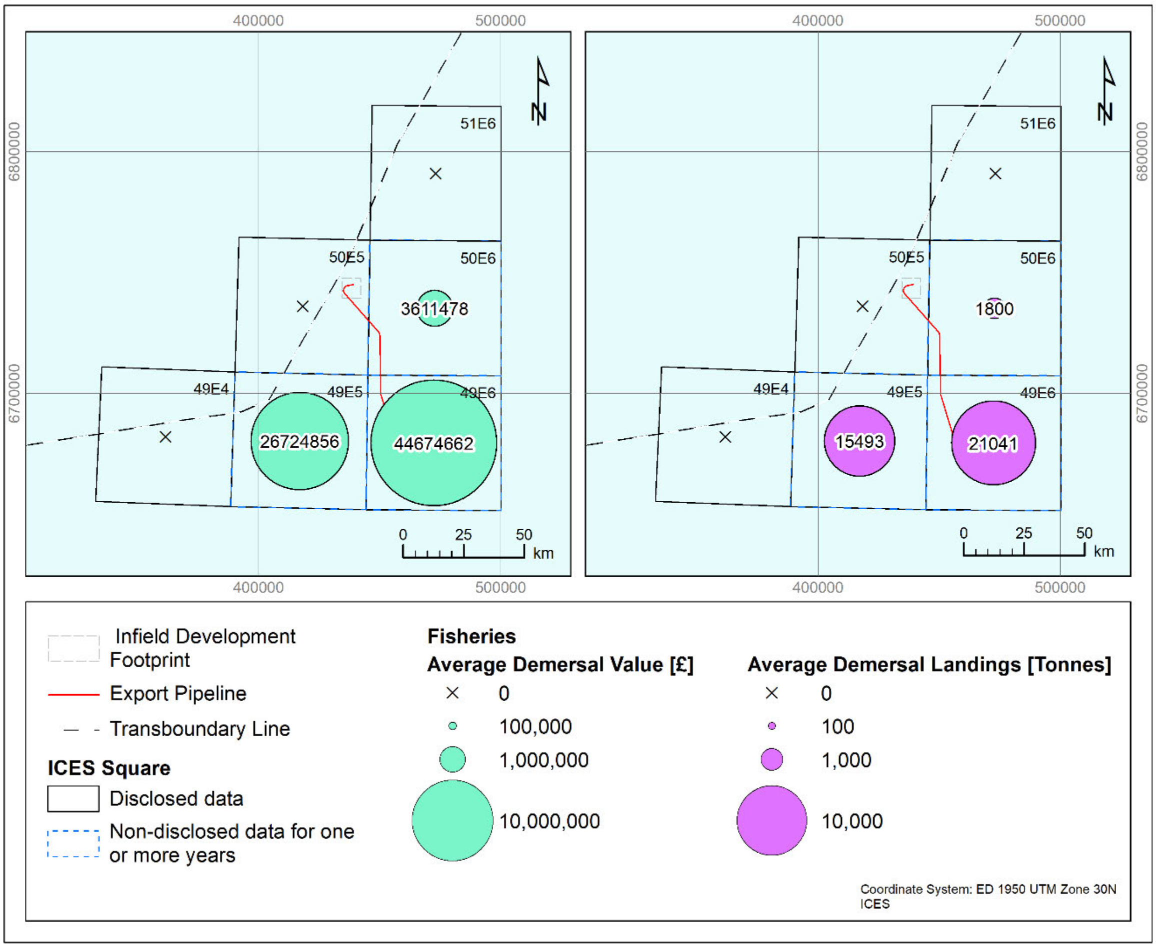

Figure 4.34: Average Demersal Value (£) and Landings (Tonnes) in the Vicinity of the Proposed Cambo Field Development Between 2015 and 2019

Source: Marine Scotland, 2020a.

Fishing effort by UK vessels of more than 10 m in length using demersal active gear between 2015 and 2019 within rectangles 51E6, 50E5, 50E6, 49E4, 49E5 and 49E6 was 2,817 days (Marine Scotland, 2021). Data show a marked decline in the amount of effort within the deep-waters of rectangles 50E6. The economic impact of demersal landings within the same rectangles follows a similar pattern, with demersal sale values increasing towards the continental shelf (Figure 4.35). The demersal sales value of rectangles 51E6, 50E5, 50E6, 49E4, 49E5 and 49E6 to the UK fishing industry between 2015 and 2019 was £75,010,997, with sales value found to increase year on year (Scottish Government, 2020a).

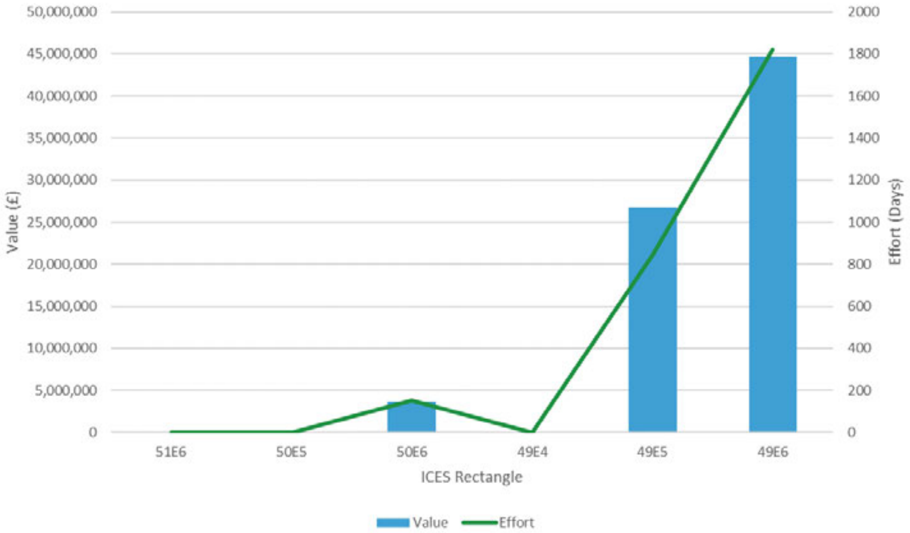

Figure 4.35: Demersal Value (£) and Effort (days) by UK Vessels >10 Length Using Demersal Active Gear in Scottish Waters for the Area Around the Proposed Cambo Field Development Between 2015 and 2019

Source: Scottish Government, 2020a and Marine Scotland 2021.

The demersal inshore fishery around the Shetland Islands is dominated by haddock and cod landings (Scottish Government, 2020a). Many commercial species such as haddock, cod, whiting, monkfish and saithe are found in inshore area during certain times of the year for spawning or as nursery grounds for juveniles.

Pelagic Fisheries

Landings data for pelagic species is limited for the area of interest, with data not disclosed or no data for rectangle 51E6, 50E5 and 49E4. Within rectangles 50E6, 49E5 and 49E6, located over the shelf, data from 2015 and 2019 show very few pelagic species were landed for the majority of the years analysed (Scottish Government, 2020a). However, large increases in pelagic landings were made in 2017 and 2019 from 49E6. The main pelagic species landed is mackerel (Scottish Government, 2020a).

Fishing effort by UK vessels of more than 10 m in length using pelagic active gear between 2015 and 2019 within rectangles 51E6, 50E5, 50E6, 49E4 and 49E5 cannot be disclosed or is given as no data (Marine Scotland, 2021). Fishing effort using pelagic active gear in 49E6 is recorded for 2017 and 2019 which coincides with the increase in pelagic landings within this particular ICES rectangle (Marine Scotland, 2021). The economic impact of pelagic landings within ICES rectangles 50E6, 49E6 and 49E5 follows a similar pattern as landings, with pelagic sale value increasing towards the continental shelf. The pelagic sales values of these ICES rectangles to the UK fishing industry between 2015 and 2019 was £12,021,909, with sales value highly variable throughout this period (Scottish Government, 2020a). Figure 4.36 illustrates that pelagic landings and value increase in rectangles located over the continental shelf.

The herring fishery operates in more inshore waters, with the pelagic fleet targeting the herring spawning ground off the Shetland Islands (DECC, 2016). Inshore landings around the Shetland Islands are dominated by herring and mackerel (Scottish Government, 2020b).

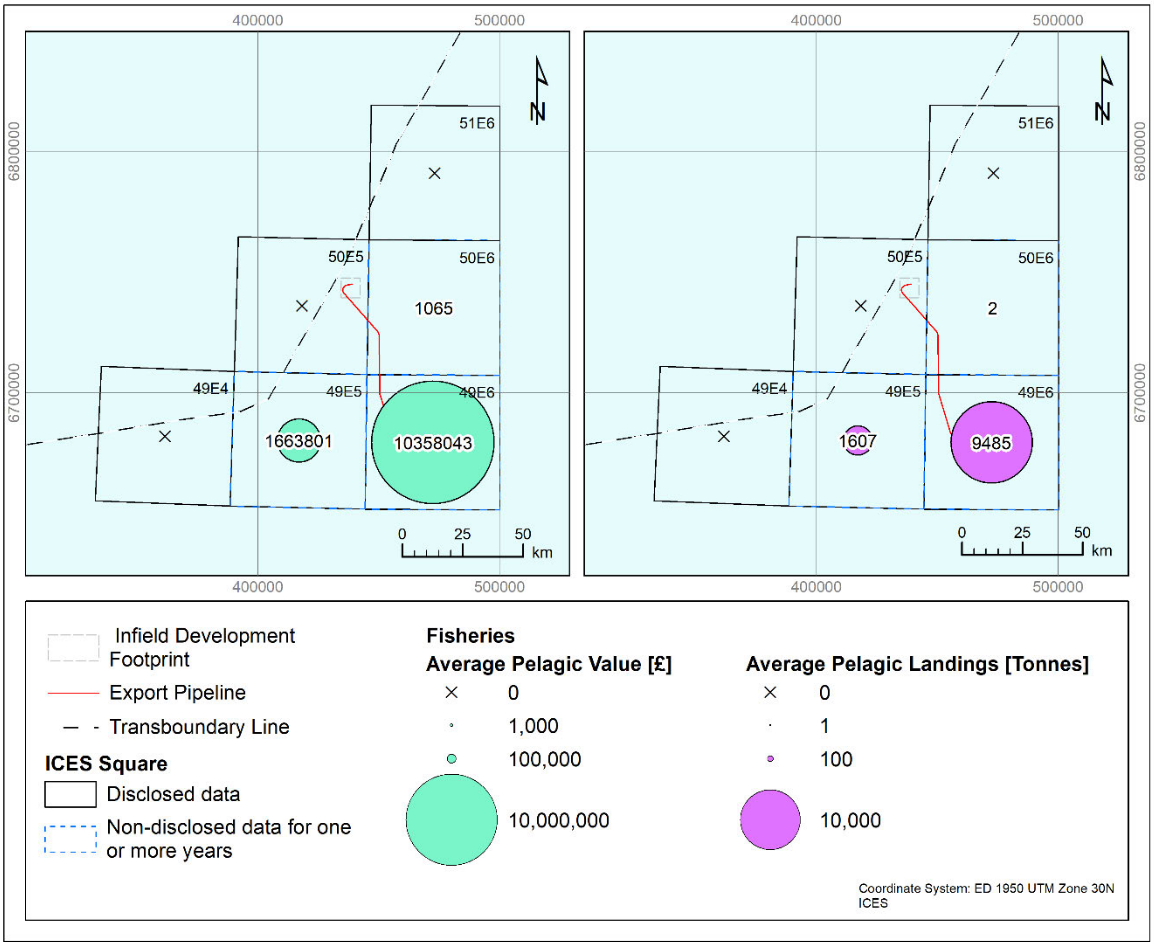

Figure 4.36: Average Pelagic Value (£) and Landings (Tonnes) in the Vicinity of the Cambo Field Development Between 2015 and 2019

Source: Scottish Government, 2020a.

Shellfish Fisheries

Landings data for shellfish species is limited for the area of interest, with data not disclosed or no data for rectangle 51E6, 50E5 and 49E4. Within rectangles 50E6, 49E5 and 49E6, located over the shelf, data from 2015 to 2019 show very few shellfish species were landed, with the largest volumes of landing commonly originating from rectangle 49E6 (Figure 4.37; Scottish Government, 2020a). The main shellfish species landed were crabs and squid (Scottish Government, 2020a).

The economic impact of shellfish landings within rectangles is limited, with shellfish sale value increasing towards the continental shelf (Figure 4.37). Between 2015 to 2019 the Scottish shellfish sales value from within 50E6, 49E5 and 49E6 was £551,102 (Scottish Government, 2020a).

Inshore shellfish fisheries are present around the Orkney and Shetland islands, where scallops are the targeted species, along with crabs and whelks (Scottish Government, 2020b). Important shellfish dredging grounds for king scallop and important shellfish creeling grounds for crab and lobster have been designated around the inshore areas of the Shetland Islands (Marine Scotland, 2021).

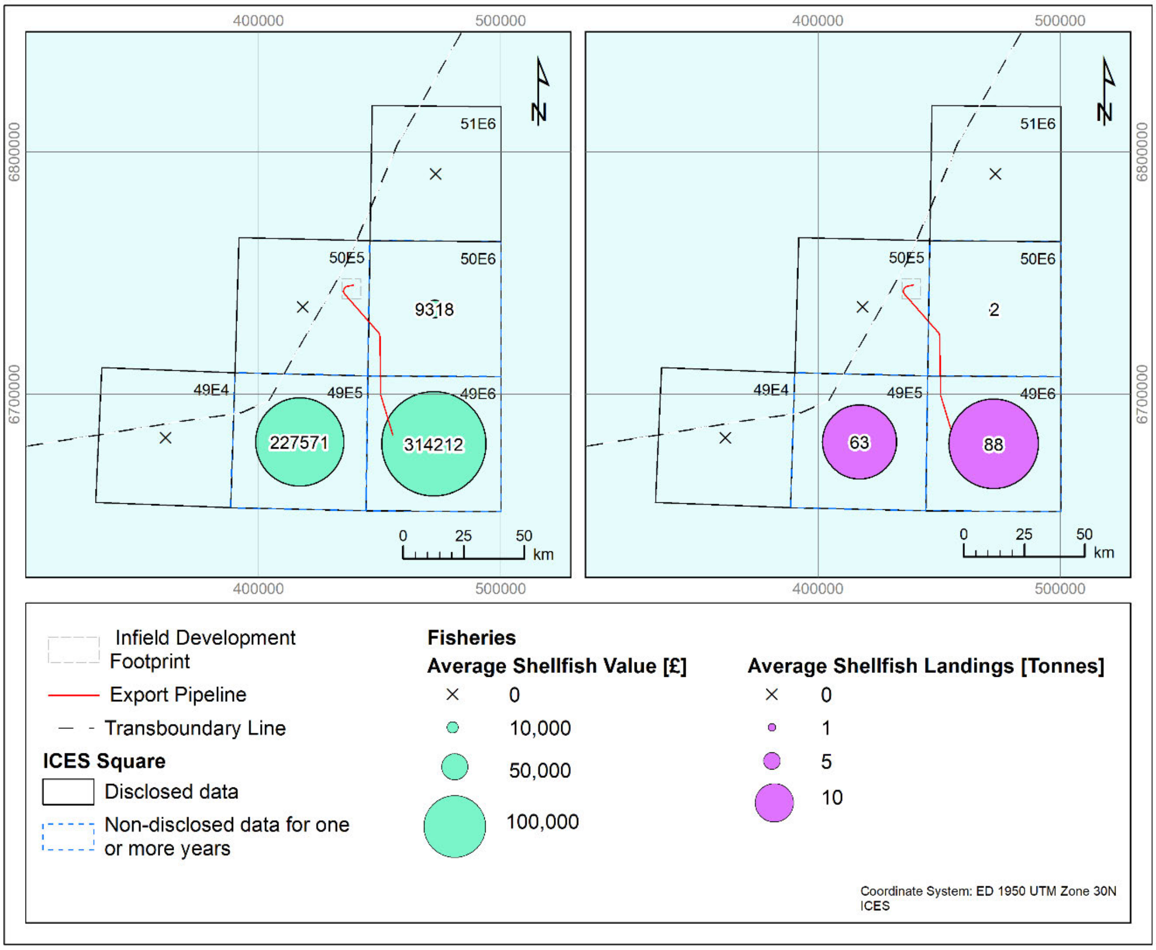

Figure 4.37: Average Shellfish Value (£) and Landings (Tonnes) in the Vicinity of the Proposed Cambo Field Development between 2015 and 2019

Source: Scottish Government, 2020a.

4.6.2 Aquaculture

Numerous fish farms are distributed across the Orkney and Shetland Islands (Figure 4.38). The many voes and inlets around the islands’ coastlines are ideal for finfish cultivation, providing shelter and appropriate current conditions (Scotland’s Aquaculture, 2021; Marine Scotland, 2021). Aquaculture therefore contributes an important component to the local economy. While salmon is the main species cultivated in this area, aquaculture in the region has diversified into producing species such as cod and halibut in recent years (Scotland’s Aquaculture, 2021; Munro, 2020a). In 2019, 36,141 tonnes of farmed Atlantic salmon were produced from Shetland and 17,758 tonnes of salmon were produced from Orkney (Munro, 2020a). Salmon cultivation begins in freshwater hatcheries, before the fish reach the smolt stage at around eight to twelve months, when they are transferred to seawater cages. In Shetland, small scale seaweed cultivation projects have been established to investigate the feasibility of growing and harvesting seaweed on a commercial scale (NAFC, 2021).

Shellfish are also cultivated in this region, with approximately 137 shellfish sites on Shetland and 5 on Orkney (Munro, 2020b). Most of Shetland’s shellfish farms are situated on the moderately exposed west coast of the mainland, the majority of which produce mussels. In 2019, a total of 5,324 tonnes of mussels were produced in Shetland, representing 79% of the total production of mussels in Scotland (Munro, 2020b). Mussels are typically cultured on rafts or ropes and nets hung in the water column.

A small amount of native and Pacific oysters, as well as scallops, are also cultivated on Shetland. Oysters are typically grown in netted bags fastened onto trestles, or on the seabed on racks (Scotland's Aquaculture, 2021). Shellfish farms on Orkney are mainly located around the mainland. Again, these chiefly produce mussels. However, in 2019, no shellfish was produced (Munro, 2020b).

The Scottish Government has introduced a package of measures to ensure the continued protection and improvement of shellfish growing waters in Scotland. Numerous Shellfish Water Protected Areas have been established around the coasts of Shetland and Orkney, with each area having environmental objectives as part of the river basin management planning process (Figure 4.38; Marine Scotland, 2021). The closest Shellfish Waters Protected Area is a site near Walls on the Shetland Islands located approximately 121 km from the pipeline route (Marine Scotland, 2021).

Aquaculture is also widespread in the Faroe Islands, with farmed salmon representing half of the country's export value (Faroe Islands, 2018). The majority of fish produced are Atlantic salmon, along with some trout and small amounts of other species such as cod (Vinnhusid, 2018). Young salmon are raised in tanks on land before being moved to seawater cages in the many firths around the Faroese coastline.

Aquaculture is also of importance to the economy of Norway. Numerous finfish farms producing species such as Atlantic salmon, rainbow trout, Arctic char, Atlantic halibut and cod from seawater cages are present along the entire coastline. A smaller number of shellfish farms are also present, mainly producing blue mussels, with smaller amounts of great Atlantic scallop, oysters, lobsters and crayfish (Norwegian Directorate of Fisheries, 2018). In Norway, algae is a new priority in aquaculture, with 15 companies licenced to harvest algae.

4.6.3 Oil and Gas Infrastructure

The waters of the West of Shetland region are relatively undeveloped in terms of oil and gas infrastructure, in comparison with the neighbouring northern North Sea (Figure 4.39). The BP operated Alligin, Loyal, Schiehallion and Foinaven fields, located at 54 km distance,south of the proposed Development Footprint. These BP Fields are tied back via the WOSP to the BP Clair platform, 89 km to the east of the proposed Development Footprint (OGA, 2021). In turn, the Clair field produces via pipeline to the Sullom Voe Terminal in the Shetland Islands. The Total owned Tormore and Laggan fields are located 50 km and 65 km east of the proposed Development Footprint, respectively, and also produce back to the Sullom Voe Terminal by pipeline. The Edradour and Glenlivet fields also tie in to this pipeline. Various oil fields in the development stage, including Rosebank, are also located in the wider area around the proposed Cambo Field Development location (OGA, 2021).

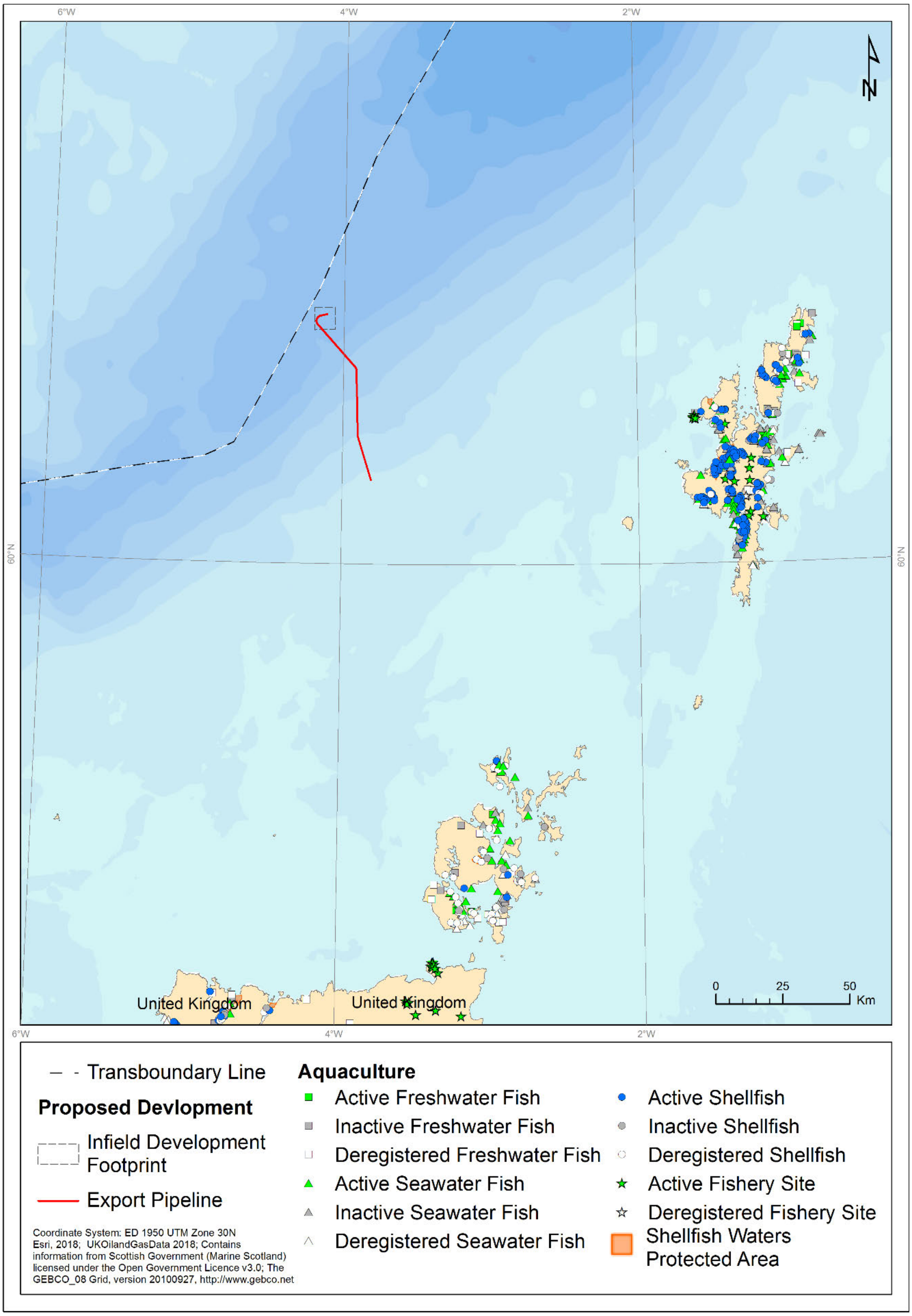

Figure 4.38: Aquaculture Sites

Source: Marine Scotland, 2021.

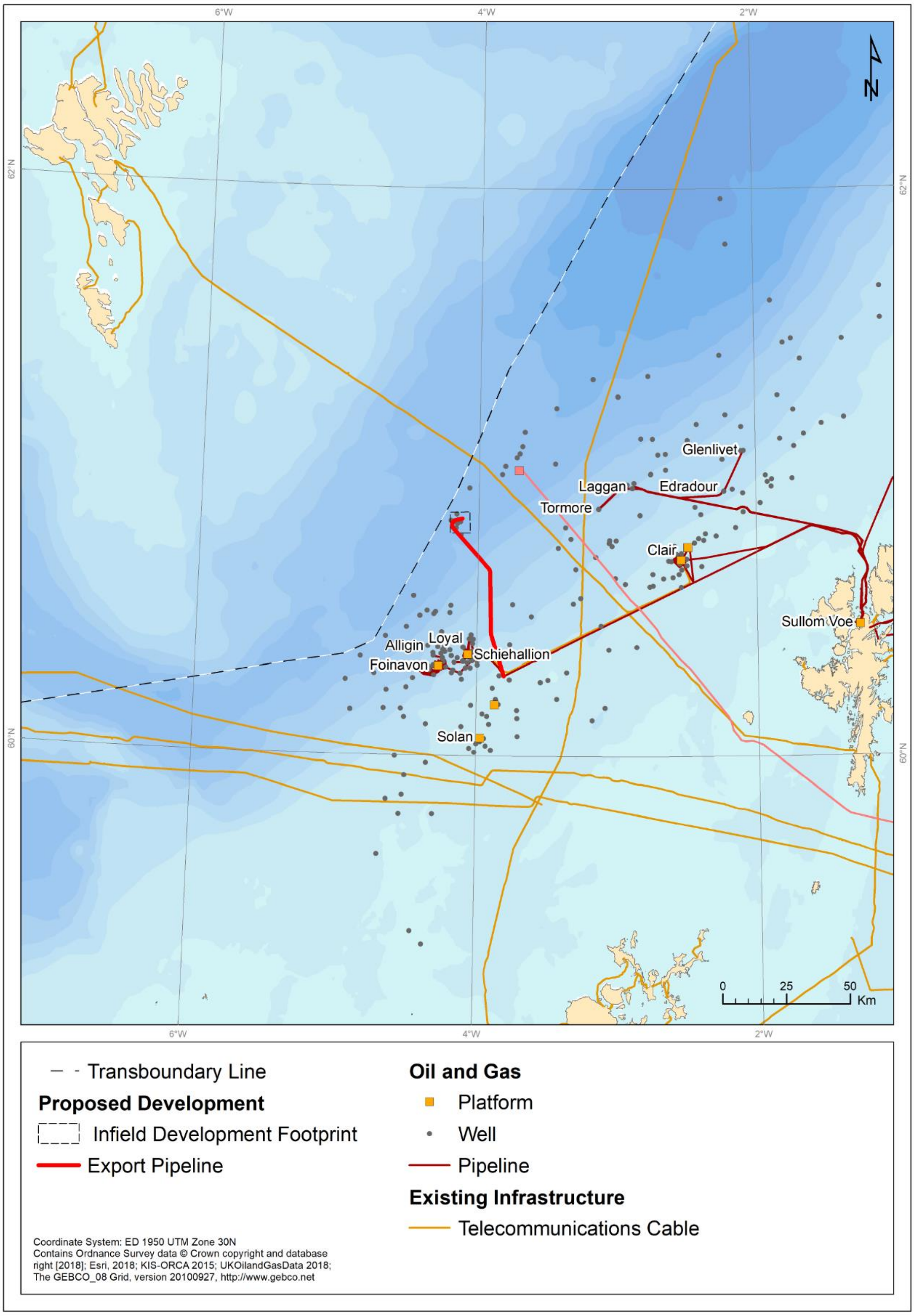

Figure 4.39: Oil and Gas Infrastructure

Source: OGA, 2021.

4.6.4 Shipping

The Faroe-Shetland Channel experiences very low densities of shipping traffic (Hartley Anderson and University of Aberdeen, 2003). Data from Automatic Identification Systems (AIS) of shipping traffic between 2012 and 2014, found the average weekly density of tankers, non-port service craft and passenger, cargo and fishing vessels transiting the Cambo Field Development location to be two transits or less (Marine Scotland, 2021).

A vessel traffic study was commissioned in 2017 within the Cambo area (Block 204/10). This study identified nine shipping routes which would pass within 18.5 km (10 nm) of the Cambo Field Development location. It was estimated that these routes were used by a total of 302 vessels each year, corresponding to an average of one vessel per day. The majority of this traffic was made up of cargo vessels, with the predominant size range being 1,500 to 5,000 dead weight tonnes. One of the drill centres would be located within the Esbjerg to Faroes route which is used by an estimated 42 vessels per year (Anatec, 2017). This corresponds to between three and four vessels per month passing along this route. The Baltic to Faroes shipping route passes nearby to two of the FPSO moorings. This route is used by an estimated 14 vessels per year, corresponding to one or two vessels per month (Figure 4.40; Anatec, 2017).

Vessel activity logs were taken during the drilling of Appraisal well 204/10a-5 in the Cambo Field between May and August 2018. These identified the presence of 161 vessels within the Cambo area during this time, with the vast majority being cargo vessels (64), fishing vessels (39), tankers (22), and passenger vessels (16), with a small number of other vessels (20) transiting the area (Anatec, 2018). The 2019 fishing vessel analysis recorded the presence of 31 vessels, however, none were recorded within 10 nm of the proposed Cambo Field Development (Anatec, 2019).

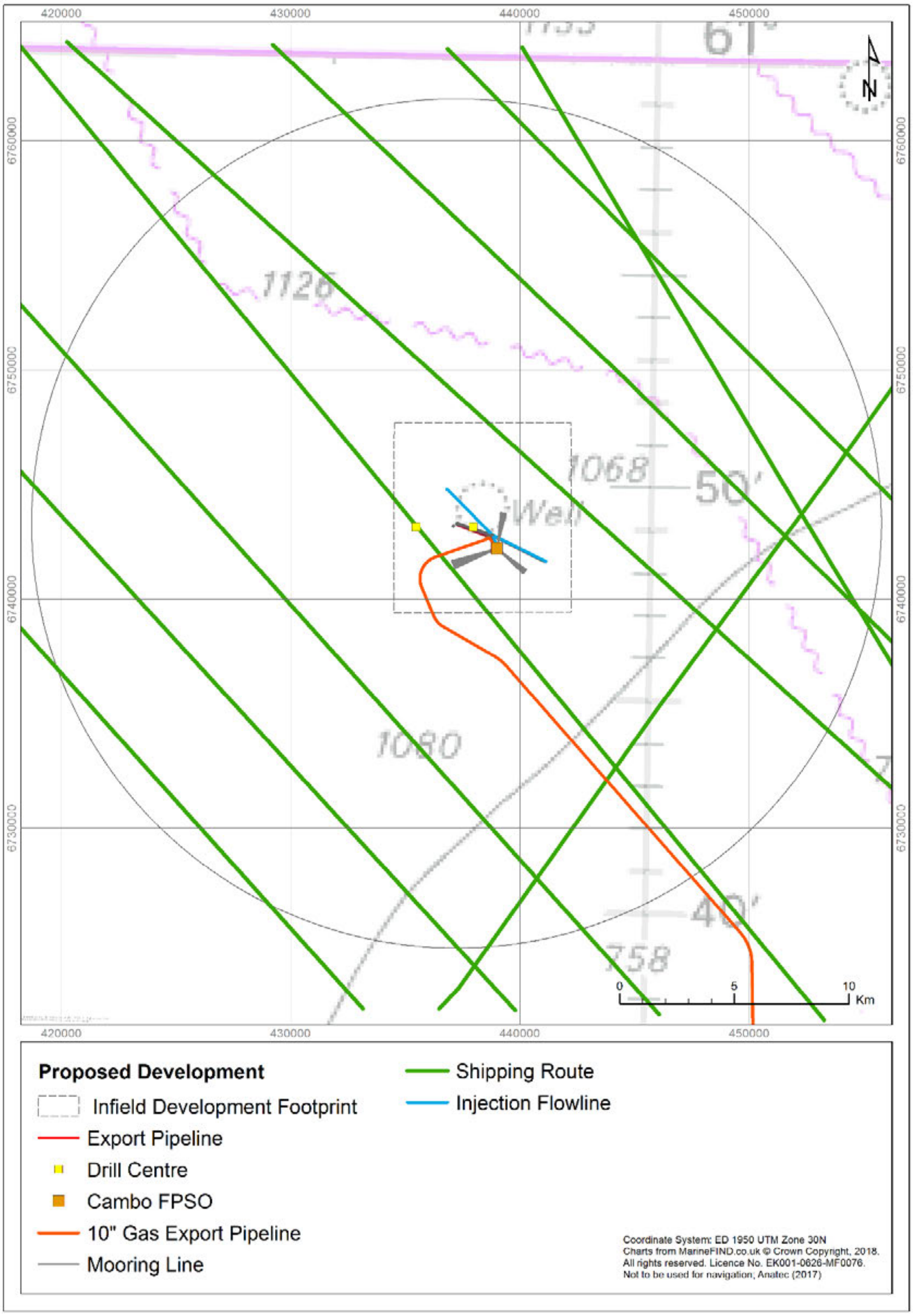

Figure 4.40: Shipping Routes

Source: Anatec, 2017.

4.6.5 Military Activity

No practice and exercise areas (PEXA) have been highlighted in the vicinity of the proposed Cambo Field Development (Marine Scotland, 2021). As required by Licence conditions, the Ministry of Defence (MoD) was contacted and it was confirmed that there are no safeguarding concerns within the area of the proposed development.

4.6.6 Wrecks and Archaeology

There are no identified wrecks or sites of archaeological interest within the proposed development location (Marine Scotland, 2021).

4.6.7 Submarine Cables

The Faroese Telecom's SHEFA-2 subsea cable passes within 20 km to the northeast of the Development Footprint (Figure 4.39). SHEFA-2 is a fibre optic submarine cable stretching 825 km from Hvítanes, Faroe Islands to Manse Bay, Banff in Scotland via Shetland Islands and Orkney Islands. The SHEFA-2 cable is the main communications link to the Faroe Islands and provides connectivity to West of Shetland oil and gas platforms as well as to Shetland Islands and Orkney Islands communities (KIS-ORCA, 2021). The closest subsea cable to the proposed pipeline route is the telecommunications line between Schiehallion and Claire, which runs alongside WOSPS at the end of the proposed pipeline route (KIS-ORCA, 2021). The Havfrue Cable System, a subsea fibre-optic cable connecting the Unites States of America, Denmark, Ireland and Norway, also follows this route (KIS -ORCA, 2021).

4.6.8 Offshore Renewables Energy

There are no proposed offshore renewable energy developments west of Shetland (Marine Scotland, 2021). A tidal energy development currently operates in Yell Sound, Shetland approximately 167 km east from Cambo (Marine Scotland, 2021). A possible development site for offshore wind has been identified on the eastern side of Shetland approximately 209 km from the Cambo development (Scottish Government, 2020c).

4.7 Summary

Table 4.6 provides a summary of the key environmental sensitivities identified throughout this chapter for the proposed Cambo Field Development.

Table 4.6: Seasonal Variation of Key Environmental Sensitivities

	Environmental Sensitivities											
	J	F	M	A	M	J	J	A	S	O	N	D
Plankton	L	L	L	L	H	H	L	L	M	M	M	L
	Phytoplankton productivity in the West of Shetland area is highest in the spring and autumn with a major peak around May and a lesser peak in August. Zooplankton productivity follows a similar pattern, but the blooms follow approximately one month later.											
Benthos	L	L	L	L	L	M	H	H	H	H	M	M
	Life cycles of organisms within the seabed communities are not well understood. Based on the characteristic species, a spawning period for those with a planktotrophic life phase and larger macrofaunal species is thought to be between July and October, with possible winter recruitment sensitivity in November or December.											
Fish and shellfish	H	H	VH	VH	VH	H	L	L	L	L	H	H
	There are no spawning grounds which fall directly within the Development Footprint, however, spawning grounds for blue whiting are found in adjacent ICES rectangles. The Pipeline route will pass through predicted spawning grounds for Norway pout and sandeel. The Cambo Field Development lies within in a year round high intensity nursery ground for blue whiting.											
Marine mammals	L	L	H	L	H	H	H	H	H	H	M	M
	The waters of Faroe-Shetland channel support a number of important and diverse populations of both resident and migratory marine mammals. Species recorded within the Cambo Field Development include, long-finned pilot whale, killer whale, white-beaked dolphin, white-sided dolphin, Risso's Dolphin, fin whale, sei whale, sperm whale and humpback whale. Hooded seals regularly visit the waters West of Shetland in autumn and winter.											
Seabirds	L	L	M	M	M	L	L	L	M	M	M	L
	Birds will generally move through the Faroe-Shetland Channel in autumn on passage to winter breeding grounds, or in spring on route to breeding colonies. Seabirds are present throughout the year in the Faroe-Shetland Channel, with mostly low to moderate densities found in the proposed Cambo Field Development. However, the fulmar, were found in high densities in the Cambo Field Development area during September.											
Coastal conservation	H	H	H	H	H	H	H	H	H	H	H	H
	Most of the coastal conservation areas are designated for the presence of birds and seals. The Shetland and Orkney Islands are of international ornithological significance, particularly as seabird breeding sites, and as such many coastal sites on the islands are designated as SPAs and IBAs. There are also a number of SAC designated for major common seal breeding sites and for the otter population.											
Offshore conservation	H	H	H	H	H	H	H	H	H	H	H	H
	The Development Footprint is located 16 km from the Faroe-Shetland Sponge Belt NCMPA, with the pipeline route traversing through the NCMPA for 34.8 km. The closest offshore SAC to the proposed Cambo Field Development is the Wyville-Thomson Ridge SAC, located approximately 117 km to the southwest.											
Other users of the sea	L	L	L	L	L	L	L	L	L	L	L	L
	Due to the remoteness and deepwaters of the Cambo Field Development, activities by other users is low.											
	No Data	▨	**No Animals**	**L**	**Low**	**M**	**Moderate**	**H**	**High**	**VH**	**Very High**	

JNCC, MS and CEFAS have assessed all UKCS licence Blocks for their environmental sensitivity throughout the year for seismic surveys and drilling operations, particularly with regard to fish spawning for seismic surveys and seabird vulnerability to oil pollution for drilling operations (OGA, 2019). No periods of concern have been identified for drilling operations within the proposed Development Footprint. A period of concern for seismic surveys during January and February and November and December has been identified for Blocks 205/16 and 205/21 (OGA, 2019).

Section 5

Identification of Potential Impacts

5. IDENTIFICATION OF POTENTIAL IMPACTS

This Section describes the scoping methods used to identify the environmental interactions and concerns associated with the proposed Cambo Field Development that could potentially cause a significant environmental impact. The following three scoping methods were used:

- Informal scoping consultation with the statutory consultees and other stakeholders;
- An environmental issues identification (ENVID) workshop by members of the project team;
- Consideration of national policies and guidance, including:
  - The Scottish National Marine Plan (NMP) policies relating to the potential impacts from oil and gas activity;
  - Assessment of the sensitive features of the local environment and corresponding relevant pressures from the proposed development based on Feature Activity Sensitivity Tool (FEAST);
  - The JNCC's formal conservation advice for the Faroe-Shetland Sponge Belt Nature Conservation Marine Protected Area (NCMPA).

The purpose of these scoping activities was to identify the main environmental concerns at an early stage of the project, so that they could be addressed and mitigated against during the environmental impact assessment (EIA) process.

5.1 Informal Stakeholder Consultation

SPE has carried out informal consultation with a number of key stakeholders, including the following statutory consultees:

- The Offshore Petroleum Regulator for Environment and Decommissioning (OPRED);
- Marine Scotland;
- Joint Nature Conservation Committee (JNCC).

As part of the early consultation process, a Scoping Report (Ref: 172865-R-002(03)) was sent to all three statutory consultees, and followed up with a meeting with OPRED, Marine Scotland and JNCC on 23 March 2018, in which SPE presented an overview of planned activities for the proposed Cambo Field Development and invited the consultees to provide any comments or concerns they might have in relation to the proposed operations.

A separate meeting was held between SPE and the Scottish Fishermen's Federation (SFF) on 22 March 2018. Subsequently, a copy of the Scoping Report was also sent to SFF for comment.

A full overview of all comments and feedback received during the informal stakeholder consultation and how these are addressed in the Environmental Statement (ES) is provided in Appendix 4. The stakeholder comments relating directly to impacts that are *potentially significant* are summarised below.

5.1.1 OPRED Comments Relating to the Assessment of Potentially Significant Impacts

The following OPRED comments refer to topics that should be scoped in or out of the impact assessment:

- Routine chemical use and discharge to sea during operation do not need to be assessed within the ES but they should be acknowledged and an overview of how this will be managed incorporated in the ES i.e. through the submission of environmental permits Master Application Template (MAT) and Subsidiary Application Templates (SAT) applications (Sections 9 and 10);

- With regard to produced water it is noted that the intention is to discharge overboard. SPE should note the OPRED expectation is for the re-injection produced water where practicable. Where not technically possible/desirable then a robust justification for not injecting must be provided (Section 2);
- In the event that there is overboard discharge of produced water SPE should note that Oil in Water (OiW) limit is likely to be less than 30mg/l and the produced water treatment system should be designed to achieve as low a concentration as practicable in line with the principles of BAT (Section 10);
- In order to support any conclusions on the impact of drilling discharges relevant modelling should be provided and any discharges of cement should be minimised and fully justified (Section 9);
- If well testing may be undertaken then this should be scoped in (no well testing is planned);
- MODU, Infrastructure installation activities and FPSO combustion emissions should be scoped in (Section 8);
- Any venting of unburned hydrocarbons should be scoped into the ES (Section 8);
- Noise emissions from the FPSO and MODU should be considered. Where piling is required then this should also be scoped in (Section 11). Similarly, if there is any seismic activity to be undertaken such as Vertical Seismic Profiling (VSP) then this should also be scoped in. (No seismic activity, such as VSP is planned);
- It is noted that the gas export pipeline is to be laid on the seabed with minimal rock dumping. The route and intended method of pipeline installation should be justified in the ES and the Department would emphasise that any rock deposits should be the minimum necessary to achieve the required protection/stability of the pipeline. The worst-case rock deposits should be discussed within the ES (Section 7);
- The presence of the FPSO and 2 × production centres (referred to as Drill Centres in this ES) (and the temporary presence of MODU and support vessels) should be scoped in as per Section 3.2.6 and 3.4.3.4 of the EIA guidance. Where it is intended that there are additional 500 m safety zone around production centres, wellheads etc then these should also be scoped into the ES (Section 7);
- Both MODU and FPSO anchor impact need to be assessed, in addition to the disturbance impact of the other infrastructure. This should include the worst-case number of FPSO anchors;
- Consideration should be given to cumulative effects e.g. potential impacts upon Faroe-Shetland Sponge-Belt NCMPA as per Section 3.2.12 of the EIA guidance (Section 7 and Section 9);
- The risk and potential impact of failure of operational equipment or control systems, the precautions to prevent these occurring and a description of how these will be managed should be provided as per Sections 3.2.6 and 3.2.10.2 of the EIA guidance (Section 13);
- A Major Environmental Incident (MEI) assessment will be required which incorporates the worst-case well blowout and total FPSO inventory as per Section 3.2.10 of the EIA guidance (Section 13);
- Section 4.4 of the Scoping Study states that the $250 million OPOL cover limit per incident is sufficient for most wells with only a small number of wells having the potential to exceed this. It is understood that none of the Cambo wells have the potential to exceed the OPOL limit but confirmation of this should be included (Section 13);
- The ES will need to consider natural disasters (at a high level) as per Section of 3.2.10.2 of the EIA guidance (Section 13);
- Waste - while detailed information is not required, wastes and waste management should be described at a high level (Section 12);

- It is noted that there is no reference to decommissioning intentions. While there are no requirements to provide detailed information at the ES stage, higher level considerations/design intentions should be addressed in line with Section 3.2.10.2 of the EIA guidance (Section 3).

5.1.2 Marine Scotland Comments Relating to the Assessment of Potentially Significant Impacts

The following Marine Scotland comments refer to topics that should be scoped in or out of the impact assessment:

- It is advised that cementing operations are detailed (Section 3) and associated environmental/ socio-economic impacts assessed in the ES (Section 9);
- The detailed assessment of chemical usage will correctly be deferred to the chemical permitting stage, however, given that produced water is to be discharged from this development, and given the waxy nature of the crude (as highlighted in the scoping meeting on 23 March 2018) an upfront overview of any potential concerns from a chemical discharge perspective, is advised (Section 10);
- Marine Scotland understand that the gas export pipeline is likely to be surface laid. Marine Scotland would expect justification in the ES as to the chosen pipeline installation method. It is advised that the installation method of other pipelines in the vicinity is also highlighted in support of the chosen method (Section 7);
- It is understood that rock protection may be required for the pipeline and it is advised that the worst-case volumes and locations of protective material are included in the ES (Section 3.6);
- It is advised that the local geo-morphological features are also considered when assessing any requirement for protective material and the potential for future free spanning of the pipeline is taken into account (Section 7);
- The use of long (2.5 km) polypropylene ropes in the mooring system of the Floating Production Storage and Offload (FPSO) vessel was discussed in the meeting on 23rd March 2018. Marine Scotland highlighted that due to lack of a metallic element, this rope can be evaded by sonar detection. Whilst fishing effort is not considered to be significant in this area, Marine Scotland would ask that this issue is discussed further with the SFF and that appropriate, proportionate mitigation is considered. Marine Scotland have been made aware in the past of transponders being fitted to each mooring line to allow fishing boats to detect the moorings (Section 7);
- It is advised that the cumulative footprint of the development is quantified and compared to the area of the NCMPA (Section 7);
- It is recommended that the ES considers decommissioning upfront and details how all installed infrastructure/protective material would be removed should this be the policy in place at that time (Section 3.7).

5.1.3 JNCC Comments Relating to the Assessment of Potentially Significant Impacts

The following JNCC comments refer to topics that should be scoped in or out of the impact assessment:

- Whilst JNCC appreciates that not all of the detailed project design will be finalised at the time of ES submission, JNCC notes that best practice would not be to submit subsequent applications where, for example, stabilisation / protection material requirements are incrementally increased. The worst-case scenario should be assessed in the ES to enable a meaningful assessment of the whole environmental impact of the project to be undertaken (Section 2 and Section 3);
- The proposed Pipeline route from the Cambo Field Development is currently projected to interact with the Faroe Shetland Sponge Belt Nature Conservation Marine Protected Area (NCMPA). The

ES should contain relevant survey and feature sensitivity information which can be used to assess if the proposed operations are capable of affecting, other than insignificantly, the features for which the site is designated. Any conclusions should be clearly justified and audited within the ES. If the proposed operations are capable of affecting the designating features then the ES should contain an evidence based complete assessment, against the sites conservation objectives and provide details of any mitigation which will be used to minimise impact. The contribution of the Cambo Field Development to the anticipated cumulative impacts effecting the Faroe Shetland Sponge Belt NCMPA should also be considered. The impacts must be assessed across all relevant features of the site and consider all of the Conservation Objectives (Section 4, Section 7 and Section 9);

- West of Shetland is considered an area of importance for marine mammals. JNCC recommends that this is recognised within the ES and that impacts including, but not limited to noise, potential changes in food distribution are considered within the ES (Section 11).

5.1.4 SFF Comments Relating to the Assessment of Potentially Significant Impacts

The following SFF comments refer to topics that should be scoped in or out of the impact assessment:

- The SFF highlighted that there is a lot of fishing activity up and down the deepwater ridge [i.e. the edge of the continental shelf]. The load bearings of the pipe need to be able to tackle the ‘hit’ from any trawling/fishing gear. Pipeline protection needs to be considered (Section 2, Section 3 and Section 7).

5.2 The ENVID Workshop

An ENVID workshop is a scoping exercise during which members of the project team identify all potential interactions of the proposed development with the environment and score their potential environmental impacts. The proposed Cambo Field Development ENVID was attended by members of the project team from SPE, advisors from Baker Hughes (BHGE) and Ocean Installer Ltd (OI), who provide integrated services in support of the Cambo Field Development, as well as by environmental consultants from Fugro.

All proposed development operations which may interact with the environment were identified during the workshop and divided into the following three categories:

- Subsea and pipeline installation and operation;
- FPSO installation and commissioning;
- Drilling and completion.

These activities are termed 'environmental aspects'. The source and pathway of each environmental aspect was defined, and the receptor identified. All aspects identified were then scored against the environmental receptors to determine whether their impact would require further detailed assessment and appropriate mitigation in the ES. The effects of each environmental aspect are systematically assessed by multiplying the Magnitude of their Effect (Table 5.1) and Value of the Receptor (Table 5.2) to produce a significance score.

Where the final significance score is ranked a score below 10, a potential interaction has been identified, but the associated impacts are deemed to be insignificant, and as such will not require further assessment, i.e. these aspects are ‘scoped out’ of the EIA. Where the aspect is ranked a score 10 or higher, it is regarded as potentially significant and will require further assessment and management measures to control it and is therefore ‘scoped in’ to be assessed further as part of the EIA process.

This assessment approach is designed to score impacts upon specific environmental and socio-economic receptors. The only exception to this is climate change impacts. The individual climate change impact of the proposed operations associated with the Cambo Field Development are comparatively so small that they are impossible to assess on their individual merit. However, it is acknowledged that they will contribute to the overall cumulative issue of climate change and are therefore of key concern to national and international sustainability objectives. Therefore, those environmental issues identified to contribute to climate change are automatically scoped in to be discussed further in the detailed impact assessment.

Table 5.1: Environmental Aspect Significance Matrix

		Receptor Value	Negligible	Low	Medium	High	Very High
Magnitude of Effect			**1**	**2**	**3**	**4**	**5**
Negligible	a. Minor change to the natural environment which is unlikely to be noticed or measurable against background variation. b. An environmental effect not likely to last more than a few days. c. Effects that are only detectable at source. d. No implications to other users of the sea or local communities. e. No risk to reputation of the company or commercial success. f. No discernible change in the existing view or other landscape characteristics. g. Usage of renewable or non supply-limited resources with no measurable effect on current or future supply.	**1**	*1*	*2*	*3*	*4*	*5*
Minor	a. A detectable change to the natural environment which is within scope of existing variability. b. A transient environmental effect not lasting more than a few weeks. c. Unlikely to contribute to cumulative effects. d. May affect behaviour, but not a nuisance to other users of the sea or general public. e. Transient issues regarding external relationships but with no long term reputational consequences. f. Virtually imperceptible change in landscape receptors causing very minor changes to the view or other landscape characteristics over a wide area or minor changes over a limited area. g. Usage of finite resources with no measurable effect on current supply and not affecting market price.	**2**	*2*	*4*	*6*	*8*	*10*
Moderate	a. Change in habitats and biological communities within the footprint of the development. b. Change in habitats and biological communities leading to short term (< 2 years) damage with a good recovery potential. c. Similar scale of effect to existing variability, but may have cumulative implications. d. May cause measurable nuisance to some other users of the sea or local communities. e. Risk of undermining reputation of the company within industry or with regulators. f. Moderate change in localised areas causing minor changes to the existing view or other landscape characteristics over a wide area or noticeable change over a limited area. g. Usage of finite resources that may affect short-term availability and local market price.	**4**	*4*	*8*	*12*	*16*	*20*
Major	a. Change in habitats and biological communities extending beyond the immediate footprint of the development. b. Change in habitats and biological communities leading to medium term (>2 years) damage, but with a likelihood of recovery within 10 years. c. Cumulative implications are understood to occur in relation to activities of this type. d. Financial loss or safety implications to other users of the sea or local communities. e. Undermining the reputation of the company with serious commercial implications. f. Notable change in landscape characteristics over an extensive area ranging to a very intensive change over a more limited area. g. Reduction in stock resource, affecting national availability and market price.	**6**	*6*	*12*	*18*	*24*	*30*
Severe	a. Wide scale change to the offshore environment or effects on coastal receptors. b. Change in the natural environment leading to long term (>10 years) damage and poor potential for recovery to baseline conditions. c. Will make a significant contribution to national or global issues, individually or cumulatively. d. Long-term economic loss or strategic business changes for other users of the sea or local communities e. Damage to company reputation of sufficient gravity to incur irreparable damage to the business. f. Extensive long lasting (>10 years) to permanent change in landscape characteristics over an extensive area. g. Reduction in stock resource, affecting global availability and market price.	**10**	*10*	*20*	*30*	*40*	*50*

Table 5.2: Environmental and Socio-economic Receptor Value

	Receptor Category	Selected Examples
Very High (5)	Natural Environment (marine, coastal, terrestrial)	1. Internationally designated site or protected species. 2. A regularly occurring, globally threatened species or habitat essential for maintaining such species. 3. Species and habitats essential to conserve biodiversity at an international level.
	Socio-economic Other Users of the sea,	4. A major fishing area contributing at a national level. 5. An internationally defined shipping lane. 6. Any areas licensed for use by other industries.
	Landscape	7. Internationally designated or recognised landscape of exceptional quality and distinctive intact character with a large number of features and strong sense of place, and uninterrupted views (visual amenity).
	Resource use	8. Rare, finite and non-reusable resource only scarcely available on the world market
High (4)	Natural Environment (marine, coastal, terrestrial)	1. Nationally designated site or protected species. 2. A nationally threatened species or habitat essential for maintaining such species. 3. Species and habitats of principal importance for the conservation of biodiversity at a national level.
	Other Users	4. An area of regional importance for fisheries or of local importance but with no nearby alternatives. 5. Major shipping activity located in a restricted area. 6. Extensive use by multiple other industries.
	Landscape	7. Nationally designated or recognised landscape of high quality and distinctive character, with a strong sense of place, and susceptible to change which would permanently alter key characteristics and elements of the landscape (National Parks and AONBs). Partial or interrupted views (visual amenity).
	Resource use	8. Finite resource with restricted availability on the world market
Medium (3)	Natural Environment (marine, coastal, terrestrial)	1. Sites or species protected on a local level, or of acknowledged conservation value. 2. The presence of a locally threatened species or habitat. 3. Species and habitats of importance for the conservation of biodiversity at a local level.
	Other Users	4. Areas used by local fisheries, but with nearby alternatives. 5. Areas of moderate-high commercial shipping intensity 6. Multiple other stakeholder interest or extensive use for a single purpose.
	Landscape	7. Locally designated or recognised landscape with some distinctive character and features in reasonable condition. Capable of tolerating low levels of change without affecting key characteristics and elements (e.g. Local Green Space). Partial or interrupted views (visual amenity).
	Resource use	8. Non-reusable finite resource presently plentiful/abundantly available on world market
Low (2)	Natural Environment (marine, coastal, terrestrial)	1. No sites or species of conservation interest. 2. No resident or regularly occurring threatened species or habitat present. 3. A natural and diverse habitat supporting widespread and common species.
	Other Users	4. Areas of low intensity fishing, not essential for supporting local communities. 5. Areas of low shipping intensity. 6. Areas of low intensity anthropogenic use.
	Landscape	7. Undesignated landscape of defined character type, but of low quality. Capable of tolerating moderate levels of change/improvement/enhancement. Views lack distinctive characteristics and/or are of low quality (visual amenity).
	Resource Use	8. Reusable or recyclable resource, abundantly available on world market
Negligible (1)	Natural Environment (marine, coastal, terrestrial)	1. No sites or species of conservation interest. 2. Not capable of supporting any threatened species or conservation interest. 3. A poor habitat with low biodiversity and productivity.
	Other Users	4. No commercially exploitable fisheries present. 5. Areas of very low shipping intensity. 6. Areas of no discernible anthropogenic use or socio-economic benefits.
	Landscape	7. Poor quality landscape, not representative of a wider type within the local area and capable of accommodating high levels of change/improvement/enhancement, with few or no views (visual amenity).
	Resource use	8. Renewable or non supply-limited resource, readily available at point of use

5.2.1 The ENVID Workshop Findings

The complete ENVID matrix, together with the scores assigned to each aspect, is provided in Appendix 3. During the ENVID workshop, the following activities were identified as having a potential significant impact:

- Impacts on seabed communities in shelf waters as a result of:
    - Laying of the gas export line;
    - Laying of infield flowlines and umbilicals;
    - Installation of subsea infrastructure;
    - Rock dumping protection of infrastructure;
    - Laying of concrete mattresses, grout bags etc for protection of flowlines or other infrastructure.

The detailed impact assessment of these impacts is provided in Section 7 - Physical Presence.

- Impacts on seabed communities in deepwater as a result of:
    - Laying of the gas export line;
    - Positioning of subsea infrastructure relating to the FPSO.

The detailed impact assessment of these impacts is provided in Section 7 - Physical Presence.

- Contribution to air pollution and climate change as a result of:
    - Fuel consumption by the MODU, installation vessels, FPSO, support vessels and helicopters;
    - Non-routine flaring and venting operations.

The detailed impact assessment of these impacts is provided in Section 8 – Atmospheric Emissions.

- Impacts on seabed and water column communities due to discharges to sea including:
    - Discharge of payzone cuttings;
    - Discharge of drill cuttings and WBM from both the top holes and lower well sections;
    - Discharge of cement.

The detailed impact assessment of these impacts is provided in Section 9 – Drilling Discharges.

- Impacts on marine mammals due to noise as a result of:
    - Piling to fix infrastructure to the seabed in shelf waters;
    - General operation of the MODU, FPSO and support vessels causing underwater sound.

The detailed impact assessment of these impacts is provided in Section 11 – Underwater Noise and Wildlife Disturbance.

The following accidental events were also identified as having a potential significant impact:

- Impacts on marine environment, the coastal environment and other users of the sea by a large spill of hydrocarbons as a result of:
    - A fuel oil spillage from an installation vessel, the FPSO or the MODU;
    - Loss of an infield flowline or the riser inventory;
    - Loss of the FPSO inventory;
    - Uncontrolled well blow-out.

- Impacts on seabed communities as a result of a loss of the FPSO, installations vessels, support vessels, the MODU or a helicopter.

The detailed impact assessment of these impacts is provided in Section 13 – Accidental Events.

5.3 National Policies and Guidance

5.3.1 Scottish National Marine Plan Requirements

As discussed in Section 1.2.13, the Scottish NMP has established policies relating to potential impacts from oil and gas activity and these policies have been taken into full consideration during the EIA process. A summary of the general and oil and gas specific policies and objectives which are of relevance to the Cambo Field Development is presented below. All activities will be carried out using the principles of Best Available Technology (BAT) and Best Environmental Practice (BEP). Consideration will be given to key environmental risks including the impacts of noise, oil and chemical contamination and habitat change.

These issues have all been considered as part of the ENVID workshop described in Section 5.2, and therefore already form part of the EIA. The NMP also requires operators to have adequate risk reduction measures and sufficient emergency response and contingency strategies in place that are compatible with the National Contingency Plan and the Offshore Safety Directive. Furthermore, it requires that any future decommissioning operations will be undertaken in line with standard practice, and as allowed by international obligations.

The proposed Cambo Field Development has been assessed against the following general Marine Plan objectives and policies: GEN 1, 2, 3 ,4, 5, 6, 9, 10, 11, 12, 13, 14, 18, 19, 20 and 21.

GEN 1 – General Planning Principle

Development and use of the marine environment should be consistent with the Marine Plan, ensuring all activities are undertaken in a sustainable manner that protects and enhances Scotland’s natural and historic marine environment. SPE will ensure that any potential impacts associated with the proposed Development will be kept to a minimum as discussed in Section 7 to Section 13.

GEN 2 – Economic Benefit

The economic benefit of the development should be considered carefully and appropriately, as sustainable development and use of the marine environment can provide economic growth, skill development, employment and opportunities for investment. The proposed Cambo Field Development will provide jobs and tax revenue to the Scottish economy.

GEN 3 – Social Benefit

Sustainable development and use which provides social benefits is encouraged when consistent with the objectives and policies of the NMP. The proposed Development is in line with sustainable development and considers other users of the sea and impacts upon them, as discussed in Section 4 and Section 7.

GEN 4 – Coexistence

Coexistence with other development sectors and activities is encouraged in planning and decision-making processes. Where conflict over space or resource exists or arises, marine planning should encourage initiatives between sectors to resolve conflict and take account of agreements where this is applicable. SPE will ensure that any potential impacts on other sea users associated with the proposed Cambo Field Development will be kept to a minimum as discussed in Section 7.

GEN 5 – Climate Change

Marine planners and decision makers must act in a way best calculated to mitigate and adapt to climate change. Developers and users of the marine environment should seek to facilitate a transition to a low carbon economy through mitigation and adaptation and consider ways to reduce emissions of carbon and other greenhouse gasses. SPE will ensure that any potential impacts associated with the proposed Development will be kept to a minimum, as discussed in Section 8.

GEN 6 – Historic Environment

Development and use of the marine environment should protect and, where appropriate, enhance heritage assets in a manner proportionate to their significance. There are no known wrecks or heritage sites within the development area, as discussed in Section 4.

GEN 9 – Natural Heritage

Development and use of the marine environment must:

- Comply with legal requirements for protected areas and protected species;
- Not result in significant impact on the national status of Priority Marine Features;
- Protect and, where appropriate, enhance the health of the marine area.

SPE acknowledges that the pipeline route for the proposed Cambo Field Development location lies within a Nature Conservation Marine Protected Area (Section 4.5.2). SPE will ensure that any potential impacts to this site, and to any other protected species and sites, associated with the proposed field development operations will be kept to a minimum, as discussed in Section 7 and Section 9.

GEN 10 – Invasive Non-Native Species

Opportunities to reduce the introduction of invasive non-native species to a minimum or proactively improve the practice of existing activity should be taken when decisions are being made. All vessels and the MODU used during the proposed Development will follow International Convention for the Control and Management of Ships' Ballast Water and Sediments 2004 requirements.

GEN 11 – Marine Litter

Developers, users and those accessing the marine environment must take measures to address marine litter where appropriate. SPE and appointed Operators for the Cambo Field will ensure that any potential impacts associated with the proposed Development will be kept to a minimum as discussed in Section 12.

GEN 12 – Water Quality and Resource

Developments and activities should not result in a deterioration of the quality of waters to which the Water Framework Directive, Marine Strategy Framework Directive or other related Directives apply. SPE and appointed Operators for the Cambo Field will ensure that any potential impacts to water quality associated with the proposed Development will be kept to a minimum as discussed in Section 9 and Section 10.

GEN 13 – Noise

Developments and use in the marine environment should avoid significant adverse effects of man-made noise and vibration, especially on species sensitive to such effects. SPE and appointed Operators for the Cambo Field will ensure that any potential impacts from noise associated with the proposed Development will be kept to a minimum as discussed in Section 11.

GEN 14 – Air Quality

Development and use of the marine environment should not result in the deterioration of air quality and should not breach any statutory air quality limits. Some development and use may result in increased emissions to air, including particulate matter and gasses. Impacts on relevant statutory air quality limits must be taken into account and mitigation measures adopted, if necessary, to allow an activity to proceed within these limits. SPE and appointed Operators for the Cambo Field will ensure that any potential impacts to air quality associated with the proposed Development will be kept to a minimum as discussed in Section 8.

GEN 18 – Engagement

Early and effective engagement should be undertaken with the general public and all interested stakeholders to facilitate planning and consenting processes. The proposed Development has been subject to stakeholder engagement, as discussed in Section 6. The ES will be subject to public consultation.

GEN 19 – Sound Evidence

Decision making in the marine environment will be based on sound scientific and socio-economic evidence, drawn from a wide range of sources including the scientific community, stakeholders and users of the marine area. SPE ensures the use of sound scientific and socio-economic evidence, as demonstrated throughout this ES.

GEN 20 – Adaptive Management

Adaptive management practices should be used to take account of new data and information in decision making. SPE will ensure the continued use of the most up-to-date data and research when assessing the impact of the proposed Development, as demonstrated throughout this ES.

GEN 21 – Cumulative Impacts

Cumulative impacts affecting the ecosystem of the marine plan area should be addressed in decision making and plan implementation. SPE and appointed Operators for the Cambo Field will ensure that any potential cumulative impacts associated with the proposed Development will be kept to a minimum as discussed in Section 7 to Section 13.

5.3.2 Oil and Gas Policies

In addition to the General Policies stated in Section 1.3.1, the Scottish NMP identifies specific environmental issues which are associated with different types of development or activity within the marine environment. The issues identified as being relevant to offshore oil and gas activities are as follows:

Noise

> *Generated from seismic exploration activity, drilling, production facilities or vessels, burial of pipelines with some noise sources e.g. seismic surveys having the potential to cause injury and disturbance to noise-sensitive species such as cetaceans.*

Potential underwater noise impacts as a result of the proposed Development have been assessed in Section 11, and appropriate mitigation measures have been identified.

Chemical or Oil Contamination

> *Causing contamination of water, sediments and fauna.*

Potential impacts associated with the use and discharge of offshore chemicals has been assessed in Section 9, whilst the risk of oil contamination has been assessed in Section 13.

Habitat Changes

> *Construction, decommissioning and protection of infrastructure can result in the local loss of species and habitats. However, infrastructure can also provide substrate for colonisation and shelter for fish.*

An environmental site survey was carried out by SPE at the proposed Cambo Field Development location in 2018. A full habitat assessment was carried out as a part of this. The findings of the survey are discussed in Section 4.3.1. Potential impacts associated with habitat changes are discussed in Section 7 and Section 9.

5.3.3 Feature Activity Sensitivity Tool (FEAST)

The Marine Scotland Feature Activity Sensitivity Tool (FEAST) has been developed to determine potential management requirements for NCMPAs (Marine Scotland, 2013a). FEAST has been used to determine the sensitive features and corresponding relevant pressures to these features from the proposed operations.

As discussed in Section 4, the proposed Development infield footprint is located 12 km northwest of the Faroe-Shetland Sponge Belt NCMPA, and 34.6 km of the Gas Export Pipeline Route traverses through the NCMPA. Sensitive features of the NCMPA, for which it was designated, include:

- Deep-sea sponge aggregations;
- Offshore subtidal sand and gravels;
- Ocean quahog aggregations;

- Continental slope;
- Continental slope channels, iceberg plough marks, prograding wedges and slide deposits representative of the West Shetland Margin paleo-depositional system Key Geodiversity Area;
- Sand wave fields and sediment wave fields representative of the West Shetland Margin contourite deposits Key Geodiversity Area.

A full list of all pressures and feature sensitivity to such pressures is provided in Appendix 6, using the Oil and Gas Infrastructure and Cables and Pipelines activity selection in FEAST. The corresponding pressures exerted on the sensitive features within the Faroe-Shetland Sponge Belt NCMPA were found to have a feature sensitivity of *Sensitive*, *High* or *Medium*, and have therefore been scoped in to the impact assessment:

The detailed assessment of this impact on the sensitive features is provided in Section 7.

- Physical change (to another seabed type):
  - Deep-sea sponge aggregations;
  - Ocean quahog aggregations;
  - Sand wave field;
  - Offshore sands and gravels.

The detailed assessment of this impact on the sensitive features is provided in Section 7.

- Sub-surface abrasion/penetration:
  - Deep-sea sponge aggregations;
  - Iceberg ploughmark fields;
  - Ocean quahog aggregations;
  - Sediment wave field;
  - Slide deposits;
  - Offshore sands and gravels.

The detailed assessment of this impact on the sensitive features is provided in Section 7.

- Non-synthetic compound contamination (including heavy metals, hydrocarbons, produced water):
  - Deep-sea sponge aggregations;
  - Ocean quahog aggregations;
  - Offshore sands and gravels.

The detailed assessment of this impact on the sensitive features is provided in Section 9 and Section 10.

- Synthetic compound contamination (including pesticides, antifoulants, pharmaceuticals):
  - Deep-sea sponge aggregations;
  - Ocean quahog aggregations;
  - Offshore sands and gravels.

The detailed assessment of this impact on the sensitive features is provided in Section 9 and Section 10.

- Water clarity changes:

  - Sand wave field;
  - Sediment wave field.

The detailed assessment of this impact on the sensitive features is provided in Section 9.

- Water flow (tidal current) changes – local:
  - Slide deposits;
  - Offshore sands and gravels.

The detailed assessment of this impact on the sensitive features is provided in Section 7.

5.3.4 JNCC's Formal Conservation Advice for the Faroe-Shetland Sponge Belt Nature Conservation Marine Protected Area (NCMPA)

The JNCC Advice on Operations (AoO) Guidance (JNCC, Undated) has been developed as part of the JNCC's formal conservation advice package for individual offshore Special Area of Conservation (JNCC, Undated). The AoO provides information on those human activities that, if taking place within or near the NCMPA Faroe-Shetland Sponge Belt, can impact it and present a risk to the achievement of the conservation objectives. The Faroe-Shetland Sponge Belt AoO has been used to determine the sensitive features and corresponding relevant physical pressures to the conservation features of the NCMPA from the proposed operations.

Within the Faroe-Shetland Sponge Belt AoO Guidance, a number of pressures on specific Annex I habitats, namely those of deep-sea sponge aggregations, offshore subtidal sands and gravels and ocean quahog aggregations, have been identified which are associated with oil and gas exploration, and installation, production, pipelines and decommissioning activities relevant to the proposed Cambo Field Development.

As part of the EIA, an AoO sensitivity assessment has been undertaken, which is presented in Appendix 7. The following pressures on sensitive features within the Faroe-Shetland Sponge Belt NCMPA were classed as *Sensitive* and have been scoped in further assessment:

- Abrasion/disturbance of the substrate on the surface of the seabed:
  - Offshore subtidal sands and gravels;
  - Deep-sea sponge aggregations;
  - Ocean quahog aggregations.

The detailed assessment of this impact on the sensitive features is provided in Section 7.

- Habitat structure changes – removal of substratum (extraction):
  - Offshore subtidal sands and gravels;
  - Deep-sea sponge aggregations;
  - Ocean quahog aggregations.

The detailed assessment of this impact on the sensitive features is provided in Section 7.

- Hydrocarbon and Polyaromatic Hydrocarbons (PAH) contamination. Including those priority substances listed in Annex II directive 2008/105/EC:
  - Offshore subtidal sands and gravels;
  - Deep-sea sponge aggregations;

  - Ocean quahog aggregations.

The detailed assessment of this impact on the sensitive features is provided in Sections 9, 10 and 13.

- Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion:
  - Offshore subtidal sands and gravels;
  - Deep-sea sponge aggregations;
  - Ocean quahog aggregations.

The detailed assessment of this impact on the sensitive features is provided in Section 7.

- Siltation rate changes (low), including smothering (depth of vertical sediment overburden):
  - Offshore subtidal sands and gravels;
  - Deep-sea sponge aggregations.

The detailed assessment of this impact on the sensitive features is provided in Section 7.

- Synthetic compound contamination (incl. pesticide, antifoulants, pharmaceuticals). Includes those priority substances listed in Annex II of Directive 2008/105/EC:
  - Offshore subtidal sands and gravels;
  - Deep-sea sponge aggregations;
  - Ocean quahog aggregations.

The detailed assessment of this impact on the sensitive features is provided in Sections 9 and 10.

- Transitional elements and organo-metal (e.g. Tributyltin (TBT)) contamination. Includes those priority substances listed in Annex II of Directive 2008/105/EC:
  - Offshore subtidal sands and gravels;
  - Deep-sea sponge aggregations;
  - Ocean quahog aggregations.

The detailed assessment of this impact on the sensitive features is provided in Sections 9 and 10.

- Water flow (tidal current) changes- local, including sediment transport considerations:
  - Offshore subtidal sands and gravels;
  - Ocean quahog aggregations.

The detailed assessment of this impact on the sensitive features is provided in Section 7.

- Physical change (to another seabed type):
  - Offshore subtidal sands and gravels;
  - Deep-sea sponge aggregations;
  - Ocean quahog aggregations.

The detailed assessment of this impact on the sensitive features is provided in Section 7.

5.4 Concerns Identified for Further Assessment

The results from the ENVID workshop described in Section 5.1, the issues raised during the informal consultation process outlined in Section 5.2 and the national policies and guidance outlined in Section 5.3 together identified the potentially significant concerns associated with the proposed Development at the early planning stage. These concerns have driven the environmental considerations throughout the project and have helped guide mitigation measures incorporated into the project planning in order to eliminate or reduce the potential environmental impacts. Each concern that has been scoped in for further assessment is fully addressed in the subsequent sections of the ES.

The key concerns relating to the proposed Cambo Field Development are addressed under the following headings:

- Physical Presence (Section 7);
- Atmospheric Emissions (Section 8);
- Drilling Discharges (Section 9);
- Production Discharges (Section 10);
- Underwater Noise Generation and Wildlife Disturbance (Section 11);
- Waste Management (Section 12);
- Accidental Events (Section 13).

In line with the requirements of the Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020, any potential cumulative and transboundary impacts derived from this project have also been assessed, in the individual impact sections. Cumulative impacts are those from activities or events which individually may not be significant, but when combined with impacts arising from different sources that have an overlapping sphere of influence to the activities and events under consideration, may produce potentially significant impacts. Transboundary impacts comprise any potential environmental impacts on the seabed, water column and/or atmosphere, and which extent beyond the boundaries of the UKCS.

Section 6

Methodology for the Assessment of Impacts and Effects

6 Methodology for the Assessment of Impacts and Effects

6.1 Introduction

The assessment methodology used in this Environmental Statement (ES) is based on a ‘concerns based’ approach, which means that the emphasis has been placed on assessing those environmental aspects (i.e. activities and processes) that have been identified during the scoping phase as potential key issues or concerns.

The assessment methodology follows common legislative requirements and has drawn on a number of established guidance documents and best practice publications. Each concern is dealt with in the same manner, which involves outlining the concern, describing and quantifying the impacts and effects from the proposed activity, recognising any gaps in understanding and explaining how these are dealt with, and defining measures that have been taken to mitigate the impact.

The methodology follows a source-pathway receptor analysis for each potentially significant aspect describing its impacts, followed by an iterative assessment of the indicated effects and their significance, based on the value of those receptors that are affected (Table 6.1).

The terms ‘Impact’ and ‘Effect’ are frequently used interchangeably in many published documents, however, it is important to distinguish between these two terms.

‘Impacts’ are defined as measurable changes to the baseline environment conditions as a direct result of project activities (e.g. km^2 loss of habitat, or mg/l increase in a substance concentration).

Accordingly, ‘Effects’ are defined as the consequences of those impacts upon receptors of concern that are subject to assessments of significance. An environmental effect can be any change to the environment or its use. Effects can be positive (beneficial) or negative (adverse) and can result directly or indirectly from project activities or events.

6.2 Source-Pathway-Receptor Analysis

Determining which receptors may be affected by a specific activity relies on Source-Pathway-Receptor (SPR) analysis for the identification of the impact and consequential effects. SPR considers all potential routes and mechanisms for impacts to affect all potential receptors along predicted pathways. The SPR analysis forms the first part of the assessment process, establishing and quantifying the impact(s) of a certain activity.

The term ‘source’ describes the origin of the impact (i.e. the operational activity resulting in an impact) e.g. the discharge of drill cuttings to sea.

Pathways are processes or series of interactions (i.e. the impacts) that result in an environmental effect upon a final receptor. Hence, the ‘pathway’ is the means (e.g. deposition of xx m^2 of discharged cuttings onto the seabed) by which the source reaches the affected ‘receptor’ (e.g. benthic organisms). Pathways may be physical, chemical, biological, ecological or socio-economic processes or interactions.

A receptor is a specific component of the baseline environment or socio-economic domain that will be, or is likely to be, affected by the impacts of the project. This could be a single entity such as a species or community, or a conceptual grouping such as a population or subset of an ecosystem. A receptor may be affected only by the proposed project, or by the proposed project and other relevant projects in combination. If no likely pathway can be demonstrated, then potential receptors can be scoped out, regardless of their intrinsic sensitivity or value.

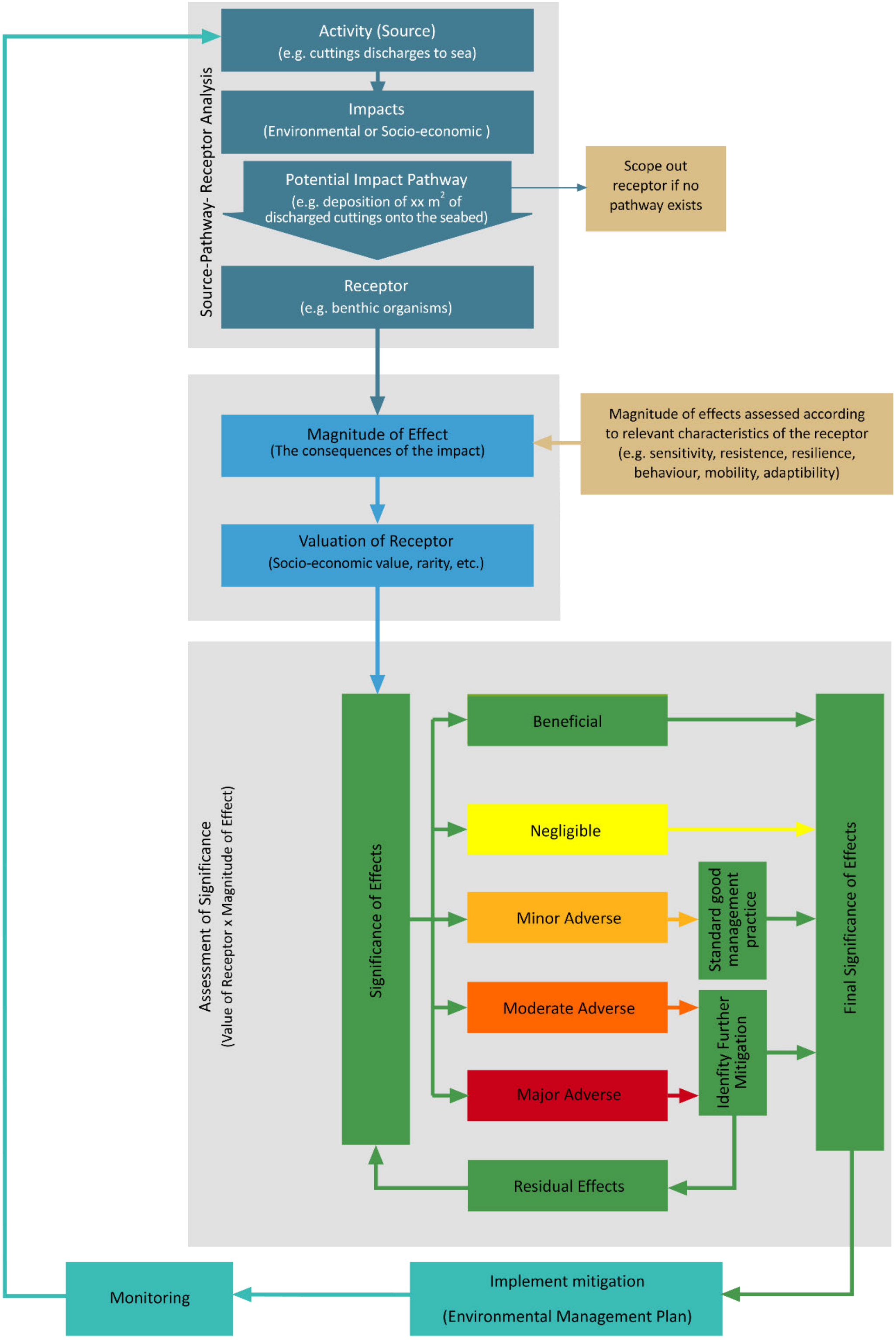

Figure 6.1: Impact Assessment Methodology

6.3 Assessment of Effects and Their Significance

6.3.1 Characterising and Assessing the Magnitude of Effects

Once the impact has been established, the environmental effect of the impact is determined by assessing the magnitude of the effect against its significance.

