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Southwark Pipeline Installation Project

ES Addendum - D/4257/2020 - Document Number 001-VSO-INT-Y-RP-0001

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Rev 0	03/03/2021	Draft for Review	[redacted]	[redacted]	[redacted]
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Rev 2	16/04/2021	Final for submission	[redacted]	[redacted]	[redacted]

Intertek Energy & Water Consultancy Services is the trading name of Metoc Ltd, a member of the Intertek group of companies.

ES SUBMISSION INFORMATION

Environmental Statement Details

Section A: Administrative information

A1 – Project Reference Number

ES identification number: D/4257/2020

A2 - Applicant Contact Details

Company name: IOG UK LTD

Contact name: Mark Yates

Contact title: HSE Manager

A3 - ES Contact Details (if different from above)

Company name: As above

Contact name: As above

Contact title: As above

A4 - ES Preparation

Company	Title	Role	Relevant Qualifications/ Experience
Intertek	Associate Director	Authorisation of ES	>25 years practical, technical, managerial and commercial experience of a broad range of coastal and offshore projects in the UK and overseas
	Associate Director Senior Consultant	Technical Review of ES	Both with 15+ years' experience working in oil and gas and environment impact assessment.
	Consultant	Technical Review of ES	8 years
	Consultant	Writing ES	4- 8 years
IOG UK LTD	Head of HSE	Technical Review of ES.	More than 30 years' experience of international oil and gas exploration and production, in HSE management, corporate governance and risk management.

A5 - Licence Details

a) Licence(s):

b) Licensees and current equity outlined in table(s) below:

Licence number -	P1915
Licensee	**Percentage Equity**
IOG UK LTD	50%
Cal Energy Resources UK Limited	50%

Section B: Project Information

B1 - Nature of Project

a) Name of Project: Southwark Pipeline Installation Project

b) Please specify the name of the ES (if different from the project name): Southwark Pipeline Installation Project Environmental Statement Addendum

c) Brief description of the project: Development of the field will comprise of:

- A single 24" pipeline (PL4943), 5.67km long
- Seabed clearance and pipeline installation.
- Tie-in spools to allow tie-in to the existing Thames pipeline and the Southwark pipeline.
- Deposition of up to 200 concrete mattresses, nominally 100 at the Thames pipeline (PL370) tie-in and 100 at the Southwark Platform tie-in.
- Deposition of 2900 grout bags, nominally 1450 at the Thames pipeline tie-in and 1450 at the Southwark Platform tie-in.

B2 - Project Location

a) Offshore location(s) of the main project elements.

Quadrant number(s): 49
Block number(s): 49/21c and 49/26
Latitude: Start: Latitude 53° 10' 58.817" N, Longitude 002° 5' 45.913" E. End: Latitude 53° 8' 11.360" N, Longitude 002° 7' 13.543" E
Distance to nearest UK coastline (km): 52km
Which coast? Norfolk
Distance to nearest international median line (km): 65km
Which line? UK/Netherlands median line

B3 - Previous Applications <if applicable>

Name of project: Blythe Hub Development ES Addendum
Date of submission of ES: August 2019
Identification number of ES: D/4208/2018

0. NON-TECHNICAL SUMMARY

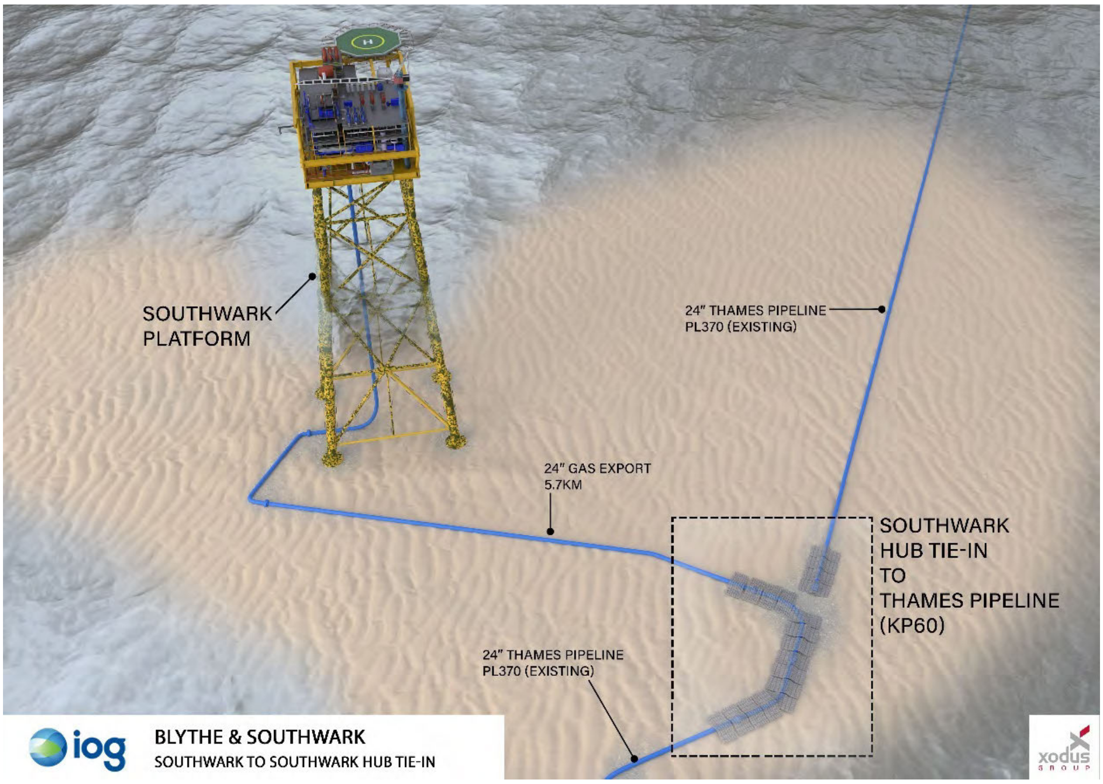
This non-technical summary (NTS) of the Southwark Pipeline Installation Project Environmental Statement (ES) Addendum (D/4257/2020) provides a summary of the following aspects of the Proposed Development:

- Introduction to the project and selected concept;
- Project approach;
- The baseline environment;
- Environmental hazards, effects and mitigation measures;
- Unplanned events;
- In-combination, cumulative and transboundary effects; and
- Conclusions

0.1 Introduction

The Proposed Development consists of a single 24" gas export pipeline which will transport the production gas and fluids from the Southwark platform for eventual processing at onshore Bacton terminal on the north Norfolk coast (Figure 0-1). The Southwark field is located approximately 52km east of the Norfolk coast and 65km west of the UK/Netherlands Exclusive Economic Zone (EEZ) boundary at its closest points and lies within Licence Blocks 49/21c and 49/26.

Figure 0-1 Southwark Field Layout



The Southwark project elements were previously part of a wider field development plan (the Vulcan Satellites Hub development) for which an ES was submitted to the Offshore Petroleum Regulator for Environmental and Decommissioning (OPRED) in April 2018, reference D/4213/2018. Since the submission of the ES, the Vulcan Satellites development has been split into two development phases (the Vulcan Satellites Hub Development and the Blythe Hub Development), with the Southwark specific components to be developed as part of the Blythe Hub development programme. Therefore, in 2019 an Addendum to the Blythe Hub Development ES, reference D/4208/2018 was submitted to cover details of the Southwark Field Development.

Following approval of the Blythe Hub Development ES Addendum (reference D/4208/2018), geophysical (topographic) survey data acquired in May 2020 showed that, since the previous survey in March 2018, sandwaves had moved in a north or north-west direction up to 50m. Subsea 7 (Engineering, Procurement and Construction (EPC) Contractor) indicated that these changes mean that the seabed preparation required to facilitate the pipeline installation described in the approved Blythe Hub Development ES Addendum are no longer appropriate. Consequently, this ES Addendum (D/4257/2020) has been prepared to cover the newly proposed seabed preparation and installation methods.

0.2 Proposed Concept

The Southwark pipeline is located within the North Norfolk Sandbank and Saturn Reef (NNSSR) Special Area of Conservation (SAC) and Southern North Sea (SNS) SAC. Given the environmental sensitivity of the European protected sites, the new environmental impact assessment (EIA) reported in this ES Addendum demonstrates careful consideration of potential impacts of the Proposed Development and appropriate choice of techniques.

As part of the option selection process, a re-route of the Southwark pipeline has been considered and discounted. The route selected represents the shortest route from the Southwark pipeline to the Thames pipeline, taking into account physical limitations, seabed topography and geohazards. Re-routing the pipeline would extend the overall length of the pipeline within the NNSSR SAC, increasing the degree of seabed preparation and the potential for future remediation.

During early consultation with the OPRED, IOG committed to carry out a Comparative Assessment (CA) of pipeline seabed preparation, installation, and protection options to identify the Best Practicable Environmental Option (BPEO). This BPEO process followed an eight step process and considered seven different installation methods for the Southwark pipeline (Table 0-1). The comparative assessment concluded that the BPEO for pipeline installation and protection is Option 6.

Table 0-1 Summary of Comparative Assessment

Option	Description	CA Conclusion
1	No seabed modification, pipeline installed as-found seabed	**Screened out** – not technically viable
2	Re-route pipeline	**Screened out** – not technically viable
3	Rock infill between sandwaves	**Screened out during the comparative assessment**, because this option is considered not environmentally acceptable.
4	Concrete mattress infill between sandwaves	**Screened out** – not technically viable
5	Sandwaves removed to local mean seabed level across the width of the pipe lay corridor	Concluded **Not the BPEO** – as scoring worse than option 6.
6	**Sandwaves removed to local mean seabed level across the width of the pipe lay corridor then pipeline installed and trenched below local mean seabed level**	**BPEO**
7	Pipeline self-burial	**Screened out** as not technically viable.

0.3 Project Description

The Southwark Field Development aims to produce gas for onshore processing at the Bacton Gas Terminal on the north Norfolk Coast. The development includes three gas production wells in the Southwark field, an offshore gas production platform together with an export pipeline which will be tied-in to the existing 24" Thames to Bacton pipeline (PL370) to deliver produced gas to the Bacton onshore terminal (Figure 0-1).

The Proposed Development will comprise of:

- A single 24" pipeline, 5.67km long
- Seabed clearance and pipeline installation
- Tie-in spools to allow tie-in to the existing Thames pipeline and the Southwark Platform.
- Deposition of up to 200 concrete mattresses, nominally 100 at the Thames pipeline tie-in and 100 at the Southwark Platform tie-in.
- Deposition of up to 2900 grout/sand bags, nominally 1450 at the Thames pipeline tie-in and 1450 at the Southwark Platform tie-in.

The pipeline installation works are scheduled to occur between mid-January 2022 and early June 2022, with first gas from the Southwark Platform in Quarter 2 of 2022. End of field life will be in 2037.

A sandwave pre-clearance survey, using a multi-beam echosounder, will be carried out along the pipeline route to confirm the status of the seabed and location of sandwaves along the route. A-pre lay survey will also be conducted to ensure there are no debris, obstructions or potential unexploded ordnance (UXO) present within the pipeline corridor.

The objective will be to install and bury the pipeline below the mean seabed level. To achieve this sandwaves will be removed to mean seabed level using one of three options: i) controlled flow excavation, ii) trailing suction hopper dredging, or iii) seabed excavators. It is calculated that 575,000m^3 of sediment will be cleared. Due to limitations in the data sets and the clearance methodology, the value assessed includes a conservative 50% contingency. Sediment will be either pushed to one side of the pipeline corridor or will be side cast from a dredger on either side of the dredged area. All displaced sediment will remain with the local area.

The next step could be one of two options: i) cutting a trench and laying the pipeline in to the trench, or ii) laying the pipe on the seabed and then trenching to below mean seabed level. After either option the trench will be backfilled, either naturally or mechanically. The only sections where the pipeline will not be trenched are at the tie-in locations, where it will be protected by concrete mattresses and grout/sand bags.

At this stage it is not known which specific vessels will be used, this will depend on vessel availability at the time of installation. However, the assessment considers both an anchored pipelay vessel with associated anchor handling tugs and a dynamically positioned pipelay vessel. Pipe supply vessels, a guard vessel, a survey vessel and either a trailing suction hopper dredger or dynamically positioned construction support vessel will also be used.

This ES Addendum also covers the potential requirement for remedial operations during the lifetime of the Proposed Development, this will be dependent on the occurrence of upheaval buckling. If upheaval buckling did occur the only technical solution available is the targeted deposit of rock material to protect the pipeline. For the assessment, Subsea 7 (EPC contractor) have estimated that approximately 10% of the pipeline route may require rock remediation in the form of rock protection.

Decommissioning will be carried out in compliance with United Kingdom Government legislation and international agreements in force at the end of the field life. Agreement to the Cessation of Production (CoP) will be sought as a pre-requisite for approval of the Decommissioning Programme.

0.4 The Baseline Environment

For the EIA, the baseline environment has been divided and considered as follows:

- Physical: metocean, air and water quality and sediment conditions;
- Protected and sensitive sites;
- Biological: benthos, plankton, fish and shellfish, marine birds, marine mammals and marine reptiles; and
- Socio-economic: commercial fisheries, shipping, navigation and other marine users.
- Natural evolution of the baseline

A good understanding of the baseline for these attributes has been achieved through two activities:

- Reviewing marine survey data for the Proposed Development area and surrounds; and
- Collating and reviewing secondary data sources (e.g. existing studies, literature and reports).

0.4.1 Marine Surveys

A field survey was undertaken within and near to the Proposed Development in 2018 to inform the original Blythe Hub Development area EIA. The data acquired provides an overview of the Proposed Development in terms of geological, seabed and sediment features, bathymetry, and habitats. The survey details the sensitive/protected features found around the Southwark proposed platform and the Southwark to Thames East proposed pipeline route. In May 2020, a pre-lay bathymetry survey was carried out by Subsea7. The objective of the 2020 was survey gather information on the status of the seabed in the immediate vicinity of the Proposed Development.

0.4.2 Physical Environment

The Proposed Development lies in the Southern North Sea (SNS) off the north Norfolk coast. The Proposed Development lies on the flanks of the Inner Bank, one of the main banks in the North Norfolk Sandbank system. The superficial sediments consist of sand, gravelly sand, and sandy gravel and may be classified as the European Nature Information System (EUNIS) habitat 'Deep circalittoral sand' (A5.27). Water depth along the proposed pipeline route ranges from approximately 22m to 34m.

The main physical feature of the route are the sandwaves and megaripples that occur throughout. Comparing the 2018 and the 2020 survey data, it appears that the sandwaves are travelling in a northerly direction. It has been calculated by Xodus that the sandwaves are migrating at a rate of 14 - 26 m/year (Xodus 2021c); with the smaller sandwaves travelling less than the larger ones. It also appears that the sandwaves have grown in height between the two surveys, in some cases by as much as a metre. In the wider area covered by the 2018 survey, there is also evidence of bifurcating and converging sandwaves, associated with steep asymmetric profiles of up to 18°, which all confirm an active and dynamically evolving environment (Xodus 2021c).

0.4.3 Protected and sensitive areas

The Proposed Development lies within the following protected sites:

- Southern North Sea SAC – designated for the protected of harbour porpoise.
- North Norfolk Sandbank and Saturn Reef SAC – designated for the protection of Sandbanks which are slightly covered by sea water all the time (Annex I habitat) and Reefs (Annex I habitat).

The Proposed Development is situated within 40km of the following protected and sensitive sites:

- Haisborough, Hammond and Winterton SAC - located 15km southwest of the Proposed Development. Designated for the protection of Sandbanks which are slightly covered by sea water all the time (Annex I habitat) and Reefs (Annex I habitat).
- Greater Wash Special Protection Area (SPA) - located 34km southwest of the Proposed Development. Designated for the protection of breeding populations of sandwich tern, common tern and little tern and non-breeding populations of red-throated diver, common scoter and little gull.
- Annex I Reefs - The closest *Sabellaria spinulosa* reef to the Proposed Development outside of an SAC is located 30km southwest at Winterton Ridge. The closest high confidence reef habitat (associated with the NNSSR SAC) is located approximately 5-15km from the Proposed Development.

0.4.4 Biological environment

- **Benthos** - Benthic communities comprise of species (excluding commercially exploitable shellfish) that live on (epifauna) or in (infauna) sediments. The 2018 survey reported that sediments generally support a macrofauna community largely dominated by annelids and arthropods, with the remainder including echinoderms and other phyla. The 2018 survey reported that epifauna was extremely sparse throughout the survey area. Inspection of sidescan sonar data and ground-truthing with visual camera systems indicated that there are no areas of *Sabellaria spinulosa* that could be classified as 'reef' within the surveyed area.
- **Plankton** - Plankton comprises aquatic organisms which are incapable of swimming against a current. They include two main groups: phytoplankton and zooplankton. Phytoplankton assemblages in the Proposed Development are characterised mostly by the dinoflagellate genera *Ceratium* and the diatoms *Thalassiosira* and *Chaetoceros* (*Hyalochaete*, and *Phaeoceros)*. The zooplankton community is noted to comprise of *C. helgolandicus* and *C. finmarchicus* as well as *Paracalanus spp., Pseudocalanus spp., Acartia spp., Temora spp*. and cladocerans such as *Evadne spp.*
- **Fish and shellfish** – Fish species observed within the Proposed Development and its surrounds include, ray finned fish (i.e., cod and bass), sharks, skates and rays along with a number of commercially exploitable shellfish species. The Proposed Development is located within the spawning and nursery grounds of 11 fish species, namely: Atlantic herring, Atlantic cod, Atlantic mackerel, common sole, European plaice, European sprat, lemon sole, Nephrops, sandeel, tope shark and whiting.
- **Marine birds** - Seabirds found in offshore areas around the Proposed Development 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, but frequently feed far offshore. The Seabird Oil Sensitivity Index (SOSI) for Block 49/21c is extremely high from November through to February, very high from March to April and low from June to September. In Block 49/26 the SOSI is extremely high in January and February, decreasing to moderate from March to April, decreasing again to low from May to September (with the exception of August being moderate), but then increasing again to high in October and November and very high in December.
- **Marine Mammals** - Sightings data for the region surrounding the Proposed Development suggests that harbour porpoise are observed in low to moderate densities for most of the year, with high densities observed in July; and Atlantic white-beaked dolphin are observed in low densities in January, April to May and in October. Other sightings in the region include bottlenose dolphin, common dolphin, Sowerby's beaked whale, Northern bottlenose whale, minke whale and humpback whale.

Grey and harbour seal are found at low densities in the waters surrounding the Proposed Development, with the expected mean number of individuals estimated to be 0-1. Rare sightings of leather back turtle have been recorded in the Southern North Sea.

All cetaceans and marine turtles are European Protected Species (EPS) protected in UK waters under The Conservation of Offshore Marine Habitats and Species Regulations 2017 (as amended). It is an offence to deliberately capture, kill, injure, or disturb animals classed as EPS.

0.4.5 Socio-economic environment

- **Commercial fisheries –** The Proposed Development is located within International Council for the Exploration of the Sea (ICES) rectangle 35F2. Fisheries data for ICES rectangle 35F2 shows that the most intense fisheries in the area is targeting demersal fish; although fisheries effort is average relative to the neighbouring ICES rectangles. The quantity and value landed by species type over 2015-2019, indicates that shellfish are the most landed category, while demersal are the most valuable and pelagic catch is low. Fishing in ICES rectangle 35F2 is dominated by whelk and sole. The most common gear type used for fishing in ICES rectangle 35F2 in 2019 was beam trawl, accounting for 95% of all landings.
- **Shipping and navigation –** The Proposed Development is in an area of low fishing vessel density all year round, with activity focused to the northeast of the development area. A desktop Vessel Traffic Survey (VTS) conducted for the Southwark field identified 16 shipping lanes/established patterns of vessel movement within 10 nautical miles of the platform location, comprising a total of 2,874 vessel tracks. Most of these shipping lanes are located either northeast and southwest of the Proposed Development. The route between Tees (England) and Antwerp (Belgium) being the busiest with 1,264 tracks (44%) across the study year.
- **Other marine users -** The oil and gas industry in the SNS is dominated by gas developments with a comprehensive network of installations (177 gas platforms in the SNS) and pipelines in Quadrants 43, 44, 47, 48 and 49. The Proposed Development is located within 40km of existing wells, pipelines, platforms, telecommunications cables, disposal sites, military practice area, sailing routes, windfarms and aggregate dredging sites. No sites of marine archaeological interests or aquaculture sites have been identified within 40km of the Proposed Development.
- **Unexploded ordnance (UXO) -** The Proposed Development is within an area which saw an extremely high level of wartime activity. This included attacks on coastal shipping routes, the laying of individual mines and minefields, and overflight by military aircraft. A desktop study of the potential for encountering UXO at the Southwark platform site (Ordtek 2021) indicated that the Southwark platform lies within an area where encounters with large UXO (projectiles, depth charges and torpedoes) is possible. Charge weights for these types of ordnance ranged up to 730kg but were typically around 250kg. It is considered likely that this reflects the situation along the pipeline route.

0.4.6 Natural evolution of the baseline

The baseline environment is not static and will exhibit some degree of natural change over time due to naturally occurring cycles and processes. Over the last 11,000 years seabed habitats around the UK have been subject to change associated with post-glacial trends in sea level, climate, and sedimentation. In the shorter term, seasonal, inter-annual and decadal natural changes in benthic habitats, community structure and individual species population dynamics may result from physical environmental influences (e.g. episodic storm events; hydroclimatic variability i.e. hot summers and cold winters; and sustained trends) and/or ecological influences such as reproductive cycles, larval settlement, predation, parasitism and disease. The sandbank habitat within which the Proposed Development is found, changes on an annual basis and is thought that the sandbanks are elongating, very slowly, in a north-easterly direction.

The effects of climate change are predicted to affect various habitats and species in UK waters in different ways, for example: increase in invasive non-native species, shift in the distribution of habitats and species (warm water species and a reduction is cold water species, reduction of specific habitats (i.e. blue mussel beds), increase in disease and an increase in storm events which could damage areas of biodiversity.

Taken this information into consideration, it is expected that over the lifetime of the Proposed Development (18 years) habitats could be affected by shorter term seasonal events (i.e. storm events) but longer term effects as a result of climate change may also be observed.

Discussion with local fishermen has indicated that despite demersal fishing being the current dominant method of fishing in the region, static gear fishing and fishing for shellfish are predicted to increase in effort in the coming years. This is partly due to changes in the sediment composition of the seabed making the region less suitable for demersal fish species and more habitable for crustacean and shellfish species.

0.5 Environmental hazards, effects and mitigation measures

The impact assessment has been carried out in three stages:

1. Definition of the existing baseline environment.
2. Identification of the activities that have the potential to impact the baseline environment.
3. Assessment of the significance of the impact. This has been based on the potential severity of the impact and the probability of the impact occurring. The assessment ensures that potential risks are considered and that activities will be carried out in accordance with all current legislation and good industry practice. The susceptibility of the Proposed Development to a natural disaster and/or climate change is also discussed.

Potential environmental impacts have been categorised using severity classes adapted from the environmental risk assessment guidance produced by UK Offshore Operators Association (UKOOA) (1999). These potential impacts have then been assessed using a risk matrix, based upon International Standard BS EN ISO 17776:2002. This has been adapted for use by Intertek to provide the criteria for oil and gas operations. Risk is a term in general usage to express the combination of the likelihood of a specific impact occurring and the severity of the consequences that might be expected to follow from it.

Impacts identified and assessed in the EIA are summarised below:

0.5.1 Physical presence

A temporary safety exclusion zone will be established around installation vessels for the duration of the operation (approximately 65 days, excluding hydrotesting and tie-ins which will be within existing 500m safety zones). The size of the exclusion zone will depend on the type of vessel. A standard 500m radii zone will be used for most vessels. If an anchored pipelay vessel is used, the safety zone would be extended to 1km to the front and back of the vessel and 500m either side.

There is potential that fishing vessels may be displaced from their fishing grounds due to the presence of the temporary exclusion zones around the project vessels. However, the area affected by the installation is small and disruption will be of limited duration (up to 65 days). It is possible that fishing may be impacted through the introduction of potential snagging points for fishing nets and trawls. During installation the presence of guard vessels at times when the pipeline is exposed seeks to mitigate this risk. During operation, the pipeline will be buried with between 90-100% sediment coverage, therefore the snagging risk will be largely removed.

Most of the shipping lanes are located either northeast and southwest of the Proposed Development and there is sufficient sea room for vessels to change passage without causing a significant nuisance to their routes.

This assessment concluded that the risk posed to the environment by the physical presence of the Proposed Development is acceptable.

0.5.2 Seabed disturbance

A seabed footprint will result from: anchor lay vessel (if used), pipeline anchors, sandwave clearance, dredging and trenching, pipeline installation and tie-in, and contingency remediation works.

0.5.2.1 North Norfolk Sandbanks and Saturn Reef SAC

The Proposed Development is located within the NNSSR SAC. The assessment of seabed disturbance has focused on potential impacts to the designated features of this site, Annex I Sandbanks which are slightly covered by sea water all the time and Annex I Reef. It is estimated that the Proposed Development will result in a temporary footprint of 0.38km^2 (equivalent to 0.01% of the SAC) and a permanent footprint of 0.007km^2 (equivalent to 0.0002% of the SAC). The section on seabed disturbance, assesses whether the project activities and associated impacts will have a significant effect on the conservation objectives (extent and distribution, structure and function and supporting processes of the habitats) and therefore adversely affect the integrity of the European site.

Seabed disturbance from sandwave clearance, trenching and dredging: - Sediment removed during sandwave clearance and trenching will remain within the vicinity of the Proposed Development. This sediment will become quickly re-distributed by the sediment transport regime in the area. The extent and distribution of the sandwaves within the SAC will not significantly change. The evidence presented from Racebank Offshore Windfarm (OWF) indicates that any change to the structure and function of the sandbanks within the NNSSR SAC as a result of the Proposed Development will be temporary, with full recovery expected within 2 – 10 years. Sandwave and sandbank systems are naturally subject to variations in topography based on the dynamic nature of the environment and therefore no lasting changes to hydrodynamic processes are anticipated to occur as a result of seabed disturbance. ***Conclusion: there will be no significant effect from sandwave clearance, trenching and dredging to the conservation objectives of the NNSSR SAC.***

Indirect seabed disturbance resulting from sandwave clearance, trenching and dredging sediment plumes - An indirect effect of the sandwave clearance, dredging and trenching is the generation of sediment plumes. The biogenic reef habitat found within the NNSSR SAC is formed by *Sabellaria spinulosa* which could be impacted by sediment plumes should they reach any patches of reef. The closest occurrence of Sabellaria reef is between 5 and 10km from the Proposed Development to the northwest. It is not expected that the sediment plume will reach this Sabellaria reef in sufficient deposition thicknesses to cause an effect. ***Conclusion: there will be no significant effect from sediment plumes to the conservation objectives of the NNSSR SAC.***

Seabed disturbance from deposits – the impacts from the deposition of temporary deposits on the NNSSR sandbanks will be localised. In addition, given that the habitats associated with the sandbanks are highly tolerant to disturbance, any impacts are not expected to be significant. The introduction of grout/sand bags, mattresses and contingency rock remediation will be deposited in an area of sandy substrate and would therefore constitute a localised coarsening of these sediments and a re-classification of the biotope. The deposits will not remove sediment from the system and evidence suggests that the permanent deposits will not physically affect the transportation of sand or the overall morphology of the sandbank. In addition, although there is potential for localised scour around the permanent deposits, this localised scour will not affect the overall supporting processes of the SAC. The proposed solution offers the best practicable environmental option and minimises the potential requirements for permanent deposits. ***Conclusion: there will be no significant effect from temporary and permanent deposits to the conservation objectives of NNSSR SAC.***

0.5.2.2 Southern North Sea SAC

The Proposed Development is located entirely within the SNS SAC. The assessment has focused on potential impacts from seabed disturbance to the designating feature of this site, harbour porpoise. For harbour porpoise the conservation objective: the condition of supporting habitats and processes, and the availability of prey is maintained is applicable to seabed disturbance. It was concluded that for both the temporary and permanent footprints of the installation activities comprise a negligible area (0.001%) in relation to the overall SNS SAC area. As such, the installation activities will have a negligible impact on the overall habitat of the SAC, and the condition of supporting habitats and processes, and the availability of prey will continue to be maintained. ***Conclusion: there will be no significant effect from temporary and permanent deposits to the conservation objectives of the SNS SAC.***

0.5.2.3 Fish and shellfish and commercial fisheries

The loss or disturbance of habitat during operations will be localised, representing only a very small footprint of the wider region and therefore unlikely to affect these species at a population level. The potential impacts to fish and shellfish from seabed disturbance caused by the Proposed Development is localised and is not expected to be significant.

The Proposed Development is within an area of low to medium importance for demersal, pelagic and shellfish fisheries when compared with the rest of the UKCS. The Proposed Development will increase the oil and gas footprint of the area; however, the seabed footprint is not expected to impact the wider population of fish species and therefore will not affect fish stocks. The burial of the pipeline will significantly reduce the snagging risk posed by the pipeline to the fishing industry. A very localised risk remains but this has been assessed as acceptable.

This assessment concluded that the risk posed to the environment from seabed disturbance is acceptable.

0.5.3 Generation of atmospheric emissions

Air quality, as measured by concentrations of gases with the potential to cause environmental or human harm, other than through contribution to climate change i.e. carbon dioxide (CO_2), carbon monoxide (CO), nitrogen oxides (NOx), nitrous oxide (N_2O), sulphur oxides (SO_x), methane (CH_4), and volatile organic compounds (VOC), is generally not considered a significant issue offshore, as there are no proximate receptors. It is estimated that approximately 57,389 tonnes carbon dioxide equivalent (CO2-e) will be released from the Proposed Development during construction. This figure represents a very small and negligeable amount (0.4%) of the total CO_2 emissions produced by the upstream oil and gas industry in the UKCS in 2018.

In that context, IOG recognise the importance of the UK’s 2050 Net Zero target as part of global efforts to meet the goals of the 2015 Paris Accord. To achieve this target IOG has committed to eight targets within which IOG will evaluate their greenhouse gas emissions and put measures in place to mitigate their existing and projected emissions.

IOG aims to contribute positively to the UK’s energy transition by helping to supply stable and affordable energy to UK homes and businesses as part of a lower-carbon energy supply mix.

This assessment concluded that the risk posed to the environment by the generation of atmosphere emissions is acceptable.

0.5.4 Marine discharges

The safe installation and integrity testing of a pipeline requires use of chemicals. The majority of chemical discharges will be of low quantity 'PLONOR' (posing little or no risk to the environment) chemicals. All proposed chemical discharges must be risk assessed ahead of activities commencing as part of the chemical permitting process, and will be subject to the conditions set in the approved permit. Water column and benthic species are only likely to be vulnerable within a short distance of any discharge, as chemicals will be rapidly diluted and dispersed to below potentially toxic concentrations under the energetic conditions prevalent in the UKCS.

This assessment concluded that the risk posed to the environment from discharges to the marine environment is acceptable.

0.5.5 Generation of underwater sound

The main environmental receptors potentially impacted by underwater sound are marine mammals, plankton (including fish eggs and larvae) and adult fish. Underwater sound has the potential to modify behavioural patterns (e.g., causing avoidance behaviour) and in certain situations the pressure waves associated with the sound may cause physical injury and even mortality.

0.5.5.1 Vessels

Machinery sound (e.g. use of thrusters on pipelay project vessels) will be the main source of underwater noise generation. Machinery sound generation is generally considered to be of relatively low intensity and near continuous, although some events will result in short term peaks in intensity.

Evidence suggests that disturbance of marine mammals may occur but that animals will need to remain within 3.4km of the project vessels for 24-hours to experience sufficient levels of noise to cause significant disturbance. Therefore, the actual risk to marine mammals is very low. No effects on fish and plankton species at population level are expected.

With regards to the SNS SAC, given that the disturbance zone is less than 0.1% of either the summer or winter grounds of the SAC any potential disturbance can be regarded as non-significant.

This assessment concluded that the risk posed to the environment by the generation of underwater sound by vessels is acceptable.

0.5.5.2 UXO detonation

It is unknown if a UXO detonation will be required within the Proposed Development. However, given the historic use of the region, a desktop study of the Southwark platform site indicates it is possible that a large UXO such as a projectile, depth charge or torpedo could be encountered.

The primary objective will be to avoid encountered potential UXO. It is possible that a minor route-adjustment to the pipeline centreline could be made to avoid extensive anomalies although micro-routeing is not a feasible solution due to the inflexibility of the pipeline. If it is safe to do so, the UXO will be removed. Only as a last resort will in-situ detonation be undertaken. Should UXO be found which require clearance by detonation it is assumed that there would be a relatively large release of impulsive sound energy, creating high amplitude shock waves. At close range there would be risk of mortality and serious injury to marine mammals and fish as relatively small quantities of explosive can result in significant sound pressure levels.

The UXO detonation, if required, will be an instantaneous event. Although animals in the wider area may display a startle reaction there will not be widespread or prolonged displacement or disturbance. The Statutory Nature Conservation Bodies advise that a precautionary 26km effective deterrence range (EDR) should be used to assess the impacts of a high order detonation. They also note that a single explosion would probably be of too short duration to cause widespread displacement.

With regards to the potential effects on harbour porpoise from the SNS SAC. Noise disturbance within the SAC is significant if it excludes harbour porpoises from more than 20% of the relevant area of the site in any given day, and an average of 10% of the relevant area of the site over a season. The Proposed Development lies close the boundary of the summer and winter grounds. A UXO detonation therefore has the potential to affect both relevant areas. It is calculated, using a GIS, that approximately 1577km^2 of the summer ground (detonation at Southwark platform tie-in end) and 136km^2 of the winter ground (detonation at Thames pipeline tie-in end) could be affected by the 26km EDR; equivalent to 5.83% and 1.07% of the relevant areas respectively. Given that the effected area is less than the 20% threshold the EIA concluded that the underwater noise disturbance will not be significant.

This assessment concluded that the Proposed Development will not cause significant noise disturbance.

0.5.6 Generation of waste

Waste will be generated during all phases of the Proposed Development. The intention is to minimise waste production and to manage all produced waste, by applying approved and practical methods and by adhering to a waste hierarchy. Waste is anticipated to be generated from vessels associated with the Proposed Development. Waste will be managed by the individual vessel in accordance with the International Convention for the Prevention of Pollution from Ships (MARPOL) requirements.

This assessment concluded that the risk posed to the environment from generation of waste is acceptable.

0.5.7 Susceptibility to natural disaster and climate change

In the North Sea, the frequency of occurrence of a magnitude 4 natural seismic event is expected to be approximately every two years and that of a magnitude 5 event every 14 years (British Geological Survey 2020). These events will not cause a natural disaster or likely to result in significant damage to offshore infrastructure. Anthropogenic climate change is expected to increase the frequency of storm surge events in the North Sea toward the end of the century; however, this is not expected to affect the east coast of the UK, from which Southwark is located. Increases in storm surge frequency are therefore not expected to affect the pipelay operation or the integrity of the pipeline over its lifetime.

Global warming will not change the wind climate over the North Sea beyond the large range of natural climate variability that has been experienced in the past. Meteorological variations are therefore not expected to affect the pipelay operation or the integrity of the pipeline over its lifetime.

0.5.8 Mitigation measures

Table 0-2 presents the mitigation measures that will be adopted in the Proposed Development. Mitigation measures to control unplanned events are presented separately in Section 0.6.

Table 0-2 Mitigation measures

ID	Mitigation measures
M1	Project vessels will follow the international maritime organisation (IMO) standards to reduce the likelihood of collision i.e. will comply with Standard Marking Schedule. This includes requirements for navigation, lighting, obstruction lighting and beacons.
M2	Users of the sea will be notified of the presence and intended movements of the project vessels via the Kingfisher Fortnightly Bulletins, Notices to Mariners and very high frequency (VHF) radio broadcasts.
M3	Guard vessels will be utilised to prevent other none-project vessels entering the Proposed Development area during pipeline installation, and to protect the pipeline prior to burial.

ID	Mitigation measures
M4	Concrete mattresses, grout/sand bags and rock remediation will only be employed where the integrity of the pipeline is at risk. Cover will be kept at the minimum required to ensure pipeline protection is adequate. Good industry practice will be used when deploying any pipeline protection.
M5	If a trailing suction hopper dredger is used, sediment will not be retained onboard but will be deposited within 2NM of the pipeline corridor, to ensure all sediment is retained in the local system.
M6	Practical steps to minimise emissions will be implemented, e.g. ensuring efficient operations and monitoring fuel consumption
M7	Project vessels employed will comply with the Merchant Shipping (Prevention of Air Pollution from Ships) Regulations 2008, which controls the levels of pollutants entering the atmosphere.
M8	Chemical use and discharge will be monitored and kept to the minimum consistent with operational requirements.
M9	Where suitable alternatives are available and deemed fit for purpose, chemicals with lower potential for environmental impact will be utilised.
M10	Chemical storage and usage will be in accordance with the vessel's control of substances hazardous to health (COSHH) procedure. Material Safety Data Sheets (MSDS) will be carried for all hazardous substances.
M11	A UXO survey will be undertaken along the pipeline corridor to identify anomalies. If any significant UXO is identified, the decision-making hierarchy taking into account environmental sensitivities, safety and technical considerations shall be: 1. Avoid 2. If the UXO cannot be avoided, undertake clearance to surface or move UXO outside the installation corridor. 3. If the UXO cannot be safely moved, clearance by on-site detonation
M12	If clearance by on-site detonation is the only feasible option, all charge sizes shall be detonated using deflagration (low order detonation).
M13	UXO clearance by deflagration shall comply with the JNCC guidelines for minimising the risk of injury to marine mammals from using explosives (JNCC 2010, or as updated), including: a. Establishment of a default 1km mitigation zone for marine mammal observation, measured from the explosive source and with a circular coverage of 360 degrees b. Provision of two trained marine mammal observers (MMO) to implement the JNCC guidelines c. Provision of a Passive Acoustic Monitoring (PAM) to be operated by a suitably trained and experienced MMO to support visual observations. d. Commencement of explosive detonations only during daylight hours and good visibility e. Accurate determination of the amount of explosive required for the operation, so that the amount is proportionate to the activity and not excessive. f. If necessary, planning of a sequence of multiple explosive discharges so that, wherever possible, the smaller charges are detonated first to maximise the 'softstart' effect. g. if the UXO identified is greater than 10kg then a soft-start procedure shall be used whereby charges of 50g, 100g, 150g, and 200g will be deployed at 5 minute intervals with a further 5 minute interval before the detonation of the UXO.
M14	Lofitech AS seal scarer (or similar) acoustic deterrent device will be used prior to UXO deflagration.
M15	Waste will be managed in line with waste management procedures, striving to reduce the amount of waste going to landfill (disposal). All waste will be correctly documented, transported, processed and disposed of in accordance with applicable legal requirements line with legislation and in an environmentally responsible manner.

0.5.9 Residual effects

The EIA concluded that there will be no residual impacts from the Proposed Development activities.

0.6 Unplanned events

It is possible that, during the lifecycle of a development, events may occur which result in unplanned releases of hydrocarbons (including fuels) or chemicals to the environment.

Any unplanned release has the potential to impact the environment. However, the significance of the impact depends on numerous factors including (but not limited to) the substance released, the volume of the release, toxicity of the release, meteorology conditions at the time, and the sensitivity of the receptors.

The risks associated with releases of hydrocarbons were presented in the Blythe Hub Development ES Addendum – Southwark Field Development (IOG 2018) and at the request of OPRED have been reproduced in this section. It concluded that:

- A spillage of diesel, from the platform or service vessels, had the potential to impact the shoreline, with persistence on the water surface up to 14 days following the end of release.
- Condensate, whether released as a result of a well blowout or of pipeline failure would not reach the shoreline, with persistence on the water surface up to 3 days following the end of release.

Release of diesel was therefore considered by the Blythe Hub Development ES Addendum – Southwark Field Development to represent the worst case and is the basis of the Field Development Oil Pollution Emergency Plan (OPEP) which covers the drilling of wells and any operations within 500m of the Southwark platform.

Unplanned releases from EPC Contractor vessels outside of the 500m zone around the Southwark platform, are the responsibility of the EPC Contractor, and are managed through the implementation of the individual vessels Shipboard Oil Pollution Emergency Plan (SOPEP). Oil spill modelling is not required under the SOPEP. The modelling results presented for a diesel spill within the 500m safety zone should therefore only be regarded as indicative for releases from vessels outwith the 500m safety zone.

The assessment provided is based on unplanned events which would be the responsibility of the pipeline operator, ODE AM.

Diesel is an International Tanker Owners Pollution Federation (ITOPF) Group 2 hydrocarbon which will form surface slicks if significant quantities are released. The diesel inventory is based on the worst-case fuel load on a rig or vessel at the Southwark platform. Southwark is primarily a gas field. While natural gas, as such, has little potential to cause harm to the marine environment, the associated gas condensate has the potential to form surface slicks; however, it is an ITOPF Group 1 hydrocarbon. This is considered non-persistent in the marine environment. The condensate inventory is based on the potential release due to pipeline failure.