The magnitude of the potential environmental effects for each receptor is assessed independently of its value or designated status, using the same categories that were used during the scoping stage, as described in Table 5.1 in Section 5 of this ES. However, the assessment at this stage of the Environmental Impact Assessment (EIA) will be more in depth, including consideration of the sensitivity of each receptor. Ecological sensitivity is the relative change of a system or population in relation to the level of disturbance or perturbation (Miller et al., 2010). The sensitivity of socio-economic and socio-ecological systems may be defined in a similar manner (Holling, 2001).

The magnitude of ecological effects is the product of the project-specific impacts and the receptor specific characteristics that make those receptors sensitive or responsive to the relevant impacts.

6.3.2 Valuation of Receptors

The next stage of the assessment is to determine the nature conservation, socio-economic or heritage value of the affected receptor, following the selected examples provided in Table 5.2 in the previous chapter.

6.3.3 Assessment of Significance of Effects

The significance of each effect is determined by scoring the value of the ecological, socio-economic or heritage feature against the magnitude of the predicted effect (Table 6.1). This methodology is applied individually with respect to the specific ecology, socio-economic or heritage characteristics of each receptor.

Table 6.1: Determining Significance of Adverse Effects

Magnitude of Effect	**Nature Conservation Value, Socio-economic Value or Heritage and Cultural Value**				
	Negligible	**Low**	**Medium**	**High**	**Very High**
Negligible	Negligible	Negligible	Negligible	Negligible	Minor
Minor	Negligible	Minor	Minor	Minor	Moderate
Moderate	Minor	Minor	Moderate	Moderate	Major
Major	Minor	Moderate	Moderate	Major	Major
Severe	Moderate	Major	Major	Major	Major

The level of effect significance is used to determine the use and level of mitigation measures. Where a potential effect is assessed as ‘moderate’ or ‘major’, then then this should be considered “significant” in EIA terms. So far as practicable, mitigation (including offsetting) should be identified that reduces the potential magnitude or significance of effects, or the likelihood of significant effects. Minor adverse effects would not usually require any action beyond standard good management practices.

Significance categories are defined in Table 6.2 below. Significance criteria are generally consistent for all ES topics, however alternative criteria may be defined on a receptor specific basis in individual ES chapters.

Table 6.2: Effect Significance Categories

Category	Definition
Negligible	An effect that is found to be not significant in the context of the stakeholder and/or regulator objectives, or legislative requirements.
Minor	An effect considered sufficiently small (with or without mitigation) to be within accepted standards. No further action is required if it can be controlled by adopting normal good working practices.
Moderate	A significant effect that exceeds accepted limits and thresholds but is less serious than a 'major' adverse effect. Moderate adverse effects may include a reduction in the integrity or quality of a protected site or habitat, or a reduction in a local population of a protected species. Predicted moderate adverse effects require mitigation recommendations.
Major	A serious effect of the highest significance where an acceptable limit or threshold is likely to be exceeded that would result in a breach of statutory objectives or law. Major adverse effects would include a major or permanent loss of a protected habitat or a local population of a protected species. Predicted major adverse effects require mitigation recommendations.

Mitigation recommendations should be explored as part of the EIA process for 'moderate' or 'major' effects. Effects are reassessed as described above until either the effect significance is reduced to acceptable levels ('Minor' or 'Negligible') or no more mitigation can be applied. Residual effect significance is estimated, from which consenting decisions can be made.

6.3.4 Environmental Risk Assessment

While some potential effects may be very improbable, they may also be extremely serious should they occur, resulting in major adverse effects on some receptors. Therefore, as the final step of the assessment, it is also important to consider the likelihood that a potential effect could occur as predicted.

For accidental events, where it may not be possible to reduce the magnitude of potential impacts or effects, the overall environmental risk may be decreased by reducing the likelihood of an adverse event occurring through adequate designed-in mitigation measures (Gormley et al., 2011).

6.4 Cumulative and Transboundary Effects

In line with the requirements of the Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020, which replaces the Offshore Petroleum Production and Pipelines (Assessment of Environmental Effects) Regulations 1999, any potential cumulative and transboundary impacts derived from this project have also been assessed, in the individual impact sections.

Cumulative impacts are those from activities or events which individually may not be significant, but when combined with impacts arising from different sources that have an overlapping sphere of influence to the activities and events under consideration, may produce potentially significant impacts on the same or different receptors. Such effects may arise due to their proximity in space or time or because a certain receptor is particularly sensitive.

Transboundary impacts comprise any potential environmental impacts on the seabed, water column and/or atmosphere, which extend beyond the boundaries of the United Kingdom Continental Shelf (UKCS).

6.5 Mitigation and Monitoring

The term mitigation is used in general to cover all efforts used to reduce potential impacts (and consequently, effects). These may include design changes, alteration of proposed methods, or other activities in addition to the core project-related activities to reduce or ameliorate impacts. Mitigation is often used as a catch-all term that also includes avoidance, minimisation, mitigation and offsets or compensatory measures.

Mitigation measures are predominantly applied at source, to reduce impacts, with the intention of a corresponding reduction in residual effects upon the receptors in question to acceptable levels. However, mitigation may also be applied directly at the receptor-level, with the intention of reducing effects, without any influence on the source or the impact.

All mitigation recommendations described within the ES are based upon the realistic worst-case scenarios, ensuring that all measures described are adequate to ameliorate the range of predicted effects. Mitigation recommendations may be revised during the determination of application.

Countries with mature oil and gas industry and well-developed regulatory framework, such as the UK, have incorporated comprehensive mitigation measures within their permitting and consenting regime. These mitigation measures are further informed and/or augmented with good industry practice guidance from organisations and institutions such as OSPAR, Oil and Gas UK and the International Association of Oil and Gas Producers (IOGP).

SPE’s management systems and that of third-party contractors e.g. Installation Operator will ensure all regulatory and industry standards are met, thus incorporating many inherent mitigation measures, as part of its “normal” operational procedures and practices. During the procurement process, all major third-party contractors (e.g. the Installation Operator) will be audited to ensure they have suitable management systems in place.

Environmental mitigation and monitoring requirements are stated throughout the ES will be taken forward in an Environmental Management Plan (EMP). A Commitments Register summarising these mitigation measures has been included in Appendix 2.

Section 7

Physical Presence

7 PHYSICAL PRESENCE

This Section assesses the potential impacts arising from the physical presence of the proposed Cambo Field Development infrastructure. This includes the impacts of associated drilling and construction activities, as defined in Section 3 (Project Description), upon benthic communities, other users of the sea and the nature conservation objectives of the Faroe-Shetland Sponge Belt Nature Conservation Marine Protected Areas (NCMPA). The scope of this assessment has been informed by the outcomes of the Environmental Issues Identification (ENVID) exercise (Appendix 3), informal statutory consultation and National Marine Plan policies and statutory guidance as explained in Section 5 (Identification of Potential Impacts).

Potential impacts of the physical presence of the proposed Cambo Field Development assessed in this Section relate to the following aspects:

- Installation of the proposed gas export pipeline (including trenching and surface laying) impacting on seabed communities in deep and shelf water;
- Laying of flowlines within the infield area of the proposed Development site impacting on seabed communities in deepwater;
- Installation of seabed infrastructure including the Floating Production, Storage and Offloading Vessel (FPSO) and at the Pipeline End Manifold (PLEM) impacting on seabed communities in shelf and deepwater;
- The placement of rock protection impacting on seabed communities in shelf water;
- The presence of the pipeline on the seafloor and associated effects on the conservation objectives of the Faroe-Shetland NCMPA considering the outcomes of consultation (Section 5: Impact Identification), Marine Scotland' Feature Activity Sensitivity Tool (FEAST) Tool (Appendix 6) and JNCC's Advice on Operations (AoO) (Appendix 7).

7.1 Seabed and Associated Communities

7.1.1 Physical Extent of the Area Affected by the Proposed Operations

Proposed Export Gas Pipeline

A new 10" (25.4 cm) diameter Gas Export Pipeline (GEP) is proposed to be installed across 69.6 km of seabed between the proposed Cambo Field Development and a new tie-in structure connected to the existing WOSPS Pipeline End Manifold (PLEM). Figure 7.1 provides an indicative illustration of the proposed Pipeline route elevation from the Cambo field to the WOSPS PLEM.

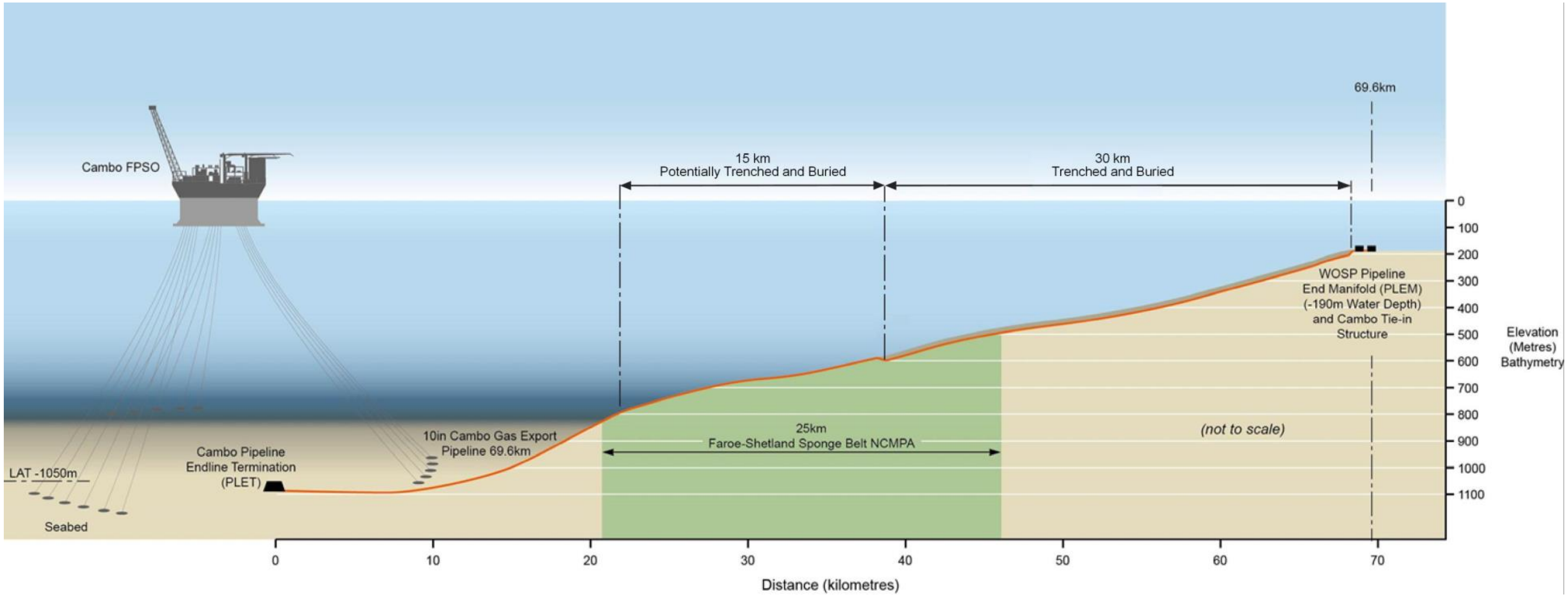

Figure 7.1: Proposed Cambo Gas Export Pipeline (GEP) Elevation

The first 24.6 km length of pipeline between the proposed field and the 800 m depth contour (or up to 39.4 km to the 600 m depth contour) will be surface laid, depending on the outcome of the trenching assessment and fisheries risk assessment that will be undertaken to assess the minimum safe trenching requirement[1]. The remaining 45 km of pipeline between the 800 m depth contour (or 30 km above the 600 m depth contour) and the WOSPS PLEM will be trenched and buried to a target depth of 1.5 m below the seabed to avoid potential interaction with other users of the sea, for example demersal mobile fishing. Burial will be achieved by laying the pipeline into a trench using a remotely operated jet trenching tool. This type of tool works by fluidising the seabed using water jets allowing the pipeline to settle within the fluidised trench under its own weight or with the aid of downwards forcing depressors (BERR, 2008). Jetting does not create any sediment berms either side of the trench, which would otherwise require subsequent remedial bed levelling works and associated environmental disturbances, and in terms of sediment displacement, jetting by means of a Remotely Operated Vehicle (ROV) is considered to produce the lowest environmental impact (OSPAR, 2012) compared to other techniques. Since no sediment berms are created either side of the trench, the overall width of the trench affected area is limited to the trench itself and is estimated to be 0.75 m for the purposes of this assessment. Therefore, over the entire length of the proposed trenched section of pipeline, an estimated area of seabed disturbance due to the trenching of up to 33,750 m^2 is expected to occur.

In the event that the target burial depth is not achieved then the pipeline will be surface laid or laid in a shallower trench above the target depth. In such instances, rock placement to create a protective rock berm over the exposed, or shallow trenched, section of pipeline may be required. The rock berm would cover the relevant section of pipeline to a height of 1 m above the seabed and will be approximately 4 to 5 m in width. The exact quantities of rock placement required is not yet known but for the purposes of this assessment, it has been assumed that the maximum length of pipeline needing protection in this way is 3.5 km (Section 3, Project Description), requiring up to 20,000 tonnes of rock protection material. Based on this assumption then an area of up to 17,500 m^2 of seabed will be impacted by rock placement.

The placement of rock material on the seabed has the potential to affect local bottom current flows to due altered seabed bathymetry which may increase erosion of the adjacent sediment creating localised scour depressions (Pidduck, 2017). The extent of any scour depressions due to the current proposals is not known and will be dependent on the local hydrodynamic conditions, the nature of local sediments and the final design of the protective rock berms. However, for the purposes of this assessment it is assumed that scour effects would extend up to 1 m from the edge of the rock protection material reflecting observations of scouring at the base of an offshore structure in the North Sea (Schröder et al., 2006). Given that the maximum distance over which rock material may be placed is 3.5 km, then the maximum extent of seabed scouring is assumed to be 3,500 m^2.

Connection of the proposed GEP to the existing WOSPS pipeline will be achieved with the Cambo Tie-In Structure (CTIS) using divers working at 175 m depth. The CTIS will have an overall footprint on the

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[1] As explained in Section 3.8, the impacts of trenching and burying the GEP from the 800 m water depth contour are assessed in this chapter as the potential worst-case scenario for most activities.

seabed of 212 m^2 and will include concrete mattresses covering an additional 648 m^2 of seabed (total 860 m^2) to protect tie-in structure.

Table **7.1** summarises the worst-case footprint of seabed disturbance due installation of the proposed gas export pipeline.

Table 7.1: Summary of the Worst-Case Seabed Footprint of the Proposed Gas Export Pipeline

Line Type	Installation Method	Length [m]	Pipeline/Rock Protection Width [m]	Seabed Affected Width [m]	Total Area Affected [m^2]
Gas export pipeline > 800 m	Surface laid	24,600	0.254	-	6,248.4
CTIS (including concrete mattresses)	Divers	-	-	-	860
Gas export pipeline < 800 m	Jet trenching	45,000	-	0.75	33,750
	Rock placement	3,500	5	-	17,500
	Seabed scour	3,500	1	-	3,500
Total					61,858.4

7.1.2 Infield Infrastructure and Associated Risers, Umbilicals and Flowlines

Infield seabed infrastructure to be installed as part of the proposed Cambo Field Development will include wellheads for production wells, wellheads for water injection wells, drill centre manifolds and water injection manifolds. It is currently planned that all infrastructure will be installed on the seabed under gravity i.e. using the weight of the structure to partially penetrate the seabed sediment. However, depending on the results of the geotechnical survey some structures may require suction piles to complete the installation (see Section 3.5.1).

There will be a total of 13 wellheads. One production wellhead has already been installed but remains suspended and will become operational on commencement of the scheme. This existing wellhead was installed using a CAN-ductor method (see Section 3: Project Description) which allows for the wellhead to be installed using gravity and suction. This technology removes the need for tophole drilling, conductor installation and cementing and thus avoids any associated discharges or accumulation of cuttings and excess cement on the adjacent seafloor.

For assessment purposes it is assumed that the remaining 12 wellheads will also be installed using this technique as the CAN-ductors create the largest footprint on the seabed (28.3 m^2 each) compared to conventional drilling and thus represent the worst-case design in terms of seabed habitat take.

Two drill centre manifolds and two water injection manifolds will also be installed within the infield area. The manifolds are rectangular box shaped structures and will occupy an area of seabed of 60 m^2 and 90 m^2 respectively. Table 7.2 summarises the worst-case footprint of the infield seabed infrastructure.

Table 7.2: Summary of the Worst-case Footprint of Proposed Infield Infrastructure

Asset Type	Dimensions	Footprint on Seabed [m^2]
Drill Centre (DC) Manifold (× 2)	11.5 m × 9.5 m	218.5
Water Injection (WI) 1 and 2 Manifold (× 1)	13.5 m × 10 m	135
Water Injection and Controls Distribution Structure (WICDS) (× 1)	13.5 m × 10 m	135
Wellhead/CAN-ductor (× 13)	6 m (diameter)	367.9
Total		**856.4**

In addition, several new risers, umbilicals and flowlines will be installed on the seafloor to connect the wellheads, manifolds and other seabed infrastructure within the infield area of the proposed Development. The exact lengths of the risers, umbilicals and flowlines to be used have not yet been finalised (see Section 3, Project Description) For the purposes of this ES, a worst-case length of 50 m has been assumed for each of the production and gas lift flowline jumpers between the drill centre manifolds and Xmas trees. Table 7.3 summarises the overall worst-case footprint of the different types of in-field risers, umbilicals and flowlines on the seabed based on their assumed maximum lengths.

Table 7.3: Summary of the Worst-case Footprint of all in-Field Umbilicals, Risers and Flowlines

Pipeline Type	Installation Method	Total Area Affected [m^2]
Production jumpers	Surface laid	101.5
Gas lift jumpers	Surface laid	51.0
Control umbilicals	Surface laid	811.5
Production flowlines	Surface laid	2,315.4
Gas lift flowline	Surface laid	487.6
Injection flowline	Surface laid	1,913.0
Gas export riser	Surface laid	35.6
Gas flowline	Surface laid	45.8
Riser Suction Cans (16×)	Surface laid	201.6
Total		**5,963.0**

Anchors and Anchor Lines

The FPSO will be anchored to the seafloor using suction piles which each having a footprint on the seabed of 44.2 m^2 (see Section 3: Project Description). Based on 16 anchor piles (see Section 3.5.2), the overall footprint will be 707.2 m^2.

Anchor lines will connect the FPSO to the anchor piles. These lines will comprise polyester ropes which are connected to the FPSO by a 200 m long top chain. The anchor lines will be suspended in the water column and will be terminated at the seabed anchor pile by a 150 m long bottom chain. As a worst-case estimate it is assumed that 120 m of each bottom chain will raise and lower on the seafloor over a lateral distance of up to 5 m either side at the end where it is connected to the polyester rope, i.e. due to swell movement during adverse weather conditions. This would result in the periodic disturbance of 600 m^2 of seabed per anchor chain equating to an overall area of 9,600 m^2 for 16 anchor chains. Table 7.4 summarises the worst-case seabed footprint due to the presence of anchor piles and anchor chains.

Table 7.4: Worst-Case Footprint of Anchor Piles and Anchor Chains

Anchor Feature	Individual Pile or Line Footprint [m^2]	No. of Anchor Piles/Lines	Total Footprint [m^2]
Suction pile	44.2	16	707.2
Anchor chain	1,200	16	9,600
Total			10,307.2

Prior to the FPSO arriving at the Cambo field for installation, the anchor chains and polyester mooring lines will be installed and laid on the seabed ('wet stored') leading to a temporary disturbance on the seabed lasting for up to 2 months. Table 7.5 summarises the worst-case seabed footprint due to the temporary wet storage of the anchor chains and mooring lines on the seabed.

Table 7.5: Worst-Case Footprint of Temporary Storage of Anchor Chains and Mooring Lines

Mooring Line Feature	Length [m]	Width [m]	Total Footprint [m^2]
Polyester Mooring Line × 16	2,100	0.27	9,072
Top Anchor chain × 16	200	0.68	2,176
Bottom Anchor Chain × 16	150	0.68	1,632
Total			12,880

Fibre optic cable

A fibre optic cable (FOC) will be installed connecting the FPSO with the SHEFA-2 cable which is located 25 km to the northwest of the Cambo field. The FOC is approximately 23 mm wide and will be installed close to the location of the SSIV/WIDCS within the Cambo field and then surface laid on the seabed until it connects with the SHEFA-2 cable. Table 7.6 summarises the worst-case seabed footprint due to the presence of the FOC.

Table 7.6: Worst-Case Footprint of FOC

Cable Feature	Cable Length [m]	Cable Width [m]	Total Footprint [m^2]
FOC	25,000	0.023	575
Total			575

7.1.3 Potential Effects on Seabed Communities

Potential effects of the physical presence of the proposed Development on seabed communities include seabed habitat take, habitat alteration, deposition of suspended sediment plumes and seabed disturbances as summarised in Table 7.7 and assessed below.

Table 7.7: Summary of Benthic Effects

Impact	Relevant Development Aspect	Extent [m^2]	Duration
Seabed habitat take	Installation of wellheads, drill centre manifolds, water injection manifolds, risers umbilicals and flowlines, anchor suction piles, CTIS, PLET, SSIV and FOC	8,314	Permanent (for duration of development)
	Surface laid part of Gas Export Pipeline	10,058	Permanent, depending on outcome of Comparative Assessment
Habitat alteration	Rock protection placement	35,000	
	Seabed scour	3,500	
	CTIS concrete mattresses	648	
Deposition of suspended sediment plumes	Trenching (jetting)	Adjacent seabed areas	Short term (will cease on passage of trenching tool)
Seabed disturbance		33,750	
	Anchor chains	9,600	Permanent (for duration of development)
	Temporary wet storage of anchor chains and mooring lines	12,880	Temporary (wet stored on seabed before FPSO installation)

Seabed Take

The installation of the proposed subsea infrastructure on the seabed will result in a reduction in the total extent of the original seabed habitat available (i.e. 'seabed take') over an area of up to 18,372 m^2 (0.018 km^2), by changing the original available habitat to an artificial substrate.

Up to 0.01 km^2 of the overall seabed habitat take is attributable to the surface laying of the proposed GEP between the infield site and the 600 m contour[2]. Seabed habitats that would be affected by the surface laid section of pipeline include deep-sea muddy sand and deep-sea mixed substrata together with a number of important habitat types including 'Annex I stony reef' (EC Habitats Directive), 'burrowed mud' (Scottish Priority Marine Feature) (PMF) and 'sea pens and burrowing megafauna

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[2] In this scenario trenching from the 600 m contour, rather than from the 800 m depth contour presents the worst-case for impact assessment purposes.

communities' (OSPAR) (which is a component of the burrowed mud habitat) (Section 4.2.5) (MMT, 2019).

The potential Annex I stony reef habitat was recorded during recent site specific survey (MMT, 2019) within the northern boundary of the Faroe-Shetland Sponge Belt NCMPA as a short expanse of poorly sorted cobbles and boulders with intermediate gravel. It was distinguished from the surrounding coarse sediment types by the presence of a comparatively rich epifaunal community comprising soft corals, possibly *Drifa* sp., anemones and massive and encrusting forms of sponges (MMT, 2019). A detailed review of the MMT geophysical (MBES and SSS) and seabed imagery data (MMT, 2019) was undertaken to determine the extents of this potential Annex I stony reef feature for this section of the pipeline route (Fugro, 2020). The review concluded that the potential stony reef habitat feature constituted a mound of dimensions 13 m × 7 m. The limited extent of this feature suggests that this feature can be easily avoided by the pipeline route, and this will be taken into consideration during detailed engineering design.

'Burrowed mud' PMF habitat, including the 'sea pens and burrowing megafauna communities' habitat was found to be present throughout the majority of surface laid section the proposed pipeline route between the northern boundary of the Faroe-Shetland Sponge Belt NCMPA and the 600 m contour following site specific survey (MMT, 2019). The distance over which the proposed pipeline will interact with this habitat type is estimated to be 15 km. Assuming a maximum pipeline width of 0.254 m then an area of 3,810 m^2 of Scottish PMF and OSPAR threatened and/or declining habitat would be lost beneath the proposed surface laid gas export pipeline.

In addition, the installation of the proposed CTIS at the southernmost end of the proposed gas export pipeline where it connects to the WOSPS, will result in a take of 212 m^2 of coarser substrate which characterises the shallower, more southern seabed areas of the proposed development (MMT, 2019) and which is consistent with the 'offshore sands and gravels' PMF habitat.

The remaining seabed habitat take (0.007 km^2) is attributable to the installation of the anchor suction piles, wellheads, manifolds, risers, umbilicals and flowlines at the proposed FPSO site and infield area. Seabed habitats potentially affected by the installation of this infrastructure will include deep-sea mixed substrata and deep-sea muddy sand together with patches of sparse cobbles and boulders on the deep seabed (MMT, 2019; Fugro 2017). These habitats are not considered rare or representative of protected features but are instead widely distributed across the Faroe-Shetland Channel region as identified in seabed mapping (Section 4, Local Environment) and other studies (Bett, 2003; Jones et al., 2007; Jones et al.,2012).

Seabed video surveillance (MMT, 2019) revealed a low sponge coverage (5% or less) within the infield area and along the surface laid section of the proposed Pipeline. This agrees with other video surveys within the Faroe-Shetland Sponge Belt NCMPA. For example, Kazanides et al. (2019) found that sponge assemblages within the wider area are generally constrained to a narrow depth band of between 450 and 530 m, due to fisheries and other physical environmental factors. Consequently, surface laying of the proposed pipeline below the 600 m contour and installation of the in-field infrastructure is not forecast to affect significant sponge assemblages.

No specimens of ocean quahog (Scottish PMF) have been recorded during site specific surveys but as a comparatively deep burrowing species (around 10-15 cm below the seabed surface) it may not be conspicuous within video and grab surveys. JNCC (2018) advises that all ocean quahog records from the NCMPA so far have been collected from the far western corner of the site, away from the current proposed activities, where the water depth is less than 600 m, but that the whole site could be considered suitable for colonisation. Installation of the infield infrastructure and pipeline could damage or kill individuals of ocean quahog if present, although impacts at population levels are highly unlikely given the limited footprint of the effects and the wider distribution of ocean quahog populations.

The effects of seabed habitat take due to the installation of the proposed subsea infrastructure on the seabed will be long term, lasting for the duration of the proposed Development. However, once the Cambo Field is decommissioned, all subsea infrastructure placed on the seabed will be removed again, after which habitats and associated communities will recover over time.

Recovery of the original seabed habitat will involve the infilling of any seabed depressions that have been left following the removal of seabed infrastructure and the return of the pre-construction seabed topography and stability. Some partial infilling of the depressions will take place through the slumping of the sides of the depressions as each item of infrastructure is withdrawn from the sediment, subject to the cohesiveness of the sediment, while subsequent infilling of remaining seabed depressions will be achieved by natural sedimentation and by any transient fine sediments within the regional bedload transport over time.

The timescale for habitat recovery is dependent on a number of factors including the cohesiveness of the affected sediment, the degree of local seabed mobility and the quantities of fine transient sediment available for infilling. Studies of seabed recovery following offshore wind farm construction, for example, (English et al, 2017), show that seabed impacts from the placement of spud legs of construction vessels and from cable laying may take months to years to be infilled and that seabed habitats in lower energy environments may take a number of years to recover compared to those in higher energy and more mobile sediment areas. Given the deep-water location of the proposed Development it is likely that the local environment is comparatively low energy suggesting seabed impacts from the installation of the proposed infrastructure may persist for a period of years following decommissioning.

Species will begin to re-colonise affected seabed areas as seabed topography and stability is gradually restored. Recolonisation will be achieved through the passive import and settlement of larvae and migration of adults and mobile benthos depending on the availability of local reproducing populations, local hydrodynamic conditions and the severity of the original impact and is expected to follow classic models of species succession (e.g. Newell et al, 1998; Pearson and Rosenberg, 1978). These typically involve an initial influx of small, short-lived and highly fecund species (opportunists) which are capable of tolerating disturbed conditions, but which are gradually replaced by larger, competitively superior species until an equilibrium community, reflective of the prevailing habitat conditions, is achieved. Timescales for seabed communities to return to pre-installation conditions are not known at present due to the paucity of observations in equivalent deep sea areas. However, studies in coastal shelf waters following the cessation of commercial aggregate dredging suggests that recovery of benthic community structure following physical impacts may require several years (Boyd et al, 2005; Cooper et al, 2007). Recovery of the local benthos at the proposed Development area may take even longer due to the slow growth and long-lived nature of the deep-sea species (Cordes, 2016; Jones et al., 2012).

Habitat Alteration

The placement of rock protection material and concrete mattresses onto predominately sedimentary seabed areas will change the particle size distribution characteristics of ambient sediment habitat to a rocky and stony habitat. To mitigate effects, only minimal amounts of rock protection material are proposed to be used to protect any exposed, or shallow trenched, sections of the pipeline where the target burial depth has not been achieved. Otherwise, the pipeline will be buried to a sufficient depth (target 1.5 m) and no rock placement will be required. Rock and concrete mattress placement will be limited to the southernmost sections of the proposed gas export pipeline which corresponds to a predominately sand and gravel seabed representative of ‘offshore sands and gravels PMF habitat. As a worst-case, the amount of rock protection and concrete mattresses used would cover an area of 0.0181 km^2 of this seabed type and so if used, an area of PMF habitat of up to 0.0181 km^2 will be altered to a rocky and stony habitat.

Seabed animals within the direct footprint of the protective rock material and concrete mattresses will be damaged, displaced or smothered resulting in the mortality and loss of individuals of species but the material itself could, over time, function as reef habitat providing additional attachment sites for the indigenous sessile communities, such as sponges, as well as refugia for mobile epibenthos such as *Munida* sp. (squat lobster) or fish. Pidduck et al (2017) highlight that rock dump material has the potential to act as an artificial reef supporting reef communities. HDR (2018) found fish and lobster apparently sheltering below concrete mattresses at an offshore wind farm in US. The rate of colonisation of the rock protection material, if used, and concrete mattresses will be dependent on recruitment rates from local reproducing populations but is expected to be slow due to the slow growth, low recruitment rates and late maturity of deep, cold water assemblages (Cordes, 2016; Jones et al., 2012).

The placement of rock berms and concrete mattresses on the seafloor could change bottom water flow patterns and increase seabed scouring (Pidduck et al., 2017). Scouring can alter habitats by changing local seabed morphology, increasing sediment instability and increasing the coarseness of sediments due to the erosion and winnowing of fine sediment particles from the seabed. Assuming a worst-case placement of rock protection, then the total area that might be affected by scouring would be up to 0.0035 km^2.

Deposition of Suspended Sediment Plumes

The proposed placement of protective rock material and concrete mattresses and the jet trenching of the proposed pipeline will disturb and mobilise the seabed sediments for re-deposition over adjacent seabed areas. Sand and gravel size particles ejected into the water column by this disturbance will re-settle very quickly (within seconds) and in close proximity to the original disturbance. Finer silt and clay sized particles, on the other hand, will take longer to re-settle (minutes to hours) and may be dispersed over adjacent seabed areas depending on the tidal state and bottom current strengths at the point of disturbance.

Significant deposition of sediment plumes can smother or bury seabed communities causing damage to sensitive respiratory organs or preventing feeding resulting in the loss of sensitive species within affected areas. Sediment dwelling species will be largely tolerant to the effects of light sediment deposition but sessile, filter feeding epifauna which live on the seabed surface will be more sensitive.

Particle size analysis and seabed video shows that the sediments proposed for trenching above the 800 m contour, and the locations of the rock and concrete mattress placement, are dominated by sand and gravel and contain varying proportions silt and clay, between 7% and 26% (MMT, 2019). Consequently, only limited quantities of fine sediment material are predicted to be mobilised and re-deposited by the proposed jetting and placement of protective material. Furthermore, the jetting tool will be continually moving along the trench route so that there will not be any prolonged raised sediment plumes or sediment deposition at any one location. Also, any fine sediments that are deposited over adjacent seabed areas will be rapidly re-mobilised during subsequent tidal movements or periods of increased bottom current velocities and will be eventually diluted and dispersed out of the area.

Local seabed communities are dominated by sediment dwelling species which will be tolerant to temporary light sediment accumulation although a number of sessile epifauna species, including various sponge species, are also present nearby on coarser cobble and boulder substrates (MMT, 2019). Sponges have the ability to naturally clear sediment from their systems and are considered to have a good potential for recovery due to light sediment accumulation (OSPAR, 2010) although it is acknowledged that this can be energetically demanding. Any additional energy spent clearing significant quantities of sediment could increase susceptibility to other impacts. For example, sponges subjected to smothering are less able to regenerate wounded tissue (OSPAR, 2010). Significant smothering however is not predicted to occur as the tool with be continuously moving along the trench so that there will be no accumulation of sediment plumes at any one location.

Seabed Disturbance

The seabed will be disturbed as a result of both the trenching (jetting) for the proposed gas export pipeline and the raising and lowering of the anchor chains of the FPSO during high energy wave events.

Seabed disturbances caused by the jetting of the trench will only occur once between the 800 m contour and the proposed connection point to the WOSPS equating to an area of up to 0.0338 km^2 and will cease on completion of the trench. In contrast, the seabed disturbance caused by the movement of the anchor chains on the seafloor will be long term lasting for the duration of the project but will be intermittent during this time and limited to periods of high energy wave events. Long term but intermittent effects of seabed disturbance will occur adjacent to each of the sixteen FPSO suction anchor piles over a combined area of 0.0192 km^2.

Jetting fluidises the substrate through which the trenching tool passes and reduces the sediment structure and density (BERR, 2008). This may result in the displacement of sediment dwelling species to lower depths within the sediment profile within the trench footprint while sensitive fauna may also be damaged or suffer mortality due to associated erosion and scour effects. Depending on the jet pressure over the seabed surface, individuals of species may be ejected into the overlying water column within the sediment plume and may become available for mobile scavenging and predatory fauna. Larger, robust species, such as the ocean quahog which has a thick shell, may be able to tolerate the effects of the jetting although individuals may be displaced to deeper depths below the seabed surface. Any individuals displaced in this way would be expected to be able to re-locate to preferred feeding depths although at some energetic cost. Sponges, and other sessile epifauna, which attach to and encrust the seabed surface however, may be more sensitive to the effects of the trenching and are likely to suffer damage to tissues or be dislodged or buried if in the direct path of the trenching tool (BERR, 2008) resulting in a reduced abundance and biomass of these species locally. Mobile species, such as fish and crabs, are likely to be able to move away from the trenching tool. Effects of trenching will only occur once and will cease when the trenching tool has passed after which habitat and species recovery will occur.

The ‘wet storage’ of the anchor chains and mooring lines are not expected to penetrate the seabed to any appreciable depth and are only likely to agitate the surficial sediment layers during any significant movement during placement and subsequent removal from the seabed. Any effects will only be temporary, lasting for up to two months.

Once installed, the anchor chains of the FPSO are also not expected to penetrate the seabed to any appreciable depth and only likely to agitate the surficial sediment layers during any significant movement of the mooring lines as a result of high energy wave events. Burrowing species which may be present at depth below the seabed surface are therefore not expected to be significantly affected although sessile epibenthic species attaching to and encrusting the seabed surface may be damaged or dislodged resulting in a reduced abundance and biomass of these populations locally. The effects of seabed disturbance due to the action of the anchor chains will be intermittent, limited to high energy wave events, but will be permanent, lasting for the duration of the Cambo Field Development. The intermittent nature of the disturbance is expected to allow some partial recovery of communities in affected areas during intervening periods between storm events resulting in a reduced epifaunal community within the footprint of the anchor chains, compared to adjacent non-affected areas. Full recovery of the seabed within the influence of the movement of the anchor chains is anticipated following decommissioning.

Recovery characteristics of disturbed seabed sediments will be dependent on a number of factors including the nature of the seabed and the communities present, the severity of the original impact and the degree of disturbance already experienced at the site, i.e. from storm events or commercial fishing. BERR (2008) highlights that in general, recovery from trenching in shallow water areas, where seabed disturbances are more frequent and opportunistic species are more likely to dominate the community, is relatively rapid whereas in deeper water recovery to a more stable community could take many years. Ocean quahog and deep-water sponges are particularly slow growing, the former taking 5 to 15 years to reach sexual maturity, depending on location (Tyler Walters and Sabitini, 2017), while the latter may require several years to recover from damage. The degree of existing disturbance, for example fishing, is an important factor in the consideration of benthic recovery from physical seabed impacts (BERR, 2008).

7.1.4 Impacts on Nature Conservation Marine Protected Areas (NCMPA)

The proposed GEP traverses the Faroe-Shetland Sponge Belt NCMPA which is designated for a number of ecological and geological features (Figure 7.7 and Section 4, Local Environment). including deep-sea sponge aggregations, ocean quahog populations and offshore sands and gravels features. Conservation objectives in respect of these features include maintenance or increase of feature extent and maintenance of relevant structures and functions and populations. Temporary deterioration can be disregarded if habitat and species features are sufficiently healthy and resilient and are able to recover.

Both surface laid and trenched sections of the proposed gas export pipeline will be installed within the boundary of the NCMPA and have the potential to exert certain pressures on interest features. To identify relevant pressure – feature relationships for assessment purposes, reference has been made to Marine Scotland's FEAST, JNCC's Advice on Operations (AoO) (JNCC, 2018) as well as the outcomes of scoping feedback (Appendix 4).

Physical Change (To Another Seabed Type)

Physical change (to another seabed type) is flagged by both the FEAST tool and by the AoO as a pressure to which deep-sea sponge aggregations, ocean quahog aggregations and offshore sands and gravels features are sensitive.

This pressure type relates to the placement of rock protection material on the seabed within the boundaries of the NCMPA. This will alter the particle size distribution of the ambient sediment habitats and may increase local scour patterns changing them to coarser, hard bottom, rock and stony habitats. If the worst-case quantity of rock protection is installed (i.e. up to 20,000 tonnes), then physical (seabed type) change will occur over an area of 0.022 km^2. Given that the total area of the MCMPA is 5,278 km^2 then physical (seabed type) change due to the permanent placement of rock protection material and associated increased sediment scour has the potential to occur over a maximum of 0.0004% of the NCMPA..

Seabed video surveillance conducted in 2018 showed that sponge coverage is low throughout the proposed pipeline corridor through the NCMPA (5% or less) with only four short sections within the proposed trenched pipeline supporting sponges covering between 5% and 10% (MMT, 2019). No areas along the proposed pipeline corridor were classified as deep sea sponge aggregations (i.e. coverage of >10%) and no Boreal 'ostur' aggregations that are regarded as typical of Faroe-Shetland Channel were recorded (MMT, 2019). The proposed pipeline is therefore unlikely to exert the physical (seabed type) change pressure in respect of designated sponge assemblages and significant effects on the NCMPA conservation objectives are therefore not expected in this regard.

Physical (seabed type) change would adversely impact upon ocean quahog populations as a change to a harder, rocky habitat would remove the finer particulate sediment habitat upon which this species relies (Tyler Walters and Sabitini (2017). This would result in a permanent reduction in ocean quahog habitat but only over a maximum of 0.0004% of the potential ocean quahog habitat resource within the NCMPA. While individual specimens may be affected within the direct footprint of rock placement, significant effects at the population level are unlikely. Consequently, the site's nature conservation objectives will not be significantly affected in this regard.

The offshore sands and gravels habitat PMF occurs throughout the southern extents of the proposed buried portion of the gas export pipeline (MMT, 2019). Placement of rock protection material on the seabed would change the particle size distribution characteristics of sand and gravels sediments resulting in a permanent reduction in the spatial extent of this feature within the NCMPA therefore impacting on the site's nature conservation objectives. Effects will however, only occur over a very small spatial extent (up to 0.0004% of the NCMPA) and are therefore not anticipated to significantly affect the overall conservation objectives of the NCMPA. Only the minimum quantity of rock protection material will be used to protect any exposed or shallow trenched sections of pipeline from potential damage from demersal fishing gears.

Penetration and/or Disturbance of the Substrate Below the Surface of the Seabed and Smothering and Siltation Rate Changes (Light)

Seabed disturbance below the surface together with light smothering and siltation are also identified within FEAST and AoO as potential pressures on the NCMPA's sponge assemblages and offshore sands and gravels PMF. Seabed disturbance below the surface is also recognised within both assessment tools as a potentially relevant pressure on ocean quahog populations.

Both pressure types may arise as a result of the jet trenching of the 19 km section of the proposed gas export pipeline within the NCMPA. Assuming a trench affected width of 0.75 m then the area of seabed disturbance below the surface within the NCMPA will be 14,250 m^2 or 0.00027% of the total designated site.

Smothering and siltation is predicted to be light as the trenching tool will be continuously moving along the pipeline corridor so there will be no prolonged disturbance or sediment accumulation at any one location. The spatial extent of effects of light smothering and siltation will depend on the state of any bottom water currents at the point of disturbance for the dispersion of fine sediment plumes arising the trenching operation.

Both pressure types will be short-lived and will occur only once and will cease on completion of the trenching after which species and habitat recovery can occur. Any fine sediments deposited on the seafloor will be quickly re-mobilised on subsequent tides or periods of increased water flows and will eventually be diluted and dispersed out of the area. Long term accumulation of fine sediments on offshore sand and gravel PMF is thus not expected.

Sponge assemblages (>10% coverage) have not been recorded along the proposed pipeline route and are tolerant to light sediment accumulation in any case (OSPAR, 2020). Furthermore, individuals of ocean quahog could be displaced within the sediment profile within jetted trenches but significant mortality at population levels is highly unlikely. Recolonisation of any denuded areas can be achieved through colonisation from surrounding reproducing populations in non- affected areas.

Given the short-lived and highly localised nature of the trenching operation and the recovery potential of sensitive features, significant effects on the site's nature conservation objectives are not expected with regard to these pressure types.

7.2 Other Users of the Sea

7.2.1 Impacts on Commercial Fisheries

Under Regulation (EU) 2016/2336, bottom trawling in waters deeper than 800 m is prohibited in international waters of the Northeast Atlantic (Section 4, Local Environment) and so no displacement of fishing vessels from the proposed FPSO site is forecast. A recent survey showed that no fishing took place within 10 nm of the proposed Cambo Field Development during a 31-week observation period. Fishing effort by the over 10 m vessel class is low or none in this deep-water location (Section 4, Local Environment). The absence of significant fishing effort within and around the proposed FPSO site aligns with acoustic datasets (MMT, 2019) which shows that there are no trawl marks on the seabed within the proposed FPSO site area. Instead, trawl marks were only evident at depths of around 600 m and above (MMT, 2019). The Protection Philosophy Document, which sets out the requirements for the gas export pipeline system, indicates that bottom trawling in the area may take place to a depth of 760 m. Significant displacement of commercial fishing activities due to the installation and operation of the FPSO and MODU and physical presence of the proposed infield infrastructure on the seabed is therefore not anticipated.

Demersal fishing is more important in shallow areas above the approximately 600 m depth contour and corresponding to the trenched sections of the proposed Pipeline route (Xodus, 2019). The presence of the pipeline laying vessel may temporarily displace fishing from an imposed safety area of 500 m around the installation vessel although this is only expected to be temporary as pipe laying is only scheduled for 23 days. Also, the pipe laying vessel will be travelling along the proposed Pipeline route during the installation period and so fishing vessels will not be excluded from any one area during this time. Once installed, the pipeline above the 600 m (and potentially from the 800 m) depth contour will be buried to a target depth of 1.5 m below the seabed surface, with any exposed, or shallow trenched, sections covered using rock protection material, while the tie in structure at the WOSPS will be protected using concrete mattresses as explained in Section 3 (Project Description). No fishing vessels will be excluded from the area of the pipeline post installation.

Given the low level or absence of fisheries at and around the proposed FPSO site together with the temporary nature of the pipe laying operation and the protection measures that will be provided then the potential effects of the physical presence of the proposed Development are considered to be insignificant.

7.2.2 Impacts on Shipping and Navigation

The installation of the proposed development will require a number of construction and support vessels which could pose obstructions to local sea users during the installation phase. Section 3 (Project Description) itemises the numbers and types of construction and support vessels that are proposed to be used and presents a schedule for the installation activities. Construction vessels will be continuously present within the vicinity of the site between Q3 2021 and Q3 2024 with the exception of the winter period (Q4 – Q1) of 2021 and 2023 when no activity is planned. Anchor suction piles will be installed in 2024. Once installed, the FPSO will pose a permanent obstruction to other vessels in the area for the life of the development.

Section 4 (Local Environment) explains that there is currently a low level of shipping activity within the vicinity of the proposed Development. One of the two drill centres will be located within the Esbjerg to Faroes shipping route, estimated to be used by 3 to 4 vessels per month, and 2 of the FPSO moorings will be located close to the Baltic to Faroes shipping route which is used by 1 or 2 vessels per month. Given the low numbers of other vessels, and the ample free space available to avoid the 500 m safety zones, then the effects of the presence of these infrastructure items on shipping and navigation are considered minimal. Further obstruction will occur over a period of 51 days in Q2 and Q3 2024, when the anchor piles are installed. Once the installations are complete, any obstruction will be removed. A safety vessel will be present, once the FPSO arrives, and will remain onsite throughout the production phase of the development to ensure that other sea users maintain a safe distance.

The pipeline laying vessel could also pose a short term obstruction to shipping and navigation. However, the vessel will be moving continually along the proposed pipeline route during the 23 day installation period so any obstruction will be of very short duration and long term exclusion from any one area will not occur. The pipeline will be trenched as soon as practical after lay. Installation of the pipeline and subsequent surveying, flooding and testing will take 4-5 weeks and involve several vessels. Therefore, in areas where fishing is anticipated, the pipeline will be protected by a guard vessel until trenching is complete.

Given the low volume of vessel traffic and the temporary nature of any installation obstruction then impacts on shipping and navigation due to the physical presence of the proposed Development are considered to be insignificant.

7.2.3 Impacts on Military Operations

No practice or exercise areas (PEXA) are located within the vicinity of the proposed Development and the Ministry of Defence (MoD) has been informed of the proposed operations and has confirmed that there are no safeguarding concerns. As such, there should be no impact on military activities.

7.3 Mitigation Measures

Safe working distances will be imposed during installation activities and 500 m safety zones will be put in place around field infrastructure. This will ensure that other sea users are kept at a safe distance protected from any negative interactions. The FPSO and infield infrastructure 500 m safety zones will be enforced during operations by a dedicated Emergency Response and Rescue Vessel (ERRV).

All construction vessels will be highly visible and display the appropriate light or daytime signals to warn other sea users of the presence and their activities. When installed, the FPSO will also be highly visible and be in full compliance with the necessary Class and United Kingdom Continental Shelf (UKCS) legal requirements for identification, lighting and sound signals to alert all approaching vessels of its presence.

A Vessel Traffic Study (VTS) was carried out within the Cambo area (Block 204/10) and a further VTS will be undertaken as part of the permitting application process to support a Consent to Locate application, before drilling and installation operations commence.

Furthermore, to aid the safety of navigation, a Notice to Mariners will be posted prior to the FPSO and MODU moving onto location, ensuring that all vessels, including fishing vessels, will be aware of its presence in advance and for the duration of operations. In addition, Kingfisher will be notified of the exact location of the FPSO and MODU activities and the planned installation operations allowing inclusion in their fortnightly bulletin to fishing vessels. The Hydrographic Office will also be notified as to the location of the FPSO and the gas export pipeline so that these can be marked on navigational charts.

7.4 Cumulative and Transboundary Impacts

The nearest existing surface infrastructure to the current proposals include the BP operated Schiehallion FPSO and the Foinavon FPSO. These structures are located 54 km and 59 km to the south of the proposed Development area respectively. Other surface infrastructure within the wider region includes two platforms at the Clair Ridge field located 89 km to the east of the current proposals. An FPSO is planned at the Rosebank field located to the north east.

The Esbjerg to Faroes shipping route and the Baltic to Faroes shipping route lie close to the proposed Cambo FPSO but only support a very low volume of vessel traffic (between 3 to 4 vessels per month and 1 to 2 vessel per month respectively). Similarly, fisheries activity within and around the site of the FPSO is very low or absent (Section 4: Local Environment) and burial of the proposed gas export pipeline means that there will be no interaction with commercial fishing above the 600 m (and potentially above the 800 m) contour.

Given the distances of separation between the existing platforms at Schiehallion, Foinavon and Clair, the planned FPSO at Rosebank and the proposed Cambo FPSO, together with the low quantity of local vessel traffic and fishing activity locally, then any contribution to potential cumulative effects of the physical presence of the proposed Development on shipping, navigation and fisheries is likely to be insignificant.

Seabed infrastructure associated with the Schiehallion and Foinavon field developments together with the Laggan and Tormore and Glenlivet gas fields occupy areas of benthic habitat within Faroe-Shetland Sponge Belt NCMPA. The proposed pipeline associated with the Rosebank development may further contribute to the overall habitat take within this designated site once installed. With regard to the current proposals, the surface laid section of the proposed GEP will also contribute to the overall habitat take of the NCMPA but will only affect an area of 3,810 m^2 (0.0038 km^2) or just 0.00007% of the total site. Consequently, the contribution of the current proposals to the cumulative habitat take is expected to be very small and are therefore not anticipated to significantly affect the overall conservation objectives of the NCMPA.

The proposed Development lies approximately 7 km from the UK/Faroe Island transboundary line at its nearest point. No potential for transboundary effects has been identified.

7.5 Conclusions

There are no protected or sensitive habitats or species associated with the proposed location of the FPSO site and infield infrastructure and so significant adverse effects on nature conservation are not expected in this regard.

The proposed Pipeline, on the other hand, will traverse the Faroe-Shetland Sponge Belt NCMPA resulting in benthic habitat take, benthic habitat disturbance and alteration and temporary deposition of sediment plumes. Features potentially affected include 'offshore sands and gravels' and 'burrowed mud' PMF habitats and the 'ocean quahog' PMF species as well as a very short section of potential Annex I stony reef. The proposed pipeline also has the potential to interact with important sponge assemblages although sponge coverage along the entire pipeline route was found to be very low and no Boreal 'ostur' communities, which are characteristic of the Faroe-Shetland Channel, were found during a recent pipeline route survey. The spatial extent of the predicted effects of the pipeline installation and operation will be very small within the context of the NCMPA and with respect to habitat disturbance and plume deposition, will be very short term lasting for the duration of the pipeline laying only. Effects of habitat take and habitat alteration will last for the duration of the development and for as long as the infrastructure installed on the seabed remains in place. A Comparative Assessment will be undertaken to assess all potential decommissioning options available for the gas export pipeline at the time, including complete recovery of the pipeline as well as leaving sections of the pipeline in-situ. In conclusion therefore, effects of the physical presence of the proposed export pipeline on high value receptors will be long term, but will be highly localised and will have no significant effects on the conservation objectives of the NCMPA.

The proposed location of the FPSO site and infield infrastructure is not associated with significant fishing or vessel traffic activity and so is highly unlikely to displace or interfere with fishing, shipping and navigation. A safety vessel will be available throughout the installation and operational phases of the Cambo Field Development to ensure other vessel users maintain a safe distance from the infrastructure. Some exclusion from fishing grounds around the immediate area of the pipelaying vessel may occur during pipe laying but this will be temporary lasting for the duration of the pipe laying operation, estimated to be 23 days. Also, the pipe laying vessel will be continuously moving along the pipeline route and so long term obstruction and exclusion at any one location will not occur. Effects on fishing, shipping and navigation due to the physical presence of the proposed Development are therefore considered to be insignificant.

Section 8

Atmospheric Emissions

8 ATMOSPHERIC EMISSIONS

This section addresses issues and concerns associated with atmospheric emissions, which were raised during the Environmental Issues Identification (ENVID), informal stakeholder consultation and those which are part of the National Marine Plan, namely:

- Contribution to air pollution and climate change as a result of:
    - Fuel consumption by the FPSO, MODU, installation vessels, support vessels and helicopters;
    - Non-routine flaring and venting operations;
- The National Marine Plan, objectives and policies list the potential impacts resulting from reduced air quality and climate change. Therefore, the atmospheric emissions discharged during operations and the potential air pollution from an accidental release are considered in this section.

During the operations at the proposed Cambo Field Development, various atmospheric emissions will be generated. The individual climate change impact of the planned operations at the Cambo field are comparatively so small that they are impossible to assess on their individual merit. However, it is acknowledged that they will contribute to the overall cumulative issue of climate change, which is of key concern to overall sustainability objectives and atmospheric emissions are therefore considered further in this section of the environmental Statement (ES). As the individual climate change effects from a single development cannot be assessed, the estimated atmospheric emissions and their associated global warming potential (GWP) in this chapter are presented to provide context to the proposed operations and to allow for generic comparison with the overall values for emissions for the UK offshore oil and gas industry.

It should be noted that the overall strategy to address cumulative global environmental issues, such as climate change, from a UK perspective, ultimately lies with the government. Developing the Cambo field for oil and gas extraction is in line with the UK Government's long-term vision for the offshore oil and gas industry on the UKCS to achieve net zero emissions by 2050, as set-out in the UK Energy White Paper released in December 2020. The 'Net Zero Stewardship Expectation 11' sets out the OGA's view as to how the oil and gas Industry should manage its existing operations and new developments in order to reduce their GHG emissions and support delivery of the UK's net zero (OGA,2021). Similarly, the Oil & Gas UK report 'Pathway to a Net Zero Basin: Production Emissions Targets' outlines the sector is committing to emissions reductions of 50% by 2030 and 90% by 2040 in order to achieve net zero by 2050, accounting for all GHG emissions from all upstream oil and gas operations, compared with a 2018 baseline (OGUK, 2020). SPE is committed to work along with these government and industry bodies as well as with other industry partners towards achieving these ambitious targets by 2050. For example, although neither technically nor economically viable from the outset at the start of production, the FPSO has been designed to accommodate the installation of a future electrical infrastructure to facilitate electrical power import and eventual replacement (in whole or in part) of the proposed gas-turbine driven power and heat generation system. This could reduce direct emissions from FPSO operations by circa 95% from the point of electrification, with residual emissions arising from intermittent non-routine flaring operations and diesel consumption.

The hydrocarbons that will be produced from the Cambo field contain a substantial fraction of natural gas, which will contribute to the transition to cleaner forms of fossil fuels. During operations at the Cambo field, various atmospheric emissions will be generated. The extent of these emissions has been quantified and the significance of their associated effects assessed in this section.

8.1 Description and Quantification of Atmospheric Emissions

Atmospheric emissions contribute to a variety of environmental effects and associated impacts, including climate change.

Table **8.1** provides a summary of potential sources of atmospheric emissions at the proposed Cambo Field Development.

Table 8.1: Summary of the Activities with the Potential to Generate Atmospheric Emissions

Phase	Operational Activity
Drilling and Completion Operations	▪ Energy consumption during drilling and completion.
Installation and Commissioning of FPSO, Subsea infrastructure and export pipeline	▪ Energy consumption during installation.
FPSO (Operations During Production Phase)	▪ Fuel combustion - produced gas and diesel for power generation; ▪ Fuel combustion - produced gas for flare pilots; ▪ Non-routine flaring and venting operations.

The quantification of emissions in this Section of the ES are mainly based on generic emission factors and should be used as an indication of the order of magnitude only. The calculations are based on the fuel consumption estimates presented in Section 3 (Project Description), namely from Table 3.4 worst-case scenario for the drilling operation, Table 3.10 for the SPS SURF Installation, Table 3.12 for FPSO installation and the fuel consumption of the FPSO during the production phase as discussed in Section 3.6.11.

8.1.1 Quantification of Drilling Emissions

It is estimated that the MODU will consume 38 tonnes of diesel per day, based on general industry figures for MODUs capable of working West of Shetland. With a total operational time of approximately 753 days to drill and complete all 13 wells, this will amount to approximately 28,614 tonnes of diesel being used for power generation during drilling and completion operations.

In addition to the fuel used by the MODU itself, all support vessels (supply vessels, standby vessel and helicopter) will also consume fuel and produce exhaust emissions. Table 8.2 provides the predicted emissions from these sources, based on their total fuel consumption.

Table 8.2: Estimated Emissions During Drilling and Well Completion

		MODU	Standby Vessel	Supply Vessel	CSV	Helicopter Flights	Total
Consumption (tonnes)		28,614	1,130	3,440	1,606	969	N/A
Emissions (tonnes)	CO_2	91,564.80	3,614.40	11,008.00	5,139.20	3,100.80	114,427.20
	CO	237.50	9.04	27.52	13.33	5.04	283.84
	NO_x	1,041.55	66.64	202.96	58.46	12.11	2,028.40
	N_2O	6.30	0.25	0.76	0.35	0.21	7.87
	SO_2	114.46	4.52	13.76	6.42	3.88	143.03
	CH_4	3.15	0.30	0.93	0.18	0.08	9.22
	VOC	34.34	2.71	8.26	1.93	0.78	82.34
	GWP	**99,619.07**	**4,049.10**	**12,331.92**	**5,591.26**	**8,625.39**	**133,174.85**

Calculations according to UKOOA atmospheric emissions guidance (1999) and the GWP conversion factors as shown in Table 8.7.

SPE has made a conscious effort to minimise drilling emissions, by introducing a number of technical optimisations and efficiencies during the conceptual planning phase. An internal study showed that the greatest gain in minimising CO_2 emissions from drilling was to be made by minimising the time that the MODU will be in the field. Table 8.3 shows the measures that have been implemented to minimise the overall CO_2 emissions, compared to drilling and completing production wells using conventional methods.

Table 8.3: Estimated CO_2 Emissions Reduction at Cambo Drilling Operations

Technical Optimisation / Efficiency Method vs Conventional Drilling/Completion Method	CO_2 Reduction (tonnes)	CO_2 Reduction (%)
Slimhole well design vs Conventional well design	12,000	5.5%
Well clean-up to FPSO vs Well clean-up to MODU	23,000	10.8%
Use of CAN-Ductors vs Conventional tophole sections	5,000	2.4%
Xmas tree deployment on wire using construction vessel vs conventional Xmas installation from MODU	5,500	2.6%
BOP Hopping and batch drilling vs sequential drilling of individual wells	11,500	5.3%
Total	**57,000**	**26.6%**

8.1.2 Quantification of Emissions during the Installation of the SPS/SURF and FPSO

The installation of the Subsea Production System/Subsea Umbilicals, Risers, and Flowlines (SPS/SURF) is expected to take 132 days, during which the Remotely Operated Vehicle Support Vessel (ROVSV) installation vessel will consume an estimated 2,640 tonnes of diesel. During this time there will be 6 helicopter flights to the FPSO, to support the operations, using an estimated 18 tonnes of helifuel.

The installation and hook-up of FPSO moorings will also be undertaken by the ROVSV installation vessel will take an estimated 51 days to complete. These operations will be supported by 3 tow tugs, using an estimated 1,470 tonnes of diesel fuel.

Table 8.4 presents the estimated emissions and GWP generated by these installation operations.

Table 8.4: Estimated Emissions during SPS/SURF Installation

		ROVSV during SPS/SURF Installation	Helicopter	ROVSV during FPSO Installation	Support tugs (3×) during FPSO Installation	Total
Consumption (tonnes)		2,640	18	1,020	1,470	N/A
Emissions (tonnes)	CO_2	8,448.00	57.60	3,264.00	4,704.00	16,473.60
	CO	21.12	0.09	8.16	11.76	41.13
	NO_x	155.76	0.23	60.18	86.73	302.90
	N_2O	0.58	0.00	0.22	0.32	1.13
	SO_2	10.56	0.07	4.08	5.88	20.59
	CH_4	0.71	0.00	0.28	0.40	1.39
	VOC	6.34	0.01	2.45	3.53	12.33

	GWP	**9,533.73**	**60.26**	**3,683.49**	**5,308.55**	**18,586.02**

Calculations according to UKOOA atmospheric emissions guidance (1999) and the GWP conversion factors as shown in Table 8.7.

8.1.3 Quantification of Emissions during the Installation of the Gas Export Pipeline

The Gas Export Pipeline will be reel-laid from a pipelay vessel and will take 23 days to complete. To protect the pipeline from any potential trawling or other mechanical impacts, a remotely operated jet trenching vehicle will be used to trench up to 45 km of pipeline from 800 m water depth to the WOSPS PLEM location. The pipeline will be connected to the WOSPS PLEM by divers. Table 8.5 presents the estimated emissions and GWP generated by the pipeline installation operations.

Table 8.5: Estimated Emissions during Pipeline Installation

		Pipelay Vessel	ROVSV	Dive Support Vessel (DSV)	Trenching Vessel (TSV)	Total
Consumption (tonnes)		460	800	520	216	1,996
Emissions (tonnes)	CO_2	1,472.00	2,560.00	1,664.00	691.20	6,387.20
	CO	3.68	6.40	4.16	1.73	15.97
	NO_x	27.14	47.20	30.68	12.74	117.76
	N_2O	0.10	0.18	0.11	0.05	0.44
	SO_2	1.84	3.20	2.08	0.86	7.98
	CH_4	0.12	0.22	0.14	0.06	0.54
	VOC	1.10	1.92	1.25	0.52	4.79
	GWP (CO_2 equivalents)	**1,661.18**	**2,889.01**	**1,877.86**	**780.03**	**7,208.07**

Calculations according to UKOOA atmospheric emissions guidance (1999) and the GWP conversion factors as shown in Table 8.7

8.1.4 Quantification of Emissions During Operations / Production

During production, the Cambo FPSO is expected to produce emissions via the combustion of produced gas and diesel as fuel, and via the flaring of produced gas during transient, non-routine conditions. All emissions calculations are based on 92 days of production in 2025 (when production is expected to commence), followed by 365 days of production in subsequent years. Table 8.6 presents the estimated emissions and GWP generated by the FPSO during operations from fuel gas use, flaring and diesel use, over the life of the field (i.e. 25 years and 192 days).

Table 8.6: Estimated Emissions from FPSO Operations over the Life of Field

		Fuel Gas	Flaring	Diesel Use	Total
Consumption (tonnes)		1,174,1778.4	17,739.6	11,982.1	1,203,900.1
Emissions (tonnes)	CO_2	3,250,962.1	49,670.9	38,342.7	3,338,975.7
	CO	2,095.0	21.3	161.8	2278.1
	NO_x	258.3	1.4	2.6	262.4
	N_2O	15.0	0.2	47.9	63.2
	SO_2	1,275.9	118.9	11.0	1,405.8
	CH_4	591.7	319.3	0.4	911.4
	VOC	139.0	35.5	3.5	178.0
	GWP	**3,351,817.8**	**59,845.7**	**39,933.0**	**3,451,597**

Calculations according to UKOOA atmospheric emissions guidance (1999) and the GWP conversion factors as shown in Table 8.7.

The FPSO will use produced gas as its main fuel source. A fuel gas consumption profile has been developed based on the production profiles, project heat and material balance and electrical load schedule which establishes facility power demand. The estimated peak fuel gas rate (on an annualised average basis) is anticipated to remain relatively flat throughout the life of field, averaging around 46,792 tonnes per year and peaking at 48,091 tonnes in 2029. Produced gas will be supplemented by gas imported from the WOSPS pipeline system when the field becomes fuel gas deficient, and therefore there will be relatively low consumption of diesel for power generation. Occasional running of power generation on diesel will be required in the event that fuel gas import is not available, or recovery from shutdown requires re-start on liquid fuel. Other diesel consumers include the following:

- Inert Gas Generation (when hydrocarbon blanket gas unavailable);
- Emergency power generation;
- Firewater pump drives;
- Totally Enclosed Motor Propelled Survival Craft (TEMPSC).

As such, there are no routine users of diesel during normal production operations. For the purposes of estimating emissions, a diesel consumption figure for Cambo has been determined assuming production re-start with main power generation on diesel fuel. Allowing for 6 restarts on diesel per year, diesel consumption of 1.3 tonnes per day, gives a total of 119.6 tonnes per year for the first year of production, followed by 474.5 tonnes per year for the years 2026 to 2050.

As explained in Section 3.6.7, all processing facilities on the FPSO will be designed to operate without the need for routine flaring of hydrocarbons for operational purposes. However, occasional flaring will occur during process upsets and other emergency situations.

To account for atmospheric emissions as a consequence of these transient events, it is estimated that, averaged out on a daily basis, <2 tonnes of natural gas will be flared per day. Figure 8.1 displays Greenhouse Gas (GHG) Emissions and intensity from the FPSO over the production life of the Cambo field. The GHG Intensity calculation is based upon the total GHG emissions (calculated GWP in tonnes of CO_2 equivalent; tCO_2e) from the Cambo field divided by the total amount of hydrocarbons produced (tHC) on an annual basis, over the expected production life of the field. The calculation excludes emissions arising from installation and decommissioning activities. The Figure shows that the GHG intensity increases from 0.031 tCO_2e/tHC in 2025 at the start of production to 0.392 tCO_2e/tHC in 2050, at the end of field life.

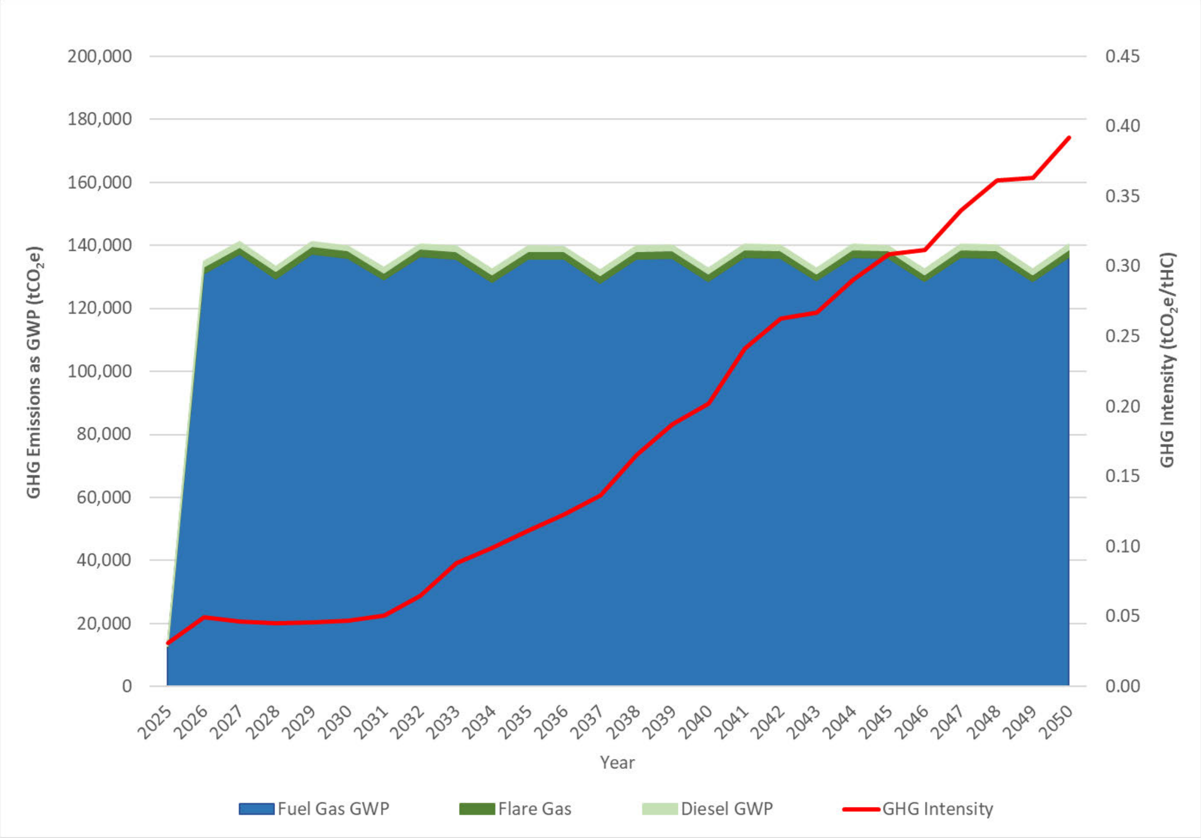


Figure 8.1: Greenhouse Gas Emissions and Intensity for the Cambo Field

8.2 Environmental Impacts Resulting from Atmospheric Emissions

The emissions produced from the planned operations are known to have the potential to contribute to a number of environmental processes and impacts including global warming (greenhouse gases), acidification (acid rain), the formation of low-level ozone, and local air pollution.

The most commonly used general indicator of atmospheric emissions is the global warming potential (GWP), expressed in tonnes of carbon dioxide (CO_2) equivalents. GWP is a measure of the relative radiative effect of a given gas compared to that of CO_2, integrated over a chosen time horizon (often a 100 year time period). Simply stated, the GWP of a specific gas is a measure of its climate change impact relative to carbon dioxide (AEA, 2007). All gaseous substances that contribute towards global warming (e.g. CO_2, CH_4, N_2O, CO, and NO_x) have a GWP factor that allows the conversion of individual emissions into CO_2 equivalents. As such, GWP can be used to estimate the potential future impacts of gaseous emissions upon the climate system. The GWP factor of each of the most common combustion gases is given in Table 8.7.

Table 8.7: Environmental Effects of Atmospheric Emissions

Gaseous Emission	Environmental Effect	100 year GWP Factor*
Direct Greenhouse Gases		
Carbon dioxide (CO_2)	CO_2 is a greenhouse gas, meaning that it inhibits the radiation of heat into space, which may increase temperatures at the Earth's surface.	1
Methane (CH_4)	May contribute to climate change.	28
Nitrous oxide (N_2O)	May contribute to climate change.	265
Indirect Greenhouse Gases		
Carbon monoxide (CO)	Direct effects upon human health (asphyxiant). May contribute indirectly to climate change.	3
Oxides of nitrogen (NO_x)	NO_2 has direct effects upon human health and vegetation and has the potential to cause respiratory illness and irritation of the mucous membranes. NO_x acts as a precursor to low-level ozone formation. NO_x contributes to acid deposition (wet and dry) which impacts both freshwater and terrestrial ecosystems.	5**
Volatile organic compounds (VOC)	Volatile organic compounds (VOC), which include non-methane hydrocarbons (NMHC) and oxygenated NMHC (e.g. alcohols, aldehydes and organic acids), have short atmospheric lifetimes (fractions of a day to months) and small direct impact on radiative forcing. VOC influence climate through their production of organic aerosols and their involvement in photochemistry, i.e. production of ozone (O_3) in the presence of NO_x and light. Generally, fossil VOC sources have already been accounted for as the release of fossil C in the CO_2 budgets and therefore are not counted as a source of CO_2.	-
Sulphur dioxide (SO_2)	SO_2 has direct health effects - causes respiratory illness. SO_2 contributes to acid deposition (wet and dry) which impacts both freshwater and terrestrial ecosystems.	-
Other		
Particulate matter (PM)	The environmental effect of particulate matter is mainly determined by the size (and shape) of the particles. Particles emitted from modern diesel engines (commonly referred to as Diesel Particulate Matter, or DPM) are typically in the size range of 100 nanometres (0.1 micrometre) and can penetrate the deepest part of the lungs. In addition, these soot particles also carry carcinogenic components. In high concentrations particulate matter can also affect plant growth.	-

* *Direct GWPs are from IPCC (2007) and indirect from IPPC (2001) and refer to the 100 year horizon values.*

** *The GWP factor of 5 is for surface emissions. Higher altitude emissions (i.e. from aircraft) have greater impacts both because of longer NO_x residence times and more efficient tropospheric O_3 production, as well as enhanced radiative forcing sensitivity. NO_x emissions from aircraft can therefore have GWPs in the order of 450 for considering a 100 year time horizon. It must be noted however that these numerical values are subject to very large quantitative uncertainties.*

Greenhouse gases can be divided into 'direct' and 'indirect' greenhouse gases. Direct greenhouse gases have an effect on the balance of energy entering and exiting the atmosphere ('radiative forcing') and include combustion gases such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), as well as naturally occurring gases such as tropospheric ozone (O_3). Reactive gases such as carbon monoxide (CO), volatile organic compounds (VOC), nitrogen oxides (NO and NO_2) and sulphur dioxide (SO_2) are termed indirect greenhouse gases. These pollutants are not significant as direct greenhouse gases but, through atmospheric chemistry, they impact upon the abundance of the direct greenhouse gases thereby increasing the overall greenhouse effect. The environmental effects of the most common combustion gases are presented in Table 8.7.

8.3 Wider Scale Impacts

The estimated GWP of the emissions associated with the proposed operations is presented in Table 8.2, Table 8.4, Table 8.5, Table 8.6 and Figure 8.1. All UK operators report their atmospheric emissions to the Environmental Emissions Monitoring System (EEMS). The EEMS report does not account for emissions from support vessels and helicopters, hence those values are not included in the following comparisons.

Approximately 3 million tonnes of CO_2 equivalents were flared on the UKCS in 2018 (Oil and Gas UK, 2020). Annual flaring from the proposed Development (2,340 tonnes of CO_2 equivalents per year on average over the life of field) would account for less than 0.082% of the overall flaring on the UKCS.

In 2018, a total of 18.3 million tonnes of CO_2 equivalent were released from upstream oil and gas operations, equating to 4% of the total UK GHG emissions (Oil and Gas UK, 2020). Compared to this value, the combined average annual GWP generated by operations at the proposed Development, including flaring (i.e. 134,280 tonnes of CO_2 equivalents per year on average over the life of field) would account for less than 0.73%, a minor proportion of overall annual exploration and production operations undertaken on the UKCS. In this context, the atmospheric emissions generated during the proposed operations are not considered to be significant.

8.4 Localised Impacts

Combustion emissions have the potential to reduce local air quality through the introduction of contaminants such as oxides of nitrogen (NO_X), volatile organic compounds (VOCs) and particulates which contribute to the formation of local low-level ozone and photochemical smog. However, seafaring vessels, such as ships and MODUs, are built and operated to standards that preclude impacts to the health of crews, whilst other environmental receptors present in the immediate vicinity of the operations (e.g. flora and fauna) tend to be sparsely distributed and/or mobile in their distribution. Local impacts are further mitigated by the open and dispersive nature of the offshore environment. Any impacts at this level are therefore difficult to measure and to distinguish from background variation. On this basis, localised impacts from combustion and flaring emissions at the Cambo Field are considered to be negligible, and therefore not significant.

8.5 Cumulative and Transboundary Impacts

The assessment of the impacts of atmospheric emissions, as discussed above, is unchanged by the consideration of other emission sources local to the proposed operations. Whilst emissions from the proposed operations have the potential to combine with those from local low-density shipping, and the limited oil and gas infrastructure in the West of Shetland region, this is not expected to increase any local impacts significantly due to the relatively large distances between these developments, and the highly dispersive nature of the offshore environment. The proposed operations are therefore not expected to have any significant cumulative effects in combination with other local sources of emissions.

As indicated in Section 8.3 above, on a wider scale the additive contribution to the emissions of the overall UK oil and gas industry from the proposed operations can be viewed as of little significance and therefore their cumulative effect is also expected to be minimal. SPE acknowledges that the atmospheric emissions from the proposed Development to wider global environmental impacts, such as global climate change. However, it would be impossible to assess the individual contribution of the Cambo Field Development to such effects.

Local wind conditions may result in the transboundary transport of atmospheric emissions generated at the proposed Cambo Field Development location. However, as the quantities involved are minimal in relation to national scale emissions and of a relative short duration, the resulting incremental effects of transboundary emissions on other nation's total emissions levels are not expected to be detectable. Transboundary atmospheric emissions require international collaborative action to control their formation and effects.

8.6 Impacts on Conservation Areas

As discussed in Section 4, the proposed Cambo Field Development Footprint is located 12 km northwest of the Faroe-Shetland Sponge Belt NCMPA, with 32 km of the Gas Export Pipeline Route traversing thought the NCMPA. The only activity being undertaken within the NCMPA which will produced atmospheric emissions is the installation of the pipeline. However, the atmospheric emissions will not interact with nor affect any of the conservation objectives of the Faroe-Shetland Sponge Belt NCMPA or any other sites of conservation importance in the wider area. Therefore, local and cumulative impacts on sites of conservation importance, such as Special Areas of Conservation (SAC), Special Protected Areas (SPA) and NCMPA from atmospheric emissions are considered to be negligible, and thus not significant.