The modelling shows that hydrocarbons could potentially travel in any direction, although travel in a north easterly direction appears slightly more likely than travel in other directions. Beaching and/or crossing the EEZ boundary line is predicted to occur following a diesel release, as modelled. During summer months the area which could experience oiling is smaller than during winter months, because of generally lower wind speeds.

The potential environmental impacts of an unplanned hydrocarbon release have been assessed with reference to the key sensitive receptors, under the worst-case scenario.

- **Plankton, fish and shellfish** - Unplanned releases of hydrocarbons have the potential to cause toxic harm to plankton and fish communities. In general, lighter refined petroleum products such as diesel and gasoline are more likely to mix in the water column and are therefore more toxic to marine life. However, they tend to evaporate quickly and do not persist long in the environment as soluble components are readily biodegradable. Therefore, in the highly unlikely event of a hydrocarbon release from an unplanned event at the Proposed Development it is expected to have a minor impact on the plankton and fish community at population level. The assessment concluded that a release poses an **acceptable** risk to plankton and fish

- **Seabirds** – Seabird sensitivity to oiling in the Proposed Development for Block 49/21c is extremely high from November through to February, very high from March to April and low from June to September. In Block 49/26 the SOSI is extremely high in January and February, decreasing to moderate from March to April, decreasing again to low from May to September (with the exception of August being moderate), but then increasing again to high in October and November and very high in December. It is therefore considered that the risk to seabirds will be **tolerable**.
- **Marine mammals** – The Proposed Development is within the SNS SAC, designated for harbour porpoise, and marine mammals are present in low densities, with harbour porpoise present in medium and high densities in June and July, respectively. Cetaceans are generally considered to have a low vulnerability to oil as they appear to be able to detect hydrocarbons. Many cetacean species found in offshore or open coastal waters are highly mobile and have a wide range, so their contact with released oil may be relatively brief. Pinniped species are sparsely distributed in the area due to the distance from land and subsequently haul out sites. The potential for an accidental release of hydrocarbons during the Proposed Development poses an **acceptable** risk to marine mammals.
- **Protected sites** – A number of protected sites may be affected by a potential hydrocarbon release from the Proposed Development. The Proposed Development is within the NNSSR SAC (designated for the protection of Sandbanks which are slightly covered by sea water all the time (Annex I habitat) and Reefs (Annex I habitat)) and the Southern North Sea SAC (designated for the protected of harbour porpoise). The designated features of the NNSSR SAC will not be impacted by an accidental release. Due to the nature of the hydrocarbon releases, resulting in short term impacts, the conservation objectives of the Southern North Sea SAC will not be impacted.

  The closest SPA is the Greater Wash SPA - designated for the protection of breeding populations of sandwich tern, common tern and little tern and non-breeding populations of red-throated diver, common scoter and little gull). As diesel is not persistent in the marine environment, any impact on the conservation objectives of the SAC, through impacts on seabirds, will be short term. It is therefore considered that risk to protected sites will be **acceptable.**

An event leading to a Major Environmental Incident (MEI) (e.g., a collision leading to total fuel loss from the vessel inventory over 1 hour) is possible. However, this will not affect the conservation objectives of protected sites and European Protected Species, nor is it likely to result in a significant adverse effect. Therefore, if a worst case release occurred this will not constitute an MEI. In addition, the probability of such an event occurring is very low and therefore the risk is **acceptable**.

Mitigation measures that will be implemented to minimise the risks of unplanned releases include:

- **M16: Spill prevention** – All operational personnel, whether in the direct employ of IOG, the Installation and Pipeline Operator or appointed contractors will be made aware of existing environmental protection procedures and the crucial importance of hydrocarbon containment and Asset Integrity. The risk of a release is addressed on a day-to-day basis by IOG employees and contractors following good practice, collision avoidance and fuel handling and transfer procedures. Every effort will be made to prevent such releases. It is noted that most releases occur during offshore fuel transfer operations (bunkering), which are not expected to occur during this operation. If they are required IOG & the Installation and Pipeline Operator require vessel contractors to take the following measures:
  - The connection between the fluid transfer hose and the supply vessel will be a self-sealing, dry-break hose connection.

  - Preference will be given to carrying out external fluid transfers during the hours of daylight. If operational reasons dictate that external fluid transfer are carried out during the hours of darkness, then they will be subject to documented risk assessment which will include environmental and safety considerations.
  - Fluid transfer during hours of darkness will not commence without provision of sufficient illumination to allow the entire length of the transfer hose to be visually monitored from the installation.
  - If operational reasons dictate that simultaneous external fluid transfers of more than one hydrocarbon liquid product is required, it will not take place until a full documented risk assessment has been made.
  - Integrity of the pipeline is ensured by application of corrosion protection measures and regular monitoring and maintenance.
- **M17: Control** – In line with the Merchant Shipping (Oil Pollution Preparedness, Response and Co-operation Convention) (Amendment) Regulations 2015 and the Offshore Installations (Emergency Pollution Control) Regulations 2002 an approved OPEP will be in place for the project. This will cover response measures to be taken to protect the environment in the event of a release. As discussed in the preceding section, this OPEP provides detailed hydrocarbon release scenarios to enable the determination of appropriate offshore actions. In addition, it outlines reporting and training requirements for mitigating accidental spillage throughout all phases.

  A three-tier response system will be operated, based on the following key factors: hydrocarbon type and properties, potential quantities released, metocean and metrological data, environmental and economic sensitivities and the response capability.

  - Tier 1 is a local response, geared at the most frequently anticipated oil release.
  - Tier 2 is a regional response for a less frequently anticipated oil release where external resources and assistance in monitoring and clean-up will be required.
  - Tier 3 is a national response for very rarely anticipated oil releases of major proportions which will potentially require national and international resources to assist in protecting vulnerable areas and in the clean-up.

  The response strategy available following a release will be aerial surveillance. Any releases including sheens, will be reported to the statutory authorities using the PON1 reporting system. For larger releases, a comprehensive range of back-up resources is available to IOG through oil spill providers.

  All contractors vessels will have an approved SOPEP in place.

0.7 In-combination, cumulative and transboundary impacts

The term 'in-combination impacts' refers to impacts upon receptors from different activities within the same proposed development. The way in which the EIA has been conducted e.g. by looking at the impacts of project activities on receptors, means that intrinsically it has already considered in-combination impacts.

The term 'cumulative impact' refers to impacts upon receptors arising from the Proposed Development when considered alongside other past, present or reasonably foreseeable projects, plans or licensed activities, that may result in an additive impact with any activities of the Proposed Development.

There have been a total of 818 wells drilled within 40km of the Proposed Development. Of this total, 19 were drilled between 2010 and 2019 with the closest being approximately 19.5km south east of the Southwark platform tie-in.

There are two wind farm leases and three windfarm cable leases within 40km of the Proposed Development. The closest windfarm is the East Anglia North Tranche One West (Norfolk Vanguard West) located 25.5km southeast of the Proposed Development. The closest wind farm cable array is the consented Hornsea Three Transmission Asset 23.5km northeast of the Proposed Development.

The nearest aggregate site, Humber 3 (Area 484) licensed by DEME Building Materials Ltd, is located 32.1km to the north of the Proposed Development.

The EIA assessed the potential for a cumulative impact with respect to physical presence, seabed disturbance, greenhouse gas emissions, air pollutants, marine discharges, generation of underwater noise, generation of waste and unplanned events. It concluded that the risk of cumulative impacts is **acceptable**.

The Proposed Development is approximately 64.5km to the west of the UK/Netherlands EEZ boundary. Greenhouse gas emissions, planned marine discharges, and underwater noise will not reach the EEZ boundary. The unplanned release of hydrocarbons could result in oil crossing the EEZ boundary, both at the surface and within the water column, but oiling of international shorelines will not occur given the type of hydrocarbons present. Due to the nature of the expected hydrocarbons the Proposed Development will not add to the existing risk of transboundary effects. In the event of an unplanned release crossing the EEZ boundary, international cooperation will be necessary; this will be addressed within the oil pollution emergency plan (OPEP[1]).

0.8 Environmental management

0.8.1 Environmental Management System

IOG recognises the critical importance of maintaining effective environmental management processes in the development and operation of UK Continental Shelf offshore fields, and in maintaining their licence to develop the Blythe field. IOG's Environmental Management System (EMS) was verified on 5th June 2020 by a third-party external verifier.

The IOG EMS:

- Is implemented at a strategic level, being driven by the Chief Executive Officer (CEO) as an integral part of the corporate aspirations and growth of the IOG enterprise.
- Is designed to deliver and manage compliance with environmental laws and regulations on an ongoing basis, including a register of environmental legislation which describes the key requirements of each piece of legislation relevant to IOG's activities as a licence operator on the UK Continental Shelf. This includes UK legislation, industry guidelines and other standards as well as European Union and other international requirements such as OSPAR and the International Convention for the Prevention of Pollution from Ships (MARPOL). Through the use of compliance tracking and commitment registers, IOG is able to detect potential non-compliance and initiate corrective action in a timely manner.
- Delivers suitable resource management; through the office of the IOG HSE Manager, supporting line management in the discharge of their environmental responsibilities and reporting directly to the CEO on environmental matters.

[1] Note there will be an Offshore OPEP (tier 1 response) and an Onshore OPEP (tier 2/3 response)

- Incorporates performance metrics that are developed according to each aspect of the particular operation, and with a view to meeting the clear public reporting requirements as administered by the Department for Business, Energy and Industrial Strategy.

Environmental Management is an ongoing process that will continue beyond implementation of the mitigation measures identified during this Environmental Statement Addendum to strive for continuous improvement and to meet changing regulatory requirements.

Contractors are expected to demonstrate a high level of health, safety, security and environment commitments and to have systems in place for managing HSE and plant integrity.

0.8.2 IOGs Climate Change and Sustainability Policy and commitment to Net Zero 2050.

IOG's ambition is to be a safe and efficient developer and producer of high-value, low-carbon gas.

IOG appreciates that limiting climate change and transitioning to a more sustainable economy are critical challenges of our time. In that context, IOG recognise the importance of the UK's 2050 Net Zero target as part of global efforts to meet the goals of the 2015 Paris Accord.

To achieve this target IOG has committed to eight targets within which IOG will evaluate their greenhouse gas emissions and put in place measures to mitigate their existing and projected emissions.

IOG aims to contribute positively to the UK's energy transition by helping to supply stable and affordable energy to UK homes and businesses as part of a lower-carbon energy supply mix.

0.9 Conclusion

The ES has established the following for the Proposed Development:

- Risks posed to the marine environment from the physical presence of the installation vessels, generation of atmospheric emissions, marine discharges, the generation of underwater sound from vessels and the generation of waste have been assessed as acceptable.
- Southern North Sea SAC - the risk posed to the Southern North Sea SAC from the generation of underwater sound from UXO detonation has been assessed as tolerable. Industry standard, appropriate and feasible mitigation has been proposed which lowers the scoring of the risk but it is recognised that there is the potential for a residual impact and the risk remains tolerable. It was concluded that the Proposed Development will not hinder the achievement of the conservation objectives and therefore will not adversely affect the integrity of the European site.
- North Norfolk Sandbanks and Saturn Reef SAC - the risk posed to the NNSSR SAC from seabed disturbance has been assessed as tolerable. The assessment concluded that the Proposed Development will not hinder the achievement of the conservation objectives and therefore will not adversely affect the integrity of the European site.
- The risk posed by the potential for cumulative effects is acceptable.
- Transboundary impacts will only result from a major unplanned hydrocarbon release (pipeline failure or spillage of diesel scenario).

It is concluded that the Proposed Development can be completed without causing any unacceptable risks to the environment.

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GLOSSARY

AA
Appropriate Assessment

AHT
Anchor Handling Tug

AIS
Automatic Identification System

BEIS
Department for Business, Energy and Industrial Strategy

BPEO
Best Practicable Environmental Option

CA
Comparative Assessment

CEO
Chief Executive Officer

CFE
Controlled flow excavation

CH4
Methane

CO
Carbon Monoxide

CoP
Cessation of Production

CRA
Collision risk assessment

CWC
Concrete Weight Coating

DCENR
Department of Communications, Energy & Natural Resources

DECC
Department of Energy and Climate Change

DP
Dynamic Positioning

DPEI
DP Energy Ireland

DSAW
Double Submerged Arc Welded Pipe

DVL
Doppler velocity log

EBS
Environmental Baseline Survey

ECMWF
European Centre for Medium-Range Weather Forecasts

EPC
Engineering, Procurement and Construction

EEZ
Exclusive Economic Zone

EIA
Environmental Impact Assessment

EIAR
The Environmental Impact Assessment Report

EMS
Environmental Management System

EPS
European Protected Species

ES
Environmental Statement

EU
European Union

EUNIS
European Nature Information System

FCS
Favourable Conservation Status

GHG
Greenhouse Gases

GIS
Geographical Information Systems

HSE
Health, safety and Environment

HZ
Hertz

ICES
International Council for the Exploration of the Seas

IMO
International Maritime Organization

INS
Inertial Navigation system

IOG
Independent Oil and Gas UK Ltd

ITOPF
International Tanker Owners Pollution Federation

JNCC
The Joint Nature Conservation Committee

Km
Kilometre

KP
Key Point

LAT
Lowest Astronomical Tide

MARPOL
International Convention for the Prevention of Pollution from Ships

MBES
Multi Beam Echo Sounder

MCA
Maritime and Coastguard Agency

MEI
Major Environmental Incident

MMO
Marine Management Organisation

MSL
Mean Seabed Level

MU
Management Units

NM
Nautical Mile

NNSSR
North Norfolk Sandbank and Saturn Reef

N^2O
Nitrous Oxide

NOx
Nitrogen Oxides

OGA
Oil & Gas Authority

OGUK
Oil and Gas UK

OPEP
Oil Pollution Emergency Plan

OPRED
Offshore Petroleum Regulator for Environmental and Decommissioning

OSCAR
Oil Spill Contingency and Response

OWF
Offshore Wind Farm

PIMS
Pipeline Integrity Management System

PLR
Pig Launchers/Receivers

PSV
Pipe Support Vessels

ROV
Remotely Operated Vehicle

RYA
Royal Yachting Association

SAC
Special Area of Conservation

SBP
Sub-bottom profiler

SCR
The Offshore Installations (Offshore Safety Directive) (Safety Case etc) Regulations 2015

SNS
Southern North Sea

SO^2
Sulphur Dioxide

SOPEP
Shipboard Oil Pollution Emergency Plan

SOSI
Seabird Oil Sensitivity Index

SPA
Special Protection Area

SSS
Side Scan Sonar

TIN
Triangulated Irregular Network

TSHD
Trailing suction hopper dredging

UK
United Kingdom

UKBAP
United Kingdom Biodiversity Action Plan

UKCS
United Kingdom Continental Shelf

USBL
ultra-short baseline acoustic positioning system

UXO
Unexploded Ordnance

VTS
Vessel Traffic Survey

1. INTRODUCTION

1.1 Overview

This Environmental Statement (ES) Addendum, including an environmental impact assessment (EIA), has been prepared on behalf of IOG UK LTD (IOG) for the proposed installation, commissioning and operation of the Southwark Pipeline. It has been prepared on behalf of IOG by Intertek Energy and Water Consultancy Services (Intertek).

The Proposed Development consists of a single 24" gas export pipeline which will transport the production gas and fluids from the Southwark platform for eventual processing at onshore Bacton terminal on the north Norfolk coast (Figure 1-1). The Southwark field is located approximately 52km east of the Norfolk coast and 65km west of the UK/Netherlands Exclusive Economic Zone (EEZ) boundary at its closest points (Figure 1-2 Drawing No: P2371S3-LOC-001).

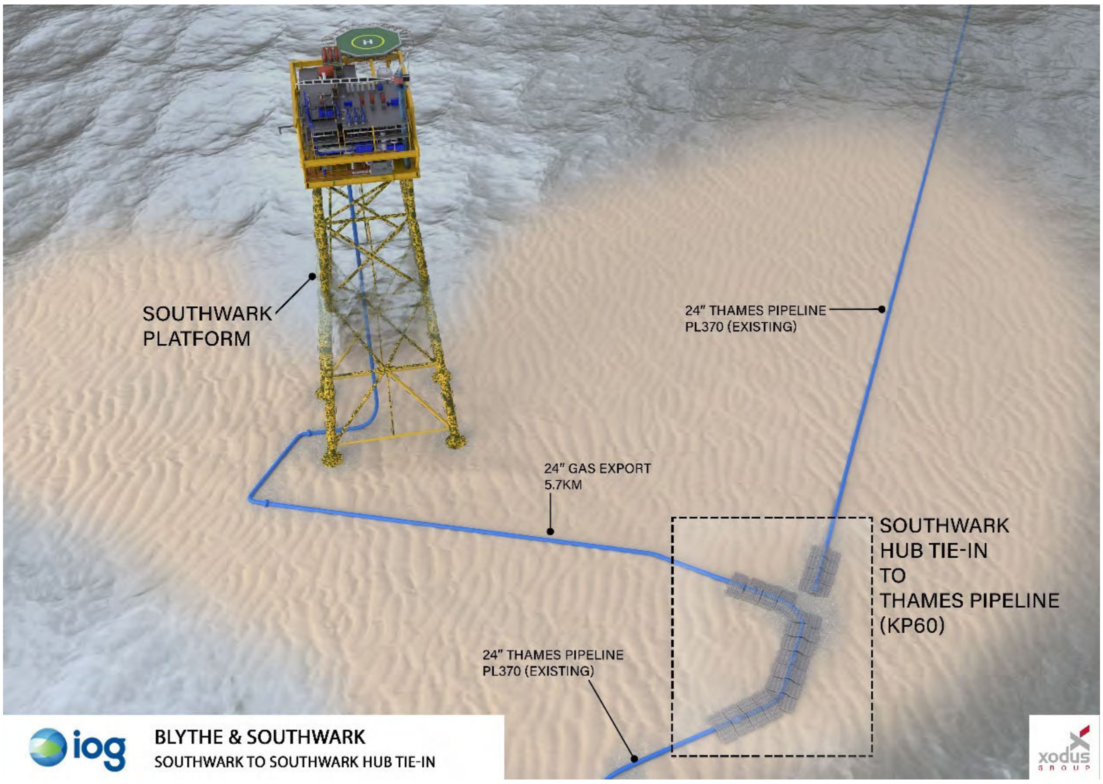
The Southwark project elements were previously part of a wider field development plan (the Vulcan Satellites Hub development) for which an ES was submitted to the Offshore Petroleum Regulator for Environmental and Decommissioning (OPRED) in April 2018, reference D/4213/2018. Since the submission of the Vulcan Satellites Hub Development ES, the Vulcan Satellites development has been split into two development phases (the Vulcan Satellites Hub Development and the Blythe Hub Development), with the Southwark specific components to be developed as part of the Blythe Hub development programme (Figure 3-2). Therefore, in 2019 an Addendum to the Blythe Hub Development ES, reference D/4208/2018 was submitted to cover details of the Southwark Field Development; subsequently approved in April 2020. The Vulcan Satellites Hub Development ES is now redundant and has been removed from the OPRED website.

Following approval of the Blythe Hub Development ES Addendum (reference D/4208/2018), geophysical (topographic) survey data acquired in May 2020 (Technical Appendix-C) showed that, since the previous survey in March 2018, sandwaves had moved in a north or north-west direction up to 50m, with smaller sandwaves travelling less than larger ones. Crests have increased in places by 1m. Subsea 7 (Engineering, Procurement and Construction (EPC) Contractor) indicated that these changes mean that the seabed preparation required to facilitate the pipeline installation described in the approved Blythe Hub Development ES Addendum are no longer appropriate. Consequently, this ES Addendum (D/4257/2020) has been prepared to cover the newly proposed seabed preparation and installation methods. As such the Proposed Development will comprise of:

- A single 24" pipeline (PL4943), 5.67km long
- Seabed clearance and pipeline installation.
- Tie-in spools to allow tie-in to the existing Thames pipeline and the Southwark pipeline.
- Deposition of up to 200 concrete mattresses, nominally 100 at the Thames pipeline (PL370) tie-in and 100 at the Southwark Platform tie-in.
- Deposition of 2900 grout/sand bags, nominally 1450 at the Thames pipeline tie-in and 1450 at the Southwark Platform tie-in.

Any works on the Thames pipeline (PL370) are out with the scope of this Addendum, these works will be covered under the appropriate permits for the Thames pipeline. An ES was not required for the Thames pipeline as it was existing infrastructure.

Figure 1-1 Southwark Field Layout



1.1.2 Location

The Proposed Development is physically located across Blocks 49/21c and 49/26 in the Southern North Sea area, 52km east of mainland UK and 65km west of the United Kingdom (UK)/Netherlands EEZ boundary line at its points of closest approach. The Proposed Development area is located within two protected sites; North Norfolk Sandbanks and Saturn Reef Special Area of Conservation (SAC) and the Southern North Sea SAC.

Coordinates for the Proposed Development are presented in Table 1-1.

Table 1-1 Project coordinates

Structure	Location			
	Coordinates provided in WGS 1984 degrees, minutes, seconds (DMS)			
	Start		End	
	Latitude	Longitude	Latitude	Longitude
24" 5.67km pipeline (PL4943)	53° 10' 58.817" N	002° 5' 45.913" E	53° 8' 11.360" N	002° 7' 13.543" E

1.1.3 Field operatorship

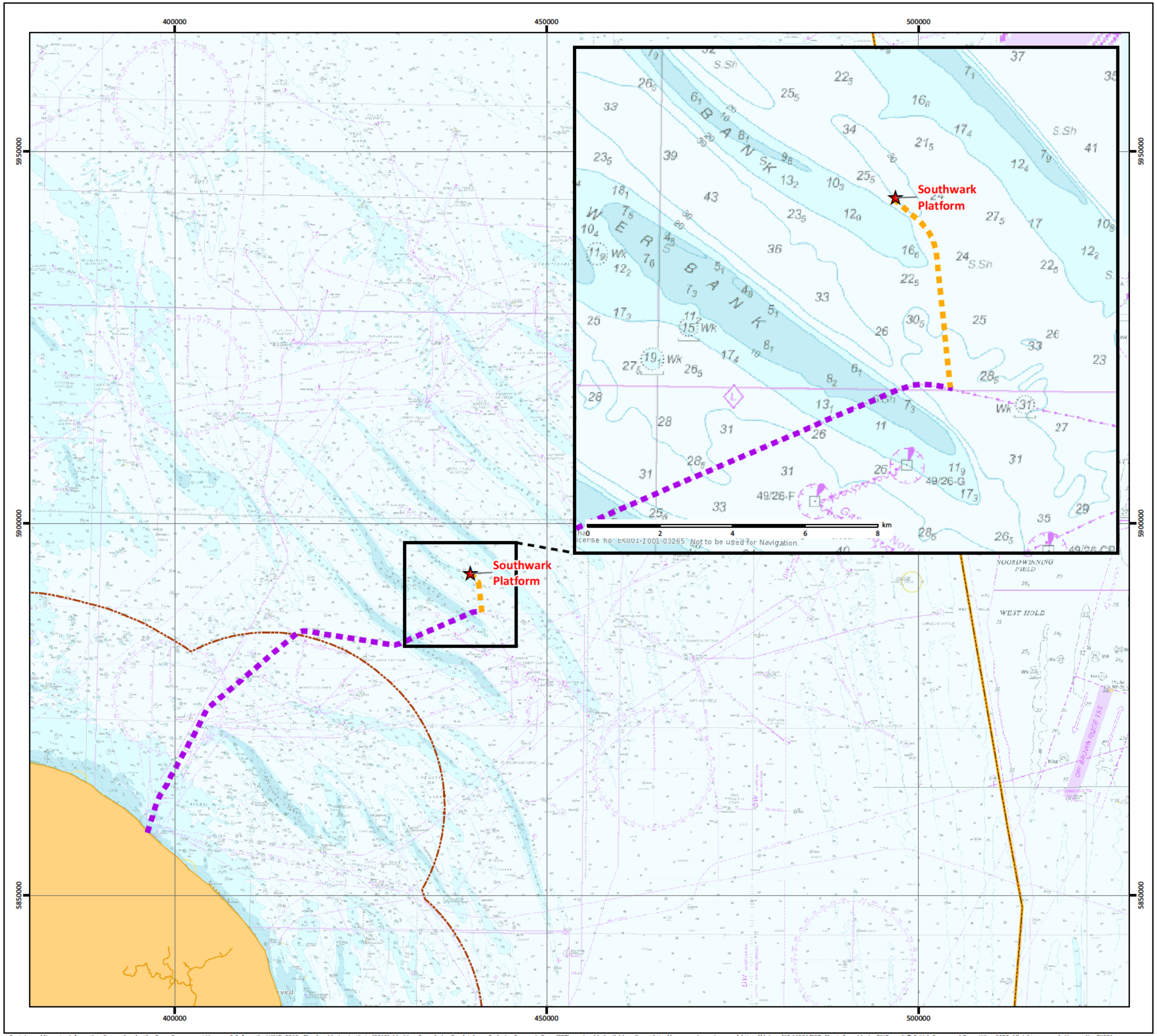
The Southwark field was discovered in 2000 by well 49/21-8a drilled by Conoco, which encountered gas in the underlying Leman Sandstone Formation. In 2016 Independent Oil and Gas plc purchased Oyster Petroleum Limited, a company whose assets included Verus Petroleum, the then licence holder of the Southwark field. The Verus Petroleum company under IOG ownership was renamed IOG UK LTD.

The Southwark field lies within Block 49/21c under licence P1915 which is presently in 50% equity ownership of IOG UK LTD a wholly owned subsidiary of Independent Oil and Gas plc and 50% equity of Cal Energy Resources UK Limited

IOG SOUTHWARK ENVIRONMENTAL STATEMENT

LOCATION OVERVIEW
Southwark Platform and Pipeline

Drawing No: P2371S3-LOC-001	A



Legend

- Southwark Platform
- Southwark 24" Pipeline
- Thames Pipeline (PL370)
- 12nm Territorial Sea Limit
- EEZ Boundary

NOTE: Not to be used for Navigation

Date	03 March 2021
Coordinate System	ED 1950 UTM Zone 31N
Projection	Transverse Mercator
Datum	European 1950
Data Source	UKHO; MarineRegions; MarineFind; ESRI; OSOD;
File Reference	J:\P2371\Mxd\P2371S3\01_LOC\P2371S3-LOC-001.mxd
Created By	Chris Dawe
Reviewed By	Emma Storey
Approved By	Stuart McLaren

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1.2 Scope and objectives of the ES Addendum

This ES Addendum, and EIA, support the proposed installation, commissioning and operation of the Southwark Pipeline under the requirements of:

- The Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020;
- The Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001 (as amended); and
- The Conservation of Offshore Marine Habitats and Species Regulations 2017.

This ES Addendum reports the results of the EIA, which was conducted to evaluate the environmental impacts of the proposed development. These potential impacts include physical presence of vessels; generation of atmospheric emissions; changes in underwater sound; marine discharges; seabed footprint; and unplanned events. This EIA also considers socio-economic impacts such as impacts on commercial fisheries, shipping, navigation and other marine users.

See Appendix A for international policy and regulatory frameworks.

This ES Addendum covers:

- Installation of the 24" Southwark pipeline

High level details of the assumed decommissioning plan are provided in Section 3.6. However, decommissioning activities at the end of field life will be subject to a further EIA.

1.3 Report structure

This ES is divided into the principal sections outlined below:

- Non-technical summary – The aim of the non-technical summary is to provide a high-level description of the project, baseline environment, the conclusions of the EIA, mitigation proposed and the overall conclusion of the ES in a short and concise form.
- Environmental statement addendum – The main report which presents the findings of the EIA. It is subdivided into ten chapters as described in Table 1-2.
- Appendices – These include the additional information and data supporting the EIA. It is subdivided into six sections as described in Table 1-3.

Table 1-2 ES Addendum report structure

Section	Title	Brief description of content
1	Introduction	This section establishes the context for the project and the ES Addendum. It provides information on the developer, the project location and design and scope of the EIA.
2	Project justification and alternatives	This section provides an overview of the alternatives considered during concept selection. This section will present the conclusions of a comparative assessment workshop undertaken to determine the Best Practicable Environmental Option.
3	Project description	This section provides the basis upon which prediction and evaluation of the environmental and human impacts is conducted. It is split into the following subsections: ▪ Schedule; ▪ Infrastructure; ▪ Installation ▪ Tie in and commissioning ▪ Inspection and maintenance; and

Section	Title	Brief description of content
		▪ Decommissioning.
4	The baseline environment	This section discusses the prevailing or existing conditions for the proposed development area (physical, biological and human). This section will also detail the projected natural evolution of the baseline.
5	Environmental hazards, effects and mitigation measures	This section describes the footprint of planned project activities, their potential effects on the environment and where possible quantifies the risk they represent, taking into consideration mitigation where appropriate. The potential for accidental events and natural disasters are also discussed.
6	Unplanned events	This section presents oil spill modelling for worst-case scenario established in project description and describes the mitigation measures in place to prevent a release, the likely fate of the release, the proposed response measures and potential environmental impacts of a hydrocarbon or chemical release.
7	Cumulative and transboundary effects	This section identifies activities in the vicinity of Southwark, considers the additional impact to the existing or upcoming impacts to environmental/human receptors of the area and considers the effects and likelihood of effects occurring transboundary.
8	Environmental management	This section provides details on how the environmental risks associated with the proposed development will be managed and a summary of environmental commitments.
9	Conclusions	A concise summary of the key findings of the EIA.
10	References	Sources of baseline information.

Table 1-3 Appendices content

Appendix	Title
A	Policy and legislation framework
B	Consultation
C	Technical Note - Calculation of Dredged Volume for 24" Route (Subsea7 2021b)
D	Southwark 24” Pipeline Comparative Assessment Final Report (Intertek 2021)
E	Seabed Preparation Options for Installation of 24" Southwark Pipeline (Subsea7 2021a)
F	Southwark Pipeline Morphological Assessment (Xodus 2021)

1.4 Availability of the ES

A digital copy of this ES is available on request from:

IOG UK LTD

Mark Yates, HSE Manager

Endeavour House, 189 Shaftesbury Avenue, London, WC2H 8JR

Email: mark.yates@iog.co.uk

2. PROJECT JUSTIFICATION AND ALTERNATIVES

2.1 Overview

The Southwark pipeline is located within the North Norfolk Sandbank and Saturn Reef (NNSSR) Special Area of Conservation (SAC) and Southern North Sea SAC (See Section 4.3). Given the environmental sensitivity of the sites, it is particularly important the new environmental impact assessment (EIA) reported in this Environmental Statement (ES) Addendum demonstrates careful consideration of potential impacts of the development and appropriate choice of techniques.

Justification for the Southwark development is provided in the Blythe Hub Development ES Addendum, Southwark Field Development, reference D/4208/2018. As stated in this previous ES Addendum, it is worth noting that the Southwark field development is founded on re-use of existing Southern North Sea oil & gas infrastructure, namely the previously decommissioned Thames export pipeline PL370.

As part of the option selection process, a re-route of the Southwark pipeline has been considered and discounted, with the justification for this assessment provided below.

During early consultation with the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED), IOG committed to carry out a Comparative Assessment (CA) of pipeline seabed preparation, installation, and protection options to identify the Best Practicable Environmental Option (BPEO). To inform the CA process consultation was undertaken with OPRED and the Joint Nature Conservation Committee (JNCC) to understand the sensitivities of the SACs. A record of this consultation is provided in Technical Appendix B.

The key stages in a BPEO process are:

1. Definition of purpose and scope
2. Identification of options
3. Screening
4. Selecting attributes and criteria
5. Option analysis
6. Weighting factors
7. Identification of the BPEO
8. Integration into decision making

IOG contracted Subsea 7 to engineer, procure and construct the pipeline, and within this scope to carry out a feasibility study of seabed preparation and installation options. The 'Subsea Preparation Options for Installation of 24" Southwark Pipeline' report (hereon referred to as Technical Options Report) prepared by Subsea 7 (Subsea 7 2021a, Technical Appendix E) addressed steps 2, 3 and 4 of the BPEO process.

Steps 5, 6 and 7 were addressed through a CA workshop, carried out on the 29th of January 2021. The CA workshop was attended by representatives of the project team from IOG, Intertek (EIA Lead Consultant), Subsea 7 (EPC Contractor), and Xodus (Environmental Consultancy supporting EPC Contractor). Further details of the CA workshop are provided in (Intertek 2021, Technical Appendix D).

Step 8 was undertaken after the workshop, through a combination of further stakeholder consultation, the EIA process and integration with pipeline engineering and further site investigation planning.

2.2 Pipeline Re-Route

A technical note written by IOG (IOG 2021) outlines the rationale for the pipeline route, between the Southwark platform and the existing Thames pipeline. The route of the pipeline is governed by the start and end points; the end point is the connection to the Thames pipeline, which is flexible and could occur at any point.

The engineering analysis performed by the Wood Group in July 2018 – which was undertaken in consultation with IOG's pipeline engineering department – considered the options for the Southwark platform export pipeline and its connection with the Thames export pipeline PL370.

A primary physical factor considered in the study is the quality of the seabed, particularly in this part of the Southern North Sea where seabed mobility can lead to unpredictable sand wave features, leaving previously buried pipelines exposed and unsupported or, conversely, leaving previously exposed pipelines buried and inaccessible for future inspection, maintenance or modification. Other factors considered, particularly with regard to pipeline sizing and routing, included flow modelling, physical limitations and seabed topography, environmentally sensitive zone demarcation, and geohazards.

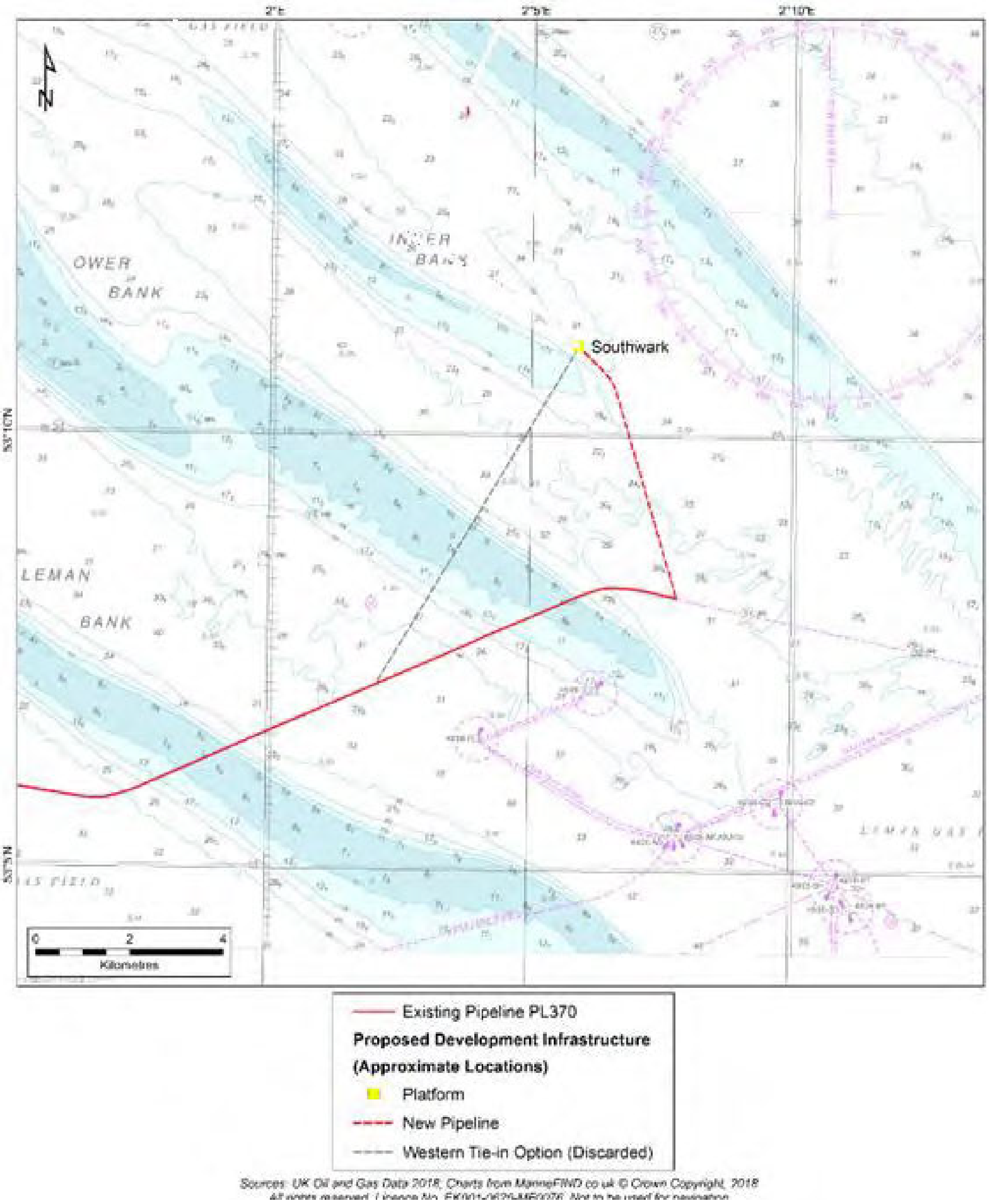
Flow assurance modelling determined that a 24" pipeline (internal diameter of 24") is required for the export pipeline linking Southwark with the Thames export pipeline PL370, and two alternative pipeline routes for the pipeline were identified. These alternative route options are referred to as the eastern and the western route options, both of which tie-in to the Thames export pipeline within UKCS Block 49/26 (Figure 2-1).

The eastern route was selected as the preferred option primarily in view of the comparatively higher risk of environmental damage presented by the western route. The western route would be approximately 8.2km in length and would cross the Ower Bank that rises to approximately 5m below Lowest Astronomical Tide (LAT), whilst the eastern route would be 5.6km in length and avoids crossing this sandbank. This can be seen in Figure 2-1.

A route to the east of the 'eastern route' was not considered a viable alternative. Although it still avoids crossing the Ower Bank, it would still cross extensive areas of sand waves and mega ripples, similar to the topography along the 'eastern route'. However, the pipeline length would be increased, resulting in increased requirements for seabed modification and high impacts to seabed habitats.

The pipeline at the Southwark platform (KP0) is located in water depth of 29.1 m LAT. The preferred eastern route, passes from the platform through an area of sandwaves, becoming shallower. The shallowest point along the pipeline (KP2.089) reaches a depth of 24.1 m LAT in another area of sandwaves. Ultimately, the pipeline route enters deeper water to 34.2 m LAT at the point of tie-in at KP62 of the Thames to Bacton 24" pipeline (PL370). The point of tie-in at KP62 of the Thames pipeline sits to the north of the Ower Bank and presents the shortest route from KP0 to the tie-in point, whilst taking into consideration the inflexibility of the pipeline, which will be concrete coated.

Figure 2-1 Southwark field to Thames export pipeline PL370 eastern and western tie-in route options, showing the Inner Bank and Ower Bank



Re-routing the pipeline to avoid large sandwaves would reduce the need for seabed modification during pipeline installation, as well as during the pipeline operational phase for maintenance.

The Southwark field development is located entirely within the sandbank system of the NNSSR SAC. There is little scope for re-routing due to the presence of sandwaves either side of the route, and constraints of shallower water at the northern end (close to the platform) which would limit access for pipelay vessels. A route in any direction from the Southwark platform to the Thame pipeline would remain entirely within the SAC.

Re-routing the pipeline around the sandbanks would also extend the overall length of the pipeline within the SAC. This would increase the degree of seabed preparation, and therefore seabed disturbance, as well as the potential amount of future remediation required, increasing the environmental effects of the pipeline installation and maintenance.

The sand waves and mega ripples present between the sandbanks within the SAC are part of the Primary Feature habitat for which the SAC is designated. When identifying route options priority was given to avoiding the sandbanks, followed by reducing the distance through which the pipeline routed through sandwaves and mega ripples, to reduce the requirement for seabed modification.

The route selected for the Southwark 24" export pipeline is the optimum route for connecting the Southwark platform to the existing Thames pipeline (PL370) whilst minimising potential environmental impacts on the North Norfolk Sandbanks and Saturn Reef SAC and considering the technical requirements of the export pipeline and its installation.

2.3 Seabed Preparation and Installation Options Identification

The Technical Options Report prepared by Subsea 7 (Subsea 7 2021a, Technical Appendix E) identified seven options in the analysis for the installation of the Southwark pipeline. The options identified are outlined in Table 2-1 below and details on what these options involved are provided in Sections 2.3.2 – 2.3.8.

Table 2-1 Initial concept options summary

Option	Description
1	No seabed modification, pipeline installed as-found seabed
2	Re-route pipeline
3	Rock infill between sandwaves
4	Concrete mattress infill between sandwaves
5	Sandwaves removed to local mean seabed level across the width of the pipe lay corridor
6	Sandwaves removed to local mean seabed level across the width of the pipe lay corridor then pipeline installed and trenched below local mean seabed level
7	Pipeline self-burial

2.3.2 Option 1 – No Seabed Modification

This option would involve the installation of the Proposed Development on the as-found seabed with no seabed modification.