8.7 Mitigation Measures

Cambo development facilities will be selected and designed such that, as far as is reasonably practicable, Greenhouse Gas (GHG) emissions are minimised from the outset, and to accommodate potential future modifications over the life of field. For example, the FPSO has been designed to accommodate the installation of a future electrical infrastructure to facilitate electrical power import and eventual replacement (in whole or in part) of the proposed gas-turbine driven power and heat generation system.

In addition, Cambo will not have continuous routine flaring or venting of gas associated with production. Flaring and venting of hydrocarbon gas shall be minimised by employing BAT. All associated gas from the various separation stages shall be recovered through compression. Dual fuel units have been selected that are gas fuel Dry low NO_x (DLE)/liquid fuel Lean Direct Injection (LDI) equipped.

All equipment will be well maintained according to a strict maintenance regime; including regular monitoring and inspections to ensure an effective maintenance regime is in place. The maintenance regime will ensure all equipment will operate at optimum efficiency, and therefore minimise the overall fuel consumption. The combustion plants onboard the MODU and FPSO, will be built to be fuel efficient and to meet all current emission standards. Low sulphur fuels according to International Maritime Organisation requirements will be used. Fuel gas import from WOSPS will also help to minimise diesel consumption. When scheduling the drilling operations, optimising fuel use has been considered, including batch drilling of the wells, for example, to minimise fuel use.

The atmospheric emissions from the MODU and the FPSO will be reported under EEMS.

8.8 Conclusions

Atmospheric emissions will be produced during drilling, installation and production operations, as a result of power generation onboard the MODU and FPSO, as well as on the standby vessel, supply vessels, subsea construction vessel and helicopter activity. In addition to these, there will be flaring emissions from the pilot flare onboard the FPSO. These emissions will contribute to local and global environmental effects. At a local level, impacts are mitigated by Health and Safety measures in place to control emissions and by the dispersive nature of the offshore environment. As such, any local air pollution effects are expected to be negligible, and therefore not significant. Effects from atmospheric emissions generated by the proposed Development on conservation areas are also expected to be negligible, with no impact on conservation objectives or site integrity anticipated.

Emissions will also contribute to global environmental issues, including climate change. The contribution of the proposed drilling programme is comparable to similar operations, and small in comparison to emissions at an industry wide level. Therefore, it may be concluded that the individual GWP generated by the operations associated with the proposed Cambo Field Development and its resulting impacts are too small to be assessed by itself. Although the urgency of the requirement to reduce GWP emissions resulting from hydrocarbon combustion is fully acknowledged, the ultimate cumulative global implications of global climate change are still poorly understood and therefore very hard to assess. The overall strategy to address this issue ultimately lies with national and international governance. Development of the Cambo field for oil and gas extraction is in line with the UK Government’s long-term vision for the offshore oil and gas industry on the UKCS to achieve net zero emissions by 2050 as set out in the UK Energy White Paper released in December 2020. SPE is committed to contribute towards achieving this ambitious target by 2050, where it can.

Section 9

Drilling Discharges

9 DRILLING DISCHARGES

This section addresses issues and concerns associated with drilling discharges, which were raised during the Environmental Issues Identification (ENVID) workshop, informal stakeholder consultation and those which are part of the National Marine Plan (NMP), namely:

- Impacts on seabed and water column communities due to discharges to sea including:
    - Discharge of payzone cuttings;
    - Discharge of drill cuttings and water based mud (WBM) from both the top holes and lower well sections;
    - Discharge of cement;
- The NMP, Oil and Gas Objectives and marine planning policies list the potential impacts resulting from chemical contamination. As a result, the discharge to sea of chemical additives used during the drilling process and the potential discharge of oil contaminated cuttings from the payzone section has been considered in this section.

This section assesses the potential impacts of drilling discharges upon benthic communities as well as the impacts on the Faroe-Shetland Sponge Belt Nature Conservation Marine Protected Area (NCMPA) and its conservation objectives.

As described in Sections 5.3.3 and 5.3.4, Feature Activity Sensitivity Tool (FEAST) and the JNCC’s Formal Conservation Advice were also used to review the pressures exerted by drilling discharges upon the sensitive features within the Faroe-Shetland Sponge Belt NCMPA. Features of interest include continental slope channels, deep-sea sponge aggregations, Iceberg plough mark fields, ocean quahog aggregations, sand and sediment wave fields, slide deposits and offshore sands and gravels. A full list of pressures and feature sensitivities according to FEAST and the JNCC’s Formal Conservation Advice, including Advice on Operations (AoO) sensitivity assessment, are provided in Appendices 6 and 7. However, as only three of these features, offshore sands and gravels, Iceberg plough mark fields and deep-sea sponge aggregations, are present in the immediate vicinity of the proposed Development (MMT, 2019), no further assessment was deemed necessary on ocean quahog aggregations, slide deposits, continental slope channel sand and sediment wave fields, which are out with the Development location.

During the drilling operations associated with the proposed Development, various discharges will be made both directly onto the seabed and at the sea surface. These discharges have the potential to affect the marine environment through both chemical and physical mechanisms. The extent of these discharges has been quantified and the significance of their associated effects assessed in this Section. As explained in Section 3.5.2, there is a preference to use CAN-ductors on all wells. However, for any wells where the use of the CAN-ductor proves to be not suitable, conventional tophole sections will be drilled by the Mobile Operated Drilling Unit (MODU) instead. Hence, for the purposes of assessing the effects of drilling discharges in this Environmental Statement (ES), the larger volume of the discharges of drilling all wells with conventional tophole sections has been assessed, to represent the worst-case scenario.

9.1 Description and Quantification of Discharges

9.1.1 Mud and Cuttings

During drilling of the proposed Cambo well, drill cuttings and spent drilling muds will require disposal. Drill cuttings consist of the chips of crushed rock broken off by the drill bit as it extends the wellbore. Drill cuttings therefore vary in nature depending on the characteristics of the rock layers present and the drill bit used, but generally range in size between very fine clay sized particles (<2 µm) to coarse gravels (>30 mm) (Neff, 2005). As described in Section 3 (Project Description), WBM typically consists of a base fluid, either seawater, freshwater or brine within which clays and other mineral weighting agents such as bentonite are suspended. Additional chemical additives, including organic polymers such as glycol, may also be used to maintain the optimal performance of the mud.

Drill cuttings and particulate material from the spud mud (i.e. seawater with high viscosity bentonite sweeps) will be used to drill four sections in total. Assuming no CAN-ductors are used as a worst-case scenario, the first two sections (36″ and 17½″ diameters) will be drilled open hole and the cuttings will be discharged near the seabed.

Following the drilling of the two conventional top-hole sections, two successively deeper 12¼" and 8½" sections will be drilled with a full WBM system. The cuttings generated from these deeper sections will be returned to the MODU and discharged near the sea surface. The WBM recovered during the cuttings cleaning process will be reconditioned and re-used where possible but will ultimately be discharged during operations. It is estimated that a total of 751 tonnes of cuttings and 2,188 tonnes of WBM will be discharged for the largest production well (well P10; see Appendix 8 for details on each well). A total of 769 tonnes of cuttings and 2,232 tonnes of WBM will be discharged from the largest injection well (well I7) (Table 3.5 and 3.6, Section 3.5.3).

9.1.2 Cement

The two well design options have a direct impact on the amount of cement that will be discharged, depending on whether a CAN-ductor is used for the tophole section of the well, or if the well is drilled with conventional tophole sections instead. The worst-case scenario, with regard to cement discharges, will be for the conventional well design, i.e. without a CAN-ductor, and thus this scenario has been assessed in this chapter.

It is anticipated that up to 41.1 m^3 of cement slurry may be discharged in this fashion per well. As explained in Section 3.5.4, no cement returns are expected from the deeper well sections under normal operational conditions. The only potential discharge during this part of the cementing operations would be from an unplanned vent, such as an aborted cement job due to technical or mechanical failures. If for any reason cement is circulated back to the MODU, it would need to be discharged to sea before it solidifies. No unmixed cement will be discharged overboard.

9.1.3 Payzone and Associated Drilling Fluids

Cuttings generated when drilling through the reservoir formation may become contaminated with the hydrocarbons therein. These are commonly referred to as ‘payzone cuttings’. It is proposed that the payzone cuttings will be discharged to sea under an Oil Pollution Prevention and Control (OPPC) permit, which is common practice on the UKCS. The amount of payzone cuttings will make up a small fraction of the overall of cuttings generated, and the amount of associated oil will be small. This discharge will be monitored. Should the cuttings contain more hydrocarbons than permitted, then they will be shipped back to shore for appropriate treatment and disposal.

9.2 Impacts from Water Based Muds (WBM) and Cuttings Discharges

9.2.1 Physical Extent of Discharges

Cuttings dispersion modelling has been undertaken for the proposed drilling operations (Fugro, 2019c) in order to estimate the physical extent of the discharged drill cuttings. Prevailing hydrological current conditions were sourced from the Massachusetts Institute of Technology general circulation model (MITgcm). The model simulates circulation at a regional scale and has been validated against current oceanographic datasets.

The potential dispersion of the drill cuttings has been predicted using an advection-diffusion model, whereby two scenarios were modelled as follows:

- Scenario 1 (Planned release)– Estimation of (maximum) anticipated thickness of deposition;
- Scenario 2 (Spread release) – Estimation of (maximum) anticipated extent of cuttings deposition.

For Scenario 1, the drill cuttings were released according to the planned drilling schedule providing the best estimate of the cuttings deposit thickness on the seafloor at increasing distances from the well location. However, as the conditions at the actual time of drilling will differ from those considered at the time of modelling, this scenario will not capture the potential (full) range of directional spreading of the deposits, because the zone of deposition will be influenced by the magnitude and orientation of the currents in the selected modelling period.

Therefore, Scenario 2 was run to account for the variability associated with the tidal cycles and residual currents. It considers that the drill cuttings are released continuously during a longer period of 25 days. This approach ensures that the dispersion modelling captures the variability of the currents both intensity and orientation. It provides the best estimate for the maximum directional spreading of the drill cuttings away from the well location. However, the modelling results from Scenario 2 will underestimate the deposit thickness, as the drill cuttings are being dispersed over a wider area.

To reduce the number of numerical analyses the simulation was based on the drilling schedule for one production well and one injector well. Well P10 was selected as it represents the worst-case scenario with the largest cuttings volume. A conservative estimate for the total thickness of the deposits, corresponding to the drilling of all the production wells, is then estimated by transposing and adding the simulation results from well P10 to the other well locations. An overall cumulative thickness can then be estimated. The same methodology was applied to the injector wells with well I7 representing the worst-case scenario.

Planned Release Model Outputs

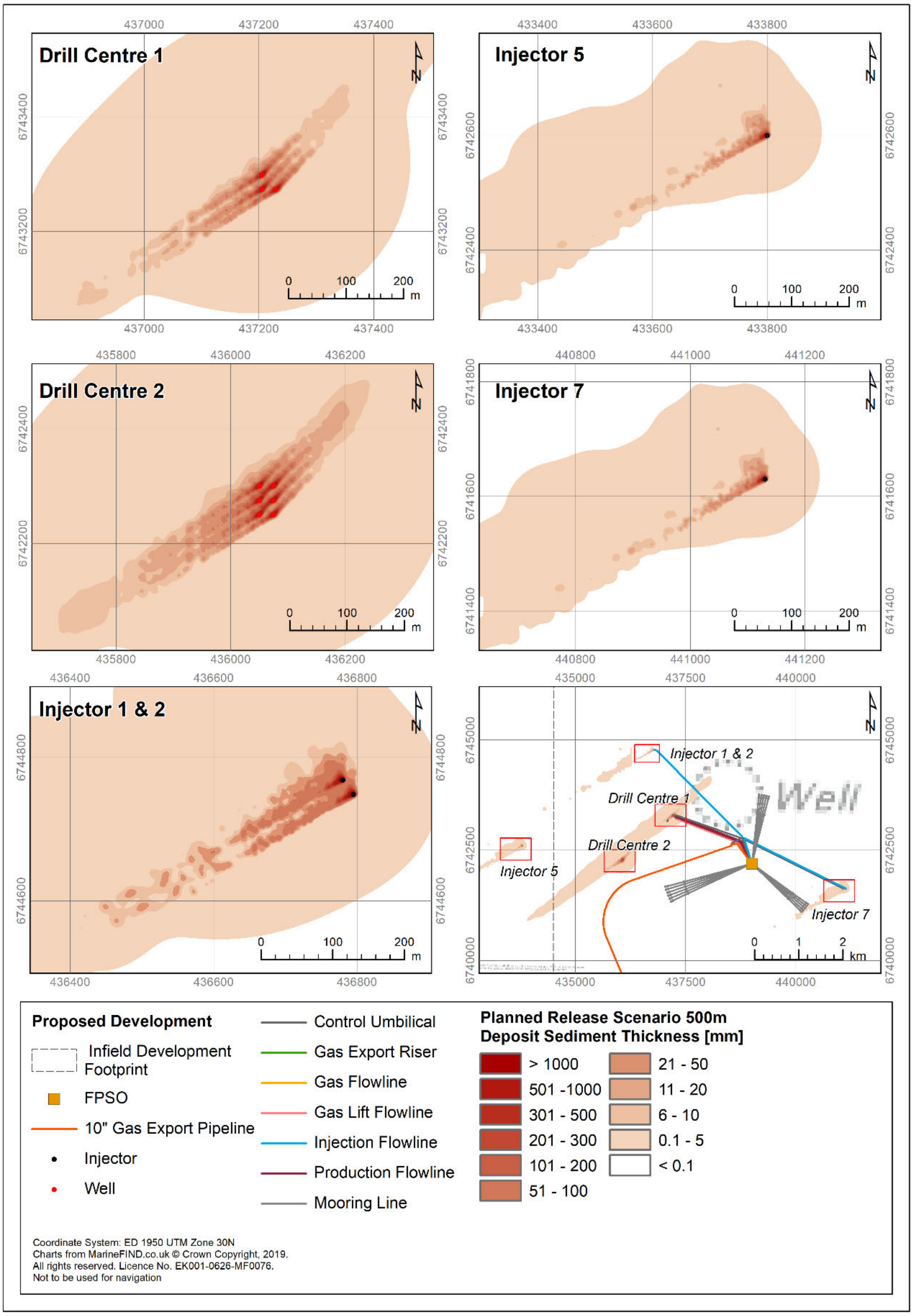
The modelling results for the Planned Release scenario (maximum thickness) indicate that the maximum area where a measurable change in seabed deposits is observed (i.e. thickness over 0.1 mm) is predicted to cover a total of 2.32 km^2. Significant deposits, of a thickness above 50 mm, are predicted to cover an area of 0.015 km^2 and are restricted to within 200 m of well locations (Table 9.1).

Table 9.1: Topographical Metrics of Combined Cuttings Piles for the Planned Release Scenario

Thickness [mm]	Area [km^2]	Area Within 200 m of Wells [km^2]
0.1 - 5	2.21166	0.55356
5 - 10	0.05253	0.02891
10 - 20	0.02717	0.02408
20 - 50	0.01808	0.01808
50 - 100	0.00780	0.00780
100 - 200	0.00322	0.00322
200 - 300	0.00130	0.00130
300 - 500	0.00111	0.00111
500 - 1000	0.00086	0.00086
> 1000	0.00033	0.00033
Total	**2.32410**	**0.63929**
Total >50 mm	**0.01465**	**0.01465**
Maximum Thickness (m)	**1.76 m**	

The results show that the mud and cuttings are mainly transported along a southwest-northeast axis, aligned with the dominant currents, with a net residual deposition in a south-westerly direction. The larger coarser particles, which have the highest settling velocity, travelled much shorter distances in comparison to the finer particles. Therefore, the larger particles generally settle closer to the release point with the finer particles being transported and settling onto the seabed at further distances.

Figure 9.1 shows the maximum cuttings deposition thickness at the well location has been modelled to be 1.76 m in height, quickly reducing to a thickness of 1 cm slightly beyond 200 m from each well location. Beyond 500 m from wells, the thickness drops to sub-millimetric scale (Figure 9.2).



Coordinate System: ED 1950 UTM Zone 30N
Charts from MarineFIND.co.uk © Crown Copyright, 2019.
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Figure 9.1: Maximum Anticipated Thickness of Deposition for All Wells (Planned Release Scenario)

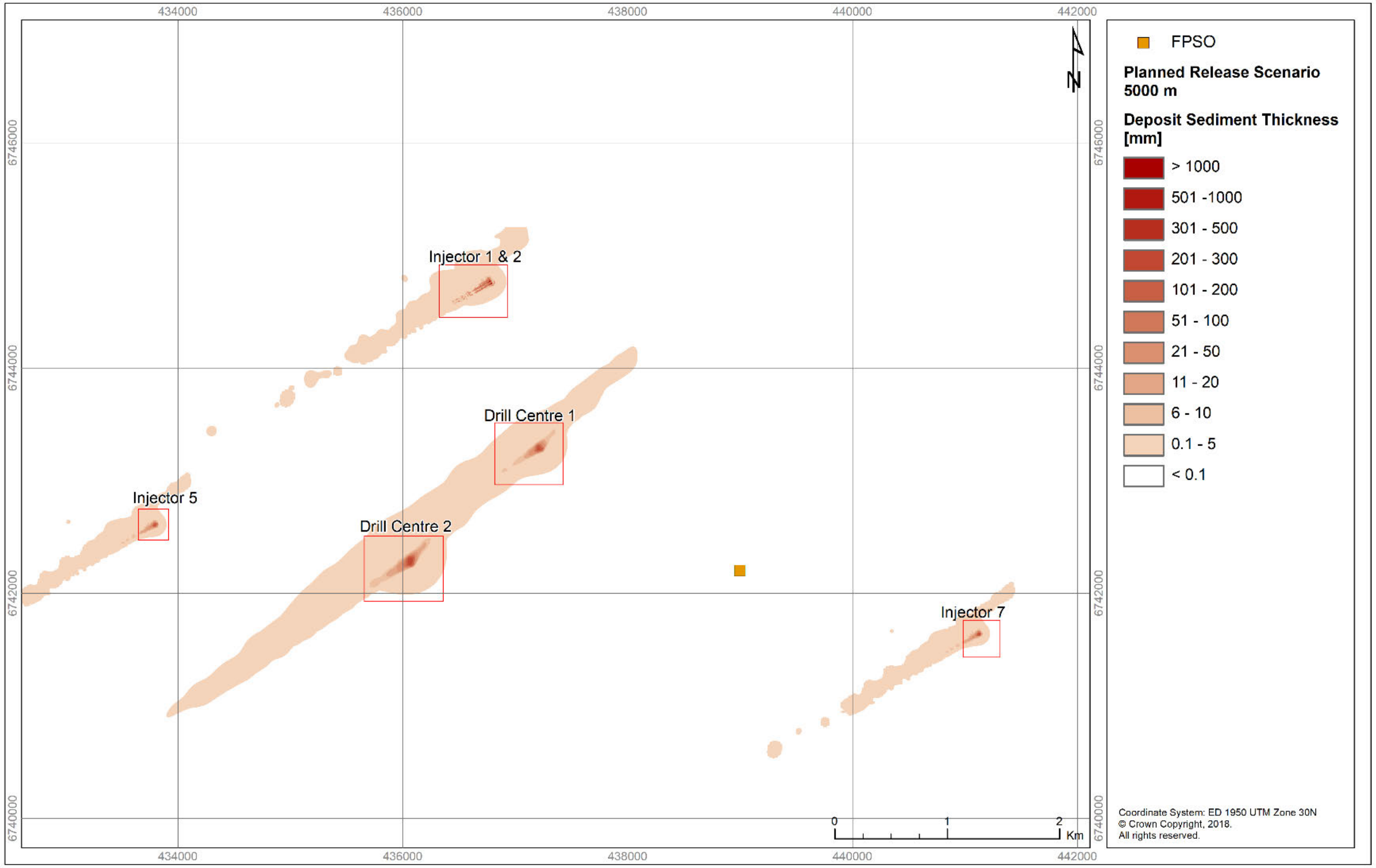


Figure 9.2: Maximum Anticipated Thickness of Deposition for all Wells over Main Field Development Area (Planned Release Scenario)

Spread Release Model Outputs

The modelling results for the Spread Release scenario (maximum extent) indicate that the maximum area where a measurable change in seabed deposits is observed (i.e. thickness over 0.1 mm) is predicted to cover a total of 2.97 km^2. Significant deposits, of a thickness above 50 mm, are predicted to cover an area of 0.0071 km^2 and are restricted to within 200 m of well locations (Table 9.2), which an order of magnitude smaller than the Planned Release scenario.

Table 9.2: Topographical Metrics of Combined Cuttings Piles for the Spread Release Scenario

Thickness [mm]	Area [km^2]	Area Within 200 m of Wells [km^2]
0.1 - 5	2.86711	1.30754
5 - 10	0.05897	0.05202
10 - 20	0.02756	0.02588
20 - 50	0.01180	0.01179
50 - 100	0.00369	0.00369
100 - 200	0.00207	0.00206
200 - 300	0.00074	0.00074
300 - 500	0.00058	0.00058
Total	2.97254	1.40432
Total > 50 mm	0.00707	0.007078
Max Thickness (m)		0.49 m

Under the spread Release scenario, cuttings deposition still shows a clear southwest-northeast axis, however there is a slightly greater degree of radial deposition than under the Planned Release scenario. However, most of the descriptive characteristics of the Spread Release deposition are broadly similar to the Planned Release scenario, when considered within the spatial context of this impact assessment.

Figure 9.3 shows the maximum cuttings deposition thickness at the well location has been modelled to be 0.49 m in height, quickly reducing to a thickness of 1 cm slightly beyond 200 m from each well location. Beyond 500 m from wells, the thickness drops to sub millimetric scale (Figure 9.4).

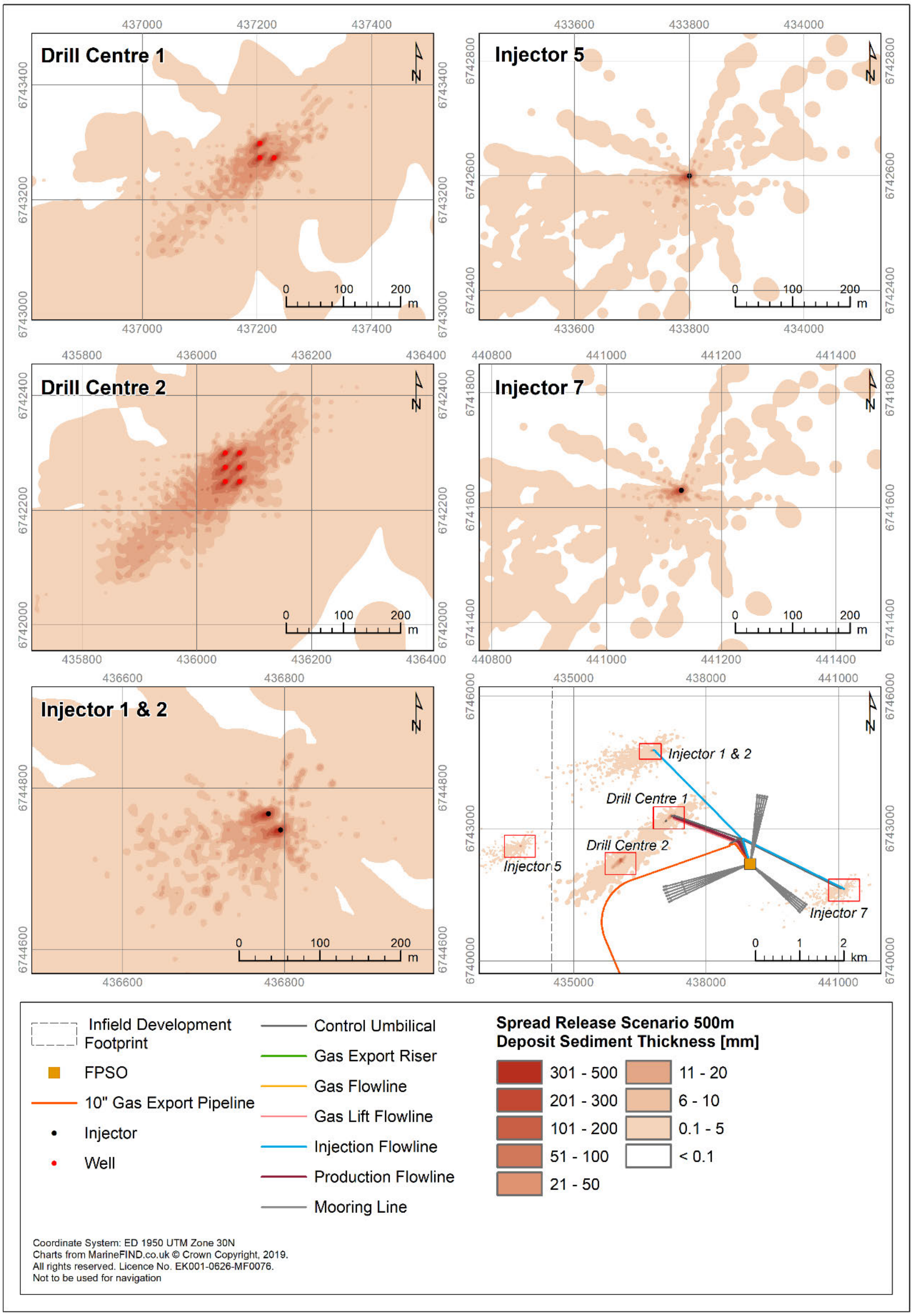


Figure 9.3: Maximum Anticipated Extent of Deposition for All Wells (Spread Release Scenario)

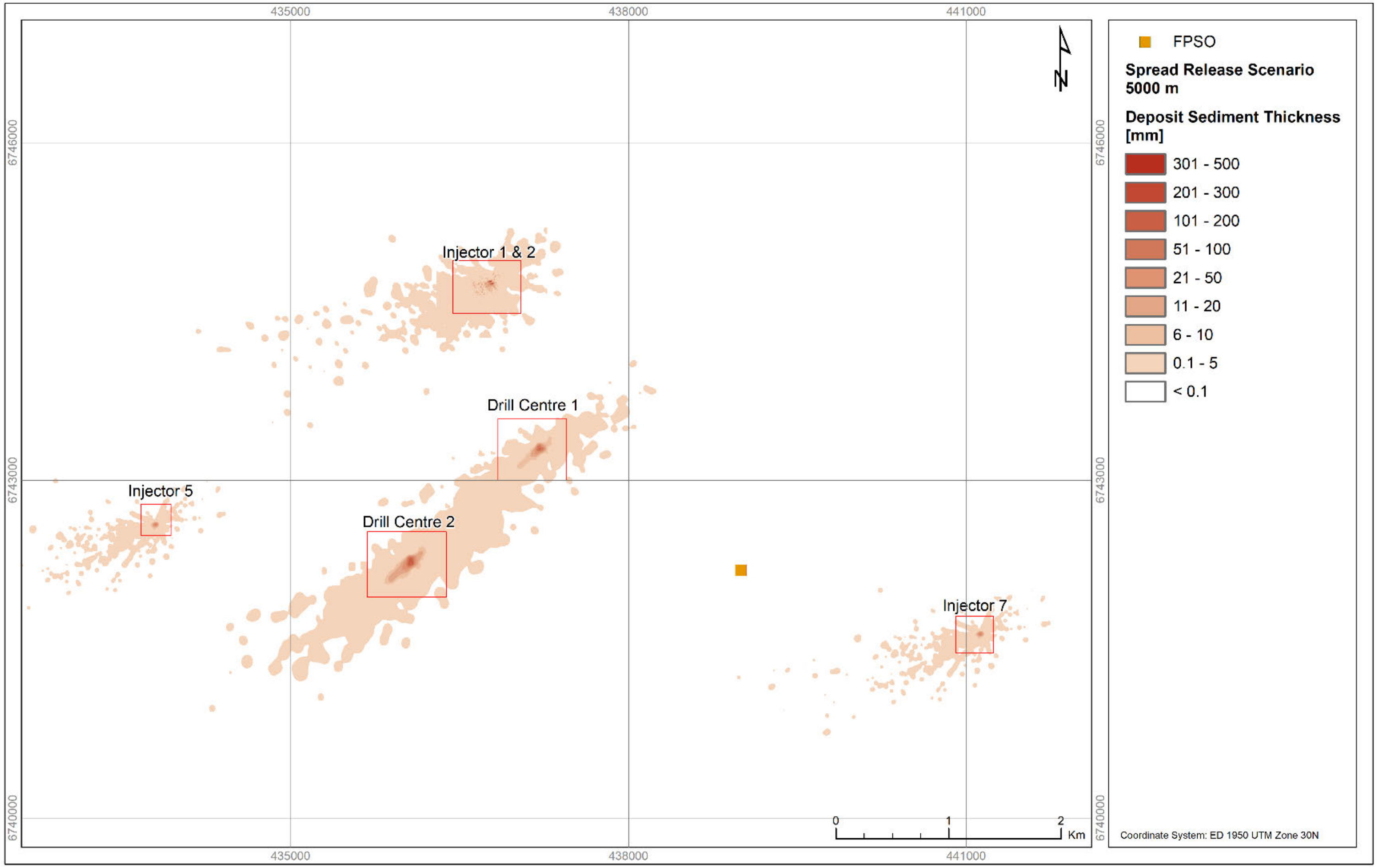


Figure 9.4: Maximum Anticipated Extent of Deposition for All Wells over Main Field Development Area (Spread Release Scenario)

Proximity to Protected Areas

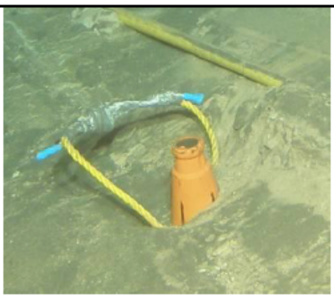
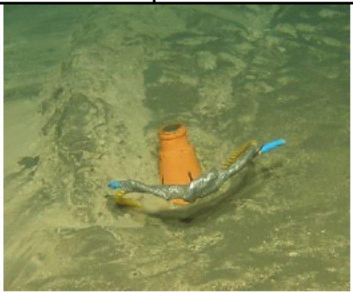
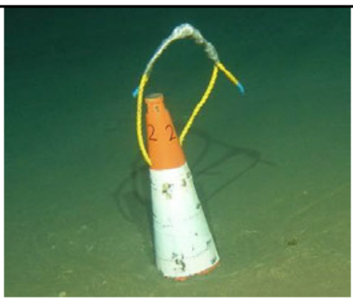
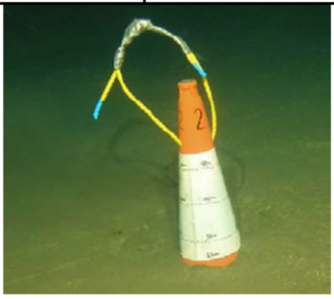
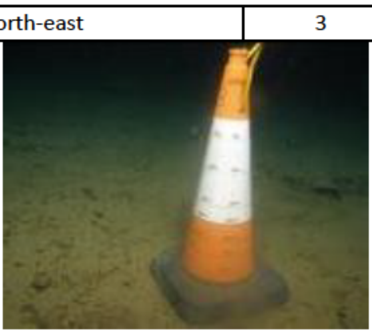
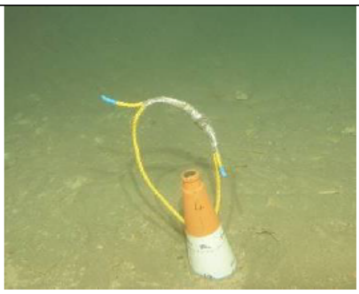
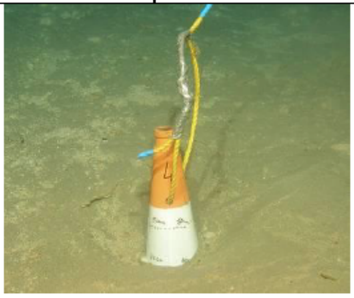
The closest protected area to the drilling locations is the Faroe-Shetland Sponge Belt NCMPA, which lies 14.2 km to the southeast of the nearest well location, Injector 7 (Figure 4.25). The strong southwest-northeast axis of deposition ensures that there is very limited transport of cuttings towards the NCMPA. The closest boundary point of the significant thickness threshold (50 mm) is 14.1 km from the Faroe-Shetland Sponge Belt, and the furthest extent of the 0.1 mm thickness class is 13.9 km from the NCMPA.

Comparison to Other Drill Cuttings Studies in the Area

As part of the Cambo 4 operations a pre- and post-drilling habitat assessment was carried out. Four marker cones were positioned around the wellhead before drilling commenced to allow the height of the cutting and cement to be assessed. Table 9.3 provides measurements of observed cuttings and cement accumulations around each of the visible cones. The total volume of cuttings at the Cambo 4 and 4z wells amounted to a total of 1,155 MT of cuttings with 568 MT generated at the seabed during riserless drilling and the remaining 587 MT from the rig. This volume is significantly greater than the worst case planned production well at the Cambo Development due to the inclusion of a 26" surface section, and a 12-1/4" sidetrack.

The proposed use of CAN-ductors for the Cambo development wells are expected to reduce cuttings and cement accumulations.

Table 9.3: Approximate Cuttings and Cement Accumulation for all Visible Cones and Distances from Cambo 4 Well

<table>
<tr><th>Transect</th><th>Cone Number</th><th>Distance from Well Centre (m)</th><th>Heading (°)</th><th>Cement Accumulation (~cm)</th></tr>
<tr><td rowspan="2">Southwest</td><td rowspan="2">1</td><td rowspan="2">18.55</td><td>212</td><td>60</td></tr>
<tr><td>30</td><td>60</td></tr>
<tr><td colspan="2">
Southwest cone 1: Pre-drill 212º</td><td>
Southwest cone 1: Post-drill 212º</td><td colspan="2">
Southwest cone 1: Post-drill 30º</td></tr>
<tr><td rowspan="2">South-east</td><td rowspan="2">2</td><td rowspan="2">16.50</td><td>141</td><td>24</td></tr>
<tr><td>320</td><td>22</td></tr>
<tr><td colspan="2">
Southeast cone 2: Pre-drill 145º</td><td>
Southeast cone 2: Post-drill 141º</td><td colspan="2">
Southeast cone 2: Post-drill 320º</td></tr>
<tr><td>North-east</td><td>3</td><td>4.81</td><td>170</td><td>Assumed to be >70</td></tr>
<tr><td colspan="2">
Northeast cone 3: Pre-drill 170º</td><td colspan="3">No photographs available of the northeast cone post drilling, assumed buried completely underneath the cuttings and cement discharges</td></tr>
<tr><td rowspan="2">Northwest</td><td rowspan="2">4</td><td rowspan="2">14.92</td><td>296</td><td>40</td></tr>
<tr><td>160</td><td>42</td></tr>
<tr><td colspan="2">
Northwest cone 4: Pre-drill 300º</td><td>
Northwest cone 4: Post-drill 296º</td><td colspan="2">
Northwest cone 4: Post-drill 160º</td></tr>
</table>

As part of the operations at the Rosebank well (Block 213/27), drilled approximately 25 km to the northeast of the proposed Cambo location, detailed Remotely Operated Vehicle (ROV) monitoring was conducted around the well location, both pre- and immediately post-drilling. This was carried out by SERPENT project of the National Oceanography Centre, Southampton (NOCS) in order to assess the effects of such discharges on local benthic communities, particularly larger seabed organisms known as megafauna. The water depth, seabed and hydrographic characteristics are largely consistent with the proposed Cambo location. Although the quantity of cuttings estimated to be generated from the tophole sections in this case differs, the observations of the SERPENT study at the Rosebank location can be used as a reference point for the cuttings modelling for the proposed Cambo well.

Post drilling monitoring of the seabed around the Rosebank well observed that at least partial coverage of drill cuttings extended to approximately 80 m to 90 m in all directions. The seabed within 40 m of the well site was characterised by a uniform coverage of drill cuttings material with no visual evidence of the natural seabed, although the depth of coverage was not recorded. At distances between 40 m and 90 m from the well, areas of darker sediment `patches’ were identified, interspersed between the natural sediments. Deposited material was observed at greater distances (over 100 m) to the southwest of the well, which coincided with the estimated net current movement in the area (SERPENT, 2009). However, generally at distances beyond 100 m, no visible evidence of drill cuttings deposition was observed.

The SERPENT research conducted in Block 213/27 has been collated with observations of nine other ROV surveys at drilling sites in the Faroe-Shetland Channel and Norwegian sea as part of a 5 year monitoring programme. Water depths at these sites varied between approximately 400 m and 1,750 m. Although there was some variation between sites, generally speaking, at distances greater than 100 m from the drilling location cuttings deposition was very thin and some of the natural seabed was visible; at distances greater than 200 m there was almost no evidence of discharge.

This general pattern largely corresponds with the results from the proposed Cambo cuttings modelling. For each scenario a large percentage of the cuttings and mud volume is deposited within 100 m of the well location. The volume of cuttings and mud distributed drops rapidly once it reaches 200 m from the drilling location, with less than 5% of the total cuttings and mud volume being deposited per every additional 100 m beyond the 200 m mark.

9.2.2 Effects on Benthic Communities

Considerable data have been gathered from studies into the effects of drill cuttings and WBM on benthic communities, conducted at various sites on the UKCS and worldwide as part of academic research and general environmental monitoring of the oil and gas industry e.g. DTI, 2001; Neff, 2005; OSPAR, 2007, Jones et al, 2012. This work has led on from earlier and ongoing studies into the long term persistence and effects of oil base mud (OBM) contaminated cuttings, the discharge of which is generally no longer permitted due to concerns over environmental disturbance. This work has led to a broad consensus on the potential effects that discharged cuttings and associated fluids can have on benthic organisms and communities.

Physical Impacts on Benthic Communities

The primary impact identified with regard to WBM cuttings is the direct smothering effect of burial by material discharged as it settles on the seabed (Neff, 2005; OSPAR, 2007). Any cement discharged at the seabed will add to this impact, resulting in very similar effects.

Vulnerability to the impact caused by cuttings and cement discharges varies between different benthic groups, depending on their physiology and ecology, and some species (such as sessile species among others) are likely to be more sensitive than others. For example, in the case of burrowing organisms, which feed on subsurface sediments, many such species are capable of burrowing up through deposited sediment ranging from 10 mm to 300 mm in thickness to live at the new sediment surface (e.g. Maurer et al, 1979; Kukert, 1991). However, it is unlikely that whole communities would survive burial under more than a few centimetres.

A study on the recovery of deepwater megafaunal assemblages from hydrocarbon drilling disturbance at the Laggan Well in the Faroe-Shetland Channel (Jones et al, 2012) observed partial recovery of deepwater megafaunal density and diversity after 3 and 10 years, except for very close to the well location where densities and diversity were still reduced. In fact, few megafauna were observed in the area remaining completely covered in drill cuttings, even after 10 years.

An OSPAR review of environmental monitoring results from the United Kingdom, the Netherlands and Norway concluded that the effects of WBM cuttings discharge on the seabed fauna tend to be very subtle or undetectable. Any disturbance of the fauna typically only occurs within 50 m from single well locations, although the presence of drilling material at the seabed is often detectable chemically at distances beyond this (OSPAR, 2007).

Increased concentrations of suspended particles in the water near the seabed may also cause damage to feeding and respiratory organs, causing metabolic stress and reducing growth, and also affecting reproductive and survival rates. This, for example, has been demonstrated in scallops and other bivalves (Cranford et al, 1999; Bechmann et al, 2006). Larger individuals are generally more resistant to elevated levels of suspended solids in the water column, and some species are likely to be more sensitive than others. It should also be noted that effects related to increased suspended sediment levels will mostly take place close to the well location and for a limited time period.

There is also limited evidence available indicating that rock material brought up from within wells has a lower nutrient value than natural sediments. This may lead to increased mortality due to starvation in affected communities (Trannum et al, 2010). Alteration of the substrate by drilling discharges can also affect the settlement of benthic organisms that subsequently colonise the area (Trannum et al, 2010).

The ROV monitoring at the Rosebank location recorded that, generally , beyond 40 m to 60 m from the well, the coverage of cuttings was only partial and both sessile and mobile epifauna including anemones, brittlestars and sabellid worm tubes were still present, although at a reduced density (SERPENT, 2009). Beyond 80 m to 100 m, the fauna was largely unaffected. This concurs with the wider findings of the SERPENT monitoring programme (Jones and Gates, 2010). Although some variation was observed between sites, the greatest level of distribution to the benthos (reduced diversity and density) was usually encountered within 100 m. Evidence of disturbance was not seen beyond 200 m at any of the discharge sites investigated.

The Cambo 4 pre- and post-drilling habitat assessment concluded that top-hole cuttings and cement discharges extend >100 m from the well centre with the highest levels of deposition to the southwest. Cuttings and cement deposits were observed beyond the limits of the survey to the northwest (87 m), northeast (91 m) and southwest (137 m). Although, southeast cuttings and cement deposition was only visible within 50 m of the well centre. Epifauna were recorded beyond 50 m to the north and southeast as well as beyond 70 m to the north and south west where the deposition was reduced to a thin veneer.

Assessment of the sensitivity of deep-sea sponge aggregations to changes in siltation rate have identified that these systems have low resistance and high sensitivity (Tillin et al., 2010), even for deposits of 50 mm of sediment in a single event. Additionally, the hydrodynamic regime at these depths means that even light deposition will persist for longer than in shallower areas (Tyler-Walters et al., 2018). Therefore, 50 mm is considered the threshold for assessing significant effects.

Using this, and other relevant studies, as a worst-case scenario for the proposed Cambo well, the impact of the discharge is, therefore, expected to be experienced no more than a 200 m radius from each well. This amounts to a total area of approximately 0.013 km^2 for all wells. The furthest extent of this benthic impact zone is 14.1 km away from the nearest area known to support deep-sea sponge aggregations.

The accumulation of cuttings, WBM particles and cement at the proposed Cambo wells is, therefore, likely to mainly affect the local benthic community by burying animals and also by impairing the feeding and respiration activities of others.

Chemical Impacts on Benthic Communities

The constituent chemicals used in both the WBM itself and additional drilling chemicals are generally highly water soluble and show low persistence, toxicity and likelihood to be incorporated into the tissues of marine organisms. Weighting agents found in drilling muds, such as barite, may contain elevated levels of barium and other metals, which will typically be higher than those found in naturally occurring seabed sediments. However, the metals and metal salts associated with barite, clay, and cuttings particles are not readily bio-accumulated by animals living in close association with cuttings piles and the metals are not passed efficiently through marine food chains (Neff, 1987; Neff et al, 1989; Leuterman et al, 1997; URS, 2002). For example, upon intake through ingestion or by adhering to epithelial surfaces, the metals found in cuttings material are often not assimilated into the tissues but remains compartmentalised within the tissues of the organism as insoluble, inert matter, probably of the original barite particles (Jenkins et al, 1989). Therefore, any toxic effects of WBM associated with cuttings discharge have generally been deemed to be negligible (Neff, 2005; OSPAR, 2007).

WBMs may also occasionally contain some organic components such as glycol. The discharge of such substances onto sediments can lead to organic enrichment, whereby increased levels of microbial activity feeding on the organic matter results in oxygen depletion within the affected sediments. The presence of cuttings material on the seabed also prevents the flow of oxygen and nutrients to the affected areas. This oxygen depletion and associated disruption of nutrient flow can be sufficient to reduce the abundance and diversity of the benthos (Neff, 2005; Trannum et al, 2010). Nonetheless, previous monitoring studies around well sites drilled with WBMs have rarely shown any medium to long term disturbance of benthic infauna (at a community level) detectable beyond 50 m (OSPAR, 2007; Neff, 2005). Moreover, these types of additives will only be present in the drilling fluids for the deeper well sections, that will be discharged from the sea surface. The dispersion modelling study shows that cuttings deposition from these sections will disperse over a wide area, resulting in very low deposition. At such low concentrations it is not anticipated to lead to any oxygen depletion effect, as described above.

9.2.3 Impacts on Marine Protected Areas

As described in Section 4.5.2 (Offshore Conservation Areas) the proposed Development is located 14.2 km from the nearest NCMPA, the Faroe-Shetland Sponge Belt NCMPA.

The Feature Activity Sensitivity Tool (Section 5.3.3 and Appendix 6) and JNCC's AoO sensitivity assessment have been developed to determine potential management requirements for NCMPAs (Marine Scotland, 2013a; JNCC, 2018b). Both sensitivity assessments have been used to determine the sensitive features and corresponding relevant pressures to these features from the proposed operations.

In FEAST, a number of pressures on specific conservation features have been identified which are relevant for the proposed Development drilling discharges impact assessment. These pressures include non-synthetic and synthetic contamination and water clarity changes, namely on deep-sea sponge aggregations, offshore subtidal sand and gravels and Iceberg plough mark fields.

Within the JNCC's AoO sensitivity assessment, pressures on specific conservation features have also been identified, these include hydrocarbon and polycyclic aromatic hydrocarbon (PAH) contamination, synthetic compound contamination, transitional elements and organo-metal contamination, namely on deep-sea sponge aggregations, offshore subtidal sand and gravels and Iceberg plough mark fields.

Biodiversity Features

Deep-sea Sponge Aggregations

The JNCC AoO sensitivity assessment and FEAST outcome of pressures exerted by discharges by oil and gas activities and pipelines on deep-sea sponge aggregations within the Faroe-Shetland Sponge Belt NCMPA are included within Appendices 6 and 7.

The sensitivity assessment describes the pressure exerted on deep-sea sponge aggregations within the Faroe-Shetland Sponge Belt NCMPA by synthetic and non-synthetic compound contamination, transitional elements and organo-metal contamination and hydrocarbon and PAH contamination, as being *sensitive*.

During the 2018 environmental baseline and habitat assessment surveys, no deep-sea sponge aggregations were observed within the FPSO in-field area where the wells are located (MMT, 2019). Within the Faroe-Shetland Channel MPA, deep-sea sponge aggregations are generally located higher up the Continental slope, with the nearest observed aggregations being located more than 14.2 km southeast of the closest proposed Cambo well, I7. These aggregations are generally located at depths of 400 m to 600 m, which are far shallower and upslope than the depths experienced at the proposed Cambo wells (1,050 m).

As the maximum modelled extent of discharges (at a thickness of 0.1 mm) is predicted to lie no closer than 13.9 km to the sponge belt, there are no effects anticipated on deep-sea sponge aggregations as a result of drilling discharges at Cambo.

Offshore Sand and Gravels

The JNCC AoO sensitivity assessment and FEAST outcome of pressures exerted by discharges by oil and gas activities and pipelines on offshore subtidal sand and gravel within the Faroe-Shetland Sponge Belt NCMPA are included within Appendices 6 and 7.

FEAST does not specifically identify offshore sands and gravels within the tool, therefore, the assessment on the effects on this feature has been made using the Marine Scotland offshore sand and gravels FEAST translation table (Marine Scotland, 2013b). The translation table identified the features compatible with FEAST as deep-sea mixed sediments and deep-sea muddy sands.

Both sensitivity assessments describe the pressure exerted on offshore subtidal sand and gravel (deep-sea mixed sediments and deep-sea muddy sands) within the Faroe-Shetland Sponge Belt NCMPA by synthetic and non-synthetic compound contamination, transitional elements and organo-metal contamination and hydrocarbon and PAH contamination, as being *sensitive*.

The closest proposed well location (I7) is situated in an area of offshore deep-sea muddy sand 14.2 km northwest of the Faroe-Shetland Sponge Belt MPA. No effects are anticipated due to the MPA's distance from the drilling location.

Iceberg Plough Marks

The FEAST outcome of pressures exerted by discharges from oil and gas activities and pipelines iceberg plough marks within the Faroe-Shetland Sponge Belt NCMPA are included within Appendix 6.

The FEAST sensitivity assessments describe the pressure exerted on iceberg plough marks within the Faroe-Shetland Sponge Belt NCMPA by water clarity changes, as *not sensitive*.

The upper slope (300 m to 500 m) of the Faroe-Shetland Channel is known as the "Iceberg plough mark zone". The environmental survey observed partially infilled iceberg plough marks in the southeast section of the Faroe-Shetland Sponge belts in water depths between 184 m to 294 m (MMT, 2019). Therefore, no effects are anticipated due to the distance from the development location and the FEAST assessments not sensitive outcome.

9.3 Mitigation

An environmental baseline survey and habitat investigation of the proposed Cambo well locations were undertaken in 2018, which confirmed no features of conservation importance were present in the immediate vicinity of the well location, where the main impacts from drilling discharges are anticipated.

All chemicals used for the drilling operations are regulated under the Offshore Chemicals Regulations 2002 (as amended), which aims to replace chemicals with poor environmental characteristics by more environmentally friendly chemicals. Selection of all chemicals that may be used in drilling the proposed well will be based upon both their technical specifications and their environmental performance. The use of all chemicals will be minimised, where practicable.

For cement discharges from the tophole section, the amount discharged onto the seabed during installation of the conductor will be minimised by visual monitoring of the operation by a ROV. Once returns are observed, pumping will be stopped in order to minimise discharged volume. If a CAN-ductor is used, there will be no tophole cement discharges, as no offshore cementing operation is involved in CAN-Ductor installation. For the riserless 20" × 13⅜" section, the ROV will monitor for returns where possible, however, due to the use of a wiper plug system, it will not be possible to vary the cement volumes and hence any discharged volume.

A closed mud circulation system (i.e. shale shakers) will be used for the 17½" and 12¼" sections, so the returned drilling fluids can be reconditioned and reused, thus minimising the quantity of drill fluids and chemicals to be discharged. In addition, the drilling mud and cuttings discharged from the drilling rig will be discharged close to the sea surface, allowing dilution and dispersion over a large area and thereby minimising the overall environmental impact.

Any cuttings contaminated with liquid from the payzone will be treated in the same way as uncontaminated cuttings, i.e. using the shale shakers to ensure that as much mud and oil as possible is retained in the circulating system. As such, this treatment will result in some of the oil being incorporated into the (water based) mud system which will ultimately be discharged. However, this discharge would take place over a longer period rather than the batch discharge of the cuttings and will be considerably diluted by the drilling fluid prior to discharge, both of which will assist dispersion and breakdown of the payzone fluids (i.e. oil) in the water column. This potential discharge will be included within the OPPC permit.

The oil content of payzone cuttings will be measured onboard the drilling rig, and a number of samples will also be returned to shore for further analysis and verification. If the oil concentration on cuttings exceeds the limits described in the OPPC permit, cuttings discharge will be ceased, and cuttings collected onboard the drilling rig and shipped back to shore for appropriate disposal. However, previous drilling activity experience monitoring oil on cuttings indicates that this is unlikely.

With regard to chemical discharge, only WBM will be used and the selection of all chemical additives will be conducted with reference to the CEFAS templates to ensure the most environmentally benign chemicals will be chosen wherever technically possible. Finally, the actual mud and chemical usage will be monitored during drilling operations and subsequently reported to OPRED.

9.4 Cumulative and Transboundary Impacts

Oil and gas activity West of Shetland is relatively low, in comparison with the neighbouring northern North Sea. The BP operated Alligin, Loyal, Schiehallion and Foinaven fields are located around 54 km to the south of the proposed Development Footprint, and are tied back via the West of Shetland Pipeline (WOSP) to the BP Clair platform, 89 km to the east of the Development Footprint (UK Oil and Gas, 2018).

The proposed Cambo Field Development lies 5 km east of the UK/Faroe Island maritime boundary.

As described in the sections above, the effects of the drilling discharges will be limited to within a few hundred metres from the well location. Therefore, no overlap with existing effects, either in in spatial or temporal context are anticipated. Consequently, the potential of cumulative and transboundary effects from drilling discharges is extremely limited, and therefore considered to be not significant.

9.5 Conclusion

The drilling discharges from the proposed drilling operations associated with the proposed Development have the potential to cause moderate effects in the immediate vicinity of the well locations, primarily through physical changes to the seabed.

As a general rule, effects of WBM and cuttings discharges on the benthic environment are related to the total quantity discharged and the energy regime encountered at the discharge site, particularly the currents close to the seabed itself (Neff, 2005). Based on these factors, the discharge of cuttings, mud and cement at the Cambo wells have the potential to cause a localised impact to the benthic environment, primarily through direct physical changes to the seabed.

This impact section is based on a worst-case modelling exercise that assumes all tophole sections are drilled. However, wherever technically feasible, CAN-ductors will be used, reducing the overall extent, thickness and impact of drill cuttings.

Evidence from long-term monitoring at other wells drilled West of Shetland at the Laggan field (Jones, et al., 2012) indicate that recovery of megafaunal assemblages in the wider area will be noticeable after a few years, but that full recovery of megafaunal assemblages in areas directly affected by cuttings will be slower and may take >10 years.

As a conservative estimate, it is expected that all benthos will be lost within the area with cuttings deposits >50 mm. Beyond this immediate area of effect, survival rates will increase with decreasing cutting deposition thickness.

The cuttings dispersion modelling study shows that cuttings deposition >50 mm will cover an area between 0.0067 and 0.01324 km^2, indicating the area in which all benthos is expected to be lost, which represent a very small fraction of the available local habitat in the wider project area.

In addition, no species or habitats of conservation interest have been previously identified in immediate area around the proposed well location. Seabeds covered with WBM contaminated drilling discharges generally have a good potential for recovery, over time.

The magnitude of effect in this small area is considered to be moderate, and receptor value is assessed as ‘low’, and therefore the effect is considered to be not significant.

The impacts from discharges of cuttings and muds from the sea surface are expected to have only a minor effect. This is largely attributable to the fact that any cuttings and mud discharged at the sea surface and will become widely dispersed as they settle through the water column and will form a patchy very thin layer with a maximum deposition thickness of 0.1 mm. Impacts from these discharges can therefore be considered minor to negligible and thus insignificant.

Section 10

Produced Water Discharges

10 PRODUCED WATER DISCHARGES

This Section addresses issues and concerns associated with the discharge of produced water on the marine environment. Produced water discharge was discussed during the Environmental Issues Identification (ENVID) workshop, informal stakeholder consultation and is part of the National Marine Plan (NMP).

As described in Section 5 (Impact ID), Feature Activity Sensitivity Tool (FEAST) and Joint Nature Conservation Committee (JNCC) Formal Conservation Advice on Operations were used to review the pressures exerted by produced water discharges upon sensitive features within the Faroe-Shetland Sponge Belt Nature Conservation Marine Protected Areas (NCMPA). Relevant sensitive features of interest identified by both tools include deep-sea sponge aggregations, iceberg plough mark fields and offshore sands and gravels. A full list of pressures and justification of feature selection for assessment is provided in Appendices 6 and 7.

10.1 Produced Water Discharge

Produced water can be defined as water from the formation which is produced together with oil and gas (OSPAR, 2009b). Produced water may contain residues of reservoir hydrocarbons as well as chemicals added during the production process, along with dissolved organic and inorganic compounds that were present in the geological formation.

As described in Section 2 (Option Selection), several options were investigated for the treatment and disposal of produced water before the decision was made to clean-up and discharge it to sea. Two key factors were the main drivers for this decision, (i) the potential for reservoir souring and (ii) issues with reservoir injectivity into the weak, consolidated rock associated with the Cambo reservoir. With regard to the first factor, it was considered that due to the low temperature of the Cambo reservoir it is susceptible to Sulphate Reducing Bacteria (SRB) activity. In addition to this, the Cambo produced water has a high volatile fatty acid content that will provide nutrients to the SRB, resulting in Hydrogen Sulphide (H_2S) generation. As a consequence, the H_2S can be expected to ‘sour’ the reservoir fluids. With regards to the second factor, the Cambo reservoir is considered to have specific injection requirements due to the relatively weak, unconsolidated rock. In order to maintain injectivity and pressure support for oil recovery it is preferred that only filtered, treated seawater is injected to reduce the risk of near-wellbore fouling and poor operability of produced water re-injection systems. Due to these issues the final decision was taken to clean up and discharge the produced water.

10.2 Treatment of the Produced Water

Sections 2 and 3 (Option Selection and Project Description) present detail of the rationale for selection of the produced water management approach and proposed treatment process for produced water. A summary of this rationale is provided below.

Produced water will be treated to remove potential hydrocarbon contamination as far is possible prior to discharge to sea.

As mentioned in Section 2.2.5.6, the treatment process will be designed to treat 100% of the anticipated water production and reduce the residual dispersed oil content in the produced water to a target concentration of 15 mg/l or less (measured on a monthly average basis) before being discharged to sea. This target concentration is below the OSPAR recommended performance standard of 30 mg/l limit for oil in produced water, as implemented by the Oil Pollution Prevention and Control Regulations, 2005 (as amended).

When the produced fluids arrive on the Floating Production, Storage and Offloading Vessel (FPSO) from the wells they will be directed into the separation train before being routed to produced water hydrocyclones. At this stage reject oily water (approximately 2% of the oily water feed to the hydrocyclones), will be returned to the process with the remainder routed to a Compact Flotation Unit (CFU). The CFU further reduces the oil content before the water is routed to produced water transfer pumps. The water is pumped through produced water coolers and discharged overboard, or if required, routed to the cargo off-spec tank. Discharge is via a disposal caisson below the water line.

10.3 Produced Water Modelling

Numerical modelling was undertaken to determine the fate and dispersion of produced water following discharge to sea and to inform assessment of potential environmental impacts. An initial modelling study was undertaken using Cormix (Fugro, 2019a), to consider near field and far field dispersion patterns, followed by a subsequent model investigation using Visual Plumes (Fugro 2019b); which again considered near and far field dispersion patterns but which also accounted for revised discharge conditions, including a revised depth of discharge, consideration of two discharge ports (east and west) and three different discharge temperatures (Fugro 2019b). The initial Cormix modelling study indicated that the discharge dilution was strongly affected by temperature, and hence the subsequent Visual Plumes modelling was undertaken, which better represents the effects of temperature variations. Both models are industry standard techniques employed by the US Environmental Protection Agency (US EPA) for simulation and a decision support system for environmental assessment and generated comparable results. Therefore, only the findings of the second model investigation which considered the revised treatment designs and different temperature ranges (Fugro, 2019b) have been used for the remainder of this Section.

10.3.1 Ambient Characteristics

The prevailing normal current conditions used for the modelling have been sourced from the Massachusetts Institute of Technology general circulation model (MITgcm) for a 1 year period (2012) and are intended to simulate the water circulation on a regional scale. Model validation was achieved using several current metres while temperature, salinity and velocity input parameters were taken from measurements at nearby locations.

The produced water will be released at shallow depths and because of its higher temperature, will be less dense than the receiving waters. As such, it is considered that the discharge plume will remain close to the sea surface.

As part of this investigation, the modelling considers two situations as follows:

- Near-field mixing;
- Far-field mixing.

The near-field zone is the area of strong initial mixing that is sensitive to the discharge design conditions. It is defined here as the area within which the discharge reaches the surface or when it achieves vertically stability within the water column. Typically, this stage occurs over a matter of minutes. The far field relates to the area beyond this initial mixing zone and beyond the influence of the initial discharge momentum. Here plume dispersion is largely dependent on ambient current conditions. To assess far field plume dispersion, several model simulations were performed over time periods of up to several hours, using a worse-case (low) water flow rate (based on the lowest recorded flow rate within the 2012 dataset (0.05 m/s)) and a more representative (yearly average) water flow rate of 0.21 m/s representing typical conditions. Table 10.1 presents the parameters used in the model scenarios to represent worse-case and typical receiving water conditions.

Table 10.1: Worse-case and Typical Conditions of the Receiving Waters Considered in the Updated (Visual Plumes) Modelling Study

Case	Current Speed [m/s]	Direction [Degrees]	Surface Salinity [psu]	Seabed Salinity [psu]	Surface Temp [^{0}C]	Seabed Temp [^{0}C]	Dispersion Constant α [$m^{2/3}/s$]
Worse	0.05	154	35.16	34.94	9.23	0.34	0.0001
Typical	0.21						0.0003

10.3.2 Discharge Characteristics and Scenarios

The maximum yearly-averaged flowrate (P10) of produced waters (i.e. the highest annual produced water scenario) expected during the lifetime of the operations was selected for modelling. In addition, a discharge caisson with a diameter of 14 inches (i.e. 0.3556 m) was chosen. In order to identify and assess possible mitigation measures that may increase the plume dilution factor, and therefore reducing its environmental impact, several discharge characteristics were considered:

- Temperature (and density) of the released waters – the temperature of the released water was expected to significantly affect the dynamics of the plume, with the plume either sinking to greater water depth or rising towards the sea surface. A range of temperatures (50°C (High Temperature), 45°C (Medium Temperature) and 40°C (Low Temperature)) were chosen to assess the influence of the release temperature on the plume near-field dilution;
- Depth of the release - for a positively buoyant discharge, a higher depth of release (lower release level) would result in an increased initial dilution factor as well as an increased cooling before the plume reaches the sea surface. A positive side-effect of a greater depth of release would also be that the produced water discharge would undergo some additional degree of cooling along the outfall pipe prior to reaching the bottom outlet, which would increase its density and reduce its tendency to rise as a surface plume. Two release depth variations of 5 m and 9 m are considered for the modelling, in order to assess the sensitivity of the plume dilution to the release depth;
- Number of discharge ports – installing multiple discharge ports may be a useful way to increase initial dilution and accelerate the produced water cooling to favour plume sinking rather than rising to surface. The number of discharge locations considered for the modelling was set to either one or two, in order to assess the effect of an additional discharge location on the plume dilution. This flowrate was split into two equal rates when two discharges locations were considered;
- Angle of the discharge - the discharge of produced water was considered to be oriented 30° downwards at the tip of the release caisson. However, an additional simulation with a horizontal discharge was performed to assess the sensitivity of the plume dilution to the angle of release;
- Salinity and density of the released waters – salinity was incorporated into the density of the produced water and adjusted for the release temperature at the release point as both factors influence the buoyancy of the discharge plume.

Having established the worst-case and typical environmental conditions of the receiving waters, the investigation then considered a number of scenarios to represent different discharge configurations and flow characteristics. Table 10.2 shows the range of discharge configurations considered.

Table 10.2: Range of Discharge Scenarios Considered in the Updated (Visual Plumes) Modelling Study

Scenario		Discharge Diameter [m]	Vertical Angle [degrees]	Direction [Degrees]	Flow [m/s]	Discharge Depth [m]	Temp [^{0}C]
S1	9 m depth*, high temperature, horizontal discharge	0.3556	0	90	0.1251	9	50
S2	9 m depth, high temperature	0.3556	-30	90	0.1251	9	50
S3	9 m depth, low temperature	0.3556	-30	90	0.1251	9	40
S4	9 m depth, 2 locations, high temperature	0.3556	-30	90 270	0.0626	9	50
S5	9 m depth, 2 locations, low temperature	0.3556	-30	90 270	0.0626	9	40
S6	5 m depth, high temperature	0.3556	-30	90	0.1251	5	50
S7	9 m depth, medium temperature	0.3556	-30	90	0.1251	9	45
S8	9 m depth, 2 locations, medium temperature	0.3556	-30	90 270	0.0626	9	45

* Depth = Depth of the release [m below LAT]
Temperature = PW discharge temperature
Locations = Location of the discharge caissons, 82 metres apart on either side of the Sevan FPSO

10.4 Model Results

Model outputs include a range of predicted dilution factors of produced water at selected distances from the discharge point. These are compared against the OSPAR Recommendation for a Risk Based Approach (RBA) to the Management of Produced Water Discharges from Offshore Installations (RBA Recommendation) which recognises that other potentially hazardous substances other than oil, may be entrained within discharged produced water. It is based on the ratio of the calculated predicted environmental concentration (PEC) and the predicted no effect concentration (PNEC) with an acceptance criterion of a PEC:PNEC ≤ 1 within a specified body of water as indicative of a discharge that is unlikely to result in significant harm in the marine environment (DECC, 2014). As part of the implementation of the RBA Recommendation in the UK, discharges of produced water may be screened out from further assessment if the whole effluent PEC:PNEC at 500 m from the discharge point is ≤ 1 using generic dilution factors. For discharges of between one and eight million cubic metres per year into receiving waters of over 125 m then the dilution factor required to meet this screening threshold is 400. It is therefore preferred that the proposed Cambo produced water discharges achieve a dilution of 400 times at a distance of 500 m. Results of the current modelling are compared against this threshold.

10.4.1 Worst-case Scenario

Figure 10.1 shows the depth profiles and the horizontal distances and dilution factors achieved for each simulated plume within the near field following discharge under the worst-case scenario (i.e. low currents). Table 10.3 summarises the worst-case near field plume dispersion behaviours.

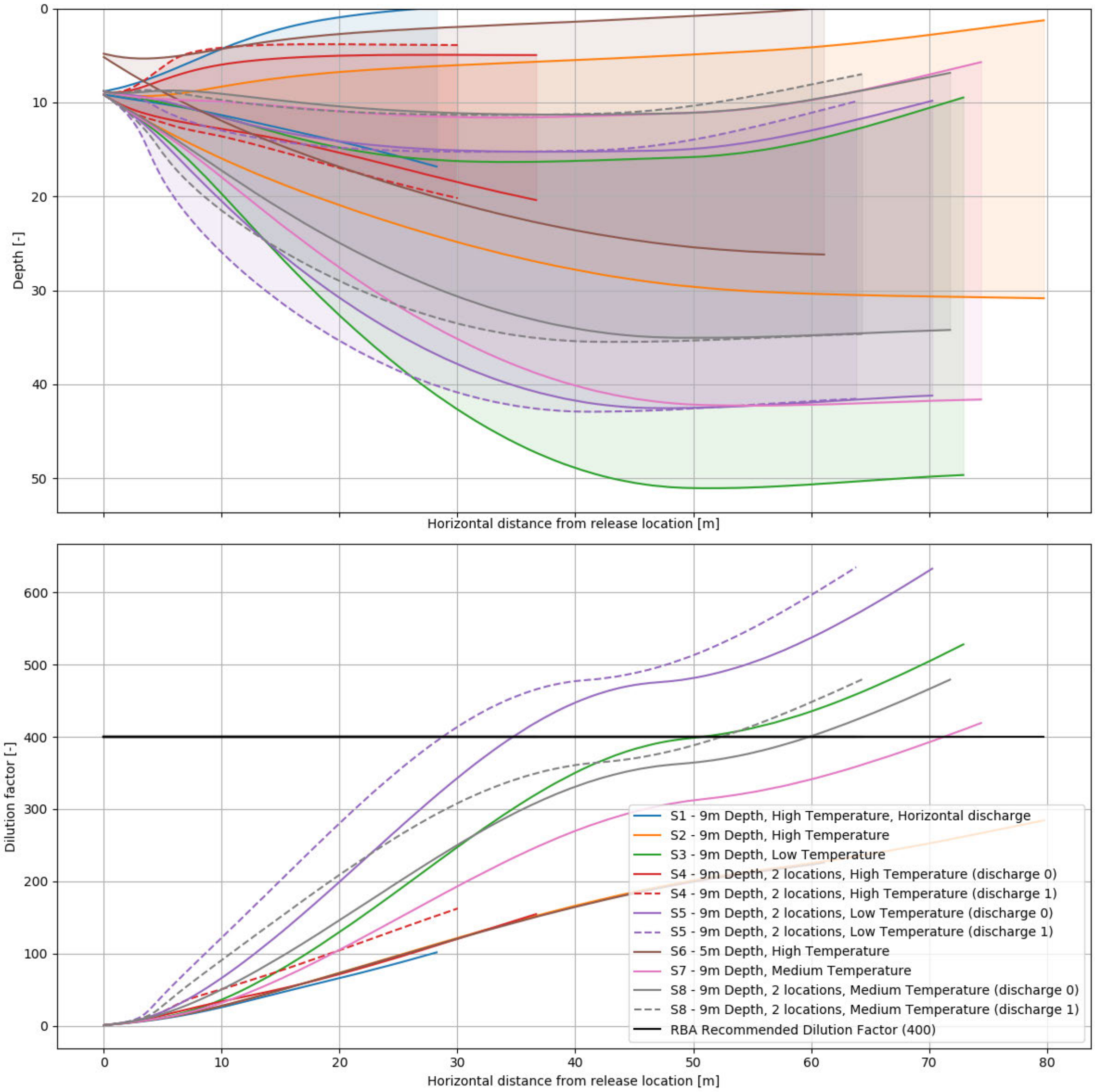


Figure 10.1: Simulated Worse-case Depth, Dilution and Distance Profiles for Produced Water Discharges at the Proposed Cambo Field Development

Table 10.3: Worst-case Dispersion Characteristics of Produced Water Discharges

Scenario		Discharge Port Locations	Horizontal Distance from Discharge [m]	Initial Dilution Factor	Plume Diameter [m]	Propagation Time [s]
S1	9 m depth, high temperature, horizontal discharge		28	102	16.9	376
S2	9 m depth, high temperature		80	284	29.6	1408
S3	9 m depth low temperature		73	528	40.2	1326
S4	9 m depth, 2 locations, high temperature	Eastward	37	155	15.4	647
		Westward	30	163	16.3	681
S5	9 m depth, 2 locations, low temperature	Eastward	70	633	31.4	1349
		Westward	64	635	31.7	1350
S6	5 m depth, high temperature		61	226	26.3	1043
S7	9 m depth, medium temperature		74	419	35.9	1340
S8	9 m depth. 2 locations medium temperature	Eastward	72	479	27.4	1369
		Westward	64	479	27.7	1372

The model results showed that discharging produced water at lower temperatures (40˚C) and at greater depths is predicted to achieve the greatest dilution rates. Also, the use of two discharge locations appears to improve initial dilution but only for low (40˚C) and medium (45˚C) temperature discharges. For higher temperature discharges (50˚C) the use of two discharge locations is forecast to derive only marginal or no benefit in this respect. The model outputs also showed that with the exception of the high-water discharges considered under scenarios S1 and S6, the plume is not predicted to reach the surface but instead will achieve vertical stability within the water column between a few metres and approximately 50 m depth.

Figure 10.2 shows the dilution of each simulated produced water discharge with distance from the release point within both the near field and far field under worst-case conditions (i.e. low water flow rates). Table 10.4 summarises the plume characteristics within the near and far field at selected dilution levels and highlights the horizontal distance achieved at which a dilution factor of 400 is forecast to occur for comparison against the RBA Recommendation.

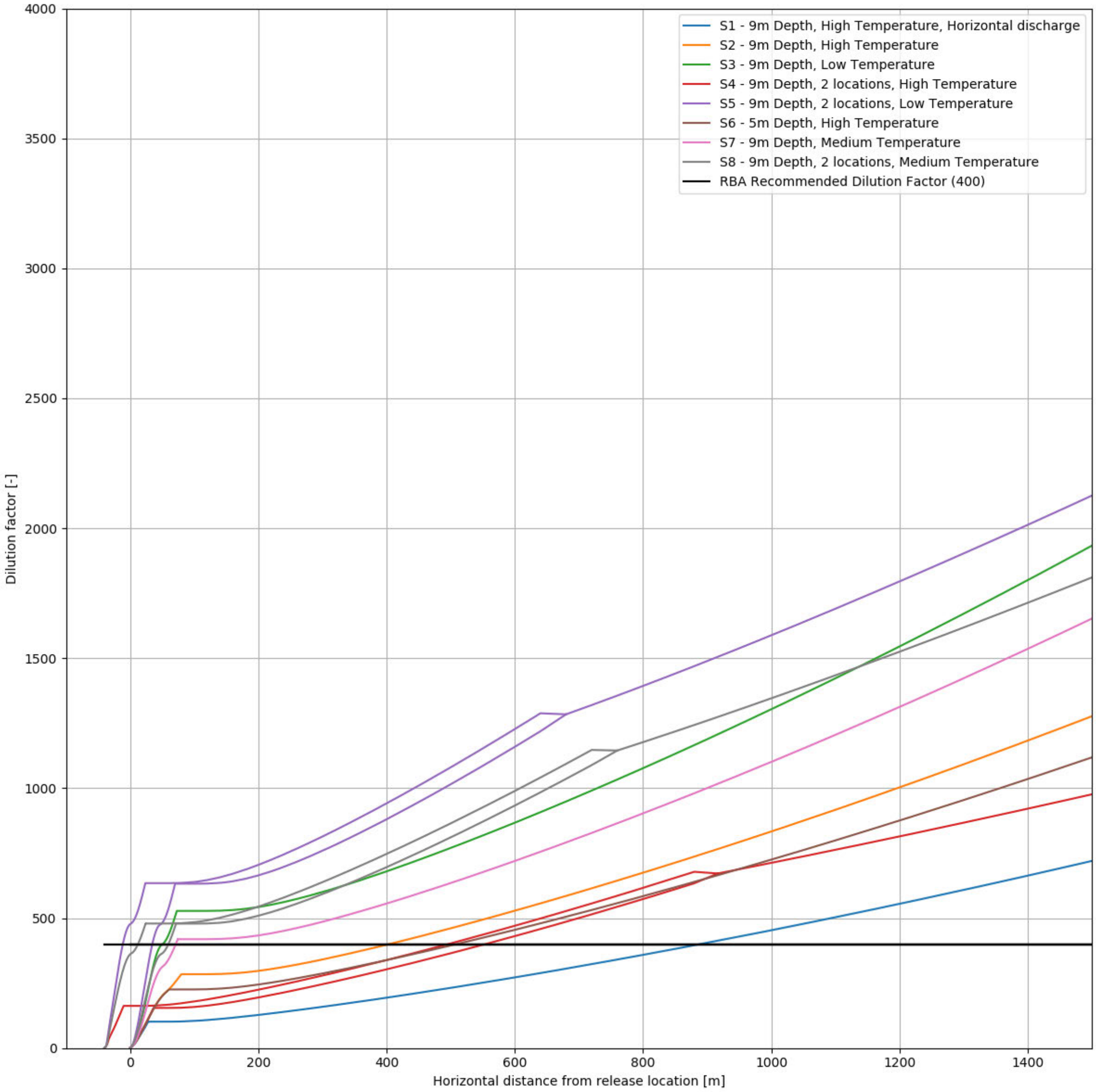


Figure 10.2: Worst-case Rates of Dilution and Distances over which these are Forecast to be Achieved for Simulated Discharges of Produced Water from the Proposed Cambo Field Development

Table 10.4: Worst-case Dispersion Characteristics for Produced Water Discharges at Selected Dilution Levels at the Proposed Cambo Field Development

Scenario		Dilution Factor	Distance from Discharge Location [m]	Plume Width [m]
S1	9 m depth, high temperature, horizontal discharge	10	5.0	3.2
		25	9.8	6.9
		50	16.0	11.1
		100	27.8	16.8
		250	546.0	57.4
		400	888.9	91.9
		1000	1961.1	229.9
S2	9 m depth, high temperature	10	4.6	3.4
		25	9.3	7.1
		50	15.0	11.3
		100	25.5	16.9
		250	69.2	27.7
		400	403.8	56.6
		1000	1196.5	143.7
S3	9 m depth, low temperature	10	4.4	3.2
		25	8.1	6.4
		50	11.8	10.0
		100	17.2	15.3
		250	30.2	26.6
		400	50.8	35.3
		1000	728.7	104.8
S4	9 m depth, 2 locations, high temperature	10	3.7	3.1
		25	7.6	5.7
		50	14.7	8.5
		100	26.0	12.3
		250	307.6	34.2
		400	554.0	55.1
		1000	1542.4	277.6
S5	9 m depth, 2 locations, low temperature	10	3.3	2.8
		25	5.7	5.1
		50	8.5	7.6
		100	12.8	11.3
		250	23.4	19.0
		400	34.7	24.8
		1000	489.2	67.9
S6	5 m depth, high temperature	10	4.6	3.4
		25	9.3	7.1
		50	15.1	11.3
		100	25.6	16.9
		250	214.5	37.9
		400	508.7	64.0
		1000	1356.8	160.8

Scenario		Dilution Factor	Distance from Discharge Location [m]	Plume Width [m]
S7	9 m depth, medium temperature	10	4.5	3.3
		25	8.6	6.8
		50	12.9	10.7
		100	19.4	16.2
		250	37.1	27.4
		400	71.3	35.0
		1000	899.7	118.3
S8	9 m depth, 2 locations, medium temperature	10	3.5	3.0
		25	6.5	5.5
		50	9.9	8.1
		100	15.5	11.8
		250	30.0	19.5
		400	59.8	25.0
		1000	652.4	78.7

Table 10.4 shows that the desired dilution factor of 400 at 500 m distance is forecast to be achieved for the majority of simulated produced water discharges even under a worst-case scenario with the exception of scenarios S1, S4 and S6 which all involve high temperature (50˚C) discharges. Note that Scenarios S4 and S6 do not quite meet the criteria, but the required distance to reach a dilution factor of 400 is only slightly above 500 m threshold (554.0 m and 508.7 m respectively). Scenario S1, involving a higher temperature (50˚C) horizontal discharge at 9 m, however, is forecast to require a horizontal distance of 888.9 m to meet the target dilution factor.

10.4.2 Typical Scenario

Under a typical scenario, as represented by the average current speed for the available (2012) dataset for the area, dilutions rates are predicted to be considerably improved. Figure 10.3 presents the depth profiles and dilution characteristics of the simulated produced water discharges under typical environmental conditions within the near field. Table 10.5 summarises the near field characteristics of produced water discharges considering the typical scenario.

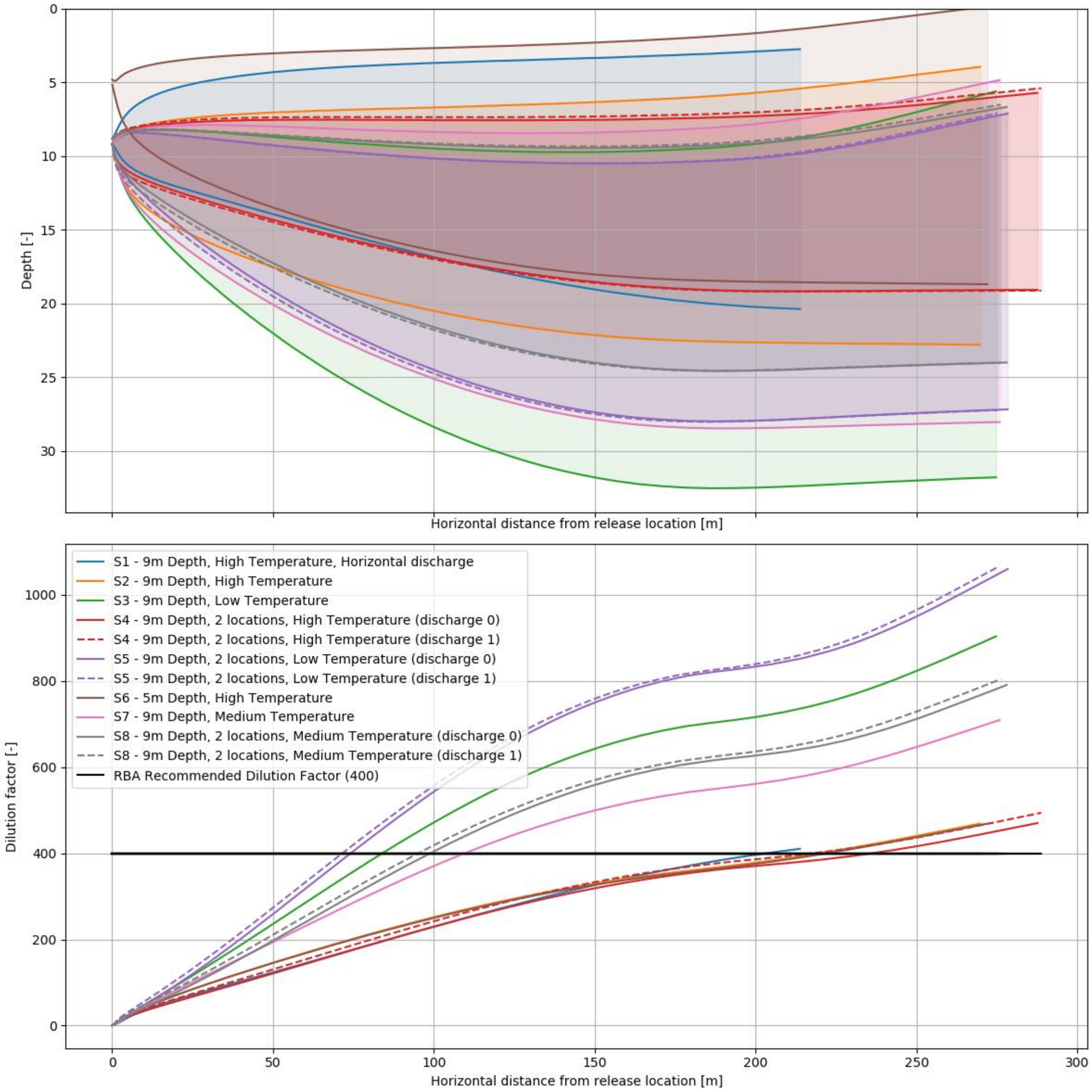


Figure 10.3: Simulated Depth, Dilution and Distance Profiles for Produced Water Discharges at the Proposed Cambo Field Development Under Typical Conditions

Table 10.5: Dispersion Characteristics of Produced Water Discharges within the Nearfield Under Typical Conditions

Scenario		Discharge Port Locations	Horizontal Distance from Discharge [m]	Initial Dilution Factor	Plume Diameter [m]	Propagation Time [s]
S1	9 m depth, high temperature, horizontal discharge		214	411	17.6	1003
S2	9 m depth, high temperature		270	469	18.8	1273
S3	9 m depth, low temperature		274	904	26.2	1300
S4	9 m depth, 2 locations, high temperature	Eastward	288	470	13.4	1368
		Westward	289	49	13.7	1397
S5	9 m depth, 2 locations, low temperature	Eastward	278	1060	20.1	1324
		Westward	275	1064	20.1	1325
S6	5 m depth, high temperature		272	469	18.8	1284
S7	9 m depth, medium temperature		276	710	23.2	1304
S8	9 m depth, 2 locations, medium temperature	Eastward	278	791	17.3	1323
		Westward	276	804	17.5	1332

Under typical conditions, the behaviour of the plume within the near field remains under the influence of the discharge characteristics with the exception that depth is forecast to have no significant effect and that the use of two discharge locations improves plume dilution for any release temperature considered within the modelling. The depth of the plumes within the water column is predicted to remain closer to the surface (above approximately 30 m) compared to the worst-case scenario. Furthermore, the desired dilution factor of 400 is achieved within 500 m for all simulations (see also Figure 10.4).

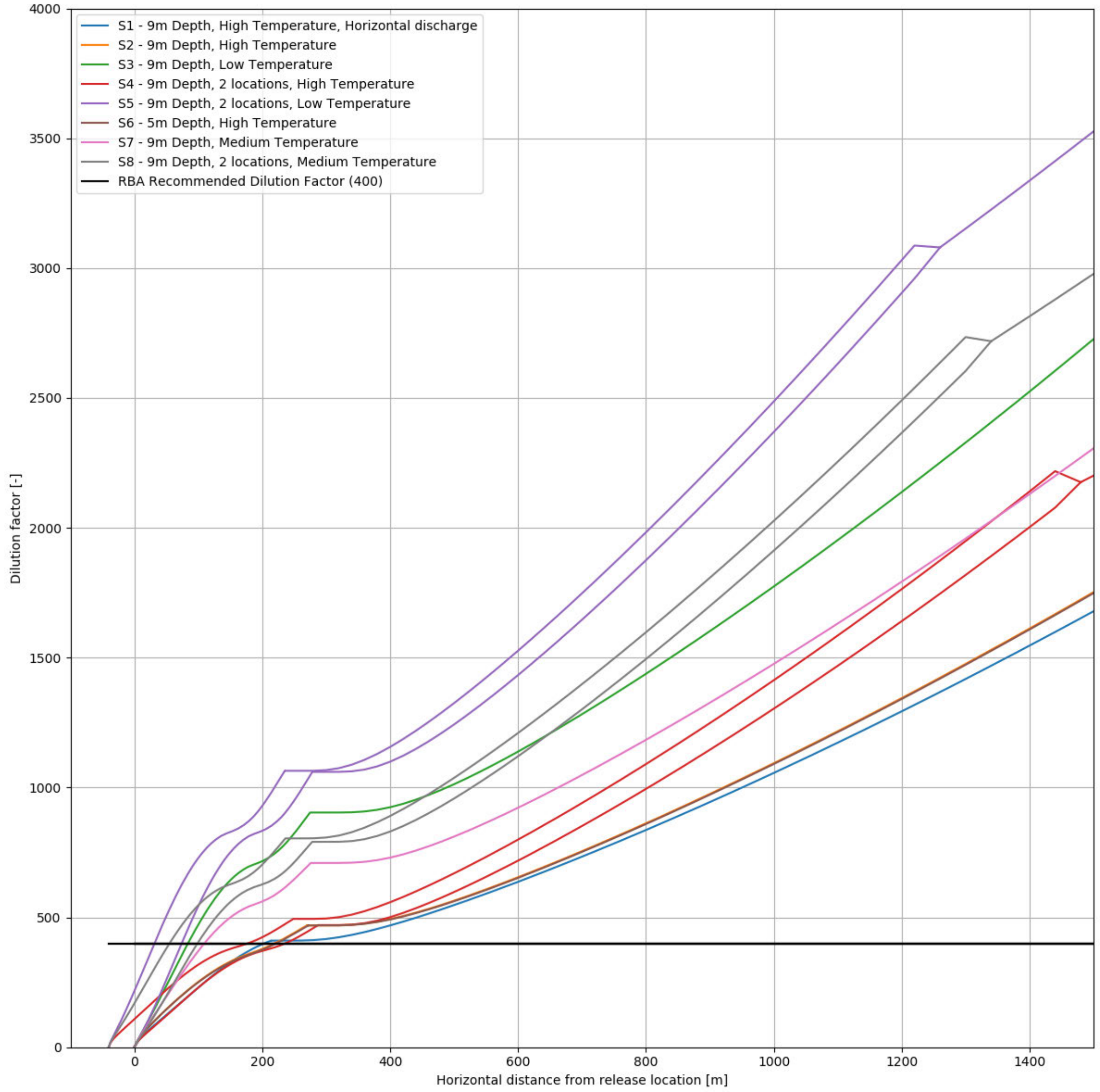


Figure 10.4: Dilution and Distances over which these are Forecast to be Achieved for Simulated Discharges of Produced Water from the Proposed Cambo Field Development Under Typical Conditions

Table 10.6 summarises the plume characteristics at selected dilution levels and further highlights the achievement of the desired dilution of all discharge configurations considered at the proposed Cambo Field Development in compliance with the RBA Recommendation.

Table 10.6: Dispersion Characteristics for Produced Water Discharges at Selected Dilution Levels at the proposed Cambo Field Development under typical conditions

Scenario		Dilution Factor	Distance from Discharge Location [m]	Plume Width [m]
S1	9 m depth, high temperature, horizontal discharge	10	2.7	2.4
		25	6.6	4.2
		50	15.3	6.0
		100	38.6	8.6
		250	109.7	13.7
		400	203.2	17.4
		1000	950.5	59.2
S2	9 m depth, high temperature	10	2.4	2.5
		25	5.6	4.2
		50	12.7	6.1
		100	30.9	8.6
		250	99.0	13.7
		400	219.6	17.4
		1000	921.2	55.4
S3	9 m depth, low temperature	10	2.3	2.4
		25	5.1	4.2
		50	10.4	6.0
		100	21.4	8.6
		250	52.8	13.7
		400	83.9	17.4
		1000	488.3	37.8
S4	9 m depth, 2 locations, high temperature	10	1.9	1.9
		25	6.4	3.1
		50	17.0	4.3
		100	40.3	6.2
		250	10.1	9.7
		400	236.0	12.3
		1000	803.8	39.2
S5	9 m depth, 2 locations, low temperature	10	1.7	1.9
		25	4.9	3.1
		50	10.5	4.3
		100	21.0	6.1
		250	48.4	9.7
		400	74.1	12.3
		1000	263.2	19.5
S6	5 m depth, high temperature	10	2.4	2.5
		25	5.6	4.2
		50	12.7	6.1
		100	31.0	8.6
		250	99.9	13.7
		400	222.0	17.4
		1000	923.8	55.4

Scenario		Dilution Factor	Distance from Discharge Location [m]	Plume Width [m]
S7	9 m depth, medium temperature	10	2.3	2.5
		25	5.3	4.2
		50	11.3	6.1
		100	24.6	8.6
		250	65.1	13.7
		400	109.5	17.4
		1000	663.0	44.5
S8	9 m depth, 2 locations, medium temperature	10	1.8	1.9
		25	5.5	3.1
		50	12.5	4.3
		100	26.0	6.1
		250	62.3	9.7
		400	98.8	12.3
		1000	527.4	29.5

In all cases considered within the modelling study, the plumes initially propagate along their release direction due to the initial discharge momentum but are quickly deflected south-east along the axis of the principal current axis (Fugro, 2019b). Any environmental effects of produced water discharged at the proposed Cambo Field Development are therefore likely to be limited to the area to the south-east of the Cambo discharge location and within 500 m under typical conditions or within 888.9 m under a worst-case scenario, although ultimately this can only be definitively confirmed once the constituents of the produced water at Cambo are known and are demonstrated to have a PEC:PNEC ratio of ≤1.

10.5 Impacts on Benthic and Water Column Communities

Significant impacts on benthic communities due to discharges of proposed water at the proposed Development are highly unlikely to occur due to the rapid dilution of discharge plumes to below acceptable RBA thresholds which is predicted to occur within close proximity of the discharge point (within 900 m) even considering the worst-case scenario. Under typical environmental conditions, produced water discharges at the proposed Development are predicted to be diluted at a considerably faster rate and are forecast to achieve the RBA threshold within a maximum of 236 m for any discharge configuration considered. Furthermore, the numerical model studies described above forecast that plumes of produced water discharged at the proposed Development will remain close to the sea surface (within approximately 50 m even under a worst-case scenario) during their dispersion and therefore will not interact significantly with sea bed communities within and around the site which occur at a depth in excess of 1,000 m. Equally, significant accumulation of chemicals that may be contained within the produced water discharges within seabed sediments is not anticipated due to the open ocean nature of the proposed Development site, the rapid dilutions predicted to be achieved, the buoyant nature of the plumes and the water depths involved. Adverse impacts on benthic communities, including important ocean quahog populations, and benthic environmental quality conditions are therefore not expected.

Results of monitoring the ecological effects of oil and gas activity indicate that ecological effects of discharges of produced water are not probable (Research Council of Norway, 2012) while the risk of widespread, long term ecological impact from operational discharges can be considered low (Bakke et al., 2013), although evidence in the available literature is lacking in this regard (Blanchard et al., 2013; Bakke et al, 2013). Because of the rapid dilution, dispersion and transformation rates of most chemicals in produced water in open-ocean conditions, harmful biological effects of produced water discharges are expected to be minimal and localised (Neff, 2002). Furthermore, although several substances potentially harmful to the reproductive success of fish may be present in some produced water discharges, the concentrations that have given rise to adverse effects are normally only found within a few kilometres of the discharge sites and extensive and long term reproductive effects of produced water on fish are not very probable (Research Council of Norway, 2012). Other effects of the components of produced water include alteration in fish enzyme activity, liver oxidative metabolism and cell death, deoxyribonucleic acid (DNA) damage, impaired immunity and gene modification which can affect overall fish health while among invertebrate groups, adverse effects on mussel egg development and DNA damage in mussel larvae after hatching have been observed (Research Council of Norway, 2012; Gagnon, 2011; Hamoutene et al., 2011). However, ecological effects that have been detected have typically been associated with a dilution of produced water of 0.1% to 1% or higher which is found very close to discharge points indicating that effects are usually local (Research Council of Norway, 2012).

Given that benthic communities are highly unlikely to significantly interact with rapidly diluted and buoyant plumes of produced water coupled with the general improbability of ecological effects occurring beyond the immediate discharge and mixing zone, then it is considered that the any effects of produced water discharges at the proposed Development on benthic and water column communities will be of negligible significance.

10.5.1 Impacts on Marine Protected Areas

The proposed Development is located 35 km north of the Faroe-Shetland Sponge Belt NCMPA (JNCC, 2017a) (see Section 4, Environmental Description).

FEAST (Appendix 6) identifies non-synthetic and synthetic contamination and water clarity changes as pressures relevant to the consideration of effects of the proposed Development on the following features of the NCMPA;

- Deep-sea sponge aggregations;
- Offshore subtidal sand;
- Iceberg plough marks.

Similarly, JNCC's Advice on Operations (AoO) (Appendix 7) highlights these features of the NCMPA as sensitive to hydrocarbon and polyaromatic hydrocarbons (PAH) contamination, synthetic compound contamination and transitional elements and organo-metal contamination. The following assesses the potential effects of the identified pressures associated with the proposed produced water discharges on these sensitive NCMPA features.

10.5.2 Biodiversity Features

10.5.2.1 Deep-sea Sponge Aggregations

The Faroe-Shetland sponge belt NCMPA lies to the south of the proposed Development and therefore potentially within the general south-easterly direction of propagating plumes discharged during operations as indicated by the produced water discharge modelling. However, it is predicted that the plumes will be rapidly diluted within a short distance achieving a dilution factor of 1000 within a few hundred metres under typical conditions. Given the distance separation between the proposal and the NCMPA (35 km) as well as the buoyant nature of the plumes, which are predicted to remain at the sea surface, then no significant interaction with the seabed or associated sponge communities located within the NCMPA is expected. There are no sponge aggregations within or around the proposed FPSO site as reported during recent site specific ecological survey (MMT, 2019) so communities upon which the NCMPA populations may be reliant (i.e. for recruitment) will not be affected. Significant adverse effects on the deep-sea sponge aggregation interest of the NCMPA are therefore highly unlikely to occur and conservation objectives for the site are thus not anticipated to be significantly affected in this regard.

10.5.2.2 Offshore Sand and Gravels

FEAST does not specifically identify offshore sands and gravels within the tool, therefore, the assessment on the effects on this feature has been made using the Marine Scotland offshore sand and gravels FEAST translation table (Marine Scotland, 2013b). The translation table identified the features compatible with FEAST as deep-sea mixed sediments and deep-sea muddy sands.

As explained above, the distance separation between the proposed Development, the dilution of the plumes that are predicted to be achieved and the buoyant nature of the discharges, suggests that any significant interaction with seabed features and accumulation of chemicals within the produced water discharges within the boundary of the NCMPA is highly unlikely. Significant adverse effects on the offshore sand and gravel interest of the NCMPA are therefore highly unlikely to occur due to the discharges of produced water and conservation objectives for the site are thus not anticipated to be significantly affected in this regard.

10.5.2.3 Iceberg Plough Marks

Similarly, significant interaction between produced water discharges and iceberg plough marks within and around the boundary of the NCMPA are not expected due to the distance separation involved, the predicted dilution of the plumes and the buoyant nature of the discharges. Significant adverse effects on the iceberg plough marks interest of the NCMPA are therefore highly unlikely to occur due to the discharges of produced water and conservation objectives for the site are thus not anticipated to be significantly affected in this regard.

10.6 Mitigation

No significant effects on benthic communities or nature conservation interests are predicted due to the proposed produced water discharges, and mitigation is thus not considered as being required, although the following observations are provided:

- Reducing the discharge temperature to 45˚C will ensure the RBA dilution rates of 400 at 500 m from the discharge is met under all meteorological conditions, and therefore SPE will ensure the discharge temperature will be 45˚C (or less) to further improve initial dilution rates;
- A downward orientation of the discharge will increase the horizontal distance travelled during the near-field propagation stage and further improves predicted dilution factors, and hence an angled discharge port will be used.

10.7 Cumulative and Transboundary Impacts

Oil and gas activity West of Shetland is relatively low, in comparison with the neighbouring northern North Sea. The BP operated Loyal, Schiehallion and Foinaven fields are located around 54 km and 59 km, respectively, to the south of the proposed Development Footprint, and are tied back via the West of Shetland Pipeline (WOSP) to the BP Clair platform, 89 km to the east of the Development Footprint (UK Oil and Gas, 2018). Given the distance separations between these facilities and the current proposals, then no significant mixing of produced water discharges are anticipated and no significant cumulative or synergistic impacts are forecast. The RBA threshold used in this assessment is forecast to be achieved within a very short distance from the discharge point suggesting that contributions of significant produced water discharges to the wider region will be negligible.

The proposed Cambo wells lie approximately 7 km east of the UK/Faroe Island transboundary line. The dominant movement of produced water discharges from the proposed Development within the ambient current flows is to the south-east and away from the UK/Faroe boundary and rapid dilution to below the RBA threshold is forecast to be achieved within a few hundred metres even under worst-case conditions. No significant transboundary issues are therefore expected.

The potential for cumulative and transboundary effects from produced water discharges is considered extremely limited, and therefore considered to be not significant.

10.8 Conclusion

The fate of produced water discharges has been subject to detailed numerical modelling which shows that plumes will be rapidly diluted to below the RBA threshold of 400 times within a few hundred metres of the discharge point even under worst-case meteorological and oceanographic conditions. Any environmental effects of produced water discharged at the proposed Cambo Field Development are expected to be limited within 500 m under typical conditions or within 888.9 m under a worst-case scenario, although ultimately this can only be definitively confirmed once the constituents of the produced water at Cambo are known and are demonstrated to have a PEC:PNEC ratio of ≤1. The modelling results have influenced the design parameters of the produced water outfall, so that appropriate mitigation is built into the design (i.e. discharge temperature of 45˚C or less and discharge orientated at a downwards angle).

Only industry standard production chemicals will be used and discharged during operations at the Cambo field. All chemicals used will be included in the Offshore Chemical Notifications Scheme (OCNS) and the most environmentally friendly options evaluated and, where possible, chemicals that pose little or no risk (PLONOR) to the environment will be used. Additionally, chemical risk assessments will be undertaken as part of the environmental permitting process.

Significant interaction with seabed sediments and communities are highly unlikely due to the rapid dilution rates within receiving waters and the buoyant nature of the plumes so that they will remain near to the sea surface. Other oil and gas facilities are located far beyond the point at which plumes are diluted to below RBA threshold such that potential mixing of respective plumes and potential synergistic effects are highly unlikely to occur. Consequently, significant effects on the interests of the Faroe-Shetland Sponge Belt NCMPA are not forecast to occur and associated conservation objectives are not expected to be significantly affected. In conclusion, significant effects of the discharge of produced water on benthic and water column communities either alone or cumulatively with other discharges in the region are not expected.

Section 11

Noise Generation and Wildlife Disturbance

11 NOISE GENERATION AND WILDLIFE DISTURBANCE

The following issues and concerns were raised during the Environmental Issues Identification (ENVID) workshop, informal consultation and/or are referred to in national policies and guidance, and will therefore be considered in this Section on underwater noise generation and wildlife disturbance:

- The ENVID identified underwater noise generated by piling to fix the Cambo Tie-in Structure (CTIS) to the seabed at the West of Shetland Pipeline System (WOSPS) Pipeline End Manifold (PLEM) as having a potential significant effect on the marine environment, namely on marine mammals and fish. This issue was also raised during early consultation by OPRED. All other subsea infrastructure will be gravity based or use suction piles instead, and thus will not generate any significant underwater sound;
- The ENVID identified underwater noise generated by the engines and thrusters of the Mobile Operated Drilling Unit (MODU) and support vessels as having a potential significant effect on the marine environment, namely on marine mammals. This issue was also raised during early consultation by OPRED;
- JNCC notes that West of Shetland is considered an area of importance for marine mammals and this should be recognised within the Environmental Statement (ES) by considering noise impacts and potential changes in food distribution;
- The Scottish National Marine Plan identifies noise generated from drilling, production facilities or vessels, burial of pipelines as having the potential to cause injury and disturbance to noise-sensitive species such as cetaceans;
- The Scottish National Marine Plan identifies cumulative impacts (GEN21) as one of its General Policies.

During the drilling operations at Cambo, noise will be generated by the MODU, its support vessels (i.e. the standby vessel and supply vessels), and by helicopters. Additional (shipping) noise will be generated by the vessels used for the installation of the Floating Production, Storage and Offloading Vessel (FPSO) and its associated subsea infrastructure, as well as during the installation of the export pipeline.

During the operational life of the field, the main sources of underwater noise will be from the FPSO and its associated support vessels and the shuttle tankers visiting periodically to offload the crude oil.

Hence the two main underwater sound sources to be assessed are engine/propeller/thruster noise from the FPSO, its support vessels and shuttle tankers, and the piling noise associated with the installation of the CTIS at the WOSPS PLEM. All these sources will emit low frequency noise into the water column.

This section will also assess the requirement for a wildlife disturbance licence, using the criteria for undertaking such an assessment outlined in the latest version of the JNCC draft guidance notes (JNCC, 2010a).

11.1 Quantification of Noise

11.1.1 Ambient Noise

Ambient or background noise in the ocean consists of a broad range of individual sound sources and is made up of natural as well as manmade sources (Hildebrand, 2004). The ambient acoustic environment of the ocean is highly variable.

The dominant source of naturally occurring noise is associated with ocean surface waves generated by the wind. This noise occurs across a range of frequencies from 1 Hz to 100 kHz (NRC, 2003). Other natural sounds in the sea include currents, rain, ice-breaking, echo-location and communication noises generated by cetaceans and other natural sources such as tectonic activity. Table 11.1 displays some of the different types of sounds found naturally in the marine environment.

Table 11.1: Examples of Natural Sounds in the Marine Environment

Sound Source	Dominant Frequency Range	Sound Pressure Density Spectrum Level (dB re 1 µPa^2/Hz)	Noise Characteristics
Wind	1 to 25 kHz	100 to 200 Hz 65 dB (force 3) 85 to 95 dB (force 12)	Greatest levels at higher wind speeds, noise is continuous on a scale of hours to days
Rain	Broad spectrum	0 dB (no rain) to 80 dB (heavy rainstorm)	Flat frequency spectra (white noise)
Earthquakes	5 to 15 Hz	0 dB (no earthquake) to 200 to 240 dB (at 10 km from earthquake of ML 4 to 6, broadband)	Short term transitory events on a scale of minutes, noise levels may be high
Baleen whales	16 to a few hundred Hz	128 to 190 dB re µPa @ 1 m	Communication (low frequency moans, grunts, down sweeps)
	2 kHz to 25 kHz	151 dB re µPa @ 1 m	Communication (clicks)
Toothed whales	100 Hz to 20 kHz	to 180 dB re µPa @ 1 m	Communication
	6 kHz to 325 kHz	120 to 228 dB re µPa @ 1 m	Echolocation

In addition to naturally occurring sounds, anthropogenic noise is generated by air traffic, shipping activity and the oil and gas industry. Of these, shipping is the dominant source of sound in the world's oceans, generally within a range from five to a few hundred Hertz (NRC, 2003). All vessels generate noise as a consequence of their operation. Modern powered vessels typically produce low-frequency (i.e. less than 1000 Hz) sound from hydrodynamic flow noise, onboard machinery, and, primarily, from propeller cavitation (Southall et al., 2007).

However, sound generated by airguns is also a major contributor to the low-frequency background sound recorded in certain areas, such as the North Atlantic (Nieukirk et al., 2004; Tyack, 2008). These anthropogenic noise levels in the oceans have increased significantly over the last few decades (e.g. Hatch and Wright, 2007; Andrew et al., 2002) giving marine animals little time to adapt to these changes in an evolutionary sense.

Table 11.2 shows various anthropogenic sources and received levels of sound in the marine environment. Underwater noise levels in the Atlantic Margin have been monitored in an Atlantic Frontier Environmental Network (AFEN)-sponsored study using "pop-up" autonomous monitoring devices around the BP operated Foinaven and Schiehallion production fields. They were deployed at various distances from the installations, ranging from approximately 7 km to 13 km from Foinaven and 7 km to 22 km from Schiehallion. The work suggests that these facilities are the predominant source of ambient noise in the area (DTI, 2000).

Table 11.2: Sound Sources from Various Maritime Activities

Activity	Dominant Frequency Range (kHz)	Average Source Level (dB re 1µPa-m)	Estimated Received Level at Different Ranges (km)			
			0.1 km	1 km	10 km	100 km
High resolution geophysical survey; pingers, side scan, fathometer	10 - 200	<230	190	169	144	69
Low resolution geophysical seismic survey; seismic air gun	0.008 - 0.2	248	210	144	118	102
			208	187	162	87
Production drilling	0.25	163	123	102	77	2
Jack-up drilling rig	0.005 - 1.2	85 - 127	45 - 87	24 - 66	<41	0
Semi-submersible rig	0.016 - 0.2	167 - 171	127 - 131	106 - 110	81 - 85	6 - 10
Drill ship	0.01 - 10	179 - 191	139 - 151	118 - 130	93 - 105	18 - 30
Large merchant vessel	0.005 - 0.9	160 - 190	120 - 150	99 - 129	74 - 104	<29
Military vessel	Not known	190 - 203	150 - 163	129 - 142	104 - 117	29 - 42
Super tanker	0.02 - 0.1	187 - 232	147 - 192	126 - 171	101 - 146	26 - 71

Sources: Adapted from: Evans and Nice, 1996 and Richardson et al., 1995.

Figure 11.1 represents ambient noise as a function of frequency; the ambient noise spectrum normally lies between the two thick green lines shown.

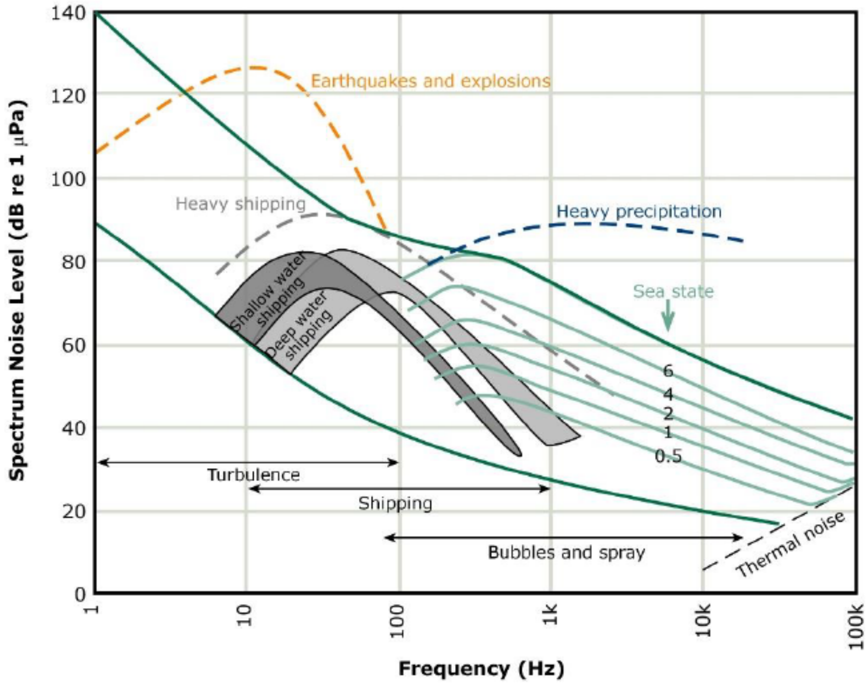


Figure 11.1: Ambient Noise Spectra in the Open Ocean

Sources: Adapted from Wenz, 1962; NRC, 2003; and Harland et al., 2005.

At the lower frequencies, shipping noise predominates, while at the higher frequencies noise from waves and precipitation dominates (Figure 10.1). The frequency at which the change occurs is a complex function of local bathymetry, propagation conditions, shipping levels and weather conditions.

11.1.2 Underwater Sound Behaviour

As sound spreads underwater, it decreases in strength with distance from the source. This transmission loss is the sum of spreading loss and attenuation loss. Spreading loss is the geometric weakening of a sound signal as it spreads outwards from a source. Attenuation losses are the physical processes in the sea that distort the mathematical spreading laws. A number of factors including sound absorption or scattering by organisms in the water column, reflection or scattering at the seabed and sea surface, and the effects of temperature, pressure, stratification and salinity affect these physical processes. Variations in temperature and salinity with depth cause sound waves to be refracted downwards or upwards causing increases or decreases in sound attenuation and absorption. Actual sound transmission therefore has considerable temporal and spatial variability that is difficult to quantify.

In the area West of Shetland, a large asymmetry between upslope and downslope propagation can be expected over larger distances. Sound propagating downslope may connect with the deep sound channel, allowing it to propagate to long range with little attenuation. In contrast, sound propagating upslope can be expected to suffer rapid attenuation due to frequent interactions with the seabed.

In general though, in waters >50 m in depth with a relatively flat seabed, it can be assumed that, in the immediate vicinity of the sound source (i.e. within a few km of the source), attenuation will more or less follow the laws of spherical spreading and can be calculated as:

$$SPL_R = SPL_{Source} - 20 \cdot Log_{10}(R) + A \cdot R \qquad (Formula\ 1)$$

SPL_R = Sound Pressure Level at distance ‘R’ from the sound source (dB re 1µPa at 1 m)

SPL_{Source} = Sound Pressure Level at 1 m distance from the sound source (dB re 1µPa at 1 m)

R = Distance from sound source (in metres)

A Attenuation loss/absorption loss coefficient (0.00043 dB/m)

For longer distances (>10 km), moving downslope into deep-water, the sound attenuation is more likely to follow the laws of cylindrical spreading, which generally means it will attenuate much more slowly and propagate further, with the potential for sound to become ‘trapped’ in the deep sound channel. To calculate cylindrical spreading the number 20 in the formula above should be replaced by the number 10.

A second metric that is often used to quantify underwater sound is the Sound Exposure Level (SEL), which is the dB level of the time integral of the squared instantaneous sound pressure normalised to a 1 second period (Southall et al., 2007). SEL effectively averages the total acoustic energy released over a one second period and is a particular useful metric for estimating the (cumulative) impact over a set period of time.

11.1.3 Underwater Sound Generated by the MODU

All types of mobile drilling unit generate low-frequency noises, which are, to some extent, transferred into the water column. Due to the relatively high surface area in contact with the sea, and hence increased transmission of machinery noise and vibration into the water column, MODUs are inherently noisier than fixed platforms (Simmonds et al., 2004). A MODU is likely to produce sounds in the range of 0.16 kHz to 0.2 kHz, with received tonal levels between approximately 167 and 171 dB re 1 µPa-m (Richardson et al., 1995; Evans and Nice, 1996; Simmonds et al., 2004). Table 11.2 compares noises produced by drilling activities with those from other maritime activities.

11.1.4 Underwater Sound Generated by Support Shipping

Shipping is a major contributor to noise in the oceans, especially at low frequencies between 5 Hz and 500 Hz (NRC, 2003; Richardson et al., 1995; Davis et al., 1990). Sound levels and frequency characteristics are roughly related to ship size and speed, but there is significant individual variation among vessels of similar classes. The primary sources of sound from shipping are the propellers, engines and associated propulsion machinery. Other sound sources from ships include auxiliary machinery such as pumps, generators, ventilators, compressors etc (Richardson et al., 1995). Shipping operations associated with the proposed Cambo Field Development include regular supply vessel visits and the standby vessel throughout the drilling and subsequent production operations. Typical source levels associated with these types of shipping range between 170 and 180 dB re 1µPa @ 1 m (Richardson et al., 1995). During the production phase, shuttle tankers will periodically visit the FPSO to offload the crude oil and an estimated peak source level of 184.1 dB re 1 µPa at 1 m was used by McPerson et al (2016) for similar operations, estimated over a frequency range from 10 Hz to 11 kHz, peaking at around 500 Hz.

11.1.5 Underwater Sound from Piling during Installation of the Cambo Tie-in Structure

The amount of underwater sound generated during the proposed piling operations depends on many factors, including size (length and diameter) and material of the pile itself, properties of the hammer, water depth, and underlying geology, and is therefore very hard to estimate. Wyatt (2008) shows there is a strong correlation between the diameter of the pile and the piling noise generated. Section 3.5.14 describes the piling operations required to install the CTIS at the WOSPS PLEM. The CTIS will have four piles of 0.61 m (24”) diameter, corresponding to an estimated peak to peak sound pressure level of 222 dB re 1µPa at 1 m, based on the correlation between pile diameter and generated piling noise presented in Wyatt (2008). Consequently, the associated or ‘flat peak’ or ‘0-peak’ value will be approximately 216 dB re 1µPa at 1 m.

Although the Sound Exposure Limit (SEL) can be measured in the field fairly easily, it is very hard to predict accurately beforehand. Therefore, an analogue SEL value has been calculated using a linear regression on the normalised SEL_{Max} values of various piling operations reviewed by Betke (2008). The SEL_{Max} for piling operations at Cambo has been estimated at 202 dB re $1µPa^2s$ for a single strike at 1 m distance.

The existing WOSPS PLEM made use of an IHC S280 hammer, which is a typical hammer size for this type of construction activity. An average blow count of 509 blows/pile was recorded and this should be considered typical for the new structure piling i.e. a total blow count in the region of 2,050 is anticipated.

11.1.6 Underwater Sound Generated by the FPSO

There is very limited information available on the underwater sound levels of FPSOs. Erbe et al (2013) compared the underwater sound levels of six FPSOs operating offshore Australia and found mean source levels between 174 and 181 dB re 1 µPa at 1 m. Dominant frequencies were broadly similar to that of the shuttle tanker described above ranging between 10 Hz to 11 kHz, and also peaking at around 500 Hz. It is expected that the underwater sound generated by the Cambo FPSO will be of a similar levels and frequency range.

11.1.7 Impacts from Sound Generated by Activities Associated with the Proposed Cambo Field Development

This section assesses potential impacts from underwater and airborne sound, focussing on marine mammals and fish which are the receptors believed to be most at risk from noise impacts.

Sound is a particularly efficient way to propagate energy through the ocean, and many marine animals use hearing as their primary sense. Cetaceans, in particular, are heavily dependent on sound for food finding, communication, reproduction, detection of predators, and navigation (Weilgart, 2007; Hildebrand, 2004).

As described in Section 11.1.1, the ocean is a naturally noisy environment and cetaceans in particular have evolved ears that function well within this context. Recent anatomical and behavioural studies suggest that whales and dolphins may be more resistant than many land mammals to temporary threshold shifts. However, these data also show that they are subject to disease and aging processes and are therefore not immune to hearing loss. Increasing ambient noise via human activities is a potential candidate for exacerbating or accelerating such losses (Ketten, 2004).

The introduction of additional noise into the marine environment could potentially interfere with the animals' ability to determine the presence of other individuals, predators, prey and underwater features and obstructions. This increase in noise could therefore cause short term behavioural changes and, in more extreme cases, cause auditory damage. In addition to marine mammals, underwater sound may also cause behavioural changes in other animals such as fish and diving seabirds.

11.2 Impacts on Marine Mammals

Marine mammals use sound in various important contexts, such as in social interactions, foraging, and response to predators (Southall et al., 2007). Hearing is the primary sensory system for marine mammals, which is clearly shown by their level of ear and neural auditory centre development (Ketten, 2004). As the sea has never been a silent place, the ears of marine mammals, and those of whales and dolphins in particular, have evolved to function well within this context of ambient noise. However, little information exists to describe how marine mammals respond physically and behaviourally to intense sounds and to long term increases in ambient noise levels (NRC, 2003).

Marine mammals vary in regard to their hearing sensitivities and in order to assess the impacts of sound can be classed into functional hearing groups (Southall et al., 2007; NOAA, 2016; NOAA, 2018; and most recently Southall et al., 2019). The classification into functional hearing groups takes into account that not all marine mammal species have identical hearing or susceptibility to noise-induced hearing loss. Table 11.3 applies the most up to date classification by Southall et al (2019) to the species that may be present in the wider area around the proposed Development. Outside their generalized hearing ranges, the risk of auditory impacts from sounds is considered highly unlikely or very low. According to this classification, harbour porpoises are regarded as 'very high-frequency cetaceans', white-beaked dolphins and Atlantic white-sided dolphins are classified as 'high-frequency cetaceans'. This classification is based on the fact that odontocetes have highly advanced echolocation systems that use intermediate to very high frequencies. They also produce social sounds in a lower-frequency band, including generally low to intermediate frequencies (1 kHz to tens of kHz). Consequently, their functional hearing is expected to cover this whole range; however, their hearing sensitivity typically peaks at or near the frequency where echolocation signals are strongest (Southall et al., 2019).

All mysticetes (i.e. the large baleen whales) are all categorised as 'low-frequency cetaceans'. No direct measurements of hearing exist for these animals and theories regarding their sensory capabilities are consequently speculative. In these species, hearing sensitivity has been estimated from behavioural responses (or lack thereof) to sounds at various frequencies, most common vocalisation frequencies, body size, ambient noise levels at the frequencies they use most, and cochlear morphology. At present, the lower and upper frequencies for functional hearing in mysticetes, collectively, are estimated to be 7 Hz and 35 kHz (NOAA, 2016).

Table 11.3: Functional Hearing Groups for Marine Mammals Potentially Present in the Cambo Area

Functional Hearing Group	Estimated Auditory Band Width	Species Potentially Present in the Cambo Area
Low-frequency cetaceans	7 Hz to 35 kHz	Minke whale; Blue whale*, Humpback whale*; Sei whale*; Fin whale;
High-frequency cetaceans	150 Hz to 160 kHz	Atlantic white-sided dolphin; White-beaked dolphin; Risso's dolphin; Killer whale; Long finned pilot whale; sperm whale; Northern bottlenose whale*; Short-beaked common dolphin
Very High-frequency cetaceans	275 Hz to 160 kHz	Harbour porpoise
Pinnipeds in water	50 Hz to 86 KHz	Grey seals; Common seal; Hooded seals

* *Have been recorded in the area as migratory species.*

Sources: NOAA,2018; Pollock et al., 2000; Reid et al., 2003; DECC, 2016.

Research indicates that marine mammals can react differently to the introduction of additional noise into the marine environment. Reactions may vary depending on sound source level, propagation conditions and ambient noise, in addition to species, age, sex, habitat, individual variation, and previous habituation to noise (Richardson et al., 1995). It should also be noted that marine mammals react differently to stationary noise, compared to sudden bursts of noise and noises that appear to be coming towards them. Studies suggest that most cetaceans will alter their course or display avoidance reactions to a noise that appears to be moving directly towards them. Stationary noises, such as drilling noises, outwith an immediate zone of discomfort to the animal, seem to have a lesser effect in disturbing migration patterns and animal feeding, although data and observations on this matter are limited (Davis et al., 1990).

11.2.1 Injury Thresholds for Cetaceans

The proposed Development will contribute and add to the existing ambient sound in the development area. The underwater sound produced by the FPSO itself, its support vessels, the shuttle tankers and the MODU all produce 'non-impulsive' sounds at relatively low frequencies.

In contrast, the underwater sound generated during the proposed piling operations at the CTIS will produce intermittent, or 'impulsive' sound pulses which are considerably more intense than the continuous noise emitted by most industrial noises in the ocean, including those from the FPSO, MODU or their support vessels.

There are few direct data regarding the effects of intense sound on cetaceans, making it difficult to predict accurate safe exposure levels for these mammals (Finneran *et al.*, 2000). Nonetheless attempts have been made to create a set of injury criteria for individual marine mammals exposed to discrete noise events, by Southall et al,. (2007), and more recently by the US National Oceanic and

Atmospheric Administration (NOAA) which introduced a new set of injury criteria in 2016 (NOAA, 2016), which were updated in 2018 (NOAA, 2018) and are maintained in Southall et al,. (2019).

These injury criteria aim to set acoustic thresholds, at which individual marine mammals are predicted to experience changes in their hearing sensitivity (either temporary or permanent) for acute, incidental exposure to underwater anthropogenic sound sources. These thresholds are referred as 'Temporary Threshold Shift' (TTS) and Permanent Threshold Shift (PTS), respectively. The NOAA guidance makes a clear distinction between impulsive and non-impulsive sound sources, based on their physical characteristics at the source, with impulsive sound having physical characteristics making them more injurious (NOAA, 2018).

The cumulative SEL is calculated as the summation of the total sound energy to which the receptor is exposed during a set period of time (in this case 24 hrs). The SEL_{CUM} can be calculated as:

$$SEL_{CUM} = 10 \cdot Log_{10} \sum_{i=1}^{n} 10^{\frac{SEL_{Max} - 20 \cdot \log(R_i) + A \cdot R_i}{10}} \qquad (Formula\ 2)$$

SEL_{CUM} = Cumulative Sound Exposure Level received by the receptor

SEL_{Max} = Source Exposure Level at distance 'R' at time interval 'i'

Table 11.4 presents the acoustic thresholds for 'non-impulsive' sound sources, based on the cumulative sound exposure level of the source over a 24 hr period for sounds with a peak frequency around 500 Hz.

Assuming that any marine mammal would never be closer than 10 m from the sound source and that any animal experiencing high sound levels will move out of the area causing it discomfort, Formula 2 can be used to calculate the cumulative amount of sound energy any animal would receive in 24 hours, when swimming away from the sound source at a constant speed of 1.5 m/s. Under these conditions then SEL_{CUM} from the FPSO would be around 172 dB re 1µPa^2s. If the marine mammal would only move to outside the 500 m zone, and stay there for the remaining time during a 24 hr period, the SEL_{CUM} would be around 177 dB re 1µPa^2s. Comparing these values with the PTS and TTS thresholds in Table 11.4 shows that no PTS or TSS would be expected to occur for any of the species. The sound emitted by the standby and supply vessels, the shuttle tanker and the MODU are less of that of the FPSO, hence, no PTS/TTS thresholds are expected to be breached for any of these vessels either.

Table 11.4: PTS and TTS Onset Thresholds for <u>Non-impulsive Sounds</u> (NOAA, 2018) for Marine Mammals in the Cambo Area

	PTS Onset SEL_{cum}, Weighted*, 24hr (dB re 1μPa^{2}s)	TTS Onset SEL_{cum}, Weighted*, 24hr (dB re 1μPa^{2}s)
Minke whale, Blue whale, Humpback whale, Sei whale, Fin whale	200	180
Atlantic white-sided dolphin, White-beaked dolphin, Risso's dolphin, Killer whale, Long finned pilot whale, sperm whale, Northern bottlenose whale and Short-beaked common dolphin	237	217
Harbour porpoise	221	201
Grey, common and monk seals	230	210

* SEL_{CUM} values have been adjusted for peak frequency at 500 Hz.

For 'impulsive' sounds, such as the piling noise during the CTIS installation, dual metric acoustic thresholds for either the unweighted ('flat') sound pressure level (SPL) of a single impulse, or the cumulative sound exposure level over a 24 hr period (whichever results in the largest isopleth for calculating PTS onset) should be used.

The weighted auditory thresholds for the SEL_{CUM} during the piling operations, can be computed as described above for continuous underwater noise, but by using 4 second intervals between each hammer strike instead. The model does also take a soft start into account, during which the hammer energy is gradually increased over a 20 minute period for each pile.

Table 11.5 shows the PTS and TTS onset thresholds for impulsive sounds for the piling noise generated during the CTIS installation.

Table 11.5 PTS and TTS Onset Thresholds for <u>Impulsive Sounds</u> (NOAA, 2018) for Marine Mammals in the Cambo Area

	PTS Onset, SPL_R, 0-pk, Flat (dB re 1μPa)	PTS Onset SEL_{cum}, Weighted*, 24hr (dB re 1μPa^{2}s)	TTS Onset, SPL_R, 0-pk, Flat (dB re 1μPa)	TTS Onset SEL_{cum}, Weighted*, 24hr (dB re 1μPa^{2}s)
Minke whale, Blue whale, Humpback whale, Sei whale, Fin whale	219	184	213	169
Atlantic white-sided dolphin, White-beaked dolphin, Risso's dolphin, Killer whale, Long finned pilot whale, sperm whale, Northern bottlenose whale and Short-beaked common dolphin	230	224	224	209
Harbour porpoise	202	203	196	188
Grey, common and monk seals	218	196	212	181

* SEL_{CUM} values have been adjusted for peak frequency at 500 Hz

The unweighted, or 'flat', threshold value for impulsive sounds is based on the 0-peak SPL of a single exposure (i.e. in this case one single hammer blow). Using the spreading model presented in Section 11.1.2, the distances to the PTS and TTS thresholds for a single hammer strike can be calculated.

Table 11.6 shows that the PTS and TTS isopleths for a single hammer strike are all within 10 m of the sound source, and for some even below the 'flat' threshold value.

Assuming the piling operations will only be started with no marine mammals present within 500 m from the piling location in line with the JNCC guidelines on underwater piling noise (JNCC, 2010b), the cumulative SEL over 24 hours received by any animal swimming away from the sound source would be approximately 161 dB re 1μPa^{2}s, which is below all NOAA PTS and TTS threshold values quoted in Table 11.6.

Table 11.6: PTS and TTS Isopleths for Single Hammer Strike

PTS/TTS Isopleths	NOAA PTS/TTS Thresholds and Distance (metres) from Sound Source in which these Threshold Values are Exceeded Per Species			
	Minke whale, Blue whale, Humpback whale, Sei whale, Fin whale	Atlantic white-sided dolphin, White-beaked dolphin, Risso's dolphin, Killer whale, Long finned pilot whale, sperm whale, Northern bottlenose whale and Short-beaked common dolphin	Harbour porpoise	Grey, common and monk seals
Single strike PTS Isopleth to Threshold 'flat' peak	SPL below 'flat' threshold value	SPL below 'flat' threshold value	5.0 m	SPL below 'flat' threshold value
Single strike TTS Isopleth to Threshold 'flat' peak	1.4 m	SPL below 'flat' threshold value	10 m	1.6 m
PTS Isopleth to weighted cumulative SEL Threshold	SEL below threshold	SEL below threshold	SEL below threshold	SEL below threshold
TTS Isopleth to weighted cumulative SEL Threshold	SEL below threshold	SEL below threshold	SEL below threshold	SEL below threshold

Therefore, taking into account the above assessment for a single strike as well as cumulatively over a 24 hour period, together with the use marine mammal observers (MMOs) to ensure there are no marine mammals present with 500 m at the commencement of the piling operations, it is deemed unlikely that the piling operations would cause any physical injury to marine mammals in the area.

11.2.2 Behavioural Responses of Small Odontocetes to Piling Operations

Although it is unlikely that any piling operations will cause injury, they may very well evoke some behavioural responses from any cetaceans in the vicinity of such operations.

There is limited information available of the behavioural effects of the larger baleen whale species to piling operations. However, as sound levels and dominant frequencies of piling sound are in many ways quite similar to the sound generated during offshore geophysical (i.e. seismic) surveys, the following examples have been used as a proxy to describe some of the anticipated effects and spatial extent.

Baleen whales have hearing sensitivity ranges between 10 Hz and 10 kHz, with greatest sensitivities usually below 1 kHz (Evans, 1998; Southall et al., 2007). This hearing range overlaps the low frequency sounds produced by the planned piling operations, which may mask long distance communication between whales and prevent the detection of other faint sounds (Evans and Nice, 1996).

Most studies on low-frequency cetaceans report behavioural responses to 'pulsed sound', such as that produced by piling operations or seismic surveys, at received sound levels around 140 to 160 dB re 1 µPa, and sometimes even higher (e.g. Southall et al., 2007; Richardson et al., 1995). These responses typically consist of subtle effects on surfacing and respiration patterns. Sound levels of 150 dB to 180 dB will generally evoke behavioural avoidance reactions (Richardson et al., 1995).

JNCC (2020b) uses the term 'Effective Deterrent Radius' (EDR) to define the displacement range, based on the empirically derived displacement range of harbour porpoise from piling operations. JNCC proposed a minimum EDR of 15 km based on a study of harbour porpoise responses to pile driving operations (Graham et al., 2019). The study identified a 50% probability of pin piling operations eliciting a behavioural response in Harbour porpoises within 7.4 km in the 12 hours after piling operations had ended as well as showing a 25% probability of a response within approximately 18 km. Potential habituation was also recorded with response distances decreasing over the duration of the piling operations. Therefore, an EDR of 15 km has been adopted due to the likelihood that the majority of effects during piling would be detected at distances greater than 7.4 km.

Given the intermittent nature and short overall duration of the piling operations (1 day), the fact that the impact on cetaceans is expected to be limited to some potential avoidance responses for individual animals up to a distance of 15 km from the piling operations and that mitigation measures outlined in the JNCC Guidelines for piling operations (JNCC, 2010b) will be followed, the impact of piling operations on cetaceans is considered to be not significant.

11.2.3 Behavioural Responses of Cetaceans to the Presence of the FPSO, MODU, Shuttle Tanker and Other Support Vessels

Underwater sound levels generated by MODUs typically range between 167 and 171 dB re 1µPa @ 1 m, with the strongest tones produced at frequencies between 0.16 kHz and 0.2kHz (Table 11.2). The review of Southall et al (2007) indicates that low frequency cetaceans (i.e. the large baleen whales) generally start to show some avoidance and other behavioural effects to this type of 'non-pulsed' sound in the 120 to 160 dB re: 1µPa range. Using Formula 1, this would translate to a behavioural response threshold of between 4 m and 355 m from the MODU.

The reactions of mid frequency cetaceans (i.e. dolphin species and toothed whales) to non-pulsed sounds were much more varied and did not lead to a clear conclusion about received sound levels coincident with various behavioural responses (Southall et al., 2007). However, upon reviewing those studies based on vessel noise and presence, and playbacks of drilling sounds, for example, it seems that the general behavioural response threshold may range between a few hundred metres to a few kilometres from the sound source. It seems therefore reasonable to assume that similar response distances can be expected around the FPSO, MODU, shuttle tanker and other support vessels associated with the proposed Development.

Based on the limited scale of effects described above and the limited range over which these effects occur, the underwater noise produced by the FPSO, MODU, shuttle tanker and other support vessels at Cambo are not expected to have any significant impacts on cetaceans.

11.2.4 Impacts on Pinnipeds

Pinnipeds (seals, sea lions, and walruses) also produce a diversity of sounds, although generally over a lower and more restricted bandwidth (generally from 100 Hz to several tens of kHz). Their sounds are used primarily in critical social and reproductive interactions (Southall et al., 2007). Most pinniped species have peak sensitivities between 1 and 20 kHz (NRC, 2003). Common seals are most sensitive to sounds between 6 to 12 kHz (Wolski et al., 2003), although their threshold for hearing and responding to sound lies at frequencies much lower than that. Kastak and Shusterman (1998) measured the underwater sound detection threshold of a common seal, which ranged between 101.9 dB and 62.8 dB for frequencies between 75 Hz and 6,400 Hz respectively. The audiograms of common and grey seals are very similar (Thompson, 1998), and their reaction to anthropogenic underwater sound is therefore expected to be similar as well.

The majority of sounds produced by the FPSO, MODU, shuttle tanker and other support vessels are continuous and of low frequency, as described above. Continuous sound levels of between 90 and 140 dB re 1µPa @ 1 m do not appear to induce strong behavioural responses in pinnipeds (Southall et al., 2007). Using Formula 1, the sound levels produced by the loudest sound source, i.e. the FPSO (estimated to be around 182 dB, as indicated in Section 11.1.6) would be expected to attenuate to 140 dB within 112 m of the source. Due to the low number of pinnipeds likely to be present in the area around Cambo, together with the limited spatial extent of the anticipated impact on seals, the effects of noise generated by the FPSO, MODU, shuttle tanker and other support vessels are therefore considered to be negligible.

Very few studies have been conducted on the effects of impulsive noise on pinnipeds, even though they are known to have good underwater hearing and their feeding grounds often overlap with areas subject to manmade high intensity underwater noise activities.

Russell et al. (2017) found that seal usage (abundance) was significantly reduced up to 25 km from piling operations at a wind farm location in the southern North Sea. Within 25 km of the centre of the wind farm, there was a 19% to 83% decrease in usage of the area compared to during breaks in piling. This amounted to significant displacement starting from predicted received levels of between 166 and 178 dB re 1 µPa(p-p). Within 2 hours of cessation of pile driving, seals were distributed as per the non-piling scenario. However, these piling operations were much larger in scale than the small diameter piles required for the CTIS installation assessed in this ES and therefore the sound levels and intensity can perhaps better be compared to that of a small seismic survey instead.

A review of the effects of seismic survey impacts on marine mammals by Gordon et al. (2003) quotes a study by Thompson et al. (1998) on the behavioural and physiological responses of grey and common seals to small airguns. The study indicated that reactions observed in common seals included initial fright responses as the air guns were switched on, generally followed by strong avoidance behaviour, demonstrated by swimming rapidly away from the sound source. However, the study also reported that one seal showed no detectable response and approached to within 300 m of the airgun (source levels of the airgun were 215 to 224 dB re 1 µPa at 1 m peak-to-peak). The seals ceased feeding during this time. The behaviour of the common seals seemed to return to normal soon after the air guns were switched off.

Bearing in mind that the piling operations will be intermittent over a short overall period of 1 day, and any affected seals are expected to return to the area quickly after piling operations have seized, the overall impacts from piling are not believed to cause any long term effects on pinnipeds and therefore are deemed insignificant.

11.2.5 Impacts on Fish

This section assess the potential effect of the proposed piling operations on fish. The inner ear of fish including elasmobranchs (sharks, skates and rays), is very similar to that of terrestrial vertebrates, and hearing is understood to be present in virtually all fish (NRC, 2003). Most species of fish are able to detect sounds from below 50 Hz (some as low as 10 Hz or 15 Hz) to upward of 1,000 Hz. Moreover, a number of fish species have auditory adaptations that enhance sound detection and enable them to detect sounds of 3 kHz and above, giving them better sensitivity than non-specialist species at lower frequencies (NRC, 2003; Popper, 2003). Many species of fish use sound to find prey, to avoid predators, and for social interactions. In addition, the sensory systems used by fish to detect sounds are very similar to those of marine (and terrestrial) mammals, and, as a consequence, sounds that damage or affect marine mammals could in other ways have similar consequences for fish (Popper, 2003). Some fish species, such as herring, have swim bladders which may be susceptible to damage by underwater high noise levels, making these species comparatively more sensitive.

The effect of piling operations on fish is strongly related to their life cycle stage. Adult and juvenile fish are rarely affected by piling operations because they are able to detect and physically avoid the area but fish eggs and larvae may be more vulnerable. Fish can detect impulsive sound sources over large distances (up to 30 km), yet they seldom react to the sound before it is above a certain threshold. Alarm responses in adult or juvenile fish can be expected at distances of 1 km to 5 km from the piling operations, depending upon their auditory thresholds and the level of sound transmission loss (Nakken, 1992). Given the limited spatial extent of the anticipated impact and the limited (1 day) period over which the piling will take place, and the ability of fish to temporarily avoid areas of adverse noise, the proposed piling operations is not anticipated to cause any significant impacts on fish.

11.3 Assessment of the Requirement for a Wildlife Disturbance Licence

Under the Offshore Marine Conservation (Natural Habitats, and c.) Regulations 2007 (or Offshore Marine Regulations, OMR), as amended by the Offshore Marine Conservation (Natural Habitats, and c.) (Amendment) Regulations 2009, it is an offence to deliberately disturb European Protected Species (EPS; species listed in Annex IV of the Habitats Directive), in such a way that is likely to:

- Impair their ability to survive, to breed or reproduce, or to rear or nurture their young; or in the case of a hibernating or migratory species, to hibernate or migrate;
- Affect significantly the local distribution or abundance of the species to which they belong.

SPE has therefore assessed if the proposed piling operations would potentially cause a ‘disturbance offence’ to any EPS, and subsequently would require a disturbance licence under these regulations. The potential disturbance caused by piling operations mainly refers to (underwater) noise.

The EPS include all cetaceans, turtles and sturgeon. In UK waters, the latter two are at the limits of their global distributions (which are centred elsewhere in the western Atlantic or Europe) and only occur in low numbers around the UK. It is therefore extremely unlikely that a significant group of these animals would be present, or that their local abundance or distribution would be significantly affected by marine impacts (JNCC, 2010a). Therefore, only cetaceans will be considered from hereon.

As described in Section 11.2.1, none of the proposed piling operations are expected to cause any injury to cetaceans, and only a certain level of avoidance responses are expected within 15 kilometres of the piling operations during installation of the CTIS. Therefore, this assessment will be based on whether any of these behavioural responses could potentially result in a disturbance offence in relation to marine EPS, as defined under regulations 41(1)(b) and 39(1)(b) of the Habitats Regulations and Offshore Marine Regulations, respectively.

Table 11.7 identifies the cetacean species that have been recorded in the Faroe-Shetland Channel, and therefore may be present in the wider area during the piling operations. It also specifies the number of individuals per species that can be expected to show any behavioural response (i.e. within a radius of 15 km from the piling operations) to represent the worst-case estimate for the area in which potential ‘disturbance’ effects could be expected to occur. Abundance data has been used from the Cetaceans Offshore Distribution and Abundance in the European Atlantic (CODA) (NPWS, 2009) and Small Cetacean Abundance in the North Sea (SCANS) III surveys (Hammond et al ,2017). Where species were reported during both surveys, the higher abundance estimates has been used. Further information on the cetacean species is presented in Section 4.3.4.

Table 11.7: Numbers of Cetaceans Present within 15 km from the proposed Piling Operations

Cetacean Species	Abundance Data (Animals/km^2)	Data Source	Estimated Number of Animals Within 15 km Radius of Piling Operations	% of Population Affected
Minke whale	0.016	CODA, 2009 (Block 1)	11.3	0.08%
Blue whale	No data	--	--	--
Humpback whale	No data	--	--	--
Sei whale	No data	--	--	--
Fin whale	0.001	CODA, 2009	0.7	0.00%
Atlantic white-sided dolphin	0.015	SCANS III (Block 8)	10.6	0.07%
White-beaked dolphin	0.217	SCANS III (Block K*)	153.4	0.42%
Risso's dolphin	0.014	SCANS III (Block K*)	9.9	0.07%
Killer whale	No data	--	--	--
Long finned pilot whale	0.054	CODA, 2009	38.2	0.15%
Sperm whale	0.060	SCANS III (Block 8)	42.4	0.31%
Beaked whales (which include Northern bottlenose whales)	0.011	CODA, 2009	7.8	0.07%
Short-beaked common dolphin	0.010	CODA, 2009	7.1	0.00%
Harbour porpoise	0.308	SCANS III (Block K*)	217.7	0.05%

* *The Cambo Field Development area is not covered by the SCANS III survey area. Therefore, abundance data from Block K and Block 8 have been used as the nearest Blocks surveyed near the Cambo Field Development.*

Table 11.7 shows that only a few individual cetaceans would potentially be affected by the proposed piling operations at the CTIS. Of these, harbour porpoise and white-beaked dolphins appear to be relatively more abundant than the other species. As the abundance data in

Table 11.7 is based on the mean values, it does not take account of the fact some of these animals live in larger pods, which means that in reality their distribution will be much more clustered. It should also be noted that both species are classed as the more abundant cetacean species living in the water surrounding the UK, as can be seen by the very low percentage of the wider 'population' (based on the estimated total numbers of individuals present in the SCANS III survey area) being affected. Moreover, it is expected that any effects would be of short duration and limited to small behavioural changes of a few individual animals. Any affected individuals would also be expected to move back into the area once the piling operations have finished.

Risso's dolphins and coastal bottlenose dolphins have been identified by the JNCC as the two EPS most likely to require a wildlife disturbance licence for any activity in UK offshore waters that might affect their distribution or abundance (JNCC, 2010a). There are no known resident bottlenose dolphins in the vicinity of the proposed piling operations. The proposed operations are not believed to pose any risk to bottlenose dolphins.

Table 11.7 shows that up to 1.7 Risso's dolphins may show some behaviour response to the piling operations. This would only affect a very small fraction (0.013%) of the wider population. Risso's dolphins are mainly distributed off western and northern coasts of Britain and Ireland and along the continental shelf, with a few records from waters immediately over the shelf break. They are known to use only a portion of UK waters and this is highly variable both seasonally and inter annually.

Greatest numbers have been observed from western Scotland with the waters around the Hebrides forming an obvious concentration (JNCC, 2010b). Risso's dolphins are not as common as other dolphin species around Scotland. Although they have been recorded in the Faroe-Shetland Channel, only the waters east of Lewis have been identified as an area where they might be considered as resident (Pollock et al., 2000), well over 200 km from the proposed piling operations.

As described in Section 11.2, any behavioural reactions of any of the cetacean species to underwater sound produced by the piling operations (or any other activities associated with the proposed Development) are expected to be limited to within a few km. The strongest anticipated response would be the temporary avoidance of certain individuals within a 15 km radius. It is believed that the relatively small area, in which this temporary avoidance behaviour may occur, can be easily avoided by any individual, without causing a serious degree of nuisance to the animals involved or the larger population as a whole.

It seems therefore extremely unlikely that the proposed piling (or any other operations) associated with the proposed Development would adversely affect animals in such a way as to cause 'deliberate disturbance' of a European Protected Species, as such, SPE believes it is unnecessary to apply for a wildlife disturbance licence.

11.4 Cumulative and Transboundary Impacts

Noise is transmitted through water very efficiently and may be detectable over many kilometres from its source. This has led to concern that increasing anthropogenic activity in the sea, and consequent increasing noise levels, may have effects on marine mammals through interruption of their communication and hearing mechanisms. The potential outcomes of having multiple noise sources in the sea include more frequent masking, behavioural disruptions and short term displacement, although this could potentially be mitigated by a certain level of habituation. Prolonged or repeated disturbance is generally considered to be of more concern than isolated short term disturbance.

Although there is minimal potential for overlap with noise from existing oil and gas activity, the presence of the MODU and subsequent FPSO will add to the ambient noise in the Faroe Shetland Channel, and the adjacent West of Shetland Continental Shelf, which include various sources of industrial noise such as other oil and gas installations and that from shipping and the fishing activity.

The long term, synergistic and cumulative impact of sound sources is not known, and the introduction of additional low frequency noise into the marine environment from the proposed Development should be considered to have the potential to contribute to the overall cumulative effect of anthropogenic generated underwater noise. However, the risks in this instance are considered to be low, for the following reasons:

- Piling noise will be transitory, lasting only for 1 day;
- Noise levels generated by the MODU and FPSO are well below any harmful sound levels;
- The relatively low number of other anthropogenic sound sources in the wider Faroe Shetland area means that the potential to interfere with any migration routes in the area will be very low, as there will be ample space available to avoid the noise signature around the proposed Development.

Therefore, the increase in local, mainly low frequency, underwater noise produced by the FPSO and MODU and the temporary noise generated by the piling operations are considered to be insignificant. SPE is not aware of any other activities taking place concurrently in the immediate vicinity of the proposed Development.

With regard to potential transboundary effects, the proposed piling operations will be undertaken over 60 km south-east of the UK/Faroe Islands transboundary line. Although underwater sound produced during the planned piling survey may have the potential to travel into Faroese waters, at these distances the sound levels will have attenuated to such a low level, that no observable effects would be expected to occur. Although the MODU and FPSO will be located closer to the transboundary line, their underwater sound levels will also be much lower, again, to below a level where any observable effects would be expected to occur.

Therefore, no significant cumulative and/or transboundary impacts from noise generated by the MODU, FPSO or during the proposed piling operations associated with the proposed Development.

11.5 Mitigation Measures

The amount of underwater sound generated during drilling operations will be kept to a minimum where possible. The main priority will be to minimise the time over which sound energy is emitted into the marine environment during the proposed piling operations (1 day). Therefore, any noise associated with the operations will be transitory.

The planned piling operations will be conducted in accordance with the JNCC Protocol for minimising risk of injury to marine mammals from piling noise (JNCC 2010b), at all times. This will include the use of a trained Marine Mammal Observer (MMO) to undertake cetacean monitoring duties before any piling operations commence and the use of “soft start” procedures.

Throughout the proposed Development, logistics will be optimised to minimise unnecessary or low payload helicopter flights and vessel sailings.

11.6 Conclusions

Anthropogenic noise from shipping, and potentially also from existing oil and gas installations, is currently believed to be the main source of anthropogenic background noise in the area of the proposed Cambo Field Development. The addition of (mainly) low frequency noise generated by the MODU and subsequently by the FPSO and their support vessels will add to the overall anthropogenic footprint in the area. No good practice guidelines exist in the UK for drilling or production activities since these are thought to be of low concern in terms of disturbance to cetaceans (JNCC, 2010a). Consequently, these are not expected to cause any significant impacts on marine mammals potentially present in this area.

In addition, the planned piling operations of the CTIS to the seabed at the WOSPS PLEM may cause avoidance responses and other, more subtle, behavioural reactions in cetaceans within a few kilometres of the piling operations. Given the short duration of such operations (1 day), any such effects are expected to be transient and are therefore also not considered likely to be significant.

SICCAR POINT ENERGY

Section 12

Waste Management

12 WASTE MANAGEMENT

12.1 Introduction

This Section provides a high-level description of waste management with regard to the proposed Cambo Field Development, as requested by OPRED during the informal statutory consultation, which was undertaken as part of the scoping for this EIA.

The management of waste is well regulated in the UK. The principal legislation governing waste from offshore vessels and facilities (including from FPSOs) is the Merchant Shipping (Prevention of Pollution by Sewage and Garbage from Ships) Regulations 2008. These Regulations implement both the revised Annex IV of MARPOL 73/78 - Regulations for the Prevention of Pollution by Sewage from Ships, and the Annex V of MARPOL 73/78 (including amendments) - Regulations for the Prevention of Pollution by Garbage from Ships. Under these Regulations it is prohibited to dispose of any garbage (including plastics) and galley waste (except for ground food waste to <25 mm and treated sewage) from any offshore installations or vessels.

Consequently, the sewage treatment system onboard the FPSO will be designed to meet the following standards in line with regulation 21(3) of the 2008 Regulations:

- Faecal Coliform Standard: Faecal coliform bacteria in the effluent should not exceed 1000/100 cm^3 Most Probable Number (MPN);
- Chlorine residual level to be no more than 0.5 mg/l, (by test) post maceration;
- Comminuting Standard: A sample of 1 litre is passed through a US Sieve No. 12 (with openings of l.68 mm). The weight of the material retained on the screen after it has been dried to a constant weight in an oven at 103 °C must not exceed 10% of the total suspended solids (TSS) and shall not be more than 50 mg;
- The holding tanks used for the temporary storage of sewage will be constructed to prevent leakage of its contents under the normal operation of the FPSO and in all likely weather conditions, until such times as it can be discharged in accordance to the Regulations.

All other waste generated offshore by the proposed Development will be returned to shore for appropriate treatment and disposal. All waste will be segregated in a manner that will encourage the reuse and recycling and to reduce, for as far as is possible, disposal of this waste to landfill.

The eventual disposal of any waste is intrinsically related to its nature. Waste handling onboard the MODU, FPSO and associated support vessels will be the responsibility of the vessel contractors. However, SPE will ensure that the collection, handling and disposal of all waste generated by the proposed Development is achieved in compliance with current environmental legislation and meets the objectives stated within its own Environmental Care Policy.

12.2 The Waste Hierarchy

SPE will ensure that all waste generated by the Cambo Field Development will be managed in line with the waste hierarchy. The waste hierarchy ranks waste management options according to the best environmental outcome, taking into consideration the lifecycle of the material. The lifecycle of a material is an environmental assessment of all the stages of a product's life from-cradle-to-grave (i.e. from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling).

In its simplest form, the waste hierarchy gives top priority to preventing waste. When waste is created, it gives priority to preparing it for reuse, then recycling, then other recovery, and last of all disposal (i.e. landfill).

For example, one tonne of food waste in landfill produces 450 kg CO_2eq (equivalents), whereas preventing one tonne of food waste saves 3,590 kg CO_2eq. The benefits of selecting options higher up the hierarchy extend beyond carbon savings and include reduced water consumption, protection of important raw materials, creation of jobs and other economic opportunities (Scottish Government, 2017b).

12.3 Monitoring and Recording of Offshore Waste

All waste for disposal onshore will be accurately described and appropriately segregated for onshore disposal at appropriate licensed sites through properly licensed waste disposal contractors. Every offshore installation and vessel must have a Garbage Management Plan (per guidance in Merchant Shipping Notice No.1807) and Garbage Record Book.

In addition, the amount and disposal route of any waste will be recorded in the UK Environmental Emissions Monitoring System (EEMS). EEMS records operator and installation specific data for all atmospheric emissions, liquid discharges and solid wastes. It also provides a starting point for monitoring the final disposal site of offshore wastes.

Bulk wastes generated offshore will be segregated by type, and periodically transported to shore for disposal or recycling in an auditable manner through authorised waste contractors. Waste is typically segregated and recorded according to the following categories:

- **Group I: Special waste**, such as oils, paints, adhesives, solvents, surplus chemicals, etc, and these are mainly recycled;
- **Group II: General waste**, including non-hazardous work-over/completion/drilling fluids, brines, galley waste, accommodation waste, compactor waste, and much of this has to go to landfill. Segregated materials such as scrap metal, plastics, aluminium cans, paper/cardboard, glass, cooking oil and clean wood are recycled;
- **Group III: Other waste**, including asbestos, clinical and explosive materials;
- **Group IV: Backloaded cuttings**, including oil based mud (OBM) or synthetic based mud (SBM) drill cuttings backloaded for treatment, as well as Water Based Mud (WBM) drill cuttings backloaded for disposal onshore. This also includes any solid material (e.g. powder or stabilised products) generated by the treatment process, Oil recovered from the backloaded cuttings through the treatment process and any water separated from the oil and solids through the cuttings treatment process.
- **Group V: Naturally occurring radioactive material (NORM)** from mineral scales which build up in processing equipment and pipework (generally from production installations only).

12.4 Waste Disposal Management Onboard the FPSO

All waste will be transferred to shore via supply vessel, as and when required. Suitable and adequate facilities and procedures will be provided onboard the FPSO and its support vessels to enable efficient segregation, storage and handling of waste streams.

The FPSO will be designed with adequate space for waste storage and segregation facilities, including laydown areas for skips and deck space for other waste storage receptacles. Waste will be segregated into hazardous and non-hazardous waste types. Solid domestic waste will normally be compacted with a garbage compactor, placed in disposal bags and returned to the mainland in waste skips. Separate storage areas will be provided for solid and liquid waste that can be reused. Waste storage areas will be well ventilated and bunded with drainage to appropriate storage or treatment areas. Hazardous waste containers will be covered to reduce rainwater contact in the containment structure. Furthermore, segregation of recyclable materials will be implemented to avoid contamination and consequent reduction of the quality of recycled products.

12.5 Conclusions

Several different waste streams will be generated throughout the development's lifespan. Waste management will be undertaken in compliance with current environmental legislation and in line with the waste hierarchy, as described above. The management of offshore waste generated on the UKCS is strictly regulated and the UK has well-established infrastructure in place to manage this waste effectively. Therefore, no significant impacts are anticipated.

Section 13 - Accidental Events

13 ACCIDENTAL EVENTS

As well as assessing operational processes, the Environmental Impact Assessment (EIA) process also examines potential accidental events that may result in impacts upon the environment and for which mitigation measures may be implemented. The following issues and concerns were raised during the Environmental Issues Identification (ENVID) workshop and informal consultation and are considered in this section on the potential impacts from accidental events that could occur during operations at the proposed Cambo Field Development.

- Impacts on marine environment, the coastal environment and other users of the sea by a large spill of hydrocarbons to sea;
- Impacts on seabed communities as a result of the loss of the Floating Production, Storage and Offloading Vessel (FPSO), installation vessels, support vessels, the Mobile Operated Drilling Unit (MODU) or a helicopter.

The remainder of this Section describes the potential impacts of hydrocarbon spills (Sections 13.1 to 13.6) and from the loss of the FPSO, installations vessels, support vessels, the MODU or a helicopter (Section 13.7).

13.1 Sources of Hydrocarbon Spill

The risk of an accidental hydrocarbon spillage to sea is often one of the main environmental concerns associated with oil-industry activities. Spilled oil at sea can have a number of environmental and economic impacts, the most conspicuous of which are on seabirds and coastal areas. The actual impacts depend on many factors, including the volume and type of hydrocarbon spilled, the sea and weather conditions at the time of the spill, and the oil spill response.

The following events associated with the proposed Development have been identified as having the potential to cause an oil spill:

- Uncontrolled well blow-out;
- Loss of the FPSO inventory;
- A fuel oil spillage from an installation vessel, support and supply vessel or the MODU;
- An oil spillage when carrying out offloading operations to shuttle tanker;
- Loss of inventory of an infield flowline or riser.

The Cambo Field will produce crude oil with a density 902 kg/m^3 to 916 kg/m^3. A crude oil spill from either a well blow-out or a catastrophic failure of the FPSO storage tanks have been identified as the two worst-case oil spill scenarios, that could potentially result in a Major Environmental Incident (MEI).

13.1.1 Potential Crude Oil Spillages

Uncontrolled Well Blow-out

During drilling operations, a well blow-out would represent the largest potential source of a large hydrocarbon spill. For a blow-out to occur, the primary well control element, the hydrostatic pressure exerted by the drilling mud, would have to be overcome by the inflowing hydrocarbons. The secondary well control measure, the blow-out preventer (BOP), would also have to fail in closing off the well. The actual flow rate and duration of any such event, and hence the severity of the incident, are dependent upon the pressure and geology of the well, which vary with each well.

The flow rate encountered during an uncontrolled blow-out event may be very different from that expected during production, as there may be no equipment or other measures in place to restrict the flow. To model the potential worst-case blow-out scenario, it was assumed that there would be no physical restriction to the flow inside the well, such as drill string or tubing obstructing the wellbore, chemical build-up coating in the wellbore, a disconnected riser, or damaged wellhead and well control equipment on top of the well.

13.1.2 Potential Diesel (Fuel Oil) Spillages

Diesel will be the main fuel used for power generation during the proposed drilling operations and will be the largest volume of hydrocarbons stored on the MODU during the drilling operations. Similarly, the FPSO will have diesel storage capacity to run its diesel consumers. The diesel will be split between multiple fuel oil bunker tanks. The worst-case diesel spill scenario is considered to be the complete loss of the diesel inventory from all of the fuel tanks.

Smaller diesel spills can result from equipment failures, such as the rupture of pipes or open valves. As explained in Section 13.2.1, small spills most frequently occur during bunkering operations and are generally caused by hose failures. Diesel will be supplied from a supply vessel to the FPSO/MODU on regular intervals, via a flexible hose. As the hose is suspended between the two vessels, there is the potential for a direct diesel release to sea, if the hose or any of its connections are damaged during the bunkering operations.

13.1.3 Other Potential Sources of Oil

Lubricating and hydraulic oils are stored separately in tanks or sealed drums. Storage tanks for lubricating oil range in size, but each will normally contain a maximum of 15 m^3, while hydraulic oils are stored in much smaller 1 m^3 tanks. Additional oils may be transported and stored in sealed 0.025 m^3 or 0.21 m^3 drums or 1 m^3 tote tanks, all of which will be stored in dedicated, bunded storage areas, with oil spill kits located nearby. Up to approximately 12 m^3 of aviation fuel, contained in 2.7 m^3 or 4.0 m^3 helifuel tanks, will be held in a bunded area.

Waste oil will be generated on the FPSO and the MODU from a variety of sources, including waste engine, gear and hydraulic oil. These waste oils will be held in designated storage tanks and their volumes kept to minimum before being transferred to shore on regular intervals. Therefore, the possibility of a spillage from any of these sources is very small.

The amounts of lubricating, hydraulic and waste oil stored onboard the FPSO and the MODU will be very small in comparison to the main fuel supply. The probability of any spillages from any of these sources is considered to be minimal, as the containers are relatively small, sealed and stored in bunded areas. Therefore, the risk to the environment from these oils is regarded as negligible and is not considered further within this section.

13.2 Likelihood of a Hydrocarbon Spill from the MODU

Historical data, covering the period between January 1990 and April 2019, indicate that the possibility of a large hydrocarbon spill from a MODU operating on the UKCS is very low. As shown in Figure 13.1, most spillages from MODUs are caused by other/unknown (316) and hydraulic/lube (313). However, these are typically quite small spillages. Looking at the overall volume of hydrocarbons spilled over this period, it can be seen that OBM spillages make up nearly 46% of the overall volume spilled. OBMs will not be used during the proposed Cambo wells, removing the risk of this type of spill.