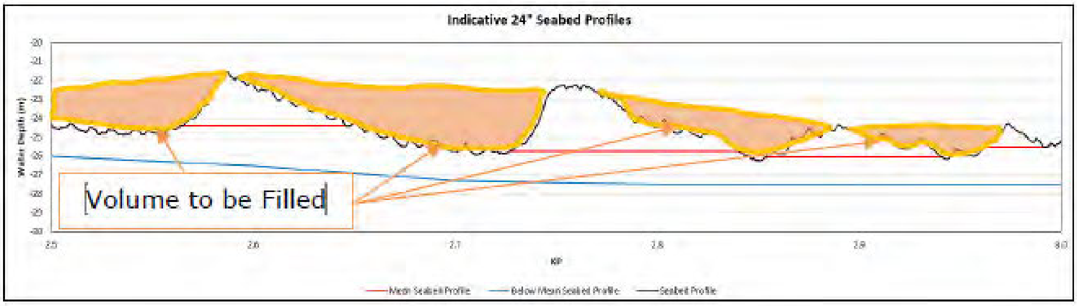
2.3.3 Option 2 – Re-route Pipeline

Option 2 involves changing the route of the pipeline to avoid large sand waves and therefore reducing the need for or completely removing the need for seabed modification. However, there is little scope for re-routing due to the presence of sand waves either side of the route.

2.3.4 Option 3 – Rock Installation between Sandwaves

This option involves subsea rock installation between sandwaves to create a smooth profile for the installation of the pipeline in order to mitigate against premature pipeline failure. Figure 2-2 demonstrates a typical rock infill arrangement between sandwaves.

Figure 2-2 Typical Rock Infill Arrangement



Source: Subsea 7 (2021a)

2.3.5 Option 4 – Concrete Mattress Installation between Sandwaves

In a similar fashion to Option 3, this Option will use concrete mattresses placed between sandwaves to create a smooth seabed profile in order to install the pipeline and combat against premature pipeline failure.

2.1.2 Option 5 – Sandwave Removal to Mean Seabed Level

This option comprises the removal of sand waves to mean seabed level within the footprint of the Proposed Development to create a smooth seabed profile for the installation of the Proposed Development. Sandwave removal would be undertaken using one of the following methods:

- Controlled flow excavation (CFE);
- Trailing suction hopper dredging (TSHD);
- Seabed excavators; or
- Jet trenching.

2.3.6 Option 6 – Sandwave Removal and Trenching Below Mean Seabed Level

This option comprises the removal of sand waves to mean seabed level within the footprint of the Proposed Development to create a smooth seabed profile for the installation of the Proposed Development. Sandwave removal would be undertaken using one of the following methods:

- CFE;
- TSHD;
- Seabed excavators; or
- Jet trenching.

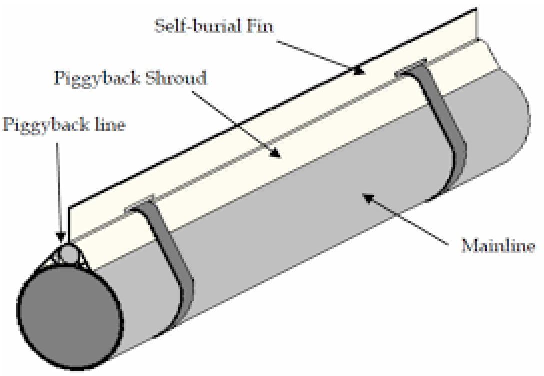
Following the removal of sandwaves, the pipeline would be trenched beneath the seabed using the following methods:

- CFE;
- Jet trenching; or
- Mechanical plough and backfill.

2.3.7 2.1.4 Option 7 – Pipeline Self Burial

This option involves attaching an external fin to the pipeline during installation. The fin will disrupt water flow over the pipeline, leading to the deposit of any suspended sediment in the water over the pipeline. The fin eventually helps the pipeline to bury into the seabed. A typical example of a self-burial pipeline is shown in Figure 2-3.

Figure 2-3 Pipeline with Self Burial Fin



Source: Jee (2018)

2.4 Screening and Selecting Attributes and Criteria

The seven identified options for the pipeline installation and seabed preparation were evaluated in terms of technical feasibility, environmental impacts, health & safety, cost, and schedule. In particular, the lifecycle and sustainability of the options, e.g. reducing the requirement for future remediation, as well as concerns raised by stakeholders with respect to effects on the SACs and the fishing community were considered.

Options 1, 2, 4 and 7 were screened out from further consideration based on the following technical grounds:

Table 2-2 Technical reasons for screening out options

Option	Reasons for screening out
1 – No seabed modification	Given the uneven seabed and morphodynamically active environment, this option was judged not feasible on the basis that unacceptable freespans (i.e. where the pipeline would come away from the seabed) are formed between sandwaves immediately following laydown. This will cause the pipeline to become exposed to environmental loads which severely reduce the pipeline's fatigue life and cause the pipeline to fail shortly after installation or during operation. Additionally, large free spans would present a hazard to fishing activity and other users of the sea.
2 – Re-route pipeline	A local re-route pipeline was also judged not feasible because much of the re-routed pipeline will remain subject to the environmental loads which render Option 1 not feasible.
4 – Concrete mattress installation between sandwaves	This option was considered not feasible as this would require 22,500 mattresses, taking approximately 3.75 years to install. The extent of stacking required also raises stability and safety concerns.
7 – Pipeline self-burial	This option was considered not feasible due to combination of: ▪ Presence of unacceptable freespans immediately following laydown (similar to option 1). ▪ Depth of self-burial unlikely to be enough for the sand wave heights (localised heights up to 4m)

Option	Reasons for screening out
	▪ Impact on fatigue life over the period before self-burial achieved and/or sections which remain unburied. ▪ New unproven technology: would require research and trials with no guarantee of success in the timescales required for the project (i.e. <9 months).

Following screening, three options (3, 5 and 6) were assessed as being technically viable and caried forward for comparative assessment. The environmental appraisal methodology used, was developed by Xodus (Subsea 7's Environmental Consultant) and agreed with IOG and Intertek. This method involved developing the criteria (see Table 2-3) and ranking, which were both used to complete the appraisal based on the potential environmental impacts of the different options. The criteria were developed on the basis of the following:

- The conservation objectives and supplementary advice for the qualifying interest features within the NNSSR SAC;
- Stakeholder concerns raised during consultation;
- The known morphodynamic properties of the sandbank system within the NNSSR SAC; and
- The installation method and likely operational requirements of the different options.

The ranking (a scoring system of 1 to 5) used to evaluate the environmental criteria were developed to account for the varying degrees of risk to the conservation objectives of the qualifying interest features and potential impacts to the wider supporting habitats and users. In accounting for the potential risk, the ranking considered the spatial extents and temporal longevity of any impacts. The completed appraisal then assessed the scale and magnitude of the potential environmental impact from the different options and sub-options based on the installation method and perceived risk to the respective environmental criteria. The environmental appraisal scores were then assigned to each option and sub-option as a basis to compare the potential for, and magnitude of, environmental impacts.

The project team identified at an early stage that based on the conservation objectives of the site removal of sediment from the SAC or indeed to a different location within the SAC would not constitute the best practicable environmental option. It was therefore agreed that with respect to the TSDH options the methodology and assessment would be based on side casting, whereby material is returned to the seabed via a fall pipe or the vessel hopper doors as the dredging operation proceeds.

Table 2-3 Assessment criteria

Criteria	Description
1	Area and volume of direct disturbance (sediments and benthic communities)
2	Temporal recovery of conservation objectives/ attributes (sediments and benthic communities)
3	Development, extent, and persistence of a sediment plume
4	Changes to sediment composition
5	Introduction of new substrate
6	Changes to the seabed morphodynamic regime
7	Impacts on commercial fisheries
8	Potential for and magnitude of scour development and free span, necessitating the need for remedial works

2.5 Comparative Assessment

The aim of the CA workshop was to be able to demonstrate that the techniques used to prepare the seabed, install and protect the pipeline are the BPEO.

The specific outputs of the workshop are as follows:

- BPEO
- Spread of scores for comparative purposes (i.e. to show whether an option is clearly preferred, or is one within a group having very similar scores)
- Sensitivities around the outcome (i.e. to show what would need to change in order to select different options)

2.5.1 Workshop process

The objectives of the CA workshop were to:

- Confirm that steps 2 and 3 of the BPEO process had been appropriately addressed by the Subsea 7 Technical Options Report (Subsea 7 2021a, Technical Appendix E).
- Confirm the suitability of attributes and criteria (Step 4) provided in the Subsea 7 Technical Options Report
- Establish opinion concerning BPEO through comparative assessment of the options (Steps 5, 6 and 7 of the BPEO process).

The CA workshop was broken down into three stages:

1. Verification of Technical Options Report outputs:
    - Conclusions concerning screening out of options (Options 1, 2, 4 and 7)
    - Suitability of scoring process
2. For technically feasible options (Options 3, 5 & 6), review of criteria scores presented in Technical Options Report, to establish/confirm:
    - Whether a range of ranking is applicable to reflect differences between 'Best estimate' and 'Worst Case' rankings
    - Extent of uncertainty concerning individual scores
    - Meeting agreement of the scores
3. Comparative Assessment of feasible options, to examine overall score sensitivity to:
    - Potential adjustments to scores identified above
    - Changes to the weight given to each rank
    - Change to the relative weights given to environmental criteria

2.5.2 Verification of the Technical Options Report

During the CA workshop the rationale for screening out Options 1, 2, 4 and 7 was confirmed and it was agreed that Option 3, 5 and 6 were taken forward for further consideration in the workshop.

2.5.3 Review of criteria scores

The Subsea 7 Technical Options Report (Subsea 7 2021a, Technical Appendix E) provided the starting point for option scoring. It was confirmed that the scoring undertaken to date was based around worst case assumptions. The CA workshop focused on testing underlying assumptions and establishing agreement for the scores. Discussions tested:

- That scoring between options was on merit and not relative to other options / sub-options
- That scoring did not double count potential impacts between criteria
- Whether options allowed for a best case and worst-case assessment score
- The justification behind the score to establish consensus

Where there was any doubt e.g. as to potential effects, a precautionary approach was taken and effect assumed (as an upper value if a range was judged appropriate). Participants, who had the opportunity to review the report in advance, confirmed the report conclusions, with minor changes to the summary table and verified the choice of environmental criteria and ranking scheme.

2.5.4 Examination of overall score sensitivity

To establish the BPEO, the scores were tested for sensitivity. This was undertaken in two ways; by adjusting the weighting applied to score ranking; and by adjusting weighting assigned to individual criteria.

However, prior to any testing the rock-infill option (option 3) was considered not environmentally acceptable, scoring in the highest impact ranking against 5 of the criteria: recovery of conservation objectives, introduction of new substrates, impact on seabed morphodynamics, impact on commercial fisheries and likelihood of further operational intervention. The option was therefore dropped from the comparative assessment.

Criteria were scored on a 1 to 5 scale, 5 being the highest impact. Noting that a score of 5 has a considerably higher impact than 5 times that of a score of 1. This method is referred to as linear scoring. Alternative scoring methods were tested to determine if they changed the overall ranking of the options being assessed. These included Square, Cubic, Exponent (2^{R-1}), Exponent (e^{R-1}), and Exponent (10^{R-1}). The CA was able to demonstrate that the scoring methodologies have little effect on the ranking of options.

2.6 Comparative Assessment Results

Table 2-4 summarises the evaluation of technical, safety, cost, and environmental implications of the seven options. A summary of the comparative analysis conducted on Options 3, 5 and 6 can be found in Figure 2-4 below. Full details can be found in (Intertek 2021, Technical Appendix D).

Table 2-4 Summary of Comparative Assessment

Option	Description	Environmental Effects	Technical Viability	Safety	Project Risk	CA Conclusion
1	No Seabed Modification	Direct impacts to designated qualifying features and environmental features of conservation importance (Sandbanks and *Sabellaria spinulosa*). Pipeline would change sediment type to hard artificial structure until decommissioning. Significant risk of free spans requiring significant remedial works through the introduction of rock placement increasing the level of disturbance. Surface laid pipe and the likely high number of free spans would present a significant snagging risk to fishers.	Not feasible as the pipeline is exposed to environmental loads which will fatigue the pipelines life from weeks to days in some places.	Pipeline would fail during operation. Large free spans would present a hazard to other sea users. Unexploded ordnance (UXO) clearance certificate would be required	No additional Capital Expenditure (CAPEX) required Operating Expenditure (OPEX) includes replacing the pipeline and additional decommissioning costs for failed pipeline	**Screened out** as not technically viable. See Section 2.3 above.
2	Re-route Pipeline	It is not possible to avoid the sandwaves. Therefore, the environmental effects will be the same as Option 1 (see above)	The current pipeline route is considered optimal with little scope to re-route due to sandbanks and shallow water which limits pipe-lay vessels. Based on survey data, seabed modification works likely to be required along any re-route and route is likely to be longer. The risk of future free spans requiring remedial works is high.	Pipeline would fail during operation. Large free spans would present a hazard to other sea users. Standard offshore pipelay and rock installation operations, no additional safety concerns. Additional UXO surveys and certificates required.	Increased CAPEX due to any increase in pipeline length Additional survey required to support new route. Additional pre-lay survey required prior to installation. Additional UXO surveys required. Regular operational surveys required to monitor seabed movement and free spans. Free span remedial works likely. Increase in decommissioning costs if route is longer.	**Screened out** as not technically viable. See Section 2.3 above.
3	Rock Installation between Sandwaves	Installation of rock would result in the direct and permanent loss of Sandbanks and *Sabellarira spinulosa* reef Loss of approximately 80,000m^2 of sandy habitat and associated communities and introduction of approximately 125,000m^3 of hard artificial substrate	Approximately 125,000m^3 of rock required. Rock infill to occupy approximately 80,000m^2 of seabed. Rock infill would be required along the majority of the pipeline.	Standard offshore pipelay and rock installation operations, no additional safety concerns. UXO clearance certificate required	Additional CAPEX for the charter of a subsea rock installation vessel. The cost of rock installation expected to be approximately £7.7million. Regular surveys of the pipeline during operation will increase OPEX.	**Screened out during the comparative assessment,** because this option is considered not environmentally acceptable: it scored the highest impact ranking against five of the eight

Option	Description	Environmental Effects	Technical Viability	Safety	Project Risk	CA Conclusion
		Potential disruption to the hydrodynamic and sediment regime for sandbanks Rock and surface laid sections of pipe represent a snagging risk to other sea users	Rock would be a permanent deposit on the seabed. Any future free spans would require additional rock infill.			environmental assessment criteria.
4	Concrete Mattress Installation between Sandwaves	The effects associated with option 3 are also applicable here. However, this option would result in a much larger footprint of direct impact (approximately 130,000m²) and loss of designated/qualifying features and supporting habitat compared to Option 3. Theoretically mattress protection is a non-permanent measure, however considering the high-volume and safety concerns the mattresses are likely to be a permanent deposit on the seabed.	Approximately 22,500 concrete mattresses would be required at approximately 20 locations along the pipeline route, covering an area of seabed estimated to be approximately 130,000m². Concrete mattress installation is more sensitive to weather and tidal conditions that other options. The removal of concrete mattresses at decommissioning is difficult and is therefore considered a permanent deposit. Likely some concrete mattresses will self-bury over time and cannot be recovered.	Standard offshore pipelay and rock installation operations, no additional safety concerns. The stacking of concrete mattress more than 2 high is unusual and is at risk of instability and collapse and makes decommissioning risky. Large volume of mattresses and repetitive nature increase chances of a safety incident. UXO clearance certificate required.	Additional CAPEX required for a Diving Support Vessel / Remote Operated Vehicle Support Vessel anticipated to cost approximately £188 million. Additional CAPEX to procure concrete mattresses approximately £11.3 million. Mattress laying of this quantity is anticipated to take 3.7 years prior to pipeline installation. Regular operational surveys required and remedial works (rock installation) of any free spans. Significant OPEX associated with the removal of concrete mattresses. Increase OPEX from disposal of recovered concrete mattresses.	**Screened out** as not technically viable. See Section 2.3 above.
5	Sandwave Removal to Mean Seabed Level (MSL)	**Common environmental effects cross all sub-options:** Sandwave levelling to have a direct but temporary impact (approximately 60,000m² footprint area) with sandwave recovery expected to occur. Sandwave levelling will result in the direct and medium to long-term loss of designated	Approximately 60,000 – 100,00m³ of seabed material to be relocated totalling a footprint of approximately 60,000m².	Standard offshore pipelay and rock installation operations and seabed modification works, no additional safety concerns.	Additional CAPEX required to charter seabed modification equipment spreads and support vessels alongside pipeline installation. Cost of sand wave removal is dependent on technology but	Concluded **Not the BPEO** – as scoring worse than option 6. The scores between Options 5 and 6 would only be levelled up when the Criteria 1 (direct

Option	Description	Environmental Effects	Technical Viability	Safety	Project Risk	CA Conclusion
		qualifying features, however recovery is expected following the removal of the pipeline. Temporary alteration to the morphology and localised modification of the hydrodynamic and sediment transport regime. Sandwave levelling will result in the direct temporary loss of any *S. spinulosa* aggregations within the footprint of the excavation operations. Surface laid sections of pipe would introduce hard artificial substrate in a soft sediment environment and there is the potential for scour which may result in the requirement for rock infill. Surface laid pipe and rock infill represents a snagging risk for other sea users	Jet trenching not feasible due to height of sandwaves. CFE and TSHD less sensitive to weather conditions. The risk of future free spans requiring remedial work is considered medium. TSHD will produce a more accurate seabed profile and can be configures to side-cast material back into the locality; Seabed excavators cannot operate on steep seabed slops	Seabed preparation will need to be carried out just before pipeline installation and will require a Simultaneous Operations (SIMOPS) for pipelay and seabed preparation support vessels UXO clearance certificate required	estimated to cost between approximately £2.9 to £7.4 million. Regular operational surveys of exposed pipeline to monitor seabed movement on pipeline free spans. Any unacceptable fee spans will require remedial works. Remedial works likely to involve rock installation. No additional decommissioning costs expected above that required for a standard pipeline.	disturbance) weighting was increased by a factor of 4. An increase of this magnitude to the weighting of Criteria 1 is not considered justifiable and it can therefore be concluded that Dredging to MSL cannot be considered BPEO.
5a	CFE	Seabed footprint to be disturbed likely to be marginally larger than other methods. A larger volume of sediment is likely to be disturbed resulting in greater suspended sediment concentrations. Bulk of levelled sediment would be pushed to the side only slightly influencing the seabed depths.				
5b	TSHD	Smaller footprint compared to CFE. The drag head is likely to develop a large plume during the dredging process. Suspended sediment concentration and duration less than CFE. Continuous side casting adjacent to the dredge area would result in deposition mounds resulting in the burial and loss of supporting habitats.				
5c	Seabed Excavator	Similar environmental effects to Option 5b.				
6	Sandwave Removal and Trenching Below MSL	Sandwave removal effects across all options are considered the same as reported for Option 5 (and sub-options above).	**Sandwave removal:** Estimated volume of seabed material varies between approximately	Standard offshore pipelay and rock installation operations and seabed modification	Additional CAPEX required to support the chartering of seabed modification equipment and support vessels to be in the field alongside pipeline installation.	**BPEO** - On a best estimate basis, options 6F and 6I (dredging to MSL by either suction trailing hopper or seabed

Option	Description	Environmental Effects	Technical Viability	Safety	Project Risk	CA Conclusion
		There will be an additional footprint of environmental impact resulting from trenching of the seabed. **Common environmental effects across all sub-options:** Trenching would entail the clearance of designated qualifying features and supporting habitats within the footprint along the length of the pipeline, although effects are considered direct and temporary due to recovery of features. The levelled and trenched sandwaves and seabed are considered to have a limited impact on the long-term hydro-morpho dynamic regime. Seabed preparation works are likely to generate seabed disturbance resulting in sediment plumes that would spread beyond the extent of the works. For the CFE and jetting options, the pipeline would be partially covered by sediment which greatly reduces the potential for scour and free spans. Open trenching without active re-burial represents a snag risk for fishing along the pipeline. Following natural infilling immediately after trenching, this risk is greatly reduced.	235,000m^3 and 263,000m^3 (including the volume trenched material to be removed depending on installation method). Jet trenching is not feasible based on sandwave depths. CFE and TSHD are less sensitive to weather conditions. TSHD will produce a more accurate seabed profile than CFE. CFE displaces material locally whereas TSHD requires material transport to another location for disposal. Seabed excavators cannot operate on steep seabed slopes. **Trenching pipeline:** Jet trenching requires one pass, mechanical ploughing would require two. Mechanical plough has a larger footprint. Potential issues with mechanical plough handling a pipeline of this size and weight. Pipeline field joint coating must be suitable for	works, no additional safety concerns. Seabed preparation will need to be carried out before pipeline installation. SIMOPS therefore required for pipelay and seabed preparation support vessels. UXO clearance certificate required.	The cost of this option depends on the methodology selected but ranges between £5 to £10million. Survey requirements likely to be less for a buried pipeline compared to the exposed option. The risk of future free spans is significantly reduced and therefore requirement for permanent rock deposits also reduced. No additional decommissioning cost expected above what is required for standard pipeline decommissioning.	excavator followed by ploughing to below MSL) represent BPEO. However, ploughing and jetting are considered to have a similar worst-case performance (options 6E, 6F, 6H and 6I).
6a	CFE (sandwave removal) & CFE (pipeline burial)	Lower accuracy of CFE means a larger footprint may be disturbed during trenching resulting in a direct impact over a greater area. The lower accuracy of CFE for trenching will result in a longer duration of works and contribute to a plume over a wider extent. Damage and disturbance to *S.spinulosa* reef cannot be discounted. CFE would entail moving sediment to the sides of the trench creating mounds along the length of the pipeline, however would winnow down over				

Option	Description	Environmental Effects	Technical Viability	Safety	Project Risk	CA Conclusion
		time. The hydrodynamic or sediment transport regime is unlikely to be affected by deposition mounds. A build-up of sediment along the trench margins would potentially cause the temporary loss of benthic communities along the entire length of the pipeline.	passing through plough roller boxes and may need further engineering.			
6b	CFE & Jetting	Jetting involves the fluidisation of the seabed where sediment is temporarily entrained. A large proportion of this sediment is deposited within the trench or immediately adjacent. The sedimentation effects would be larger than CFE. Due to potential smaller plume extents associated with jetting, the damage and disturbance to *S.spinulosa* reef is less likely than from CFE. With jetting, a large proportion of the disturbed material would be retained within the trench or immediately next to it. This would result in the burial and temporary loss of sediment communities along the length of the pipeline, however recovery is expected within 2 years.				
6c	CFE & Plough	Due to the wider levelled width required for the plough than the trenching tool, a larger area of direct impact will occur for sandwave clearance. Longer period of disturbance associated with sandwave levelling resulting in increases in sediment concentration, therefore greater potential damage, and disturbance to nearby areas of reef. During trenching, the plough will create berms of excavated material that will be present for a short period of time. These berms are unlikely to affect the hydrodynamic regime. The plume generated by a plough is considerably smaller compared to CFE and jetting. The use of the plough will likely create will create berms adjacent to the trench for very short				

Option	Description	Environmental Effects	Technical Viability	Safety	Project Risk	CA Conclusion
		periods of time and environmental impacts are limited.				
6d	TSHD & CFE	Effects the same as reported for TSHD sub option 5b and CFE sub-Option 6a.				
6e	TSHD & Jetting	Effects the same as reported for TSHD sub option 5b and jetting sub-Option 6b.				
6f	TSHD & Plough	Effects the same as reported for TSHD sub option 5b and plough sub-Option 6a.				
6g	Seabed Excavator & CFE	Effects the same as reported for seabed excavator sub option 5c and CFE sub-Option 6a.				
6h	Seabed Excavator & Jetting	Effects the same as reported for seabed excavator sub option 5c and jetting sub-Option 6b.				
6l	Seabed Excavator & Plough	Effects the same as reported for seabed excavator sub option 5c and plough sub-Option 6c.				
7	Pipeline Self Burial	Direct impacts to designated and qualifying features would be limited to those located within the footprint of the pipeline, however following burial the sandy sediment habitat will return. The impact is medium to long-term as the time required for burial is unknown. The steep asymmetric profiles and no seabed modification means free spans and requirement for additional remedial works are increased and would result in the permanent introduction of a hard substrate (rock placement/concrete mattress). High risk of free spans represents a significant snagging risk to fishing vessels.	Contractor has no experience with this method. Depth of self-burial achieved is highly unlikely to be enough to mitigate the larger sandwaves which have heights in excess of 4m. Pipeline fatigue due to free spans may exceed allowable limits before the pipeline self-buries. Self-burial would have to been considered in combination with one of the sand wave removal options.	The installation of pipeline fins is not a standard operation for the contractor and therefore represents an increased risk. UXO clearance certificate required.	Additional CAPEX for the procurement of pipeline fins roughly approximately £1.8million. Slower lay speed during pipeline fabrication therefore increased vessel time and associated cost. Testing and qualification programme required to build confidence in this method prior to deployment. Self-burial would need to be considered in combination with one of the sandwave removal options. Regular surveys required to monitor the progress of pipeline self-burial. If self-burial is not sufficient, additional OPEX from remedial works.	**Screened out** as not technically viable. See Section 2.3 above.

Option	Description	Environmental Effects	Technical Viability	Safety	Project Risk	CA Conclusion
			The risk of future free spans requiring remedial work is medium.		No additional decommissioning cost expected above that for a standard pipeline.	

Table 2-5 Comparative Assessment Scores

	Best Estimate		Worst Case	
Pipeline installation option	**Score**	**Rank**	**Score**	**Rank**
5A: Controlled Flow Excavation (CFE)	11.6	12	11.6	12
5B: Trailing Suction Hopper Dredging	11.0	10	11.0	10
5C: Seabed Excavators	11.0	10	11.0	10
6A: Controlled Flow Excavation + CFE	9.4	9	9.4	9
6B: Controlled Flow Excavation + Jetting	6.1	3	6.6	5
6C: Controlled Flow Excavation + Plough	6.1	3	6.6	5
6D: Trailing Suction Hopper Dredging + CFE	7.8	7	7.8	7
6E: Trailing Suction Hopper Dredging + Jetting	6.1	3	6.1	1
6F: Trailing Suction Hopper Dredging + Plough	5.5	1	6.1	1
6G: Seabed Excavators + CFE	7.8	7	7.8	7
6H: Seabed Excavators + Jetting	6.1	3	6.1	1
6I: Seabed Excavator + Plough	5.5	1	6.1	1

2.7 The Proposed Option – Option 6

The comparative assessment concluded that the BPEO for pipeline installation and protection is Option 6 - the removal of sandwaves and subsequent burial of the pipeline below the mean seabed level. The conclusion proved to be resilient against a variety of weightings that were applied to the rankings and the effect of changing the weighting given to individual criteria.

On a best estimate basis, options 6F and 6I (dredging to MSL by either suction trailing hopper or seabed excavator followed by ploughing to below MSL) represent BPEO. However, ploughing and jetting are considered to have a similar worst-case performance (options 6E, 6F, 6H and 6I). A variety of weightings were applied to the rankings and none we found to affect the overall result.

Overall, and with the exception of the use of CFE, all sub options for dredging to MSL followed by trenching to below MSL (Option 6) yielded similar scores such that, within the accuracy of the assessment, any could be considered to represent BPEO. Recognising that detailed engineering is yet to be done and that it is possible that choice of seabed preparation technique may be limited by market availability of equipment, it was recommended that CFE was not dropped from further consideration and was taken forward to the EIA along with the other sub-options.

3. PROJECT DESCRIPTION

3.1 Overview

The project description provides an overview of the proposed activities to be undertaken during the installation, commissioning and operational phases of the Proposed Development and the associated timeframe.

The Proposed Development consists of: a single 24" gas export pipeline which will transport the production gas and fluids from Southwark for eventual processing at onshore Bacton terminal on the north Norfolk coast. This pipeline will be tied into the existing Thames pipeline and the Southwark platform.

3.1.1 Marine Plans

The Proposed Development is in the area covered under the East Offshore Marine Plan. The East Offshore Marine Plan area covers the marine area from 12 nautical miles (NM) out to the Exclusive Economic Zone (the maritime borders with the Netherlands, Belgium and France), a total of approximately 49,000 square kilometres of sea. The area is predominantly open, shallow water supporting oil and gas platforms and commercial activities such as shipping, aggregate extraction and fishing.

There are nine objectives and two oil and gas policies of the East Offshore Marine Plan that are applicable to the Proposed Development, these are included below. Within Technical Appendix A, the Proposed Development has been assessed for compliance against these objectives. This assessment concluded that the Proposed Development complies with the applicable objectives in the East Offshore Marine Plan.

- **Objective 1:** To promote the sustainable development of economically productive activities, taking account of spatial requirements of other activities of importance to the East Marine Plan Areas.
- **Objective 2:** To support activities that create employment at all skill levels, taking account of the spatial and other requirements of activities in the East marine plan areas.
- **Objective 5:** To conserve heritage assets, nationally protected landscapes and ensure that decisions consider the seascape of the local area.
- **Objective 6:** To have a healthy, resilient and adaptable marine ecosystem in the East marine plan areas.
- **Objective 7:** To protect, conserve and, where appropriate, recover biodiversity that is in or dependent upon the East marine plan areas.
- **Objective 8:** To support the objectives of Marine Protected Areas (and other designated sites around the coast that overlap, or are adjacent to the East marine plan areas), individually and as part of an ecologically coherent network.
- **Objective 9:** To facilitate action on climate change adaptation and mitigation in the East marine plan areas.
- **Objective 10:** To ensure integration with other plans, and in the regulation and management of key activities and issues, in the East marine plans, and adjacent areas.
- **Objective 11:** To continue to develop the marine evidence base to support implementation, monitoring and review of the East marine plans.

- **Policy OG1:** Proposals within areas with existing oil and gas production should not be authorised, except where compatibility with oil and gas production and infrastructure can be satisfactorily demonstrated.
- **Policy OG2:** Proposals for new oil and gas activity should be supported over proposals for other development.

3.1.2 Development overview

The Southwark Field Development aims to produce gas for onshore processing at the Bacton Gas Terminal on the north Norfolk Coast. The development includes three gas production wells in the Southwark field, an offshore gas production platform together with an export pipeline which will be tied-in to the existing 24" Thames to Bacton pipeline (PL370) to deliver produced gas to the Bacton onshore terminal (Figure 3-1). Figure 3-2 provides an overview of the wider Blythe and Southwark Field Development Hub.

The Proposed Development will comprise of:

- A single 24" pipeline, 5.67km long
- Seabed clearance and pipeline installation
- Tie-in spools to allow tie- in to the existing Thames pipeline and the Southwark platform.
- Deposition of up to 200 concrete mattresses, nominally 100 at the Thames pipeline tie-in and 100 at the Southwark Platform tie-in.
- Deposition of up to 2900 grout/sand bags, nominally 1450 at the Thames pipeline tie-in and 1450 at the Southwark Platform tie-in.

The tie-in operation to the Southwark Platform and to the Thames to Bacton pipeline (PL370) were covered under the previous ES Addendum (D/4208/2018) (IOG 2018a). However, following a dropped objects study and due to the geometry of the installation vessel to the tie-in site, tie-in operations now require additional spools and concrete mattresses. Therefore, tie-in and commissioning operations have been re-assessed as part of this ES Addendum.

The previous ES Addendum (D/4208/2018) (IOG 2018a) also assessed the subsequent production phase, until the field becomes economically unviable and will be decommissioned. However, given that this ES Addendum is covering a new installation method, the estimated quantity of rock protection required for remedial works has changed. Therefore, remedial works during the production phase has been re-assessed as part of this ES Addendum.

It is currently planned to commence pipeline installation operations in Quarter 1 of 2022.

Figure 3-1 Southwark Field Layout

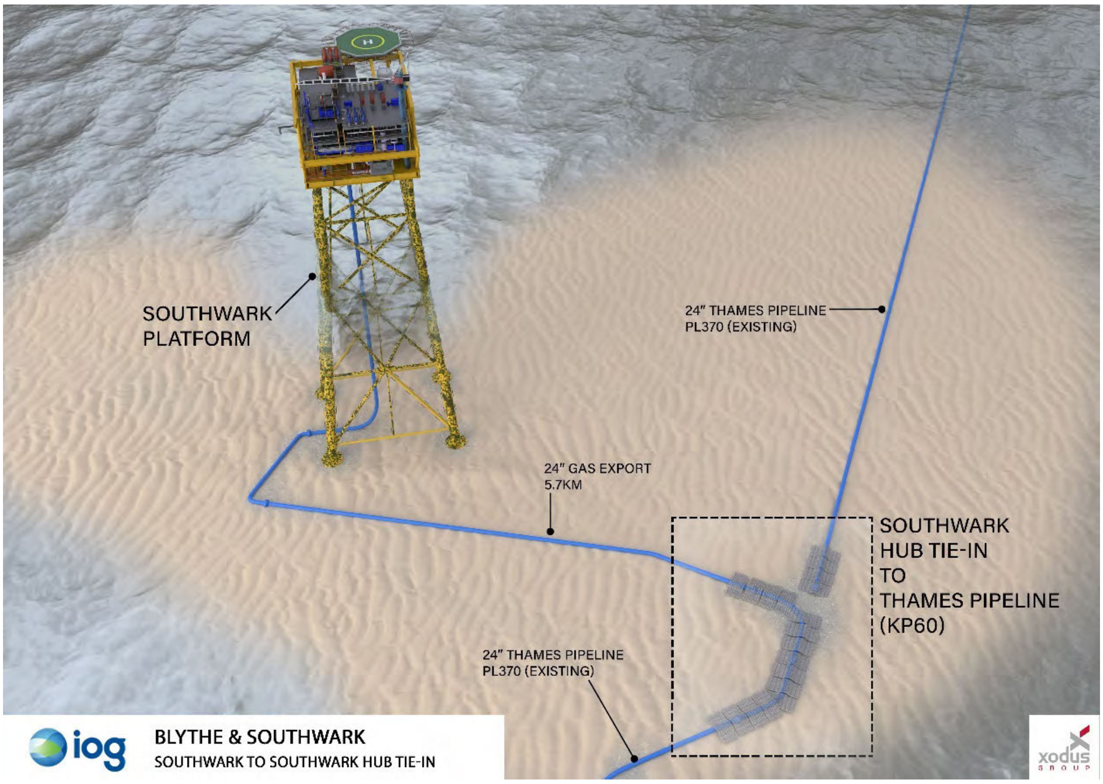
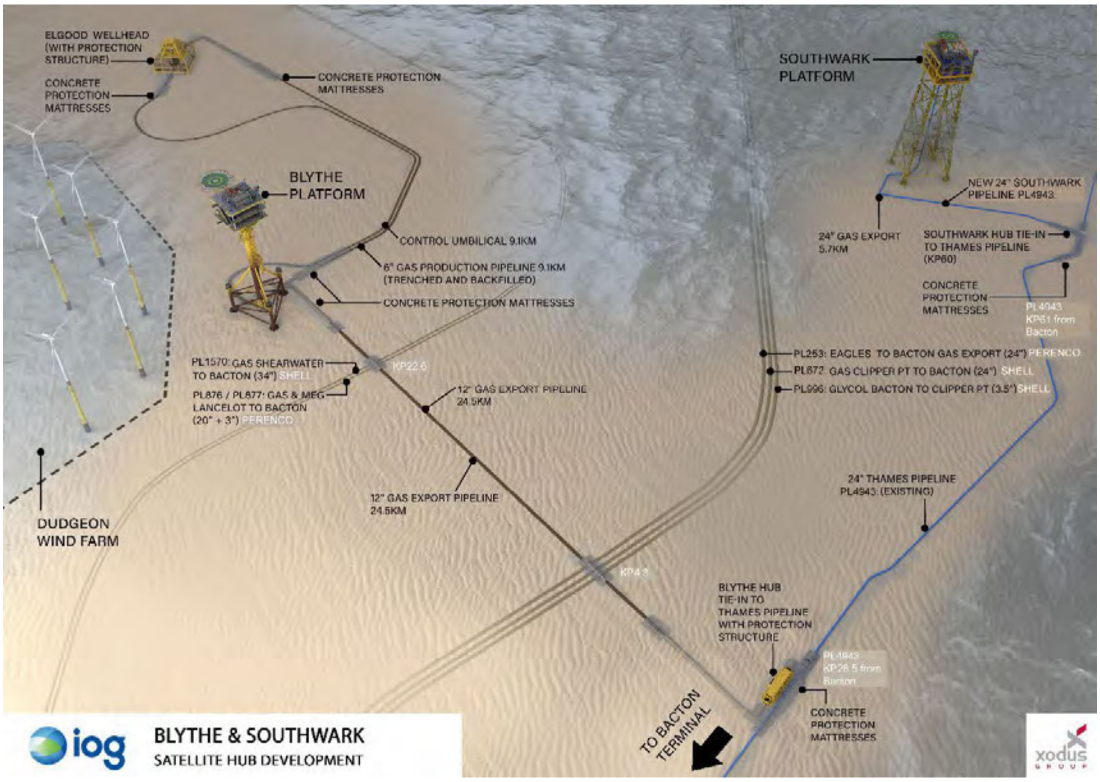


Figure 3-2 Blythe and Southwark Field Layout



3.1.3 Facilities accountability and ownership

The Southwark field lies within Block 49/21c under licence P1915 which is presently in 50% equity ownership of IOG UK LTD a wholly owned subsidiary of Independent Oil and Gas plc and 50% equity of Cal Energy Resources UK Limited.

3.1.4 Schedule

The indicative schedule for pipeline installation works is provided in Table 3-1.

Table 3-1 IOG Southwark 24" pipeline indicative schedule – 2021/2022

Operation	Duration	Start	End
Pre-lay survey	4 days	Late Nov	Early Dec
Sand wave clearance	32 days	Late Dec	Late Jan
Pipelay	9 days	Early Feb	Mid Feb
Trenching	15 days	Mid Feb	Late Feb
Flood, clean, gauge and strength test (DSV operations to prepare the site)	17 days	Early March	Late March
Tie-ins	21 days	Mid April	Late April

It is estimated that first gas from the Southwark Platform will be in Quarter 2 of 2022 and end of field life will be in 2037.

3.2 Southwark Pipeline

3.2.1 Infrastructure

The Southwark pipeline will consist of a single concrete-armoured 24" (outside diameter) pipeline, approximately 5.67km long. Design parameters are provided in Table 3-2.

The pipeline will be tied in at the Southwark Platform and to the Thames to Bacton pipeline (PL370) (see Figure 3-1). The pipeline will be tied in using spool pieces. The diameter of these spool pieces will be the same as the pipeline, 24". It is estimated that the length of the spool pieces at the Southwark platform and the Thames pipeline tie-ins will be approximately 150m (+/- 75m) and 65m (+/- 20m), respectively. These spool pieces will be protected using concrete mattresses (Section 3.4).

Anodes will be fitted within the fabricated pipe joints, which are embedded within the concrete armour. There may be a requirement to retrofit some additional anodes to the pipe joints to ensure ongoing protection. The tie-in spools will also be fitted with anodes.

Table 3-2 24" Gas Export Pipeline design parameters

Parameter	Unit	Value
Pipeline Number	-	PL4943
Pipeline Length	km	5.67
Pipeline Design Life	Years	15
Pipeline Steel Outside Diameter	mm	609.6
Pipeline Steel Inner Diameter	mm	571.4 mm
Pipeline Steel Material Grade	-	API 5L X65 PSL2 MO
Manufacturing Process	-	DSAW Double Submerged Arc Welded Pipe

Parameter	Unit	Value
Pipeline Coating Material	-	Three Layer Polypropylene (3LPP) + Concrete Weight Coating (CWC)
Pipeline 3LPP Coating Thickness	mm	3.2
Pipeline 3LPP Coating Density	kg/m³	900
Concrete Weight Coating Thickness	mm	100-120
Concrete Weight Coating Density	kg/m³	3040
Total Outer Diameter including coating	mm	KP0 - KP2: 856mm KP2 - KP5.677: 816mm
Design Pressure	bar(g) at LAT	129

3.2.2 Pipeline installation

3.2.2.1 Overview

The route of the Southwark 24" pipeline leaves the Southwark Platform on a south east heading then turns south towards the tie-in point on the Thames Pipeline. The pipeline route is approximately 5.67km in length.

The Southwark pipeline does not follow a straight line between the Southwark Platform and Thames Pipeline tie-in points. It has been optimised to avoid sandwaves, where possible. However, as discussed in Section 2.2, there is little scope for further re-route due to the presence of sandwaves either side of the route.

Prior to installation and to confirm the optimal route, a sandwave pre-clearance survey will be carried out along the pipeline route to confirm the status of the seabed and location of sandwaves along the route. A-pre lay survey will also be conducted to ensure there are no debris, obstructions or potential unexploded ordnance (UXO) present within the pipeline corridor. The sandwave pre-clearance and pre-clearance survey programme will provide seabed bathymetry, surface target type (i.e. sediments and any obstructions) and sandwave dimensions along the pipeline corridor. Due to poor visibility on previous surveys, these surveys will be conducted using a dual head multibeam echosounder (MBES) data positioned using an Inertial Navigation system (INS) aided ultra-short baseline acoustic positioning system (USBL)/ Doppler velocity log (DVL). This is a method of underwater acoustic positioning, which consists of a MBES mounted on a remotely operated vehicle (ROV) or a towed fish, this will then send bathymetry and obstruction data back to the vessel. Vessel details for this scope are not yet known however this survey is likely to be undertaken using the dynamically positioned (DP) MMA Pinnacle, or similar.