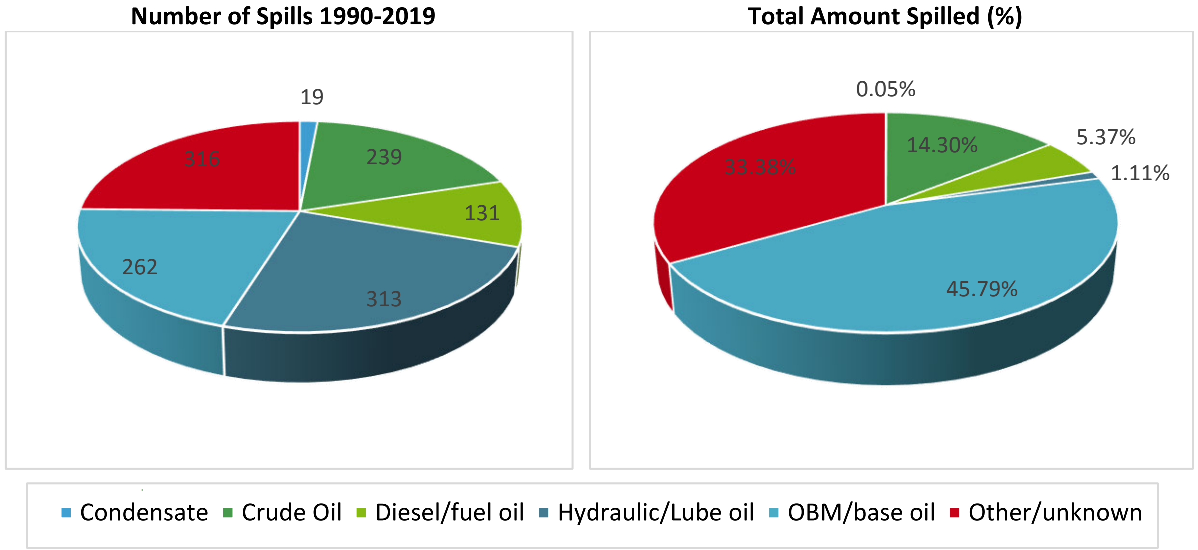


Figure 13.1: Oil Spills on the UKCS from MODUs Between 1990 and 2019

Source: Fugro, 2019.

Using data presented in HSE (2007), it can be calculated that on average, the probability of an oil spill from a MODU is 0.0015 spills per rig day, or one spill every 647 rig days.

Next to frequency, the size of a potential hydrocarbon spill is also very important in spill response planning. Figure 13.2 illustrates the proportion of oil spills from MODUs which fall into each of three size categories. The dataset shows that the majority of spills (82.9%) are smaller than 1 tonne (Fugro, 2019). It is expected that the response to a spill of this size could be undertaken and fully managed by the MODU itself, requiring only monitoring while the slick evaporates and disperses naturally.

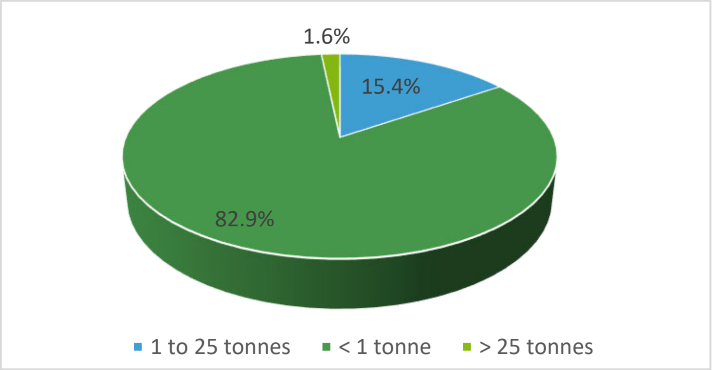


Figure 13.2: Percentage of Hydrocarbon Spills from MODUs, by Size, Between 1990 and 2019

Source: Fugro, 2019.

Based on the probability of an oil spill of any size from a MODU being one spill every 647 days (0.0015 spills per rig day) and 82.9% of spills being smaller than 1 tonne it is calculated that the probability of an oil spill of less than 1 tonne from a MODU is one spill every 804 rig days.

The probability of an oil spill of between 1 tonne and 25 tonnes from a MODU is one spill every 4,202 rig days (i.e. 0.00024 spills per rig day). The probability of an oil spill larger than 25 tonnes from a MODU is one spill every 40,486 rig days (i.e. 0.000025 spills per rig day).

The proposed Cambo wells are each estimated to take between 37 and 61.6 days to drill and complete. Therefore, by extrapolating the spill probabilities calculated above, the chance of a small spill (i.e. less than 1 tonnes) during drilling operations at any of the proposed Cambo wells ranges from 4.6 % to 7.7 % per well. Similarly, the probability of a spill over 1 tonne in size is one spill per 3,807 days (i.e. 0.00026 spills per rig day). This translates to a probability of 0.97 % to 1.62 % for any of the proposed Cambo wells.

Uncontrolled Well Blow-out

The probability of an uncontrolled well blow-out event occurring is very low. Well blow-outs resulting in the uncontrolled release of hydrocarbons have happened too infrequently on the United Kingdom Continental Shelf (UKCS) for a meaningful analysis of the historic frequency to be carried out. However, the following paragraphs give a brief overview on historic well control events on the UKCS.

Prior to 1990, only two significant uncontrolled blow-outs occurred in the North Sea. These events occurred during drilling operations on the West Vanguard semi-submersible on the Norwegian continental shelf and on the Ocean Odyssey semi-submersible on the UKCS, during 1985 and 1988 respectively (DTI, 2007). Both blow-outs involved gas and did not result in hydrocarbon spills to sea. Moreover, lessons learnt from these events resulted in major legislative and operational changes for offshore drilling on the UKCS to prevent such events from happening again.

Between 1990 and 2007, a total of 343 well incidents were recorded from MODUs (both drilling and production). These incidents included several issues of varying severity, but only 17 resulted in loss of well control. This translates to 0.00004 incidents per rig day, or one incident every 26,827.5 rig days. Furthermore, none of the 17 recorded incidents resulted in an uncontrolled well blow-out with a crude oil spill of any size (OGUK, 2009).

The most recent well control incident in the North Sea involved a gas and condensate blow-out from Well 22/30c-G4, located close to the Elgin Platform, in March 2012. This incident resulted in the temporary cessation of production from the Elgin/Franklin area. SPE will review the lessons learnt from this incident, with consideration to the proposed drilling operations at Cambo.

13.2.1 Diesel Spills

Diesel spills from mobile drilling units account for 5.37% of oil spilled on the UKCS from MODUs (Figure 12.1). Diesel will be the main fuel used for power generation during the proposed drilling operations and, therefore, will be the largest volume of hydrocarbons stored on the MODU. Historical oil spill data indicate that the probability of a diesel spill is 0.0002 spills per day, or one spill in every 4,719 days. When extrapolating this probability to the Cambo wells, this equates to a probability of between 0.78% and 1.3% of a diesel spill occurring (Fugro, 2019; HSE, 2007).

Spill records indicate that most diesel spills tend to occur during bunkering operations and that they are mostly caused by hose failures. Therefore, the volumes of diesel spilled tend to be relatively small. For example, of the 132 recorded diesel spills, 119 (90.2%) were less than 1 tonne (Fugro, 2019). If a diesel spill of this size were to occur, it is likely that only onsite response personnel and equipment would be required to control the incident, due to the tendency of diesel to evaporate and disperse relatively quickly from the sea surface (see Section 13.4). Only three of the recorded diesel spills were greater than 5 tonnes, and each of these also occurred during bunkering operations.

The worst-case scenario, complete loss of the diesel inventory, will only occur as a result of a major accident, such as a catastrophic collision with another vessel. The probability of such an event occurring is very low, particularly with the low vessel traffic in this area (see Section 4.6.4).

13.3 Likelihood of a Hydrocarbon Spill from the FPSO

Historical data, covering the period between January 1990 and April 2019, indicate that the possibility of a large hydrocarbon spill from an FPSO operating on the UKCS is very low. In contrast to spillages from MODUs, the largest number of spills from FPSO are from crude oil (Figure 13.3). Looking at the overall volume of hydrocarbons spilled over this period, it can be seen that crude oil spillages make up just over 47% of the overall volume spilled. However, individual spills are typically quite small spillages, with 616 (89.4 %) out of 689 recorded spills being less than 1 tonne (Figure 13.4).

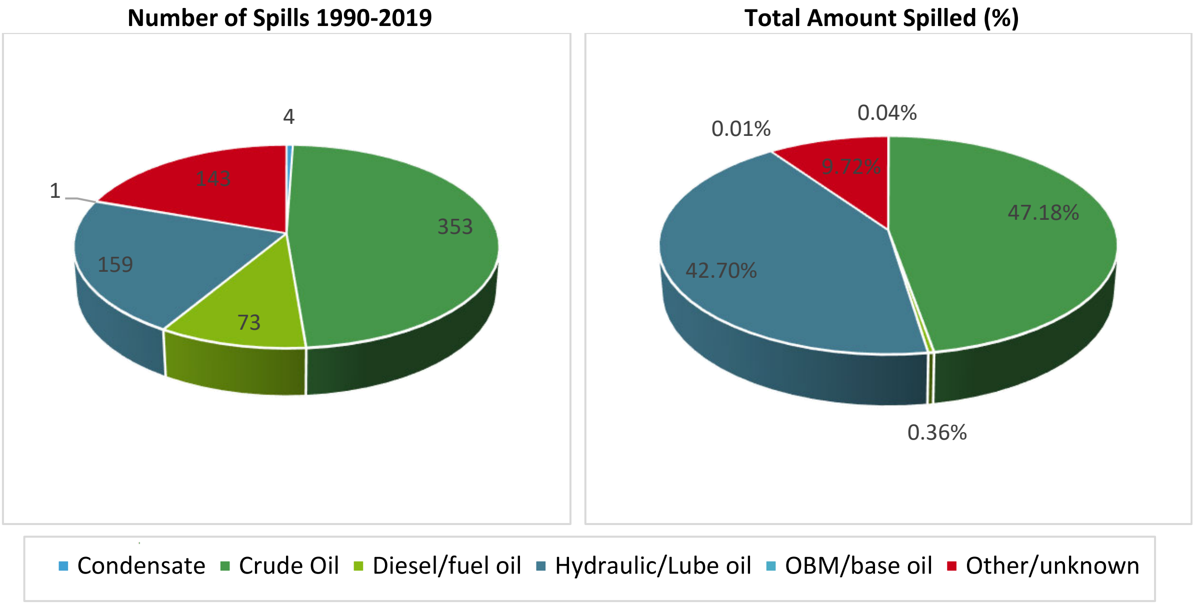


Figure 13.3: Oil Spills on the UKCS from FPSOs Between 1990 and 2019

Source: Fugro, 2019.

Using data presented in HSE (2007) and Fugro (2019), it can be calculated that on average, the probability of an oil spill from a FPSO is 0.017 spills per day, or one spill every 60.5 days. It should be noted that the vast majority (89.4%) of FPSO spills are small. It is expected that the response to a spill of this size could be undertaken and fully managed by the FPSO, itself, requiring only monitoring while the slick evaporates and disperses naturally.

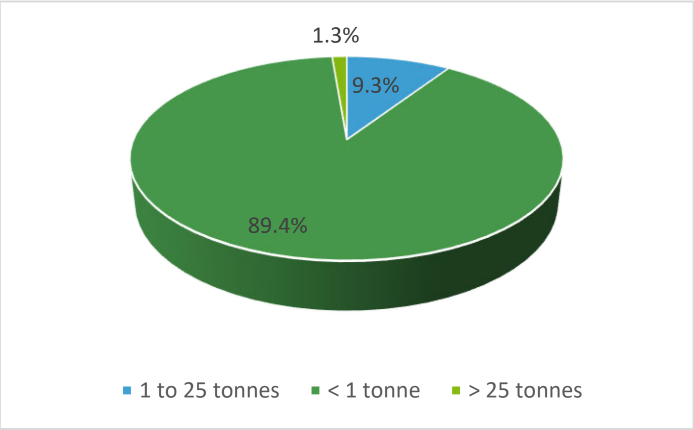


Figure 13.4: Percentage of Hydrocarbon Spills from FPSOs, by Size, Between 1990 and 2019

Source: Fugro, 2019.

13.4 The Fate and Behaviour of a Hydrocarbon Spill at Sea

Oil characteristics, spill location and the wave, wind and current conditions all govern the fate of spilled hydrocarbons. The behaviour of hydrocarbons when released from the sea surface and from the seabed are described in the following section. During the proposed drilling operations, it is expected that the most likely release point for a release of reservoir hydrocarbons (crude oil and gas) would be at the seabed. Meanwhile, the most likely release point for a spill of crude from the FPSO storage tanks would be from the sea surface.

The fate of hydrocarbons spilled at sea is relatively well understood. As soon as oil is released, the weathering process begins and the oil begins to move across the sea surface. Oil characteristics, spill location and wave and wind conditions govern the fate of the spilled oil. These processes are described below.

13.4.1 Oil Spill Movement

Spreading

Due to the influence of gravity, oil starts to spread out over the sea surface as soon as it is spilled. Oil slicks can spread very quickly to cover extensive areas of the sea surface, the speed of which depends mainly on the viscosity of the oil. Lighter oils spread out more quickly than heavier crudes. Although a spill will spread quickly in the first few days, the processes of evaporation and dispersion quickly remove the lighter, more volatile and water soluble, fractions of a slick from the sea surface. Then, as only the heavier, more viscous fractions are left, slick spreading will slow down.

Initially an oil spill will spread out as a single slick, covering an increasingly larger area while the slick becomes correspondingly thinner. However, as the slick spreads further, it will start to break up into smaller breakaway slicks due to the wind and water movement. Wind and wave conditions West of Shetland can be regarded as very dynamic, due to a combination of the relatively high wind speeds and increased water movement, created by a combination of the wind speed and the large fetch across the Atlantic Ocean. As such, it is expected that a large oil slick in this area would tend to break up very quickly into smaller patches.

Direction of Movement

Wind and surface current speed and direction are the main parameters influencing the movement of an oil slick. Any oil slick will travel roughly at the same speed and direction as the surface water current, while the prevailing wind drives a slick downwind at 3% to 4% of the wind speed.

The ocean current regime in the Faroe-Shetland Channel is complex (Section 4.2.1), due to the bathymetry of the area and the interaction of a number of different water masses. On a broad scale, cold, dense bottom water from the Arctic Basin flows southwest along the channel floor, whilst warmer Atlantic water flows over the top of it to the northeast. This suggests that any slick occurring in the surface waters of the Faroe-Shetland Channel would move with the dominant current to the northeast.

Although offshore winds West of Shetland may blow from any direction, they most frequently originate from the southwest (Section 4.2.2). This also suggests that a slick occurring on the sea surface would generally be directed to the northeast by the wind.

13.4.2 The Weathering Process

When oil is released into the marine environment it undergoes a number of physico-chemical changes, some of which assist in the degradation of the spill, while others may cause it to persist. These changes are dependent upon the type and volume of oil spilled, and the prevailing weather and sea conditions. An overview of the main processes influencing the fate and behaviour of spilled oil at sea is given in Figure 13.5. Evaporation and dispersion are the two main mechanisms that act to remove oil from the sea surface.

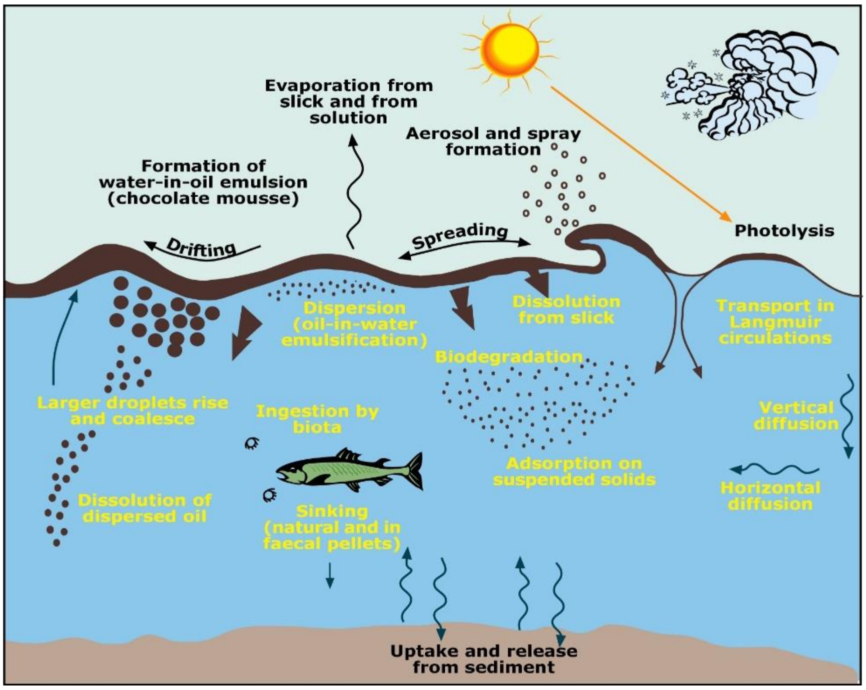


Figure 13.5: Fate and Behaviour of Spilled Oil at Sea

Evaporation

Following a hydrocarbon spill, evaporation is the initial predominant mechanism of reducing the mass of oil, as the light fractions (including aromatic compounds such benzene and toluene) evaporate quickly. Evaporation can cause considerable changes in the density, viscosity and volume of the spill. If the spilled oil contains a high percentage of light hydrocarbon fractions, a large part of it will evaporate relatively quickly in comparison to heavier oil.

Diesel displays very high evaporative losses upon exposure to air. Under ideal environmental conditions, i.e. a warm, sunny day with only moderate wind, a large proportion of the spill volume may be lost by evaporation in the first few hours after release. The evaporation process will be enhanced by warm temperatures and moderate winds.

Dispersion

After the light fractions have evaporated from the slick, natural dispersion becomes the dominant mechanism in reducing slick volume. The speed at which oil disperses is largely dependent upon the nature of the oil and the sea state. Lighter and less viscous oils tend to have more water soluble components, allowing them to mix and remain suspended within the water column.

The process of dispersion is dependent upon waves and turbulence at the sea surface, which can cause a slick to break up into fragments and droplets of varying sizes. This turbulence mixes these droplets into the upper levels of the water column, where some of the smaller droplets will remain suspended, while the larger ones will tend to rise back to the surface. Therefore, rough seas will break up a slick and disperse the oil at a faster rate than calm seas. There have been incidences of large oil spills being broken up and dispersed into the water column during large storm events, with little visible effect on the surrounding environment. As oil droplets are dispersed into the water column, the oil has a greater surface area which encourages the natural processes of dissolution, biodegradation and sedimentation.

Water movement at the sea surface is affected by wind speed. The West of Shetland area is a very active environment, with relatively high average wind speeds. Although wind speeds are generally reduced during the summer months, the sea state still reaches a Beaufort Force 5, a fresh breeze generating moderate waves, or greater for around 39% of the time. Water movement and wave size is also related to fetch, the distance over which the wind can blow without being interrupted. As the prevailing south-westerly winds blow uninterrupted across the Northeast Atlantic to the proposed Cambo Field Development, the waves this wind generates have the potential to become very large in size.

Emulsification

The immiscible components of an oil spill may either emulsify and disperse as small droplets in the water column (an oil-water emulsion) or aggregate into tight water-in-oil emulsions, often referred to as 'chocolate mousse'. The rate at which this happens, and the type of emulsion formed, is dependent upon the oil type, sea state and the thickness of the oil slick. Large, thick oil slicks tend to form water-in-oil emulsions, while smaller thinner slicks tend to form oil-in-water emulsions that usually disappear by natural dispersion. In practice, usually only one of the two processes will dominate.

When a water-in-oil emulsion (chocolate mousse) is formed, the overall volume of the slick increases significantly, as it may contain up to 70 or 80% water. This chocolate mousse will form a thick layer on the sea surface reducing slick spreading and inhibiting natural dispersion. The formation of this thick layer causes the surface area available to weathering and degradation processes to diminish, which can make 'chocolate mousses' difficult to break up using dispersants. In their emulsified form, and with their drastically increased volume, they can also cause difficulties for mechanical recovery devices. A water-in-oil emulsion is therefore very unlikely to occur in diesel spills, for example.

13.4.3 Oil Spill Modelling

The amount of time a hydrocarbon spill remains on the sea surface before becoming insignificant, and the extent to which it spreads from the point of release, may dictate the severity of any impacts on the marine life, particularly seabirds. Whether it reaches the shore is also a major consideration, due to the sensitivity of the nearest coastlines at Shetland and Orkney, and the additional clean up resources required. Both deterministic and stochastic oil spill modelling has been conducted to provide information on whether a spill might beach, and if so, how much time this would take. In view of this, the end points for the oil spill risk assessment are considered to be:

- Probability of oil reaching a shoreline, or crossing a median line to reach international waters;
- Minimum time taken for oil to reach a shoreline or crossing a median line to reach international waters.

Stochastic oil spill modelling has been conducted to assess these two criteria. Stochastic oil spill modelling is based on actual statistical wind speed and direction frequency data and provides a probability range of sea surface oil and beaching, representative of the prevailing conditions.

All modelling has been undertaken using SINTEF's Oil Spill Contingency and Response (OSCAR) model (Version 9.0.1). As discussed in Section 13.1, the two scenarios which may result in a large release of hydrocarbons to sea are an uncontrolled well blow-out, or a catastrophic failure of the FPSO storage tanks. Both scenarios would result in the release of a large crude oil spill. Modelling has therefore been undertaken for both of these scenarios.

Oil spill modelling for both scenarios has been carried out for all four seasons i.e. winter, spring, summer and autumn. This provides a range of risk profiles throughout the year in the event of a delay to operations.

Uncontrolled Well Blow-out

The parameters used in the modelling on an uncontrolled well blow-out are detailed in Table 13.1. The results of the well blow-out modelling scenario are provided in Table 13.2.

Minimum arrival time of surface oiling is shown in Figure 13.6 and the probability of surface oiling in Figure 13.7. It should be noted that surface oiling is shown with a thickness threshold of 0.3 micro-metre (µm) (equal to 0.0003 mm), in accordance with OPRED's oil spill modelling requirements. Potential impacts relating to the modelling results are described in Section 13.5.

Table 13.1: Well Blow-out Modelling Parameters

<table>
<tr><td colspan="9">Well Blow-out Parameters</td></tr>
<tr><td colspan="2">Loss from Well/FPSO/Rig/Other</td><td colspan="3">Well</td><td colspan="2">Instantaneous Loss?</td><td colspan="2">No</td></tr>
<tr><td colspan="2">Worst Case [m^3]</td><td colspan="3">109,948 m^3 / 30 days</td><td colspan="2" rowspan="2">Will the Well Self-Kill?</td><td colspan="2" rowspan="2">No</td></tr>
<tr><td colspan="2">Flow Rate [m^3/day]</td><td colspan="3">Day 0 to 5: 5,239 m^3
Day 6 to 10: 3,806 m^3
Day 11 to 20: 3,356 m^3
Day 21 to 30: 3,117 m^3</td></tr>
<tr><td colspan="2">Justification for Predicted Worst Case Volume</td><td colspan="7">It would be expected to take 30 days to install the well capping device</td></tr>
<tr><td colspan="9">Location</td></tr>
<tr><td colspan="2">Spill Source Point</td><td colspan="7">60° 48' 34.453" N, 4° 10' 31.998" W</td></tr>
<tr><td colspan="2">Installation/Facility Name</td><td colspan="3">Well P3</td><td colspan="2">Quad/Block</td><td colspan="2">204/10a</td></tr>
<tr><td colspan="9">Hydrocarbon Properties</td></tr>
<tr><td colspan="2">Hydrocarbon Name</td><td colspan="7">Cambo</td></tr>
<tr><td colspan="2">Assay Available</td><td colspan="3">Yes</td><td colspan="2">Was An Analogue Used For Spill Modelling?</td><td colspan="2">Yes</td></tr>
<tr><td></td><td>Name</td><td>ITOPF Category</td><td>Specific Gravity</td><td>API Gravity</td><td>Viscosity [cP]</td><td>Pour Point [°C]</td><td>Wax Content [%]</td><td>Asphaltene Content [%]</td></tr>
<tr><td>Hydrocarbon</td><td>Cambo crude</td><td>3</td><td>0.918</td><td>25.4</td><td>600</td><td>-36</td><td>8.4</td><td>0.35</td></tr>
<tr><td>Analogue</td><td>Schiehallion</td><td>3</td><td>0.899</td><td>25.9</td><td>180</td><td>3</td><td>7.0</td><td>0.36</td></tr>
<tr><td colspan="9">Metocean Parameters</td></tr>
<tr><td colspan="2">Air Temperature (°C)</td><td colspan="3">2°C to 15°C</td><td colspan="2">Sea Temperature (°C)</td><td colspan="2">7°C to 15°C</td></tr>
<tr><td colspan="2">Wind Data</td><td colspan="7">2 years' (2012 to 2013) Oil & Gas UK Data from the European Centre for Medium-Range Weather Forecasts (ECMWF) Wind Data</td></tr>
<tr><td colspan="2">Current Data</td><td colspan="7">2 years' (2011 to 2013) Oil & Gas UK Data: Shelf daily currents</td></tr>
<tr><td colspan="9">Modelled Release Parameters</td></tr>
<tr><td colspan="2">Surface or Subsurface</td><td colspan="3">Subsurface</td><td colspan="2">Depth [m]</td><td colspan="2">1,082 m</td></tr>
<tr><td colspan="2">Release Duration [days]</td><td colspan="3">30 days</td><td colspan="2">Instantaneous?</td><td colspan="2">No</td></tr>
<tr><td colspan="2">Persistence Duration [days]</td><td colspan="3">45 days</td><td colspan="2">Release Rate [m^3/hour]</td><td colspan="2">Day 0 to 5: 218 m^3
Day 6 to 10: 159 m^3
Day 11 to 20: 140 m^3
Day 21 to 30: 130 m^3</td></tr>
<tr><td colspan="2">Total Simulation Time [days]</td><td colspan="3">45 days</td><td colspan="2">Total Release [m^3]</td><td colspan="2">109,948 m^3</td></tr>
<tr><td colspan="9">Oil Spill Modelling Software</td></tr>
<tr><td colspan="2">Name of Software</td><td colspan="3">MEMW-OSCAR</td><td colspan="2">Version</td><td colspan="2">11.0.1</td></tr>
</table>

Source: OSRL, 2020a.

Table 13.2: Well Blow-out Modelling Results

Well Blow-out Modelling Summary				
Spill Scenario/Descriptor	Cambo P3 well blow-out			
Median Crossing				
Identified Median Line	**Highest Probability and Shortest Time to Reach**			
	Dec to Feb	Mar to May	Jun to Aug	Sep to Nov
Faroe Islands	100%	100%	100%	100%
	0 days, 3 hrs	0 days, 3 hrs	0 days, 3 hrs	0 days, 3 hrs
Iceland	10%	N/A	N/A	N/A
	29 days, 12 hrs	N/A	N/A	N/A
Norway	99%	59%	90%	100%
	6 days, 6 hrs	7 days, 15 hrs	9 days, 15 hrs	5 days, 15 hrs
Landfall				
Predicted Locations	**Highest Probability and Shortest Time to Reach**			
	Dec to Feb	Mar to May	Jun to Aug	Sep to Nov
The Faroe Islands	23%	72%	54%	5%
	8 days, 19 hrs	6 days, 11 hrs	8 days, 21 hrs	11 days, 15 hrs
Norway	64%	2%	8%	49%
	22 days, 5 hrs	35 days, 3 hrs	33 days, 10 hrs	17 days, 11 hrs
The Shetland Islands (United Kingdom)	89%	63%	56%	56%
	6 days, 23 hrs	7 days, 2 hrs	7 days, 6 hrs	5 days, 0 hrs
The Orkney Islands (United Kingdom)	1%	10%	19%	N/A
	40 days, 6 hrs	14 days, 21 hrs	11 days, 9 hrs	N/A
Highland (United Kingdom)	N/A	10%	8%	N/A
	N/A	13 days, 14 hrs	27 days, 18 hrs	N/A
Eilean Siar (United Kingdom)	N/A	3%	N/A	N/A
	N/A	19 days, 12 hrs	N/A	N/A
Shoreline Impact				
Mass of oil onshore	333 tonnes	2,494 tonnes	3,382 tonnes	386 tonnes
Volume of oil onshore	370 m^3	2,774 m^3	3,762 m^3	429 m^3
Water content	73%	73%	73%	73%
Volume of emulsion onshore	1,372 m^3	10,275 m^3	13,933 m^3	1,590 m^3
Key Sensitivities At Risk				
Discussed in Section 13.5.4				

Source: OSRL, 2020a.

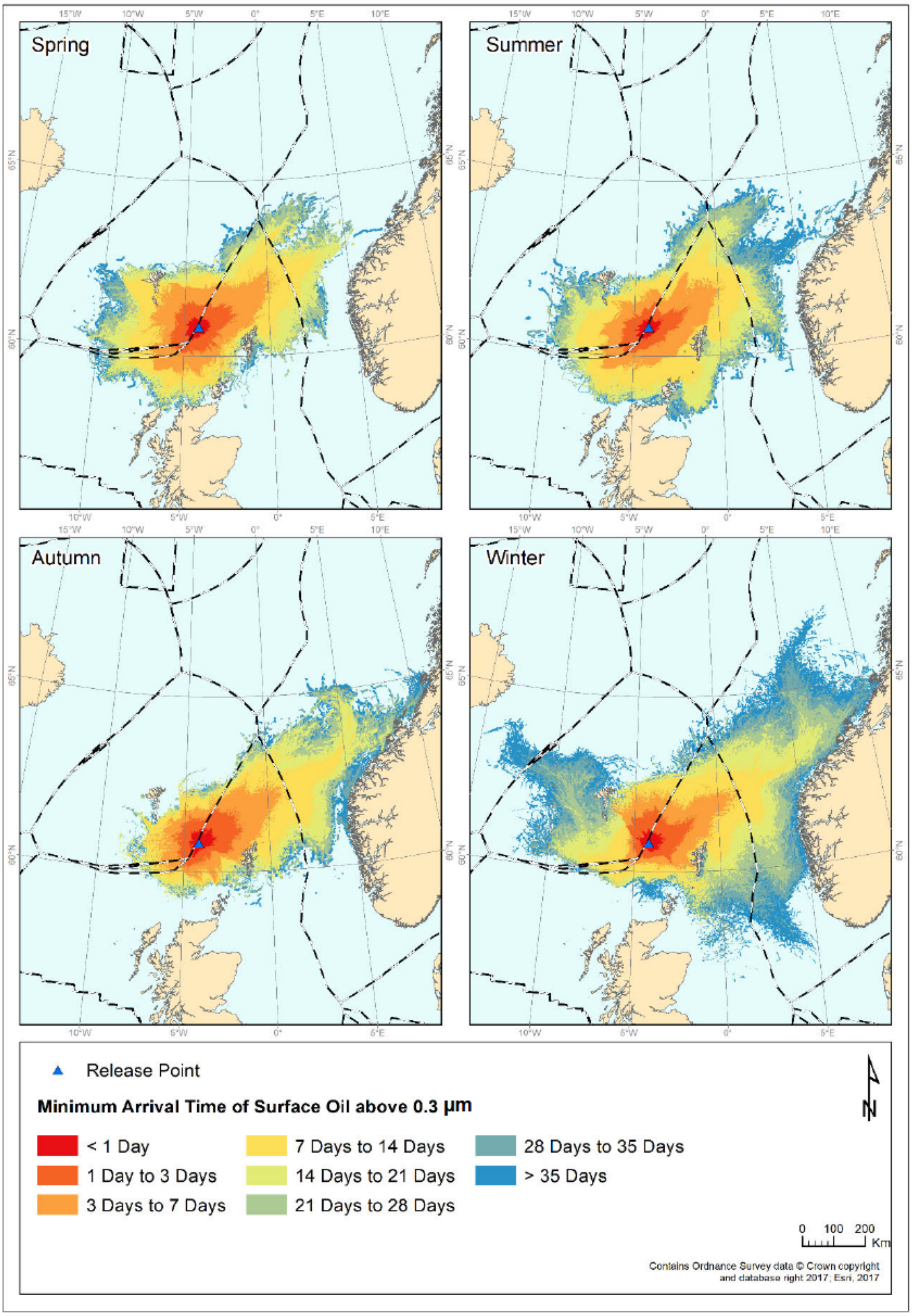


Figure 13.6: Well Blow-out Modelling: Arrival Time Plot

Source: OSRL, 2020a.

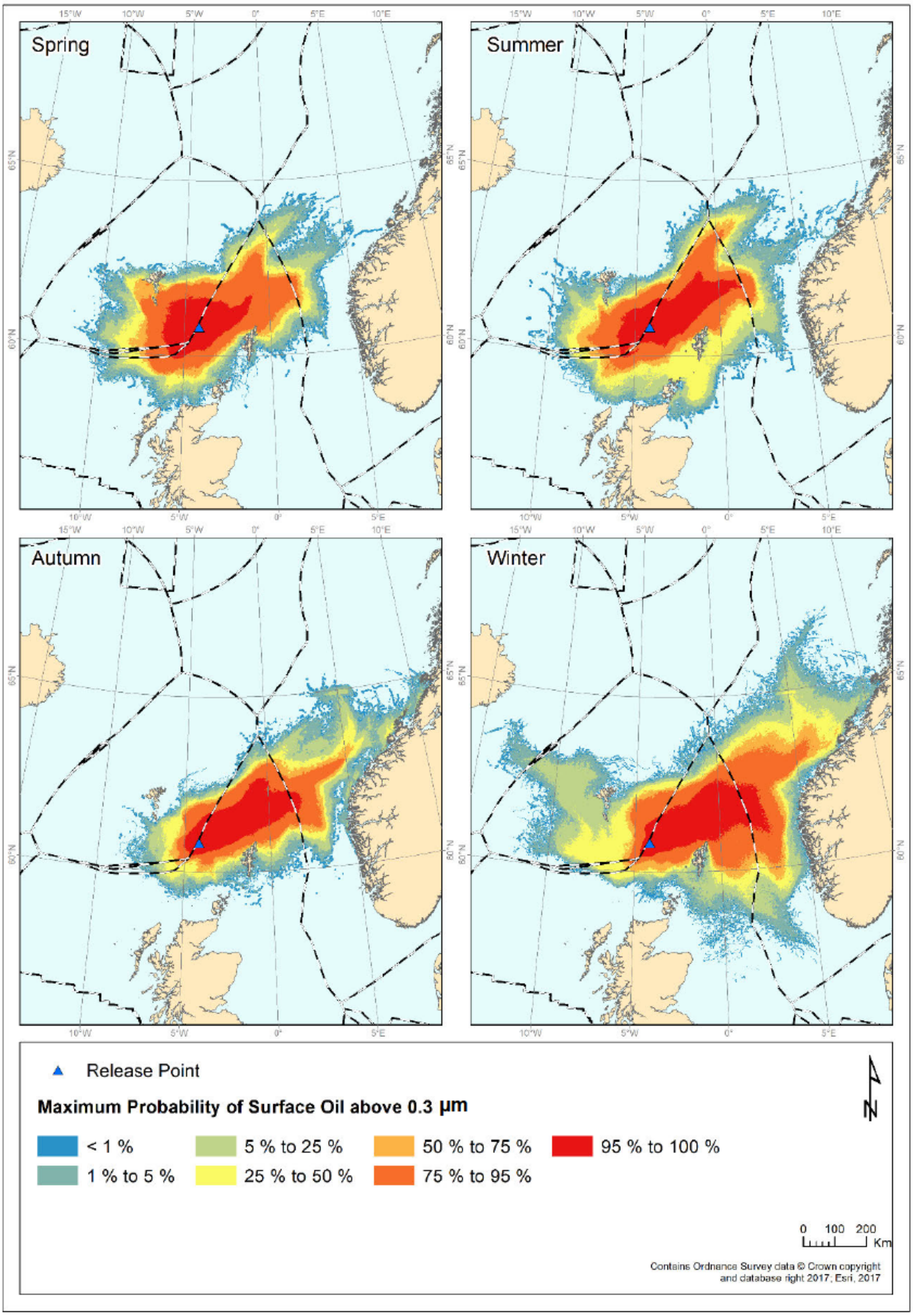


Figure 13.7: Well Blow-out Modelling: Probability of Surface Oil

Source: OSRL, 2020a.

Vertical Profile Modelling

In addition to the stochastic modelling detailed above, a vertical trajectory modelling run was undertaken, to provide a predication of the behaviour of crude oil in the water column in the event of a subsea blow-out release. The parameters used matched those used in the stochastic modelling, as detailed in Table 13.1.

The vertical profile shows the oil plume rising to the sea surface from the release depth of 1,082 m in approximately 2½ hours (Figure 13.8). The associated gas plume does not reach the sea surface, and is absorbed into the water column. As the small oil droplets encounter the thermocline at approximately 400 m below the sea surface, the speed of plume rising slows and some of the smaller droplets are halted. A sub-surface oil plume could potentially be trapped at this level, although the model does not show this outcome. Once the plume has risen to the surface, the plume model shows that it is likely to be driven by the Faroe-Shetland slope current that generally flows towards the north-east (towards Norway) all year around.

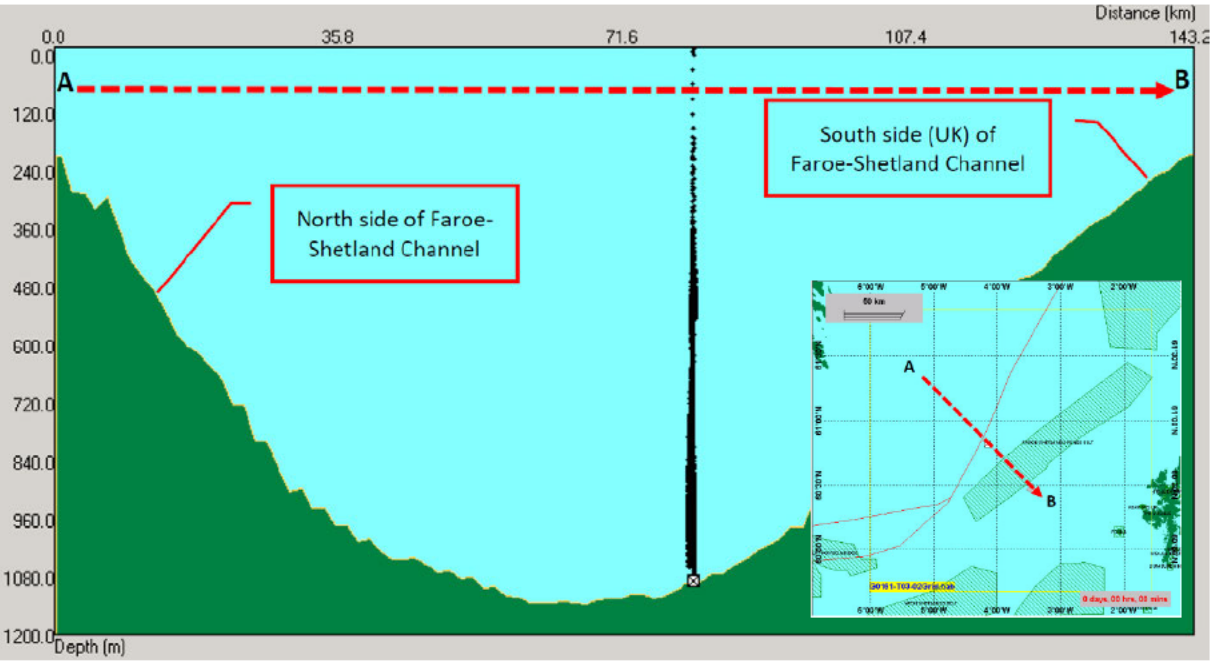


Figure 13.8: Vertical Movement of Cambo Crude Oil Plume

Source: OSRL, 2018a.

Complete Loss of FPSO Inventory

Guidance detailing oil spill modelling requirements states that the maximum possible inventory of crude oil onboard the FPSO (i.e. 103,342 m3) should be modelled as an 'instantaneous release' (BEIS, 2019). However, when attempting to model the maximum FPSO crude oil inventory as an instantaneous release (i.e. all oil is released in 1 second), this can result in unreliable modelling outputs in OSCAR. To avoid this, a more realistic worst-case maximum release rate of just over 1,000 m3/hr has been applied, with the release duration extended appropriately. This scenario represents an instantaneous release as closely as possible, without compromising the reliability of the modelling results.

Table 13.3: Complete Loss of FPSO Inventory Spill Modelling Parameters

<table>
<tr><td colspan="9">FPSO Inventory Spill Parameters</td></tr>
<tr><td colspan="2">Loss from Well/FPSO/Rig/Other</td><td colspan="2">FPSO</td><td colspan="2">Instantaneous Loss?</td><td colspan="3">No</td></tr>
<tr><td colspan="2">Worst Case [m^3]</td><td colspan="2">103,342 m^3</td><td colspan="2" rowspan="2">Will the Well Self-Kill?</td><td colspan="3" rowspan="2">N/A</td></tr>
<tr><td colspan="2">Flow Rate [m^3/day]</td><td colspan="2">1,003 m^3</td></tr>
<tr><td colspan="2">Justification for Predicted Worst Case Volume</td><td colspan="7">Maximum FPSO Storage Inventory</td></tr>
<tr><td colspan="9">Location</td></tr>
<tr><td colspan="2">Spill Source Point</td><td colspan="7">60° 48' 32.606" N, 004° 07' 15.914" W</td></tr>
<tr><td colspan="2">Installation / Facility Name</td><td colspan="2">FPSO</td><td colspan="2">Quad/Block</td><td colspan="3">204/5</td></tr>
<tr><td colspan="9">Hydrocarbon Properties</td></tr>
<tr><td colspan="2">Hydrocarbon Name</td><td colspan="7">Cambo</td></tr>
<tr><td colspan="2">Assay Available</td><td colspan="2">No</td><td colspan="2">Was An Analogue Used For Spill Modelling?</td><td colspan="3">Yes</td></tr>
<tr><td></td><td>Name</td><td>ITOPF Category</td><td>Specific Gravity</td><td>API</td><td>Viscosity [cP]</td><td>Pour Point [°C]</td><td>Wax Content [%]</td><td>Asphaltene Content</td></tr>
<tr><td>Hydrocarbon</td><td>Cambo crude</td><td>3</td><td>0.918</td><td>25.4</td><td>600 cP</td><td>-36 °C</td><td>8.4 %</td><td>0.35 %</td></tr>
<tr><td>Analogue</td><td>Schiehallion</td><td>3</td><td>0.899</td><td>25.9</td><td>180 cP</td><td>3.0 °C</td><td>7.0 %</td><td>0.36 %</td></tr>
<tr><td colspan="9">Metocean Parameters</td></tr>
<tr><td colspan="2">Air Temperature (°C)</td><td colspan="2">2°C – 15°C</td><td colspan="2">Sea Temperature (°C)</td><td colspan="3">7°C – 15°C</td></tr>
<tr><td colspan="2">Wind Data</td><td colspan="7">2 years' (2012 to 2013) Oil & Gas UK Data from the European Centre for Medium-Range Weather Forecasts (ECMWF) Wind Data</td></tr>
<tr><td colspan="2">Current Data</td><td colspan="7">2 years' (2011 to 2013) Oil & Gas UK Data: Shelf daily currents</td></tr>
<tr><td colspan="9">Modelled Release Parameters</td></tr>
<tr><td colspan="2">Surface or Subsurface</td><td colspan="2">Surface</td><td colspan="2">Depth [m]</td><td colspan="3">0 m (Surface)</td></tr>
<tr><td colspan="2">Release Duration [days]</td><td colspan="2">103 hours</td><td colspan="2">Instantaneous?</td><td colspan="3">No*</td></tr>
<tr><td colspan="2">Persistence Duration [days]</td><td colspan="2">20 days</td><td colspan="2">Release Rate [m^3/hour]</td><td colspan="3">1,003 m^3/hour</td></tr>
<tr><td colspan="2">Total Simulation Time [days]</td><td colspan="2">20 days</td><td colspan="2">Total Release [m^3]</td><td colspan="3">103,342 m^3</td></tr>
<tr><td colspan="9">Oil Spill Modelling Software</td></tr>
<tr><td colspan="2">Name of Software</td><td colspan="2">MEMW-OSCAR</td><td colspan="2">Version</td><td colspan="3">11.0.1</td></tr>
</table>

Source: OSRL, 2020b.

*Although the guidance notes state that an instantaneous release rate should be modelled, in the case of such a large volume release, a longer release duration was used as it provides a more realistic approach and prevents possible errors within the model.

The results of the FPSO inventory loss oil spill modelling scenario are provided in Table 13.4. Minimum arrival time of surface oiling is shown in Figure 13.9 and the probability of surface oiling in Figure 13.10. It should be noted that surface oiling is shown with a thickness threshold of 0.3 µm, in accordance with OPRED's oil spill modelling requirements.

Table 13.4: Complete Loss of FPSO Inventory Spill Modelling Results

Complete Loss of FPSO Inventory Modelling Summary				
Spill Scenario/Descriptor	FPSO Release			
Median Crossing				
Identified Median Line	Highest Probability and Shortest Time to Reach			
	Dec to Feb	Mar to May	Jun to Aug	Sep to Nov
Faroe Islands	85 %	94 %	82 %	74 %
	0 days, 3 hrs	< 1 hr	0 days, 3 hrs	0 days, 3 hrs
Norway	76 %	34 %	62 %	86 %
	6 days, 9 hrs	9 days, 9 hrs	7 days, 12 hrs	6 days, 21 hrs
Landfall				
Predicted Locations	Highest Probability and Shortest Time to Reach			
	Dec to Feb	Mar to May	Jun to Aug	Sep to Nov
UK (The Shetland Islands)	49 %	29 %	50 %	41 %
	5 days, 3 hrs	5 days, 13 hrs	5 days, 2 hrs	5 days, 3 hrs
Norway	N/A	N/A	N/A	3 %
	N/A	N/A	N/A	17 days, 14 hrs
Faroe Islands	N/A	23 %	11 %	4 %
	N/A	7 days, 2 hrs	7 days, 24 hr	9 days, 8 hrs
Shoreline Impact				
Mass of oil onshore	466 tonnes	808 tonnes	5,061 tonnes	1,184 tonnes
Volume of oil onshore	518 m^3	899 m^3	5,630 m^3	1,317 m^3
Water content	73 %	73 %	73 %	73 %
Volume of emulsion onshore	1,920 m^3	3,329 m^3	20,850 m^3	4,878 m^3
Key Sensitivities at Risk				
Sensitivities/Sites of Concern	Highest Probability and Shortest Time to Reach			
Faroe-Shetland Sponge Belt MPA	100 %	91 %	100 %	100 %
	0 days, 6 hrs	0 days, 6 hrs	0 days, 9 hrs	0 days, 6 hrs
North-East Faroe-Shetland Channel MPA	96 %	67 %	95 %	97 %
	2 days, 21 hrs	3 days, 15 hrs	3 days, 6 hrs	2 days, 15 hrs
West Shetland Shelf MPA	5 %	25 %	15 %	4 %
	11 days, 9 hrs	4 days, 12 hrs	5 days, 12 hrs	5 days, 15 hrs
North West Orkney MPA	10 %	27%	9 %	16 %
	6 days, 18 hrs	4 days,18 hrs	8 days, 21 hrs	6 days, 0 hrs
Pobie Bank Reef SAC	43 %	14 %	41 %	36 %
	7 days, 6 hrs	9 days, 15 hrs	7 days, 21 hrs	8 days, 6 hrs
Wyville Thompson Ridge SAC	9%	47%	19%	7%
	11 days, 6 hrs	2 days, 15 hrs	3 days, 18 hrs	10 days, 3 hrs
Darwin Mounds SAC	N/A	10%	8%	N/A
	N/A	7 days, 3 hrs	6 days, 15 hrs	N/A
Solan Bank Reef SAC	N/A	4%	N/A	N/A
	N/A	13 days, 9 hrs	N/A	N/A
Seas off Foula proposed SPA	5%	4%	5%	9%
	8 days, 12 hrs	12 days, 6 hrs	8 days, 0 hrs	5 days, 12 hrs
Hermaness, Saxa Vord and Valla Field SPA	44%	25%	49%	41%
	5 days, 3 hrs	5 days, 21 hrs	5 days, 3 hrs	6 days, 9 hrs
Fetlar SPA	22%	16%	25%	20%
	9 days, 3 hrs	8 days, 12 hrs	8 days, 0 hrs	9 days, 15 hrs
Fetlar to Haroldswick MPA	26%	16%	28%	22%
	9 days, 0 hrs	7 days, 15 hrs	8 days, 0 hrs	8 days, 18 hrs
Foula SPA	5%	4%	5%	9%
	8 days, 12 hrs	12 days, 6 hrs	8 days, 0 hrs	5 days, 12 hrs

Source: OSRL, 2020b.

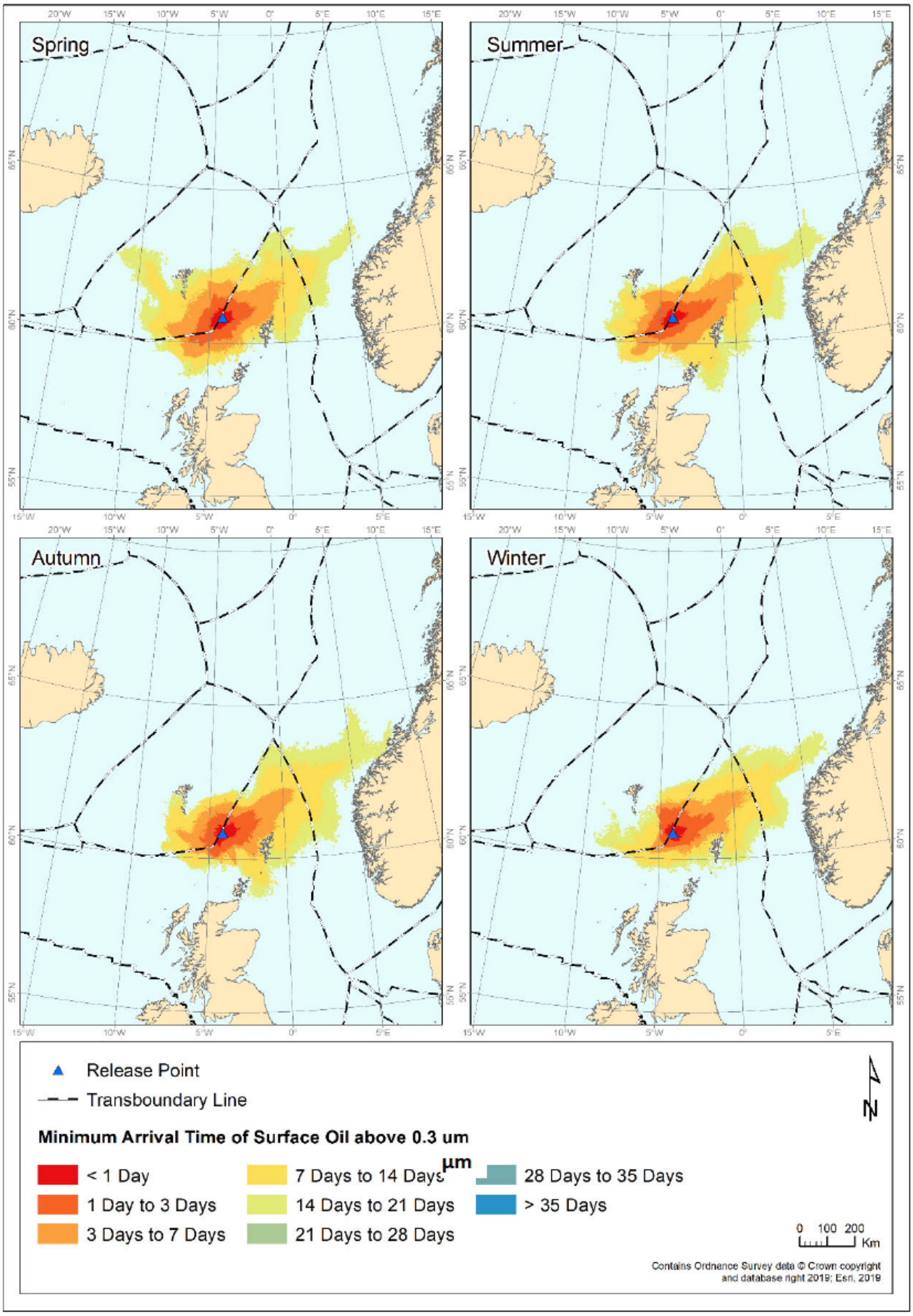


Figure 13.9: Complete Loss of FPSO Inventory Spill Modelling: Arrival Time Plot

Source: OSRL, 2020b.

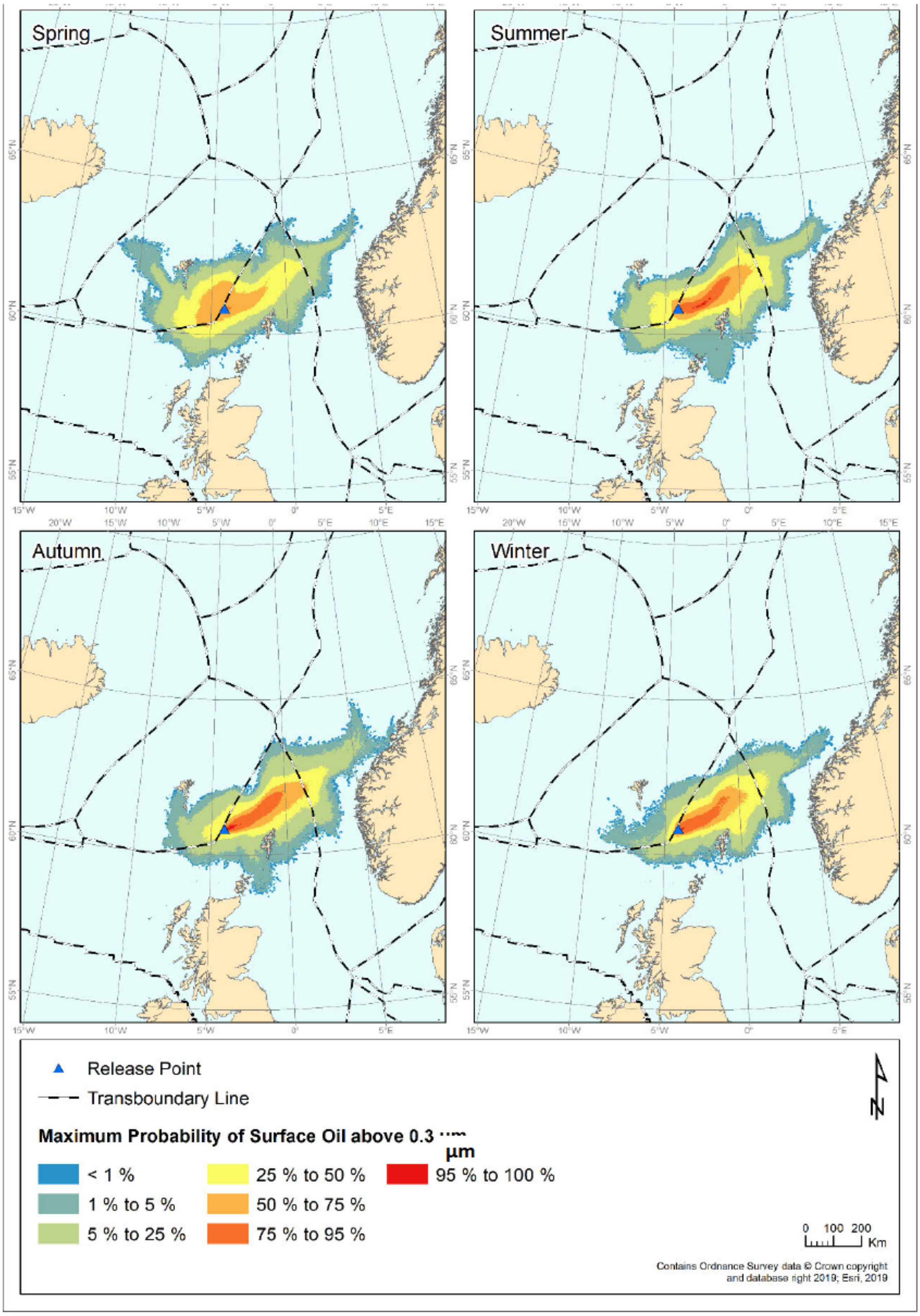


Figure 13.10: Complete Loss of FPSO Inventory Spill Modelling: Probability of Surface Oil

Source: OSRL, 2020b.

13.5 Potential Environmental Impacts

13.5.1 Impacts on Marine Life

The risk of accidental hydrocarbon spillage to the marine environment is one of the main environmental concerns associated with oil-industry activities. Although the effects of oil spills are well understood, the effects of each individual spill are unique and some assumptions have been made regarding predicting the effects of a large crude oil spill at the proposed Cambo Field Development.

Plankton

Oil, particularly diesel, is toxic to a wide range of planktonic organisms. Those living near the sea surface are particularly at risk, as water-soluble components leach from floating oil. Although oil spills may kill individuals, the effects on whole plankton communities generally appear to be short-term. Following an oil spill incident, plankton biomass may fall dramatically, due either to animal deaths or avoidance of the area. However, after only a few weeks, populations would be expected to return to previous levels through a combination of high reproductive rates and immigration from outside the affected area.

Benthos

Shallow Coastal Communities

It is generally assumed those animals associated with the seabed will remain unaffected by a surface slick as the floating oil moves above them. However, a fraction of the water soluble components of a slick may dissolve into the water column, assisted by rough seas or agitation of the sea surface, where these could potentially be harmful to benthic organisms. In deeper offshore areas, these impacts will be very limited. However, if the spilled oil drifts inshore, the benthic communities of the shallow coastal areas may be affected. Parameters such as local bathymetry and sediments types would significantly influence the distribution of oil contamination at the seabed.

It should be noted that any oil that reaches these shallow areas will have travelled a considerable distance through the water column and across the sea surface, and will therefore have been affected by the range of degradation processes described in Section 13.4. These mechanisms will have contributed to remove the various toxic components of the oil and the primary impact of the oil deposition on benthic communities is anticipated to be related to smothering. As the oil will also have become widely dispersed by this point, the physical effects of smothering are expected to be limited.

The shoreline itself is particularly susceptible to oil beaching. The potential impacts arising from beached oil in coastal habitats are discussed separately in Section 13.5.2.

Deepwater Communities

As described above, the buoyancy of the produced oil (and associated gas) will carry all hydrocarbons straight up to the sea surface in the event of a subsea spill. Therefore, it is expected to be very unlikely for the crude oil to reach the surrounding benthic communities.

The habitats and associated benthic communities of the Faroe-Shetland Channel vary in relation to water depth, with a series of broad zones recorded (Section 4.3.1). The upper to mid continental slope is characterised by the presence of iceberg ploughmarks which, through infilling over time, create a complex mosaic of seabed habitats alternating between areas of cobbles and boulders, and fine sediment. These areas of boulders and cobbles can be extensive and support diverse epifaunal communities. Beyond this zone, few distinct features are supported and sediments become finer with increasing depth. As sediments become finer, the characteristic benthic species present change from largely suspension feeding to deposit feeding types.

Suspension feeders gather their food directly from the seawater and would, therefore, take in any oil present within the surrounding water leaving them more vulnerable to the toxic effects of oil dispersed in the water column. Deposit feeders are supported by the fine organic matter trapped between the fine sediments and these animals would only be affected if the dispersed oil settled on the seabed.

Any subsea release of crude oil would be pushed directly up in a plume to the sea surface, rather than towards the surrounding benthic communities. It would then be carried away from the spill location by the local current systems, with the majority of the oil moving to the northeast (Figure 13.7). Due to the time it would take to reach these areas and the large surface area available for microbial attack, it is expected that most of the toxic constituents would have been lost from the plume. It therefore seems unlikely that the released oil would significantly affect either suspension feeding or the more prevalent deposit feeding species comprising deep-water benthic communities.

No seabed features of conservation value have been recorded in the immediate area surrounding the proposed Cambo Field Development. The nearest area of conservation importance is Faroe-Shetland Sponge Belt Nature Conservation Marine Protected Areas (NCMPA), which lies 35 km southeast of the Development Footprint. Potential impacts of non-synthetic compound contamination (e.g. hydrocarbons) have been assessed using the Feature Activity Sensitivity Tool (FEAST) Tool. However, as stated above, it is expected that all spilled oil would be transported to the sea surface, and so benthic communities in the Faroe-Shetland Sponge Belt NCMPA would not be impacted in the event of a seabed spill.

Fish

Offshore fish populations remain relatively unaffected by oil pollution, as oil concentrations below the surface slick are generally low (Clark, 2001). There is also evidence that fish are able to detect and avoid oil-contaminated waters. This avoidance may, however, cause disruption to migration or spawning patterns.

Comparatively little is known about the distribution and abundance of deepwater fish species in the Faroe-Shetland Channel. Many of these species have slow growth rates, late onset of sexual maturity and low fecundity, leaving them vulnerable to the effects of disturbance.

Rather than impacting the fish directly, heavily contaminated sediments may have an adverse effect on local populations of demersal fish species, due to the impact it has lower down the food chain. However, as described in the benthos section above, heavy contamination of the sediments is not expected.

Fish eggs and larvae are more vulnerable to oil pollution than adult fish. In many fish species, these stages float to the surface where contact with spilt oil is more likely. A number of commercial species have spawning grounds in the Faroe-Shetland region (see Figure 4.18 in Section 4.3.3). However, as these species have extensive spawning grounds and produce large numbers of pelagic young, there is unlikely to be any long-lasting effect on numbers in the adult populations. Certain fish stocks may be more affected than others, particularly if the spill is very large, coincides with spawning periods, or enters the grounds of species with restricted spawning areas.

Shellfish

If oil reaches the seabed, shellfish species that cannot swim away from oiled sediments are susceptible to its effects. Mortalities may occur if shellfish become smothered by settling oil. Only low levels of oil in seawater may cause tainting in shellfish, which may be commercially damaging to shellfish fisheries. This is more common in filter feeding shellfish, principally bivalves, as they would take up fine oil droplets from the water column. In the deepwater of the Faroe-Shetland Chanel, commercially important shellfish are only found in very small quantities. Moreover, as explained above, it is extremely unlikely that any hydrocarbons released from a subsea blow-out would remain near the seabed. The inshore waters around Shetland do, however, support commercially important shellfish fisheries, which may be at risk if a spill reaches these waters.

Marine Mammals

Whales, dolphins, porpoises and seals are generally able to avoid a spill and are rarely affected significantly. However, if they do come into contact with a spill, possibly by surfacing in a slick to breathe, they may suffer from irritation of the eyes, mouth, nasal passages and skin. Volatile hydrocarbon fractions may also cause respiratory problems.

A thick layer of blubber protects cetaceans and adult seals from the cold and these animals are less vulnerable to the physical impacts of oil lowering their resistance to the cold. Seal pups and otters are, however, at risk from hypothermia if their fur becomes oiled and loses its thermal properties, as they do not have sufficient blubber underneath their fur to keep them warm. Both grey and common seals are known to breed on the Shetland and Orkney Islands (Section 4.3.4). The Shetland and Orkney Islands also support important otter populations. These marine mammals may be at risk if a slick reaches coastal areas.

Seabirds

Seabirds are particularly vulnerable to oil pollution at the sea surface which can cause a range of physical and physiological effects. Following contact with oil, seabirds risk loss of buoyancy and thermal insulation as the water-repellent properties of their plumage is lost. In an attempt to clean their plumage of the contaminating oil seabirds can also ingest the oil when preening, which may lead to an array of physiological effects. In addition to the direct mortality of adult birds only small quantities of ingested oil can have an indirect effect on reproduction, with depressed egg production and reduced hatching success.

The aerial habits of the fulmar and gulls, together with their large populations and widespread distribution, reduce vulnerability of these species. Gannets, skuas and auk species are considered to be most vulnerable to oil pollution due to a combination of heavy reliance on the marine environment, low breeding output with a long period of immaturity before breeding, and the regional presence of a large percentage of the biogeographical population (DTI, 2003).

The vulnerability of bird species to oil pollution is dependent on several factors and varies considerably throughout the year. The JNCC has produced a Seabird Oil Sensitivity Index (SOSI) which identifies areas at sea where seabirds are likely to be most sensitive to oil pollution. The SOSI uses seabird survey data collected between 1995 and 2015, in addition to individual species sensitivity index values, combined at each location to create a single measure of seabird sensitivity to oil pollution (JNCC, 2017c).

Monthly vulnerability for seabirds in the area around the proposed Cambo Field Development is presented in Table 13.5 and Figure 13.11. With increasing distance from shore, seabird abundance decreases, and their distribution becomes increasingly patchy. These patterns are generally governed by the availability and distribution of prey, and also oceanographic features such as water depth and sea temperature. As a result, in the deepwater of the Faroe-Shetland Channel, and well over 100 km from either the Shetland or Faroe Islands, seabird abundance in the area of the proposed development remains relatively low throughout the year.

The vulnerability of birds in the vicinity of the proposed Cambo Field Development is low to medium during the breeding season, generally between March and June, when large numbers of birds congregate in coastal breeding colonies (RSPB, 2018; Table 13.5; Figure 13.11). Seabird vulnerability in the area is generally, high to extremely high in September and November, possibly in association with the movement away from colonies after breeding. The vulnerability is increased by the numbers of auks, primarily guillemots, but also puffins, found at sea during this time (BODC, 1998; DTI 2001). Congregating into large groups referred to as 'rafts', these birds undergo a full moult at sea, rendering them flightless and leaving them highly susceptible to surface pollution (RSPB, 2018).

Table 13.5: Seabird Vulnerability to Surface Pollution in the Vicinity of the Proposed Development (JNCC, 2018)

UKCS Block	January	February	March	April	May	June	July	August	September	October	November	December
212/30	5	5*	5*	5	5	3	4	5	1	5	5*	5
213/26	5	5*	3	4	5	5	4	5	2	2*	5	5
204/4	5	5*	5*	5	5	5	5*	5	1	5	5*	5
204/5	5	5*	5*	5	4	4	5	5	1	5	5*	5
204/8	5	5*	5	4	4	5	5*	5	5	5	5	5
204/9	5	5	5	4	5	5	5*	5	2	5	2	5
204/10	5	5	4	4	5	4	5	5	1	5	5*	5
204/13	4	4	5	4	4	5	5*	5	5	5	5	5
204/14	5	4	5	4	4	5	5	5	5	5	3	5
204/15	5	5	5	4	5	4	5	5	5	5	2	5
205/1	5	5*	4*	4	3	5	5	5	3	5	5	5
205/6	5	5*	5	4	4	5	5	5	3	5	5	5
205/11	5	5	5	4	4	4	5	5	5	5	3	5

1 Extremely High
2 Very High
3 High
4 Medium
5 Low
ND No data
* Indicates blocks for which no data was available, and therefore score has been calculated using that of an adjacent month or Block

Seabird vulnerability in the inshore waters around Orkney and Shetland are classified as high to very high throughout the year due to breeding seabirds foraging. The Shetland, Orkney and Faroe Islands are of international importance for the seabird breeding colonies they support, with many coastal sites and their surrounding inshore waters designated as Special Protection Areas (SPAs) under the European Birds Directive. These colonies may be at risk from a large surface slick.

Overall, the average for Blocks 204/4, 204/5, 204/9 and 204/10 shows a medium vulnerability to oil and surface pollutants, with a peak in vulnerability occurring in September (JNCC, 2018).

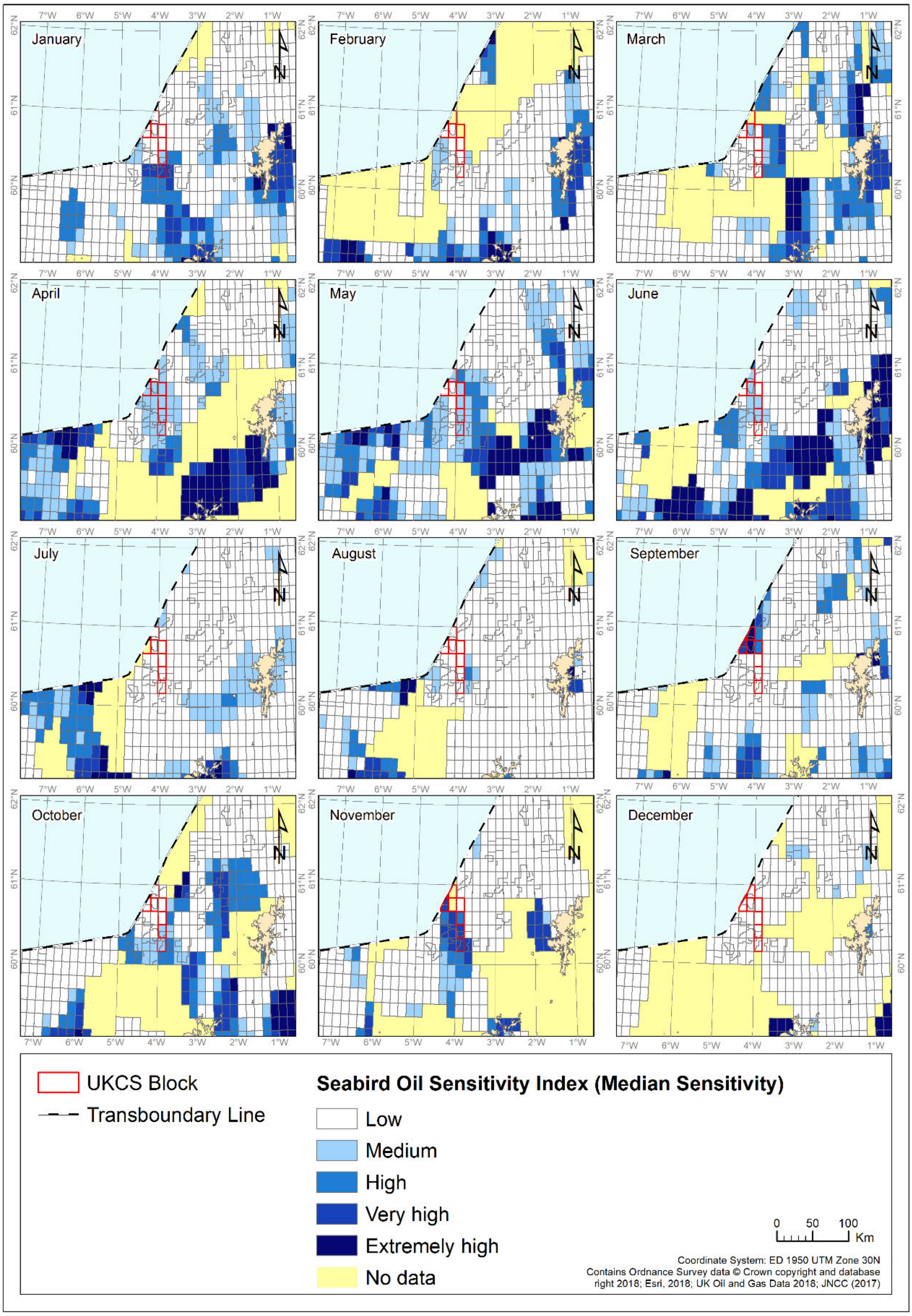


Figure 13.11: Seabird Vulnerability to Surface Pollution in the Vicinity of the Proposed Cambo Field Development

Source: JNCC, 2017c.

13.5.2 Impacts on Coastal and Inshore Habitats

The coastlines of the Shetland, Orkney and Faroe Islands support a range of different habitat types. These coastlines are important for nature conservation, with numerous sites along the coastline designated under national and international legislation (Section 4.5.1). In the unlikely event of a large spill, these coastlines are potentially at risk. Although the probability of a spill reaching shore, and the amount of crude oil that would do so, is very low.

Rocky Shores

Rocky shores can be very varied in structure, ranging from exposed vertical walls to flat bedrock, or stable boulder fields to aggregations of cobbles. These shores can support a variety of sessile animal and plant communities which live attached to the rock surface, as well as a range of associated mobile invertebrates and fish. More exposed rocky shores are generally dominated by sessile animals and smaller more robust seaweeds, while the more sheltered shores are characterised by the large brown kelps.

Rocky shores are generally high energy beaches and, while oil may have an impact on the animals and plants which live on them, stranded oil is often quickly removed by wave action and water movement. The vulnerability of rocky shore habitats to oiling is dependent on the type of rocky shore and its exposure. The action of the waves may start to remove the oil from an exposed vertical wall almost immediately but the oil may remain for longer in more sheltered, kelp dominated areas.

Many of the animals and small seaweeds found on rocky shores would be killed by exposure to fresh and light oils, but much of the crude oil potentially reaching the shore from a large spill from a spill at the proposed Development location would have been at sea for several days (3 to 7 days) and would have lost most of its toxic constituents. Various shoreline species have been observed to survive shoreline oiling and continue feeding in oiled areas, suggesting that the toxic impacts would be minimal (Clark, 2001). However, even if the beached oil is relatively non-toxic, heavily weathered oil may still cause damage due to its physical properties. Large amounts of stranded oil may impact upon shoreline animals by smothering them. Those animal species that are large enough to protrude above the oil or can move away quickly may survive, but smaller species would be killed by inhibition of their feeding and respiration mechanisms. Many of the larger brown seaweeds which dominate the more sheltered rocky shores secrete mucus which would prevent oil adhering to them. However, if oil does adhere to the seaweed fronds, instead of killing the seaweeds directly, the oil will increase their overall weight causing them to be pulled from the rocks by the wave action.

The rate of recovery and the form it takes will depend upon the type of rocky shore and the animals and plants that live on it. The general experience of oil spills on rocky shores is that substantial recovery can be achieved within two years, but biological factors may intervene and cause a prolonged change. Rocky shores are high energy, highly productive environments, where the physical and biological factors exerted upon them lead to intense competition between the species which live there. The physical factors, such as desiccation, extremes of temperature, and changes in salinity, can cause mortalities in rocky shore communities, while the severe winter storms can pull many animals and plants from the shore each year (Little and Kitching, 1996). As a result, these communities, particularly those on the coastlines surrounding the highly dynamic west of Shetland area, have the capability to regenerate quickly in order to take advantage of the newly available space.

Oil spill modelling indicates that, under the majority of meteorological circumstances, a large oil slick will drift northeast of the Cambo Field Development, leaving the coasts of Shetland and Norway under the greatest threat (Section 13.4.3). The coastlines of the Orkney and Faroe Islands may also be affected. During spring and summer time the northern coasts of the Isle of Lewis and the Scottish mainland may also be at risk. These shores are all dominated by steep sea cliffs and high energy rocky shores (Section 3.3). It could therefore be assumed that these northerly rocky shores could recover relatively quickly from a beaching oil spill.

Sedimentary Shores

The fate of oil stranded on sediment shores depends on the nature of the substratum (IPIECA, 2008). Due to the increased sediment movement and relatively large gaps between the particles, beached heavy oil can penetrate further into the more mobile shingle or coarse sand shores. These coarse sediment shores tend to be less productive than sheltered mudflats, where waterlogged sediments, rich in organic matter, can accommodate huge numbers of invertebrates. Gaps between the shingle or sand grains allow the water to drain away quickly between the tides and the movement of the sediment itself is very abrasive, meaning few animals can survive in it. If the beaching of an oil spill becomes inevitable, sandy beaches have in the past been considered as sacrificial areas. A spill may be directed towards a sandy beach in order to protect other, more sensitive, shorelines. Soft sediment areas are rare on the Shetland Islands, with sandy beaches making up less than 5% of the total coastline (Section 4.4.1).

In contrast, oil does not readily penetrate the sediments in areas of firm waterlogged mud or fine sand and tends to be carried away with the next tide (Clark, 2001). However, there is a concern over oil beaching on sheltered mudflats or associated sensitive areas of saltmarsh and these are often priority areas for protection following oil spills. These are generally highly productive areas, with high numbers of invertebrates living within the sediments which may provide a valuable food source for juvenile fish and birds (Little, 2000). Recovery times tend to be longer in these sheltered areas, due to the reduced bacterial degradation and persistence of the oil, particularly if it penetrates into the sediment (IPIECA, 2008). The process of cleaning the sediments and vegetation can be very difficult in these areas and could potentially exacerbate any damage to the habitat. In the most sheltered of intertidal areas, where very fine sediments accumulate, saltmarshes may be found. Small patches of saltmarsh are found at the heads of voes and in other very sheltered areas on the Shetland Islands, but these make up only 0.2% of the available coastline (Section 4.4.1).

13.5.3 Impacts on Other Users of the Sea

Commercial Fisheries

The effects of oil spills on commercial fish and shellfish, and the indirect impacts on their habitats, are described above. Fish and shellfish exposed to oil may become tainted which could prevent an entire catch from being sold (Clark, 2001). There is evidence that fish are able to detect and avoid oil-contaminated waters, therefore tainting is more a concern for immobile shellfish which cannot swim away. This is more common in filter feeding shellfish, such as scallops, as they could take up fine oil droplets from the water column. Very small quantities of crab are the only shellfish taken from the area around the proposed Cambo Field Development, and significant shellfish landings are confined to areas much further inshore (Section 4.6.1).

If fishing in the area of an oil spill, nets may become fouled with floating oil. This not only causes damage to the nets themselves but contact with fouled fishing gear may also contaminate subsequent catches. Fishing activity in the area immediately around the proposed Cambo Field Development is very low when compared with the shallower slope and shelf waters (Section 4.6.1; Marine Scotland, 2017).

The mixed demersal fisheries take the greatest proportion of fish landed from the continental shelf and shelf break, to the east of Cambo. These trawl fisheries operate year round and nets could potentially become tainted in the unlikely event of a large oil spill occurring. Major spills may also result in loss of fishing opportunities with boats unable or unwilling to fish due to the risk of fouling causing a temporary financial loss to commercial fishermen. Herring fisheries operate in more inshore locations around the Shetland and Orkney Islands.

Aquaculture

Numerous fish and shellfish farms are distributed across the Shetland and Faroe Islands (Section 4.6.2) and, therefore, aquaculture is an important contributor to the economies of these island groups. Tainting is of concern for all caged fish and shellfish farms as the animals are unable to swim away. If a large surface spill is allowed to reach these islands the many mariculture farms which cultivate fish and shellfish may be at risk from tainting and fouling, potentially leaving their stock unmarketable.

Although all oils can cause taint, lighter oils are generally more potent (Clark, 2001). Any large oil spill from the proposed Cambo Field Development would have undergone the weathering processes described above (Section 13.4.2) and, therefore, will have lost many of its lighter fractions by the time it reached the shore. Although this would not completely prevent the environmental impact of the oil with regard to tainting, it may limit the severity.

13.5.4 Potential for a Major Environmental Incident

The Offshore Safety Directive (2013/30/EU) came into force, via UK Regulations, on 19 July 2015. These Regulations require that a Safety Case defining Major Accident Hazards (MAH) with the potential to cause Major Accidents (MA) must be in place to cover all relevant offshore operations. The potential for MAs to cause a Major Environmental Incident (MEI) must also be defined in the Safety Case. For the proposed Development, two scenarios with the potential to cause a MEI have been identified (Section 13.1):

- Spillage of hydrocarbons in the event of an uncontrolled well blow-out;
- Rupture of crude oil storage tanks.

Therefore, these two scenarios have been used as the basis for the MEI Assessment.

MEI Assessment Methodology

The Offshore Safety Directive defines a MEI as an incident which results, or is likely to result, in significant adverse effects on the environment (Article 2[37]). Environmental vulnerability to oil spills is dependent on both the size of the spill and also the sensitivity of receptors. There is no standard quantitative method of determining the environmental impact likely to be associated with an oil spill, and so a qualitative approach based on the “Impact Scales and Gradation of Oil Spill Ecological Hazards and Consequences in the Marine Environments” classification guide by Patin (2004) has been used for this MEI assessment.

Table 13.6 shows the consequence assessment methodology defined by Patin (2004). These criteria have been used to consider the potential impact of a worst-case scenario oil spill from the proposed Development on UK protected sites, including Special Protection Areas (SPA), Special Areas of Conservation (SAC) and Nature Conservation Marine Protected Areas (NCMPA), which have been designated for the protection of habitats and species. Whilst the MEI Assessment is solely required to consider the impact to UK sites, it is acknowledged that the oil spill modelling results show potential for oil reaching the waters of the Faroe Islands, Iceland and Norway, and potential for oil beaching in Norway or the Faroe Islands. In the event of an incident that could impact the waters of an adjacent State, SPE would liaise with the relevant national authorities to assess the scale of any potential impacts.

Table 13.6: Consequence Assessment Methodology based on Patin (2004)

A. Spatial Scale (Area)	
Spatial Scale	**Area Under Impact**
Point	Less than 100 m^2
Local	Range from 100 m^2 to 1 km^2
Confined	Range from 1 km^2 to 100 km^2
Sub-regional	More than 100 km^2
Regional	Spread over shelf area

B. Temporal Scale	
Temporal Scale	Longevity
Short term	Several minutes to several days
Temporary	Several days to one season
Long-term	One season to 1 year
Chronic	More than 1 year

C. Reversibility of Changes	
Reversibility of Changes	Longevity of Disturbance
Reversible (acute stress)	Acute disturbances in the state of environment and stresses in biota that can be eliminated either naturally or artificially within a short time span (several days to one season)
Slightly reversible	Disturbances in the state of environment and stresses in biota that can be eliminated either naturally or artificially within a relatively short time span (one season to 3 years)
Irreversible (chronic stress)	Prolonged disturbances in the state of environment and stresses in biota that exist longer than 3 years

D. Consequence Assessment – General Assessment	
General Assessment	Disruption
Insignificant	Minimal changes that are either absent or not discernible.
Slight	Slight disturbances to the environment and short-term stresses in biota are discernible (below minimum reaction threshold 0.1% of natural population reaction).
Moderate	Moderate disturbances to the environment and stresses in biota are observed (changes up to 1% of natural population reaction are feasible).
Severe	Severe disturbances to the environment and stresses in biota are observed (up to 10% of natural population).
Catastrophic	Catastrophic disturbances to the environment and stresses in biota are observed (up to 50% of natural population). Changes are irreversible and stable structural and functional degradation of a system is evident.

Figure 13.12 details the maximum extent of surface and shoreline oiling. The oil spill modelling results show that the majority of crude oil would be expected to move to the northeast and east, with the coastlines of Shetland and Norway most likely to be affected, followed by the coastlines of the Orkney and Faroe Islands (Section 13.4.3). During spring and summer, in the case of the well blow out scenario, there is also a small probability of an oil slick reaching the north coasts of Scottish mainland or the Island of Lewis. Figure 13.12 shows the maximum extent of the area that may become oiled

over all four seasons which were modelled. Protected sites which overlap with the maximum potential extent of oiling are also shown in Figure 13.12.

Table 13.7 lists the protected sites that have been shown by the modelling to have the potential to be affected by a large oil spill from the proposed Cambo Field Development. As shown by the vertical plume modelling (Section 13.4.3; Figure 13.8), oil released from the seabed in the event of an uncontrolled well blow-out would be expected to quickly rise to the sea surface. Therefore, marine protected sites designated for the protection of deep-water benthic habitats (such as the North-East Faroe-Shetland Channel MPA and the Faroe-Shetland Channel Sponge Belt MPA) are not expected to be affected in the event of a spill from the proposed Development, and have not been included in Table 13.7 or in Figure 13.12.

The potential impact of surface or shoreline oiling on the habitats and species of the protected sites listed in Table 13.7 has been assessed. As an initial step in the assessment, thresholds have been applied in terms of the minimum arrival time and maximum probability of oiling to screen these protected sites in or out of the MEI assessment.

The modelling results provide a worst-case scenario with the assumption that there would be no intervention in the slick. In practice, oil spill response resources would be mobilised immediately if a spill occurred, and oil spill response efforts would prioritise the protection of sensitive habitats and species. Therefore, it is assumed that sites at which oil would be expected to take more than three weeks to reach, or with a probability of less than 5% for any oiling to occur, would be very unlikely to be subject to significant adverse effects and consequently can be screened out of the assessment. Therefore, these sites (Copinsay SPA; Noss Head NCMPA; North Caithness Cliffs SPA, East Caithness Cliffs NCMPA, SAC and SPA, Cape Wrath SPA, Hoy SPA and the Inner Hebrides and the Minches NCMPA) have not been considered further in this assessment. The remaining protected sites have been assessed according to the consequence assessment methodology detailed above.

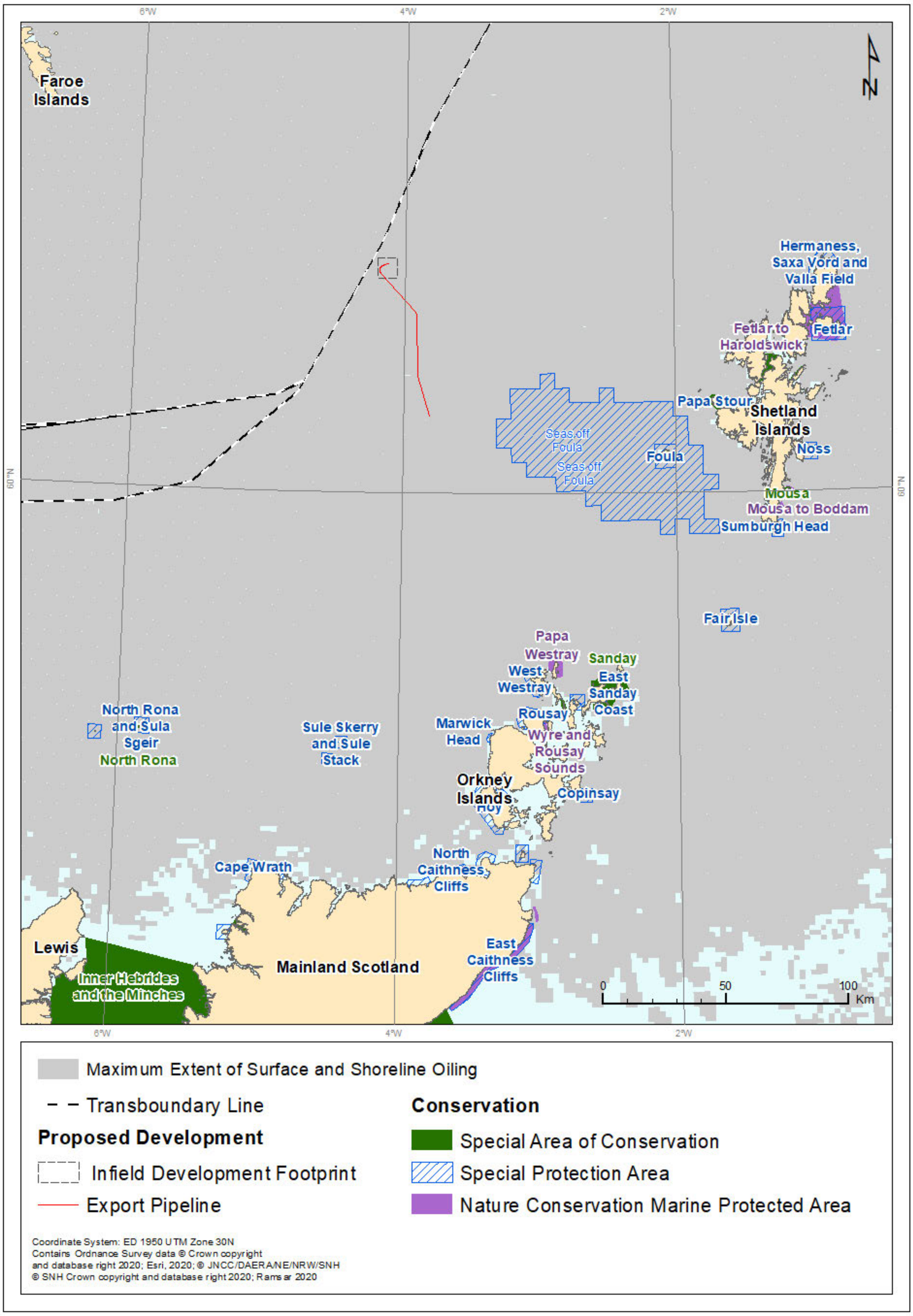


Figure 13.12: Maximum Potential Surface or Shoreline Oiling from an Uncontrolled Well Blow-out (a) or Crude Oil Storage Tank Rupture (b) overlain with Protected Sites

Source: OSRL, 2020a; OSRL, 2020b; NatureScot, 2021; JNCC, 2021.

Table 13.7: Protected Sites which may be Impacted by a Large Oil Spill from the Proposed Cambo Field Development

Name	Designation	Location	Well Blow Out		Complete loss of FPSO inventory		Qualifying Features (SAC: Only coastal habitats are listed; SPA: percentage bird populations listed refer to relevant biogeographic area for each species; MPA: Geodiversity Features not listed)
			Maximum Probability	Minimum Arrival Time	Maximum Probability	Minimum Arrival Time	
Hermaness, Saxa Vord and Valla Field	SPA	Coastal, Shetland	89.0%	7 Days 18 Hrs	49.0%	5 Days 3 Hrs	Breeding seabird assemblage and individual species of international importance (including at least 3% of red-throated diver, 4.6% of gannet, 4.6% of great skua and 2.8% of puffin)
Seas off Foula	pSPA	Offshore Shetland	80.5%	2 Days 12 Hrs	25%	3 Days 18 Hrs	Breeding seabird assemblage and individual species of international importance (including at least 5% of Great Skua), as well as migratory seabird assemblage during non-breeding season.
Fetlar to Haroldswick	NCMPA	Inshore, Shetland	60.0%	11 Days 0 Hrs	28.0%	8 Days 0 Hrs	Biodiversity: black guillemot; circalittoral sand and coarse sediment communities; horse mussel beds; kelp and seaweed communities on sublittoral sediment; maerl beds; shallow tide-swept coarse sands with burrowing bivalves
Fetlar	SPA	Coastal, Shetland	53.0%	11 Days 0 Hrs	25.0%	8 Days 0 Hrs	Breeding seabird assemblage and individual species of international importance (including at least 1.2% of Arctic tern, 75% of UK of red-necked phalarope, 0.8% of dunlin, 3.8% of great skua and <0.1% of whimbrel)
Foula	SPA	Coastal Shetland with marine component	42.0%	5 Days 0 Hrs	9.0%	5 Days 12 hrs	Breeding seabird assemblage and individual species of international importance (including at least 2.5 % of Arctic tern, 0.1% of Leach's storm petrel, 1.2% of red-throated diver, 16% of world population of Great Skua, 1.1% of guillemot, 5.3% of puffin and 1.9% of shag)
North Rona and Sula Sgeir	SPA	Coastal, off mainland Scotland	32.0%	9 Days 21 Hrs	5.0%	12 Days 9 Hrs	Breeding seabird assemblage and individual species of international importance (including at least 5.0% of Leach's storm petrel, 1.2% of

Name	Designation	Location	Well Blow Out		Complete loss of FPSO inventory		Qualifying Features (SAC: Only coastal habitats are listed; SPA: percentage bird populations listed refer to relevant biogeographic area for each species; MPA: Geodiversity Features not listed)
			Maximum Probability	Minimum Arrival Time	Maximum Probability	Minimum Arrival Time	
							storm petrel, 3.4% of gannet and 1.3% of guillemot)
Sumburgh Head	SPA	Coastal, Shetland	29.0%	13 Days 15 Hrs	3.0%	12 Days 15 Hrs	Breeding seabird assemblage and individual species of international importance
Noss	SPA	Coastal, Shetland	26.0%	18 Days 12 Hrs	4.0%	14 Days 6 Hrs	Breeding seabird assemblage and individual species of international importance (including at least 2.8% of gannet, 3.0% of great skua and 1.4% of guillemot)
Fair Isle	SAC	Coastal, Fair Isle	25.0%	11 Days 12 Hrs	5.0%	10 Days15 Hrs	Annex I Habitats: Vegetated sea cliffs of the Atlantic and Baltic coasts
Fair Isle	SPA	Coastal, Fair Isle	25.0%	11 Days 12 Hrs	5.0%	10 Day s15 Hrs	Breeding seabird assemblage of international importance and breeding species of European importance (including at least 2.5% of Arctic tern, 100% of Fair Isle wren and 1.1% of guillemot)
Papa Stour	SAC	Coastal, Shetland	22.0%	8 Days 3 Hrs	6.0%	7 Days 15 Hrs	Annex I habitats: reefs; submerged or partially submerged sea caves
Papa Stour	SPA	Coastal, Shetland	22.0%	8 Days 3 Hrs	6.0%	7 Days 15 Hrs	Individual species of international importance (including at least 2.3% of Arctic tern)
Sule Skerry and Sule Stack	SPA	Coastal, off Orkney	21.0%	12 Days 21 Hrs	1.0 < %	13 Days 9 Hrs	Breeding seabird assemblage and individual species of international importance (including at least 0.0% of Leach's storm petrel, 1.2% of storm petrel, 1.9% of gannet and 4.8% of puffin)
Mousa	SAC	Coastal, Shetland	18.0%	16 Days 12 Hrs	2.0%	16 Days 6 Hrs	Annex II species: common seal
North Rona	SAC	Coastal, off mainland Scotland	18.0%	10 Days 6 Hrs	2.0%	17 Days 18 Hrs	Annex II species: grey seal

Name	Designation	Location	Well Blow Out		Complete loss of FPSO inventory		Qualifying Features (SAC: Only coastal habitats are listed; SPA: percentage bird populations listed refer to relevant biogeographic area for each species; MPA: Geodiversity Features not listed)
			Maximum Probability	Minimum Arrival Time	Maximum Probability	Minimum Arrival Time	
Papa Westray	NCMPA	Coastal, Orkney	18.0%	10 Days 15 Hrs	3.0%	10 Days 15 Hrs	Black guillemot
Sanday	SAC	Coastal, Orkney	18.0%	11 Days 6 Hrs	3.0%	11 Days 12 Hrs	Annex I habitats: reefs. Annex II species: common seal
Calf of Eday	SPA	Coastal, Orkney	16.0%	12 Days 0 Hrs	3.0%	11 Days 3 Hrs	Breeding seabird assemblage of international importance
West Westray	SPA	Coastal with marine component, Orkney	14.0%	11 Days 12 Hrs	3.0%	12 Days 0 Hrs	Breeding seabird assemblage and individual species of international importance
North Caithness Cliffs	SPA	Coastal, mainland Scotland	12.0%	22 Days 18 Hrs	N/A	N/A	Breeding seabird assemblage and individual species of international importance (including at least 0.5% of peregrine falcon and 1.2% of guillemot)
Marwick Head	SPA	Coastal, Orkney	11.8%	14 Days	N/A	N/A	Breeding seabird assemblage and individual species of international importance (including at least 1.1% of world population of Great Skua)
Copinsay	SPA	Onshore, Orkney	11.0%	24 Days 6 Hrs	N/A	N/A	Breeding seabird assemblage of international importance
East Sanday Coast	SPA	Coastal, Orkney	8.0%	12 Days 6 Hrs	3.0%	11 Days 15 Hrs	Overwintering species of European importance
Rousay	SPA	Coastal, Orkney	8.0%	15 Days 12 Hrs	1.0 < %	14 Days 18 Hrs	Individual species of international importance (including at least 2.3% of Arctic tern)
Cape Wrath	SAC	Coastal, mainland Scotland	4.0%	15 Days 18 Hrs	N/A	N/A	Annex I Habitats: Vegetated sea cliffs of the Atlantic and Baltic coasts
Cape Wrath	SPA	Coastal, mainland Scotland	4.0%	15 Days 9 Hrs	N/A	N/A	Breeding seabird assemblage of international importance
Hoy	SAC	Coastal, Orkney	3.0%	19 Days 18 Hrs	N/A	N/A	Annex I Habitats: vegetated sea cliffs of the Atlantic and Baltic coasts

Name	Designation	Location	Well Blow Out		Complete loss of FPSO inventory		Qualifying Features (SAC: Only coastal habitats are listed; SPA: percentage bird populations listed refer to relevant biogeographic area for each species; MPA: Geodiversity Features not listed)
			Maximum Probability	Minimum Arrival Time	Maximum Probability	Minimum Arrival Time	
Hoy	SPA	Coastal, Orkney	3.0%	19 Days 18 Hrs	N/A	N/A	Breeding seabird assemblage and individual species of international importance (including at least 0.5% of peregrine falcon, 6.0% of red-throated diver and 14.0% of great skua)
Noss Head	NCMPA	Coastal, mainland Scotland	2.1%	32 Days 12 Hrs	N/A	N/A	Biodiversity: horse mussel beds
East Caithness Cliffs	SAC	Coastal, mainland Scotland	0.7%	33 Days 0 Hrs	N/A	N/A	Annex I Habitats: vegetated sea cliffs of the Atlantic and Baltic coasts
East Caithness Cliffs	SPA	Coastal, mainland Scotland	0.7%	33 Days 0 Hrs	N/A	N/A	Breeding seabird assemblage and individual species of international importance (including at least 0.5% of peregrine falcon, 3.2% of guillemot, 1% of herring gull and kittiwake, 1.6% of razorbill and 1.9% of shag)
East Caithness Cliffs	NCMPA	Coastal, mainland Scotland	0.7%	33 Days 0 Hrs	N/A	N/A	Biodiversity: Black guillemot
Inner Hebrides and the Minches	SAC	Marine, off mainland Scotland	0.7%	22 Days 18 Hrs	N/A	N/A	Annex II species: harbour porpoise

Source: OSRL, 2020a; OSRL 2020b; NatureScot, 2021; JNCC, 2021.

Sea Surface Oiling

Section 13.5.1 describes the sensitivities of birds on the sea surface to oiling, and Figure 13.11 demonstrates that at certain times of year there is potential for high densities of birds to be present on the sea surface in the wider vicinity of the proposed Development. Seventeen of the protected sites listed in Table 13.7 are SPAs designated for the protection of birds listed under Annex I of the Birds Directive, whilst one (Seas Off Foula) is a proposed SPA currently under consultation. Two NCMPAs are also designated for the black guillemot. The majority of these sites are designated for the assemblage of birds that they support, and some are additionally designated for supporting a significant proportion of the population of certain species. It would be very unlikely for a spill to affect all of these sites, and so it would be expected that in the event of an oil spill affecting one of the sites, population recruitment would occur from other neighbouring sites by the following breeding season. The Fair Isle SPA supports 100% of the breeding population of Fair Isle wren, and so this species would not be able to recruit from neighbouring populations. However, this species forages inland and would therefore not be expected to be impacted by an oil spill.

Marine mammals may also be sensitive to sea surface oiling, as discussed in Section 13.5.1. The Sanday and Mousa SACs, listed in Table 13.7, are both designated for the protection of common seals, whilst the North Rona SAC is designated for grey seals. However, marine mammals are known to be able to avoid surface oiling. Therefore, given the temporary nature of an oil spill to surface, it would not be expected that marine mammals would suffer a significant adverse effect.

Using the environmental consequence assessment Table 13.6 (Patin, 2004), the assessment of this scenario is summarised in Table 13.8.

Table 13.8: Environmental Consequence Assessment for Sea Surface Oiling

Scale	Assessment	Justification
Spatial	Sub-regional	Maximum extent of spill as shown in Figure 13.12
Temporal	Long-term	Expected recovery by the following breeding season, in around one year
Reversibility	Reversible	The disturbance to the environment would be removed within one year
General	Moderate	Change expected in no more than 1% of the population

In summary, although potential for recovery would be good, surface oil contamination has the potential to cause a measurable significant adverse effect to protected bird species. Therefore, there is the potential for a MEI to occur as a result of sea surface oiling at the following protected sites:

- SPAs: Sumburgh Head; West Westray; Fetlar; Foula; Hermaness, Saxa Vord and Valla Field; Sule Skerry and Sule Stack; Marwick Head; Noss; North Rona and Sula Sgeir; Calf of Eday; Fair Isle; Papa Stour; Rousay; and East Sanday Coast.
- pSPA: Seas off Foula.
- NCMPAs: Fetlar to Haroldswick; and Papa Westray.

Shoreline Oiling

A number of the SACs listed in Table 13.7 have been designated for the protection of coastal or shallow water habitats. These habitats include reefs (Sanday and Papa Stour), submerged or partially submerged sea caves (Papa Stour) and vegetated sea cliffs of the Atlantic and Baltic coasts (Cape Wrath, Fair Isle and Hoy). Additionally, the Fetlar to Haroldswick NCMPA has been designated for circalittoral sand and coarse sediment communities; horse mussel beds; kelp and seaweed communities on sublittoral sediment; maerl beds; and shallow tide-swept coarse sands with burrowing bivalves. These habitats have varying vulnerability to oiling.

As previously discussed, deeper water benthic habitats are not expected to be affected by oiling. Therefore, reefs, submerged sea cliffs, horse mussel and maerl beds would not be expected to be subject to significant adverse effect.

As discussed in Section 13.5.1, rocky shores are high energy environments which generally have the ability to recover quickly in the event of oiling. Partially submerged sea caves would therefore not be expected to be a vulnerable habitat. Exposure to the sea is a key determinant for which vegetated sea cliff habitats are designated, and this habitat is found in the spray zone of high energy cliffs. However, this small amount of exposure to sea water means that the potential for oil to cause significant adverse effect to this habitat is minimal.

Circalittoral sand and coarse sediment communities; kelp and seaweed communities on sublittoral sediment; and shallow tide-swept coarse sands with burrowing bivalves are all comprised of softer sediments in the tidal zone, which tend to be more vulnerable to the effects of oil spills (Section 13.5.1). This lower energy environment is also likely to take a longer time to recover in the event of significant adverse effect.

The SPAs (and NCMPAS designated for black guillemot) listed in Table 13.7 are considered less vulnerable to shoreline oiling. Breeding and overwintering sites used by birds tend to be on the upper stretches of cliffs or on grassy slopes beyond the high water mark, and so shoreline oiling is likely to have less of an impact on birds than that on the sea surface.

Using the environmental consequence assessment Table 13.6 (Patin, 2004), the assessment of this scenario is summarised in Table 13.9.

Table 13.9: Environmental Consequence Assessment for Shoreline Oiling

Scale	Assessment	Justification
Spatial	Sub-regional	Maximum extent of spill as shown in Figure 13.12
Temporal	Chronic	Expected recovery to soft sediment habitats to take more than one year
Reversibility	Slightly reversible	The disturbance to the environment would take longer than one year to be removed from soft sediment environments
General	Moderate	Change expected in no more than 1% of the population.

In summary, shoreline oil contamination has the potential to cause a measurable significant adverse effect to protected sedimentary shores. Therefore, there is the potential for a MEI to occur as a result of shoreline oiling at the Fetlar to Haroldswick NCMPA.

Conclusion

The MEI assessment shows that a large oil spill from either an uncontrolled well blow out or the complete loss of the maximum FPSO inventory at the Cambo Field Development will have the potential to cause a significant adverse effect to up to 17 SPAs, 1 pSPA and 3 NCMPAs due to oil on the sea surface, and to 1 NCMPA as a result of shoreline oiling. It should be noted however, that this assessment is based on stochastic modelling results. Stochastic modelling results are not representative of the effects of a single spill event, but illustrate the potential total geographic range of any oil spill event, based on hundreds of individual spill scenarios using a wide variety of metocean conditions. In the event of an actual oil spill, the affected area(s) will be much more localised, and will depend on the volume of oil spilled and local metocean conditions at the time.

13.6 Mitigation Measures

13.6.1 Preventative Measures

In order to prevent an oil spill occurring, stringent safety and operational procedures will be followed at all times.

Training, Experience and Suitability of Equipment

SPE, the Installation Operator for the FPSO and the Well Operator will be aware of the risk of a hydrocarbon spill at the proposed Cambo Field Development. Before offshore operations commence, the Installation/Well Operator will fully assess the competence and experience of all contractors, and the suitability of all equipment to operate in the West of Shetland area. All offshore personnel will be appropriately trained, experienced and certified to carry out their specific duties. The crew of the FPSO and the MODU will also undergo environmental awareness and safety training.

Well Design

The Cambo wells have been designed to minimise the potential for well control problems.

A thorough and formal peer-review approach will be used to review all critical elements of the well designs and the execution of drilling and abandoning the well. In addition, the well designs will be independently reviewed by a Well Examiner, as is required for all wells in the UK. The Well Examiner will also monitor the actual construction and any modifications to the wells.

Any change or deviation to the drilling programme, the subsurface parameters for the well design, or the well construction itself, will be subject to a formal management of change process. The purpose of this process is to identify, assess and document any changes prior to them being made. Each change requires management approval.

Well Control

Well control procedures will be in place, to prevent uncontrolled well flow to the surface and a full risk assessment will be performed as part of the planning phase of each well. Data on well pressure will be monitored throughout the drilling operations, to allow suitable mud composition and mud weights to be used.

A blow-out preventer (BOP) will be put in place once the 17½" section has been drilled and 20" × 13⅜" casing run in order to prevent the uncontrolled release of hydrocarbons from the well. The BOP stack and associated well control equipment on the MODU will be all rated to at least 15,000 psi working pressure. The BOP will be fully redundant, which means it can be operated independently from two physically separated locations onboard the MODU. In addition to the standard control systems, the BOP typically has several other backup emergency control systems, namely:

- Emergency Disconnect System (EDS). A single activation button closes the shear rams (large valves) on the BOP, followed by Choke and Kill line fail safe valves. The control system then automatically unlatches the top section of the BOP, i.e. the Lower Marine Riser Package (LMRP), from the main BOP;
- Autoshear System. In the event of an unplanned unlatch of the LMRP from the BOP, a pre-selected series of BOP rams shut and will close off the well;

- Acoustic Control System. Remote activation of the BOP via acoustic transponders can be used to operate a number of the BOP functions to make the well safe;
- Remotely Operated Vehicle (ROV) Intervention Panel. Numerous functions on the BOP can be operated by an ROV either by manual valve operation or stabbing into the BOP and using a pump on the ROV;
- Automatic Mode Function (AMF). On total loss of electric controls and hydraulic supplies, the BOP shear rams close automatically by means of a dedicated accumulator supply.

The BOP will be independently inspected and verified periodically. Regular testing of the BOP and its back up systems takes place onboard the MODU, typically at 7 and 21 day intervals.

Diesel/Fuel Oil Bunkering and Crude Oil Tanker Offloading Procedures

The highest risk of spillages occurs during bunkering operations between the FPSO/MODU and supply vessels and during transferring crude oil from the FPSO to the shuttle tanker. Vessel audits will be performed to confirm sea worthiness of supply vessels and shuttle tankers, and only DP vessels will be used, thus reducing likelihood of collision and potential tank rupturing. Bunkering and offloading operations will only take place in suitable weather conditions, and with a dedicated and continuous watch posted at both ends of the fuel/offloading hose. Where offtake operations require to be undertaken during periods of low visibility, initial connection operations for crude offtake will be limited to connection and planned disconnection during daylight hours only, with offloading within the prescribed weather limitation continuing throughout the night.

All hoses used during bunkering/offloading will be segmented with pressure valves that will close automatically in the event of a drop in pressure, such as might be caused by a broken connection or a leaking hose. In addition, the bunkering/offloading hoses will be stored on reels, to prevent wear and damage. These hoses will be visually inspected and their connections tested prior to every loading and offloading operation. The hose is visually checked for any obvious damage as it is spooled off the reel during connection operations with the tanker. Bunkering/offloading procedures will be followed throughout all bunkering/offloading operations. In addition, vendor specific hose leak detection systems will be reviewed and assessed during the procurement of the hoses.

FPSO Design

The loss of crude oil from one or all of the cargo storage tanks onboard the FPSO is extremely unlikely and would only be expected to occur during a major collision with another vessel or as a result of a natural disaster or similar event, whereby the integrity of the FPSO itself would be compromised. The FPSO will be designed with double bottom/doubled-sided hull. In addition, the cargo tanks will be configured with ballast tanks on the outside, offering protection from cargo tanks and reduced probability of loss. Section 13.8, on the potential impacts in case of catastrophic loss of the FPSO, describes further mitigation measures in place to prevent a serious collision event from happening.

Other Safety Measures

All equipment used on the FPSO and the MODU will have safety measures built in to minimise the risks of any hydrocarbon spillage. For example, the FPSO and the MODU will have open and closed drain systems in place that will route any operational spills onboard the FPSO or MODU to the slop tanks where they can be contained and recovered. There are also a number of spill kits available to deal with (smaller) spillages. All supply vessels will operate via DP, in order to reduce likelihood of collision and therefore potential tank rupturing.

13.6.2 Action to Stop a Subsea Spill During Drilling with the MODU

Initial Actions

The initial response to a subsea spill will be to use the ROV to identify the source of the leak. However, if at any time the safety of the MODU becomes compromised, the first priority will be to close the BOP immediately, disconnect the MODU from the well, and move off location. While the BOP is designed as fail safe closed, ROV and acoustic overrides are available should this not work correctly. This will allow the BOP to be closed within 24 hours (as a worst case), even if the MODU has to move off location first. Once at a safe distance from the well location, the ROV can be deployed to verify the BOP is properly closed, and no more oil is being spilled.

In a situation where the MODU is not disconnected from the well, and depending on when in the programme of operations a blow-out occurs, there may be various other methods available to control the flow of hydrocarbons to the surface. These include varying the pump rate and the use of various chemicals, such as weighting material (barite or calcium carbonate) and cement. Therefore, a contingency stock of cement and barite will be kept onboard the MODU. Although the time required to kill the well will be dependent on the how and why it has failed, a standard well kill operation takes between 12 and 48 hours. Once control of the well has been regained, the well can be fully abandoned with cement plugs.

Capping the Well

In the event of a subsea blow-out, whereby the BOP has failed and oil is freely flowing into the sea, the possibility of fitting a temporary capping device to the well will be considered. Once installed, this type of cap will completely seal off the well and stop oil from spilling into the sea whilst a relief well is drilled, and the original well is killed. This is currently regarded as the most likely successful approach to containing an uncontrolled subsea blow-out.

SPE is a member of Oil Spill Response Ltd (OSRL), which allows SPE access to the OSPRAG (the Oil Spill Prevention and Response Advisory Group) Capping Device. The OSPRAG well capping device is of a modular design which will allow installation at various points of the subsea wellhead or the blow-out preventer (BOP). SPE has reviewed the technical specifications of the cap and has confirmed that it is compatible with the subsea equipment proposed for use at Cambo. The Cambo wells all fall within the maximum technical specifications for well flow rate, pressure and temperature, confirming that this device is suitable for use. This capping device would be SPE’s primary option for sealing the well, if required.

At approximately 40 tonnes, the capping device is suitable for installation by a light intervention vessel. In the event that it is required, the device would be transported from Aberdeen to the Cambo Field, for deployment from a light well intervention vessel. Although no contract is in place for such a vessel, the type of vessel required to install the cap is relatively easy to procure and deploy. SPE is confident that a suitable vessel would be able to be procured at very short notice.

In the event of an uncontrolled well blow-out, it is anticipated that it would take a total of 30 days until the capping device could be deployed and the well contained. This timeframe would include sourcing of an appropriate vessel, mobilisation of the capping device to the Cambo Field, site preparation and clearance at the well location, deployment of the capping device and well containment. A full timetable for this procedure will be provided in the Well Operator’s Temporary Operations Oil Pollution Emergency Plan (TOOPEP) covering the drilling operations at Cambo operations.

Drilling a Relief Well

In the extremely unlikely event where a blow-out situation occurred and all options to kill the well failed, the only remaining option to bring the well back under control to stop the spill may be to drill a relief well. This would also apply as the required operation to permanently close the well once the well capping device (described above) was fitted. In this situation, SPE and the Well Operator will comply with the Oil and Gas UK “Guidelines on Relief Well Planning – Subsea Wells” (currently Issue 2, January 2013) which has been prepared by the OGUK Well Life Cycle Practices Forum.

Securing Required Equipment

As a worst-case scenario, it is assumed that an additional suitable MODU*,* would be required to conduct the relief well operations. The harsh conditions in the West of Shetland environment, and the deep-water at the proposed well locations, limits the number of MODUs which are technically capable of drilling in this geographic area. Therefore, an assessment of the suitability of available MODUs will be undertaken and the availability of these rigs will continue to be monitored throughout the drilling operations at Cambo. It has been estimated that it would take between four and six weeks to source an alternative suitable drilling unit, for the current operations to be suspended, and to move the unit onto the well location.

In addition to the drilling unit, all of the required drilling equipment will also have to be sourced and mobilised. In order to minimise the time involved, equipment would be sourced from off the shelf supplies and borrowed from other operators. Throughout this planning and preparation process, it is assumed that other license holders, drilling rig contractors and the government agencies would co-operate where necessary.

The initial relief well planning will be undertaken as part of the planning phase of the Cambo Field Development and will be carried out prior to the commencement of the drilling activities, including identification of relief well locations. In the event of an actual uncontrolled well blow-out, requiring the drilling a relief well, the next planning phase will include a review of the original well design and the reasons for the uncontrolled well blow-out, allowing any required changes to be made to the proposed relief well design, equipment and operating procedures. Preparation of equipment, procedures and consent applications will all be conducted in parallel with the activities required to gain access to a suitable replacement drilling unit.

Drilling the Relief Well

Several alternative relief well locations around the Cambo Field will be identified in the Relief Well Plan. All of these locations will be covered by digital site survey lines, enabling shallow gas and drilling hazard studies to be carried out within 5 days of the best relief well site being selected. A well path will be created to ensure that the suggested well surface locations are suitable and can be quickly tailored to the actual relief well programme if required in a blow-out situation. In order to optimise the relief well design, planning at the time of an incident will include a review of the current location and directional plans, along with the reasons for well failure and the resultant uncontrolled blow-out. This will allow any required changes to be made to relief well design and equipment, and additional operating procedures to be implemented if required.

Once a suitable MODU has been sourced and mobilised to location (expected to take four to six weeks, as stated above), and a relief well design selected, is anticipated that it would then take approximately 50 days to drill a relief well and kill the original well. Once the relief well reaches the original well, well kill operations would be carried out to permanently abandon it.

13.6.3 Oil Spill Response

If a large well control incident were to occur, it would be a priority to avoid spilled hydrocarbons impacting the coastline and, therefore, all available and suitable oil spill response techniques would be employed in the event of a spillage moving towards the shore.

Oil Pollution Emergency Plan

The FPSO's Installation Operator and the MODU's Well Operator will have an OPEP/TOOPEP in place, respectively. The OPEP/TOOPEP will conform to the Merchant Shipping (Oil Pollution, Preparedness, Response and Co-operation Convention) (Amendment) Regulations 2015 and the Offshore Installations (Emergency Pollution Control) Regulations 2002. The OPEP/TOOPEP will fully consider the specific oil spill response requirements for Cambo, taking into account the location, the prevailing meteorological conditions and the environmental sensitivities of the area. The plans will be designed to assist the decision-making process during a hydrocarbon spill, indicate what resources are required to combat the spill, minimise any further discharges and mitigate its effects.

Training, Exercises and Experience

Offshore Personnel

Specific members of the FPSO/MODU and standby vessel crew will have undertaken Oil Pollution Emergency Plan (OPEP) level oil spill response training. The Offshore Installation Manager (OIM) and the Installation/Well Operator offshore representatives will have undertaken the OPRED course for On-Scene Commander (OPEP Level 1).

As a minimum, the OPEP/TOOPEP will be distributed to personnel with designated duties in the event that an oil spill response is required, and to the regulatory authorities and statutory consultees. On receipt of the OPEP/TOOPEP, personnel will undergo awareness training in oil spill response prior to the commencement of drilling operations. The aim of this training is to familiarise offshore personnel with the Well Operator's oil spill procedures, levels of response effort, equipment orientation and use, and communication and reporting during an oil spill of any size.

The FPSO and MODU will regularly undertake training exercises, including vessel-based oil spill response exercises for the crew and an Offshore TOOPEP Exercise while on site, to ensure that offshore personnel are familiar with the TOOPEP and their responsibilities during a response. Similar offshore exercises will be held periodically for the FPSO's OPEP, once it is in operation.

Onshore Personnel

External oil spill response training will be organised for key onshore personnel, in line with the OPRED requirements and the internal requirements of environmental training and continual improvement in the Well Operator's Management Systems. Relevant SPE and Installation/Well Operator Duty Managers will, as a minimum, have undertaken the OPRED course, Corporate Management oil spill response awareness (OPEP Level 2). SPE is a member of Oil Spill Response Ltd (OSRL), with activation rights being provided to the Installation/Well Operator. A response advisor with OPEP Level 4 training would also be provided by OSRL.

Desktop exercises will be undertaken prior to commencement of operations to test the effectiveness of the oil pollution emergency plan. The Installation/Well Operator will conduct these oil spill response exercises to ensure that all personnel are aware of their roles in an actual oil spill incident. The exercises will also familiarise personnel with the lines of communication between the FPSO/MODU, offshore, the Installation/Well Operator onshore and SPE. The exercises will also include familiarisation of the roles and responsibilities of the various interested parties, and the chosen response strategies. If necessary, the OPEP/TOOPEP will be updated to reflect any changes required as a result of these exercises.

13.6.4 Oil Spill Response Strategies

The most appropriate response to a hydrocarbon spill from the planned drilling operations will be determined by oil type, logistics and prevailing physical conditions. A precise response strategy, which may employ one or more of the response options described below, can only be decided at the time of the spill. Oil spill response personnel must be prepared to adapt their actions as the spill develops as changes in both the prevailing conditions and the oil properties dictate.

In general, there are several response strategies which could be deployed in the event of an oil spill:

- Natural dispersion and monitoring;
- Application of chemical dispersants;
- Containment and recovery (surface and subsea);
- Shoreline protection and clean-up.

Natural Dispersion and Monitoring

Small to medium crude spill and diesel spills of all sizes are often best monitored but otherwise left to naturally degrade, if spilled offshore far away from any coastline. The natural evaporation and dispersion processes described in Section 13.4.2 will often be enough to successfully disperse the crude or diesel. These processes can be enhanced, where practicable, by physical agitation of the slick by the standby vessel and other vessels on site.

It is proposed that, in the event of a crude or diesel spill incident, the principal response strategy will be the monitoring and surveillance of the slick, where evaporation and natural dispersion will be the principle mechanisms for removal of oil from the sea surface.

On-site and Aerial Surveillance

A standby vessel will be on site at all times during drilling and production operations through the life of the proposed Development. In the early stages of an incident, the slick may be monitored by this onsite standby vessel, provided it can still meet its safety function. For larger, ongoing spills, aircraft will be mobilised to undertake aerial surveillance. However, in the short term, aerial surveillance may be undertaken by the helicopter contractor, until the dedicated surveillance aircraft is onsite.

A contract with OSRL will be put in place, allowing the rapid deployment of a dedicated aerial surveillance aircraft. The use of aerial surveillance in the monitoring of oil spills, as opposed to sea level vessels, allows for a more accurate picture of spill size and movement to be formed, especially in the monitoring of larger, more mobile spills. This would enable the development of various response options, including the decision to monitor the spill as it disperses naturally.

Oil Spill Modelling

Tracking and monitoring of the spilled oil would commence as soon as possible after the incident has occurred and continue for the duration of the response. This will be used to evaluate the extent of the slick, monitor its movement and dispersal, and decide on the appropriate response.

Initially, manual predictions can be used to estimate the movement of the oil on the sea surface as a function of the wind and current speed and direction. Oil spill modelling would also be employed to gain a more accurate indication of oil spill movement, using real time parameters to assist the predictions.

Chemical Dispersants

To aid natural dispersion of a large oil spill, or when sensitive receptors such as flocks of seabirds are at risk, the use of chemical dispersants will be considered. As a member of ORSL, SPE will have access to the UK Dispersant Stockpile. The use of chemical dispersants has been found to be effective when sprayed onto fresh oil in moderate sea states, which are often present in the Cambo area. However, chemicals dispersants are ineffective on emulsified or weathered oils spills. Before use, the effectiveness of the available dispersant must always be tested on an actual sample of the spilled oil before using dispersants on the slick itself. Due to modelling parameters for the Cambo oil not yet being available for use in the OSCAR oil spill database, an analogue crude was used for the oil spill modelling as described in Section 13.4.3. Once Cambo starts producing oil, SPE will undertake dispersant tests to determine the actual emulsification rates of the Cambo crude to verify if the emulsification potential predicted by the oil spill modelling is accurate, and to confirm whether the use of chemical dispersant will be effective or not.

The use of chemical dispersants may therefore be considered for oil spills which are observed to not disperse naturally, in order to protect vulnerable concentrations of seabirds at sea or to prevent the oil slick from reaching a sensitive coastline. Dispersants can be sprayed directly onto floating oil as a fine mist, either from aircraft or boats. Large slicks can be treated quickly, deterring the formation of emulsions and accelerating the biodegradation of oil in the water column.

The natural processes of evaporation and dispersion will usually remove the lighter fractions from the spilled oil rapidly, without the need for chemical treatment. Dispersants are generally less effective on light oils, such as diesel, as the dispersants sink through the oil, reducing the contact time between the oil and water interface. As a result, chemical dispersants should generally not be used on these spilled light oils.

The use of chemical dispersants will result in increased concentrations of toxic components within the upper water column. Many spawning species have pelagic eggs and larvae which are vulnerable to oil which is chemically dispersed into the water column. These eggs and larvae may become exposed to higher concentrations of oil if dispersants were used, than if the oil had been allowed to evaporate and disperse naturally.

Therefore, the decision to use chemical dispersants will always need to consider its positive benefits against any resulting impacts in the water column.

Containment and Recovery

Booms may be used to contain a large slick on the sea surface, concentrating the oil for recovery by skimmers. The effectiveness of both booms and skimmers depends on the sea and weather conditions, with the most efficient containment and recovery of oil only achieved under calm conditions. In order to create a barrier with which to prevent the oil escaping, booms must move with the surface water. However, with the increasing flexibility required to achieve this in rougher seas, comes reduced boom rigidity and a corresponding reduction in its ability to contain oil. As skimmers float on the sea surface, they also experience many of the operational difficulties that apply to booms. The increased wind and water movement experienced in the West of Shetland offshore environment suggests that surface containment and recovery equipment are unlikely to be effective on a spill at the proposed Development.

Recovery equipment requires the spilled oil to be of sufficient thickness to allow it to be lifted and sucked from the surface while disturbing the underlying water as little as possible. If the slick is too thin large quantities of water will be taken up by the process not only reducing the effectiveness of oil collection, but also causing additional issues for containment and disposal of the oily water. As the slick becomes increasingly spread out and broken up, the effectiveness of this response option decreases.

Shoreline Protection and Clean-up

Shoreline Protection

Where possible, the first priority should be to prevent spilled hydrocarbons from reaching coastal areas. As described above, a number of different response options are available to contain the spilled oil offshore or to limit the movement of the slick across the sea surface. However, there remains the potential for a large slick to threaten the shoreline communities.

The initial response to any spill will be onsite and aerial surveillance to track its movement, supplemented by modelling to predict which shorelines the spilled oil may threaten. With a better understanding of the shorelines at risk from the spill, information will be gathered on the coastal habitats present in these areas and their associated communities. Any coastal sensitivities, including vulnerable shoreline types, coastal and inshore protected areas (including those designated under the European Habitats and Birds Directives), areas of inshore fisheries or aquaculture, coastal tourist or recreational areas, and other coastal industries, will be identified. Throughout the well planning process, basic information has been gathered on the surrounding coastal sensitivities and this will be included within the TOOPEP during drilling and subsequent OPEP during the production phase to assist in any required oil spill response. This will be supplemented by the OSRL Geographical Information System (GIS) facility (which maps coastal sensitivities around the UK), local authority plans, strategy documents, maps, and other available resources. The closest coastlines to the proposed Cambo Field Development are those associated with the Shetland Islands; the Shetland Oil Terminal Environmental Advisory Group (SOTEAG) has produced shoreline sensitivity maps for the Shetland coastline. Broad-scale surveys, from vehicles, inshore vessels or helicopters, will be mobilised to gain an overview of the shoreline types and main sensitivities along the potentially affected stretch of coast, and consideration will be given to carrying out more detailed surveys of particularly environmentally sensitive or commercial important areas of shoreline prior to any oil beaching.

Once the coastal sensitivities under immediate threat have been identified, coastal protection resources will be deployed to protect priority areas. Although SPE and the Installation/Well Operator will provide all necessary assistance as required, all shoreline protection strategies will be determined by the local authority in consultation with their environmental advisors. Details of local equipment suitable and available for shoreline booming will be available through coastal strategy documents. Additional response personnel and appropriate shoreline protection equipment will be provided by SPE and the Installation/Well Operator, through their oil spill response contractor, OSRL.

Oil spill modelling has indicated that the coastlines of Norway, the Faroe Islands and the Shetland Islands are under the greatest threat from beaching of crude oil (Section 13.4.3). These high energy coastlines are characterised by sea cliffs with little or no intertidal zone or exposed rocky shores consisting of bedrock platforms and boulders. Although oil may persist on more sheltered shores for longer, wave action may start to remove the oil from more exposed rocky shores more rapidly. With the dominance of exposed, vertical cliffs, it could be assumed that these northerly rocky shores would recover relatively quickly from a beaching oil spill, with minimum requirement for human intervention. These shores will also be the most difficult to protect with booms, due to access issues and the size of the approaching waves. As a result, priority is likely to be given to the more sensitive muddy shores and the large voes which hold fish and shellfish farms.

Shoreline Clean-up

Every effort will be made to clean-up up any oil that reaches the shoreline. Depending on the type of coastline affected, various methods exist to remove oil from the shore. Sediment shores are generally more amenable to methods that will physically 'scoop' the oil from the beach, whereas appropriate washing and rinsing techniques are likely to be more effective on rocky substrata.

If a spill does reach the shoreline, aerial surveillance will be used to gain a broad overview of where it has beached, while vehicles or vessels will be used to make a more detailed, shore specific assessment. Through OSRL, stretches of shoreline will be surveyed, recording the type of shoreline (sediment type, slope, exposure etc), its use (tourism, recreation, etc), and any environmental sensitivities (protected areas, seal breeding sites, otter holts, etc), as well as the severity of any oiling (mobile oil, surface or subsurface oil, stranded oil, sheen etc). Information on access arrangements, parking and storage arrangements, and proximity to other facilities will also be recorded. This information will be used to determine where to focus the clean-up effort by making the optimum use of the available clean-up resources.

In certain instances, the physical disturbances caused by some clean-up methods may be more damaging to shorelines and their associated communities than the direct effects of an oil spill. This is particularly true in more sensitive, less dynamic habitats, such as mudflats or saltmarsh. In addition, steeply sloping and unstable rocky shores or large soft mudflats are often difficult to access. Therefore, if oil does reach the shore, clean-up methods should be chosen carefully so as to not cause a greater degree of damage.

With all required assistance and information provided by SPE and the Installation/Well Operator, the strategy for shoreline clean-up ultimately will be directed by the affected local authorities. Adequately trained personnel and clean-up equipment will be made available to assist any clean-up operations, through OSRL.

13.6.5 Liability and Insurance

SPE will ensure that it has sufficient finances and insurance in place to cover the cost of responding to a large oil spill (including the use of a well capping device and drilling a relief well, if required). SPE is a member of the Offshore Pollution Liability Association Limited (OPOL). OPOL is a voluntary oil pollution compensation scheme to which all offshore operators currently active on the UKCS are party to. OPOL is accepted as representing the committed response of the oil industry in dealing with compensation claims arising from offshore oil pollution incidents from exploration and production facilities. At present the OPOL Limit of Liability is US $250 million per incident. Based on a recent oil spill modelling study undertaken on behalf of the Oil Spill Prevention and Response Advisory Group (OSPRAG), the current occurrence limit should be sufficient to cover the third party pollution compensation and remediation costs associated with the majority of spill scenarios, with only a small number of wells having the potential to exceed the OPOL Limit (OGUK, 2018).

While OPOL provides for third party clean-up and compensation costs to a predetermined limit, there may be additional extra expenses that the SPE as the Licence Operator may have to cover in the event of a blow-out, such as those related to bringing the well back under control and drilling a relief well. SPE will ensure that sufficient finance or insurance/indemnity provision is available to cover the drilling of relief wells.

13.7 Conclusions

The risk of a large-scale hydrocarbon spill during drilling operations or during the subsequent production phase of the proposed Cambo Field Development is very low. Historic spill data shows that large (crude) oil spills from oil and gas installations are very rare on the UKCS, and the overall volume spilled each year continues to reduce gradually over time. There has never been an oil spill as a result of a well blow-out on the UKCS. The largest oil spills (>25 tonnes) from MODUs were related to OBM discharges, with only 2 recorded crude oil spills of this size during the period 1990-2019. OBMs will not be used during the proposed Cambo wells, removing the risk of this type of spill. Similarly, large oil spills from FPSOs are also very rare, with only 9 spills over 25 tonnes from a total of 689 spills from FPSOs in the period 1990-2019.

The oil spill modelling scenario shows that a large spill, such as from a well blow-out or a complete loss of inventory from the Sevan FPSO, would, under the majority of meteorological circumstances, drift northeast of the proposed well location. A large oil spill would have the potential to reach the coasts of Shetland, Orkney, Faroe Islands or Norway, and during spring and summer time there would be a small probability of oil beaching on the north coast of mainland Scotland and the Isle of Lewis as well. These conclusions are based on modelling results that assume no intervention in the slick. In practice oil spill response resources would be mobilised immediately if a spill occurred. It would be a priority for SPE and the Installation/Well Operator to attempt to ensure no spilled oil would impact the coastline and, therefore, all appropriate oil spill response techniques would be employed in the event of a spillage moving towards the shore.

It should be noted that these potential impacts would only occur under extreme circumstances in the event of a very large oil spill, as modelled in this ES. Historic data on oil spills from oil and gas installation operating on the UKCS show that there has only been one crude oil spill of such a large size (112 tonnes) in the period 1990 to 2019. This spill happened in 1990. Historic data suggest small spills of less than 1 tonne represent the most likely spill scenarios.

Throughout the life of field, the focus will be on the prevention of oil spills. Stringent safety and operational procedures will be adhered to throughout the operations. A robust well design has been developed to minimise the potential for well control issues, and all critical elements of this design and the execution operations have been both peer and independently reviewed.

The Installation/Well Operator will have a detailed operation specific OPEP/TOOPEP in place to ensure that immediate and appropriate action is taken in the event of any hydrocarbon spillage, minimising any impact to the marine environment. A contract with OSRL is in place, allowing the rapid deployment of oil spill response equipment and personnel in the event of a large oil spill incident. Specific response equipment would be available including booms to contain surface spills at sea or protect sensitive shorelines. Ultimately, the type and size of spill, along with the metocean conditions at the time of the spill, will dictate which of these resources is most suitable for the spill event. Additional shore clean-up equipment is also available.

With the measures in place to prevent an oil spill incident from happening and the oil spill contingency planning and response resources available to the Well Operator/Installation Operator in the event of a large oil spill event, the residual environmental risk posed by the proposed Cambo Field Development is judged to be reduced to an acceptable level.

13.8 Catastrophic Loss of the FPSO, MODU, a Vessel or the Helicopter

Under extreme circumstances, the FPSO, MODU, a support vessel or a helicopter may sink. This could be caused by a variety of reasons, such as a serious blow-out situation, shallow gas release, a collision with another vessel, a freak weather event or other natural disaster, a catastrophic error during ballasting or offloading of the FPSO or ballasting of the MODU. These events are extremely rare and happen so infrequently that no reliable statistics could be obtained to quantify them.

A raft of mitigation measures are in place for preventing such an event from happening. These include all mitigation measures mentioned in Section 13.6 above, as well as the following:

- The FPSO and the MODU will be inspected for sea worthiness and the Well Operator/Installation Operator audited prior to operations commencing;
- The MODU will have disconnect procedures in place, to be able to quickly move off the wells, if required;
- A blow-out preventer will be installed after the 17½" section is drilled and the 20" × 13⅜" casing cemented in place;
- Well control procedures will be in place and an appropriate mud programme will be designed in order to maintain well control at all times;
- Personnel will be appropriately trained, experienced and certified;
- The competence and experience of all contractors will be assessed before they are contracted;
- All supply vessels will operate via DP, to reduce the likelihood of a collision;
- A digital site survey for drilling hazards has been carried out to confirm that there is no shallow gas in the area;
- A 500 m exclusion zone will be enforced around the FPSO and the MODU for general shipping in the area;
- A standby vessel will be on site throughout the life of field to enforce the 500 m exclusion zone;
- The FPSO and the MODU and associated vessels will use appropriate lighting;
- The suitability of supply, other support vessels and the helicopter will be assessed before they are contracted;
- The standby vessel will be equipped with radar and communication equipment so that any vessel in the area can be detected and contacted, if required;
- The United Kingdom Hydrographic Office (UKHO) and Ministry of Defence (MoD) will be kept informed of drilling activities.

In the event of the loss of the FPSO, the MODU, a support vessel or a helicopter, it would be unlikely that the vessel or aircraft would be salvageable in this deepwater environment and, therefore, would most probably remain on the seabed as a wreck. Attempts would be made to salvage any remaining hydrocarbons and other potentially harmful products onboard the FPSO/MODU/vessel, although it should be noted that, in practice, these types of operations are prone to causing pollution incidents. The potential impact of the release of oil to the marine environment is described above in Section 13.5.

The wreck of the FPSO, MODU, vessel or helicopter would be marked on navigational charts to prevent the snagging of fishing nets and other towed equipment. Shipwrecks UK (2019) has identified more than 46,000 wrecks in the waters around the UK and Ireland. In general, the presence of wrecks on the seabed is not considered to have any long lasting negative environmental effects. Therefore, given the remote chance of such an event happening due to appropriate mitigation measures in place, and minimal negative long-term environmental impacts, the residual impact of a loss of rig is considered to be insignificant.

Section 14

Conclusions

14 CONCLUSIONS

Siccar Point Energy E&P Limited (SPE) proposes the development of the Cambo oil field in Blocks 204/4a, 204/5a, 204/9a and 204/10a, in the West of Shetland region of the United Kingdom Continental Shelf (UKCS). The proposed infield development location is centred approximately 125 km to the West of the Shetland Islands, in a water depth of 1,050 m to 1,100 m. The proposed development comprises one field, two drill centres and a pipeline to the West of Shetland Pipeline System (WOSPS). The expected hydrocarbons from the wells are oil and gas.

Hydrocarbons will be produced from two drill centres using a Floating Production, Storage and Offloading vessel (FPSO). Oil will be exported via shuttle tanker, whilst gas will be exported via a 70 km pipeline to the WOSPS. SPE proposes that a Well Operator will be appointed to drill and complete the wells. Subsequently, an Installation Operator will be appointed to operate the proposed Development. A phased development on a standalone basis is the preferred development option for the Cambo field. The first phase of the development will comprise nine production wells (this includes completion of the currently suspended Cambo 204/10a-5Y well as a producer) and four water injection wells. The wells will be drilled using a Mobile Operated Drilling Unit (MODU). In subsequent development phases SPE may develop a third drill centre comprising five additional wells that would target the additional resources present but not developed by the current two drill centre plan. However, these wells have not been included in this Environmental Impact Assessment (EIA).

SPE is currently planning to commence offshore development activities at the Cambo field in 2021, with first drilling operation in 2022. First oil is expected in 2025. The well clean-up operations from the FPSO may require some flaring.

SPE plans to use water based mud (WBM) throughout the wells, and cuttings will be returned to the MODU before being discharged at the sea surface. The wells will be left suspended until the FPSO comes online in 2025.

The proposed Selection Options are presented in Section 2, Project Description in Section 3, Environmental Description in Section 4, Impact Identification in Section 5 and Impact Assessment Methodology in Section 6. All potentially significant environmental impacts assessed in Section 7 to Section 13. The key environmental concerns identified as requiring consideration for impact assessment were:

- Physical Presence (Section 7);
- Atmospheric Emissions (Section 8);
- Drilling Discharges (Section 9);
- Produced Water Discharges (Section 10);
- Underwater Noise and Wildlife Disturbance (Section 11);
- Waste Management (Section 12);
- Accidental Events (Section 13).

The main issues identified and conclusions on their residual impacts following the incorporation of mitigation measures are summarised below.

14.1 Physical Presence

There are no protected or sensitive habitats or species associated with the proposed location of the FPSO site and associated subsea infield infrastructure and so significant adverse effects on nature conservation are not expected in this regard. Any effects on local seabed communities will be very small in size and will last for the duration of the development, for as long as the infrastructure remains in place. Impacts will cease on decommissioning when any infield infrastructure placed upon the seabed will be removed, after which the seabed communities are expected to recover to baseline conditions over time.

The proposed Gas Export Pipeline, on the other hand, will traverse the Faroe-Shetland Sponge Belt Nature Conservation Marine Protected Area (NCMPA) resulting in benthic habitat take, benthic habitat disturbance and alteration and temporary deposition of sediment plumes. Features potentially affected include ‘offshore sands and gravels’ and ‘burrowed mud’ Priority Marine Feature (PMF) habitats and the ‘ocean quahog’ PMF species as well as a very short section of potential Annex I stony reef. The proposed pipeline also has the potential to interact with important sponge assemblages although sponge coverage along the entire pipeline route was found to be very low and no Boreal ‘ostur’ communities, which are characteristic of the Faroe-Shetland Channel, were found during a recent pipeline route survey. The spatial extent of the predicted effects of the pipeline installation and operation will be very small within the context of the NCMPA and with respect to habitat disturbance and plume deposition, will be very short term lasting for the duration of the pipeline laying only. Effects of habitat take and habitat alteration will last for as long as the infrastructure remains in place. A Comparative Assessment will be undertaken to assess all potential decommissioning options available for the gas export pipeline at the time, including complete recovery of the pipeline as well as leaving sections of the pipeline in-situ. In conclusion therefore, effects of the physical presence of the proposed export pipeline on high value receptors will be long term, but will be highly localised and will have no significant effects on the conservation objectives of the NCMPA.

The proposed location of the FPSO site and infield infrastructure is not associated with significant fishing or vessel traffic activity and so is highly unlikely to displace or interfere with fishing, shipping and navigation. Consideration will be given to installing reflectors on the mooring ropes of the FPSO to allow fishing vessels to avoid entanglement with the FPSO, while a safety vessel will be available throughout installation and operational phases to ensure other vessel users maintain a safe distance from the infrastructure. Some exclusion from fishing grounds around the immediate area of the pipelaying vessel may occur during pipe laying but this will be temporary lasting for the duration of the pipe laying operation, estimated to be 23 days. Also, the pipe laying vessel will be continuously moving along the pipeline route and so long-term obstruction and exclusion at any one location will not occur. Effects on fishing, shipping and navigation due to the physical presence of the proposed Development are therefore considered to be insignificant.

14.2 Atmospheric Emissions

Atmospheric emissions will be produced during drilling, installation and production operations, as a result of power generation onboard the MODU and FPSO, as well as on the standby vessel, supply vessels, subsea construction vessel, pipeline laying vessel and helicopter activity. In addition to these, there will be flaring emissions from the pilot flare onboard the FPSO. These emissions will contribute to local and global environmental effects. At a local level, impacts are mitigated by Health and Safety measures in place to control emissions and by the dispersive nature of the offshore environment. As such, the any local air pollution effects are expected to be negligible, and therefore not significant. Effects from atmospheric emissions generated by the proposed Development on conservation areas are also expected to be negligible, with no impact on conservation objectives or site integrity anticipated.

Emissions will also contribute to global environmental issues, including climate change. The contribution of the proposed drilling programme is comparable to similar operations, and small in comparison to emissions at an industry wide level. Therefore, it may be concluded that the individual Global Warming Potential (GWP) generated by the operations associated with the proposed Cambo Field Development and its resulting impacts are too small to be assessed by itself. Although the urgency of the requirement to reduce GWP emissions resulting from hydrocarbon combustion is fully acknowledged, the ultimate cumulative global implications of global climate change are still poorly understood and therefore very hard to assess. The overall strategy to address this issue ultimately lies with national and international governance. Development of the Cambo field for oil and gas extraction is in line with the UK Government’s long-term vision for the offshore oil and gas industry on the UKCS to achieve net-zero emissions by 2050 as set out in the UK Energy White Paper released in December 2020. SPE is committed to contribute towards achieving this ambitious target by 2050, where it can.

14.3 Drilling Discharges

The drilling discharges from the proposed drilling operations associated with the proposed Development have the potential to cause moderate effects in the immediate vicinity of the well locations, primarily through physical changes to the seabed.

As a general rule, effects of WBM and cuttings discharges on the benthic environment are related to the total quantity discharged and the energy regime encountered at the discharge site, particularly the currents close to the seabed itself (Neff, 2005). Based on these factors, the discharge of cuttings, mud and cement at the Cambo wells have the potential to cause a localised impact to the benthic environment, primarily through direct physical changes to the seabed.

This impact section was based on a worst-case modelling exercise that assumed all tophole sections will be drilled. However, wherever technically feasible, CAN-ductors will be used, potentially reducing the overall extent, thickness and impact of drill cuttings.

Evidence from long-term monitoring at other wells drilled West of Shetland at the Laggan field (Jones, et al., 2012) indicate that recovery of megafaunal assemblages in the wider area will be noticeable after a few years, but that full recovery of megafaunal assemblages in areas directly affected by cuttings will be slower and may take more than 10 years.

As a conservative estimate, it is expected that all benthos will be lost within the area with cuttings deposits over 50 mm. Beyond this immediate area of effect, survival rates will increase with decreasing cutting deposition thickness.

The cuttings dispersion modelling study shows that cuttings deposition of greater than 50 mm thickness will cover an area between 0.0071 km^{2}and 0.015 km^2, indicating the area in which all benthos is expected to be lost, which represent a very small fraction of the available local habitat in the wider project area.

In addition, no species or habitats of conservation interest have been previously identified in immediate area around the proposed well location. Seabeds with WBM contaminated drilling discharges generally have a good potential for recovery, over time.

The magnitude of effect in this small area is considered to be moderate, and receptor value is assessed as ‘low’, and therefore the effect is considered to be not significant.

The furthest extent of the thinnest layer (0.1 mm) of cuttings deposition modelled is 13.9 km from the boundary of Faroe-Shetland Sponge Belt NCMPA. There are no predicted effects on the protected area or any of its features of conservation concern.

The impacts from discharges of cuttings and muds from the sea surface are expected to have only a minor effect. This is largely attributable to the fact that any cuttings and mud discharged at the sea surface and will become widely dispersed as they settle through the water column and will form a patchy very thin layer with a maximum deposition thickness of 0.1 mm. Impacts from these discharges can therefore be considered minor to negligible and thus insignificant.

14.4 Produced Water Discharges

The fate of produced water discharges has been subject to detailed numerical modelling which shows that plumes will be rapidly diluted to below the Risk Based Approach (RBA) threshold within a few hundred metres of the discharge point even under worst-case meteorological and oceanographic conditions. Any environmental effects of produced water discharged at the proposed Cambo Field Development are expected to be limited within 500 m under typical conditions or within 888.9 m under a worst-case scenario, although ultimately this can only be definitively confirmed once the constituents of the produced water at Cambo are known and are demonstrated to have a PEC:PNEC ratio of ≤1. The modelling results have influenced the design parameters of the produced water outfall, so that appropriate mitigation is built into the design of the outfall (i.e. discharge temperature of 45˚C or less and discharge orientated at a downwards angle).

Only industry standard production chemicals will be used and discharged during operations at the Cambo field. All chemicals used will be included in the Offshore Chemical Notifications Scheme (OCNS) and the most environmentally friendly options evaluated, and where possible chemicals that Pose Little or No Risk (PLONOR) to the environment will be used. Additionally, chemical risk assessments will be undertaken as part of the environmental permitting process.

Significant interaction with seabed sediments and communities are highly unlikely due to the rapid dilution rates within receiving waters and the buoyant nature of the plumes so that they will remain near to the sea surface. Other oil and gas facilities are located far beyond the point at which plumes are diluted to below RBA threshold such that potential mixing of respective plumes and potential synergistic effects are highly unlikely to occur. Consequently, significant effects on the interests of the Faroe-Shetland Sponge Belt NCMPA are not forecast to occur and associated conservation objectives are not expected to be significantly affected. In conclusion, significant effects of the discharge of produced water on benthic and water column communities either alone or cumulatively with other discharges in the region are not expected.

14.5 Underwater Noise and Wildlife Disturbance

Anthropogenic noise from shipping, and potentially also from existing oil and gas installations, is currently believed to be the main source of anthropogenic background noise in the area of the proposed Cambo Field Development. The addition of (mainly) low frequency noise generated by the MODU and subsequently by the FPSO and their support vessels will add to the overall anthropogenic underwater noise footprint in the area. No good practice guidelines exist in the UK for drilling or production activities since these are thought to be of low concern in terms of disturbance to cetaceans (JNCC, 2010a). Consequently, these are not expected to cause any significant impacts on marine mammals potentially present in this area.

In addition, the planned piling operations of the Tie-in Structure (CTIS) to the seabed at the WOSPS Pipeline End Manifold (PLEM) may cause avoidance responses and other, more subtle, behavioural reactions in cetaceans within a few kilometres of the piling operations. Given the short duration of such operations (1 day), any such effects are expected to be transient and are therefore also not considered likely to be significant.

14.6 Waste Management

Several different waste streams will be generated throughout the development's lifespan. Waste management will be undertaken in compliance with current environmental legislation and in line with the waste hierarchy. The management of offshore waste generated on the UKCS is strictly regulated and the UK has well established infrastructure in place to manage this waste effectively. Therefore, no significant impacts are anticipated.

14.7 Accidental Events

The risk of a large scale hydrocarbon spill during drilling operations or during the subsequent production phase of the proposed Cambo Field Development is very low. Historic spill data shows that large (crude) oil spills from oil and gas installations are very rare on the UKCS, and the overall volume spilled each year continues to reduce gradually over time. There has never been an oil spill as a result of a well blow-out on the UKCS. The largest oil spills (>25 tonnes) from MODUs were related to OBM discharges, with only 2 recorded crude oil spills of this size during the period 1990 to 2019. OBMs will not be used during the proposed Cambo wells, removing the risk of this type of spill. Similarly, large oil spills from FPSOs are also very rare, with only 9 spills over 25 tonnes from a total of 689 spills from FPSOs in the period 1990 to 2019.

The oil spill modelling scenario shows that a large spill, such as from a well blow-out or a complete loss of inventory from the FPSO would, under the majority of meteorological circumstances, drift northeast of the proposed well location. A large oil spill would have the potential to reach the coasts of Shetland, Orkney, Faroe Islands or Norway, and during spring and summer time there would be a small probability of oil beaching on the north coast of mainland Scotland and the Isle of Lewis as well. These conclusions are based on modelling results that assume no intervention in the slick. In practice oil spill response resources would be mobilised immediately if a spill occurred. It would be a priority for SPE and the Installation/Well Operator to attempt to ensure no spilled oil would impact the coastline and, therefore, all appropriate oil spill response techniques would be employed in the event of a spillage moving towards the shore.

It should be noted that these potential impacts would only occur under extreme circumstances in the event of a very large oil spill, as modelled in this Environmental Statement (ES). Historic data on oil spills from oil and gas installation operating on the UKCS show that there has only been one crude oil spill of such a large size (112 tonnes) in the period 1990 to 2019. This spill happened in 1990. Historic data suggest small spills of less than 1 tonne represent the most likely spill scenarios.

Throughout the life of field, the focus will be on the prevention of oil spills. Stringent safety and operational procedures will be adhered to throughout the operations. A robust well design has been developed to minimise the potential for well control issues, and all critical elements of this design and the execution operations have been both peer and independently reviewed.

The Installation/Well Operator will have a detailed operation specific Oil Pollution Emergency Plan (OPEP)/ Temporary Operations Oil Pollution Emergency Plan (TOOPEP) in place to ensure that immediate and appropriate action is taken in the event of any hydrocarbon spillage, minimising any impact to the marine environment. A contract with Oil Spill Response Limited (OSRL) is in place, allowing the rapid deployment of oil spill response equipment and personnel in the event of a large oil spill incident. Specific response equipment would be available including booms to contain surface spills at sea or protect sensitive shorelines. Ultimately, the type and size of spill, along with the metocean conditions at the time of the spill, will dictate which of these resources is most suitable for the spill event. Additional shore clean-up equipment is also available.

With the measures in place to prevent an oil spill incident from happening and the oil spill contingency planning and response resources available to the Well Operator/Installation Operator in the event of a large oil spill event, the residual environmental risk posed by the proposed Cambo Field Development is judged to be reduced to an acceptable level.

Under extreme circumstances, the FPSO, MODU, a support vessel or a helicopter may sink. This could be caused by a variety of reasons, such as a serious blow-out situation, shallow gas release, a collision with another vessel, a freak weather event or other natural disaster, a catastrophic error during ballasting or offloading of the FPSO or ballasting of the MODU. These events are extremely rare and happen so infrequently that no reliable statistics could be obtained to quantify them. Appropriate mitigation measures will be put in place for preventing such an event from happening.

In the event of the loss of the FPSO, the MODU, a support vessel or a helicopter, it would be unlikely that the vessel or aircraft would be salvageable in this deepwater environment and, therefore, would most probably remain on the seabed as a wreck. Attempts would be made to salvage any remaining hydrocarbons and other potentially harmful products onboard the FPSO/MODU/vessel, although it should be noted that, in practice, these types of operations are prone to causing pollution incidents.

The wreck of the FPSO, MODU, vessel or helicopter would be marked on navigational charts to prevent the snagging of fishing nets and other towed equipment. Shipwrecks UK (2019) has identified more than 46,000 wrecks in the waters around the UK and Ireland. In general, the presence of wrecks on the seabed is not considered to have any long lasting negative environmental effects. Therefore, given the remote chance of such an event happening due to appropriate mitigation measures in place, and minimal negative long-term environmental impacts, the residual impact of a loss of rig is considered to be insignificant.

14.8 Overall Conclusions

The only potential significant impact identified in the environmental impact assessment is that of a large-scale oil spill. However, the probability of such a spill is very low and mitigation and management procedures will be in place to prevent this from happening, as well as adequate resources to deal with any such spill should it occur.

The drilling discharges have the potential to cause moderate effects in the immediate vicinity of the well locations through physical changes to the seabed. The discharge of the drill cuttings, drilling mud and cement have the potential to cause localised impacts to the benthic environment. Where possible, CAN-ductors will be used to help reduce the overall extent and thickness of the drill cuttings. Recovery in the wider area is likely within a few years but the area with direct impact would be slower however, the area with a direct impact is relatively small and therefore the effect is not significant.

If rock dump will be required for small pipeline sections that cannot by buried to adequate depths below the seabed, the rocks will likely remain on the seabed resulting in a permanent effect. Physical change (to another seabed type) is flagged by both the FEAST tool and by the AoO as a pressure to which deep-sea sponge aggregations, ocean quahog aggregations and offshore sands and gravels features are sensitive. However, the rock protection material on the seabed within the boundaries of the Faroe-Shetland Sponge Belt NCMPA will only take up 0.022 km^2, which is a very small fraction (0.0004%) of the total area of the NCMPA. While some individual specimens of ocean quahog and/or sponges may be affected within the direct footprint of rock placement, significant effects at the population level are unlikely. Consequently, the site’s nature conservation objectives will not be significantly affected in this regard.