The pipeline route is located in a morphodynamically active environment with evidence of actively migrating sandwaves that are characteristic of the North Norfolk sandbank system. Bathymetric information from the 2018 and 2020 surveys, indicate that the sandwaves are actively evolving with migration rates of over 10 m/year for the largest sandwaves (Subsea 7 2021a). In the wider area covered by the 2018 survey, there is also evidence of bifurcating and converging sandwaves, associated with steep asymmetric profiles, which all support the conclusion of an active and dynamically evolving environment (see Section 4.2.3). The seabed in this region is characterised by large sandwaves and mega-ripples which present challenging conditions for pipeline installation and future integrity. Seabed modification works are required before the pipeline can be installed to mitigate against pipeline fatigue, free-spanning effects, and future remediation requirements.

The objective will be to install and bury the pipeline below the mean seabed level. To achieve this sandwaves will be removed to mean seabed level. The next step could be one of two options: i) cutting a trench and laying the pipeline in to the trench, or ii) laying the pipe on the seabed and then trenching to below mean seabed level. After either option the trench will be backfilled, either naturally or mechanically. Dependent on the selected trenching/backfill method, a dedicated separate backfill pass may not be required. The only sections where the pipeline will not be trenched are at the tie-in locations, as described in Section 3.4.

The installation and burial of the pipeline will follow the below process:

- Pre-installation surveys.
- Sand wave clearance to mean seabed level.
- Lay pipeline on seabed and then trench or trench and then lay the pipeline in the trench.
- Post lay and trench survey.
- Flood with chemically inhibited seawater
- Backfill trench, if required (dependent on trenching method selected).
- Hydrotest.
- Install spool pieces and tie-in pipeline at both ends.
- Leak-test.
- Protect tie-in with concrete mattresses.
- Final as laid survey.

3.2.2.2 Sandwave clearance

Overview

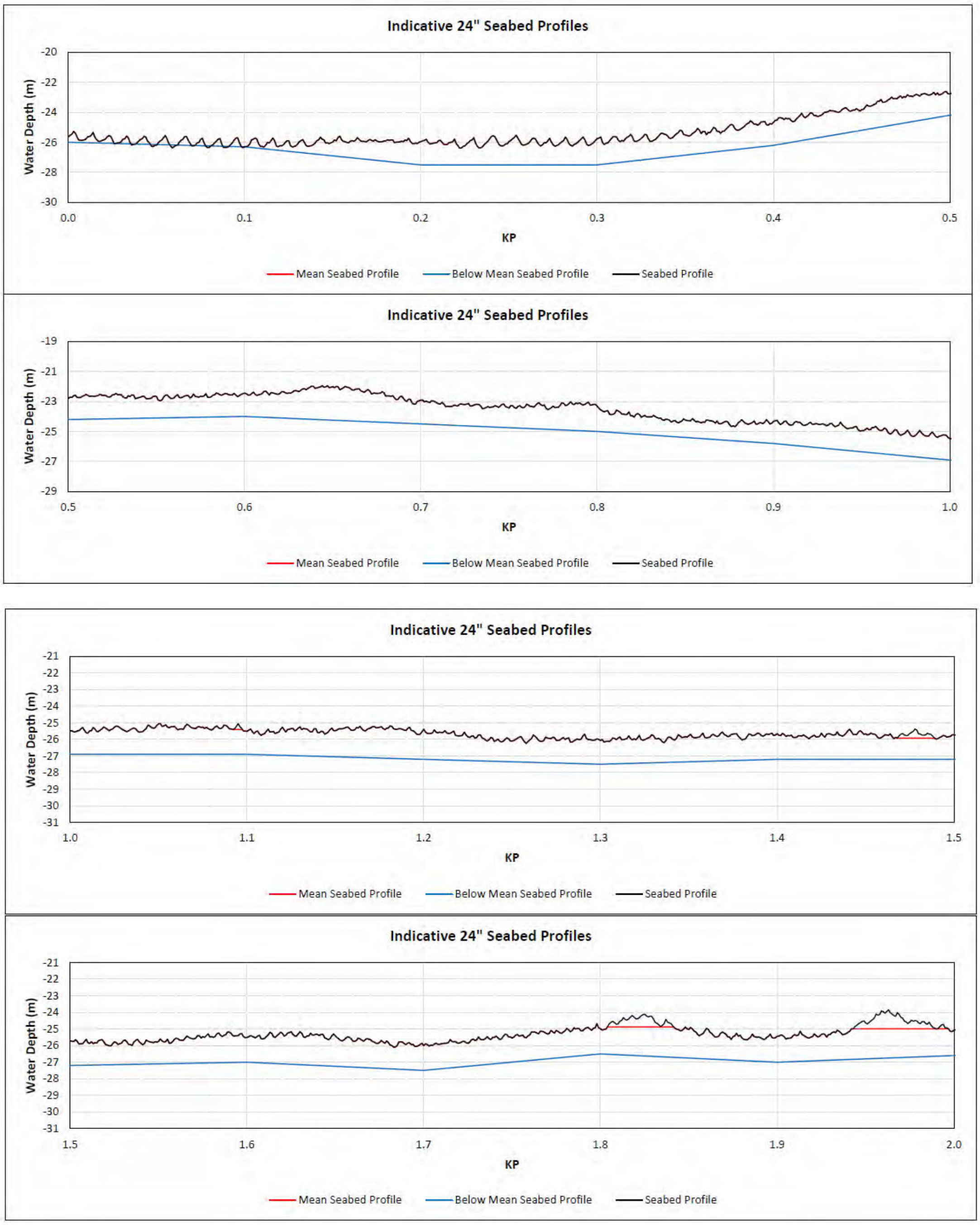
Sandwaves along the route will make the use of trenching equipment impractical if they are not removed. Therefore, sandwave clearance is required to create a smooth profile for the installation of the pipeline. It will also mitigate against premature pipeline failure due to the creation of free-spans.

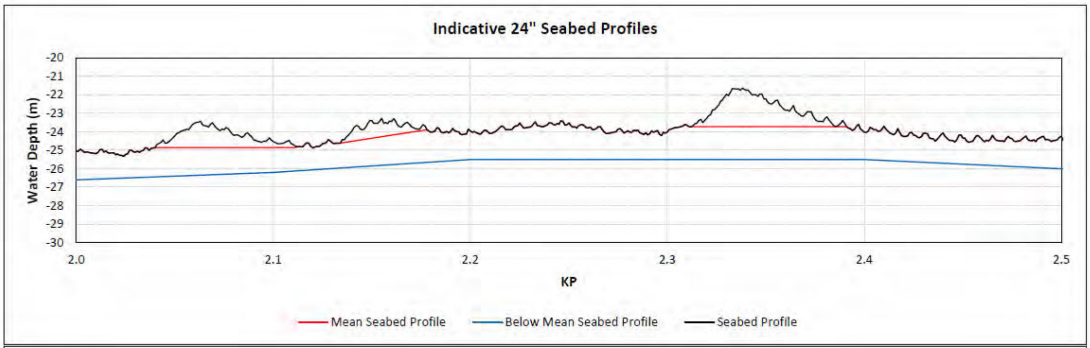
Sandwave clearance comprises the removal of sandwaves to mean seabed level within the extents of the pipe lay corridor. By removing a portion of the sandwaves prior to installation, the burial machine can reach further down and place the pipeline below the level at which it may be unaffected by the mobility of the bedform, preventing the formation of free-spans.

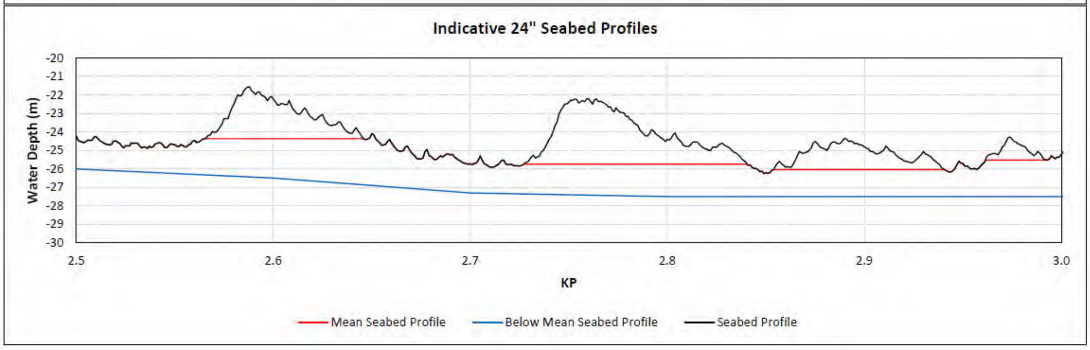
The proposed route crosses the sandwaves at varying angles, depending on the location along the route, meaning there is the potential for relatively large cross-sections of individual sandwaves to be levelled for transversal crossings, compared with perpendicular crossing sandwaves. This is evident from Figure 3-3 which shows the 2020 bathymetry along the route centreline, and an indicative below seabed profile, which is an indicative target location for the trench.

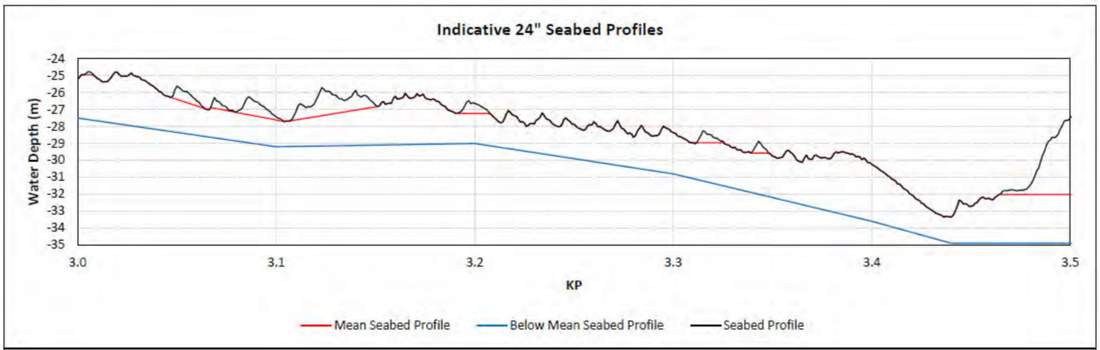
Given the mobility of sandwaves in the region it is not possible to estimate the exact locations of sandwave clearance activities. Therefore, when Subsea 7 (Engineering, Procurement and Construction (EPC) contractor) calculated the estimated volumes to be cleared and the seabed footprint from pre-sweeping activities, they assumed that pre-sweeping would be undertaken at any point along the pipeline route, from the Thames pipeline tie-in to the Southwark platform tie-in.

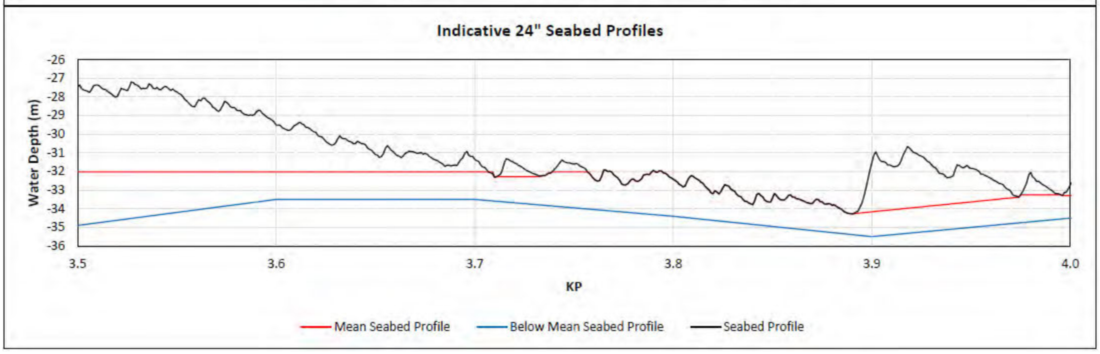
Figure 3-3 Indicative vertical seabed profiles

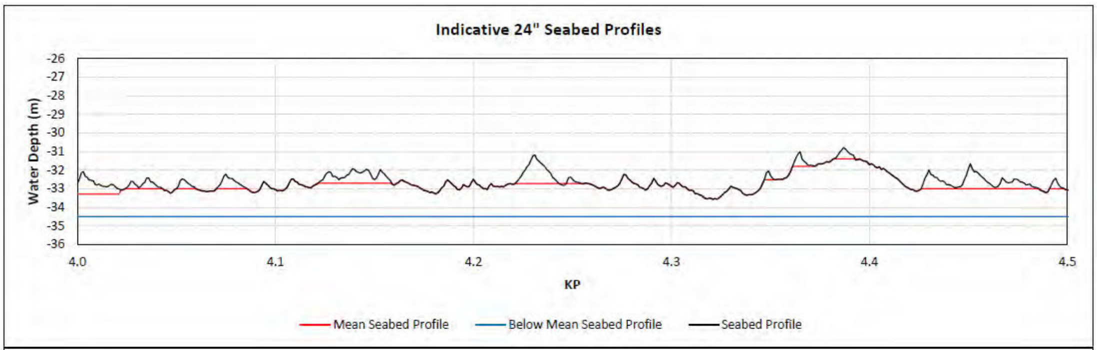


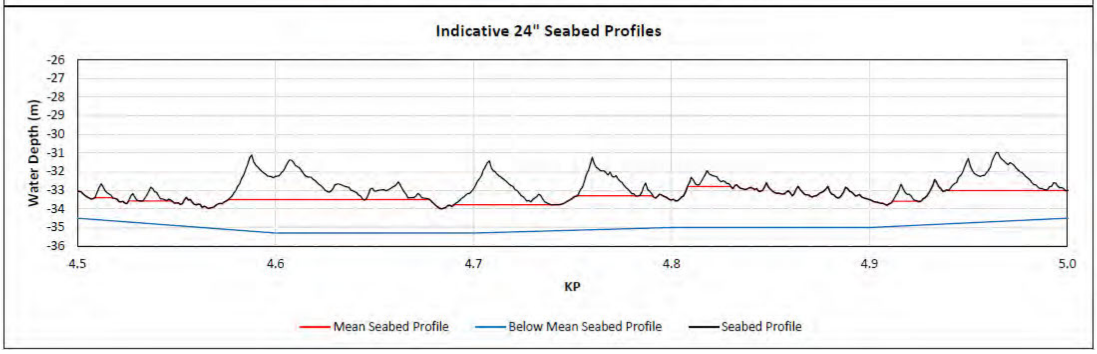

Indicative 24" Seabed Profiles
Water Depth (m)
-20
-21
-22
-23
-24
-25
-26
-27
-28
-29
-30
2.0
2.1
2.2
2.3
2.4
2.5
KP
Mean Seabed Profile
Below Mean Seabed Profile
Seabed Profile

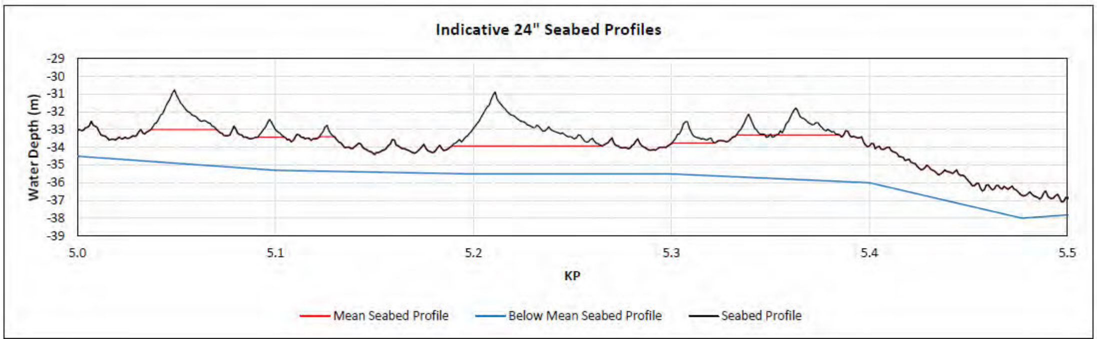

Indicative 24" Seabed Profiles
Water Depth (m)
-20
-21
-22
-23
-24
-25
-26
-27
-28
-29
-30
2.5
2.6
2.7
2.8
2.9
3.0
KP
Mean Seabed Profile
Below Mean Seabed Profile
Seabed Profile

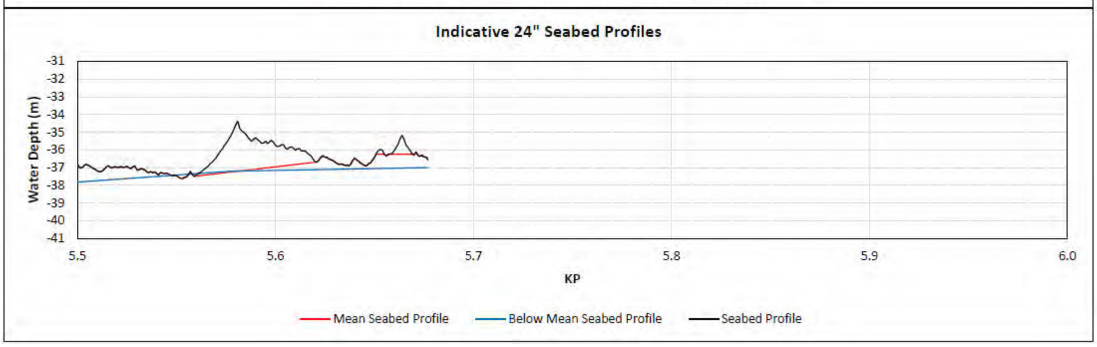

Indicative 24" Seabed Profiles
Water Depth (m)
-24
-25
-26
-27
-28
-29
-30
-31
-32
-33
-34
-35
3.0
3.1
3.2
3.3
3.4
3.5
KP
Mean Seabed Profile
Below Mean Seabed Profile
Seabed Profile


Indicative 24" Seabed Profiles
Water Depth (m)
-26
-27
-28
-29
-30
-31
-32
-33
-34
-35
-36
3.5
3.6
3.7
3.8
3.9
4.0
KP
Mean Seabed Profile
Below Mean Seabed Profile
Seabed Profile









Source: Technical Appendix E, Subsea (2021a)

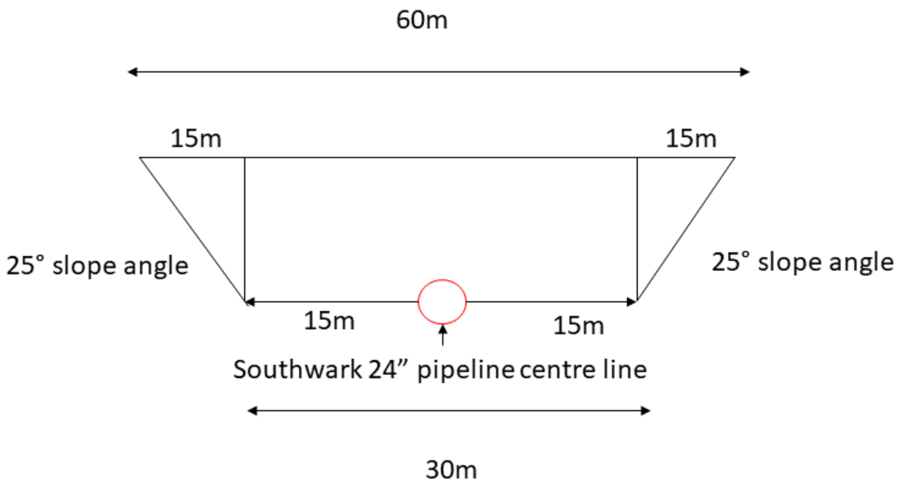
Estimated volumes

To calculate the potential volume of sandwaves requiring pre-clearance, three steps have been undertaken, and are described below:

1. Create a TIN (triangulated irregular network) model - This is a design shape of the desired trench in relation to the seabed bathymetry.
2. Predict the bathymetry along the pipeline corridor in 2022 – this was based on the migration pattern of sandwaves in the region.
3. Use computer software to calculate the volume of material to be cleared.

The TIN model was based on pipeline analysis which determined the desired depth for pipeline stability, of the route centreline below the seabed. A lateral flat corridor was extended out 15m either side of this deeper centreline to create a 30m flat bottom section; the necessary corridor width for mechanical plough and backfill equipment to proceed unhindered. Slope sections of 25° were then added on either side to go from the flat bottom section up to the seabed level. These slopes are approximately 15m wide at each side making the final corridor approximately 60m in width (see Figure 3-4).

Figure 3-4 Cross section of sandwave removal



Given the mobility and migratory nature of the sandwaves along the Proposed Development means that sediment clearance volumes estimated from the present bathymetry are unlikely to be representative for an installation in 2022. To predict the bathymetry along the pipeline corridor in 2022, IOG commissioned an assessment of sandwave migration in the region. Conducted by Xodus, this used publicly available historic bathymetric datasets and the IOG 2018 and 2020 bathymetry data to determine the following:

- Sandwave migration affecting the 24" Southwark pipeline corridor between the 2018 survey and the present; and
- Likely locations of sandwaves along the pipeline route up to the present, and an estimated installation date of July 2022 as a worst case.

The results of the study were a series of updated seabed bathymetry models, whereby the sandwaves identified in the 2020 survey have been geographically shifted to estimated positions for 2022 (proposed date for the installation of the 24" pipeline).

The TIN model and predicted 2022 seabed bathymetry models were loaded into the EIVA NaviModel by Subsea 7 (Technical Appendix C Subsea 7 2021b). This computer software used the bathymetry models to calculate the total volume of material above the TIN model. This was repeated for each shifted bathymetry model to provide estimates for the minimum and maximum volumes of sediment that could require clearance.

The estimated footprint and volume of seabed material to be cleared from the pipeline corridor is as follows:

- Area of sandwaves to be cleared – **374,220m^2**. This assumes a clearance width of 60m (Technical Appendix C Subsea 7 2021b) along the entire pipeline route (5670m) plus 10% contingency.
- Volume of sediment to be cleared from both sandwave clearance and trenching – **575,000m^3.** The EIVA NaviModel calculated volumes between 367,200m^3 and 383,300m^3 (Technical Appendix C

Subsea 7 2021b). Due to limitations in the data sets and the clearance methodology, the value assessed includes a conservative 50% contingency.

Techniques

The removal of sandwaves to mean seabed level could be carried out using the following methods:

- Controlled flow excavation (CFE).
- Trailing suction hopper dredging (TSHD).
- Seabed excavators.

A brief description of each of these methods is provided below.

The vessel used for sandwave clearance will be dependent on the method used. However, for CFE and seabed excavation it is likely that the DP MMA Pinnacle (or similar) will be used. For TSHD a DP TSHD vessel will be used.

Controlled flow excavation (CFE)

This method involves blowing sediment away from the centreline along the proposed sandwave levelling corridor. CFE tools are positioned directly above the required excavation area and fluidise non-cohesive material either blowing it away or weakening and breaking up cohesive soil material. The CFE tool height and pressure settings can influence the clearance corridor and depth achieved in a single pass; typically 2m to 3m wide depending on the specific CFE tool utilised.

The majority of the levelled sediment will be pushed to the side only slightly influencing the seabed topography on either side of the dredged area. All displaced sediment will remain with the local area. The technique will create a brief, temporary sediment plume. As the method involves displacement of a larger volume of sediment than TSHD and seabed excavators, relatively higher suspended sediment concentrations are expected within the plume, in comparison to the other methods.

CFE is relatively less accurate compared with the other levelling methods. The area being levelled can be influenced by the sea state, which influences the positioning of the tool. The duration required to achieve the target depth and levelled corridor is likely to be longer than with the other levelling methods.

Further details on CFE tools are provided in (Technical Appendix E Subsea 7 2012a). Figure 3-5 presents a typical CFE tool.

Figure 3-5 Typical CFE Tool (Rotech)

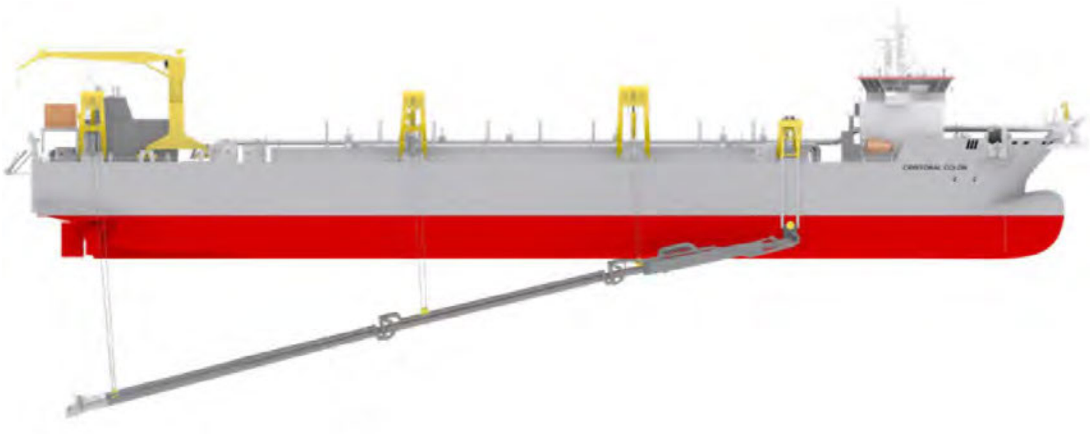
Trailing suction hopper dredging (TSHD)

This method involves applying suction to the seabed along the proposed sandwave levelling corridor and dredging a slurry of sediment and water from the seabed. It is proposed that the spoil will either be discharged from the hopper within 2NM of the dredged area or side cast within the immediate vicinity of the Proposed Development, creating deposition mounds on the seabed. This deposition of dredged sediment would constitute an additional area of seabed disturbance to that of the levelled area.

Sandwave levelling using a TSHD is considered to be more accurate than the CFE, as the drag head of the dredger can be directly targeted on the seabed. Therefore, seabed disturbance will be fairly localised to the area being levelled and is considered to be less than if a CFE tool is to be used. In addition, the TSHD is unlikely to generate a significant sediment plume.

TSHD operate by deploying either one or two suction pipe/s connected to drag heads to the seabed which applies a suction pressure to excavate seabed sediments within the area of influence. A slurry of sediment and water is pumped through the suction pipes back up into the vessel hopper. Further details on TSHD tools are provided in Technical Appendix E, Subsea (2021a). Figure 3-6 presents a typical TSHD.

Figure 3-6 Typical TSHD (Deme Group)



Seabed excavators

This method involves using a highly mobile tracked vehicle with a soil dredging system to dredge the seabed, via cutting application or high-pressured jetting. An extendable arm with a suction hose is used to excavate a slurry of sediment. The dredged material is carried through a pipe along the seabed and released away from the excavated area to the rear of the vehicle. The excavated sediment is deposited in a continuous soil heap adjacent to the excavator and the clearance corridor. Deposition of any excavated sediment would constitute an additional area of seabed disturbance, which has been accounted for in the seabed footprint calculations. A suite of survey/sonar equipment is installed to provide accurate positioning and visual aid to monitor dredging progress.

Seabed excavation involves cutting and high pressure jetting and therefore there is potential for the development of sediment plumes. The characteristics of this plume are likely to be similar to a plume generated during TSHD.

Further details on seabed excavators are provided in Technical Appendix E, Subsea (2021a). Figure 3-7 presents a typical subsea excavator.

Seabed excavators cannot operate on steep seabed slopes therefore may have difficulty working within the sand waves.

Figure 3-7 Seabed Excavator on Deck (Scanmachine)

3.2.2.3 Pipelay

After the sandwaves are removed to local mean seabed level across the width of the pipe lay corridor, the pipeline will be laid on the seabed along the route, after which the entire length of the pipeline route will be trenched.

At this stage, it is not known what specific vessel will be used for pipelay, it is currently anticipated that the pipeline will be laid using a DP vessel similar to that shown in Figure 3-8. Although deemed unlikely the pipeline may also be laid using an anchored pipelay vessel.

A typical DP pipelay vessel will use thrusters to position itself over the pipeline route. A typical DP pipelay vessel has a draught of 8-12m, with the thruster propeller housing extending 2m below this depth.

If used, an anchored pipelay vessel would have an 8-point mooring system (anchors), which are used to manoeuvre the barge during pipeline installation. An example anchor pattern from the Seven Antares is provided in Figure 3-9 (please note: it is not known if an anchored pipelay vessel will be used or the specific vessel). For assessment purposes it has been estimated that anchors are placed out to approximately 500m either side of the pipeline route and potentially up to 1000m longitudinally. To move the vessel the anchor chains are retracted at the front and extended at the back. The anchors are then moved to new positions and the process repeated.

Anchor cables are likely to contact the seabed, causing superficial scour. As the exact anchor position are unknown it has been assumed that temporary seabed disturbance will occur anywhere within a 1km corridor along the entire length of the pipeline. The actual scour will only occur with a few metres of each anchor chain within this area and will be similar in scale to scour caused by fishing activity. Assuming anchors are placed at 500m intervals along the route there will be approximately 24 anchor pits (12 each side of the track) each with an area of approximately 20m^2 (allowing for anchor drag), giving a total area of 480m^2 (0.0005km^2). This anchor footprint is indicative.

To start the pipelay an anchor handling tug will position a drag anchor and initiation cable on the seabed. One 8-25 tonne anchor with dimensions 5.5m x 5.2m will be used. This anchor has the potential to drag for 38m, resulting in a seabed footprint of 209m^2. It is assumed that the cable between the anchor and the end of the pipe will cause scour along a path approximately 1m wide and 325m in length (this length is only indicative and may vary) (325m^2 total footprint).

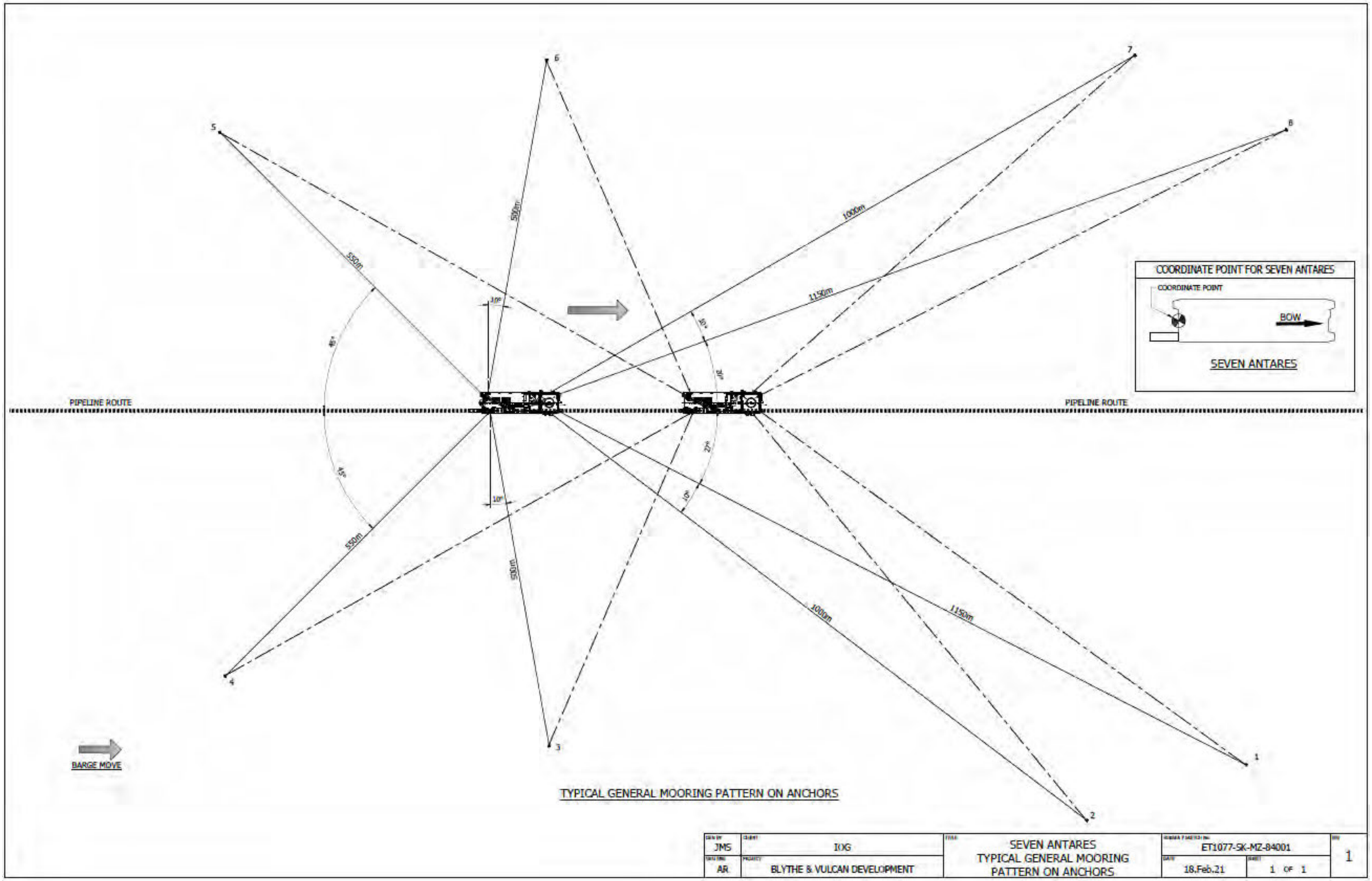
The pipelay vessel will recover the initiation cable and connect it to the pipeline, using it to lower the pipeline to the seabed. The 24" pipeline will be S-laid, meaning the pipe is eased off the stern of the vessel as the boat moves forward. The pipe curves downward from the stern through the water until it reaches the seafloor. The pipelay vessel will be supported by pipe support vessels which will be loaded with pipe joints. Pipe joints will be transferred across to the pipelay vessel to ensure that the pipeline can be continuously laid from start to finish.

ROVs will be used to monitor the performance of the pipe laying and all critical activities such as the initiation to ensure the pipe is position correctly.

A temporary flanged pig launcher/receiver assembly (launcher at one end of the pipeline and receiver at the other) and flanged pipe end pup piece will be installed on the pipeline during lay. This will be removed during commissioning.

Figure 3-8 Example pipelay vessel

Figure 3-9 Example anchor mooring pattern for the Seven Antares



3.2.2.4 Trenching

After the pipe is laid on the seabed, the entire length of the pipeline route will be trenched, the maximum achievable trench depth will be dependent on the technique use, this is likely to be in the range of 0.6m to 1.6m below the mean seabed level, within which the pipeline will lie. As detailed in Section 2, a Comparative Assessment (CA) of pipeline seabed preparation, installation, and protection options concluded that installing the pipeline below mean seabed level was the Best Practicable Environmental Option (BPEO).

Trenching to place the pipeline below mean seabed level after installation will be carried out using one of the following methods:

- Controlled flow excavation (CFE).
- Jet trenching.
- Mechanical plough and backfill.

A brief description of each of these methods is provided below.

For the trenching operations along the full length of the pipeline, a maximum trench corridor width of 6m is expected accounting for the varying sandwave heights that may occur along the route. Immediately following pipeline trenching using CFE or jetting, some proportion of the disturbed sediment in the immediate vicinity of the trench would quickly settle over the pipeline to provide a degree of burial and protective overburden. It is expected that the amount of sedimentation would be larger in relation to the jetting method. With the use of the mechanical plough it is proposed that the excavated sediment would be initially side-cast, with a separate backfill run carried out to return the excavated sediment over the pipeline, thereby providing some additional protection, while accelerating the return of the seabed to its original state.

Controlled flow excavation (CFE)

The use of CFE for trenching entails displacing the sediment by directing a high-volume flow of water at the seabed. The process forms a parabolic trench, with sediment pushed to the sides potentially creating mounds adjacent and along the full length of the pipeline trench. The size of the potential mounds are unlikely to be larger than the surrounding sand wave features, although they would have a different orientation to the features. In time, the sediment mounds would winnow down, infilling the adjacent trench or be incorporated into the nearby sandwaves as part of the sediment transport regime.

The sandwave levelling corridor width required for the CFE method will be between 30 – 40m. An estimated 50% proportion of the disturbed sediment in the immediate vicinity of the trench would quickly settle over the pipeline to provide a degree of burial and protective overburden. Collapse of the trench wall may also occur, providing additional backfill and protection.

All displaced sediment will remain with the local area. The technique will create a brief, temporary sediment plume. As the method involves displacement of a larger volume of sediment than jetting and mechanical plough and backfill, relatively higher suspended sediment concentrations are expected within the plume, in comparison to the other methods.

The CFE equipment used for trenching is the same as that proposed for sandwave clearance and the typical CFE tools are described in Section 3.2.2.2 above.

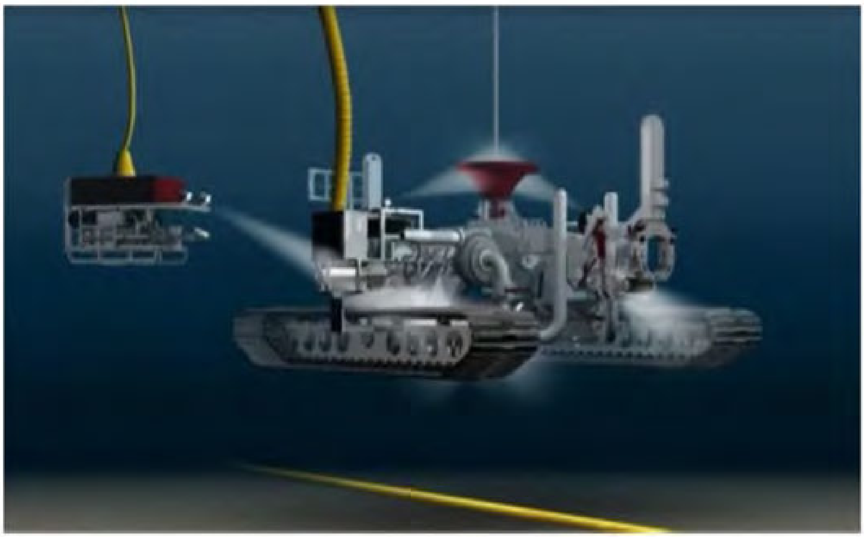
Jetting

The jetting trencher will sit on the seabed and follow the pre-laid pipeline. High powered pumps inject sea-water into the seabed either side of the cables through jetting ‘swords’ (see Figure 3-10). The deployable jetting swords are lowered and raised accordingly along with pump pressure settings to achieve a smooth trench profile. This can either be achieved along the entire product route in a continuous pass or at predetermined locations of high seabed gradients.

As the jetting method involves fluidisation of the seabed, sediment is temporarily entrained in the water column, a large proportion of which would be deposited within the trench or immediately adjacent to it as the particles settle out of suspension. Sediment deposition adjacent to the trench through natural sedimentation and sorting, would result in an asymmetric low mound. In time the deposited material would be winnowed down returning to the background seabed depths. A plume is likely to form due to fluidisation of the seabed leading to sediment suspension. However, the plume is expected to be smaller compared to the plume resulting from the use of CFE.

Similar to the CFE method, the jetting method will require the sandwave levelling corridor to be between 30 – 40m. Jetting is a more accurate and targeted method than CFE, with a simultaneous backfill during operation, so there is likely to be a larger volume of sedimentation and therefore thicker over-burden / back-fill over the pipeline. The amount of over-burden deposited with this approach is larger (estimated 50-75% backfill cover) than that for CFE, but still less than that for a mechanical plough, due to the active backfilling associated with the plough method. Collapse of the trench wall may also occur, providing additional backfill and protection.

Figure 3-10 Typical jet trencher tools that will be used



Ploughing

The ploughing method uses a mechanical plough to excavate a trench below the seabed level. This will be followed by a backfill plough to return displaced sediment to the trench. The mechanical plough is a large machine and consequently requires a wider sandwave levelling corridor, between 50m and 60m (Subsea 7 2021a), than the other methods discussed.

For mechanical ploughing and backfilling, the minimum target trench depth to below mean seabed level (BPEO as discussed above), shall be 1.6m (in comparison to 0.6 - 1.5m for the other methods). This is to allow sufficient trench wall interaction with the backfill plough front skids, necessary for stability.

The backfill run would provide a larger depth of cover over the pipeline (estimated 90-100% backfill) greatly reducing the potential for scour and free spans. It is assumed that the backfill run is carried out immediately post-ploughing, meaning that any berms associated with the plough side-cast would only be present for a very short period of time, reinstating the seabed to its original state. Collapse of the trench wall may also occur, providing additional backfill and protection.

Further details on mechanical ploughs are provided in Technical Appendix E, Subsea (2021a). Figure 3-11 presents a typical backfill plough.

Figure 3-11 Backfill plough (Subsea7)

3.2.2.5 Trenching seabed footprint

Trenching will be undertaken along the 5.67km pipeline route. The trench footprint will be within the footprint of the sandwave clearance. Section 3.2.2.2 provides the estimates of the area of seabed disturbed and volume of material to be cleared.

3.3 Installation vessels

At this stage specific vessels have not been contracted. Vessel names provided are for reference purposes only. The vessels expected to be used for pipeline installation and associated activities will consist of:

- Pre pre-sandwave clearance survey and pre-installation survey – DP vessel such as the Seven Pinnacle.
- Sandwave clearance and trenching – CFE and seabed excavator – DP vessel such as the MMA pinnacle.
- Sandwave clearance – TSHD – DP TSHD vessel.
- Pipeline installation - DP Seven Borealis or a similar vessel or an anchored pipelay vessel, such as the Seven Antares.
- Support vessel – 2 pipe supply vessels, 1 guard vessel and potentially 4 anchor handling vessels (if an anchored pipelay vessel is used).

An estimation of fuel consumption and the effects from emissions is provided in Section 5.

3.4 Pipeline tie-in and commissioning

The pipeline will be hydrotested using treated seawater to verify pipeline integrity. Hydrotesting typically involves pumping treated seawater into the pipeline (approximately 120% of line volume) to increase pressure. Pressure of the system is increased until the pressure has been established and a successful hold time and stabilisation period achieved. Test pressure will be held for 24 hours before the pipeline is depressurised, by discharging the extra volume of water to sea, at predetermined rates. It is currently expected that an intervention vessel will conduct the testing operations.

After hydrotesting, divers will tie-in the pipeline to the Southwark platform and the Thames to Bacton pipeline (PL370) using tie-in spools.

Once tied-in the pipeline is leak-tested, following a similar procedure as hydrotesting, using treated seawater. The additional quantities of treated seawater pumped into the pipeline to establish leak test pressures will be discharged to sea.

Once fully installed and tested the remaining volumes of treated seawater will be flushed out of the pipeline in a process known as dewatering. Any chemical requirements (typically oxygen scavenger, biocide and dye) used during pipeline pre-commissioning operations that fall under the Offshore Chemical Regulations 2002 (as amended) will be included on the relevant pipeline and/or installation chemical permits. The use and discharge of the exact chemicals, dose and dispersion rates, are fully risk assessed within the permits and impact to the marine environment determined.

The tie-in spools, which are not concrete coated, will be positioned on the seabed (not buried). Concrete mattresses and grout/sand bags will be used to protect the spools from dropped objects. The quantity of mattresses required for tie-in operations will be dependent on the length of the tie-in spools, therefore at this time it is not possible to quantify the exact quantity of mattresses needed. It is currently estimated that 22-100 mattresses could be needed at each tie-in location. For assessment purposes, it is assumed that as a worst case, 100 mattresses will be required at each tie-in (200 mattresses in total). The seabed footprint of the deposits is provided in Table 3-3.

It is estimated that approximately 1450 grout/sand bags could be required at each tie-in location. These bags will be required to fill in gaps between the mattresses and to rectify any free-spans if they arise. Dimensions for the bags are provided in Table 3-3. If advantageous, then a bulk bag of grout/sand bags may be used to make up any large gaps. This is expected to be around goosenecks only and is approximately 1m^2 per bulk bag used.

To aid the tie-in at the Southwark platform and Thames pipeline, localised dredging will be undertaken. This dredging is likely to be conducted using a CFE or diver or ROV operated suction dredger. The material dredged will be deposited within 100m of the dredged area. The estimated area and volume of material to be dredged is provided in Table 3-3.

Table 3-3 Pipeline tie-in seabed footprint

Location	Dimensions m	Number of deposits	Footprint m^2	Volume m^3
Mattresses Southwark platform tie-in	6 x 3	100	1800	N/A
Mattresses Thames pipeline tie-in	6 x 3	100	1800	N/A
Grout/sand bags - Southwark tie-in*	0.45 x 0.25	1450	164	N/A
Grout/sand bags - Thames pipeline tie-in*	0.45 x 0.25	1450	164	N/A
Dredging Southwark platform tie-in	100 x 15 x 2	N/A	1500	3000
Dredging Thames pipeline tie-in	15 x 15 x 2	N/A	225	450
Total			**5653**	**3450**

Note *This is a worst case, it's likely that bags will be placed on top of each other, thereby reducing the seabed footprint.

3.5 Inspection and maintenance

Post lay survey will be performed along the entirety of the laid pipeline. The survey method will be non-contact (flying just above the pipeline). This method may use a mixture of survey tools i.e. dual head MBES, pipetracker, centre and boom cameras, obstacle avoidance sonar, USBL, INS/DVL, high accuracy depth/altimeter sensor and / or including real time sound velocity. The best combination of tools will be selected during the engineering phase.

Once the pipeline comes into operation Offshore Design Engineering Asset Management Limited (ODE AM) will be the pipeline operator. ODE AM has a Pipeline Integrity Management System (PIMS) in place. Within this PIMS risk based assessments will be undertaken, considering all of the threats to the Southwark pipeline. Based on those threats, mitigation necessary to manage the integrity of the pipeline is identified. This may include for example, performing regular side-scan sonar surveys to mitigate the risk posed by the potential movement of the sandwave system which could lead to free-spans or upheaval buckling. The risk of internal corrosion will be mitigated through regular dosing of corrosion inhibitor and water sampling, with periodic intelligent pig runs.

3.5.1 Contingency remedial works

The requirement for remedial operations during the lifetime of the Proposed Development will be dependent on the occurrence of upheaval buckling. Upheaval buckling occurs as a result of axial compression (force or pressure exerted on a pipeline causing it to experience shear stress and bending) induced along the pipeline due to large temperature differences and high internal pressures. At this time, it is not possible to predict where upheaval buckling will occur or quantify the remedial measures required.

If it is identified during post-lay pipeline engineering analysis that the pipeline is susceptible to upheaval buckling at specific locations, the only technical solution available is the targeted deposit of rock material to protect the pipeline. For the purpose of assessment it has been assumed that approximately 10% of the pipeline route may require rock remediation in the form of rock protection. Some of these rock berms may join to form longer berms, however this will be dependent on where upheaval bucking may occur. The characteristics of this rock and the indicative seabed footprint is provided in Table 3-4 below.

Given that the pipeline will be installed and buried below mean seabed level, concrete coated and 24" in diameter, IOG are confident that there is a low potential for remediation due to the potential formation of free-spans.

Table 3-4 Rock protection characteristics and indicative footprint.

Type of protection	Rock berm
Density	High Density 3-9"
Rock grade	CP90-250mm
Specific particle density	3.150te/m³.
Material	Well graded igneous rock, Gneiss or similar, with no significant iron or deleterious content. Material shall be chemically stable for the design life with a target submerged unit weight of 9.5kN/m³.
Projected length of pipeline requiring remedial works	600m
Typical berm profile	Crest width of 0.5m and a length of 20m. Toe width may vary between 3-5m (dependant on heigh of rock cover)
Seabed footprint from one berm	100m²
Quantity per berm	2250 tonnes
Quantity for 600m length of pipeline	67,500 tonnes (based on 30 berms)
Seabed footprint for 600m length of pipeline	3000m²

3.6 Proposed Development seabed footprint

Table 3-5 below, provides the estimated overall seabed footprint for the Proposed Development.

Table 3-5 Overall seabed footprint

Aspect	Footprint m²	Nature of footprint
Sandwave clearance and trenching	374,220	Temporary
Pipeline*	3,456	Permanent - dependant on decommissioning
Spool pieces**	189	Permanent - dependant on decommissioning
Anchoring (pipeline and if required anchor lay barge)	1,015	Temporary
Mattresses and grout/sand bag deposition bags at tie-in locations	3,928	Permanent - however, dependant on decommissioning
Dredging at tie-in locations	1,725	Temporary
Indicative contingency rock remediation works	3,000	Permanent - however, dependant on decommissioning
Total seabed footprint – temporary	**376,960**	-
Total seabed footprint – permanent	**6,928**	-

Note: * deposit will be below mean seabed level. The footprint will be within the footprint of the sandwave clearance and is therefore not included within the total seabed footprint.

Note: ** Spool pieces will be overlaid by mattresses and are therefore not included within the total seabed footprint.

3.7 Decommissioning

End of field life is expected to be 15 years. Decommissioning will be carried out in compliance with United Kingdom Government legislation and international agreements in force at the end of the field life. Agreement to the Cessation of Production (CoP) will be sought as a pre-requisite for approval of the Decommissioning Programme. The criteria for CoP will be discussed with Oil and Gas Authority (OGA) and Department for Business, Energy and Industrial Strategy (BEIS).

Detailed cost estimates for the decommissioning will be prepared closer to the date and will reflect the circumstances pertaining at the time.

The Proposed Development plan is based on the assumption that similar requirements to current legislation will be in place. These requirements have been considered in the design of the facilities and during project planning.

It is likely that under the legislation a derogation case will be filed to allow the pipeline to be left *in-situ,* as long as there are no health, safety and environmental issues associated with this activity. Removal of the pipeline would cause disturbance of the seabed which after 15 years should have returned to pre-installation baseline conditions. Under current legislation decommissioning requires an EIA to be conducted prior to activities commencing. The EIA will assess the benefits and costs of different decommissioning scenarios i.e., removal versus remaining *in-situ*. The impacts of decommissioning activities on the environment have not been assessed under the scope of this document as they will be the subject of a separate EIA.

4. THE BASELINE ENVIRONMENT

This section describes the existing baseline environment for the Proposed Development. For the purpose of environmental impact assessment (EIA) the baseline environment has been divided and considered as follows:

- **Physical environment** (metocean, air quality, water quality, bathymetry, and seabed conditions);
- **Protected and sensitive sites**;
- **Biological environment** (benthos, plankton, fish and shellfish, marine birds, and marine mammals and reptiles); and
- **Socio-economic environment** (commercial fisheries, shipping, navigation, and other marine users).

A good understanding of the baseline for these attributes has been achieved through the following activities:

- Review of marine survey data for the Proposed Development and surrounding area;
- Southwark Pipeline Morphological Assessment (Xodus 2021c);
- Reference to the Vulcan Satellites Hub Development Environmental Statement (ES) (IOG 2018b), and the Blythe Hub Field Development ES Addendum (IOG 2020c), that covers details of the Southwark Field Development; and
- Reviewing and collating secondary data sources (e.g. existing studies, literature and reports).

4.1 Marine surveys

4.1.1 General

A field survey was undertaken within and near to the Proposed Development in 2018 to inform the original Blythe Hub Development area EIA. The data acquired provides an overview of the Proposed Development in terms of geological, seabed and sediment features, bathymetry, and habitats. The survey also details the sensitive/protected features found in the survey area, including the area around the Southwark proposed platform and the Southwark to Thames East proposed pipeline route.

The scope and objectives of this survey is discussed in Section 4.1.2 below.

In May 2020, a pre-lay survey was carried out by Subsea 7, this data is discussed in Section 4.1.3 below.

4.1.2 Fugro 2018: Blythe and Vulcan Satellites Hub Development Vulcan Environmental Baseline Survey (EBS) and Habitat Assessment Reports

The Blythe and Vulcan Satellites Hub Development Vulcan area (United Kingdom Continental Shelf (UKCS) Blocks 48/25, 49/21 and 49/26), was surveyed by the Fugro Galaxy survey vessel between 26th January 2018 and 11th April 2018. Full survey details and results are presented in the Vulcan Habitat Assessment Report (Fugro 2018a) and the Vulcan Environmental Baseline Survey Report (Fugro 2018b).

The sites included in the wider survey area were the proposed:

- Nailsworth (Block 48/25), Southwark (Block 49/21) and Elland (Block 49/21) production wells;
- Pipeline routes from Nailsworth to Southwark, Elland to Southwark and Southwark to Thames.

Figure 4-1 shows the extent of the survey data acquired around the proposed Southwark to Thames pipeline, with a 600m wide pipeline route corridor acquired by the side scan sonar (SSS). Figure 4-2 provides an overview of survey data gathered around the proposed Southwark platform. Both figures show the environmental survey sample positions, sandbank and other seabed features, and proposed infrastructure locations for the Proposed Development.

The survey programme comprised of geophysical, geotechnical, environmental, and remotely operated vehicle (ROV) pipeline inspection surveys. Sediment grab samples were taken to establish the physio-chemical and biological properties of the sediment. Camera transects were used to acquire sufficient habitat assessment data to describe all habitats recorded within the survey area and to identify and delineate the extent of any potentially sensitive habitats or species, if present.

The Blythe and Vulcan Satellites Hub Development Habitat Assessment report (Fugro 2018a) and Environmental Baseline report (Fugro 2018b) detail the results of the environmental surveys (sediment grab sampling in a cruciform pattern around each of the Vulcan Satellites Hub locations and seabed video and photography) and identify and classify seabed habitats/biotopes, sensitive habitat, and species.

Environmental conditions within the survey areas were established using a combination of seabed imaging and physical sampling of sediments. Within the area of interest, five camera transects and six environmental grab stations were located around the Southwark platform; and three camera transects and two environmental grab stations were located along the Southwark to Thames pipeline. This provides sufficient data to allow a description of habitats present in the survey area and characterisation of any potentially sensitive habitats or species, if present.

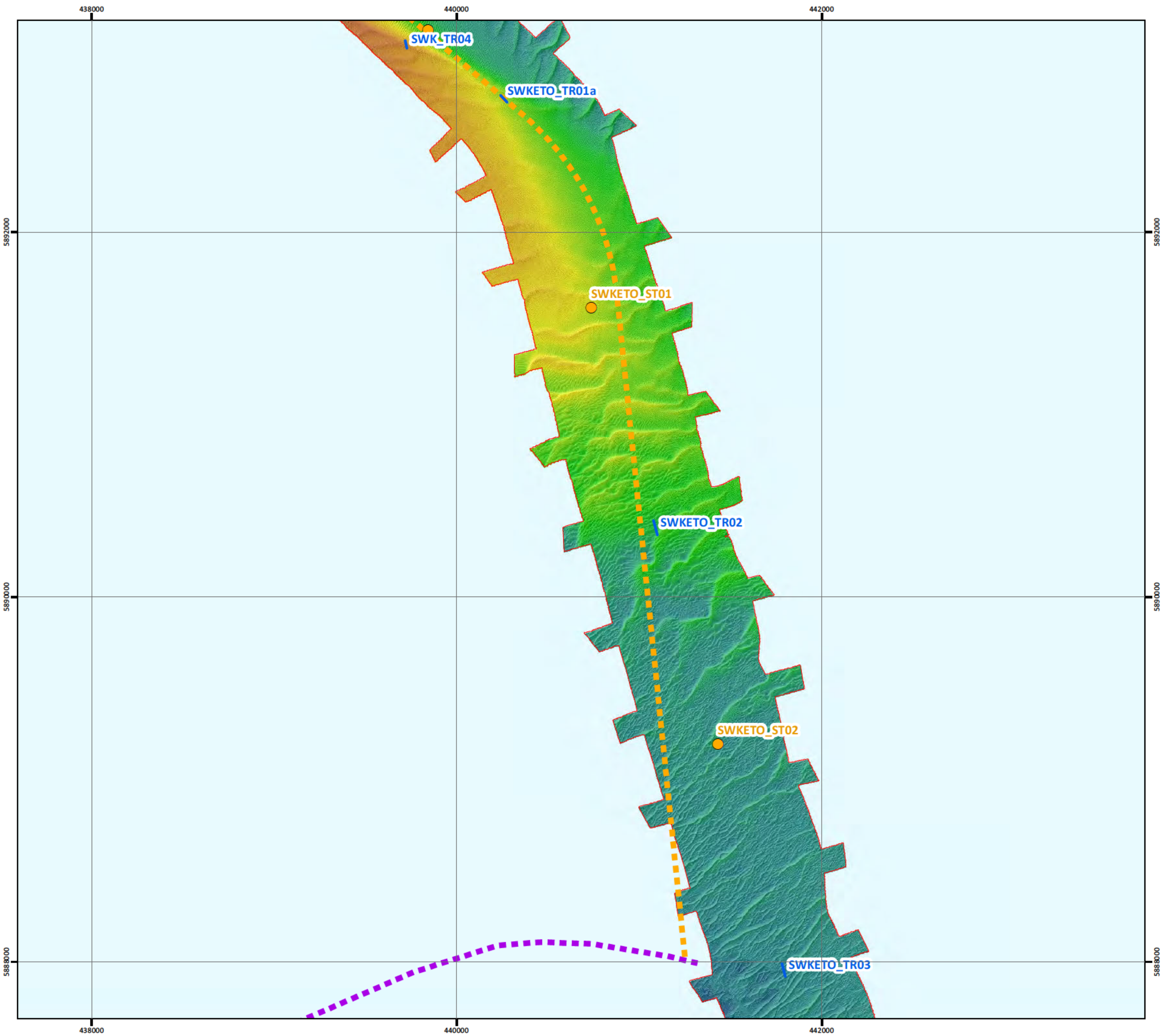
Limitations of the survey include:

- The survey period (January to April) reflects a limited presentation of the year-round conditions within the Southern North Sea.
- Photographs of samples were only obtained from a small number of locations.

Within these limitations IOG is confident that the survey data is suitable to provide an understanding of any impacts of the operation on the natural environment.

4.1.3 Subsea 7 2020: Pre-lay bathymetric survey

In May 2020, additional bathymetric data, using multi-beam echo sounding, was acquired by Subsea 7 along the proposed Southwark 24" pipeline centreline (Subsea 7 2020b). The objective of this survey was to gather information on the status of the seabed in the immediate vicinity (approximately 20-30 metres wide swathes) of the proposed pipeline installation corridor prior to pipeline installation. The initial plan was to incorporate this data into the pipeline installation report covering the pre-lay through to the as-laid (as-built), however, as the pipeline installation was delayed only bathymetry data is available from the 2020 survey. The bathymetry data from 2020 has been compared to the 2018 survey (using a geographical information system, GIS) and used to identify the sandwave movement and height differences between 2018 and 2020 (see Section 4.2.3, Figure 4-6 Drawing No: P2371S3-BATH-002-A).



IOG SOUTHWARK ENVIRONMENTAL STATEMENT

SURVEY

2018 Survey Area and Pipeline Location

Drawing No: P2371S3-SURV-001	A

N W E S

Legend

- Southwark Platform
- Southwark 24" Pipeline
- Thames Pipeline (PL370)
- 12nm Territorial Sea Limit
- EEZ Boundary

Survey

- Sampling Location
- Camera Transect
- Survey Extent

Bathymetry

Depth Below LAT (m)

High : -10

Low : -40

NOTE: Not to be used for Navigation

Date	03 March 2021
Coordinate System	ED 1950 UTM Zone 31N
Projection	Transverse Mercator
Datum	European 1950
Data Source	UKHO; MarineRegions; OGA; MarineFind; ESRI; OSOD;
File Reference	J:\P2371\Mxd\P2371S3\13_SURV\ P2371S3-SURV-001.mxd
Created By	Chris Dawe
Reviewed By	Emma Storey
Approved By	Stuart McLaren

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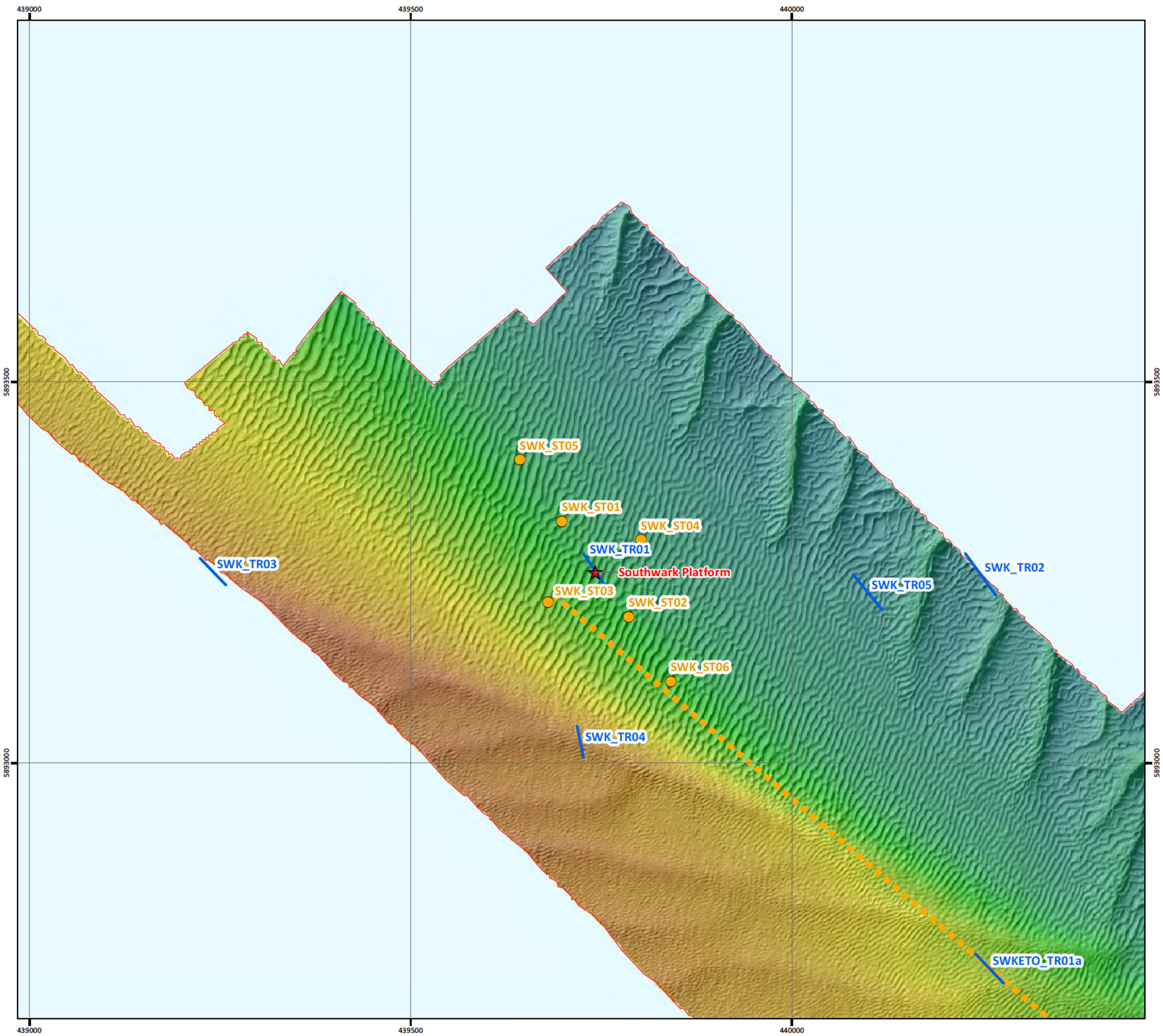


IOG SOUTHWARK ENVIRONMENTAL STATEMENT

SURVEY
2018 Survey Area and Platform Location

Drawing No: P2371S3-SURV-002	A

Legend

- Southwark Platform
- Southwark 24" Pipeline
- Thames Pipeline (PL370)
- 12nm Territorial Sea Limit
- EEZ Boundary

Survey

- Sampling Location
- Camera Transect
- Survey Extent

Bathymetry

Depth Below LAT (m)

High : -10

Low : -40

N W E S

NOTE: Not to be used for Navigation

Date	03 March 2021
Coordinate System	ED 1950 UTM Zone 31N
Projection	Transverse Mercator
Datum	European 1950
Data Source	UKHO; MarineRegions; OGA; MarineFind; ESRI; OSOD;
File Reference	J:\P2371\Mxd\P2371S3\ P2371S3-SURV-002.mxd
Created By	Chris Dawe
Reviewed By	Emma Storey
Approved By	Stuart McLaren

iog intertek

0 50 100 150 200 m

4.2 Physical environment

The Proposed Development lies in the Southern North Sea (SNS) off the north Norfolk coast. The Proposed Development lies on the flanks of the Inner Bank, one of the main banks in the North Norfolk Sandbank system. The superficial sediments consist of sand, gravelly sand, and sandy gravel and may be classified as the European Nature Information System (EUNIS) habitat 'Deep circalittoral sand' (A5.27) (EMODnet 2020). Water depth along the proposed pipeline route ranges from approximately 22m to 34m.

4.2.1 Metocean

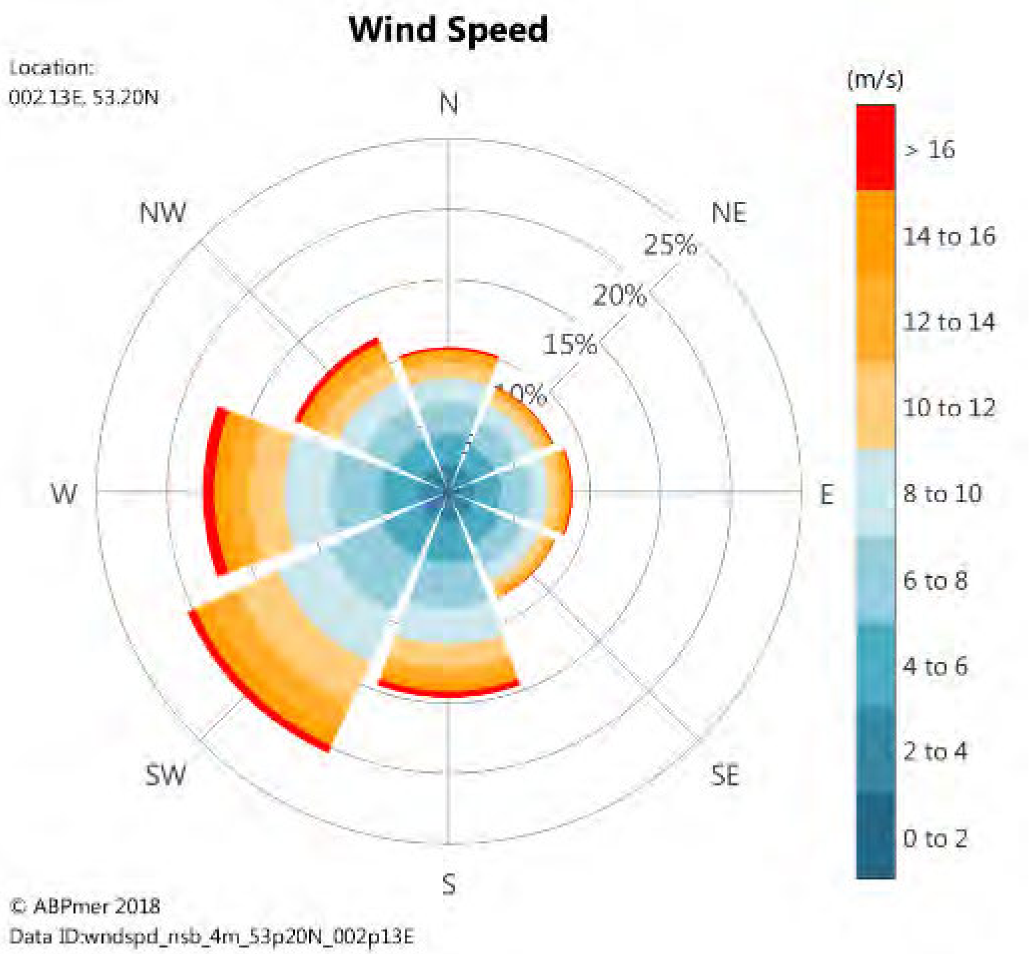
4.2.1.1 Climate

Air temperatures offshore are generally at their lowest in January and February (mean 4°C to 6°C) and highest in July and August (circa 16°C). Rainfall across the Southern North Sea decreases in a south-north direction. Rainfall in the development area is estimated to be between 200mm and 200mm per annum (DECC 2016). Snow or sleet is recorded in the south of the Southern North Sea mainly from December to April but perhaps as early as November and can be expected for 5 to 7 days a month for January and February (UKHO 2013).

4.2.1.2 Winds

Wind direction and velocity in the Proposed Development are variable throughout the year, although the most prevalent winds tend to be from the south and south-west with a mean wind speed of 7.8ms^{-1} (ABPmer 2018). Figure 4-3 present a wind rose for the location of the Southwark Platform. Seasonal wind roses for the vicinity of the Proposed Development indicate that westerly winds are the most common, particularly from July to September, with winds from the west and southwest dominating. The windiest months recorded are December and January when winds of 14ms^{-1} to 16.5ms^{-1} (Beaufort force 7) blow for more than 6 to 10 days a month. May through to August tend to be the least windy months with only 1 to 3 days reaching wind speeds of 14ms^{-1} to 16.5ms^{-1} (BGS 1995 and HSE 2001). During the summer, there are occasional thundery squalls with wind speeds greater than 14 ms^{-1} generally occurring near the coastline. Squalls associated with cold fronts can occur during any season, and showers of hail, sleet or snow that are common in winter and spring often give rise to sudden changes in wind speed and direction (IOG 2020d).

Figure 4-3 Windrose at the location of the Southwark platform



4.2.1.3 Circulation

Circulation patterns are influenced by seawater density differences, the shape and depth of the seabed, meteorology, and tides. The water of the North Sea consists of a varying mixture of North Atlantic water (salinity >35) and freshwater run-off. Temperature characteristics of different areas are strongly influenced by heat exchange with the atmosphere and source water temperature (DECC 2016).

Water circulation in the North Sea is characterised by a general southerly current along the UK coast, with a northerly return current along the coasts of Belgium, the Netherlands, Germany, Denmark and Norway. There are a series of east to west currents, broadly delineating the northern, central, and southern regions. Overlying this is an inflow of North Atlantic surface water, directed northwards through the English Channels and southwards along the Norwegian Trough. The Southern North Sea water moves in a broadly north easterly direction, away from the UK coast towards the continent, as part of this general circulation (DTI 2002 cited in IOG 2018a).

The tidal range of the SNS generally ranges between 2m and 5m, increasing towards the south and the coastline (Jones et al. 2004). Xodus (2021c) cites information from the ABPmer Renewables Atlas and observations at the Hornsea 3 Offshore Wind Farm (OWF) indicating that a mean spring and neap tidal range of around 2.4m and 1.2m respectively can be expected at the Proposed Development. The tidal flow in proximity to the Proposed Development is broadly aligned with the coast, with a south-easterly flood flow and a north-westerly ebb flow (HR Wallingford 2002; Ørsted 2018a).

Tidal measurement associated with a tidal diamond west of the North Norfolk Sandbanks and Saturn Reef Special Area of Conservation (NNSSR SAC) (53°19.0'N 1°25.4'E), indicate mean current speeds of up to 0.88ms^{-1} during spring tides and 0.46ms^{-1} during neap tides. The overall residual current is 0.049ms^{-1}, flowing northeast and associated with the ebb tide (Hydrographer of the Navy 2008 cited in IOG 2018).

Observed and modelled data associated with the nearby Hornsea 3 OWF suggest current speeds of up to 0.7ms^{-1} east of the NNSSR SAC and increasing to between 0.8 and 1.0ms^{-1} in the location of the Proposed Development (Ørsted 2018a). Complex and variable flow patterns and current speeds are expected associated with the sandbank features within the NNSSR SAC, with evidence for circulation patterns around the sandbanks (Collins et al. 1995).

A review of tidal data between 2017 and 2020 in Xodus (2021c) shows a cyclical tidal pattern with annual peaks towards the latter part of the year. Monthly tidal elevations are consistent throughout the three-year period, although a number of positive and negative surge events were evident. Surge events occur throughout the year, with similar frequency between years, although moderately larger events were recorded in the winter of 2019/2020. These events are likely to be associated with changes in current speed and may contribute to the evolution and migration of offshore bedforms such as sandwaves.

Unlike the northern and central regions of the North Sea, the shallow parts of the Southern North Sea do not show stratification in the summer months. Instead, the water column in the Southern North Sea remains well mixed throughout the year due to strong tidal action (OSPAR Commission 2000; DTI 2001 cited in IOG 2018a). The Norfolk sandbanks system is also located in water, which is considered permanently and well mixed, with evidence for stratification further offshore (Ørsted 2018a).

4.2.1.4 Waves

Wave climate is influenced by wind speed, wind duration and fetch (the distance over which the wind blows uninterrupted over the sea), which are in turn is dependent on season and location. From October to March the North Sea south of 55°N, which includes the Proposed Development, experiences significant wave heights of 4 m for <15% of the time (DTI 2002c). The mean wave height for the Proposed Development is 1.3 m (ABPmer 2018).

Information on wave characteristics between 2017 and 2020 were collated by Xodus (2021c) to inform the Southwark pipeline morphological assessment. This concludes that the wave regime within the Proposed Development is likely to be similar to that recorded at the Clipper platform (operated by Shell, approximately 40km northwest of the Proposed Development) and at the Hornsea Three OWF. The wave trends align at both locations with significant wave heights identified at 1.7m to 1.9m (with periods of 5.8s and 6.6s respectively) in summer and 2.5m and 2.7m (with periods between 6.6s and 7.1s) in winter. Data shows a consistent pattern year on year with only a very small percentage of waves are greater than 4m.

4.2.2 Air and water quality

4.2.2.1 Air quality

This section is concerned with atmospheric concentrations of gases which are potentially harmful to health; primarily carbon monoxide (CO), nitrogen oxides (NOx) and sulphur dioxide (SO_2). Offshore air quality is not routinely monitored; however, an understanding of the existing air quality in the Proposed Development is useful when assessing any impact upon air quality from the proposed operations.

In general, UK mainland air quality has been improving since 1990. Emissions of NO_x and SO_2 have decreased by 74% and 97.6% respectively due to reduced emissions from road transport and power stations (Defra 2019). Levels of primary atmospheric pollutants tend to be highest close to their sources i.e. in urban and industrial areas. It would be expected that the development area, which is approximately 35.6km from the nearest coastline, is unlikely to suffer from air quality issues.

Greenhouse gases (GHG) are gases which act to trap heat in the atmosphere. The main GHG emitted because of offshore oil and gas operations are CO_2, nitrous oxide (N_2O) and methane (CH_4), all arising from fuel combustion, flaring or from venting of unburnt gas. The contribution of the UK offshore oil and gas production to global GHG emissions is small in comparison with other UK sources; however, the industry is committed to reducing these emissions as far as possible (OGUK 2020).

4.2.2.2 Water quality

Hazardous substances enter the marine environment due to natural processes and as a result of anthropogenic activity (UKMMAS 2010). Water quality in the UKCS generally reflects the sources and modes of transport of potential contaminants to the marine environment. Contaminants that are volatile and pre-dominantly sourced through combustion processes (e.g. mercury and its compounds, volatile organic compounds, and polycyclic aromatic hydrocarbons), and therefore have an atmospheric transport route, tend to be widely distributed. Contaminants which are mainly water borne (most metals, nutrients) are largely restricted to estuarine and coastal waters, with concentrations rapidly decreasing offshore. As a result, concerns over water quality in UK waters are largely restricted to industrialised estuaries (DTI 2001; UKMMAS 2010). Given the distance to onshore contamination sources, it is not expected that there will be any specific water quality issues at the location of the Proposed Development.

4.2.3 Sediment conditions

4.2.3.1 Bathymetry and seabed features

Water depths in the Southern North Sea are generally below 50m, decreasing to 5m or less at the tops of some sand banks. Water depths along the pipeline route vary between 22m and 34m.

The pipeline at the Southwark platform (KP 0) is located in water depth of 29.1m lowest astronomical tide (LAT). It then passes through an area of sandwaves, where water depths become shallower. The shallowest point along the pipeline (KP 2.089) reaches a depth of 24.1m LAT in another area of sandwaves. Ultimately, the pipeline route enters deeper water to 34.2m LAT at the point of tie-in at KP62 of the Thames to Bacton 24" pipeline (PL370; Subsea 7 2020b).

The Proposed Development lies on part of the Norfolk Banks; one of the best known group of linear ridge sandbanks in UK waters. Figure 4-4 (Drawing No: P2371S3-BATH-001-A) presents the bathymetry in the vicinity of the Proposed Development, and clearly shows the sandbanks in the development area. The hydrodynamic regime in the Norfolk Banks area has generated large expanses of sandbanks, resulting in a complex seabed topography. Figure 4-4 shows the various sediment transport directions across the Norfolk Banks.

The Norfolk Banks comprise the Leman, Ower, Inner, Well, Broken and Swarte banks and four banks termed the Indefatigables, and a number of smaller banks. The banks are mostly parallel, running south east to north west. The Proposed Development is located at the south eastern end of the Inner Bank (Figure 4-5). The largest bank is Well Bank which is over 50km long, 1.7km wide and rises 38m above the sea floor (IOG 2020).

Sandwave and megaripple bedforms are superimposed on Inner Bank and its southeastern flank, with the sandwaves having wavelengths of hundreds of metres and heights of up to 5m. The sandwaves associated with the sandbank and identified in relation to the Proposed Development, were surveyed by Fugro 2018 and found to have local gradients of up to 18° (Fugro, 2018). The banks are considered to be 'active', as they are progressively elongating in a north-easterly direction and are generally asymmetric with a steeper face to the northeast (IOG 202c0). Recent evidence within the NNSSR SAC suggests that the more southern sandbanks within the SAC and in proximity to the Proposed

Development are moving in a northerly direction (Jenkins et al., 2015 cited in Xodus 2021c). These sandwaves are representative of the pattern of modern sand transport around the sandbanks which is influenced by environmental conditions, such as tidal currents and the local wave regime.

Figure 4-6 (Drawing No: P2371S3-BATH-002-A) shows the bathymetry profile along the proposed pipeline route from survey data gathered in 2018 (Fugro 2018a) and in 2020 (Subsea 7 2020b). Comparing the 2018 and the 2020 survey data, it appears that the sandwaves are travelling in a northerly direction. It has been calculated by Xodus that sandwaves migrate at a rate of 14 - 26 m/year (Xodus 2021c); with the smaller sandwaves travelling less than the larger ones. It also appears that the sandwaves have grown in height, in some cases by as much as a metre. In the wider area covered by the 2018 survey, there is also evidence of bifurcating and converging sandwaves, associated with steep asymmetric profiles of up to 18°, which all confirm an active and dynamically evolving environment (Xodus 2021c).

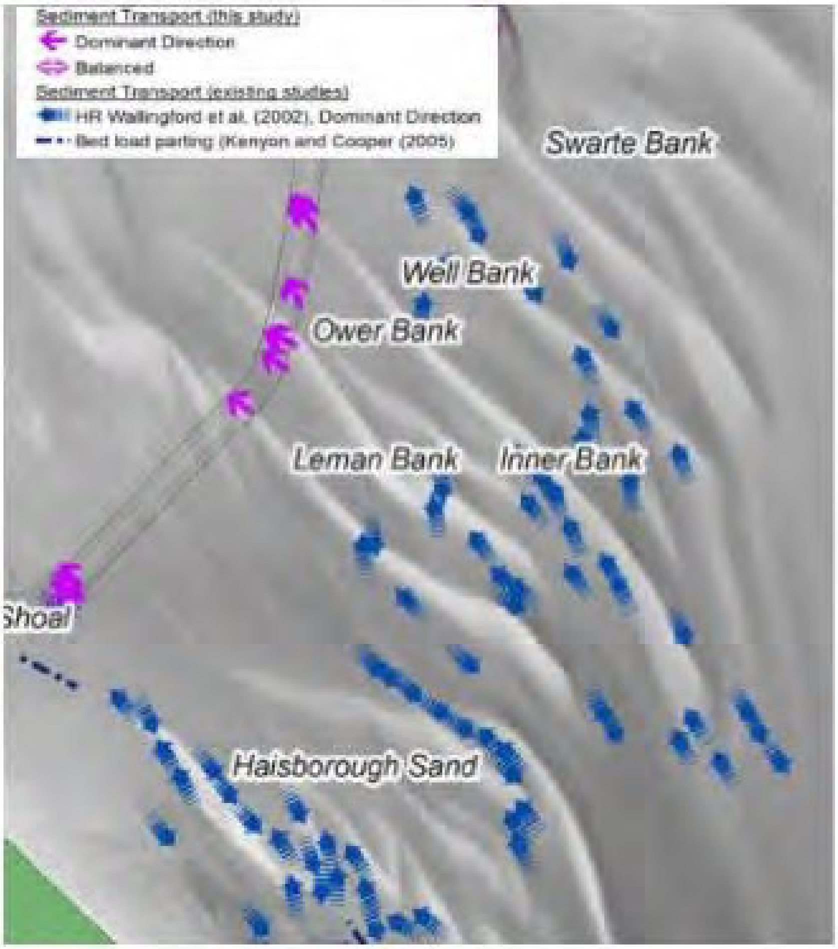
The seabed survey images and samples obtained along the Southwark to Thames pipeline route survey corridor (600m) was primarily characterised by sandwaves orientated in a predominantly north-east to south-west direction. Megaripples and sandwaves were observed throughout the survey area and an area of pitted seabed, appearing as high reflective patches on the side scan sonar output and interpreted as potential faunal bioturbation (reworking of sediments) (Fugro 2018a).