Section 15

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15 REFERENCES

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Section 16

Abbreviations

16 ABBREVIATIONS

AFEN	Atlantic Frontier Environmental Network
AIS	Automatic Identification Systems
AICD	Autonomous Inflow Control Devices
AMF	Automatic Mode Function
AoO	Advice on Operations
AP OHGP	Alternative Path Open Hole Gravel Path
API	American Petroleum Institute
BAP	Biodiversity Action Plan
BAT	Best Available Technology
bbls	Barrels
BD	Bursting Discs
BEIS	Department for Business, Energy and Industry Strategy
BEP	Best Environmental Practice
BERR	The Department of Business Enterprise and Regulatory Reform (now BEIS)
BGS	British Geological Society
BHGEs	Baker Hughes General Electric’s
BODC	British Oceanographic Data Centre
BOP	Blowout Preventer
bopd	Barrels of Oil Per Day
BP	British Petroleum
BS&W	Base Sediment and Water
BTEX	Benzene, Toluene, Ethylbenzene and Xylene
CAPEX	Capital Expenditure
CEFAS	Centre for Environment, Fisheries and Aquaculture Science
CCS	Carbon Capture and Storage
CFU	Compact Flotation Unit
CHARM	Chemical Hazard Assessment and Risk Management
CH_4	Methane
CMMS	Computerised Maintenance Management System
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COTs	Cargo Oil Tanks
CP	Chemical Permit
cP	Centipoise
CODA	Cetacean Offshore Distribution and Abundance in the European Atlantic
CP-SAT	Chemical Permit Subsidiary Application Template
Cr	Chromium
CtL	Consent to Locate
CSV	Construction Support Vessel
CTIS	Cambo Tie-In Structure
Cu	Copper

dB	Decibel
DC	Drill Centre
DECC	Department of Energy and Climate Change (now BEIS)
DEP	EIA Direction for Deposits
DEPCON	Consent to Deposit of Material on the Seabed
DP	Dynamic Positioning
DPM	Diesel Particulate Matter
DLE	Dry Low NO_x Emissions
DNA	Deoxyribonucleic Acid
DNV	Det Norske Veritas
DTI	Department of Trade and Industry
ECMWF	European Centre for Medium-Range Weather Forecasts
EDR	Effective Deterrent Radius
EDS	Emergency Disconnect System
EEMS	Environmental Emissions Monitoring System
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EMS	Environmental Management System
ENVID	Environmental Issues Identification Workshop
EOR	Enhanced Oil Recovery
EPS	European Protected Species
ERRV	Emergency Response and Rescue Vessel
ES	Environmental Statement
ESP	Electric Submersible Pump
EUNIS	European Nature Information System
EU	European Union
FARICE	Faroe – Iceland Communication Cable
FAVs	Fast Opening Valves
FDP	Field Development Plan
FEAST	Feature Activity Sensitivity Tool
FEED	Front End Engineering Design
FEPA	Food and Environment Protection Act 1985
FID	Financial Investment Decision
FLAGS	Far North Liquids and Associated Gas System
FLO	Fisheries Liaison Officer
FOC	Fire Optic Cable
FOVs	Fast Opening Valves
FPSO	Floating Production, Storage and Offloading vessel
FRG	Free Radical Generator
FSU	Floating Storage Unit
ft	Feet

FWKO	Free Water Knock Out
GEP	Gas Export PipeLine
GES	Good Environmental Status
GHG	Greenhouse Gas
GIS	Geographical Information System
GOR	Gas to Oil Ratio
GWP	Global Warming Potential
HDR	Henningson, Durham and Richardson (Company name)
H_2S	Hydrogen Sulphide
HMCS	Harmonised Mandatory Control System
HOCNS	Harmonised Offshore Chemical Notification System
HP	High Pressure
HPU	Hydraulic Power Unit
HSE	Health, Safety and Environment
Hz	Hertz
HYCOM	Hybrid Coordinate Ocean Model
HP/HT	High Pressure/High Temperature
HVDC	High-Voltage, Direct Current
IBA	Important Bird Areas
ICES	International Council for the Exploration of the Seas
IG	Inert Gas
IOGP	International Association of Oil & Gas Producers
IPPC	Integrated Pollution Prevention and Control Directive
JNCC	Joint Nature Conservation Committee
ITOPF	International Tanker Owners Pollution Federation Limited
JV	Joint Venture
kHz	Kilohertz
km	Kilometre
kV	kilovolt
LDI	Lean Direct Injection
LP	Low Pressure
LTOBM	Low Toxicity Oil Based Mud
LMRP	Lower Marine Riser Package
m	Metre
MA	Major Accident
MAH	Major Accident Hazard
MARPOL	International Convention for the Prevention of Pollution from Ships
MAT	Master Application Template
MBES	Multibeam echo sounder
MEG	Methanol and Glycol
MEI	Major Environmental Incident
MEMV	Marine Environmental Modelling Workbench

MER	Maximising Economic Recovery
mg/l	Milligram per litre
m/s	Metres per second
MITgcm	Massachusetts Institute of Technology general circulation model
MMO	Marine Mammal Observer
MMscf	Million Standard Cubic Feet
MoD	Ministry of Defence
MODU	Mobile Operated Drilling Unit
MPA	Marine Protected Area
MS	Marine Scotland
MSFD	Marine Strategy Framework Directive
MW	Megawatt
MW (th)	Megawatts Thermal
NA	Not Applicable
NAP	National Allocation Plan
NB	Nominal Bore
NCMPA	Nature Conservation Marine Protected Area
nm	Nautical Mile
NMHC	Non-Methane Hydrocarbons
NMP	National Marine Plan
NOAA	National Oceanic and Atmospheric Administration
NOCS	National Oceanography Centre Southampton
NORM	Naturally Occurring Radioactive Material
NO_x	Nitrogen Oxides
MPPE	Macro Porous Polymer Extraction
MPN	Most Probable Number
N_2O	Nitrous Oxide
O_3	Ozone
OBM	Oil Based Mud
ºC	Degrees Celsius
OCNS	Offshore Chemical Notifications Scheme
OGA	Oil and Gas Authority
O&M	Operate and Maintenance
OI	Ocean Installer
OIM	Offshore Installation Manager
OiW	Oil in Water
OMR	Offshore Marine Regulations
OMV	Austrian integrated oil and gas company
OOZI	Out of Zone Injection
OPEP	Oil Pollution Emergency Plan
OPOL	Oil Pollution Liability Agreement
OPPC	Oil Pollution Prevention and Control

OPRED	Offshore Petroleum Regulator for Environment and Decommissioning
OSCAR	Oil Spill Contingency and Response
OSD	Offshore Safety Directive
OSDR	Offshore Safety Directive Regulation
OSPAR	The Convention for the Protection of the Marine Environment of the north-east Atlantic
OSPRAG	Oil Spill Prevention and Response Advisory Group
OSRL	Oil Spill Response Limited
PAH	Polyaromatic Hydrocarbons
Pb	Lead
PEC	Predicted Environmental Concentration
PETS	Portal Environmental Tracking System
PEXA	Practice and Exercise Areas
PL	Pipeline
PLET	Pipeline Endline Termination
PLEM	Pipeline End Manifold
PLONOR	Pose Little or No Risk
PM	Particulate Matter
PMF	Priority Marine Feature
PNEC	Predicted No Effect Concentration
POBM	Pseudo Oil Base Muds
ppb	Parts per billion
PRA	Production Operations MAT
Pre-FEED	Pre-Front End Engineering and Design
pSPA	Proposed Special Protection Area
psu	Practical Salinity Unit
PTS	Permanent Threshold Shift
PWA	Pipeline Works Authorisation
PWRI	Produce Water Re-Injection
RBA	Risk Based Approach
RO	Reverse Osmosis
ROV	Remotely Operated Vehicle
ROVSV	Remotely Operated Vehicle Support Vessel
RSPB	Royal Society for the Protection of Birds
SAC	Special Area of Conservation
SAT	Subsidiary Application Template
SAS	Stand Alone Screens
SAST	Seabirds at Sea Team
SBM	Synthetic Oil Base Mud
SCANS	Small Cetaceans Abundance in the North Sea
SCOS	Special Committee on Seals
SEA	The Strategic Environmental Assessment

SECEs	Safety and Environmentally Critical Elements
SEL	Sound Exposure Limit
SELcum	Cumulative Sound Exposure Level received by the receptor
SELmax	Source Exposure Level at distance ‘R’ at time interval ‘i’
SEMS	Safety and Environmental Management System
SERPENT	Scientific and Environmental ROV Partnership using Existing Industrial Technology
SFF	Scottish Fishermen’s Federation
SHEFA 2	Shetland – Faroe Communication Cable
SIRGE	Shetland Island Regional Gas Export
SMRU	Sea Mammal Research Unit
SNH	Scottish Natural Heritage (now NatureScot)
SO_2	Sulphur Dioxide
SoS	Secretary of State
SOTEAG	Shetland Oil Terminal Environmental Advisory Group
SPA	Special Protection Areas
SPAR	Single Point Anchor Reservoir
SPE	Siccar Point Energy Limited
SPLR	Sound Pressure Level at distance ‘R’ from the sound source
SPLsource	Sound Pressure Level at 1 m distance from the sound source
SPS	Subsea Production System
SPR	Source Pathway Receptor
SRB	Sulphate Reducing Bacteria
SRU	Sulphate Removal Unit
SSS	Side Scan Sonar
SSIV	Subsea Isolation Valve
SSSI	Sites of Special Scientific Interest
SURF	Subsea Umbilicals Risers and Flowlines
SVT	Sullom Voe Terminal
SW	Seawater
tbc	To be confirmed
tCO_2-e	Tonnes of Carbon Dioxide Equivalent
TBT	Tributyltin
TEG	Tri-Ethylene Glycol
TEMPSC	Totally Enclosed Motor Propelled Survival Craft
tHC	Total Hydrocarbon Content
TLP	Tension-Leg Platform
TPH	Total Petroleum Hydrocarbons
TSS	Total Suspended Solids
TTS	Temporary Threshold Shift
TVDSS	True Vertical Depth Subsea
TOOPEP	Temporary Operations Oil Pollution Emergency Plan

UK	United Kingdom
UKBAP	UK Biodiversity Action Plan
UKCS	United Kingdom Continental Shelf
UKHO	United Kingdom Hydrographic Office
UKOOA	United Kingdom Offshore Operators
µm	Micrometre
µPa	Micro pascal
US EPA	United States Environmental Protection Agency
UTM	Universal Transverse Mercator
VTS	Vessel Traffic Survey
VFA	Volatile Fatty Acid
VMS	Vessel Monitoring Systems
VOC	Volatile Organic Compounds
VSP	Vertical Seismic Profile
WBM	Water Based Mud
WHRU	Waste Heat Recovery Units
WICDS	Water Injection and Controls Distribution Centre
WOSP	West of Shetland Pipeline
WOSPS	West of Shetland Pipeline System
Zn	Zinc

Section 17

Glossary

17 GLOSSARY

Acid rain	Precipitation of acidic pollutants, chiefly sulphur dioxide and nitrogen oxide, released into the atmosphere by the burning of fossil fuels such as oil.
Acidification	The decrease in pH of the oceans, caused by their uptake of atmospheric carbon dioxide.
Annex I Habitat	A rare or characteristic habitat which is affords protection under on the EU Habitats Directive.
Annex II Species	Animal or plant species requiring designation of Special Areas of Conservation under the EU Habitats Directive.
Annex IV Species	Animal or plant species in need of strict protection under the EU Habitats Directive.
Annulus	The space between wellbore and casing.
Appraisal well	A well drilled after a discovery well to gain more information on the reservoir.
Atmospheric emissions	A collective term for gases and particulates released to the atmosphere.
Attenuation Loss	The physical processes in the sea that distort the mathematical spreading laws relating to sound.
Baleen whales	Whales of the suborder Mysticeti. They have plates of whalebone (a baleen) along the upper jaw for filtering plankton from the water.
Barite	Barium sulphate ($BaSO_4$).
Bathymetry	The measurement of underwater depth in ocean, seas or lakes.
Benthic	Of or relating to the seabed.
Benthos	Animals that occur on or in the seabed.
Biogenic reef	This reef may be composed almost entirely of the reef building organisms and their tubes or shells, or may include sediments, stones and shells bound together by the organism.
Biota	The flora or fauna occurring in a particular area.
Biotope	The region of a habitat associated with a particular ecological community.
Block	Sub-division of territorial seas for the purpose of licensing to a company or group of companies for exploration and production rights. A UK block is approximately 200 to 250 km^2.
Blow-out	A blowout occurs when gas, oil or saltwater escapes in an uncontrolled manner from a well.
Blowout preventer	A hydraulically operated wellhead device that can be actuated to close a well in order to prevent an uncontrolled release of fluids (a blow-out).

BOP Hopping	The process of moving the BOP directly from one wellhead to another without recovering it to surface. Removing the requirement to pull the BOP stack to surface and redeploy it on the next wellhead.
Boulders	A collection of large rocks, each usually with a diameter of 25.6 cm (10.1 inches) in diameter.
CAN-ductor	A Conductor Anchor Node suction pile with integrated conductor. The CAN is a combination of suction anchor and guide pipe. The suction anchor pushes the guide pipe into the seabed, providing top support for the conductor.
Casing	Steel lining inserted into a well as drilling progresses to prevent the wall of the hole from caving in during drilling, to prevent the inflow of unwanted fluids from surrounding formations and to provide a means of extracting oil (and gas) if a well is productive.
Cephalopods	Class of mollusc characterised by having a prominent head, and a modified mollusc foot in the form of arms or tentacles. Examples include the squid and the octopus.
Cetacean	Aquatic mammals of the order Cetacea, which comprise porpoises, dolphins, and whales.
Circalittoral	The region under shoreline which extends from the lower limit of the shallow waters closest to the shore to the maximum depth at which photosynthesis is still possible.
Cobbles	A collection of rocks varying in diameter from 64 mm to 256 mm (2.5 to 10.1 inches).
Concrete Mattress	A structure made from concrete used to support and protect infrastructure on the seabed.
Conductor	First string of casing to be inserted and cemented into the borehole. Its purpose is to prevent the soft formations near the surface from caving in and to conduct drilling mud from the bottom of the hole to the surface when drilling starts.
Continental shelf	The continental shelf refers to the extension of the continent into the ocean.
Continental slope	The continental slope refers to the sloping margin between the shelf break and the shelf basin.
Contourite	Sedimentary deposit produced by deepwater currents near the bottom of continental slopes. It may be influenced by wind or tidal forces.
Copepods	Small free-living or parasitic crustaceans of the subclass Copepoda, living in marine and fresh waters. The free-living forms are an important constituent of plankton.
Cuttings	Rock chips produced by chipping and crushing action of the drill bit.
Cuttings pile	An accumulation of rock chips or formation debris, produced by the action of the drill bit, and deposited on the seabed.

dB re 1µPa-m	The sound source level measured on the decibel (dB) logarithmic scale at 1 m from the source.
Debris Fan	An alluvial (loose, unconsolidated soil or sediment) fan consisting of triangular shaped deposits of sediment transported by an underwater current or glacier.
Deep-sea sponge aggregation	Occurring in waters typically deeper than 250 m, primarily characterised by the presence of structure forming glass sponges or demosponges in high densities.
Demersal	Living in the water column at or near seabed. Usually in relation to fish.
Deterministic Oil Spill Modelling	Oil spill trajectory predictions for actual spills or exercises. Provides single expected forecasts for spills.
Diatoms	Unicellular planktonic algae with silica shells.
Dinoflagellates	Unicellular planktonic organisms often bearing a tough cellulose shell (theca).
Dispersant	A chemical that breaks up concentrations of oil in water, reducing the oil to small droplets (an emulsion).
Diversity	The variety of life forms i.e. distinct organisms within an area.
Drilling mud/fluid	A mixture of base substance and additives used to lubricate the drill bit and to counteract the natural pressure of the formation.
Dynamic positioning/ dynamically positioned	The stationing of a drilling rig at a specific location in the sea by the use of computer controlled thrusters.
Electrostatic Coalescer	A Coalescer is used to separate emulsions into their individual components e.g. water in oil. Electrostatic Coalescers use electrical fields to combine small water droplets.
Environmental aspect	An activity that causes an environmental effect.
Environmental effect	A change to the environment or its use.
Epifauna	Benthic organisms that live on the surface of the seabed, either sessile or free moving.
European Protected Species	Species listed in Annex IV of the Habitats Directive.
Far-field Mixing	The far field relates to the area beyond this initial mixing zone and beyond the influence of the initial discharge momentum; Here plume dispersion is largely dependent on ambient current conditions.
Field	An accumulation of hydrocarbons in the subsurface. Consists of a reservoir in a shape that will trap hydrocarbons and that is covered by an impermeable, sealing rock.
Flare	A vent for burning and therefore disposing of unwanted gases or to burn off hydrocarbons when there is no way to transport or utilise them.
Flexible Jumpers	Short flexible flowline sections.
Gadoids	Fish belonging to the family Gadidae, which includes cod, haddock and whiting.

Global Warming Potential	A measure of how much a given mass of gas is estimated to contribute to global warming, relative to the same mass of carbon dioxide.
Greenhouse Gas	Gas that contributes to the greenhouse effect. Includes gases such as carbon dioxide (CO_2) and methane (CH_4). The greenhouse effect results in a rise in temperature due to incoming solar radiation being trapped by carbon dioxide and water vapour in the Earth's atmosphere.
Hydrocarbon	A compound containing only the elements hydrogen and carbon. May exist as a solid, a liquid or a gas. The term is mainly used in a catch-all sense for crude oil, natural gas, condensate and their derivatives.
Iceberg plough mark	Ridges and roughs formed in the seabed through the ploughing movement of icebergs during the last glaciation period.
Important Bird Areas	A global network of sites for the conservation of birds and bird habitats, set up by BirdLife International.
Immiscible	Fluids that do not mix one another (e.g. oil and water).
Infauna	Animals living within seabed sediments mostly within the top 10 to 15 cm.
I-Tube	The conduit through which the riser passes through the FPSO's hull.
Macrofauna	Benthic organisms that are retained in a 0.3 mm sieve.
Machair	Fertile low-lying grassy plain found on some north-west coastlines of Ireland and Scotland.
Megafauna	Large or giant animals.
Meroplankton	The larval stages of fish and benthic invertebrates.
Mud	Fine materials (<0.063 mm), such as clay and silt.
Nature Conservation Marine Protected Area	An area of the marine environment designated for the conservation of nationally important marine habitats and species and features of geological or geomorphological interest.
Nautical mile	Nautical measurement of distance, equivalent to 1.852 km or 1.15 miles.
Near-field Mixing	The near-field zone is the area of strong initial mixing that is sensitive to the discharge design conditions. It is defined as the area within which the discharge reaches the surface or when it achieves vertically stability within the water column.
Ocean quahog	A long lived species of clam which lives buried in sediments
Oil based mud	Drilling mud with oil as the fluid continuous phase.
Ozone	Atmospheric gas which acts as a pollutant creating smog at ground level, and in the upper atmosphere filters out ultra violet light from reaching the earth.
Pelagic	Inhabiting the water column of the sea.
Phytoplankton	Free floating microscopic plants.

Pipeline End Termination	A connection point between the pipeline and a subsea structure or another pipeline.
Plankton	Free floating organisms found in the oceans and other aquatic systems.
Pockmarks	Craters in the seabed formed by fluids such as liquid and gas, erupting and streaming through the sediments. They can be classed as Annex 1 habitats "Submarine structures made by leaking gasses", by the Joint Nature Conservation Committee.
Polychaete	A class of marine annelid worms.
Priority Marine Feature	Priority Marine Features (PMFs) are species or habitats which the national conservation bodies responsible for Scottish waters (Scottish Natural Heritage (SNH) and Joint Nature Conservation Committee (JNCC)) consider to be marine nature conservation priorities. The aim of the PMFs work is to produce a focused list of marine habitats and species to help target future conservation work in Scotland.
Pseudo-oil/synthetic based mud	Synthetic alternative to oil based mud, created from esters or vegetable oil.
Ramsar sites	Wetlands of international importance.
Reef	A collection of rocks, corals or ridge of sand just above or below the surface of the sea.
Reservoir	The underground formation where oil and gas has accumulated. It consists of a porous rock to hold the oil or gas, and a cap rock that prevents its escape.
Riser	A pipe which connects an offshore installation to a subsea wellhead or pipeline during drilling or production operations.
Sand	Fine debris of rocks, consisting of small, loose grains. Very find sand has a diameter of no less than 0.063 mm, and very course sand has a diameter of no more than 2.0 mm.
Seabed Take	A reduction in the total extent of the original seabed habitat (take) resulting from development infrastructure on the seabed.
Semi-submersible mobile drilling unit	A semi-submersible mobile drilling unit is a floating drilling rig that is capable of working in water depths ranging from shallow through to ultra-deepwater.
Separator	A pressure vessel used for separating gas and liquid components from processed fluids.
Skirted Mud Mat Foundation	A shallow foundation in which the structure loads are transferred to deeper soil layers by vertical slender elements (skirts) that confine the soil beneath the foundation footprint.
Soft Start Procedures	Procedure used to minimise noise disturbance to marine mammals, whereby the power in the airguns is built up slowly, to give marine mammals adequate time to hear the noise and leave the area.

Sound Exposure Limit	The constant sound level which has the same amount of energy in one second as the original noise event.
Spawning	The production and release of gametes (eggs or sperm) by animals.
Special Area of Conservation	Protected sites designated under the EC Habitats Directive in order to conserve important habitats and species (excluding birds).
Special Protection Area	Sites designated by the UK Government under the EC Birds Directive to protect certain rare, vulnerable, and regularly occurring migratory species of birds.
Spreading Loss	The geometric weakening of a sound signal as it spreads outwards from a source.
Stochastic Oil Spill Modelling	Modelling based on actual statistical wind speed and direction frequency data. Provides a probability range of sea surface oil and beaching, representative of the prevailing conditions.
Suction Foundation	A foundation pile or anchor inserted into the seabed and held in place by suction.
Venting	The discharge of un-burnt, unwanted gases or hydrocarbons.
Water based mud	A type of drilling fluid (mud) consisting mainly of water, which has additives to modify it and make it more effective.
Wellhead	The unit at the surface of a well which controls pressure and connects to drilling and production equipment. The wellhead is the upper part of the well, located above the casing and under the drilling floor.
Workover	The process of performing maintenance or remedial treatments on an oil or gas well.
Xmas Tree	Assembly of valves and fittings to control the flow of oil and gas from the target reservoir.
Zooplankton	Animals which drift in the water column along with prevailing currents, mostly microscopic.

Appendix 1

Summary of Legislation

APPENDIX 1 SUMMARY OF LEGISLATION

The main environmental legislation relevant to the proposed Cambo Field Development.

Topic	Legislation
Consenting	
Environmental Statement	The Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020. The Offshore Petroleum and Pipelines (Environmental Impact Assessment and other Miscellaneous Provisions) (Amendment) Regulations 2017. The Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001, as amended. The Marine Works (Environmental Impact Assessment) (Amendment) Regulations SSI 2017/588. Offshore Marine Conservation (Natural Habitats &c.) Regulations 2007, as amended. Pollution Prevention and Control (Fees) (Miscellaneous Amendments) Regulations SI 2016/529. Convention on Environmental Assessment in the Transboundary Context (Espoo Convention) 1991.
Well Consent	The Petroleum Act 1998. The Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020. Well Operations Notification System (WONS). Offshore Petroleum Licensing (Offshore Safety Directive) Regulations 2015 (2015 licensing regulations). Petroleum Operation Notice (PON 4). Drilling Operations Application (DRA) and Chemical Permit Subsidiary Application Template (SAT).
Consent to Locate	Marine and Coastal Access Act 2009 (MCAA). Marine Scotland Act 2010. Energy Act 2008 Part 4.
Pipeline Consent	Petroleum Act 1998. The Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020. Pipeline Safety Regulations 1996, as amended. Marine and Coastal Access Act 2009. Marine Scotland Act 2010. Pipeline Works Authorisation (PWA) and consent to deposit of materials on the Seabed (DEPCON). Pipeline Operations MAT (PLA), Chemical Permit SAT (CP), EIA Direction for Pipeline Operations SAT (PL), and EIA Direction for Deposits SAT (DEP).

Topic	Legislation
Consenting Continued	
Production Consent	Petroleum Act 1998. The Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020. Offshore Petroleum Licensing (Offshore Safety Directive) Regulations 2015 (2015 licensing regulations). Production Operations MAT (PRA) and EIA Direction for Commencement of Production SAT (SP).
Produced Water	Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005, as amended. Production Operations MAT (PRA) and Oil Discharge Permit (Life) SAT (OLP).
Routine Operations	
Sewage discharges	MARPOL 73/78 Annex IV Prevention of Pollution by Sewage from Ships. Merchant Shipping (Prevention of Pollution by Sewage and Garbage from Ships) Regulations 2008. Food and Environment Protection Act 1985 (FEPA). Deposits in the Sea (Exemption) Order 1985. Convention on the Protection of the Marine Environment of the North East Atlantic 1992 (OSPAR Convention).
Oil Contaminated Discharges	Offshore Chemical Regulations 2002, as amended. Offshore Petroleum Activities (Oil Pollution Prevention and Control) (OPPC) Regulations 2005, as amended. Food and Environment Protection Act 1985 (FEPA). Convention on the Protection of the Marine Environment of the North East Atlantic 1992 (OSPAR Convention). OSPAR Decision 2000/3 on the Use of Organic-phase Drilling Fluids (OPF) and the Discharge of OPF-Contaminated Cuttings. OSPAR Recommendation 2006/5 on a Management Regime for Offshore Cuttings Piles.
Water Based Mud (WBM) Cuttings	Offshore Chemical Regulations 2002, as amended. Offshore Petroleum Activities (Oil Pollution Prevention and Control) (OPPC) Regulations 2005, as amended. Food and Environment Protection Act 1985 (FEPA). Deposits in the Sea (Exemptions) Order 1985. OSPAR Recommendation 2006/5 on a Management Regime for Offshore Cuttings Piles.

Topic	Legislation
Routine Drilling Operations Continued	
Chemical Use	Pollution Prevention and Control Act 1999. Offshore Chemicals Regulations 2002, as amended. The REACH Enforcement Regulations 2008, as amended. Convention on the Protection of the Marine Environment of the North East Atlantic 1992 (OSPAR Convention). OSPAR Recommendation 2006/3 on Environmental Goals for the Discharge by the Offshore Industry of Chemicals that are, or which contain Substances Identified as Candidates for Substitution. OSPAR Recommendation 2005/2 on Environmental Goals for the Discharge by the Offshore Industry of Chemicals that Are, or Contain Added Substances, Listed in the OSPAR 2004 List of Chemicals for Priority Action. OSPAR Recommendation 2000/2 on a harmonised mandatory control system for the use and reduction of the discharge of offshore chemicals as amended by OSPAR Decision 2005/1. Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005, as amended (OPPC). Food and Environment Protection Act 1985 (FEPA). Deposits in the Sea (Exemptions) Order 1985.
Drainage Water	Offshore Petroleum Activities (Oil Pollution Prevention and Control) (OPPC) Regulations 2005, as amended. Convention on the Protection of the Marine Environment of the North East Atlantic 1992 (OSPAR Convention). PARCOM Recommendation 86/1 of a 40 mg/l Emission Standard for Platforms. Merchant Shipping (Prevention of Oil Pollution) Regulations 1996, as amended. Merchant Shipping Act 1995. International Convention for the Prevention of Pollution from Ships (MARPOL) 73/78. Merchant Shipping (Prevention of Oil Pollution) (Amendment) Regulations 1994.
Atmospheric Emissions from the MODU	
Turbine/Combustion Emissions	MARPOL 73/78 Annex VI Prevention of Air Pollution from Ships. The Merchant Shipping (Prevention of Air Pollution from Ships) Regulations 2008, as amended. Offshore Combustion Installations (Prevention and Control of Pollution) Regulations 2001, as amended. Greenhouse Gas Emissions Trading Scheme (Amendment) Regulations 20018. The Offshore Combustion Installations (Pollution Prevention and Control) Regulations 2013. Climate Change Act 2008. National Emission Ceilings Regulations 2002. Pollution Prevention and Control Act 1999.
Halocarbons (halons, CFCs)	Ozone Depleting Substances Regulations 2015. Fluorinated Greenhouse Gases Regulations 2015. MARPOL 73/78 Annex VI Prevention of Air Pollution from Ships. The Merchant Shipping (Prevention of Air Pollution from Ships) Regulations 2008, as amended.

Topic	Legislation
Atmospheric Emissions from the MODU Continued	
Flaring and Venting	Energy Act 1976. Petroleum Act 1998. Petroleum Licensing (Exploration & Production) (Seaward and Landward) Regulations 2004. The Petroleum (Current Model Clauses) Order 1999. Climate Change Act 2008. Greenhouse Gas Emissions Trading Scheme Regulations 2005. The Greenhouse Gas Emissions Trading Scheme Order 2020. National Emission Ceilings Regulations 2002. Waste and Emissions Trading Act 2003.
Routine Drilling Operations	
Chemical Transport	
Bulked Chemicals	Environmental Protection Act 1990. Merchant Shipping (Dangerous or Noxious Liquid Substances in Bulk) Regulations 1996, as amended.
Dangerous Goods	Environmental Protection Act 1990. Controlled Waste Regulations 1992, as amended. The Merchant Shipping (Dangerous Goods and Marine Pollutants) Regulations 1997. The Environmental Protection (Duty of Care) (Scotland) Regulations 2014. The Waste (Scotland) Regulations 2011.
Hazardous Chemicals	Environmental Protection Act 1990. Controlled Waste Regulations 1992, as amended. Chemicals (Hazard Information and Packaging for Supply) Regulations 2009. The Environmental Protection (Duty of Care) (Scotland) Regulations 2014. The Waste (Scotland) Regulations 2011, as amended.
Wildlife Protection (Offshore)	
Habitats and Species	Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007 (Offshore Marine Regulations, OMR), as amended. The Conservation of Habitats and Species Regulation 2010, as amended. The Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001. The UK Marine and Coastal Access Act 2009. The Marine (Scotland) Act 2010.

Topic	Legislation
Wildlife Protection (Offshore) Continued	
Cetaceans	The Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001, as amended. Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas 1991 (ASCOBANS). Wildlife and Countryside Act (1981). Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007 (Offshore Marine Regulations, OMR), as amended. The Conservation (Natural Habitats, &c.) (EU Exit) (Scotland) (Amendment) Regulations 2019.
Waste Handling	
Transfer of Oil Contaminated Wastes	Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005, as amended. Merchant Shipping (Prevention of Oil Pollution) Regulations 1996. Prevention of Pollution (Reception Facilities) Order 1984. Merchant Shipping and Maritime Security Act 1997.
Garbage	Food and Environment Protection Act 1985, as amended. Deposits in the Sea (Exemptions) Order 1985. Merchant Shipping (Prevention of Pollution by Sewage and Garbage from Ships) Regulations 2008.
Transfer of Waste/Garbage from Installations	Merchant Shipping (Prevention of Pollution by Sewage and Garbage from Ships) Regulations 2008. Food and Environment Protection Act 1985, as amended. Deposits in the Sea (Exemptions) Order 1985. Environmental Protection (Duty of Care) Regulations 1991. Waste Management Licensing (Scotland) Regulations 2011. Waste (Scotland) Act 2011.
Transfer of Special Waste	Environmental Protection Act 1990. Controlled Waste Regulations 1992, as amended. Special Waste Regulations 1996, as amended. The Special Waste Amendment (Scotland) Regulations 2004. The Environmental Protection (Duty of Care) (Scotland) Regulations 2014. The Waste (Scotland) Regulations 2011, as amended.
Radioactive Waste	Radioactive Substances Act 1993 (RSA 93), as amended. Radioactive Substances (Phosphatic Substances, Rare Earths etc.) Exemptions Order 1962. Radioactive Substances (Substances of Low Activity) Exemption Order 1986, as amended. Merchant Shipping (Dangerous Goods and Marine Pollutants) Regulations 1997.

Topic	**Legislation**
Support Vessels	
Machinery Space Drainage from Shipping	The Merchant Shipping (Prevention of Oil Pollution) Regulations 1996, as amended. Merchant Shipping Act 1995. International Convention for the Prevention of Pollution from Ships (MARPOL) 73/78.
Sewage from Vessels	MARPOL 73/78 Annex IV Regulations for the Prevention of Pollution by Sewage from Ships. Merchant Shipping (Prevention of Pollution by Sewage and Garbage from Ships) Regulations 2008. Deposits in the Sea (Exemption) Order 1985. Food and Environment Protection Act 1985, as amended.
Garbage from Vessels	Food and Environment Protection Act 1985, as amended. Deposits in the Sea (Exemption) Order 1985. Merchant Shipping (Prevention of Pollution by Sewage and Garbage from Ships) Regulations 2008.
Atmospheric Emissions from Vessels	The Merchant Shipping (Prevention of Air Pollution from Ships) Order 2006. MARPOL 73/78 Annex VI - Prevention of Air Pollution from Ships, the regulations in this annex set limits on sulphur oxide and nitrogen oxide emissions from ship exhausts and prohibit deliberate emissions of ozone depleting substances. The Merchant Shipping (Prevention of Air Pollution from Ships) Regulations 2008.
Accidental Events (Installations)	
Oil Pollution Emergency Planning	Merchant Shipping (Oil Pollution Preparedness, Response and Co-operation Convention) Regulations 1998, as amended. Offshore Installations (Emergency Pollution Control) Regulations 2002. Offshore Installations (Prevention of Fire and Explosion, and Emergency Response) Regulations 1995. The Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005, as amended.
Spill Reporting	Model Clauses of Licence. Petroleum Operations Notice no 1.
Accidental Events (Vessels)	
Spills, Release or Possible Escape of Oil, Noxious Substance or Marine Pollutant	Merchant Shipping (Oil Pollution Preparedness, Response and Co-operation Convention) Regulations 1998, as amended. Merchant Shipping (Reporting of Pollution Incidents) Regulations 1987. Merchant Shipping (Reporting Requirements for Ships Carrying Dangerous Polluting Goods) Regulations 1995. Petroleum Operations Notice no 1.

Topic	Legislation
Decommissioning	
Well Suspension and Abandonment	Petroleum Act 1998. Energy Act 2008. The Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005, as amended. Offshore Chemicals Regulations 2002. Offshore Chemicals (Amendment) Regulations 2011. Marine and Coastal Access Act 2009 (MCAA). Marine Scotland Act 2010. Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001, as amended. The Offshore Petroleum Activities (Conservation of Habitats) (Amendment) Regulations 2007. Petroleum (Production) (Seaward Areas) Regulations 1988, as amended. Offshore Installations and Wells (Design and Construction etc) Regulations 1996. Food and Environment Protection Act 1985. Well intervention Permit via the UK Oil Portal, FEPA licence may be required, or a Marine Licence for deposits on the seabed. A MCAA licence via the UK Oil Portal.

Appendix 2

Commitments Register

APPENDIX 2 COMMITMENTS REGISTER

Table A2.1 summarises the mitigation commitments made in each of the impact sections of this Environmental Statement (ES) (Sections 7 to 13). These commitments will inform the planning stages for the Cambo Field Development (Subsea and Pipeline Installation and Operation, Floating Production, Storage and Offloading Vessel (FPSO) Installation and Commissioning and Drilling and Completion Operations) and will be incorporated into the Siccar Point Energy Limited (SPE) Project Statement of Requirements and Operations Philosophy. Where relevant, they will also form the basis of the Environmental Management Plan (EMP), which will be prepared by the Well Operator and Installation Duty Holder closer to the start of the operations, with input from SPE. The EMP will also implement all the requirements of the environmental management systems of the Well Operator and Installation Duty Holder for this specific project.

Table A2.1: Commitments Register

Impact	Mitigation	Regulatory Commitment	Stage of Operations		
			Planning/ Preparation	Installation/ Drilling	Production
Physical Presence					
Potential for Pipeline laying vessel, MODU and FPSO to be a navigation hazard for shipping and other users	▪ Safe working distances will be imposed, for the duration of operations;	✓		✓	✓
	▪ 500 m exclusion zones will be put in place around field infrastructure;	✓		✓	✓
	▪ FPSO and infield infrastructure 500 m safety zones will be enforced during operations by a dedicated Emergency Response and Rescue Vessel (ERRV);	✓		✓	✓
	▪ All construction vessels will be highly visible and display the appropriate light or daytime signals. The FPSO will be highly visible and be in full compliance with the necessary legal requirements;	✓		✓	✓
	▪ In areas where fishing is anticipated, a guard vessel will be employed to protect the pipeline during the 4-5 week period between the pipeline being installed on the seabed and it subsequently being trenched into the seabed;			✓	
	▪ A Vessel Traffic Study has been carried out for the proposed development location;	✓	✓		
	▪ Notice to mariners will be posted prior to the MODU and FPSO moving onto location, ensuring that all vessels, including fishing vessels, will be aware of its presence in advance and for the duration of operations;	✓	✓	✓	✓
	▪ The UK Hydrographic Office (UKHO) will be notified so that charts can be amended to mark the position of the FPSO and export pipeline infrastructure.	✓	✓	✓	✓
Potential for MODU or FPSO to be an obstruction to fishing operations	▪ An ERRV will be present to warn any fishing boats entering the area during drilling, FPSO installation and Production;	✓	✓	✓	✓
	▪ Kingfisher will be notified of the exact location of the MODU and FPSO prior to moving onto location, allowing its inclusion in their fortnightly bulletin to fishing vessels;		✓	✓	✓
	▪ The UK Hydrographic Office (UKHO) will be notified so that charts can be amended to mark the position of the FPSO and export pipeline infrastructure.	✓	✓	✓	✓
Potential for Gas Export Pipeline to be an obstruction to fishing operations	▪ A trenching Assessment and Fisheries Risk Assessment will be undertaken to assess the minimum water depth to which trenching will be required		✓		

Impact	Mitigation	Regulatory Commitment	Stage of Operations		
			Planning/ Preparation	Installation/ Drilling	Production
Atmospheric Emissions					
Emissions to the atmosphere from power generation on the MODU/FPSO/support and supply vessels	▪ Waste heat from the turbines will be used to provide process heating requirements through the installation of Waste Heat Recovery Units (WHRUs);		✓	✓	✓
	▪ All equipment will operate at optimum efficiency and be well maintained according to a strict maintenance regime;		✓	✓	✓
	▪ FPSO will run on dual fuel units that are gas fuel Dry low NOx (DLE)/liquid fuel Lean Direct Injection (LDI) equipped		✓		✓
	▪ Only low sulphur diesel will be used onboard MODU and FPSO;			✓	✓
	▪ Optimising fuel use during drilling operations including batch drilling of the wells;		✓	✓	
	▪ Atmospheric emissions from the MODU and the FPSO will be reported under EEMS.	✓		✓	✓
Contribution to government and industry net zero targets	▪ The Cambo FPSO will be designed, and necessary pre-investment made, to facilitate potential future electrification (either from on or offshore renewable sources) without the need to remove the FPSO off-station for modification. Specifically, provisions are being made in the FPSO design to accommodate potential future installation of a power import connection and required electrical infrastructure for power conditioning and distribution.		✓		
	▪ SPE will, through its membership of the West of Shetland Operator Electrification Workgroup and Project Orion, continue to explore opportunities to overcome the technical and financial challenges currently prohibiting the import of electricity from renewable sources to meet the Cambo FPSO power requirements.		✓		
Drilling Discharges					
Drilling discharges effecting nature conservation features	▪ Environmental baseline survey and habitat investigation of the proposed well locations were undertaken in 2018, which confirmed no features of conservation importance were present in the vicinity of the well locations.		✓		

Impact	Mitigation	Regulatory Commitment	Stage of Operations		
			Planning/ Preparation	Installation/ Drilling	Production
Discharge of chemicals into the marine environment during drilling activities	▪ Selection of all chemicals that may be used will be based upon both their technical specifications and their environmental performance. Use and discharge of chemicals will be minimised where practicable;	✓	✓	✓	
	▪ Only WBM are to be used. Selection of all chemical additives will be conducted with reference to the CEFAS templates to ensure the most environmentally benign chemicals will be chosen wherever technically possible. The actual mud and chemical usage will be monitored during drilling operations and subsequently reported to OPRED.	✓	✓	✓	
Discharge of cement into the marine environment (note that the Primary well foundations will be set with a CAN-Ductor, significantly reducing cement discharge to seabed)	▪ Use of ROV to visually monitor cement returns to seabed surface;			✓	
	▪ Once returns are observed, pumping will be stopped in order to minimise discharged volume.	✓		✓	
Discharge of cuttings and Water Based Muds (lower well sections)	▪ A closed mud circulation system will be used, so the returned drilling fluids can be reused, reducing total fluid volumes;			✓	
	▪ The drilling mud and cuttings discharged from the drilling rig will be discharged close to the sea surface, allowing dilution and dispersion over a large area;			✓	
	▪ Drill cuttings contaminated with mud will be discharged close to the sea surface, allowing dilution and dispersion over a large area and thereby minimising the overall environmental impact;			✓	
Drilling Discharges					
Discharge of cuttings and Water Based Muds (lower well sections) Continued	▪ Cuttings contaminated with liquid from the payzone will be treated using the shale shakers to ensure that as much mud and oil as possible is retained in the circulating system. This treatment will result in some of the oil being incorporated into the mud system and discharged. The discharge would take place over a longer period rather than the batch discharge of the cuttings and will be considerably diluted by the drilling fluid prior to discharge, this will assist dispersion and breakdown in the water column. This potential discharge will be included within the OPPC permit.	✓		✓	

Impact	Mitigation	Regulatory Commitment	Stage of Operations		
			Planning/ Preparation	Installation/ Drilling	Production
	▪ Oil content of payzone cuttings will be measured onboard the drilling rig, and a number of samples returned to shore for further analysis and verification. If the oil concentration on cuttings exceeds the limits described in the OPPC permit, cuttings discharge will be ceased, and cuttings collected onboard the MODU and shipped back to shore for appropriate disposal.	✓		✓	
Produced Water Discharges					
Dispersed oil	▪ Produced water discharges will comply with OSPAR 30 mg/l dispersed oil standard. However, SPE will commit to designing produced water treatment to achieve a lower dispersed oil content, with a target of ≤15 mg/l (on a monthly average basis).		✓		✓
Effects from discharge temperature	▪ The FPSO design will reduce the produced water discharge temperature to 45 ˚C; This will ensure the RBA dilution rates of 400 at 500 m from the discharge is met under all meteorological conditions.		✓		✓
Orientation of the discharge	▪ A downward orientation of the discharge caisson will increase the horizontal distance travelled during the near-field propagation stage and further improves predicted dilution factors.		✓		✓
Noise Generation and Wildlife Disturbance					
Sound produced by vessels, MODU and helicopters	▪ Logistics will be optimised to minimise unnecessary or low payload helicopter flights and vessel sailings;		✓	✓	
	▪ Underwater sound generated during drilling operations will be kept to a minimum where possible;		✓	✓	
	▪ Piling operations at the pipeline tie in will be conducted in accordance with the JNCC Protocol for minimising risk of injury to marine mammals from piling noise. Use of a trained Marine Mammal Observer (MMO) to undertake cetacean monitoring duties before any piling operations commence and the use of "soft start" procedures.	✓		✓	

Impact	Mitigation	Regulatory Commitment	Stage of Operations		
			Planning/ Preparation	Installation/ Drilling	Production
Waste Management					
Legislation	▪ The appropriate legislation will be followed.	✓	✓	✓	✓
Sewage treatment system onboard FPSO	▪ The sewage treatment system onboard the FPSO will be designed to meet regulation 21(3) of the Merchant Shipping (Prevention of Pollution by Sewage and Garbage from Ships) Regulations 2008.	✓			✓
Other waste generated by the development	▪ Other waste will be returned to shore for appropriate treatment and disposal, with recycling encouraged.	✓	✓	✓	✓
Segregation of waste	▪ The MODU and FPSO will be designed with adequate space for waste storage and segregation facilities, including laydown areas for skips and deck space for other waste storage receptacles. Waste will be segregated into hazardous and non-hazardous waste types.	✓	✓	✓	✓
Documented waste	▪ Every offshore installation and vessel must have a Garbage Management Plan (per guidance in Merchant Shipping Notice No.1807) and Garbage Record Book. The amount and disposal route of any waste will be recorded in the UK Environmental Emissions Monitoring System (EEMS).	✓	✓	✓	✓
Accidental Events (Preventative Measures)					
Training, Experience and Suitability of Equipment	▪ In order to prevent an oil spill occurring, stringent safety and operational procedures will be followed at all times. Before offshore operations commence, the Installation/Well Operator will fully assess the competence and experience of all contractors, and the suitability of all equipment to operate in the West of Shetland area;	✓	✓	✓	
	▪ All offshore personnel will be appropriately trained, experienced and certified to carry out their specific duties. The crew of the FPSO and the MODU will also undergo environmental awareness and safety training.	✓	✓		

Impact	Mitigation	Regulatory Commitment	Stage of Operations		
			Planning/ Preparation	Installation/ Drilling	Production
Well Design	▪ Well design to minimise the potential for well control problems;	✓	✓		
	▪ A thorough and formal peer-review approach will be used to review all critical elements of the well designs and the execution of drilling and abandoning the well. The well design will be independently reviewed by a Well Examiner, who will also monitor the actual construction and any modifications to the wells;	✓	✓		
	▪ Any deviation to the drilling programme, well design or well construction, will be subject to a formal Management of Change process.	✓	✓	✓	

Impact	Mitigation	Regulatory Commitment	Stage of Operations		
			Planning/ Preparation	Installation/ Drilling	Production
Well Control	▪ A full risk assessment will be performed as part of the planning phase of each well;	✓	✓		
	▪ Data on well pressure will be monitored throughout the drilling operations;	✓		✓	
	A blow-out preventer (BOP) will be put in place to prevent the uncontrolled release of hydrocarbons from the well. The BOP will be fully redundant and has several other backup emergency control systems, namely: o Emergency Disconnect System o Autoshear System o Acoustic Control System o Remotely Operated Vehicle o Automatic Mode Function ▪ The BOP will be independently inspected and verified periodically. Regular testing of the BOP and its back up systems takes place onboard the MODU, typically at 7 and 21-day intervals. ▪ [Note: the ticks in the right-hand columns relate to the BOP and all backup control systems]	✓	✓	✓	
Diesel/Fuel Oil Bunkering and Crude Oil Tanker Offloading Procedures	▪ Vessel audits will be performed to confirm sea worthiness of supply vessels and shuttle tankers, and only DP vessels will be used;	✓	✓		
	▪ Bunkering and offloading operations will only take place in suitable weather conditions, and with a dedicated and continuous watch posted at both ends of the fuel/offloading hose. Where offtake operations require to be undertaken during periods of low visibility, initial connection operations for crude offtake will be limited to connection and planned disconnection during daylight hours only, with offloading within the prescribed weather limitation continuing throughout the night. ▪ All hoses used during bunkering/offloading will be segmented with pressure valves that will close automatically in the event of a drop in pressure. Bunkering/offloading hoses will be stored on reels, to prevent wear and damage. Hoses will be visually inspected and their connections tested prior to every loading operation. Bunkering/offloading procedures will be followed throughout all bunkering/offloading operations.	✓	✓	✓	✓

Impact	Mitigation	Regulatory Commitment	Stage of Operations		
			Planning/ Preparation	Installation/ Drilling	Production
Other Safety Measures	▪ All equipment used on the FPSO and the MODU will have safety measures built in to minimise the risks of any hydrocarbon spillage. the FPSO and the MODU will have open and closed drain systems in place that will route any operational spills onboard the FPSO or MODU to the slop tanks. All supply vessels will operate via DP.		✓	✓	✓
Accidental Events (Action to Stop a Subsea Spill During Drilling with the MODU)					
Initial Actions	▪ Use the ROV to identify the source of a leak.			✓	
	▪ If at any time the safety of the MODU becomes compromised, the first priority will be to close the BOP, disconnect the MODU from the well, and move off location. The ERRV would monitor the spill.			✓	
	▪ If MODU has not been disconnected, other methods include: varying the pump rate and the use of various chemicals, such as weighting material. Therefore, a contingency stock of cement and barite will be kept onboard the MODU. Once control of the well has been regained, the well can be fully abandoned with cement plugs.			✓	
Capping the Well	▪ If BOP has failed, the possibility of fitting a temporary capping device to the well will be considered. SPE is a member of Oil Spill Response Ltd (OSRL), which allows SPE access to the OSPRAG (the Oil Spill Prevention and Response Advisory Group) Capping Device stored at the Cameron facility in Aberdeen;		✓	✓	
	▪ A full timetable for the capping device procedure will be provided in the Well Operator's Temporary Operations Oil Pollution Emergency Plan (TOOPEP) covering the drilling operations at Cambo operations.		✓	✓	
Drilling a Relief Well	▪ If attempts to cap the well fail, the only remaining option to bring the well back under control to stop the spill may be to drill a relief well. SPE will comply with the Oil and Gas UK "Guidelines on Relief Well Planning – Subsea Wells". Planning for drilling of a relief well will be progressed in parallel to the fitting of a temporary capping device;		✓	✓	
	▪ An assessment of the suitability of available MODUs will be undertaken and the availability of these rigs will continue to be monitored throughout the drilling operations at Cambo;		✓	✓	

Impact	Mitigation	Regulatory Commitment	Stage of Operations		
			Planning/ Preparation	Installation/ Drilling	Production
	▪ Relief well plans, and trajectories, will be created for each well drilled along with a relief well kill analysis.		✓	✓	
Accidental Events (Oil Spill Response)					
Oil Pollution Emergency Plan	▪ The FPSO Installation Operator and the MODU's Well Operator will have an OPEP/TOOPEP in place, respectively. The OPEP/TOOPEP will conform to the Merchant Shipping (Oil Pollution, Preparedness, Response and Co-operation Convention) (Amendment) Regulations 2015 and the Offshore Installations (Emergency Pollution Control) Regulations 2002. The OPEP/TOOPEP will fully consider the specific oil spill response requirements for Cambo, taking into account the location, the prevailing meteorological conditions and the environmental sensitivities of the area.	✓	✓	✓	✓
Training, Exercises and Experience	▪ Specific members of the FPSO/MODU and standby vessel crew will have undertaken Oil Pollution Emergency Plan (OPEP) level oil spill response training. The Offshore Installation Manager (OIM) and the Installation/Well Operator offshore representatives will have undertaken the OPRED course for On-Scene Commander (OPEP Level 1);		✓	✓	✓
	▪ The OPEP/TOOPEP will be distributed to personnel with designated duties in the event that an oil spill response is required, and to the regulatory authorities and statutory consultees. On receipt of the OPEP/TOOPEP, personnel will undergo awareness training in oil spill response prior to the commencement of drilling operations.	✓	✓	✓	✓
	▪ The FPSO and MODU will regularly undertake training exercises, including vessel-based oil spill response exercises for the crew and an Offshore TOOPEP Exercise while on site, to ensure that offshore personnel are familiar with the TOOPEP and their responsibilities during a response. Similar offshore exercises will be held periodically for the FPSO's OPEP, once it is in operation	✓		✓	✓
	▪ Training will also be organised for key onshore personnel in line with the OPRED requirements and the internal requirements of environmental training and continual improvement in the Well Operator's Management Systems. SPE is a member of Oil Spill Response Ltd (OSRL), with activation rights being provided to the Installation/Well Operator. A response advisor with OPEP Level 4 training would also be provided by OSRL.		✓	✓	✓

Impact	Mitigation	Regulatory Commitment	Stage of Operations		
			Planning/ Preparation	Installation/ Drilling	Production
Accidental Events (Oil Spill Response Strategies)					
Response Strategies	In general, there are several response strategies which could be deployed in the event of an oil spill: ▪ Natural dispersion and monitoring; ▪ Application of chemical dispersants; ▪ Containment and recovery (surface and subsea); ▪ Shoreline protection and clean-up.			✓	✓
Natural Dispersion and Monitoring	▪ Small to medium crude spill and diesel spills of all sizes are often best monitored but otherwise left to naturally degrade, but will be monitored. ▪ A standby vessel will be on site at all times during drilling and production operations. A contract with OSRL is in place, allowing the rapid deployment of a dedicated aerial surveillance aircraft.			✓	✓
Chemical Dispersants	▪ To aid natural dispersion of a large oil spill, or when sensitive receptors such as flocks of seabirds are at risk, the use of chemical dispersants will be considered. The decision to use chemical dispersants will always need to consider its positive benefits against any resulting impacts in the water column. Dispersants will not be used without the correct authorisations in place.			✓	✓

Impact	Mitigation	Regulatory Commitment	Stage of Operations		
			Planning/ Preparation	Installation/ Drilling	Production
Shoreline Protection and Clean-up	▪ In the event of a spill the first priority should be to prevent spilled hydrocarbons from reaching coastal areas. The initial response to any spill will be onsite and aerial surveillance to track its movement supplemented by modelling to predict which shorelines the spilled oil may threaten. Once the coastal sensitivities under immediate threat have been identified, coastal protection resources will be deployed to protect priority areas. Although SPE and the Installation/Well Operator will provide all necessary assistance as required, all shoreline protection strategies will be determined by the local authority in consultation with their environmental advisors. Additional response personnel and appropriate shoreline protection equipment will be provided by SPE and the Installation/Well Operator, through their oil spill response contractor, OSRL;	✓	✓	✓	✓
	▪ Every effort will be made to clean-up up any oil that reaches the shoreline. Depending on the type of coastline affected, various methods exist to remove oil from the shore. With all required assistance and information provided by SPE and the Installation/Well Operator, the strategy for shoreline clean-up ultimately will be directed by the affected local authorities. Adequately trained personnel and clean-up equipment will be made available to assist any clean-up operations, through OSRL.	✓	✓	✓	✓
Accidental Events (Liability and Insurance)					
Liability and Insurance	▪ SPE will ensure that it has sufficient finances and insurance in place to cover the cost of responding to a large oil spill. ▪ SPE is a member of the Offshore Pollution Liability Association Limited (OPOL). OPOL is a voluntary oil pollution compensation scheme to which all offshore operators currently active on the UKCS are party to.	✓ ✓	✓ ✓	✓ ✓	✓ ✓

Appendix 3

ENVID Matrix

APPENDIX 3 ENVID MATRIX

Table A3.1. Impact Scoping Matrix 1: Subsea and Pipeline Installation and Operation

Description of Aspect			Environmental Issue	Impact Significance Evaluation			Comments
Operational Activity (Source)	**Impact** (Pathway)	**Receptor**		**Magnitude of Effect** (1 to 10)	**nvironmental and Socio-economic Receptor Value** (1 to 5)	**Significance** (> 10 considered significant)	
General Operations							
Installation Operations							
Presence of installation and support vessels	Potential for the vessels to be a navigation hazard.	Other users of the sea	Physical presence	2	2	4	
Fuel use during FPSO installation operations	Use of diesel for power generation.	Society	Resource use	2	1	2	
Resource use during installation operations	The single use of various resources during installation operations, including furniture, stationary, electrical equipment, steel, refrigerants and radioactive substances will be required.	Society (future users of given resource)	Resource use	2	1	2	
Laying of flowlines infield	Physical impact of flowlines and umbilicals on the seabed will have the potential to affect benthic communities.	Marine environment (seabed communities)	Seabed impacts	4	2	8	Infield pipelines will be surface laid.
Laying of gas export line deepwater (outwith infield area)	Physical impact of pipeline on the seabed will have the potential to affect benthic communities.	Marine environment (seabed communities)	Seabed impacts	6	4	24	

Description of Aspect			Environmental Issue	Impact Significance Evaluation			Comments
Operational Activity (Source)	Impact (Pathway)	Receptor		Magnitude of Effect (1 to 10)	Environmental and Socio-economic Receptor Value (1 to 5)	Significance (> 10 considered significant)	
Trenching and laying of gas export pipeline (including any backfilling) shelf water	Physical impact of flowlines on the seabed will have the potential to affect benthic communities.	Marine environment (seabed communities)	Seabed impacts	6	4	24	The pipeline will be trenched and buried for the final 30 km. The pipeline will cross the NCMPA. A weight coating will be used.
Positioning of infrastructure on the seabed (infield)	Physical impact of manifolds/drill centres/SSIV on seabed will have the potential to affect benthic communities.	Marine environment (seabed communities)	Seabed impacts	4	2	8	
Positioning of infrastructure on the seabed (at PLEM)	Physical impact of T tie in point at the seabed at pipeline end manifold will have the potential to affect benthic communities.	Marine environment (seabed communities)	Seabed impacts	4	3	12	
Piling to fix infrastructure to the seabed (WOSPS PLEM)	Piling will cause underwater noise.	Marine environment (marine mammals and fish)	Noise and visual impacts	6	4	24	Geotechnical data gathering is being carried out to confirm foundation type. Piling may not be required.
Rock dumping protection of export pipeline	Physical impact of rock dump around pipeline will have the potential to affect benthic communities.	Marine environment (seabed communities)	Seabed impacts	4	4	16	Rock dump only considered for shallow end of export pipeline. No planned rock dumping required for in-field pipelines and structures.
Laying of concrete mattresses, grout bags etc for protection of export pipeline (shallow water)	Potential to affect benthic communities.	Marine environment (seabed communities)	Seabed impacts	4	4	16	

Description of Aspect			Environmental Issue	Impact Significance Evaluation			Comments
Operational Activity (Source)	**Impact** (Pathway)	**Receptor**		**Magnitude of Effect** (1 to 10)	**nvironmental and Socio-economic Receptor Value** (1 to 5)	**Significance** (> 10 considered significant)	**Comments**
Installation and support vessels - general noise and vibration of equipment whilst operating (below sea level)	Production of sound below sea level (e.g. from thrusters) will cause underwater noise.	Marine environment (marine mammals and fish)	Noise and visual impacts	2	4	8	
Lighting during operations	Artificial light is emitted from vessels and may attract birds.	Birds	Noise and visual impacts	2	2	4	
Production Operations							
Inspection, maintenance and repair of pipelines/flowlines/subsea infrastructure on the seabed	Physical presence of infrastructure on seabed will have the potential to affect benthic communities.	Other users of the sea (fisheries), marine environment (seabed communities)	Physical presence	2	2	4	
Presence of pipelines/flowlines/subsea infrastructure/anchors and anchor lines in wet storage on the seabed prior to production commencing	Physical presence of infrastructure on seabed will have the potential to affect benthic communities.	Other users of the sea (fisheries)	Physical presence	2	2	4	
Discharges and Emissions							
Installation Operations							
Use and discharge of chemicals during testing and commissioning of flowlines	Discharge of chemicals, including those used during riser connections and commissioning may affect water quality.	Marine environment (water column)	Discharge to sea	1	2	2	
Atmospheric emissions during installation and commissioning	Energy consumption during installation will contribute to atmospheric emissions of greenhouse gases.	Air pollution	Atmospheric emissions	1	2	2	All impacts related to atmospherics are automatically scoped in.

Description of Aspect				Impact Significance Evaluation			
Operational Activity (Source)	**Impact** (Pathway)	**Receptor**	**Environmental Issue**	**Magnitude of Effect** (1 to 10)	**nvironmental and Socio-economic Receptor Value** (1 to 5)	**Significance** (> 10 considered significant)	**Comments**
FPSO and support vessels - Discharge of domestic sewage	Sewage increases BOD resulting from organic and other nutrient matter in the detergents and human wastes	Marine environment (water column)	Discharge to sea	N/A	N/A	N/A	
FPSO and support vessels - Release of food waste to sea	Food waste increases BOD resulting from organic and other nutrient matter.	Marine Environment (water column)	Discharge to sea	N/A	N/A	N/A	
Discharge of ballast water	Potential to introduce alien species.	Marine Environment (water column)	Discharge to sea	1	2	2	
Production Operations							
Use and discharge of hydraulic fluids subsea during ongoing production	Discharge of chemicals into the marine environment may affect water quality.	Marine environment (water column)	Discharge to sea	1	2	2	An open loop system will be used.
Waste							
General operational waste - non hazardous	Effects associated with onshore disposal are dependent on the nature of the site or process. Landfills - land take, nuisance, emissions (methane), possible leachate, limitations on future land use. Treatment plants - nuisance, atmospheric emissions, potential for contamination of sites.	Landscape (landfill sites)	Solid waste	2	1	2	

Description of Aspect			Environmental Issue	Impact Significance Evaluation			Comments
Operational Activity (Source)	Impact (Pathway)	Receptor		Magnitude of Effect (1 to 10)	Environmental and Socio-economic Receptor Value (1 to 5)	Significance (> 10 considered significant)	
Emergencies/Accidental Events							
Large Release							
Installation vessels/support and supply vessels - fuel oil spillage (e.g. vessel collision)	Release of fuel oil to sea may impact species within the water column, on the sea surface and in coastal habitats.	Marine environment, coastal environment, other users of the sea	Discharge to sea	6	4	24	
Large spill of hydrocarbons due to loss of flowline/riser inventory (infield oil release)	Release of hydrocarbons to sea may impact species within the water column, on the sea surface and in coastal habitats.	Marine environment, coastal environment, other users of the sea	Discharge to sea	6	4	24	
Large release of hydrocarbons due to loss of gas pipeline inventory	Atmospheric emissions due to gas release	Air pollution	Atmospheric emissions	2	2	4	
Small Release							
Chemical spills during installation operations	Release of chemicals into the marine environment may affect water quality and species living in the water column.	Marine environment	Discharge to sea	2	2	4	
Spillage of diesel or other oils during bunkering operations and storage	Release of fuel oil to sea may impact species within the water column and on the sea surface.	Marine environment	Discharge to sea	2	2	4	
Small release of hydraulic fluid, lubes, helifuels etc., for example during pigging	Release of fluids to sea may impact species within the water column and on the sea surface.	Marine environment	Discharge to sea	2	2	4	
Other Accidental Event							
Dropped objects	Dropped objects may pose a risk to subsea infrastructure or a hazard to other users of the sea.	Other users of the sea	Seabed impacts	2	2	4	

Description of Aspect			Environmental Issue	Impact Significance Evaluation			Comments
Operational Activity (Source)	Impact (Pathway)	Receptor		Magnitude of Effect (1 to 10)	nvironmental and Socio-economic Receptor Value (1 to 5)	Significance (> 10 considered significant)	
Loss of installation vessels, or support vessels	Collision causing loss of stability or fire/explosion, resulting in vessel remaining on seabed.	Marine environment (benthic communities); other users of the sea	Resource use, socioeconomic, seabed impacts	4	4	16	

Table A3.2. Impact Scoping Matrix 2: FPSO (Operations During the Installation and Production Phase)

Description of Aspect			Environmental Issue	Impact Significance Evaluation			Comments
Operational Activity (Source)	Impact (Pathway)	Receptor		Magnitude of Effect (1 to 10)	Environmental and socio-economic receptor value (1 to 5)	Significance (> 10 considered significant)	
General Operations							
Installation Operations							
Fuel use during FPSO installation operations	Use of diesel for power generation.	Society	Resource use	2	1	2	
Resource use during installation operations	The single use of various resources during installation operations, including furniture, stationary, electrical equipment, steel, refrigerants and radioactive substances will be required.	Society (future users of given resource)	Resource use	2	1	2	
Presence of infrastructure on the seabed	Physical impact FPSO anchors on the seabed will have the potential to affect benthic communities.	Marine environment (seabed communities)	Seabed impacts	6	2	12	
FPSO and support vessels - general noise and vibration of equipment whilst operating (below sea level)	Production of sound below sea level (e.g. from thrusters) will cause underwater noise.	Marine environment (marine mammals)	Noise and visual impacts	4	4	16	
Helicopters - general noise and vibration of equipment whilst operating (on sea surface)	Production of sounds on the sea surface (including transfer routes) will cause noise in the air.	Marine environment (seabirds and marine mammals)	Noise and visual impacts	2	4	8	
Lighting during operations	Artificial light is emitted from vessels and may attract birds.	Birds	Noise and visual impacts	2	2	4	

Description of Aspect			Environmental Issue	Impact Significance Evaluation			Comments
Operational Activity (Source)	**Impact** (Pathway)	**Receptor**		**Magnitude of Effect** (1 to 10)	**Environmental and socio-economic receptor value** (1 to 5)	**Significance** (> 10 considered significant)	
Production Operations							
Ongoing presence of FPSO	Potential for the FPSO to be a navigation hazard.	Other users of the sea	Physical presence	4	2	8	
Lighting during operations	Artificial light is emitted from vessels.	Birds	Noise and visual impacts	2	2	4	
Ongoing presence of anchors	Physical presence of FPSO anchors on seabed will have the potential to affect benthic communities and fisheries.	Other users of the sea (fisheries), marine environment (seabed communities)	Physical presence	4	2	8	
Ongoing presence of anchor lines	Physical presence of FPSO anchor lines on seabed will have the potential to affect benthic communities and fisheries.	Other users of the sea (fisheries), marine environment (seabed communities)	Physical presence	4	2	8	
Discharges and Emissions							
Installation/Commissioning Operations							
Atmospheric emissions during installation and commissioning	Energy generation during installation and operation of the FPSO contribute to atmospheric emissions of greenhouse gases.	Air pollution	Atmospheric emissions	2	2	4	All impacts related to atmospherics are automatically scoped in.
FPSO and support vessels - Discharge of domestic sewage	Sewage has high BOD resulting from organic and other nutrient matter in the detergents and human wastes	Marine environment (water column)	Discharge to sea	1	2	2	
FPSO and support vessels - Release of food waste to sea	Waste has high BOD resulting from organic and other nutrient matter. Positive impact of nutrients provided for fish	Marine environment (water column)	Discharge to sea	1	2	2	

Description of Aspect			Environmental Issue	Impact Significance Evaluation			Comments
Operational Activity (Source)	Impact (Pathway)	Receptor		Magnitude of Effect (1 to 10)	Environmental and socio-economic receptor value (1 to 5)	Significance (> 10 considered significant)	
Discharge of ballast water	Potential to introduce alien species.	Marine environment (water column)	Discharge to sea	4	2	8	
Discharge of slops	Discharge of slops including seawater with MEG may affect water quality.	Marine environment (water column)	Discharge to sea	1	2	2	Seawater with MEG recovered from flowlines during commissioning could potentially be discharged with slops (to be permitted via MAT/SAT).
Production Operations							
Discharge of treated seawater during start-up	Discharge of treated seawater containing chemicals into the marine environment may affect water quality.	Marine environment (water column)	Discharge to sea	1	2	2	
Discharge of produced water during ongoing production/discharge of reservoir oil contaminated fluids during maintenance and well intervention (will include produced chemicals)	Discharges containing chemicals and oil into the marine environment may affect water quality.	Marine environment (water column)	Discharge to sea	2	2	4	
Produced sand discharge	Discharges containing sand into the marine environment may affect water quality.	Marine environment (water column)	Discharge to sea	4	2	8	Fine sand will be produced through sand screens.

Description of Aspect			Environmental Issue	Impact Significance Evaluation			Comments
Operational Activity (Source)	**Impact** (Pathway)	**Receptor**		**Magnitude of Effect** (1 to 10)	**Environmental and socio-economic receptor value** (1 to 5)	**Significance** (> 10 considered significant)	
Atmospheric emissions from diesel and fuel use by FPSO	Energy generation during operation of the FPSO contribute to atmospheric emissions of greenhouse gases.	Air pollution	Atmospheric emissions	1	2	2	
Flaring (non-routine only)	Combustion of flare gas and hydrocarbons also results in emissions of greenhouse gases to the atmosphere.	Air pollution	Atmospheric emissions	2	2	4	Gas to be exported via pipeline. All impacts related to atmospherics are automatically scoped in.
Waste							
General operational waste - hazardous	Effects associated with onshore disposal are dependent on the nature of the site or process. Landfills - land take, nuisance, emissions (methane), possible leachate, limitations on future land use. Treatment plants - nuisance, atmospheric emissions, potential for contamination of sites.	Landscape (landfill sites)	Solid waste	2	1	2	
General operational waste - non hazardous	Effects associated with onshore disposal are dependent on the nature of the site or process. Landfills - land take, nuisance, emissions (methane), possible leachate, limitations on future land use. Treatment plants - nuisance, atmospheric emissions, potential for contamination of sites.	Landscape (landfill sites)	Solid waste	2	1	2	

Description of Aspect			Environmental Issue	Impact Significance Evaluation			Comments
Operational Activity (Source)	Impact (Pathway)	Receptor		Magnitude of Effect (1 to 10)	Environmental and socio-economic receptor value (1 to 5)	Significance (> 10 considered significant)	
Emergencies/Accidental Events							
Large Release							
FPSO/installation vessels/support and supply vessels - Fuel oil spillage (e.g. vessel collision)	Release of fuel oil to sea may impact species within the water column, on the sea surface and in coastal habitats.	Marine environment, coastal environment, other users of the sea	Discharge to sea	6	4	24	
Large spill of hydrocarbons due to loss of FPSO inventory	Release of hydrocarbon inventory to sea may impact species within the water column, on the sea surface and in coastal habitats.	Marine environment, coastal environment, other users of the sea	Discharge to sea	10	5	50	
Small Release							
Chemical spills during installation operations	Release of chemicals to sea may impact species within the water column and on the sea surface.	Marine environment	Discharge to sea	2	4	8	
Spillage of diesel or other oils during bunkering operations and storage	Release of fuel oil to sea may impact species within the water column and on the sea surface.	Marine environment	Discharge to sea	2	4	8	
Small release of hydraulic fluid, lubes, helifuels etc	Release of fluids to sea may impact species within the water column and on the sea surface.	Marine environment	Discharge to sea	2	4	8	
Other Accidental Event							
Dropped objects	Dropped objects may pose a risk to subsea infrastructure or a hazard to other users of the sea.	Other users of the sea	Seabed impacts	2	2	4	
Loss of installation vessels, support vessels or FPSO	Collision resulting in hydrocarbon release, loss of stability or fire/explosion.	Marine environment (benthic communities); other users of the sea	Resource use, socioeconomic, seabed impacts	4	2	8	

Table A3.3. Impact Scoping Matrix 3: Drilling and Completion Operations

Description of Aspect			Environmental Issue	Impact Significance Evaluation			Comments
Operational Activity (source)	Impact (Pathway)	Receptor		Magnitude of Effect (1 to 10)	Environmental and socio-conomic recepto value (1 to 5)	Significance (> 10 considered significant)	
General Operations							
Physical presence of the MODU and support vessels resulting in a shipping and fishing hazard	Potential for the MODU to be a navigation hazard.	Other users of the sea (shipping)	Physical presence	2	2	4	
Physical presence of wellheads	Potential for obstruction to fishing operations resulting from the presence of wellheads.	Other users of the sea (fisheries)	Physical presence	4	2	8	
Resource use during drilling operations	The single use of various resources during installation operations, including furniture, stationary, electrical equipment, steel, refrigerants and radioactive substances will be required.	Society (future users of given resource)	Resource usage	2	1	2	
MODU/support and supply vessels - diesel usage for power generation	Use of diesel for power generation.	Society (future users of given resource)	Resource usage	2	1	2	
MODU/support and supply vessels- general noise and vibration of equipment whilst operating (below sea level)	Production of sound below sea level (e.g. from thrusters) will cause underwater noise.	Marine environment (marine mammals and fish)	Noise and visual impacts	4	4	16	
MODU/support and supply vessels/helicopter - general noise and vibration of equipment whilst operating (on sea surface)	Production of sounds on the sea surface (including transfer routes) will cause noise in the air.	Marine environment (seabirds and marine mammals)	Noise and visual impacts	2	4	8	

Description of Aspect			Environmental Issue	Impact Significance Evaluation			Comments
Operational Activity (source)	**Impact** (Pathway)	**Receptor**		**Magnitude of Effect** (1 to 10)	**Environmental and socio-conomic recepto value** (1 to 5)	**Significance** (> 10 considered significant)	**Comments**
Lighting during operations	Artificial light is emitted from the MODU and may attract birds	Birds	Noise and visual impacts	1	1	1	
Discharges and Emissions							
MODU/support and supply vessels - discharge of domestic sewage	Sewage has high BOD resulting from organic and other nutrient matter in the detergents and human wastes, which may affect water quality.	Marine environment (water column)	Discharge to sea	1	2	2	
MODU/support and supply vessels - Release of food waste to sea	Waste has high BOD resulting from organic and other nutrient matter, which may affect water quality.	Marine environment (water column)	Discharge to sea	1	2	2	
Oily water discharge during drilling and workover operations	Discharges of oily water may occur during drilling and workover operations. Oily residues in the discharged volumes may include reservoir hydrocarbons, which may affect water quality.	Marine environment (water column)	Discharge to sea	2	2	4	
Discharge of payzone cuttings	Payzone cuttings may contain oily residue, which may affect water quality.	Marine environment (water column)	Discharge to sea	6	2	12	Will be sampled before discharge.

Description of Aspect			Environmental Issue	Impact Significance Evaluation			Comments
Operational Activity (source)	**Impact** (Pathway)	**Receptor**		**Magnitude of Effect** (1 to 10)	**Environmental and socio-conomic recepto value** (1 to 5)	**Significance** (> 10 considered significant)	
Discharge of cuttings and Water Based Muds (tophole)	Water Based Mud (WBM), drill cuttings, drilling muds from top-hole sections are deposited directly onto the seabed during drilling operations, forming a cuttings pile around the wellhead.	Marine environment (seabed communities)	Seabed impacts	6	2	12	Planned use of CAN-ductor will significantly mitigate this risk.
Discharge of cuttings and water based muds (lower well sections)	Drilling of deeper well sections: Discharge of cuttings and muds at the sea surface. Presence of WBM contaminated cuttings piles on seabed.	Marine environment (seabed communities)	Seabed impacts	6	2	12	
Discharge of cement	Once each section has been drilled, a casing will be cemented into place, and any excess cement will be discharged at the seabed.	Marine environment (water column and seabed communities)	Discharge to sea	6	2	12	Planned use of CAN-Ductor will significantly mitigate this risk.
Discharge of chemicals	Discharge of chemicals, including those used for drilling and completion operations and those used on the MODU (e.g. rig wash), into the marine environment.	Marine environment (water column)	Discharge to sea	2	2	4	
Atmospheric emissions from routine operations	Energy generation on board the MODU contributes to atmospheric emissions of greenhouse gases (CO2, CO, SOX, NOX etc.).	Marine environment	Atmospheric emissions	2	2	4	All impacts related to atmospherics are automatically scoped in.

Description of Aspect			Environmental Issue	Impact Significance Evaluation			Comments
Operational Activity (source)	**Impact** (Pathway)	**Receptor**		**Magnitude of Effect** (1 to 10)	**Environmental and socio-conomic recepto value** (1 to 5)	**Significance** (> 10 considered significant)	**Comments**
Discharge of ballast water from MODU	Potential to introduce alien species.	Marine environment (water column)	Discharge to sea	4	2	8	
Waste							
General operational waste - hazardous	Effects associated with onshore disposal are dependent on the nature of the site or process. Landfills - land take, nuisance, emissions (methane), possible leachate, limitations on future land use. Treatment plants - nuisance, atmospheric emissions, potential for contamination of sites.	Landscape (landfill sites)	Solid waste	2	1	2	
General operational waste - non-hazardous	Effects associated with onshore disposal are dependent on the nature of the site or process. Landfills - land take, nuisance, emissions (methane), possible leachate, limitations on future land use. Treatment plants - nuisance, atmospheric emissions, potential for contamination of sites.	Landscape (landfill sites)	Solid waste	2	1	2	
Logging and Testing							
Wireline, logging while drilling etc	Generation of electromagnetic fields, acoustic waves, microwaves, etc	Marine environment	Electromagnetic radiation	1	1	1	Limited wireline expected.

Description of Aspect			Environmental Issue	Impact Significance Evaluation			Comments
Operational Activity (source)	**Impact** (Pathway)	**Receptor**		**Magnitude of Effect** (1 to 10)	**Environmental and socio-conomic recepto value** (1 to 5)	**Significance** (> 10 considered significant)	
Emergencies/Accidental Events							
Large Release							
MODU/support and supply vessels - fuel oil spillage (e.g. vessel collision)	Release of fuel oil to sea may impact species within the water column, on the sea surface and in coastal habitats.	Marine environment, coastal environment, other users of the sea	Discharge to sea	6	4	24	
MODU - uncontrolled well flow of hydrocarbons	Release of fuel oil to sea may impact species within the water column, on the sea surface and in coastal habitats.	Marine environment, coastal environment, other users of the sea	Discharge to sea	10	5	50	
Small Release							
MODU - chemical spills	Release of chemicals into the marine environment may affect water quality and species living in the water column.	Marine environment	Discharge to sea	2	4	8	
MODU - spillage of diesel or other oils during bunkering operations and storage	Release of fuel oil to sea may impact species within the water column and on the sea surface.	Marine environment	Discharge to sea	2	2	4	
Small release of hydraulic fluid, lubes, helifuels etc.	Release of fluids to sea may impact species within the water column and on the sea surface.	Marine environment	Discharge to sea	2	2	4	
Other Accidental Event							
Dropped objects	Dropped objects may pose a risk to subsea infrastructure or a hazard to other users of the sea.	Other users of the sea	Seabed Impacts	2	2	4	
Loss of vessel	Collision causing loss of stability or fire/explosion, resulting in vessel remaining on seabed.	Marine environment (benthic communities); other users of the sea	Resource use, socioeconomic, seabed impacts	4	2	8	

SICCAR POINT ENERGY

Appendix 4

Summary of Scoping Feedback

APPENDIX 4 SUMMARY OF SCOPING FEEDBACK

Origin	Comment/Issued Raised	SPE Response Summary	ES Section
OPRED	Alternatives to the proposed project should be discussed and environmental impacts compared. Where there is more than one option then sufficient detail for each will be required within the ES to enable a full assessment of each option (3.2.2 [EIA Guidance]). For example, it is currently proposed that the FPSO anchor moorings will be piled into the seabed however it is understood that the nature of the soils at the Cambo location may lend themselves to suction anchors and where doubt exists the ES should discuss both options. Similarly, where the Can-ductor may be used for the Cambo wells this should be considered as an option within the ES.	Project options have been presented in the ES. Survey data has confirmed that piling for infield infrastructure is not required; suction anchors to be utilised. Both conventional drilling and use of CAN-ductors are assessed in the ES.	Section 2 Section 7 Section 9
OPRED	Where the development is to be carried out in stages then the full extent of proposals should be described (3.2.3 and 3.2.6 [EIA Guidance]).	Cumulative impacts have been included in each impact section.	Section 7 to Section 13
OPRED	Gas export pipeline – while it is understood that the export pipeline gradient (~1000m to 200m depth) does not pose any technical challenges for single phase hydrocarbons (gas), the future pipeline use should be considered i.e. if gas condensates are anticipated to be exported via this pipeline then this should be considered in the ES.	The 10" gas export pipeline offers capacity above the requirements for Cambo Phase 1 alone, and so is consistent with MER UK obligations towards other Field developments. The new pipeline ties into the existing West of Shetland Pipeline System (WOSPS) to Sullom Voe - this system is a single-phase gas system, and so no gas condensates are anticipated to be exported.	Section 2 Section 3 Section 7
OPRED	It is understood that the Cambo oil is likely to have some waxing properties but that these are expected to be low. SPE are advised to consider the likelihood of pipeline waxing within the ES and any implications this may have along with any mitigation required. In particular any effects that may be caused by reduction in temperature between the well and the flowlines.	Significant wax deposition is not expected to occur based on an analysis of 2018 well test fluids. Subsea infrastructure will be designed to maintain operating temperatures above the wax appearance temperature (through passive insulation), and provisions are made in the design to allow hot oil flushing and round-trip pigging for wax management. Specifically, for the wells to production manifolds/main flowlines, individual well jumpers will also be insulated, and facilities provided for flushing via the xmas trees.	NA

Origin	Comment/Issued Raised	SPE Response Summary	ES Section
OPRED	As per Marine Scotland comments with respect to the infield survey it is advised that, in addition to ROV survey, grab samples for physio/chemical and benthos are taken to update baseline data for the Cambo area. This can be used to support existing survey information, some of which is >5 years old (3.6.1 and 3.6.2 [EIA Guidance]).	Grab samples were taken during an environmental baseline survey in 2018.	Section 4
OPRED	The Department is aware that SPE and JNCC are to discuss the survey requirements in relation to the export pipeline route through the Faroe-Shetland Sponge Belt NCMPA. During the scoping meeting it was concluded that ROV video and photographs would be sufficient to form the basis of the impact assessment for the ES. SPE are however reminded that the full survey results will be required to inform future PETS applications and that both qualitative and quantitative assessment is required.	Comment noted. The survey results are presented in the ES and will be used to support future PETS applications.	Section 4
OPRED	Routine chemical use and discharge to sea during operation do not need to be assessed within the ES but they should be acknowledged and an overview of how this will be managed incorporated in the ES i.e. MAT/SATs.	Use of chemicals has been included at a high level in the ES where relevant. More details information on chemical use and discharge will be included in future PETS applications / environmental permitting process.	Section 10
OPRED	With regard to produced water it is noted that the intention is to discharge overboard. SPE should note the OPRED expectation is for the re-injection produced water where practicable. Where not technically possible/desirable then a robust justification for not injecting must be provided. In the event that there is overboard discharge of produced water SPE should note that OiW limit is likely to be less than 30mg/l and the produced water treatment system should be designed to achieve as low a concentration as practicable in line with the principles of BAT.	Rationale for the decision to manage disposal of produced water through overboard discharge is included in the ES. Produced water dispersion modelling was also undertaken with results presented in this ES.	Section 2 Section 10
OPRED	In order to support any conclusions on the impact of drilling discharges relevant modelling should be provided and any discharges of cement should be minimised and fully justified.	Drill cuttings discharge modelling has been undertaken.	Section 9
OPRED	If well testing may be undertaken, then this should be scoped in.	A well test was undertaken in 2018 when appraisal well 204/10a-5 was drilled.	Section 2
OPRED	MODU, Infrastructure installation activities and FPSO combustion emissions should be scoped in.	Atmospheric emissions have been assessed.	Section 8
OPRED	It is noted that the installation of a gas export line is the preferred option. However, if any extended flaring of gas is proposed then this should be discussed within the ES.	There will be no extended flaring of gas from Cambo.	Section 2
OPRED	Any venting of unburned hydrocarbons should be scoped into the ES.	There will be no routine cold venting from the Cambo facilities. Low volume, non-routine venting may be necessary from time to time in readiness for maintenance e.g. hydrocarbon freeing in preparation for cargo tank entry.	Section 2

Origin	Comment/Issued Raised	SPE Response Summary	ES Section
OPRED	Noise emissions from the FPSO and MODU should be considered. Where piling is required then this should also be scoped in. Similarly, if there is any seismic activity to be undertaken such as Vertical Seismic Profiling then this should also be scoped in. Please note that new injury thresholds for marine mammals were published in 2016 (NOAA, 2016), updating those published in Southall et al 2007. JNCC (and the other SNCBs) are currently considering these new guidelines and how they may be incorporated into marine mammal noise assessments, however it is likely JNCC will be formally endorsing these new thresholds/hearing functions in 2018 and therefore it is recommended these are incorporated into future assessments. http://www.nmfs.noaa.gov/pr/acoustics/guidelines.htm	Noise emissions are assessed within the ES.	Section 11
OPRED	It is noted that the gas export pipeline is to be laid on the seabed with minimal rock dumping. The route and intended method of pipeline installation should be justified in the ES and the Department would emphasise that any rock deposits should be the minimum necessary to achieve the required protection/stability of the pipeline. The worst-case rock deposits should be discussed within the ES.	Rock dumping may be required, and conservative estimates have been included in this ES and potential impact assessed accordingly.	Section 3 Section 7
OPRED	The presence of the FPSO and 2 x production centres (and the temporary presence of MODU and support vessels) should be scoped in as per Section 3.2.6 and 3.4.3.4 of the EIA guidance. Where it is intended that there are additional 500m safety zone around production centres, wellheads etc then these should also be scoped into the ES.	Details of all relevant infrastructure, FPSO and support vessels have been included in the ES.	Section 3
OPRED	Both MODU and FPSO anchor impact need to be assessed, in addition to the disturbance impact of the other infrastructure. This should include the worst-case number of FPSO anchors.	A DP MODU will be used for Cambo. FPSO anchor impact has been assessed in the ES.	Section 3 Section 7
OPRED	Dropped objects may pose a hazard to fishing activities and SPE should consider if this needs to be addressed in the ES.	Impacts resulting from dropped objects were not considered significant during the ENVID and therefore not assessed further.	NA
OPRED	Consideration should be given to cumulative effects e.g. potential impacts upon Faroe-Shetland Sponge-Belt NCMPA (3.2.12 [EIA Guidance]).	Cumulative effects upon the NCMPA are addressed in the ES.	Section 7
OPRED	The risk and potential impact of failure of operational equipment or control systems, the precautions to prevent these occurring and a description of how these will be managed should be provided (3.2.6 and 3.2.10.2 [EIA Guidance]).	Preventative measures to reduce risk & potential impact of such failures are addressed under Accidental Events.	Section 13
OPRED	A MEI assessment will be required which incorporates the worst-case well blowout and total FPSO inventory (3.2.10 [EIA Guidance]).	An MEI assessment has been provided in the ES.	Section 13
OPRED	Section 4.4 of the Scoping Study states that the $250 million OPOL cover limit per incident is sufficient for most wells with only a small number of wells having the potential to exceed this. It is understood that none of the Cambo wells have the potential to exceed the OPOL limit but confirmation of this should be included.	For the 2018 Cambo Appraisal Well (considered a high performing well) it was established that clean-up and 3rd party liability would be covered by the OPOL Limit.	Section 13

Origin	Comment/Issued Raised	SPE Response Summary	ES Section
OPRED	The ES will need to consider natural disasters (at a high level) as per Section of 3.2.10.2 of the EIA Guidance.	No such natural disasters are anticipated or considered likely to have an environmental impact. Seismic activity is very low in and around the Cambo Project area. This suggests the likelihood of a major accident due to an earthquake or associated tsunami is extremely remote. In addition, the FPSO mooring system and hull structure has been designed to withstand 10,000-year extreme weather events.	NA
OPRED	Waste - while detailed information is not required, wastes and waste management should be described at a high level.	Waste has been included in the ES.	Section 12
OPRED	It is noted that there is no reference to decommissioning intentions. While there are no requirements to provide detailed information at the ES stage, higher level considerations/design intentions should be addressed in line with Section 3.2.10.2 of the EIA guidance.	Decommissioning is addressed at a high level in the Project Description.	Section 3
Marine Scotland	It is questioned whether a Non-Technical Summary will be provided in the ES?	A non-technical summary has been provided.	NTS
Marine Scotland	It is advised that a summary table of feedback received from stakeholders is included in the ES and detail provided as to how any feedback been addressed.	Feedback from stakeholders and information on how comments have been addressed are included in the ES.	Section 5 Appendix 4
Marine Scotland	Marine Scotland would ask that an option selection and alternatives section is included in the ES which should discuss why the proposed development (including pipeline option) is the best available option.	Options have been addressed in the ES.	Section 2
Marine Scotland	Marine Scotland note that a significant ~60 km gas export pipeline is being considered which transits through the Faroe-Shetland Sponge Belt Nature Conservation Marine Protected Area (NCMPA). Given the proximity of other proposed developments (such as Rosebank and Black Rock) and the likely future oil and gas expansion in the West of Shetland region, Marine Scotland would urge Siccar Point Energy to adopt a strategic approach for proposed pipelines by exploring all opportunities for sharing trunk lines, building in adequate capacity to accommodate future developments and considering all alternative routes in order to minimise any impact on the Faroe-Shetland Channel NCMPA. The ES should demonstrate that the chosen option represents Best Environmental Practice (BEP) using Best Available Technology (BAT) and takes account of decommissioning.	Justification for the pipeline route has been included in the ES.	Section 2 Section 3
Marine Scotland	A detailed schedule of works should be provided with any contingency periods clearly stated.	An indicative schedule of activities to first oil has been provided in the ES.	Section 3

Origin	Comment/Issued Raised	SPE Response Summary	ES Section
Marine Scotland	It is advised that cementing operations are detailed and associated environmental/socio economic impacts assessed in the ES.	Anticipated quantities of cement slurry, for a conventional well design, have been included in the ES and assessment accordingly.	Section 9
Marine Scotland	It is understood that the base case for new developments should follow the requirements of OSPAR 2001/1 (i.e. zero discharge of oil in produced water). It is therefore advised that any deviation from this position is fully justified and based on a BAT/BEP approach. Will the proposed hydrocarbon production profiles and produced water profiles be included in the ES?	The decision to discharge produced water and justification for doing so is provided in the ES. Production profiles are also provided in summary, up front in the ES, and in more detail in an appendix to the ES.	Section 2 Section 3 Section 10 Appendix 5
Marine Scotland	The detailed assessment of chemical usage will correctly be deferred to the chemical permitting stage, however, given that produced water is to be discharged from this development, and given the waxy nature of the crude (as highlighted in the scoping meeting on 23 March 2018) an upfront overview of any potential concerns from a chemical discharge perspective, is advised.	Chemical discharges are assessed in relation to drilling activities and acknowledged in relation to produced water discharge.	Section 9 Section 10
Marine Scotland	Marine Scotland welcome that a number of surveys have been conducted in this area but note that the last comprehensive survey (comprising grab sampling methodologies) was in 2001 which is now 17 years old. Future site surveys were discussed in the scoping meeting on 23 March 2018 and it is understood that a full baseline environmental survey is to be undertaken along the proposed pipeline route. The design of this survey is to be discussed further with representatives from the Joint Nature Conservation Committee (JNCC), which is welcomed. It is understood that an ROV survey is also proposed for the infield area. Marine Scotland highlighted during this meeting that given the age of the existing data, there would be benefit from collecting additional in-field grab samples to further demonstrate stability in the environment and enable a quantified analysis of infauna and physio-chemical properties to update baseline data from which to measure the impacts of the operation when it comes to decommissioning.	SPE met with the JNCC to discuss plans for the environmental baseline survey in detail. Results from the survey have been included in the ES Environmental Description.	Section 4
Marine Scotland	It is advised that the extent of the mapped geo-morphological features is shown in relation to the proposed development and in particular the proposed pipeline route. The following page would be useful in demonstrating this: (http://jncc.defra.gov.uk/page-5201)	Seabed features and bathymetry of the proposed development area have been included in the ES.	Section 4
Marine Scotland	A local scale bathymetry map for the development area is advised, highlighting any significant seabed features.	As above.	Section 4
Marine Scotland	Marine Scotland has recently added new spatial layer to the NMPi, which show predicted seabed habitats and sediment types (at 1:25,000 scale) which the author may find useful. Presenting this visually in the ES would give useful wider scale context. These spatial layers may be viewed on the National Marine Plan interactive (NMPi): http://www.gov.scot/Topics/marine/seamanagement/nmpihome.	Sediments are addressed in the ES and a sediment data map has been included in the Environmental Description, this follows BGS NERC 2018, which can be found on NMPi.	Section 4

Origin	Comment/Issued Raised	SPE Response Summary	ES Section
Marine Scotland	Good quality, high resolution images of the local sediment/benthic community, clearly linked to a map showing the location of the photographs, would be a useful addition.	Images from the 2018 survey have been provided in the Environmental Description.	Section 4
Marine Scotland	A summary of any contaminant analysis should be provided.	Containment in relation to potential accidental events has been include in the ES.	Section 13
Marine Scotland	Where species of conservation concern or species indicative of habitats of conservation concern are identified, it is advised that the abundance of animals is discussed per unit area (m^2).	Abundance has been addressed in the Environmental Description. Also, densities are provided in Table 11.7.	Section 4
Marine Scotland	Marine Scotland agree with sources of information to assess the spawning and nursery sensitivities in the area and acknowledge that the area is not highlighted by the cited literature as being of particular importance as a fish spawning area.	Comment noted.	NA
Marine Scotland	Marine Scotland welcome that deep sea/mesopelagic species have also been included but also acknowledge that information regarding such populations is limited.	Comment noted.	NA
Marine Scotland	It is advised that spurdog are also listed a Priority Marine Feature (PMF) species. These are listed a ‘spiny dogfish’ in the PMF list.	Reference to spurdog has been made in the Environmental Description.	Section 4
Marine Scotland	Marine Scotland has commissioned the Sea Mammal Research Unit at the University of St Andrews to provide updated maps showing the distribution of grey and harbour seals around the UK. These 'usage' maps are produced by looking at movement patterns from electronically tagged seals. The resulting patterns of usage are scaled to population levels using data collected in aerial survey counts at haul out sites, to produce estimates of mean density (seals per 5x5 km grid cells). These maps are an update of the previous seal usage maps described in Jones et al. (2015) and it is advised these are referred to in the ES. The maps are available to view on NMPi (https://marinescotland.atkinsgeospatial.com/nmpi/) and further information is available here (http://www.marine.gov.scot/node/12697).	Up to date At-Sea usage of Grey and Common Seals in the vicinity of the proposed Development are addressed in the Environment Description.	Section 4
Marine Scotland	Marine Scotland agree with the conservation areas highlighted and welcome that these are shown in a well-produced map.	A conservation areas map has been included in the ES.	Section 4
Marine Scotland	Marine Scotland agree with the general findings of this section that fishing activity by UK vessels is not significant in this area with fishing effort focused more on shelf areas to the south and west.	Comment noted.	NA

Origin	Comment/Issued Raised	SPE Response Summary	ES Section
Marine Scotland	Marine Scotland would recommend using the following maps available on NMPi to show effort, landings and value for the last five years; 1. tonnage for demersal, pelagic and shellfish species; 2. value (£) for demersal, pelagic and shellfish species; 3. effort (days) (by UK vessels >10 m length) for demersal active (bottom trawls, dredges etc.); pelagic active (pelagic trawls, purse seines etc.); and passive (pots/creels, gillnets etc.). Further details are available here: http://marine.gov.scot/node/12674 The above spatial layers may be viewed on NMPi and it is recommended these are represented visually: http://www.gov.scot/Topics/marine/seamanagement/nmpihome.	Graphics and maps showing tonnage, value and effort have been included in the ES.	Section 4
Marine Scotland	Representing fisheries statistics in a tabular format in addition to the above is also recommended.	As above.	Section 4
Marine Scotland	The section states that “foreign vessels spent up to 6 months fishing in rectangle 50E6. This data also indicated that foreign vessels spent under one week in the Cambo Phase 1 Development rectangle (59E5)”. It is advised that year this information relates to is highlighted (2012).	Comment noted. Commercial fisheries within relevant ICES areas have been addressed in the ES.	Section 4
Marine Scotland	A couple of anomalies are present in the report, as follows: * Data from 2016 (for ICES 50E6) only shows landings for Jan and May not January, April and June? * Demersal active gear effort between 2012 and 2016 was 162.5 days not 165 days? * The total sales value between 2010 and 2016 (from 50E6) was £4,132,785 not £4,106,026? * The total shellfish sales value between 2010 and 2016 (from 50E6) was £16,990 not £12,000?	Anomalies acknowledged. Data has been revisited for the ES and provided for 2012 to 2016.	Section 4

Origin	Comment/Issued Raised	SPE Response Summary	ES Section
Marine Scotland	Fishing measures within MPAs – the Marine and Coastal Access Act 2009 requires management action to be taken to ensure that achievement of the conservation objectives of the 13 Offshore MPAs is not hindered. These MPAs are considered necessary to comply with Article 13(4) of the EU Marine Strategy Framework Directive. The Common Fisheries Policy permits vessels from other member states, and also third countries like Norway, to fish in Scottish waters. Therefore, when fisheries management measures are required to protect offshore sites, member states must submit a proposal for measures to the European Commission (EC). This process involves working with other member states who have a direct management interest to develop suitable management proposals. Marine Scotland and JNCC have engaged with stakeholders through a number of workshops to discuss management proposals for Scotland's offshore MPAs and recommendations have now been made for fishery management measures within these areas (including the Faroe-Shetland sponge belt MPA). It can be seen in the attached timeline documentation that implementation of the measures by the EC, through a delegated Act, was due on 31/1/18, however, this now expected to be towards the end of 2018. Further developments will be published on our website as information becomes available and it is advised that it would be useful to highlight the proposed management measures in the ES. More detail on the proposals submitted to the EC can be obtained here: http://www.gov.scot/Topics/marine/marine-environment/mpanetwork/SACmanagement	Management measures are acknowledged within the Environmental Description.	Section 4
Marine Scotland	Of particular relevance (to the Faroe Shetland Sponge belt) are the documents on the following page concerning the Northern North Sea Proposal: http://www.gov.scot/Topics/marine/marine-environment/ mpanetwork/SACmanagement/Offshore2017	Comment noted.	NA
Marine Scotland	Map layers showing these proposed areas are now available on Marine Scotland's National Marine Plan interactive (NMPi) which may be accessed here: https://marinescotland.atkinsgeospatial.com/nmpi/. The relevant layer may be found by following the following hierarchy on NMPi: Healthy and biologically Diverse, Protected Areas, Marine Protected Areas (MPA) Network, Marine and Nature Conservation management in Marine Protected Areas (MPA) Network, Possible Marine Conservation Orders (MCO's) and fishery management measures for consultation (MPA and SAC's) June 2017.	Comment noted.	NA

Origin	Comment/Issued Raised	SPE Response Summary	ES Section
Marine Scotland	Marine Scotland welcome that use of the area by foreign fishing vessels is being considered and have advised previously that anecdotal information regarding foreign fishing activity, from sources such as the Scottish Fishermen's Federation (SFF), is useful to capture foreign fishing vessel activity in this area. Further information is also available via ICES (http://www.ices.dk/marine-data/dataset-collections/Pages/Fish-catch-and-stock-assessment.aspx). The data set is rather large, given that it covers all member states, but it is possible to ascertain what fish have been landed from the ICES area in question. The issue is likely to be that the data is aggregated based on an area which is quite large, so may not provide the level of detail that the UK statistics provide. Using the ICES spatial facility http://gis.ices.dk/sf/ you can see that Shetland falls within ICES division 27.4a for example, you can then open the 'Official Nominal Catches 2006 – 2015' Excel spread sheet on the right-hand side of this page http://www.ices.dk/marine-data/dataset-collections/Pages/Fish-catch-and-stock-assessment.aspx and search for landings associated with area 27.4a.	Comment noted. This has been discussed in Section 4.	NA
Marine Scotland	The location of aquaculture sites and Shellfish Water Protected areas would benefit from being shown visually. The following information sources would be useful in demonstrating this: • The National Marine Plan interactive (https://marinescotland.atkinsgeospatial.com/nmpi/); • Scotland's Aquaculture website (http://aquaculture.scotland.gov.uk/map/map.aspx); • The Scottish Shellfish Farm Production survey 2016 (http://www.gov.scot/Publications/2017/05/6435) (These statistics are usually published in May each year); • The Scottish Finfish Farm Production survey 2016 (http://www.gov.scot/Publications/2016/09/1480) (These statistics are usually published in September each year).	Aquaculture sites are shown visually in the Environmental Description of the ES. The references listed here have been used in Section 4.	Section 4
Marine Scotland	The location of existing oil and gas infrastructure and previously drilled wells would benefit from being shown in a visual format. The Oil and Gas Authority quadrant maps would be a useful addition (http://data.ogauthority.opendata.arcgis.com/datasets?q=Q&sort_by=relevance).	Details on oil and gas infrastructure in the vicinity of the proposed Development have been included in the ES and presented in a figure.	Section 4
Marine Scotland	The detailed impact assessment methodology to be used is not detailed in the scoping report, but it is advised that a systematic impact assessment methodology is applied to allow impacts to be ranked. An overview of the method used is advised and an indication of the criteria used to determine whether an impact is 'likely' and whether it is 'significant'. The magnitude of the impacts should be predicted in terms of the deviation from the established baseline conditions, for each phase or element of the proposals.	A methodology section has been included in the ES.	Section 6
Marine Scotland	Marine Scotland welcome that all impacts will be assessed against Scotland's National Marine Plan.	The proposed Cambo Field Development has been assessed against the following general Marine Plan objectives and policies: GEN 1, 2, 3 ,4, 5, 6, 9, 10, 11, 12, 13, 14, 18, 19, 20 and 21.	Section 5

Origin	Comment/Issued Raised	SPE Response Summary	ES Section
Marine Scotland	Marine Scotland welcome that cumulative impacts are to be discussed.	Also raised by OPRED. Cumulative impacts have been included in each impact section.	Section 7 to Section 13
Marine Scotland	Marine Scotland understand that the gas export pipeline is likely to be surface laid. Marine Scotland would expect justification in the ES as to the chosen pipeline installation method. It is advised that the installation method of other pipelines in the vicinity is also highlighted in support of the chosen method.	Pipeline installation methods are provided in the ES.	Section 3
Marine Scotland	It is understood that rock protection may be required for the pipeline and it is advised that the worst-case volumes and locations of protective material are included in the ES.	Some rock dumping / rock protection may be required to provide the pipeline with adequate protection from trawling activities. A worst-case quantity of rock protection has been considered for impact assessment purposes.	Section 7
Marine Scotland	It is advised that the local geo-morphological features are also considered when assessing any requirement for protective material and the potential for future free spanning of the pipeline is taken into account.	Where practicable, gas pipeline routing will be refined during detailed design to reduce of the potential for free spans which may pose a potential risk of snagging for fishing gear. Unavoidable spans that present a potential hazard to fishing will be rectified (e.g. rock placement).	Section 3
Marine Scotland	Marine Scotland would advise against the use of concrete mattresses outwith the 500 m safety zone due to the potential snagging risk this may pose to towed fishing gear.	No mattresses are proposed outwith the 500 m safety zone.	NA
Marine Scotland	Marine Scotland recommend that the extent of any 500 m safety zone is shown on a figure in relation to the proposed infrastructure and location of protective materials.	Please see Figure 3.8 of the ES.	Section 3
Marine Scotland	The use of long (2.5 km) polypropylene ropes in the mooring system of the Floating Production Storage and Offload (FPSO) vessel was discussed in the meeting on 23 March 2018. Marine Scotland highlighted that due to lack of a metallic element, this rope can be evaded by sonar detection. Whilst fishing effort is not considered to be significant in this area, Marine Scotland would ask that this issue is discussed further with the SFF and that appropriate, proportionate mitigation is considered. Marine Scotland have been made aware in the past of transponders being fitted to each mooring line to allow fishing boats to detect the moorings.	Comment noted. This issue will be addressed with mooring system designers in the detailed design phase.	NA
Marine Scotland	Marine Scotland welcome that wells at both production centres will be fitted with fishing friendly structures.	SFF advised that only structures in 'open water' i.e. outwith the 500 m exclusion zone would require fishing friendly protection structures. As structure will be protected by the 500 m exclusion zone no protection is planned.	Section 3

Origin	Comment/Issued Raised	SPE Response Summary	ES Section
Marine Scotland	It is highlighted that the Feature Activity Sensitivity Tool (FEAST - http://www.marine.scotland.gov.uk/FEAST/) contains useful information regarding pressures on selected features of conservation concern and it is recommended this is incorporated into the ES.	FEAST used in all relevant impact sections.	Used in all relevant impact sections
Marine Scotland	It is advised that the cumulative footprint of the development is quantified and compared to the area of the NCMPA.	Detailed assessment on seabed take within the NCMPA has been provided in the ES.	Section 7
Marine Scotland	The predicted effectiveness of the stated mitigation measures should be made clear, and the ES should demonstrate a firm commitment to implementing the proposed measures, where appropriate, indicating how and when the measures will be implemented and confirming lines of responsibility for ensuring implementation. It is useful to provide a tabulated summary of the mitigation measures which is then taken forward into to the ES.	A commitments register has been included as Appendix 2. Where relevant these commitments will be taken forward in an Environmental Management Plan which will confirm lines of responsibility.	Appendix 2
Marine Scotland	It is recommended that the ES considers decommissioning upfront and details how all installed infrastructure/protective material would be removed should this be the policy in place at that time.	Also raised by OPRED. Decommissioning is addressed at a high level in the Project Description.	Section 3
Marine Scotland	Please ensure the ES contains a comprehensive conclusion summarising the main environmental sensitivities and how these are to be mitigated or why they are not considered to be significantly affected.	A conclusions section has been provided in the ES.	Section 14
JNCC	It would also be beneficial if some form of timescale was attached to the identified impact receptor pathways, for example, is the impact of potential concern expected to occur over the short term, long term, or act only in a cumulative context? Providing this information may help focus the subsequent environmental impact assessment process and ensure that only potentially significant impacts are considered.	The impact assessment methodology addresses Source-Pathway-Receptor Analysis. Only potential significant impacts identified during the scoping process were carried forward for detailed assessment.	Section 6
JNCC	As per BEIS guidelines https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/644775/OPRED_EIA_Guidance_-_130917.pdf[1] the ES should outline any realistic alternatives to the proposed Cambo I development. This should include alternative pipeline routes and laying methods, alternative export options, alternative production centres, alternative disposal options for produced water and other waste products etc. The consideration of alternatives should demonstrate how environmental criteria have been considered.	Alternatives / options considered during project planning phases are described in Section 2 of the ES.	Section 2

Origin	Comment/Issued Raised	SPE Response Summary	ES Section
JNCC	Whilst JNCC appreciates that not all of the detailed project design will be finalised at the time of ES submission, JNCC notes that best practice would not be to submit subsequent applications where, for example, stabilisation/protection material requirements are incrementally increased. The worst-case scenario should be assessed in the ES to enable a meaningful assessment of the whole environmental impact of the project to be undertaken.	Worst-case scenarios are assessed throughout the ES.	Section 7, Section 8, Section 9, Section 10, Section 11, Section 13
JNCC	It is understood that activities evolve over time and that subsequent stages are often contingent on the outcome of the earlier activities. However, every effort should be made to predict the likely outcome and carry out an assessment on that basis so that all the elements have been assessed and presented in the ES. As such a realistic, worst-case scenario should be considered and reassurances provided that as the project develops the predicted environmental impact will not increase, beyond that which has already been assessed. It would therefore be beneficial for the ES to include project details such as the maximum number of possible anchors, maximum area of impact across all required infrastructure, maximum quantity of rock dump and its associated area of impact, maximum number of wells, expected vessel movements etc.	Worst case scenarios have been used to assess potential impacts where relevant within the ES.	Section 7, Section 8, Section 9, Section 10, Section 11, Section 13
JNCC	The ES should also consider expected maintenance aspects for the Cambo Phase I development and any decommissioning planning/ options as appropriate.	A high-level description of inspection and maintenance for subsea infrastructure and the FPSO have been provided in the ES.	Section 3
JNCC	It would also be beneficial if the ES contained the maximum realistic disturbance footprint expected by the Cambo Phase I Development, and how the disturbance is distributed across the various designating features of marine protected areas, or other features of nature conservation importance. The expected timescale of impact, including expected recovery times should be discussed, in the context of the site's conservation objectives.	The maximum footprint has been used in assessing physical presence impact.	Section 7

Origin	Comment/Issued Raised	SPE Response Summary	ES Section
JNCC	The proposed pipeline route from the Cambo I Development is currently projected to interact with the Faroe Shetland Sponge Belt Nature Conservation Marine Protected Area (NCMPA). This site has been designated for: * Deep-sea sponge aggregations; * Offshore subtidal sands and gravels; * Ocean quahog aggregations; * Continental slope; * Continental slope channels; * Iceberg plough marks; * Prograding wedges and slide deposits representative of the West Shetland Margin paleo-depositional system Key Geodiversity Area; * Sand wave fields and sediment wave fields representative of the West Shetland Margin contourite deposits Key Geodiversity Area. The ES should contain relevant survey and feature sensitivity information which can be used to assess if the proposed operations are capable of affecting, other than insignificantly, the features for which the site is designated. Sensitivity information can be found on the Features, Activities Sensitivity Tool (FEAST) http://www.marine.scotland.gov.uk/feast/. Any conclusions should be clearly justified and audited within the ES. If the proposed operations are capable of affecting the designating features then the ES should contain an evidence based complete assessment, against the sites conservation objectives and provide details of any mitigation which will be used to minimise impact. The contribution of the Cambo phase I development to the anticipated cumulative impacts effecting the Faroe Shetland Sponge Belt NCMPA should also be considered. The impacts must be assessed across all relevant features of the site and consider all of the Conservation Objectives.	FEAST tool has been used in relevant impact Sections 9-13 where appropriate.	Impact Section where appropriate
JNCC	Information relating to our current understanding of the Faroe Shetland Sponge Belt NCMPA, and feature sensitivities can be found on our website, with recently published updated conservation advice (under the conservation advice tab) http://jncc.defra.gov.uk/page-6479 jncc.defra.gov.uk/files/FSSB_ConsAdvice_April2018.zip. JNCC strongly recommend that this information is used to support the environmental impact assessment process. Siccar Point Energy may also find guidance within the Nature Conservation Marine Protected Areas: Draft Management Handbook helpful in undertaking the assessment.	The JNCC website has been utilised in producing Section 4. Reference has also been made to two JNCC MPA documents as well.	Section 4

Origin	Comment/Issued Raised	SPE Response Summary	ES Section
JNCC	West of Shetland is considered an area of importance for marine mammals. JNCC recommends that this is recognised within the ES and that impacts including, but not limited to noise, potential changes in food distribution are considered within the ES.	The importance of the area for marine mammals is recognised and acknowledged as such in the ES. Potential impacts are also assessed in relation to noise and accidental events.	Section 4 Section 11 Section 13
JNCC	JNCC welcomes the use of the SOSI within the Cambo Phase I Scoping Study. The SOSI was primarily developed to assist in contingency planning by identifying areas where seabirds are likely to be most sensitive to oil pollution by considering factors that make a species more or less sensitive to oil-related impacts. Therefore, when assessing the impacts of accidental events on seabird populations, inclusion of this information is appropriate. We highlight, however, that this index is not intended to inform environmental baselines on seabird populations. We recommend consideration of other data sources when describing the baseline biological environment in the EIA e.g. Kober et al., 2010 and other sources already used within the scoping report. JNCC also recommends that the SOSI is used within the ES to inform the safety case, as required under the Offshore Safety Directive.	Reference has been made to SOSI in the ES. Kober et al., 2010 has been referenced.	Section 13 Section 4
JNCC	The use of mitigation to minimise environmental impacts is an important consideration within the environmental impact assessment process. JNCC recommend that any mitigation Siccar Point Energy can commit to using is clearly outlined within the ES and is subsequently incorporated into any subsequent licence conditions, following approval by BEIS.	Commitments have been addressed in the ES.	Appendix 2
JNCC	JNCC understand that Siccar Point Energy plan to carry out environmental surveys along the proposed pipeline route and around the proposed production centres. The collection of new survey data can help provide a robust characterisation of the local environment, provide baseline information which can be used to identify and assess impact and reduce the environmental risk of the Cambo phase I development. The ES should outline which new surveys are being undertaken and how they will complement existing environmental survey information. JNCC would welcome further consultation on the development of these survey plans and as discussed on the 23 March 2018, look forward to working with Siccar Point Energy on their development.	SPE met with JNCC on 20th April 2018 to discuss survey planning in further detail. All guidance gratefully received.	NA
SFF	UK Fishing vessels currently cannot fish below 800 m due to licence (regulatory) restrictions. This is not permanent 'per se' as variations could be applied. Reviews and variations can be changed at any time.	Comment noted.	NA
SFF	Fishing activity from foreign fishing fleets occur at depths greater than 800 m e.g. depths greater than 1000m West of Shetland. These fleets include Spanish, French, German and Faroese vessels.	Comment noted and referenced in the ES.	Section 4.

Origin	Comment/Issued Raised	SPE Response Summary	ES Section
SFF	Communications on oil and gas development activity to the UK fishing fleet via FishSafe. Sea fish handle communication transfer to foreign fishing fleets usually occur every 6 months. There are no guarantees that Foreign vessels are using up to date information regarding seabed obstructions. This is also true of UK vessels but to a much lesser degree.	Comment noted.	NA
SFF	SFF requested that during drilling operations a 'log' of fishing vessels in the Cambo area is kept [during 2018 appraisal drilling operations]. SPE to action this as appropriate.	A fishing activity log was kept during 2018 drilling operations, and the results summarised in the ES.	Section 4.
SFF	SFF provided some guidance on expectations regarding design of subsea structures in relation to fishing activity. It is advised that any structures installed in 'open water' should be designed to be over-trawlable, whereas structures in the North Sea and inside a 500m safety zone are normally designed as 'fishing friendly' SPE will take this advice onboard and revert to SFF at a later date once the project scope becomes more defined.	No wellhead protection structures are planned due to the water depth in field relative to any potential fishing activity and exclusion zones will be put in place.	Section 3.
SFF	With reference to the proposed gas export pipeline, SFF queried whether there were any cables in the area.	No charted cables present.	NA
SFF	The SFF queried if there was any particular reason why surface laying the pipeline was being considered.	The ES notes that, based on further analysis, for safety reasons and protection of the gas export pipeline from any potential trawling or other mechanical impacts, up to 45 km of the pipeline (potentially from 800 m water depth to the WOSPS PLEM location) will be jet-trenched.	Section 2 Section 3
SFF	The SFF highlighted that there is a lot of fishing activity up and down the deepwater ridge. The load bearings of the pipe need to be able to tackle the 'hit' from any trawling/fishing gear. Pipeline protection needs to be considered.	Pipeline protection has been included in the ES.	Section 3 Section 7
SFF	SPE mentioned that a Scoping Report had been produced for consultation with OPRED, JNCC and Marine Scotland. The SFF would welcome the opportunity to provide comment on this report. The SFF will liaise with other relevant fishing organisations as appropriate.	The scoping report was sent to the SFF and comments gratefully received.	NA
SFF	SFF offered to present a fisheries awareness session to highlight the interactions between various fishing gear and oil industry infrastructure.	SPE gratefully accepts this offer and will action a suitable date for such a presentation to take place at an appropriate time.	NA
SFF	The anchor pattern has a large footprint however given the locality and the low fishing intensity in the development area we have no further comments at this time.	Comment noted.	NA
SFF	The proposed surface laid pipelines (65Km and 59Km) would be required to have sufficient loadings to interact with fishing methods that are deployed in the area.	Export pipeline protection is addressed in the ES.	Section 2

Appendix 5

Cambo Field Development Forecast Production Profile

APPENDIX 5 CAMBO PHASE 1 DEVELOPMENT FORECAST PRODUCTION PROFILES

Table A5.1: Average Production Profiles (P_{10})

Year	Average Annual Rate (Oilfield Units)					
	Oil [bbls/day]	Water [bbls/day]	Production Gas [MMscf/day]	F&F [MMscf/day]	Export Gas [MMscf/day]	Water Injection (WI) [bbls/day]
2025	7,689	0	2.9	0.6	2.3	4,247
2026	47,248	268	25.9	5.7	20.2	75,217
2027	52,644	2,718	29.6	6.1	23.6	71,332
2028	51,154	5,111	28.5	5.9	22.6	85,257
2029	53,400	12,198	29.1	6.2	22.9	89,000
2030	52,207	18,766	23.8	6.0	17.8	86,558
2031	45,945	23,232	21.0	5.9	15.1	82,612
2032	37,992	29,951	18.7	6.2	12.5	80,103
2033	27,589	38,115	15.0	6.0	9.0	75,637
2034	23,141	42,424	13.3	5.8	7.4	73,663
2035	21,647	45,935	13.0	6.1	6.9	74,825
2036	19,489	47,947	12.1	6.0	6.1	74,673
2037	16,540	50,278	10.9	5.8	5.0	74,284
2038	14,307	54,401	10.3	6.1	4.3	75,613
2039	12,561	56,908	9.7	6.0	3.7	75,581
2040	11,280	58,397	7.0	5.8	1.2	75,472
2041	10,281	61,545	4.4	6.1	0.0	76,898
2042	9,530	62,717	3.5	6.0	0.0	75,993
2043	8,887	63,305	3.2	5.8	0.0	74,882
2044	8,635	65,823	3.1	6.1	0.0	76,336
2045	8,107	66,333	2.9	6.0	0.0	76,070

Year	Average Annual Rate (Oilfied Units)1					
	Oil [bbls/day]	Water [bbls/day]	Production Gas [MMscf/day]	F&F [MMscf/day]	Export Gas [MMscf/day]	Water Injection (WI) [bbls/day]
2046	7,596	66,333	2.7	5.8	0.0	75,378
2047	7,370	68,666	2.7	6.1	0.0	77,222
2048	6,922	68,801	2.5	6.0	0.0	77,037
2049	6,522	68,337	2.4	5.8	0.0	76,053
2050	6,395	70,648	2.3	6.1	0.0	77,976

Note:

1. Average production rates are net of downtime.

Table 5.2: Average Production Profiles (P_{10}) in Metric Units

Year	P10 Production Rate (metric units for EIA)						
	Oil		Water	Prod. Gas	F&F	Export Gas	WI
	[m^3/day]	tonnes/day]	[m^3/day]	[m^3/day]	[m^3/day]	[m^3/day]	[m^3/day]
2025	1,222	1,111	0	81,245	16,059	65,186	675
2026	7,512	6,828	43	732,968	161,422	571,545	11,959
2027	8,370	7,608	432	838,829	171,788	667,041	11,341
2028	8,133	7,393	813	807,477	167,849	639,628	13,555
2029	8,490	7,717	1939	824,251	175,307	648,945	14,150
2030	8,300	7,545	2984	674,073	171,227	502,846	13,762
2031	7,305	6,640	3694	595,731	167,002	428,730	13,134
2032	6,040	5,491	4762	529,339	174,288	355,051	12,735
2033	4,386	3,987	6060	424,711	170,485	254,227	12,025
2034	3,679	3,344	6745	376,073	165,571	210,502	11,712
2035	3,442	3,128	7303	367,309	172,385	194,924	11,896
2036	3,099	2,817	7623	341,787	169,966	171,821	11,872

Year	P10 Production Rate (metric units for EIA)						
	Oil		Water	Prod. Gas	F&F	Export Gas	WI
	[m^3/day]	tonnes/day]	[m^3/day]	[m^3/day]	[m^3/day]	[m^3/day]	[m^3/day]
2037	2,630	2,390	7,994	307,587	165,428	142,159	11,810
2038	2,275	2,068	8,649	292,702	172,258	120,444	12,022
2039	1,997	1,815	9,048	274,149	169,826	104,324	12,016
2040	1,793	1,630	9,284	199,256	165,332	33,924	11,999
2041	1,635	1,486	9,785	125,427	172,242	0	12,226
2042	1,515	1,377	9,971	99,930	169,807	0	12,082
2043	1,413	1,284	10,065	90,458	165,249	0	11,905
2044	1,373	1,248	10,465	87,186	172,135	0	12,136
2045	1,289	1,172	10,546	81,784	169,748	0	12,094
2046	1,208	1,098	10,546	77,580	165,237	0	11,984
2047	1,172	1,065	10,917	75,322	172,154	0	12,277
2048	1,100	1,000	10,938	70,374	169,793	0	12,248
2049	1,037	943	10,865	66,757	165,264	0	12,092
2050	1,017	924	11,232	65,508	172,180	0	12,397

Table A5.3: Cumulative Production Profiles (P_{10})

Year	Cumulative Rate					
	Oil [MMbbls]	Water [MMbbls]	Production Gas [Bscf]	F&F [Bscf]	Export Gas [Bscf]	Water Injection (WI) [MMbbls
2025	2.8	0.0	1.0	0.2	0.8	1.6
2026	20.1	0.1	10.5	2.3	8.2	29.0
2027	39.3	1.1	21.3	4.5	16.8	55.0
2028	58.0	3.0	31.7	6.7	25.1	86.2
2029	77.5	7.4	42.4	8.9	33.4	118.7
2030	96.5	14.3	51.1	11.1	39.9	150.3
2031	113.3	22.7	58.7	13.3	45.5	180.5
2032	127.2	33.7	65.6	15.5	50.0	209.8
2033	137.3	47.6	71.1	17.7	53.3	237.4
2034	145.7	63.1	75.9	19.9	56.0	264.3
2035	153.6	79.9	80.6	22.1	58.5	291.6
2036	160.8	97.4	85.1	24.3	60.8	318.9
2037	166.8	115.8	89.0	26.4	62.6	346.0
2038	172.0	135.6	92.8	28.6	64.1	373.6
2039	176.6	156.4	96.3	30.8	65.5	401.2
2040	180.7	177.8	98.9	33.0	65.9	428.9
2041	184.5	200.2	100.5	35.2	65.9	456.9
2042	188.0	223.1	101.8	37.4	65.9	484.7
2043	191.2	246.2	103.0	39.5	65.9	512.0
2044	194.4	270.3	104.1	41.7	65.9	539.9
2045	197.3	294.5	105.2	43.9	65.9	567.7
2046	200.1	318.7	106.2	46.1	65.9	595.2
2047	202.8	343.8	107.1	48.3	65.9	623.4
2048	205.3	369.0	108.0	50.5	65.9	651.6
2049	207.7	393.9	108.9	52.6	65.9	679.3
2050	210.0	419.7	109.7	54.8	65.9	707.8

Table-A5.4: Cumulative Production Profiles (P_{10}) in Metric Units

Year	Cumulative P_{10} Production (metric units for EIA)						
	Oil		Water [×1,000 m^3]	Prod. Gas [×1,000 m^3]	F&F [×1,000 m^3]	Export Gas [×1,000 m^3]	WI [×1,000 m^3]
	[×1,000 m^3]	[ktonnes]					
2025	446	406	0	29,654	5,866	23,809	246
2026	3,188	2,898	16	297,188	64,825	232,566	4,611
2027	6,243	5,675	173	603,360	127,571	476,203	8,751
2028	9,220	8,381	471	898,897	188,878	709,827	13,712
2029	12,318	11,197	1,179	1,199,749	252,908	946,854	18,876
2030	15,348	13,951	2,268	1,445,785	315,449	1,130,519	23,899
2031	18,014	16,375	3,616	1,663,227	376,446	1,287,112	28,694
2032	20,225	18,384	5,359	1,856,965	440,105	1,416,794	33,355
2033	21,826	19,840	7,570	2,011,985	502,375	1,509,650	37,744
2034	23,169	21,060	10,032	2,149,252	562,850	1,586,536	42,019
2035	24,425	22,202	12,698	2,283,319	625,813	1,657,732	46,361
2036	25,559	23,233	15,488	2,408,413	687,893	1,720,490	50,706
2037	26,519	24,106	18,406	2,520,683	748,316	1,772,414	55,017
2038	27,349	24,860	21,563	2,627,519	811,233	1,816,406	59,405
2039	28,078	25,523	24,865	2,727,583	873,262	1,854,510	63,791
2040	28,735	26,120	28,263	2,800,511	933,650	1,866,901	68,182
2041	29,331	26,662	31,835	2,846,292	996,561	1,866,901	72,645
2042	29,884	27,165	35,474	2,882,767	1,058,583	1,866,901	77,055
2043	30,400	27,634	39,148	2,915,784	1,118,940	1,866,901	81,400
2044	30,902	28,090	42,978	2,947,694	1,181,812	1,866,901	85,842
2045	31,373	28,518	46,827	2,977,545	1,243,813	1,866,901	90,256

Year	Cumulative P_{10} Production (metric units for EIA)						
	Oil		Water [×1,000 m^3]	Prod. Gas [×1,000 m^3]	F&F [×1,000 m^3]	Export Gas [×1,000 m^3]	WI [×1,000 m^3]
	[×1,000 m^3]	[ktonnes]					
2046	31,814	28,919	50,677	3,005,862	1,304,166	1,866,901	94,631
2047	32,241	29,307	54,661	3,033,354	1,367,045	1,866,901	99,112
2048	32,644	29,673	58,665	3,059,111	1,429,062	1,866,901	103,595
2049	33,023	30,017	62,630	3,083,477	1,489,425	1,866,901	108,008
2050	33,394	30,355	66,730	3,107,388	1,552,313	1,866,901	112,533

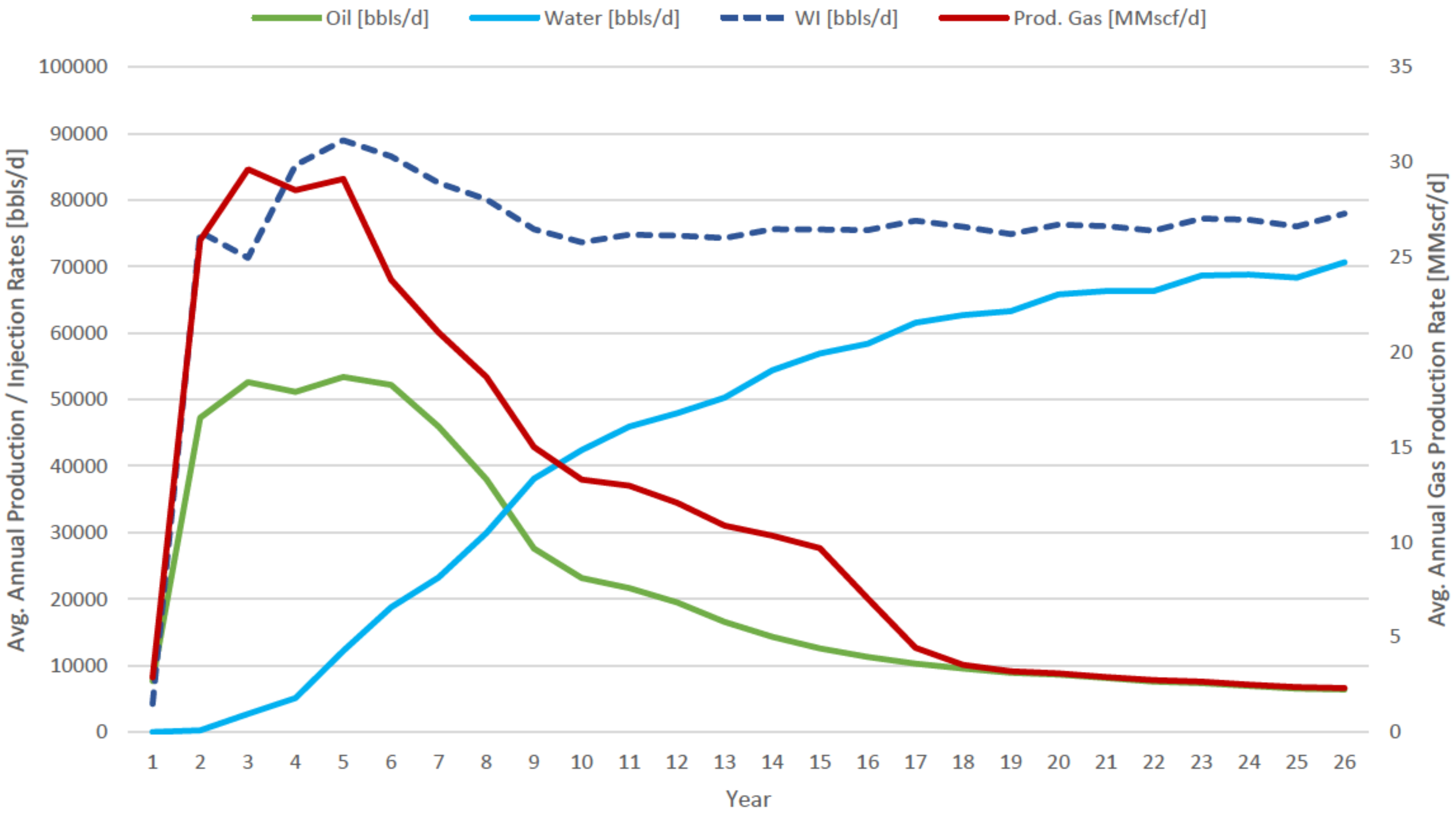

Figure A5.1: Annual Production Profile

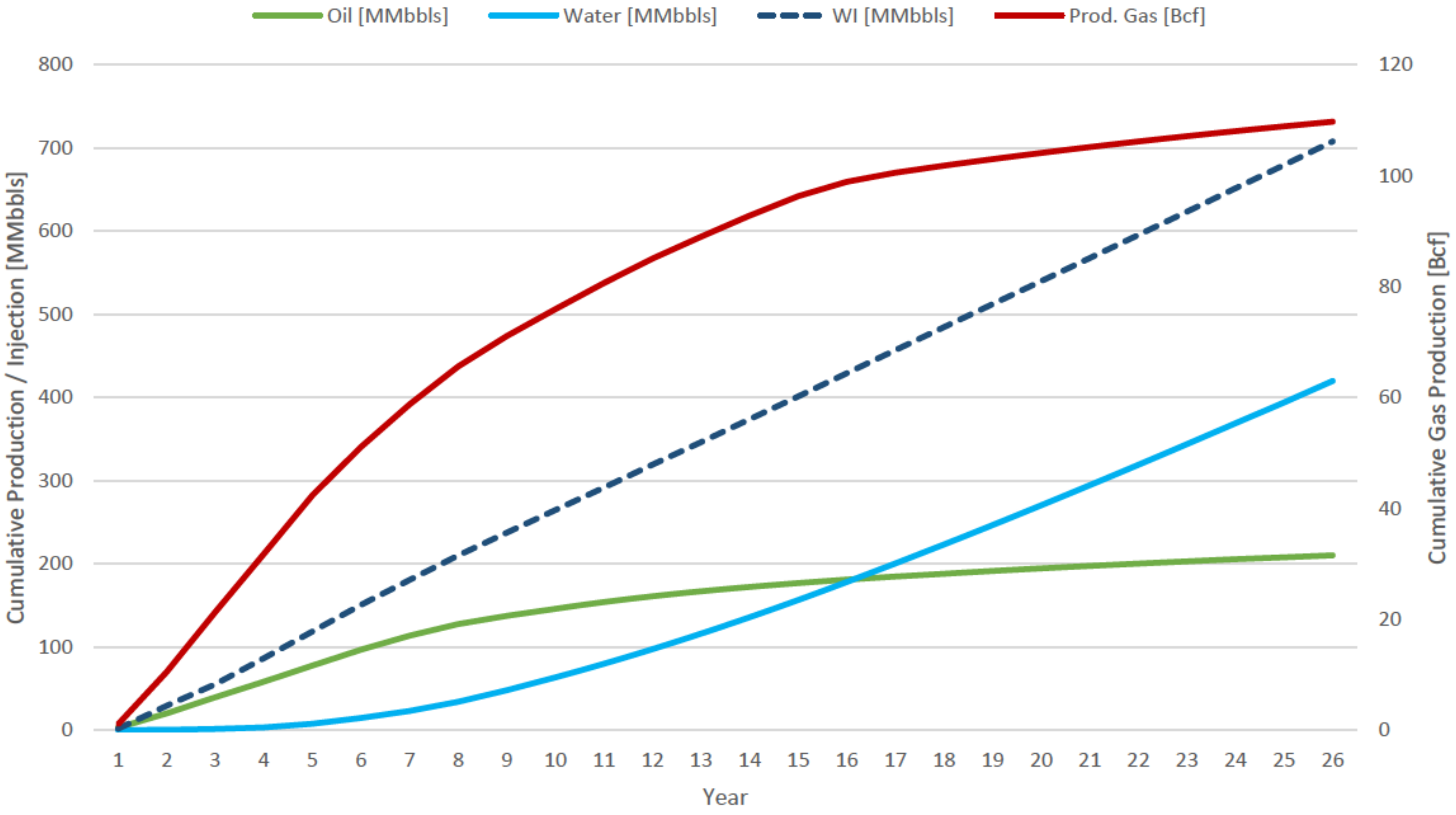

Figure A5.2: Cumulative Production Profile

Table A5.5: P_{90} Worst Case Water Production Profile

Year	P_{90} Produced Water		Year	P_{90} Produced Water	
	[m³/day]	[tonnes/day]		[m³/day]	[tonnes/day]
2025	2	2	2038	11,574	11,806
2026	415	424	2039	11,414	11,642
2027	1,745	1,780	2040	11,098	11,320
2028	3,827	3,903	2041	11,574	11,806
2029	6,384	6,512	2042	11,414	11,642
2030	7,980	8,140	2043	11,099	11,321
2031	8,845	9,022	2044	11,574	11,806
2032	9,792	9,988	2045	11,414	11,642
2033	10,155	10,358	2046	11,099	11,321
2034	10,370	10,577	2047	11,574	11,806
2035	11,045	11,266	2048	11,414	11,643
2036	11,243	11,468	2049	11,099	11,321
2037	11,099	11,321	2050	11,574	11,806

Table A5-6: Daily Tonnage of Oil Discharge Overboard (Based on P_{10} Production Profile)[1]

Year	Rate			Year	Rate		
	Water [bbls/day]	Oil Discharged			Water [bbls/day]	Oil Discharged	
		[kg/day]	[tonnes/day]			[kg/day]	[tonnes/day]
2025	0	0	0.000	2038	54,401	130	0.130
2026	268	1	0.001	2039	56,908	136	0.136
2027	2,718	6	0.006	2040	58,397	139	0.139
2028	5,111	12	0.012	2041	61,545	147	0.147
2029	12,198	29	0.029	2042	62,717	150	0.150
2030	18,766	45	0.045	2043	63,305	151	0.151
2031	23,232	55	0.055	2044	65,823	157	0.157
2032	29,951	71	0.071	2045	66,333	158	0.158
2033	38,115	91	0.091	2046	66,333	158	0.158
2034	42,424	101	0.101	2047	68,666	164	0.164
2035	45,935	110	0.110	2048	68,801	164	0.164
2036	47,947	114	0.114	2049	68,337	163	0.163
2037	50,278	120	0.120	2050	70,648	168	0.168

Note:

1. The oil that will be discharged overboard will be within the produced water and has been calculated for the target maximum of 15 mg/l oil in water concentration.

Appendix 6

Feature Activity Sensitivity Tool (FEAST) Sensitivity Assessment

APPENDIX 6 FEATURE ACTIVITY SENSITIVITY TOOL (FEAST) SENSITIVITY ASSESSMENT

The Marine Scotland Feature Activity Sensitivity Tool (FEAST) has been developed to determine potential management requirements for Nature Conservation MPAs (Marine Scotland, 2013a). FEAST has been used to determine the sensitive features and corresponding relevant pressures to these features from the proposed operations (Activity selection: *Oil and Gas Infrastructure and Cables and Pipelines*).

The FEAST sensitivity assessment scoring is described below:

- ○ Not exposed - although the feature may be sensitive to the pressure, the activity exerting that pressure does not spatially overlap with the known distribution of the feature;
- ● Not sensitive - there is a good level of evidence to suggest that although the feature may be exposed it is not considered to be sensitive to the pressure;
- ● Sensitive - not enough information is available to complete one of the sensitivity assessment stages to give a final score, but due to concern over potential impacts on feature it has been assessed as sensitive;
- ● Low - features with low sensitivity are those with high resistance or where recovery from any impacts caused by pressure is rapid, so that the feature is recovered within two years from cessation of pressure causing activity;
- ● Medium - features with medium sensitivity are those characterised by medium resistance and no to low recovery or no to low resistance and medium to high recovery;
- ● High - a feature is assessed as having high sensitivity where the pressure causes severe or significant mortality of a species population (most individuals killed). Habitat features are highly sensitive where the pressure causes severe or significant mortality of key functional or structural species or those that characterise the habitat, and/or causes changes in the habitat such that environmental conditions are changed (e.g. the habitat type is changed). If recovery is possible, the feature is anticipated to take 10 years to recover from the impacts caused by the pressure;
- ● High* - a feature is assessed as having high sensitivity where the pressure causes severe or significant mortality of a species population (most individuals killed). Habitat features are highly sensitive where the pressure causes severe or significant mortality of key functional or structural species or those that characterise the habitat, and/or causes changes in the habitat such that environmental conditions are changed (e.g. the habitat type is changed). If recovery is possible, the feature is anticipated to take 10 years to recover from the impacts caused by the pressure. An asterisk is used to denote an underlaying range of sensitivities for habitat features (e.g. due to the feature including species with a range of different sensitivities to a pressure) OR for species it denotes a sensitivity within certain key areas for that species - explained further in evidence. Where an asterisk follows a high sensitivity score, it denotes that the highest sensitivity score for the feature is high.

Associated Value is described as:

- Associated but not exposed - the pressure is thought to be caused by the activity, but the feature is not considered exposed to that activity;
- Associated - the pressure is thought to be caused by the activity and the feature is considered exposed to that activity.

FEAST does not specifically identify offshore sands and gravels within the tool, therefore, the assessment on the effects on this feature has been made using the Marine Scotland offshore sand and gravels FEAST translation table (Marine Scotland, 2013b). The translation table identified the features compatible with FEAST as deep-sea mixed sediments and deep-sea muddy sands.

Tables A6.1 to A6.10 describe the feature sensitivity and associated pressure for each of the sensitive features within the Faroe-Shetland Sponge Belt NCMPA.

Table A6.1: Offshore Sands and Gravels FEAST Sensitivity Assessment

Pressure Name	Feature Sensitivity	Associated Value
Offshore sands and gravels (deep-sea mixed sediments and deep-sea muddy sands)		
Introduction or spread of non-indigenous species & translocations (competition)	Not Sensitive	Associated
Non-synthetic compound contamination (inc. heavy metals, hydrocarbons, produced water)	Sensitive	Associated
Physical Change (to another seabed type)	High	Associated
Physical removal (extraction of substratum)	High	Associated but not exposed
Sub-surface abrasion/penetration:	High	Associated
Synthetic compound contamination (inc. pesticides, antifoulants, pharmaceuticals)	Sensitive	Associated
Underwater noise	Not Sensitive	Associated
Water clarity changes	Not Exposed	Associated but not exposed
Water flow (tidal current) changes - local	High	Associated but not exposed

Table A6: Deep-sea Sponge Aggregations FEAST Sensitivity Assessment

Pressure Name	Feature Sensitivity	Associated Value
Deep-Sea Sponge Aggregations		
Physical change (to another seabed type)	High	Associated
Sub-surface abrasion/penetration	High	Associated
Physical removal (extraction of substratum)	High	Associated but not exposed
Water flow (tidal current) changes - local	Not Exposed	Associated
Water clarity changes	Not Sensitive	Associated
Non-synthetic compound contamination (inc. heavy metals, hydrocarbons, produced water)	Sensitive	Associated
Synthetic compound contamination (inc. pesticides, antifoulants, pharmaceuticals)	Sensitive	Associated
Underwater Noise	Not sensitive	Associated

Table A6.3: Ocean Quahog Aggregations FEAST Sensitivity Assessment

Pressure Name	Feature Sensitivity	Associated Value
Ocean Quahog Aggregations		
Non-synthetic compound contamination (inc. heavy metals, hydrocarbons, produced water)	Sensitive	Associated
Physical Change (to another seabed type)	High	Associated
Physical removal (extraction of substratum)	High	Associated
Sub-surface abrasion/penetration:	Sensitive/High	Associated
Synthetic compound contamination (inc. pesticides, antifoulants, pharmaceuticals)	Sensitive	Associated
Underwater noise	Not sensitive	Associated
Water flow (tidal current) changes - local	Low	Associated

Table A6.4: Continental Slope FEAST Sensitivity Assessment

Pressure Name	Feature Sensitivity	Associated Value
Continental Slope		
Physical change (to another seabed type)	Not Sensitive	Associated
Physical removal (extraction of substratum)	Low	Associated
Sub-surface abrasion/penetration:	Low	Associated
Water clarity changes	Not Sensitive	Associated
Water flow (tidal current) changes - local	Not Sensitive	Associated

Table A6.5: Continental Slope Channels FEAST Sensitivity Assessment

Pressure Name	Feature Sensitivity	Associated Value
Continental slope Channels		
Physical change (to another seabed type)	Not Sensitive	Associated
Physical removal (extraction of substratum)	Medium	Associated
Sub-surface abrasion/penetration:	Low	Associated
Water clarity changes	Not Sensitive	Associated
Water flow (tidal current) changes - local	Not Sensitive	Associated

Table A6.6: Iceberg Ploughmark Fields FEAST Sensitivity Assessment

Pressure Name	Feature Sensitivity	Associated Value
Iceberg Ploughmark Fields		
Physical change (to another seabed type)	Not Sensitive	Associated
Physical removal (extraction of substratum)	High	Associated
Sub-surface abrasion/penetration:	Medium	Associated
Water clarity changes	Not Sensitive	Associated
Water flow (tidal current) changes - local	Low	Associated

Table A6.7: Prograding Wedge FEAST Sensitivity Assessment

Pressure Name	Feature Sensitivity	Associated Value
Prograding Wedge		
Physical change (to another seabed type)	Not Sensitive	Associated
Physical removal (extraction of substratum)	Low	Associated
Sub-surface abrasion/penetration:	Low	Associated
Water clarity changes	Not Sensitive	Associated
Water flow (tidal current) changes - local	Low	Associated

Table A6.8: Sand Wave Field FEAST Sensitivity Assessment

Pressure Name	Feature Sensitivity	Associated Value
Sand Wave Field		
Physical change (to another seabed type)	Medium	Associated
Physical removal (extraction of substratum)	Medium	Associated
Sub-surface abrasion/penetration:	Low	Associated
Water clarity changes	Medium	Associated
Water flow (tidal current) changes - local	Not Sensitive	Associated

Table A6.9: Sediment Wave Field FEAST Sensitivity Assessment

Pressure Name	Feature Sensitivity	Associated Value
Sediment Wave Field		
Physical change (to another seabed type)	Low	Associated
Physical removal (extraction of substratum)	High	Associated
Sub-surface abrasion/penetration:	Medium	Associated
Water clarity changes	Medium	Associated
Water flow (tidal current) changes - local	Not Sensitive	Associated

Table A6.10: Slide Deposits FEAST Sensitivity Assessment

Pressure Name	Feature Sensitivity	Associated Value
Slide Deposits		
Physical change (to another seabed type)	Not Sensitive	Associated
Physical removal (extraction of substratum)	High	Associated
Sub-surface abrasion/penetration:	Medium	Associated
Water clarity changes	Not Sensitive	Associated
Water flow (tidal current) changes - local	Medium	Associated

Appendix 7

JNCC Advice on Operations Sensitivity Assessment

APPENDIX 7 JNCC ADVICE ON OPERATIONS SENSITIVITY ASSESSMENT

The JNCC Advice on Operations (AoO) Guidance has been developed as part of the JNCC's formal conservation advice package for individual offshore Nature Conservation Marine Protected Areas (NCMPA) (JNCC, 2020a). The Advice on Operations provides information on those human activities that, if taking place within or near the Faroe-Shetland Sponge Belt NCMPA, can impact it and present a risk to the achievement of the conservation objectives. The Faroe-Shetland Sponge Belt AoO has been used to determine the sensitive features and corresponding relevant physical pressures to the conservation features of the NCMPA from the proposed operations.

Within the Faroe-Shetland Sponge Belt AoO Guidance, a number of pressures on specific Annex I habitats, namely those of deep-sea sponge aggregations, offshore subtidal sands and gravels and ocean quahog aggregations, have been identified which are associated with the presence of the oil and gas exploration, and installation, production, pipelines and decommissioning activities relevant to the Cambo Phase 1 Development. Within each of these activities, associated pressures have been assigned and described in Tables A7.1 to A7.4.

The AoO Guidance sensitivity category descriptions are described below:

- ● Sensitive - the evidence base suggests the feature is sensitive to the pressure at the benchmark. This activity-pressure-feature combination should therefore be taken to further assessment;
- ○ Not Assessed - a sensitivity assessment has not been made for this feature to this pressure. However, this activity-pressure-feature combination should not be precluded from consideration;
- ● Not Sensitive at the Benchmark - the evidence base suggests the feature is not sensitive to the pressure at benchmark. However, this activity-pressure-feature combination should not be precluded from consideration (e.g. thought needs to be given to activity specific variations in pressure intensity and exposure, in-combination and indirect effects);
- ● Not Relevant - the evidence base suggests that there is no interaction of concern between the pressure and the feature or the activity and the feature could not interact.

The AoO guidance also states whether the sensitivity category has a direct or indirect interaction with the activity. All interaction types associated with the Cambo Phase 1 Development were found to have a direct interaction with sensitivity. The AoO describes a direct interaction as an activity which exerts pressures that interacts with a feature within the spatial and/or temporal footprint of the operation.

Table A7.1: Oil and Gas Exploration and Installation AoO Sensitivity Assessment

Oil and Gas Exploration and Installation	Habitats		Species
Pressure Name	Offshore Subtidal Sands and Gravels	Deep-sea Sponge Aggregations	Ocean quahog Aggregations
Abrasion/disturbance of the substrate on the surface of the seabed	Sensitive	Sensitive	Sensitive
Habitat structure changes – removal of substratum (extraction)	Sensitive	Sensitive	Sensitive
Hydrocarbon and PAH contamination. Including those priority substances listed in Annex II directive 2008/105/EC	Sensitive	Sensitive	Sensitive
Introduction of Light	Not Relevant	Not Assessed	Not Relevant
Introduction or spread of non-indigenous species	Not Sensitive at the Benchmark	Not Assessed	Not Assessed
Litter	Not Assessed	Not Assessed	Not Assessed
Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion	Sensitive	Sensitive	Sensitive
Siltation rate changes (low), including smothering (depth of vertical sediment overburden)	Sensitive	Sensitive	Not Sensitive at the Benchmark
Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals). Includes those priority substances listed in Annex II of Directive 2008/105/EC	Sensitive	Sensitive	Sensitive
Transitional elements and organo-metal (e.g. TBT) contamination. Includes those priority substances listed in Annex II of Directive 2008/105/EC	Sensitive	Sensitive	Sensitive
Underwater Noise	Not Sensitive at the Benchmark	Not Sensitive at the Benchmark	Not Sensitive at the Benchmark
Vibration	Not Assessed	Not Assessed	Not Assessed

Table A7.2: Oil and Gas Production AoO Sensitivity Assessment

Oil and Gas Production	Habitats		Species
Pressure Name	Offshore Subtidal Sands and Gravels	Deep-sea Sponge Aggregations	Ocean quahog Aggregations
Deoxygenation	Not Relevant	Not Relevant	Not Sensitive at the Benchmark
Hydrocarbon and PAH contamination. Including those priority substances listed in Annex II directive 2008/105/EC	Sensitive	Sensitive	Sensitive
Introduction of light	Not Relevant	Not Assessed	Not Relevant
Introduction or spread of non-indigenous species	Not Sensitive at the Benchmark	Not Assessed	Not Assessed
Litter	Not Assessed	Not Assessed	Not Assessed
Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion	Sensitive	Sensitive	Sensitive
Radionuclide contamination	Not Assessed	Not Assessed	Not Assessed
Siltation rate changes (low), including smothering (depth of vertical sediment overburden)	Sensitive	Sensitive	Not Sensitive at the Benchmark
Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals). Includes those priority substances listed in Annex II of Directive 2008/105/EC	Sensitive	Sensitive	Sensitive
Transitional elements and organo-metal (e.g. TBT) contamination. Includes those priority substances listed in Annex II of Directive 2008/105/EC	Sensitive	Sensitive	Sensitive
Underwater Noise	Not Sensitive at the Benchmark	Not Sensitive at the Benchmark	Not Sensitive at the Benchmark
Vibration	Not Assessed	Not Assessed	Not Assessed
Water flow (tidal current) changes- local, including sediment transport considerations	Sensitive	Not Relevant	Sensitive

Table A7.3: Pipelines AoO Sensitivity Assessment

Pipelines	Habitats		Species
Pressure Name	Offshore Subtidal Sands and Gravels	Deep-sea Sponge Aggregations	Ocean quahog Aggregations
Abrasion/disturbance of the substrate on the surface of the seabed	Sensitive	Sensitive	Sensitive
Deoxygenation	Not Relevant	Not Relevant	Not Sensitive at the Benchmark
Habitat structure changes – removal of substratum (extraction)	Sensitive	Sensitive	Sensitive
Hydrocarbon and PAH contamination. Including those priority substances listed in Annex II directive 2008/105/EC	Sensitive	Sensitive	Sensitive
Introduction of light	Not Relevant	Not Assessed	Not Relevant
Introduction of other substances (solid, liquid or gas)	Not Assessed	Not Assessed	Not Assessed
Introduction or spread of non-indigenous species	Not Sensitive at the Benchmark	Not Assessed	Not Assessed
Litter	Not Assessed	Not Assessed	Not Assessed
Nutrient enrichment	Not Sensitive at the Benchmark	Not Assessed	Not Assessed
Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion	Sensitive	Sensitive	Sensitive
Physical change (to another seabed type)	Sensitive	Sensitive	Sensitive
Siltation rate changes (low), including smothering (depth of vertical sediment overburden)	Sensitive	Sensitive	Not Sensitive at the Benchmark
Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals). Includes those priority substances listed in Annex II of Directive 2008/105/EC	Sensitive	Sensitive	Sensitive
Transitional elements and organo-metal (e.g. TBT) contamination. Includes those priority substances listed in Annex II of Directive 2008/105/EC	Sensitive	Sensitive	Sensitive
Underwater Noise	Not Sensitive at the Benchmark	Not Sensitive at the Benchmark	Not Sensitive at the Benchmark
Vibration	Not Assessed	Not Assessed	Not Assessed
Water flow (tidal current) changes- local, including sediment transport considerations	Sensitive	Not Relevant	Sensitive

Table A7.4: Decommissioning AoO Sensitivity Assessment

Decommissioning	Habitats		Species
Pressure Name	Offshore Subtidal Sands and Gravels	Deep-sea Sponge Aggregations	Ocean quahog Aggregations
Abrasion/disturbance of the substrate on the surface of the seabed	Sensitive	Sensitive	Sensitive
Changes in suspended solids (water clarity)	Not Sensitive at the Benchmark	Not Sensitive at the Benchmark	Not Assessed
Habitat structure changes – removal of substratum (extraction)	Sensitive	Sensitive	Sensitive
Hydrocarbon and PAH contamination. Including those priority substances listed in Annex II directive 2008/105/EC	Sensitive	Sensitive	Sensitive
Introduction of light	Not Relevant	Not Assessed	Not Relevant
Introduction or spread of non-indigenous species	Not Sensitive at the Benchmark	Not Assessed	Not Assessed
Litter	Not Assessed	Not Assessed	Not Assessed
Penetration and/or disturbance of the substrate below the surface of the seabed, including abrasion	Sensitive	Sensitive	Sensitive
Physical change (to another seabed type)	Sensitive	Sensitive	Sensitive
Siltation rate changes (low), including smothering (depth of vertical sediment overburden)	Sensitive	Sensitive	Not Sensitive at the Benchmark
Synthetic compound contamination (incl. pesticides, antifoulants, pharmaceuticals). Includes those priority substances listed in Annex II of Directive 2008/105/EC	Sensitive	Sensitive	Sensitive
Transitional elements and organo-metal (e.g. TBT) contamination. Includes those priority substances listed in Annex II of Directive 2008/105/EC	Sensitive	Sensitive	Sensitive
Underwater Noise changes	Not Sensitive at the Benchmark	Not Sensitive at the Benchmark	Not Sensitive at the Benchmark
Vibration	Not Assessed	Not Assessed	Not Assessed
Water flow (tidal current) changes- local, including sediment transport considerations	Sensitive	Not Relevant	Sensitive

Appendix 8

Summary Table for all Proposed Wells

APPENDIX 8 SUMMARY TABLE FOR ALL PROPOSED WELLS

ACTIVITY DURATION - INSTALLATION PHASE (these steps are TBC, if the CAN-ductor is not run then Drill Phase, Drill 42" x 36" section and Run and Cement 36" x 30" conductor will be performed)																										
Well Identifier (Production or Injection)	P1		P3		P7		P10		P11		P20		P21		P22		I1		12		I5		I7		P2 (204/10a-5Y)	
Installation, Drilling or Completion Operation	Days	Section Length [m]	Days	Section Length [m]	Days	Section Length [m]	Days	Section Length [m]	Days	Section Length [m]	Days	Section Length [m]	Days	Section Length [m]	Days	Section Length [m]	Days	Section Length [m]	Days	Section Length [m]	Days	Section Length [m]	Days	Section Length [m]	Days	Section Length [m]
Mobilisation of CSV	3	NA		NA		NA		NA		NA	3	NA		NA	3	NA	3	NA		NA		NA		NA		
Vessel Transit	2.42	NA		NA		NA		NA		NA	2.42	NA		NA	2.42	NA	2.42	NA		NA		NA		NA		
Installation of CAN-ductor	1.1	NA	1.1	NA	1.1	NA	1.1	NA	1.1	NA	1.1	NA	1.1	NA	1.1	NA	1.1	NA	1.1	NA	1.1	NA	1.1	NA		
Demobilisation of CSV		NA	1	NA		NA		NA	1	NA		NA	1	NA		NA		NA		NA		NA	1	NA		

ACTIVITY DURATION - DRILL PHASE																										
Well Identifier (Production or Injection)	P1		P3		P7		P10		P11		P20		P21		P22		I1		12		I5		I7		P2 (5Y Completion)	
Installation, Drilling or Completion Operation	Days	Section Length [m]	Days	Section Length [m]	Days	Section Length [m]	Days	Section Length [m]	Days	Section Length [m]	Days	Section Length [m]	Days	Section Length [m]	Days	Section Length [m]	Days	Section Length [m]	Days	Section Length [m]	Days	Section Length [m]	Days	Section Length [m]	Days	Section Length [m]
Mobilisation of drill rig	0.9	NA	0.9	NA	0.9	NA	0.9	NA	0.9	NA	0.9	NA	0.9	NA	0.9	NA	0.9	NA	0.9	NA	0.9	NA	0.9	NA	0.9	NA
Prepare to spud	0.3	NA	0.3	NA	0.3	NA	0.3	NA	0.3	NA	0.3	NA	0.3	NA	0.3	NA	0.3	NA	0.3	NA	0.3	NA	0.3	NA	0.9	NA
Drill 42" x 36" section	1.3	90	1.3	90	1.3	90	1.3	90	1.3	90	1.3	90	1.3	90	1.3	90	1.3	90	1.3	90	1.3	90	1.3	90		
Run and cement 36" x 30" conductor	2.8	90	2.8	90	2.8	90	2.8	90	2.8	90	2.8	90	2.8	90	2.8	90	2.8	90	2.8	90	2.8	90	2.8	90		
Drill 17½ " section	3	644	3	643	3	643	3	641	3	661	3	678	3	650	3	641	3	638	3	634	3	633	3	628		
Run and cement 20" x 13⅜" surface casing and 18¾" WHH	2.6	644	2.6	643	2.6	643	2.6	641	2.6	661	2.6	678	2.6	650	2.6	641	2.6	638	2.6	634	2.6	633	2.6	628		
Install BOP and marine riser	7.6	NA	7.6	NA	7.6	NA	7.6	NA	7.6	NA	7.6	NA	7.6	NA	7.6	NA	7.6	NA	7.6	NA	7.6	NA	7.6	NA	7.6	NA
Drill 12¼" section	5.3	1089	6	1366	5.3	1053	7.7	2062	7	1787	4.9	910	7.5	1997	6	1378	5.4	1126	5.5	1143	4.6	786	7.9	2,199		
Run and cement 10¾" x 9⅝" production casing	3.1	NA	3.2	NA	3.1	NA	3.5	NA	3.4	NA	3	NA	3.5	NA	3.2	NA	3.1	NA	3.1	NA	2.9	NA	2.9	NA		
Drill 8½" section	4.2	494	4.2	500	4.2	500	4.2	500	4.2	500	4.2	500	4.2	500	4.2	501	4.2	500	4.2	500	4.2	500	4.2	500		
Run Lower Completion	4.5	NA	4.5	NA	4.5	NA	4.5	NA	4.5	NA	4.5	NA	4.5	NA	4.5	NA	4.5	NA	4.5	NA	4.5	NA	4.5	NA		
Drill Out cement plugs																									4.4	NA
Well bore Clean Up	4.6	NA	4.6	NA	4.6	NA	4.6	NA	4.6	NA	4.6	NA	4.6	NA	4.6	NA	4.6	NA	4.6	NA	4.6	NA	4.6	NA	4.6	NA
Run Upper Completion	12.9	NA	12.9	NA	12.9	NA	12.9	NA	12.9	NA	12.9	NA	12.9	NA	12.9	NA	12.9	NA	12.9	NA	12.9	NA	12.9	NA	12.9	NA
Recover BOP	4.2	NA	4.2	NA	4.2	NA	4.2	NA	4.2	NA	4.2	NA	4.2	NA	4.2	NA	4.2	NA	4.2	NA	4.2	NA	4.2	NA	4.2	NA
Suspend Well	0.3	NA	0.3	NA	0.3	NA	0.3	NA	0.3	NA	0.3	NA	0.3	NA	0.3	NA	0.3	NA	0.3	NA	0.3	NA	0.3	NA	0.3	NA
Prepare for Demob	0.7	NA	0.7	NA	0.7	NA	0.7	NA	0.7	NA	0.7	NA	0.7	NA	0.7	NA	0.7	NA	0.7	NA	0.7	NA	0.7	NA	0.7	NA
Rig Demobilisation	0.5	NA	0.5	NA	0.5	NA	0.5	NA	0.5	NA	0.5	NA	0.5	NA	0.5	NA	0.5	NA	0.5	NA	0.5	NA	0.5	NA	0.5	NA
Drill Rig Total Days	58.8		59.6		58.8		61.6		60.8		58.3		61.4		59.6		58.9		59.0		57.9		61.2		37.0	
Total Length Drilled		2,317		2,599		2,286		3,293		3,038		2,178		3,237		2,610		2,354		2,367		2,009		1,994		0

ACTIVITY DURATION - INSTALLATION PHASE																										
Well Identifier (Production or Injection)	P1		P3		P7		P10		P11		P20		P21		P22		I1		12		I5		I7		P2 (5Y Completion)	
Installation, Drilling or Completion Operation	Days	Section Length [m]	Days	Section Length [m]	Days	Section Length [m]	Days	Section Length [m]	Days	Section Length [m]	Days	Section Length [m]	Days	Section Length [m]	Days	Section Length [m]	Days	Section Length [m]	Days	Section Length [m]	Days	Section Length [m]	Days	Section Length [m]	Days	Section Length [m]
Mobilisation of CSV	3	NA		NA		NA		NA		NA	3	NA		NA		NA	3	NA		NA		NA		NA		NA
Vessel Transit	2.5	NA		NA		NA		NA		NA	2.5	NA		NA		NA	2.5	NA		NA		NA		NA		NA
Installation of X-mas tree	1.5	NA	1.5	NA	1.5	NA	1.5	NA	1.5	NA	1.5	NA	1.5	NA	1.5	NA	1.5	NA	1.5	NA	1.5	NA	1.5	NA	1.5	NA
Demobilisation of CSV		NA		NA		NA		NA	2	NA		NA		NA	2	NA		NA		NA		NA	2	NA		NA
CSV Total Days	13.5		2.6		2.6		3.6		10.0		8.1		2.6		3.6		8.1		3.6		7.5		5.6		1.5	

DRILL CUTTINGS GENERATED															
		Well Identifier (Production or Injection)													
Hole Section	Discharge Point	P1	P2 (204/10a-5Y)	P3	P7	P10	P11	P20	P21	P22	I1	I2	I5	I7	Total (MT)
Contingency 36"	Seabed	133 MT	-	133 MT	133 MT	133 MT	133 MT	133 MT	133 MT	133 MT	133 MT	133 MT	133 MT	133 MT	1,596 MT
17.5"	Seabed	225 MT	-	225 MT	225 MT	224 MT	231 MT	237 MT	227 MT	224 MT	223 MT	221 MT	221 MT	219 MT	2,702 MT
12.25"	Surface	186 MT	-	234 MT	180 MT	353 MT	306 MT	156 MT	342 MT	236 MT	193 MT	196 MT	134 MT	376 MT	2,892 MT
8.5"	Surface	41 MT	-	41 MT	41 MT	41 MT	41 MT	41 MT	41 MT	41 MT	41 MT	41 MT	41 MT	41 MT	492 MT
Total Cuttings incl. 36" contingency sections		585 MT	-	633 MT	579 MT	751 MT	711 MT	567 MT	743 MT	634 MT	590 MT	591 MT	529 MT	769 MT	7,682 MT
Total Cuttings excl. 36" contingency sections		**452 MT**	**-**	**500 MT**	**446 MT**	**618 MT**	**578 MT**	**434 MT**	**610 MT**	**501 MT**	**457 MT**	**458 MT**	**396 MT**	**636 MT**	**6,086 MT**

Contingency 36" section only required if the CAN-Ductor approach fails and the well is re-drilled with a conventional conductor