4.2.3.2 Sediment transport

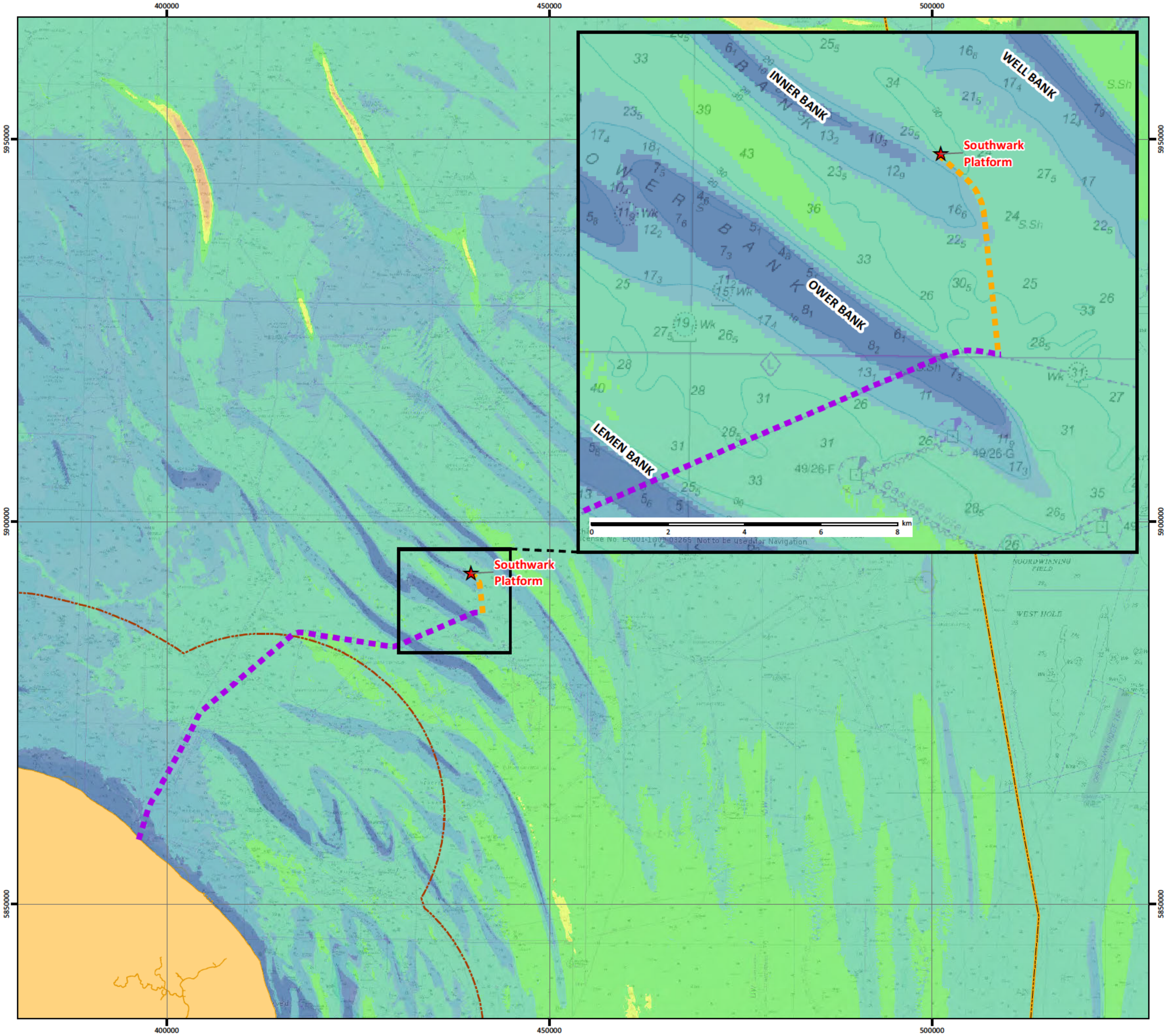
Modes of sediment transport in the marine environment are through bedload (grains rolling along the seabed) or sediment in suspension. The rates of the latter can be informed by the characteristic suspended sediment concentrations. Suspended sediment concentrations across the Norfolk sandbanks from satellite monitoring indicates a range of between 1–2 mgl^{-1} and 9–10 mgl^{-1} in the summer and winter months, respectively (Limpenny et al., 2011 as referenced in Xodus 2021c). These relatively low suspended sediment concentrations in the region suggest that the transport of sediment in suspension is the less dominant mode, with more transport occurring through bedload. This conclusion is supported by the sediment grain sizes across the region (Xodus 2021c).

Evidence of sediment transport in the SNS and locally to the Proposed Development is through the movement and evolution of the sandbanks and associated bedforms (e.g. sand waves, mega ripples etc). This sediment transport is primarily caused by tidal currents. Occasional storm surge induced currents over the North Norfolk sandbanks cause sand to be transported in directions other than those caused by the tidal currents alone (Xodus 2021c) and is expected to contribute to the transport of sand to the northeast, which has also been observed for Inner Bank. It has been suggested, with supporting evidence, that the sediment is transferred between sandbanks heading offshore, with the sandbanks acting as 'stepping stones' (Collins et al., 1995 as referenced in Xodus 2021c). Analysis of grain size supports this sandbank connectivity between Inner, Ower and Well Bank (Holmes and Wild 2003, cited in Xodus 2021c).

Figure 4-4 Sediment transport across the NNSSR SAC near the Proposed Development



Source: Subsea 7 (2020b)



IOG SOUTHWARK ENVIRONMENTAL STATEMENT

BATHYMETRY
EMODnet Bathymetry

Drawing No: P2371S3-BATH-001	A

Legend

- Southwark Platform
- Southwark Pipeline
- Thames Pipeline
- 12nm Territorial Sea Limit
- EEZ Boundary

Bathymetry

Depth Below LAT (m)

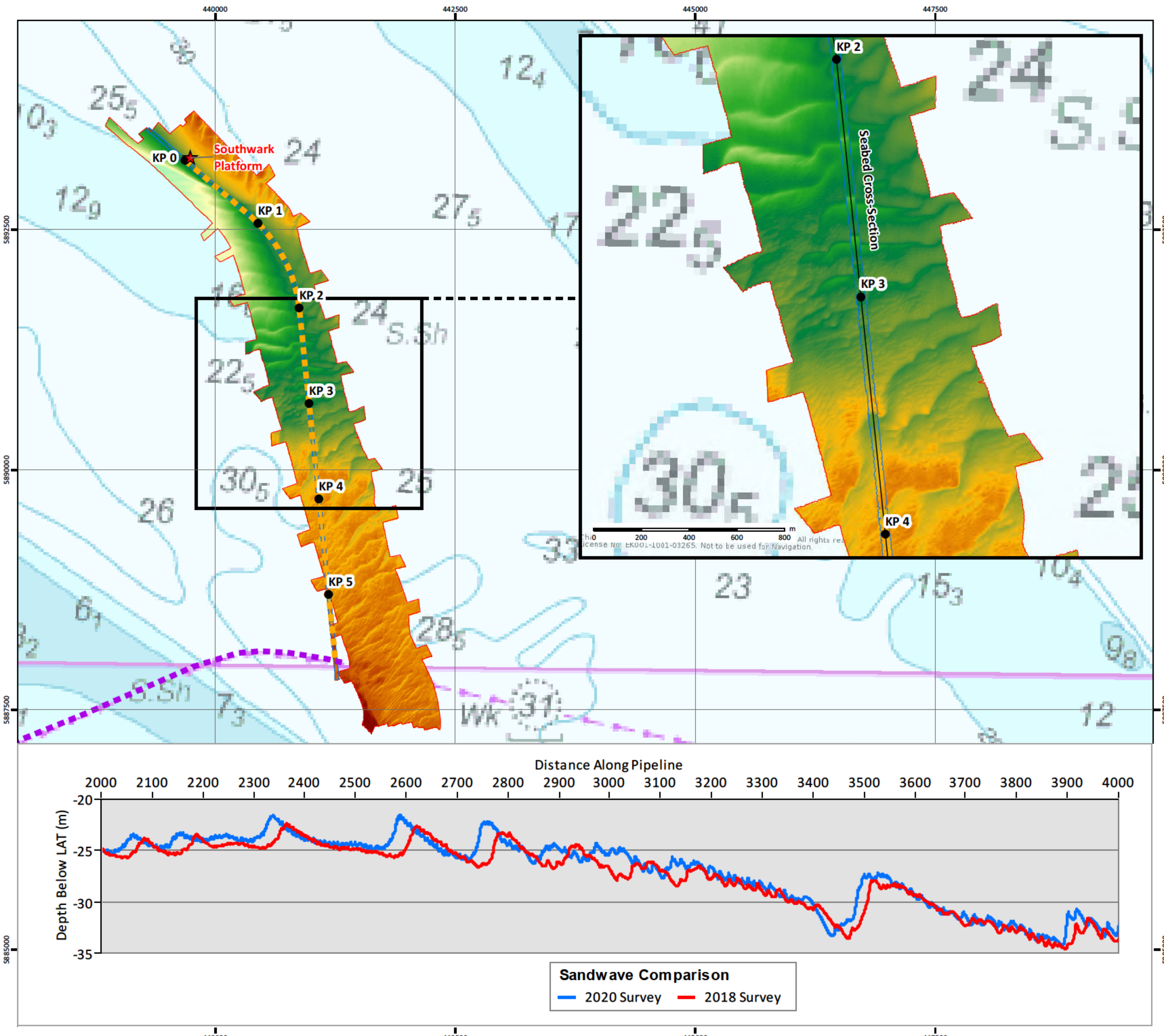
- >75
- 75 - 62.5
- 62.5 - 50
- 50 - 37.5
- 37.5 - 25
- 25 - 12.5
- 12.5 - 0

NOTE: Not to be used for Navigation

Date	03 March 2021
Coordinate System	ED 1950 UTM Zone 31N
Projection	Transverse Mercator
Datum	European 1950
Data Source	EMODnet; UKHO; MarineRegions; MarineFind; ESRI; OSOD;
File Reference	J:\P2371\Mxd\P2371S3\02_BATH\ P2371S3-BATH-001.mxd
Created By	Chris Dawe
Reviewed By	Emma Storey
Approved By	Stuart McLaren

0 5 10 15 20 km

The bathymetric metadata and Digital Terrain Model data products have been derived from the EMODnet Bathymetry portal - http //www.emodnet-bathymetry.eu.; Contains publ c sector information, licensed under the Open Government Licence v3.0, from the UKHO, 2018.; Flanders Marine Institute (2019). Maritime Boundaries Geodatabase Exclusive Economic Zone (EEZ), version 11. Available online at http //www.marineregions.org/. https //doi.org/10.14284/387; Charts from MarineFIND.co.uk © British Crown and OceanWise, 2020. All rights reserved. License No. EK001-FN1001-03265 Not to be used for Navigation; Contains Ordnance Survey data © Crown copyright and database right 2013; ; ©Esri



IOG SOUTHWARK ENVIRONMENTAL STATEMENT

BATHYMETRY
Sandwave Comparison

Drawing No: P2371S3-BATH-002 | **A**

Legend

- Southwark Platform
- Pipeline KP
- Southwark Pipeline
- Thames Pipeline
- 12nm Territorial Sea Limit
- EEZ Boundary
- 2018 Survey
- 2020 Pre-Lay Survey

Bathymetry

Depth Below LAT (m)
High : -10
Low : -40

N E S W

NOTE: Not to be used for Navigation

Date	03 March 2021
Coordinate System	ED 1950 UTM Zone 31N
Projection	Transverse Mercator
Datum	European 1950
Data Source	EMODnet; MarineFind; ESRI; OSOD;
File Reference	J:\P2371\Mxd\P2371S3\02_BATH\ P2371S3-BATH-002.mxd
Created By	Chris Dawe
Reviewed By	Emma Storey
Approved By	Stuart McLaren

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0 0.5 1 1.5 2 km

4.2.3.3 Seabed sediments and geology

The superficial deposits in the Proposed Development consist of sand, gravelly sand, and sandy gravel (DECC 2016) and may be classified as the European nature information system (EUNIS) habitat 'Deep circalittoral sand' (A5.27) (EMODnet 2020). The seabed sediments in the vicinity of the Proposed Development are presented in Figure 4-7 (Drawing No: P2371S3-SED-001-A).

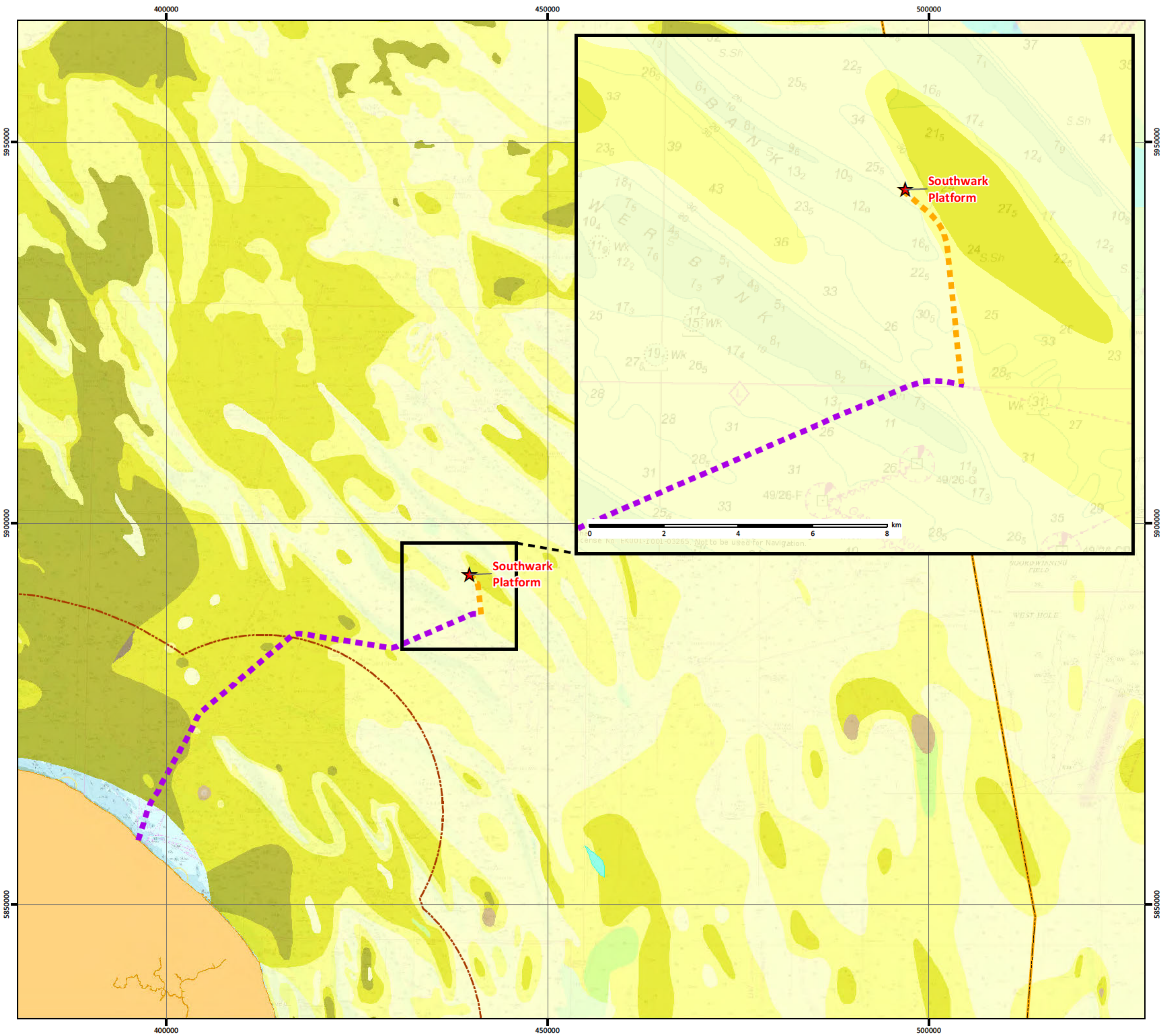
The unconsolidated sediment distribution in the Southern North Sea is complex and reflects both sediment sources and ongoing redistribution by hydrographic processes. Regional seabed sampling suggests that the seabed around the Proposed Development consists of Holocene sand, coarse sand, and gravels (JNCC 2017a; IOG 2018), where the thickness of the Holocene layer varies between 6m and 11m along the pipeline route (Fugro, 2018a and b).

The sandbanks in proximity to the Proposed Development principally comprise medium sand ranging between 280µm at the crest to approximately 430µm in the trough (Jenkins et al. 2015), where the composition was >80% sand (JNCC 2017a). Other sediment grains include gravels, with low occurrence of silts.

Off the east coast of Norfolk, the underlying offshore geology is made up of an upper cretaceous fine-grained limestone. This layer covers a lower cretaceous layer of mainly sandstones and mudstones (DECC 2016), which is also present along the proposed pipeline route (Fugro 2018a).

The potential for a reef within the Southern North Sea is less than the North and Central areas of the North Sea due to seabed sediments comprising of primarily sandy sediments (DECC 2016). However, several nearshore areas around the coast contain areas of hard ground. Additionally, the potential for biogenic reefs formed by *Sabellaria spinulosa* was confirmed through surveys and has contributed to the designation of the NNSSR SAC (IOG 2020c).

Figure 4-8 presents typical images of seabed sediment from the camera transects collected in the Southwark to Thames East survey area.



IOG SOUTHWARK ENVIRONMENTAL STATEMENT

SEABED SEDIMENTS

EMODnet Seabed Substrate

Drawing No: P2371S3-SED-001 | **A**

Legend

- Southwark Platform
- Southwark Pipeline
- Thames Pipeline
- 12nm Territorial Sea Limit
- EEZ Boundary

Seabed Substrate

Folk 16 Classification

- 1.2.1 sandy Mud
- 1.2.2 (gravelly) sandy Mud
- 1.3.1 muddy Sand
- 1.3.2 (gravelly) muddy Sand
- 2.1.1 Sand
- 2.1.2 (gravelly) Sand
- 3.1.1 gravelly Sand
- 3.2.1 sandy Gravel
- 4.1.1 gravelly Mud
- 4.3.1 gravelly muddy Sand
- 4.4.1 muddy sandy Gravel

NOTE: Not to be used for Navigation

Date	03 March 2021
Coordinate System	ED 1950 UTM Zone 31N
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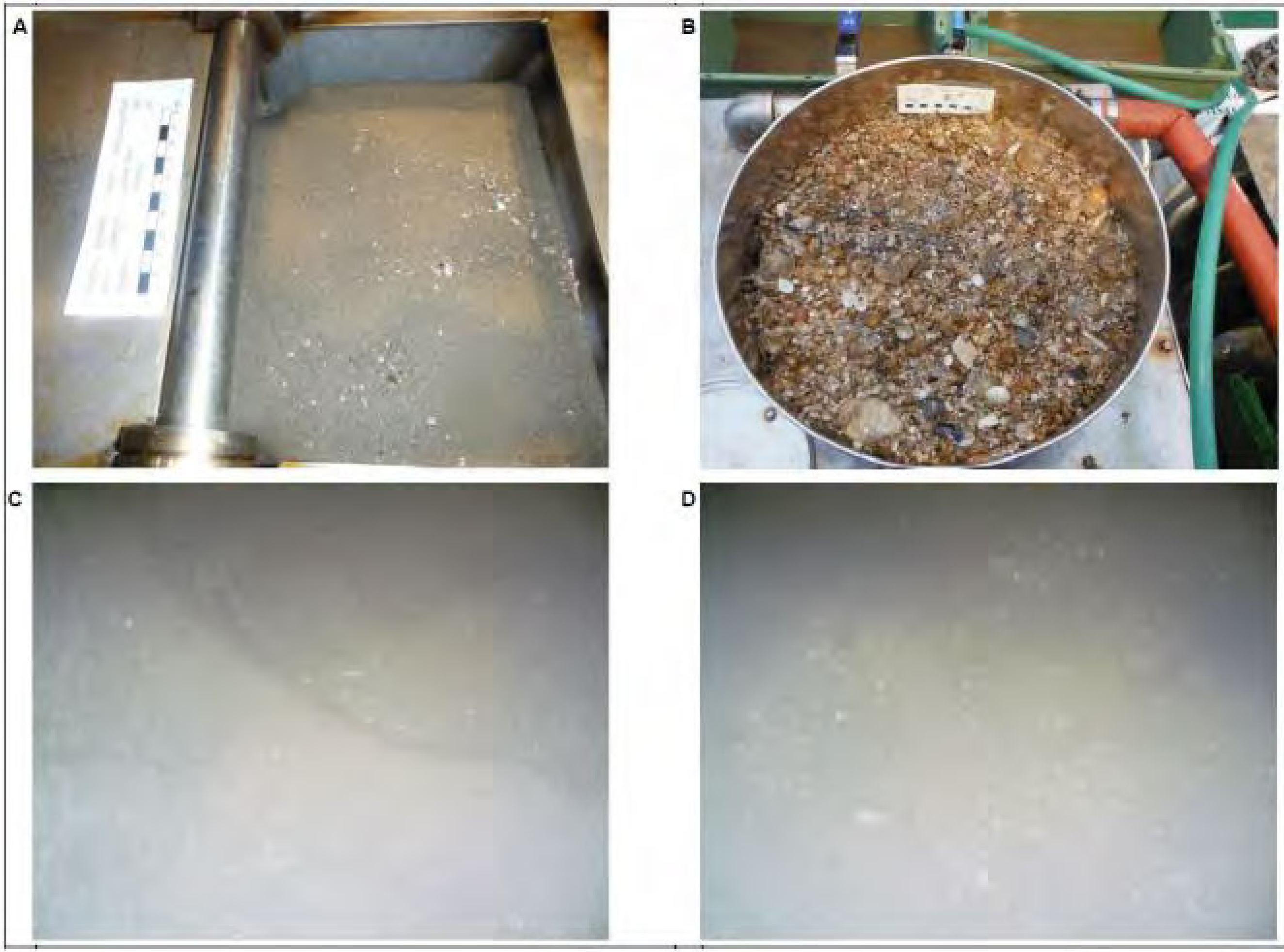
Data Source	EMODnet; UKHO; MarineRegions; MarineFind; ESRI; OSOD;
File Reference	J:\P2371\Mxd\P2371S3\03_SED\P2371S3-SED-001.mxd
Created By	Chris Dawe
Reviewed By	Emma Storey
Approved By	Stuart McLaren

0 5 10 15 20 km

Figure 4-8 Example seabed sediment photographs from within the Southwark to Thames East survey area



A: Grab photograph
SWKETO_ST01_FA

Sand with shell fragments

B: Sieve photograph
SWKETO_ST02_FA

Shell fragments
Fragment of broken and eroded *Sabellaria spinulosa* tubes

C: Seabed photograph
SWKETO_TR02_08

Rippled sand with shell fragments

D: Seabed photograph
SWKETO_TR03_21

Rippled sand with shell fragments

4.3 Protected and sensitive sites

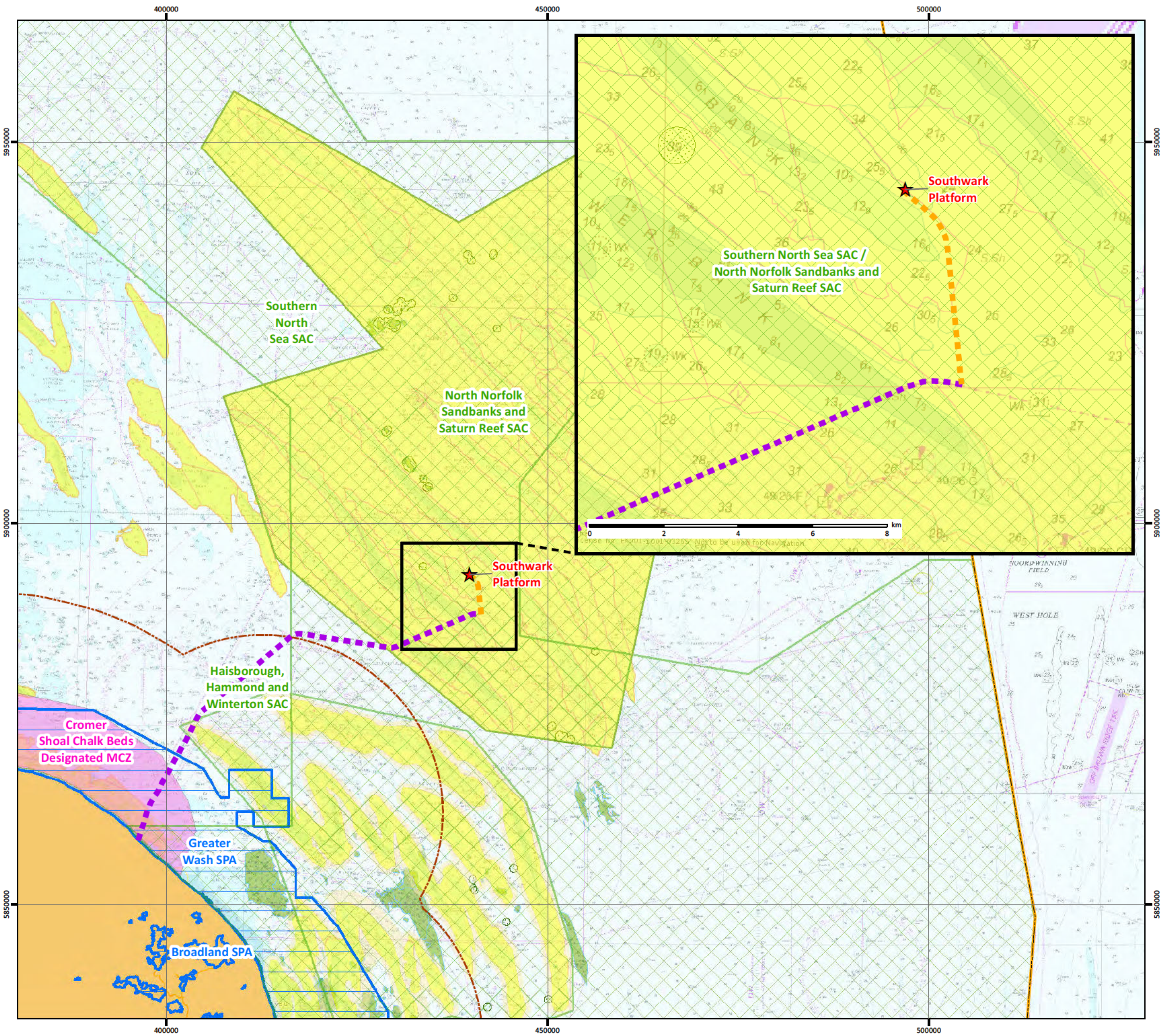
4.3.1 Overview

There are different types of designation for offshore protected and sensitive sites in UK waters. A GIS was used to identify sites within 40km of the Proposed Development. All sites found within 40km of the Proposed Development are European Marine Sites, designated under the Conservation of Offshore Marine Habitats and Species Regulations (COMHSR) 2017 (as amended). There are no Marine Conservation Zones (designated under the Marine and Coastal Access Act 2009) within 40km of the Proposed Development. The sites identified are discussed below and illustrated in Figure 4-9 (Drawing No: P2371S3-PROT-001).

IOG SOUTHWARK ENVIRONMENTAL STATEMENT

PROTECTED SITES
Environmental Designations and Annex I Habitats

Drawing No: P2371S3-PROT-001	A



Legend

- Southwark Platform
- Southwark Pipeline
- Thames Pipeline
- 12nm Territorial Sea Limit
- EEZ Boundary

Protected Sites

- SAC
- SPA
- MCZ

Annex I Habitat

- Sandbank Area
- Potential Sandbank

Potential Reef

- Biogenic
- Bedrock / Stony
- Additional Area Managed as Reef

NOTE: Not to be used for Navigation

Date	03 March 2021
Coordinate System	ED 1950 UTM Zone 31N
Projection	Transverse Mercator
Datum	European 1950
Data Source	JNCC; NE; UKHO; MarineRegions; ESRI; OSOD;
File Reference	J:\P2371\Mxd\P2371S3\06_PROT\P2371S3-PROT-001.mxd
Created By	Chris Dawe
Reviewed By	Emma Storey
Approved By	Stuart McLaren

km 0 5 10 15 20

4.3.2 Designations within 40km of the Proposed Development

4.3.2.1 Southern North Sea SAC

The Southern North Sea SAC covers an area of 36,796km^2 and is designated for the protection of harbour porpoise (*Phocoena phocoena*), an Annex II species. The site contains an estimated population of between 11,684 – 28,889 individuals. The site contains higher densities of harbour porpoise compared to the surrounding North Sea Management Unit (MU), with the site providing both summer and winter habitat for the species (JNCC 2019c). Average harbour porpoise densities around the Proposed Development remain consistent at over 3 individuals per km^2 in both summer and winter (Heinänen and Skov 2015). The Proposed Development is entirely located within the SAC and is located within the defined summer grounds for harbour porpoise (Figure 4-10). The conservation objectives for the Southern North Sea SAC are:

To ensure that the integrity of the site is maintained and that it makes the best possible contribution to maintaining Favourable Conservation Status (FCS) for Harbour Porpoise in UK waters",

In the context of natural change, this will be achieved by ensuring that:

1. Harbour porpoise is a viable component of the site;

2. There is no significant disturbance of the species; and

3. The condition of supporting habitats and processes, and the availability of prey is maintained.

With respect to the conservation objective 2 *"There is no significant disturbance of the species"* the Advice to Operators states:

Noise disturbance within an SAC from a plan/project individually or in combination is significant if it excludes harbour porpoises from more than:

1. 20% of the relevant area[1] of the site in any given day; and

2. an average of 10% of the relevant area of the site over a season.

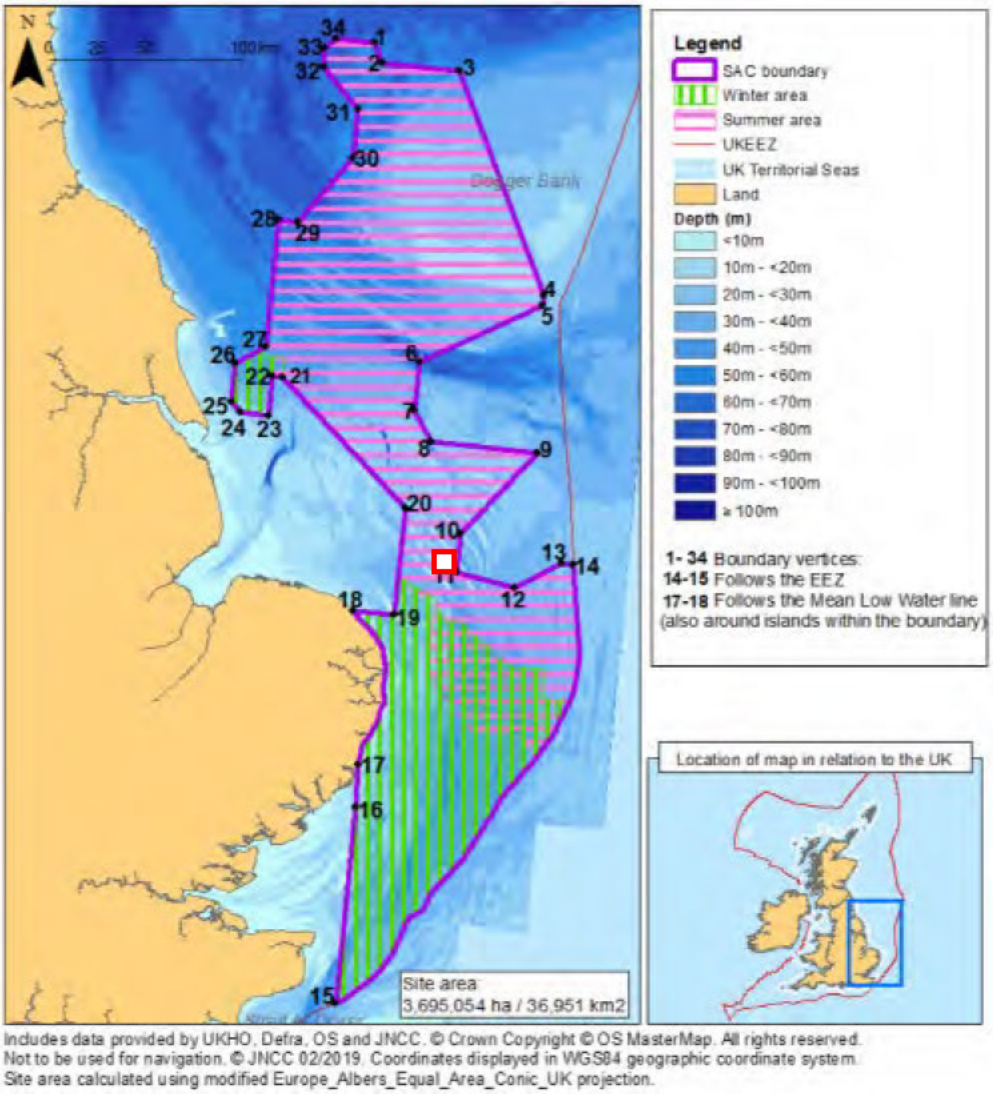
Table 4-1 Protected features of the Southern North Sea SAC

Protected feature	Type of feature	Population estimate of feature	Feature condition
Harbour porpoise	Species (Annex II species and EPS)	11,684 – 28,889 individuals	Favourable

Source: JNCC (2019a, 2019b)

[1] The relevant area is defined as that part of the SAC that was designated on the basis of higher persistent densities for that season (summer defined as April to September inclusive, winter as October to March inclusive)

Figure 4-10 Harbour porpoise seasonal density and distribution



Source: JNCC and NE (2019) **Note:** Proposed Development highlighted by red square.

4.3.2.2 North Norfolk Sandbanks and Saturn Reef (NNSSR) SAC

Located exclusively in offshore waters (beyond 12 NM), NNSSR SAC extends from approximately 22 NM to 60 NM from the north east coast of Norfolk. The SAC covers an area of 3,603.41km² and its designated features are listed in Table 4-2. The Proposed Development is located entirely within the SAC.

The NNSSR SAC is designated for the protection of '*Sandbanks which are slightly covered by sea water all the time*' (Annex I habitat) and Reefs (Annex I habitat). The SAC includes areas of biogenic reef formed by *Sabellaria spinulosa* (e.g. Saturn Reef), which is discussed further in Section 4.3.5 below.

Table 4-2 Protected features of the North Norfolk Sandbank and Saturn Reef SAC

Protected feature	Type of feature	Area of site covered by feature (hectares)	Feature condition
Sandbanks which are slightly covered by sea water all the time	Habitat (Annex I)	360232.9	Unfavourable
Reefs	Habitat (Annex I)	108.1	Unfavourable

Source: JNCC (2017c, 2020a)

The conservation objectives for the SAC are:

"For the features to be in favourable condition thus ensuring site integrity in the long term and contribution to Favourable Conservation Status of Annex I 'Sandbanks which are slightly covered by sea water all of the time' and Annex I Reefs. This contribution would be achieved by maintaining or restoring, subject to natural change:

- *The extent and distribution of the qualifying habitats in the site;*
- *The structure and function of the qualifying habitats in the site; and*
- *The supporting processes on which the qualifying habitats rely*

The attributes and objectives for each feature are detailed below:

Sandbanks which are slightly covered by sea water all the time

- Attribute – Extent and distribution
  - Objective – Restore: '*Activities must look to minimise, as far as is practicable, changes in substratum and the biological assemblages within the site to minimise further impact on feature extent and distribution*' (JNCC 2017d).
- Attribute – Structure and function
  - Objective – Restore: '*Activities must look to minimise, as far as is practicable, disturbance and changes to the sediment composition, finer scale topography and biological communities within the site*' (JNCC 2017d).
- Attribute – Supporting processes
  - Objective – Maintain: '*Activities must look to avoid, as far as is practicable, impairing the hydrodynamic regime within the site and exceeding Environmental Quality Standards*'. Standards are set out in the sites supplementary guidance (JNCC 2017d).

Reefs

- Attribute – Extent and distribution
  - Objective – Restore: '*Activities must look to minimise, as far as is practicable, damaging the established i.e. high confidence reef within the site*' (JNCC 2017d).
- Attribute – Supporting processes
  - Objective – Restore: '*Activities must look to minimise, as far as is practicable, disturbance to the hydrodynamic regime within the site and the habitats which support the reef within the site. Activities must also look to avoid, as far as is practicable, exceeding Environmental Quality Standards for aqueous contaminants.* Standards are set out in the sites supplementary guidance (JNCC 2017d).

The Annex I definition of '*Sandbanks which are slightly covered by sea water all the time*' describes areas of sand which form distinct elevated topographic features, predominantly surrounded by deeper water and slightly covered by seawater all the time. The top of the sandbank is usually in less than 20m water depth (Fugro 2018a). However, the sides of these sandbanks, can extend into deeper water up to 60m.

Sandbanks can be categorised by sediment type or by topography. The different sediments which are indicative of sandbanks are sublittoral coarse sediments, subtidal mixed sediments and sublittoral sands and muddy sands, with particles sometimes reaching the size of cobbles or boulders. For sandbanks identified through topography, there are sandy mounds, created by glacial processes, and current tidal sandbanks which can be relatively mobile with their extent and distribution being actively influenced by ongoing hydrodynamic processes.

The NNSSR SAC is comprised of 10 sandbanks, including the Leman, Ower, Inner, Well, Broken, Swarte Banks and four banks called, collectively, the Indefatigables. The Proposed Development is situated on the flanks of the Inner Bank.

These sandbanks are the most extensive example of the offshore linear ridge sandbank type in UK waters, being subject to a range of current strengths which are strongest on the banks closest to shore and which reduce offshore (JNCC 2020a). The sandbanks are maintained through offshore sediment transport, with each sandbank acting as a stepping-stone, with new sandbanks developing in the spaces between existing banks. The designated boundary of the site encompasses the whole linear sandbank system rather than attempting to separate out individual banks. The sandbanks have a north-west to south-east orientation and are thought to be progressively, though very slowly, elongating in a north-easterly direction (JNCC 2020a). Survey has confirmed that the biological communities associated with the topographic sandbanks occur across the SAC, including adjacent areas where the seabed is much deeper than 20m (JNCC 2020a). Sand is the dominant sediment type across the site, with patches of coarser and mixed sediment likely being associated in places with *Sabellaria spinulosa* reef. As such, the entire site is considered to be a representative functioning example of the Annex I feature '*Sandbanks which are slightly covered by sea water all the time*.'

On and around the Inner sandbank, primary and secondary productivity is very high. A range of fish species (e.g. sandeel (*Ammodytes tobianus*), dragonet (*Callionymus lyra*), goby (*Pomatoschistus microps*), lesser weaver (*Echiichthys vipera*), European plaice (*Pleuronectes platessa*) and common dab (*Limanda limanda*)) are associated with the sandbanks present in the site (JNCC 2020a). The fauna typically associated with these include polychaete worms, crabs, starfish, sandeel and flatfish such as plaice and sole (*Solea solea*). The presence of sandeel also makes shallow sandbanks an important feeding ground for other fish species, diving seabirds, seals and porpoises (IOG 2020c).

Based on information presented in the JNCC mapper for the NNSSR SAC (JNCC 2020c) high confidence reef habitat is located approximately 5-15 km from the Proposed Development. Reefs formed by large aggregations of the Ross Worm, *Sabellaria spinulosa* are colonised by other species not found in adjacent habitats, leading to a diverse community of epifaunal and infaunal species (Eggleton et al. 2020).

Aggregations of horse mussels and common mussels, which can also form Annex I Reef habitat were not observed in the 2018 survey (Fugro 2018a and 2018b).

4.3.2.3 Haisborough, Hammond and Winterton SAC

Haisborough, Hammond and Winterton SAC is designated for the protection of '*Sandbanks which are slightly covered by sea water all the time'* (Annex I habitat) and Reefs (Annex I habitat) (JNCC 2020b). The SAC covers an area of 1,467.59 km^2 and its designated features are listed in Table 4-3.

The nearest point of this SAC is located 15km southwest of the Proposed Development, while the nearest identified potential reef habitat (biogenic reef formed by by the polychaete worm, *Sabellaria spinulosa*) within the SAC is 33km northwest of the Proposed Development.

The conservation objectives for Haisborough, Hammond and Winterton SAC are to:

"Ensure that, subject to natural change, the integrity of the site is maintained or restored as appropriate, and that the site contributes to achieving the Favourable Conservation Status of its qualifying features, by maintaining or restoring;

- *the extent and distribution of qualifying natural habitats and habitats of the qualifying species*
- *the structure and function (including typical species) of qualifying natural habitats*
- *the structure and function of the habitats of the qualifying species*
- *the supporting processes on which qualifying natural habitats and the habitats of qualifying species rely*
- *the populations of each of the qualifying species*
- *the distribution of qualifying species within the site*

Table 4-3 Protected features of the Haisborough, Hammond and Winterton SAC

Protected feature	Type of feature	Area of site covered by feature (hectares)	Feature condition
Sandbanks which are slightly covered by sea water all the time	Habitat (Annex I)	66892.75	Unfavourable No Change
Reefs	Habitat (Annex I)	88.06	Unfavourable No Change

Source: JNCC (2017a, 2020b)

4.3.2.4 Greater Wash Special Protection Area (SPA)

The Greater Wash SPA which is located 34km southwest of the Proposed Development. The SPA is designated for the protection of breeding populations of sandwich tern, common tern, and little tern. The SPA also supports non-breeding populations of red-throated diver, common scoter, and little gull (Natural England 2019). The SPA covers an area of 3,536km^2 and its designated features are listed in Table 4-4. The conservation objectives of the SPA are:

"With regard to the SPA and the individual species and /or assemblages of species for which the site has been classified (the 'Qualifying Features' listed below), and subject to natural change;

Ensure that the integrity of the site is maintained or restored as appropriate, and ensure that the site contributes to achieving the aims of the Wild Birds Directive, by maintaining or restoring;

- *The extent and distribution of the habitats of the qualifying features*
- *The structure and function of the habitats of the qualifying features*
- *The supporting processes on which the habitats of the qualifying features rely*
- *The population of each of the qualifying features, and,*
- *The distribution of the qualifying features within the site.*

Table 4-4 Protected features of the Greater Wash SPA

Protected feature	Type of feature	Population estimate	Feature condition
Red-throated diver (*Gavia stellata*) (Non-breeding)	Species (Annex I)	1407 individuals	Unfavourable*
Common scoter (*Melanitta nigra*) (Non-breeding)	Species (Annex I)	3449 individuals	Unfavourable*
Little gull (*Hydrocoloeus minutus*) (Non-breeding)	Species (Annex I)	1255 individuals	Unfavourable*
Sandwich tern (*Sterna sandvicensis*) (Breeding)	Species (Annex I)	3852 individuals	Unfavourable*
Common tern (*Sterna hirundo*) (Breeding)	Species (Annex I)	510 individuals	Unfavourable*
Little tern (*Sternula albifrons*) (Breeding)	Species (Annex I)	798 individuals	Unfavourable*

Source: Natural England (2019) * Status inferred from Conservation objective which is to maintain or restore feature

4.3.3 Potential designations under EC Habitats Directive – Annex I habitats

4.3.3.1 Reefs

The most common biogenic reef building species in UK waters is the polychaete worm, *Sabellaria spinulosa*, which forms reef like or encrusting accretions of sandy tubes on gravel and cobble substrates (JNCC 2014). These reef structures can rise to 30cm above the seabed and can extend over considerably large areas (IOG 2020c). Biogenic reefs are of special importance in European waters as they are listed under Annex I of the EC Habitats Directive as requiring conservation as ‘reefs’. In the UK, Annex I habitats are conserved using SACs, however, Annex I habitats outside of SACs are still required to be identified and monitored. The closest *Sabellaria* reef to the Proposed Development outside of an SAC is located 30km southwest at Winterton Ridge. The closest high confidence reef habitat (associated with the NNSSR SAC) is located approximately 5-15 km from the Proposed Development (Section 4.4.1).

No other Annex I habitats e.g. biogenic reefs created by aggregations of the horse mussel (*Modiolus modiolus*) and the common mussel (*Mytilus edulis*), outside of an SAC within 40km of the Proposed Development were identified by the JNCC Mapper (JNCC 2020c).

4.4 Biological environment

4.4.1 Benthos

For the purpose of this assessment, benthic communities comprise those species (excluding commercially exploitable shellfish) that live on (epifauna) or in (infauna) sediments.

4.4.1.1 Infauna

Infauna species greater than 0.3mm in length are classed as macrofauna. The Fugro (2018b) survey reported that sediments generally support a macrofauna community largely dominated by annelids[2] and arthropods[3] (present in roughly equal numbers and together comprising about 90% of the species present), with the remainder including echinoderms[4] and other phyla.

[2] Segmented worms
[3] Crustaceans
[4] Starfish, brittle stars, sea urchins etc

4.4.1.2 Epifauna

Epifauna was extremely sparse throughout the survey area (Fugro 2018a, 2018b). The survey suggested that within the Proposed Development there was very low species richness, diversity or abundance (Fugro 2018a, 2018b). Whilst fragments of broken and eroded *Sabellaria spinulosa* tubes were found in a grab sample taken within the Southwark to East Thames survey area, approximately 4.4km from the Proposed Development (see Figure 4-11), inspection of sidescan sonar data and ground-truthing with visual camera systems indicated that there are no areas of *Sabellaria spinulosa* that could be classified as 'reef' within the surveyed area (Fugro 2018a, 2018b).

The quantitative assessment of seabed imagery obtained during the survey (Fugro 2018a, 2018b) showed that:

- No visible epifauna was recorded from transects SWKETO_TR01a and SWKETO_TR02 (0.4km southeast of Proposed Development).
- Unidentified flatfish (*Pleuronectiformes*) and sand eel (*Ammodytidae*) were observed SWK_TR01 (0.01km north of Proposed Development).
- Sand sediment and broken *Sabellaria spinulosa* tubes were observed at SWKETO_ST02 (0.6km southeast of Proposed Development).
- A starfish (*Asterias rubens*) and a hermit crab (Paguroidea) recorded at SWKETO_TR03 (0.5km southeast of Proposed Development), with one fragment of broken and eroded S. spinulosa tubes at SWKETO_TR02 (0.4km southeast of Proposed Development).
- Species diversity appeared to increase in areas of coarser sediments (favouring epilithic attachment).

Figure 4-11 Sieve sample taken from station SWKETO_ST02_FA

Source: Fugro (2018a).

4.4.1.3 Protected species and habitats

The Proposed Development is situated on the flanks of the Inner Bank, one of ten sandbanks that comprise the overall '*Sandbanks which are slightly covered by sea water all the time'* Annex I habitat for which the NNSSR SAC is designated for. The SAC includes areas of biogenic reef formed by *Sabellaria spinulosa* (e.g. Saturn Reef), a reef-building polychaete worm species. The closest high confidence reef habitat is located approximately 5-15km from the Proposed Development (JNCC 2019a). No other sensitive habitats were identified within 40km of the Proposed Development by the 2018 survey.

4.4.2 Plankton

Plankton are drifting organisms that inhabit the pelagic zone of a body of water and include single celled organisms such as bacteria, as well as plants (phytoplankton) and animals (zooplankton). Reports resulting from the long-term study of plankton distributions on the UK continental shelf (DECC 2016) suggest that, in regions which are remote from terrestrial influences, climatic changes are likely to be the predominant factor affecting the plankton distribution and abundances.

The composition and abundance of plankton communities varies throughout the year and is influenced by physical parameters such as temperature, salinity, and water inflow (Beare *et al*. 2002). Phytoplankton, and the associated grazing zooplankton, usually show a bimodal pattern of abundance through the year. The characteristics of this annual cycle are determined by local weather and oceanographic conditions and are important in biological terms as they provide important feeding areas for most animal groups within the marine ecosystem.

4.4.2.1 Phytoplankton

The main peak of phytoplankton abundance (termed a bloom) occurs towards the end of spring in response to the increased daylight, with a secondary bloom, in response to increased nutrient availability, occurring in late summer/early autumn (Johns and Reid 2001). The spring diatom bloom generally reaches its peak during April or May and is followed by a sharp decline in June (Heath *et al.* 2000). The autumn bloom, characterised by dinoflagellates, reaches its peak in mid-August. Productivity is lowest in the winter months when there are reduced hours of daylight (DECC 2009).

Phytoplankton assemblages in the Proposed Development are characterised mostly by the dinoflagellate genera *Ceratium* and the diatoms *Thalassiosira* and *Chaetoceros* (*Hyalochaete*, and *Phaeoceros)* (IOG 2020).

4.4.2.2 Zooplankton

Zooplankton abundance is typically at its highest between May and September, with increases following the phytoplankton blooms. The bloom provides an important source of food for a range of fish species (Johns and Reid 2001). Zooplankton communities in the Southern North Sea are dominated by copepod crustaceans such as *Calanus* and the larvae of echinoderms (Johns and Reid 2001; DECC 2009).

The zooplankton community is noted to comprise of *C. helgolandicus* and *C. finmarchicus* as well as *Paracalanus spp., Pseudocalanus spp., Acartia spp., Temora spp*. and cladocerans such as *Evadne spp* (DECC 2016). Commonly seen jellyfish in the region include *A. aurita* and *Chrysaora hysoscella* (DECC 2016; IOG 2020c).

4.4.3 Fish and shellfish

Over 330 species of fish have been recorded on the UK continental shelf (DECC 2016). Fish communities comprise species with complex interactions with both one another, and the natural environment. These species act as predators, consuming a wide range of prey species including benthic invertebrates, and/or as prey supporting larger predators (DTI 2001a). Most of the published information on distribution is concerned with commercial fish; however, recent data (Ellis *et al.* 2012) includes some consideration of species of conservation, rather than commercial, significance.

Statistical information for UK continental shelf fishing is published by the Marine Management Organisation (MMO), based on International Council for the Exploration of the Sea (ICES) statistical rectangles. These are a grid, in Mercator projection, of 1˚ latitude by 0.5˚ longitude rectangles covering the north-east Atlantic. Reports for ICES rectangles provided data on species landed, by tonnage and value. It should be noted that these do not provide a definitive guide to the fish and shellfish in an area and they include no information on species which are not commercially exploited. However, as many of the species found in the Southern North Sea are commercially exploitable, it does serve as a useful indicator. The following section is based on the information for rectangle 35F2, within which the Proposed Development lies, for the period 2015 to 2019. This is the most recent catch data available at present, having been published in September 2020.

Section 4.5.1 presents an analysis of fisheries statistics for these years.

4.4.3.1 Ray-finned fish

Table 4-5 lists ray-finned fish which have been reported as landed from rectangle 35F2 between 2015 and 2019 and includes the reported tonnage landed, as an analogue for occurrence.

Table 4-5 Ray-finned fish recorded in catch statistics between 2015 and 2019

Species common name	Scientific name	Habitat	Quantity (tonnes)
Bass	*Dicentrarchus labrax*	Demersal	0.01
Blue whiting	*Micromesistius poutassou*	Pelagic	0.01
Brill	*Scophthalmus rhombus*	Demersal	8.78
Cod	*Gadus morhua*	Demersal	0.46
Dabs	*Limanda limanda*	Demersal	3.16
Flounder or Flukes	*Paralichthys*	Demersal	0.03
Greater Weever	*Trachinus draco*	Demersal	0.001
Gurnard and Latchet	*Triglidae*	Demersal	0.04
Gurnards - Grey	*Eutrigla gurnardus*	Demersal	0.25
Gurnards - Red	*Chelidonichthys cuculus*	Demersal	0.01
Atlantic halibut	*Hippoglossus hippoglossus*	Demersal	0.01
Lemon Sole	*Microstomus kitt*	Demersal	0.76
Monks or Anglers	*Lophiidae*	Demersal	0.08
Mullet	*Mugilidae*	Demersal	0.001
Plaice	*Platessa platessa*	Demersal	122.36
Pouting (Bib)	*Trisopterus luscus*	Demersal	0.003
Red Mullet	*Mullus surmuletus*	Demersal	0.21
Sole	*Soleidae*	Demersal	67.06
Tub Gurnards	*Chelidonichthys lucerna*	Demersal	9.4
Turbot	*Psetta maxima*	Demersal	11.06
Whiting	*Merlangius merlangus*	Demersal	0.27

Source: UK Government (2020)

The majority of ray-finned fish taken in the area are demersal, i.e. dwelling on or near the seabed and largely reliant on the benthos for food and protection. Two pelagic species (i.e., mid and upper water species, feeding in the water column) have been reported among landings; Blue whiting and Garfish.

4.4.3.2 Sharks, skates and rays (elasmobranchs)

The term elasmobranch refers to species of cartilaginous fish such as sharks, rays, and skates. The most abundant sharks found in the Southern North Sea are the lesser and greater spotted dogfish and tope (a summer visitor). The outer Thames Estuary and the Wash are important areas for a number of ray species, including thornback rays, adults of which migrate into the Thames Estuary to breed in summer (DECC 2016). Sightings of other species, such as the common skate, basking shark and porbeagle are rare in the Southern North Sea (DECC 2016).

4.4.3.3 Shellfish

The east coast of England is a site of particularly intense spawning by brown crab (DECC 2016) but they are found throughout the region. Large populations of cockles are found in the Wash and the Thames Estuary and mussels are abundant in the Wash, as are wild and cultivated oysters along the Essex and Kent coast (DECC 2016). The main site for Nephrops is to the north and west of the shallow Dogger Bank, while pink and brown shrimp are abundant in the Wash and the Thames and Humber Estuaries. Whelks and periwinkles are widespread in the region. Razor clams, including the introduced species *Ensis directus* as well as native species, are abundant in the Wash and locally elsewhere.

4.4.3.4 Spawning and nursing

Fisheries sensitivity maps (Coull *et al*. 1998; Ellis *et al*. 2012) have been used to identify the spawning (location where eggs are laid) and nursery grounds (location where juveniles are common) for commercial fish species in the Proposed Development. It should be noted that ground fish surveys were restricted to continental shelf waters, and therefore there are limitations to the data available for the Southwark field (Ellis *et al.* 2012). The Proposed Development is located within ICES rectangle 35F2. Table 4-6 presents which species are likely to be present by month. Figure 4-12 (Drawing No: P2371S3-FISH-001-1) and Figure 4-13 (Drawing No: P2371S3-FISH-001-2) present an overview of spawning and nursery grounds by species in the vicinity of the Proposed Development.

The likelihood for presence of juveniles within the first year of their life near the Proposed Development has been determined to be low for all species (Aires *et al.* 2014). The likelihood of presence has been defined with reference to the Random Forest probability of presence scale (Breiman 2001), low probability is defined as 0 ranging to high probability at around 0.99 (maximum score is dependent on species type and ranges from 0.525 for herring to 0.99 for haddock).

4.4.3.5 Protected or vulnerable species

Atlantic herring, Atlantic cod, Atlantic mackerel, common sole, European plaice, tope, lesser sandeel and whiting are included on the UK Biodiversity Action Plan (UKBAP) list of priority species (JNCC 2007b). These species are identified as among those in the UK which are the most threatened and requiring conservation action to conserve their populations.

Atlantic cod, tope, sandeel and common sole are also listed on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species, with Atlantic cod and tope being listed as vulnerable and sandeel and common sole as data deficient (IUCN 2020). In addition, Atlantic cod populations are listed on the OSPAR List of Threatened or Declining Species and Habitats as being in decline in OPSAR Region II (the Greater North Sea), within which the Proposed Development is located (OSPAR 2021).

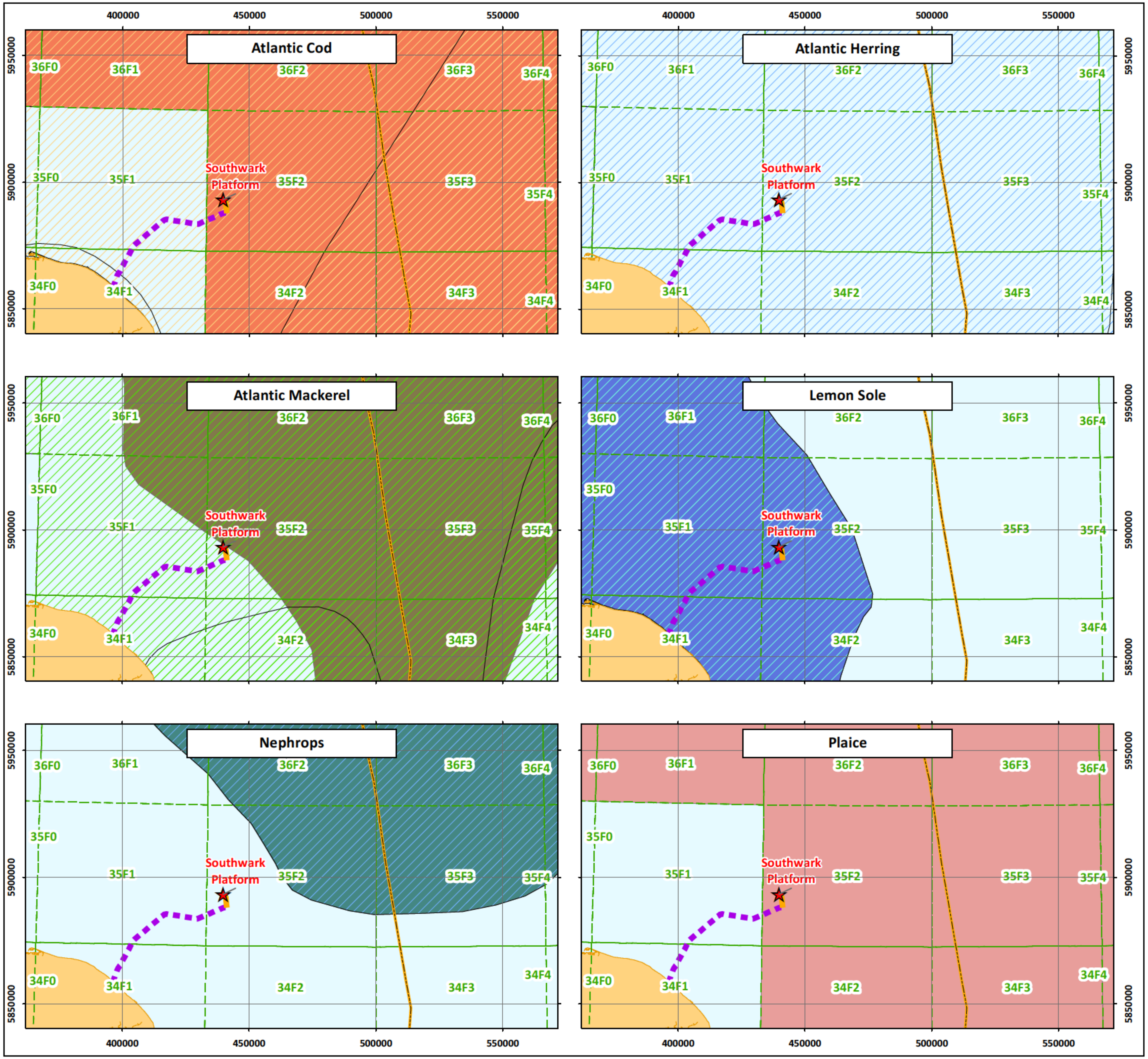
Table 4-6 Fish spawning and nursey grounds in ICES 35F2

Species	J	F	M	A	M	J	J	A	S	O	N	D
Atlantic cod (*Gadus morhua*)	SN	*SN	*SN	SN	N	N	N	N	N	N	N	N
Atlantic herring (*Clupea harengus*)	N	N	N	N	N	N	N	N	N	N	N	N
Atlantic mackerel (*Scomber scombrus*)	N	N	N	N	*SN	*SN	*SN	SN	N	N	N	N
Common sole (*Solea solea*)†	N	N	S	*S	S	N	N	N	N	N	N	N
European plaice (*Pleuronectes platessa*)	*S	*S	S	N	N	N	N	N	N	N	N	S
European sprat (*Sprattus sprattus)*	N	N	N	N	*SN	*SN	SN	SN	N	N	N	N
Lemon sole (*Microstomus kitt*)	N	N	N	SN	SN	SN	SN	SN	SN	N	N	N
Nephrops (*Nephrops norvegicus*) †	SN	SN	SN	*SN	*SN	*SN	SN	SN	SN	SN	SN	SN
Sandeel (*Ammodytes marinus and A. tobianus*.)	SN	SN	N	N	N	N	N	N	N	N	SN	SN
Tope shark (*Galeorhinus galeus*)	N	N	N	N	N	N	N	N	N	N	N	N
Whiting (*Merlangius merlangus*)	N	SN	SN	SN	SN	SN	N	N	N	N	N	N

Key	SN – Spawning and Nursery	S - Spawning	N – Nursery

Note: * Indicates a period of peak spawning † While spawning and nursery grounds for *Nephrops* and Common sole do not overlap with the Proposed Development (as shown in Figure 4-12 (Drawing No: P2371S3-FISH-001-1) and Figure 4-13 (Drawing No: P2371S3-FISH-001-2), they have been included in this table as a precaution as the boundaries of the spawning grounds are changeable.

Source: Coull *et al.* (1998) and Ellis *et al.* (2012



IOG SOUTHWARK ENVIRONMENTAL STATEMENT

FISH ACTIVITY

Spatial Patterns of Fish Spawning and Nursing

Sheet 1 of 2

Drawing No: P2371S3-FISH-001-1	A

Legend

- Southwark Platform
- Southwark Pipeline
- Thames Pipeline
- EEZ Boundary
- ICES Block

Nursery Grounds

- Atlantic Cod
- Atlantic Herring
- Atlantic Mackerel
- Lemon Sole
- Nephrops

Spawning Grounds

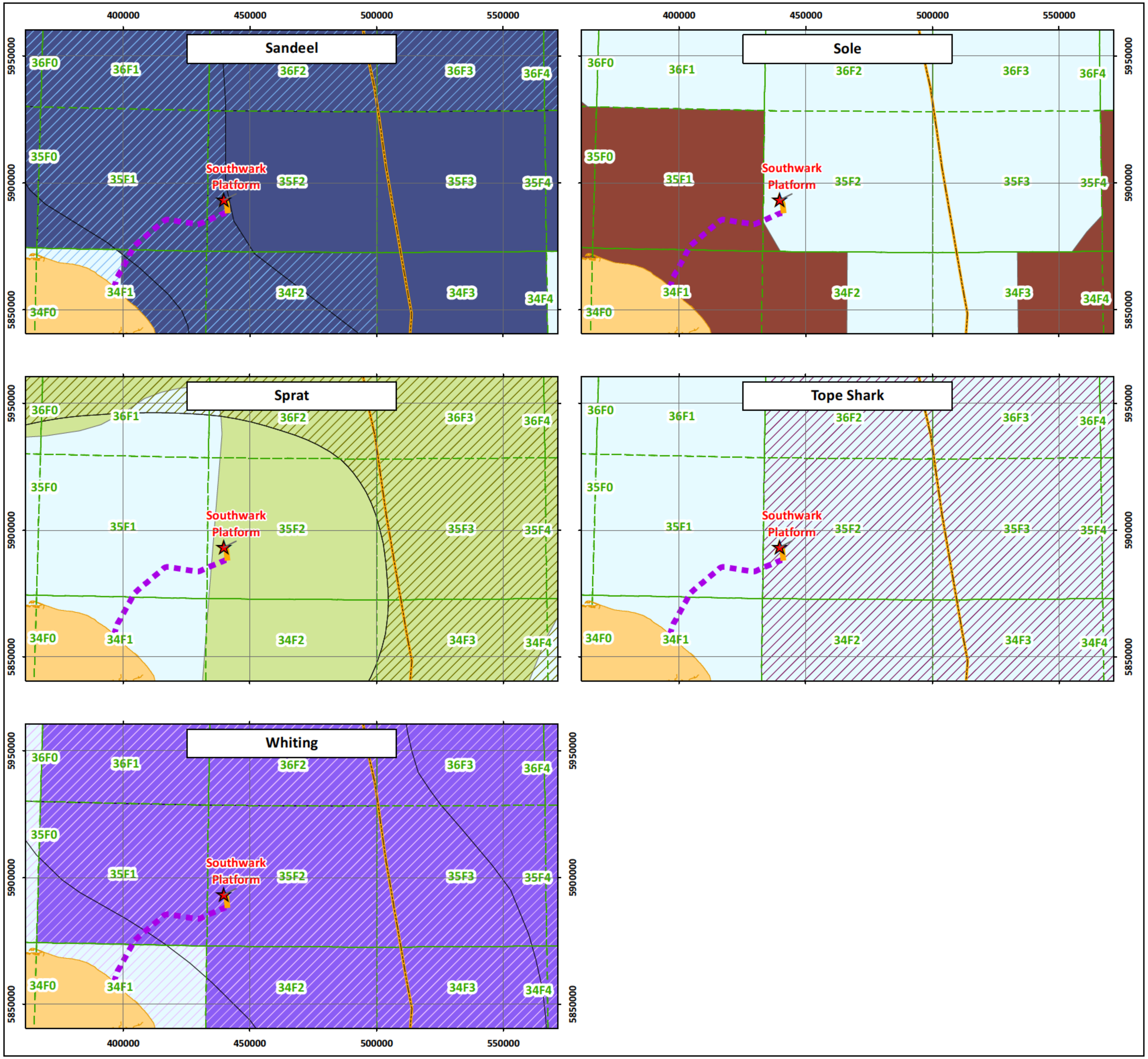
- Atlantic Cod
- Atlantic Mackerel
- Lemon Sole
- Nephrops
- Plaice

NOTE: Not to be used for Navigation

Date	03 March 2021
Coordinate System	ED 1950 UTM Zone 31N
Projection	Transverse Mercator
Datum	European 1950
Data Source	MarineRegions; CEFAS; OSOD; ESRI; ICES
File Reference	J:\P2371\Mxd\P2371S3\05_FISH\ P2371S3-FISH-001-1.mxd
Created By	Chris Dawe
Reviewed By	Emma Storey
Approved By	Stuart McLaren

0 20 40 60 80 km

Flanders Marine Institute (2019). Maritime Boundaries Geodatabase Territorial Seas (12NM), version 3. Available online at http //www.marineregions.org/. https //doi.org/10.14284/387; ; Contains Ordnance Survey data © Crown copyright and database right 2013; Contains public sector information licensed under Open Government Licence v3.0. Data from Ellis, J.R. et al. (2012) Spawning and Nursery Grounds of Selected Fish Species in UK Waters. CEFAS Lowestoft Science Series Technical Report, 147 55pp. © ESRI; ©ICES



IOG SOUTHWARK ENVIRONMENTAL STATEMENT

FISH ACTIVITY

Spatial Patterns of Fish Spawning and Nursing

Sheet 2 of 2

Drawing No: P2371S3-FISH-001-2	A

Legend

- Southwark Platform
- Southwark Pipeline
- Thames Pipeline
- EEZ Boundary
- ICES Block

Spawning Grounds

- Sandeel
- Sole
- Sprat
- Whiting

Nursery Grounds

- Sandeel
- Sprat
- Tope Shark
- Whiting

NOTE: Not to be used for Navigation

Date	03 March 2021
Coordinate System	ED 1950 UTM Zone 31N
Projection	Transverse Mercator
Datum	European 1950
Data Source	MarineRegions; CEFAS; OSOD; ESRI; ICES
File Reference	J:\P2371\Mxd\P2371S3\05_FISH\ P2371S3-FISH-001-2.mxd
Created By	Chris Dawe
Reviewed By	Emma Storey
Approved By	Stuart McLaren

0 20 40 60 80 km

Flanders Marine Institute (2019). Maritime Boundaries Geodatabase Territorial Seas (12NM), version 3. Available online at http //www.marineregions.org/. https //doi.org/10.14284/387; Contains Ordnance Survey data © Crown copyright and database right 2013; Contains public sector information licensed under Open Government Licence v3.0. Data from Ellis, J.R. et al. (2012) Spawning and Nursery Grounds of Selected Fish Species in UK Waters. CEFAS Lowestoft Science Series Technical Report, 147 55pp. © ESRI; ©ICES

4.4.4 Marine birds

The waters in the vicinity of the Proposed Development are of particular importance to seabirds. The North Norfolk sandbanks are an example of the habitat '*Sandbanks which are slightly covered by sea water all the time*.' Such habitat is typically colonised by a burrowing fauna of worms, crustaceans, bivalve molluscs and echinoderms, with mobile epifauna at the surface of the sandbank including shrimps, gastropod molluscs, crabs and fish. This assemblage of key prey species for seabirds makes sandbanks ideal feeding grounds for numerous seabird species (JNCC 2021).

Species present in the waters surrounding the Proposed Development include northern fulmar (*Fulmarus glacialis*), Manx shearwater (*Puffinus puffinus*), northern gannet (*Morus bassanus*), pomarine skua (*Stercorarius pomarinus*), Arctic skua (*Stercorarius parasiticus*), great skua (*Stercorarius skua*), little gull (*Hydrocoloeus minutus*), black-headed gull (*Chroicocephalus ridibundus*), common gull (*Larus canus*), lesser black-backed gull (*L. fuscus*), European herring gull (*L. argentatus*), great black-backed gull (*L. marinus*), black-legged kittiwake (*Rissa tridactyla*), sandwich tern (*Thalasseus sandvicensis*), common tern (*Sterna hirundo*), Arctic tern (*S.paradisaea*), common guillemot (*Uria aalge*), razorbill (*Alca torda*) and Atlantic puffin (*Fratercula arctica*) (DECC 2016).

4.4.4.1 Offshore species

Seabird distribution and abundance in the Southern North Sea varies throughout the year, with offshore areas in general, containing peak numbers of birds following the breeding season and through winter (DECC 2016). Seabirds found in offshore areas 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, but frequently feed far offshore.

Distribution and abundance of bird species found within the area vary seasonally and annually. Surveys conducted for the nearby planned Hornsea 3 offshore windfarm indicated that the most commonly observed birds in the area included northern gannet, northern fulmar, Arctic skua, great skua, Atlantic puffin, razorbill, common guillemot, black-legged kittiwake, lesser black-backed gull and great black-backed gull. Other species recorded as present but very infrequently included red-throated diver, Sandwich tern, common tern, Arctic tern and little gull (Ørsted 2018b).

4.4.4.2 Coastal species

During the breeding season, generally between March and June, large numbers of seabirds congregate in coastal breeding colonies. Most seabird species prefer isolated sea cliffs as a breeding habitat. Such habitats are relatively infrequent along the coastline adjacent to the Proposed Development. The coastline southwest of the Proposed Development is designated as the Greater Wash SPA. The Qualifying Interests of the SPA include breeding populations of Sandwich tern, common tern, and little tern; and non-breeding populations of red-throated diver, common scoter and little gull (Natural England 2019). The SPA is approximately 34km southwest of the Proposed Development. As such, the Proposed Development falls outside of the mean max foraging range of common tern, little tern and red-throated diver, but falls just within the mean max foraging range of Sandwich tern (34.3km) (Woodward *et al.* 2019). Estimated foraging ranges for little gull and common scoter are not available at the time of writing. As such, the potential for these species to use the waters surrounding the Proposed Development cannot be excluded.

4.4.4.3 Sensitivity of marine birds

Seabirds are sensitive to changes in the quality of the marine environment, especially to changes in fish stocks (which could affect food sources) and to oil pollution. Seabird sensitivity has been assessed for the Proposed Development (Blocks 49/21c and 49/26) and the surrounding ten Blocks, using the Seabird Oil Sensitivity Index (SOSI). The index identifies areas at sea where seabirds are likely to be most sensitive to oil pollution by looking at offshore densities (based on seabird survey data from 1995 to 2015) and species sensitivity. Species sensitivity takes into consideration factors such as habitat flexibility (a species ability to locate to alternative feeding sites), adult survival rate, potential annual productivity, and the proportion of the biogeographical population in the UK. The combined seabird data and species sensitivity index values are subsequently summed at each location to create a single measure of seabird sensitivity to oil pollution.

Table 4-7 presents the seabird sensitivity within and surrounding the Proposed Development. While data is not available for each block-month, where possible sensitivity values have been interpolated from adjacent months.

The SOSI in Block 49/21c is extremely high from November through to February, very high from March to April and low from June to September. In Block 49/26 the SOSI is extremely high in January and February, decreasing to moderate from March to April, decreasing again to low from May to September (with the exception of August being moderate), but then increasing again to high in October and November and very high in December (Figure 4-14 Drawing No. P2371S3-BIRD-001, Webb *et al.* 2016).

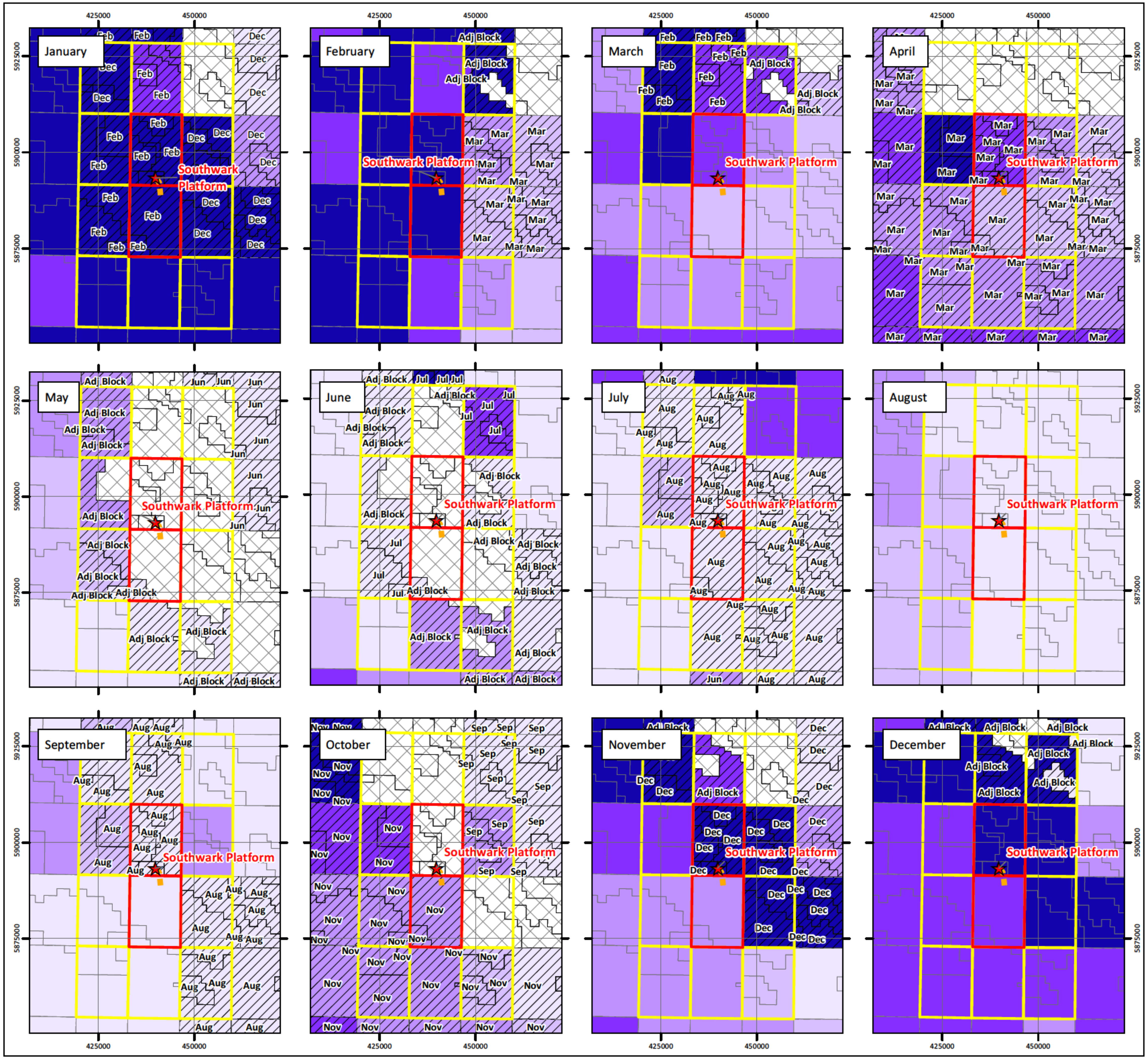
The density and distribution, and hence sensitivity, of seabirds varies throughout the year. During the pre-breeding and breeding seasons, generally between February and June, large numbers of seabirds congregate in coastal breeding colonies. Most seabird species prefer isolated sea cliffs as a breeding habitat. These habitats are relatively infrequent along the coastline adjacent to the Proposed Development. As such, the SOSI typically declines in the summer months, due to the lower densities of birds present within the licence blocks. The sensitivity of seabirds in Blocks 49/21 and 49/26 remains broadly similar, with higher sensitivities recorded in the winter months but reducing in the summer/autumn. Seabird sensitivity in Block 49/21 does remain higher further into spring as compared to Block 49/26 however, with sensitivity in Block 49/21 also increasing to extremely high in winter two months faster than Block 49/26. This difference between the two neighbouring blocks may be because Block 49/21 is found entirely within the main sandbank habitat, as opposed to Block 49/26 which extends into the relatively deeper waters beyond the sandbank. As such, Block 49/21 may offer higher quality feeding grounds for seabirds to utilise.

Table 4-7 Seabird oil sensitivity in the Proposed Development and surrounding region

Block	J	F	M	A	M	J	J	A	S	O	N	D
48/20	1*	1	1*		3**	5**	5*	5	5*		1*	1
48/25	1*	1	1	1*	4**	1**	4*	4	4*	2*	2	2
48/30	1*	1	3	3*	4**	5*	5	4	5	3*	3	2
49/16	2*	2	2*			5**	5*	5	5*		2**	1**
49/17		1*	2*			2*	2	5	5	5*		1**
49/21	**1***	**1**	**2**	**2***			**5***	**5**	**5***		**1***	**1**
49/22	1**	3*	3	3*		5**	5*	5	3	3**	1*	1
49/26	**1**	**1**	**4**	**4***	**5**	**5**	**5**	**4**	**5**	**3**	**3**	**4**
49/27	1**	4*	4	4*			5*	5	5*		1*	1
53/1	1	2	3	3*	5*	3*	5*	5	5	3*	3	2
52/5	1	1	3	3*	5	5	5	4	5	3*	3	2
53/2	1	1	3	3*	5	5	5	4	5	3*	3	2

Key	1 - Extremely High	2 – Very High	3 - High	4 - Moderate	5 - Low	No Data

Note: * Interpolated from surrounding months; ** Interpolated from surrounding blocks in the same month. Block of interest is in **bold**. **Source:** Webb *et al* (2016)



IOG SOUTHWARK ENVIRONMENTAL STATEMENT

SEABIRDS
Median Seabird Oil Sensitivity (MED SOSI)

Drawing No: P2371S3-BIRD-001 | **A**

Legend

- Southwark Platform
- Southwark Pipeline
- Licence Block of Interest
- Surrounding Licence Block
- Licence Block

Median Seabird Oil Sensitivity

- No Data
- Low
- Medium
- High
- Very High
- Extremely High
- Interpolated

Note:
Where coverage gaps are identified, data has been interpolated from the most sensitive category for the same block from adjacent months. If there are still gaps, data has been taken from the most sensitive category from directly adjoining blocks within the same month.

NOTE: Not to be used for Navigation

Date	03 March 2021
Coordinate System	ED 1950 UTM Zone 31N
Projection	Transverse Mercator
Datum	European 1950
Data Source	OGA; MarineRegions; JNCC; ESRI
File Reference	J:\P2371\Mxd\P2371S3\12_BIRD\P2371S3-BIRD-001.mxd
Created By	Chris Goode
Reviewed By	Emma Storey
Approved By	Stuart McLaren

0 10 20 30 40 km

Contains data from UKOGD.; Flanders Marine Institute (2019). Maritime Boundaries Geodatabase Exclusive Economic Zone (EEZ), version 11. Available online at http //www.marineregions.org/. https //doi.org/10.14284/386; The Seabird Oil Sensitivity Index (SOSI) Update data developed by HiDef and for a Steering Group facilitated by Oil & Gas UK is provided by Oil & Gas UK in good faith to JNCC, but Oil & Gas UK accepts no responsibility for any damage or losses that may arise from use of this SOSI dataset. © ESRI

4.4.4.4 Protected species

Most seabirds which occur on the UK continental shelf are included either in Annex I (threatened bird species) of the EC Birds Directive or are regularly occurring migratory species. The Directive requires that SPAs should be established to conserve these species. The nearest SPA is the Greater Wash SPA, which is located 34km southwest of the Proposed Development. The SPA supports breeding populations of Sandwich tern, common tern and little tern. The Greater Wash SPA also supports non-breeding populations of red-throated diver, common scoter and little gull (Natural England 2019).

Other marine birds listed as UK BAP priority species that are likely to occur in the Proposed Development include the European herring gull and Arctic skua (JNCC 2007a). The black-legged kittiwake is listed on the OSPAR List of Threatened or Declining Species and Habitats as being in decline in OPSAR Region II (the Greater North Sea), within which the Proposed Development is located (OSPAR 2021).

4.4.5 Marine mammals and reptiles

Marine mammals present in the Proposed Development are restricted to cetaceans (whales, dolphins and porpoises) and pinnipeds (seals). Chelonians (marine turtles) are the only type of reptile that may potentially be encountered.

4.4.5.1 Cetaceans

Twenty-eight cetacean species have been recorded in UK waters from sightings and strandings. Of these, eleven are known to occur regularly (DECC 2016). Cetacean abundance in the North Sea is moderate to high and both the number of species and the frequency of sightings (taken here as a measure of abundance) tends to decrease southwards through the North Sea.

Sightings data for the region surrounding the Proposed Development, presented in Table 4-8, suggests that harbour porpoise (*Phocoena phocoena*) are observed in low to moderate densities for most of the year, with high densities observed in July; and Atlantic white-beaked dolphin (*Lagenorhynchus albirostris*) are observed in low densities in January, April to May and in October. This data is reflected in surveys undertaken for the nearby Hornsea 3 offshore wind farm which found that harbour porpoise were found in significantly higher densities compared to those of white beaked dolphin (Ørsted 2018a).

Table 4-8 Cetacean sightings within the Proposed Development

Species	J	F	M	A	M	J	J	A	S	O	N	D
Harbour porpoise (*Phocoena phocoena*)		3	3	3	3	2	1	3	3			3
White beaked dolphin (*Lagenorhynchus albirostris*)	3			3	3					3		
Key	**1 – High densities**				**2 – Moderate densities**					**3 – Low densities**		

Note: Bold identifies UK BAP species (JNCC 2007b)

Source: Reid *et al.* (2003)

The SCANS III estimates (summer 2016) for cetacean abundance in European Atlantic water shows that for the Proposed Development, the species present in the highest densities were harbour porpoise (>0.3 individuals/km^2) (Hammond *et al.* 2017). Sightings from the general public in the region, published by the Sea Watch Foundation, indicate that harbour porpoise are the most common cetacean species in the area (Sea Watch Foundation 2021). Other sightings in the region include bottlenose dolphin (*Tursiops truncatus*), common dolphin (*Delphinus delphis*), Sowerby's beaked whale (*Mesoplodon bidens*), Northern bottlenose whale (*Hyperoodon ampullatus*), minke whale (*Balaenoptera acutorostrata*) and humpback whale (*Megaptera novaeangliae*).

4.4.5.2 Pinnipeds

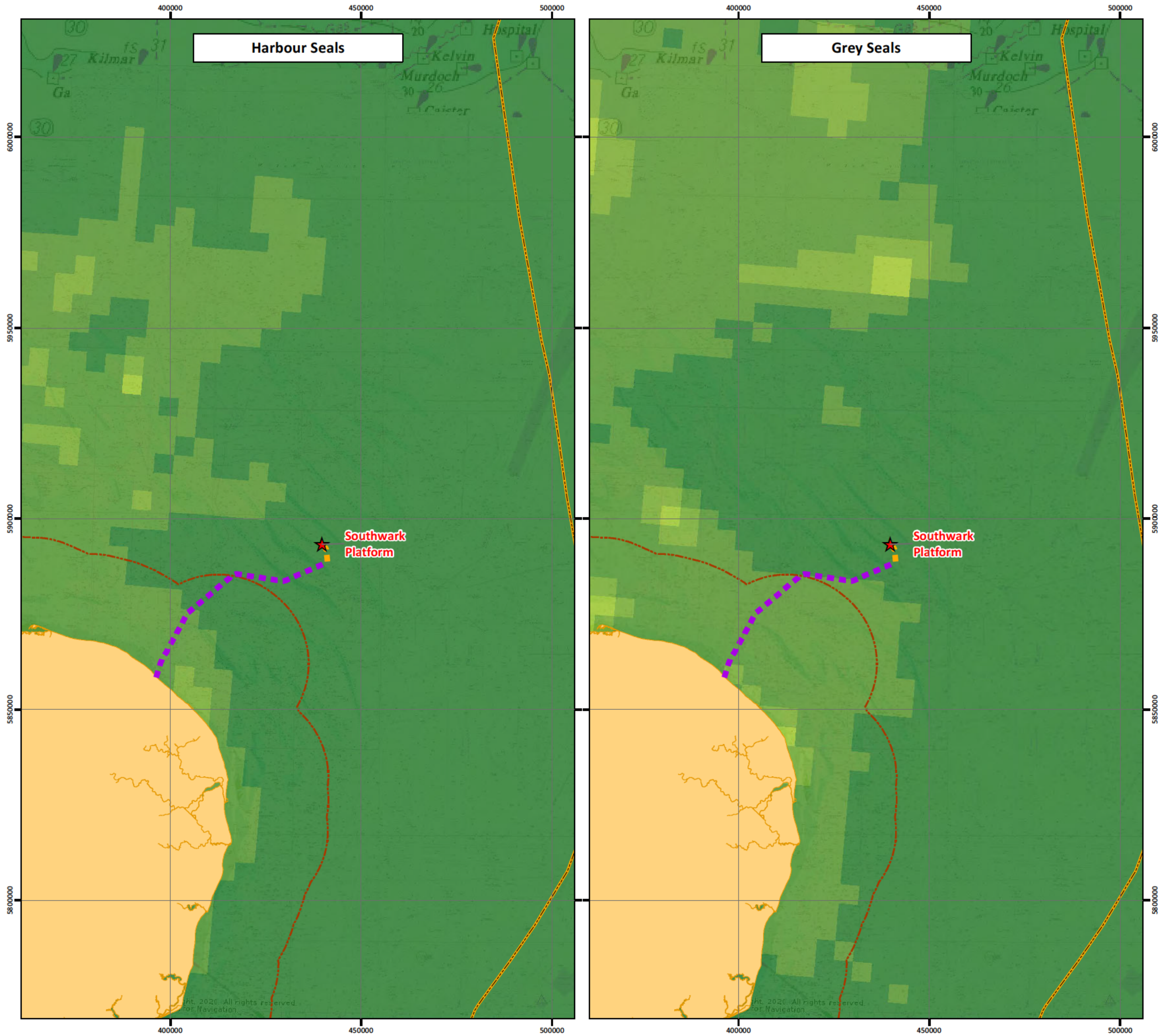
Two species of pinniped occur in the Southern North Sea: harbour seal (*Phoca vitulina*) and grey seal (*Halichoerus grypus*). Distribution of harbour and grey seal in the vicinity of the Proposed Development are presented in Figure 4-15 (Drawing No: P2371-MAMM-001).

The distribution of harbour seal at sea is limited by the need to return to land periodically. Until recently, data suggested they were unlikely to be found more than 60km from the coast, although recent telemetry studies show a wider distribution across the North Sea (Russell et al. 2017).

Harbour seal haul out, breeding and moulting sites are typically situated in sheltered estuaries and on sandbanks but they also utilise rocky areas. Harbour seal are found in high densities in The Wash and North Norfolk Coast SAC, located 67km southwest of the Proposed Development. Due to the ideal breeding and haul out conditions the site provides, the SAC contains the largest single colony of harbour seal in the UK (Duck 1995; JNCC 2016). Recent satellite imagery studies have found the foraging behaviour of the harbour seal to be very variable (IOG 2020c). Although, it is estimated that harbour seal spend only 3% of their time at distances greater than 50km from the coast (Jones *et al*. 2015).

Grey seal are observed in less abundant densities than common seal. Grey seal utilise outlying islands and remote coastlines as moulting, pupping and general haul-out sites. There are few sites of significance for grey seal along the east coast of the UK adjacent to the Proposed Development, although grey seal have been seen to forage up to several hundred kilometres from haul out sites, it is estimated that they only spent 12% of their time at distances greater than 50km from the coast (Jones *et al.* 2015).

Grey and harbour seal are found at low densities in the waters surrounding the Proposed Development, with the expected mean number of individuals estimated to be 0-1 (Russell *et al*. 2017). Given the shallow waters found around the Proposed Development and the proximity to significant seal colonies in the Wash however, there is still the potential for pinnipeds to be encountered around the Proposed Development.



IOG SOUTHWARK ENVIRONMENTAL STATEMENT

MARINE MAMMALS
Estimated Seal At Sea Usage

Drawing No: P2371-MAMM-001	A

Legend

- Southwark Platform
- Southwark Pipeline
- Thames Pipeline
- 12nm Territorial Sea Limit
- EEZ Boundary

Expected Mean Number of Seals

- 0 - 1
- 2 - 10
- 11 - 25
- 26 - 50
- 51 - 75
- 76 - 100
- 101 - 150
- 151 - 250
- 251 - 500
- 501 - 1,000
- 1,001 - 10,000

NOTE: Not to be used for Navigation

Date	03 March 2021
Coordinate System	ED 1950 UTM Zone 31N
Projection	Transverse Mercator
Datum	European 1950
Data Source	MS; UKHO; MarineRegions; MarineFind; ESRI; OSOD;
File Reference	J:\P2371\Mxd\P2371S3\11_MAMM\P2371-MAMM-001.mxd
Created By	Chris Dawe
Reviewed By	Emma Storey
Approved By	Stuart McLaren

0 10 20 30 40 km

Jones EL, McConnell BJ, Smout, S, Hammond PS and others (2015) Patterns of space use in sympatric marine colonial predators reveal scales of spatial partioining. Mar Ecol Prog Ser 534 235-249.; Contains public sector information, licensed under the Open Government Licence v3.0, from the UKHO, 2018.; Flanders Marine Institute (2019). Maritime Boundaries Geodatabase Exclusive Economic Zone (EEZ), version 11. Available online at http //www.marineregions.org/. https //doi.org/10.14284/387; Charts from MarineFIND.co.uk © British Crown and OceanWise, 2020. All rights reserved. License No. EK001-FN1001-03265 Not to be used for Navigation; Contains Ordnance Survey data © Crown copyright and database right 2013; ; ©Esri

4.4.5.3 Chelonians

Marine turtles are the only marine reptiles found in UK waters. Of the seven species of marine turtle in the world, five have been recorded in UK waters; the leatherback sea turtle (*Dermochelys coriacea*), loggerhead sea turtle (*Caretta caretta*), Kemp's ridley sea turtle (*Lepidochelys kempii*), hawksbill sea turtle (*Eretmochelys imbricata*), and (as a single occurrence – this species is generally restricted to tropical and sub-tropical seas) green sea turtle (*Chelonia mydas*). Of these, only the leatherback turtle is a regular visitor, with occasional sightings in the North Sea. These turtles are increasingly spending time in UK waters because of rising water temperatures and greater presence of the jellyfish and other gelatinous zooplankton that they prey on. In the Southern North Sea, where the Proposed Development is located, most leatherback turtle sightings up to 2017 were coastal, namely Great Yarmouth (approximately 40km southwest) (NBN Atlas 2021).

4.4.5.4 Protected species

All cetaceans and marine turtles are European Protected Species (EPS) protected in UK waters under The Conservation of Offshore Marine Habitats and Species Regulations 2017 (as amended). It is an offence to deliberately capture, kill, injure, or disturb animals classed as EPS. Harbour porpoise, grey seal and harbour seal are listed under Annex II of the Habitats Directive, which lists species whose conservation requires designation of an SAC. The Proposed Development is located within the Southern North Sea SAC, designated for the protection of harbour porpoise (JNCC 2019b).

Of the species sighted within the Proposed Development the following are included on the UK BAP list of priority species: Minke whale, common dolphin, northern bottlenose whale, white-beaked dolphin, humpback whale, Sowerby's beaked whale, bottlenose dolphin, harbour porpoise, loggerhead sea turtle, and leatherback sea turtle (JNCC 2007b). These species are identified as among those in the UK which are the most threatened and requiring conservation action to conserve their populations.

In addition, harbour porpoise are listed on the OSPAR List of Threatened or Declining Species and Habitats as being in under threat / in decline in OPSAR Region II (the Greater North Sea), within which the Proposed Development is located (OSPAR 2021).

4.5 Socio-economic environment

4.5.1 Commercial fisheries

Over 100 species of fish are commercially exploited in the North Sea. Of these, thirteen species are the primary targets for commercial fishing, either for direct human consumption or for conversion into fish meal and oil (OSPAR Commission 2000). The Proposed Development is located within ICES rectangle 35F2. The total fishing activity across all gear types from UK vessels over 15m in 2017 in terms of weight, value, and effort, for the ICES rectangle are presented in Figure 4-16 (Drawing No: P2371S3-FISH-002-A).

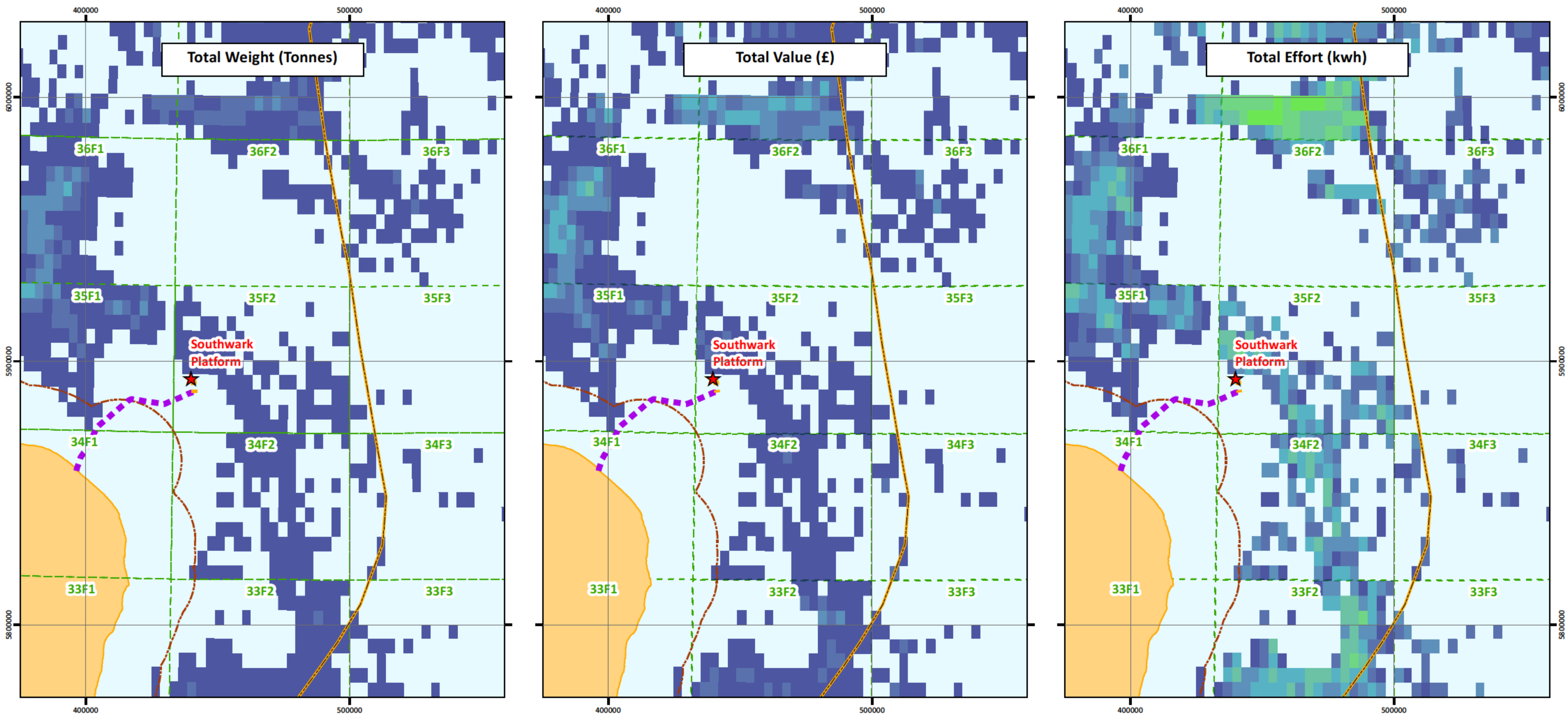
Consultation with the UK, Netherland and Belgium fishing organisations, namely the National Federation of Fishermen's Organisations (NFFO), VisNed and Rederscentrale, held in February 2021 confirmed the current understanding of the baseline presented in this section. However, it was noted that fishing grounds in the area are constantly evolving, which is discussed in Section 4.6.

4.5.1.1 Effort

An assessment of commercial fisheries efforts can provide an indication of the trends in commercial fisheries activity within and surrounding the Proposed Development (i.e. the ICES rectangle in which the Proposed Development is located and the neighbouring ICES rectangles 35F1,34F3, 34F2, 34F1, 36F1, 36F2 and 36F3). Figure 4-17 (Drawing No: P2371S3-FISH-003-A) presents the effort of fisheries targeting bottom living (demersal) fish, mid-water, and surface fish (pelagic) and passive effort targeting shellfish (including squid), derived from vessel monitoring systems data from 2017 (The UK Government 2020). The 2017 vessel monitoring systems data is currently the most recent publicly available data set. This figure shows that the most intense fisheries in the area is targeting demersal fish. However, it should be noted that Figure 4-17 (Drawing No. P2371S3-FISH-003-A) only reports the effort of vessels over 15m and thus may underestimate the coastal effort which is often dominated by passive gear effort carried out by smaller vessels. Fishing effort in ICES rectangle 35F2 is typically average compared to the neighbouring ICES rectangles, with more effort in ICES rectangle 36F1 and 35F1, similar effort in rectangle 34F2 and less effort in the remaining rectangles.

4.5.1.2 Landings

An assessment of fisheries landings over a five-year period provides an indication of the recent trends in commercial fishing activity within and surrounding the Proposed Development. Datasets of the quantity and value landed by species type are reported in the Marine Management Organisation (MMO) UK sea fisheries annual statistics reports. The average annual value of all landings from within 35F2 between 2015 and 2019, which is the most recent five-year period for which data is currently available, was £187,997 with an average quantity of 48 tonnes landed (MMO 2021). The catch data in the MMO database is subdivided into fisheries targeting demersal fish, pelagic fish, and shellfish, with information at a species level for each group. Landings tonnages and their respective values provides a good indication of the relative importance of both fisheries and species within and between areas. Table 4-9 provides an overview of the value and mass of landings by fisheries in and around ICES rectangle 35F2 between 2015 and 2019. Figure 4-18 (Drawing No: P2371S3-FISH-004-A) and Figure 4-19 (Drawing No: P2371S3-FISH-005-A) show the spatial patterns of value and mass landings within and surrounding the Proposed Development.



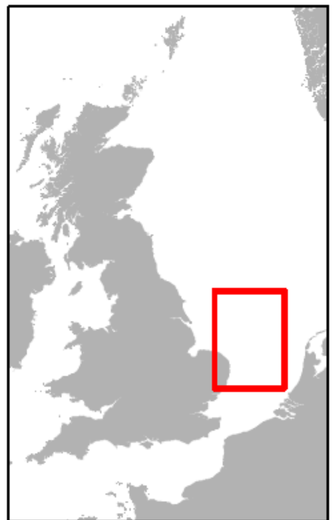
IOG SOUTHWARK ENVIRONMENTAL STATEMENT FISHING ACTIVITY - Fishing Activity for ≥ 15m UK Vessels 2017 by ICES Sub Rectangle

Drawing No: P2371S3-FISH-002 | A

Legend

- ★ Southwark Platform
- Southwark Pipeline
- Thames Pipeline
- 12nm Territorial Sea Limit
- EEZ Boundary
- ICES Rectangle

Total Weight (Tonnes)	Total Value (£ Sterling)	Total Fishing Effort (kilowatt/hours)
> 0 - 10 (Tonnes)	> £0 - £10,000	> 0 - 2,500 (kilowatt/hours)
> 10 - 20	> £10,000 - £20,000	> 2,500 - 5,000
> 20 - 40	> £20,000 - £40,000	> 5,000 - 10,000
> 40 - 80	> £40,000 - £80,000	> 10,000 - 20,000
> 80 - 160	> £80,000 - £160,000	> 20,000 - 40,000
> 160 - 320	> £160,000 - £320,000	> 40,000 - 80,000
> 320 - 640	> £320,000 - £640,000	> 80,000 - 160,000
> 640 - 1,280	> £640,000 - £1.28 million	> 160,000 - 320,000
> 1,280 - 2,560	> £1.28 - £2.56 million	> 320,000 - 640,000
> 2,560 (Tonnes)	> £2.56 million	> 640,000 (kilowatt/hours)



NOTE: Not to be used for Navigation

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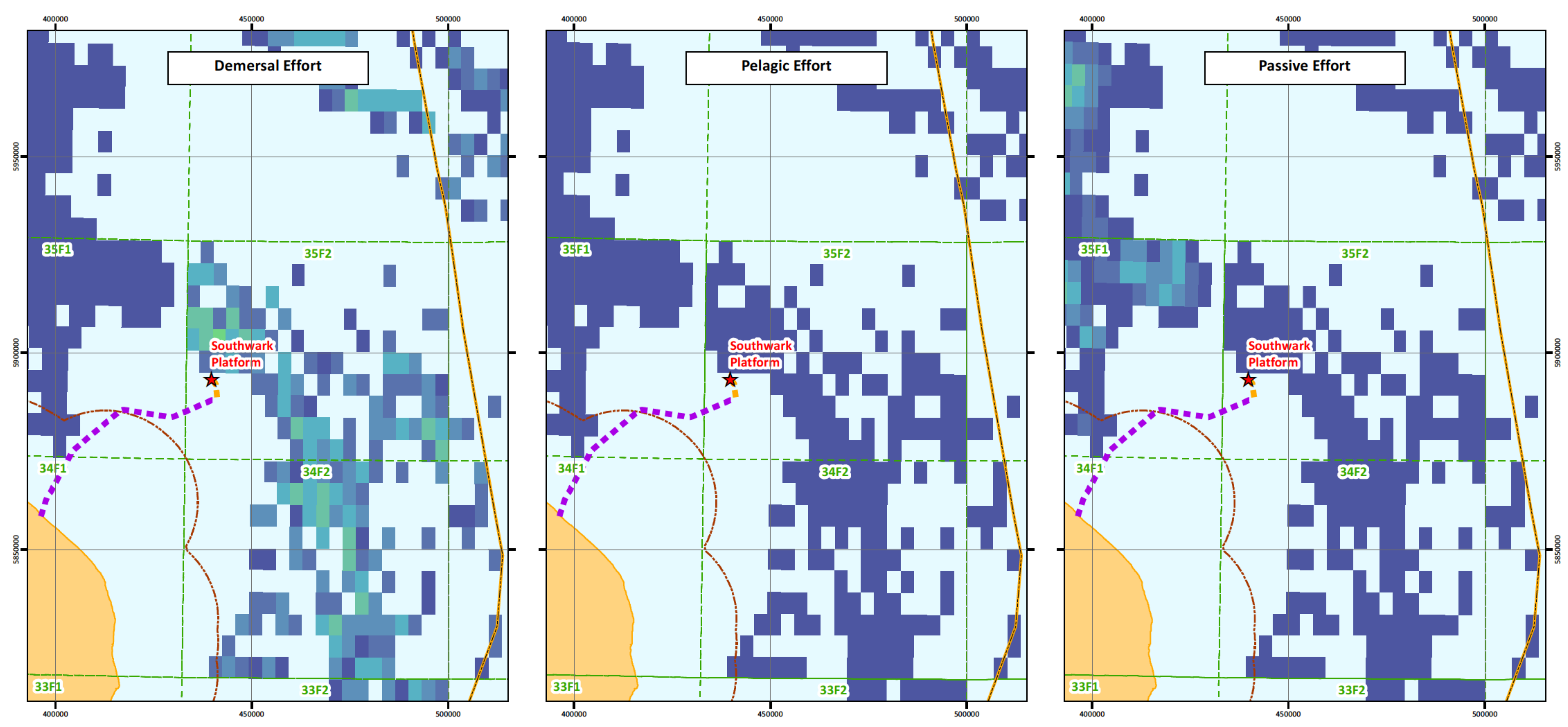
Projection	Transverse Mercator
Datum	European 1950
Data Source	UKHO; MarineRegions; ICES; MMO; GEBCO; ESRI;
File Reference	J:\P2371\Mxd\P2371S3\05_FISH\ P2371S3-FISH-002.mxd
Created By	Chris Dawe
Reviewed By	Emma Storey
Approved By	Stuart McLaren

0 20 40 60 80 km



IOG SOUTHWARK ENVIRONMENTAL STATEMENT

FISHING ACTIVITY - Fishing Effort in kwh for ≥ 15m UK Vessels 2017

Drawing No: P2371S3-FISH-003 | A

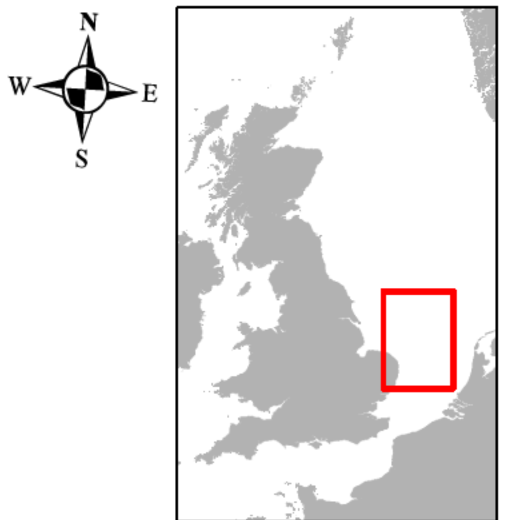
Legend

- ★ Southwark Platform
- Southwark Pipeline
- Thames Pipeline
- 12nm Territorial Sea Limit
- EEZ Boundary
- ICES Rectangle

Effort

(kilowatt/hours)

- > 0 - 2,500 (kilowatt/hours)
- > 2,500 - 5,000
- > 5,000 - 10,000
- > 10,000 - 20,000
- > 20,000 - 40,000
- > 40,000 - 80,000
- > 80,000 - 160,000
- > 160,000 - 320,000
- > 320,000 - 640,000
- > 640,000 (kilowatt/hours)



NOTE: Not to be used for Navigation

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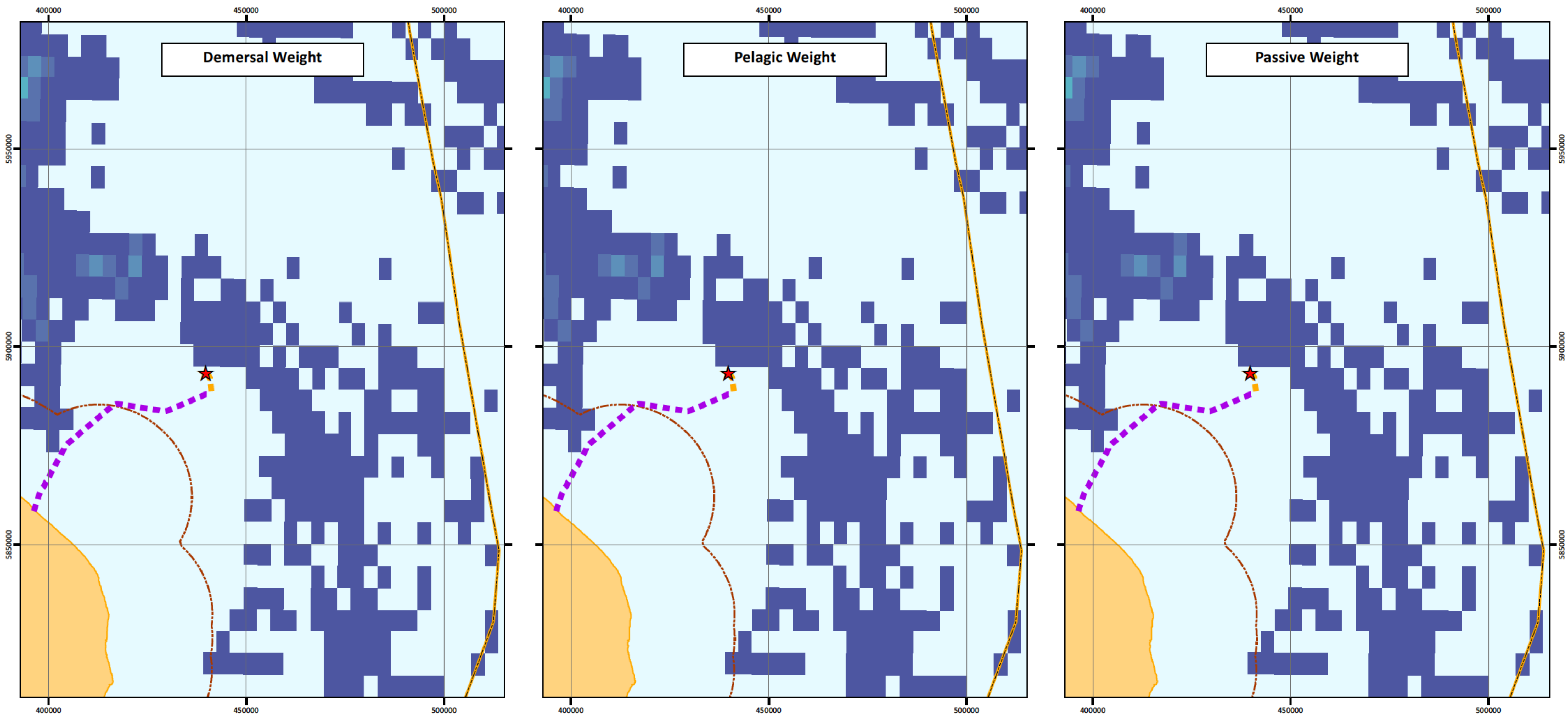
Created By	Chris Dawe
Reviewed By	Emma Storey
Approved By	Stuart McLaren

0 10 20 30 40 km



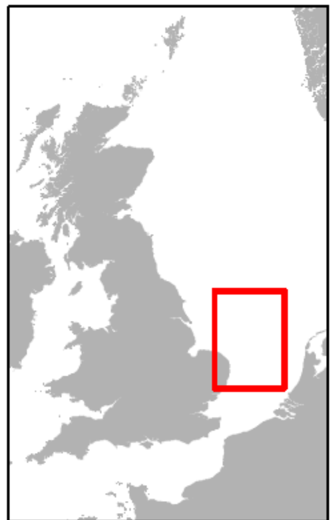
IOG SOUTHWARK ENVIRONMENTAL STATEMENT FISHING ACTIVITY - Fishing Weight in Tonnes for ≥ 15m UK Vessels 2017 Drawing No: P2371S3-FISH-004 | A

Legend

- Southwark Platform
- Southwark Pipeline
- Thames Pipeline
- 12nm Territorial Sea Limit
- EEZ Boundary

Weight (Tonnes)

- > 0 - 10 (Tonnes)
- > 10 - 20
- > 20 - 40
- > 40 - 80
- > 80 - 160
- > 160 - 320
- > 320 - 640
- > 640 - 1,280
- > 1,280 - 2,560
- > 2,560 (Tonnes)



NOTE: Not to be used for Navigation

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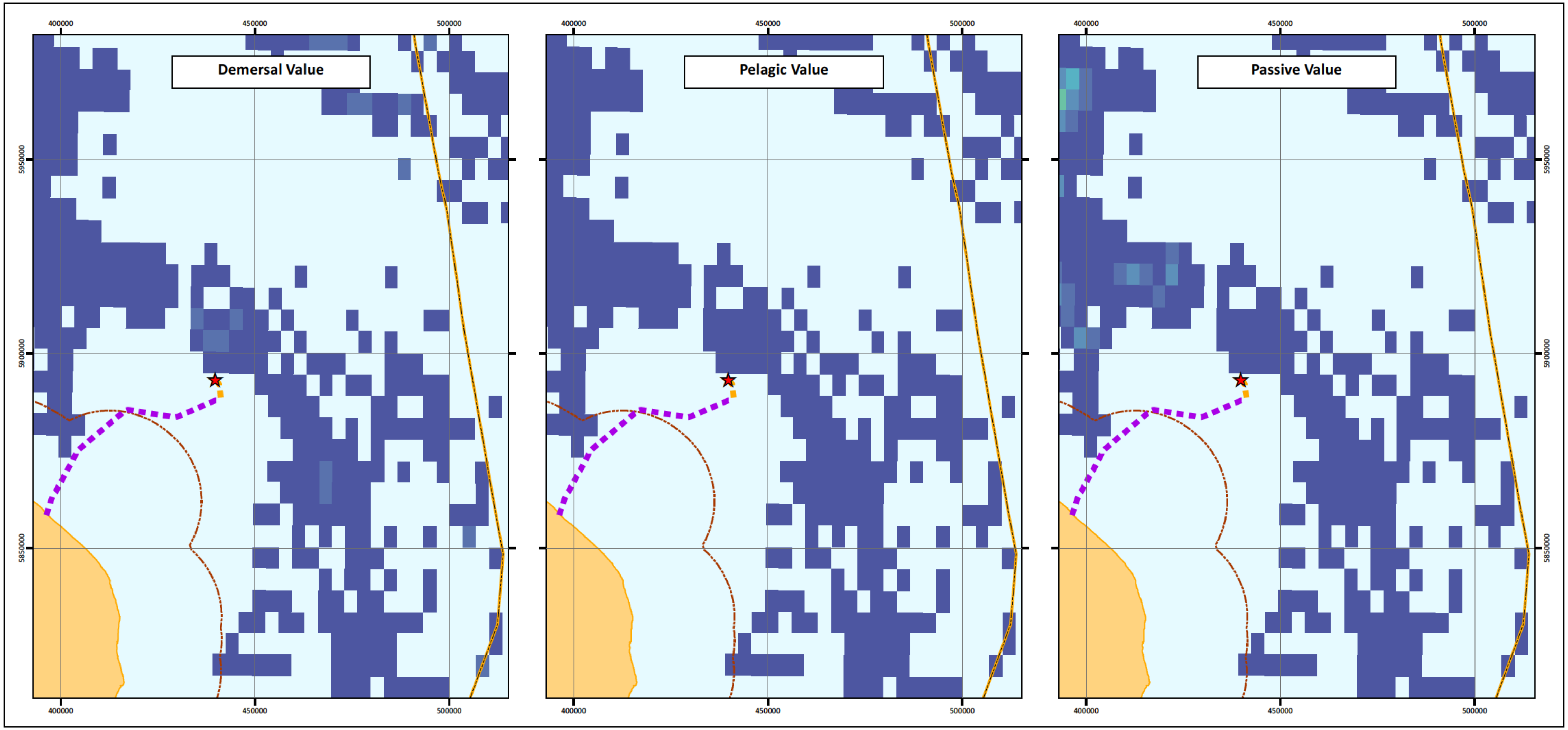
Created By	Chris Dawe
Reviewed By	Emma Storey
Approved By	Stuart McLaren

km 0 10 20 30 40



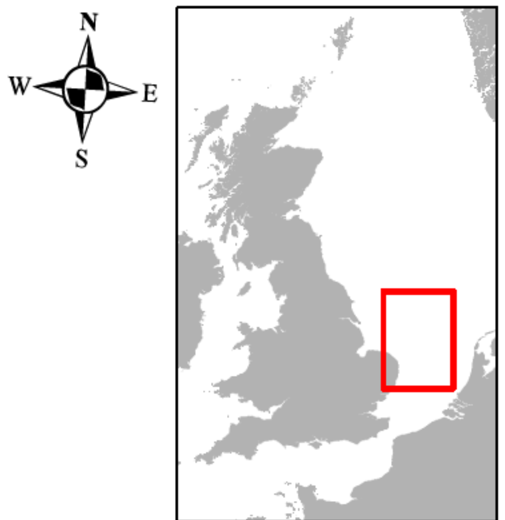
IOG SOUTHWARK ENVIRONMENTAL STATEMENT FISHING ACTIVITY - Fishing Value in £ for ≥ 15m UK Vessels 2017 Drawing No: P2371S3-FISH-005 | A

Legend

- Southwark Platform
- Southwark Pipeline
- Thames Pipeline
- 12nm Territorial Sea Limit
- EEZ Boundary

Value (£ Sterling)

- > £0 - £10,000
- > £10,000 - £20,000
- > £20,000 - £40,000
- > £40,000 - £80,000
- > £80,000 - £160,000
- > £160,000 - £320,000
- > £320,000 - £640,000
- > £640,000 - £1.28 million
- > £1.28 - £2.56 million
- > £2.56 million



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File Reference	J:\P2371\Mxd\P2371S3\05_FISH\ P2371S3-FISH-005.mxd
Created By	Chris Dawe
Reviewed By	Emma Storey
Approved By	Stuart McLaren

km 0 10 20 30 40

Table 4-9 Fishing quantity and landed values for ICES 35F2 (2015-2019)

Year	Quantity (tonnes)			Value (£)		
	Demersal	Pelagic	Shellfish	Demersal	Pelagic	Shellfish
2015	78.0	0.000	0.00	283,654	0.0	146
2016	80.0	0.000	0.03	366,215	0.0	130
2017	60.0	0.012	0.08	235,571	0.2	417
2018	6.7	0.000	3.20	15,679	0.0	4,412
2019	5.9	0.000	6.30	24,646	0.0	9,117

Note: Figures have been rounded for presentability

Source: UK Government (2020)

Over the last five years, the main trend has been a reduction in both value and quantity landed from ICES rectangle 35F2, although there was a slight increase in both from 2018 to 2019. The quantity and value landed by species type over 2015-2019, indicates that shellfish are the most landed category, while demersal are the most valuable and pelagic catch is low.

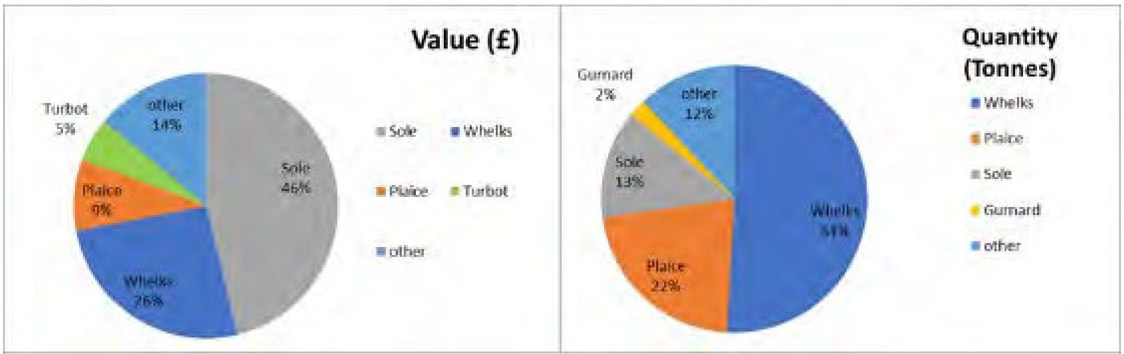
Figure 4-20 provides an overview of the total value and mass of landings in and around ICES rectangle 35F2 in 2019. Overall, both value and landed mass are considerably lower than in most of the neighbouring ICES rectangles. Further analysis revealed that the catch in the ICES rectangles closer to shore (34F1, 35F1 and 36F1) is dominated by shellfish, both in terms of value and weight.

A comparison of 2019 annual landings and value of catch in the UKCS for demersal, pelagic and shellfish by the MMO highlighted that commercial fisheries within ICES 35F2 is of low to medium importance for demersal, pelagic and shellfish fisheries when compared with the rest of the UKCS (UK Government 2020). Distribution of shellfish are concentrated towards the inshore area within ICES 35F2.

Figure 4-20 Annual value and weight within and around ICES rectangle 35F2 for 2019

Figure 4-21 presents the top five species by catch value (£) and by weight (tonnage) landed in ICES rectangle 35F2 in 2019. This illustrates that whelk was the most landed species in 2019 (51% of total quantity landed), whereas sole was the most valuable target and also accounted for the highest percentage (46%) of value landed. Fishing in ICES rectangle 35F2 is dominated by whelk and sole.

Figure 4-21 Top five most valuable (£) and most commonly landed by weight (tonnes) species in ICES rectangle 35F2, for 2019.



Source: UK Government (2020)

The most common gear type used for fishing in ICES rectangle 35F2 in 2019 was beam trawl, accounting for 95% of all landings (The UK Government 2020).

4.5.2 Shipping and navigation

The Oil and Gas Authority (OGA) provided an indication of the levels of shipping activity for each Block during the 29th Offshore Licensing round (shipping density was not issued during the 30th, 31st or 32nd Offshore Licensing Rounds). This considers tankers, cargo, ferries, and other offshore ships. Shipping density is high in Block 49/21 (OGA 2016). The Proposed Development is in relatively open waters, however, the Southern North Sea region experiences high densities of shipping activity, particularly in the south, and major shipping lanes run approximately parallel to the entire length of the coast (DECC 2016).

4.5.2.1 Shipping

The waters of the UKCS include busy shipping lanes with some 486.1 million tonnes of goods shipped to and from the United Kingdom in 2019 (Department for Transport 2020). Figure 4-22 (Drawing No: P2371S3-SHIP-001-A) below shows that there is a low fishing vessel density all year round in the Proposed Development, with activity focused to the northeast of the development area. In addition, Figure 4-23 (Drawing No: P2371S3-SHIP-002-A) shows that there is a shipping presence in the ICES rectangle and the pipeline will cross a medium dense area with respect to shipping activity; although shipping activity is generally concentrated to the north, east and southeast of the Proposed Development.

A desktop Vessel Traffic Survey (VTS) was conducted for the Southwark study area (10NM around the Southwark platform) for the period 31st March 2019 to 30th March 2020 (Xodus 2021b). The objective of this study was to outline the vessel traffic in the vicinity of the Blythe, Elgood and Southwark platforms and present the vessel collision risk assessments. During the period analysed, 16 shipping lanes/established patterns of vessel movement were identified in the Southwark study area, comprising a total of 2,874 vessel tracks. Figure 4-24 presents the shipping lanes identified by the VTS from processed track data and shows that most shipping lanes are located either northeast and southwest of the Proposed Development. The route between Tees (England) and Antwerp (Belgium) being the busiest with 1,264 tracks (44%) across the study year. Table 4-10 below presents the shipping lane traffic in the Southwark study area divided into cargo, tanker, and other lane traffic.

Table 4-10 Shipping lane vessel tracks by vessel type category in the Southwark 10 NM study area

Vessel Type Category	Number of Tracks	Percentage of Total
Cargo Traffic	1,604	55.8
Tanker Traffic	964	33.5
Other Lane Traffic	306	10.6
Total Shipping Lane Traffic	2,874	

Source: Xodus (2021b)

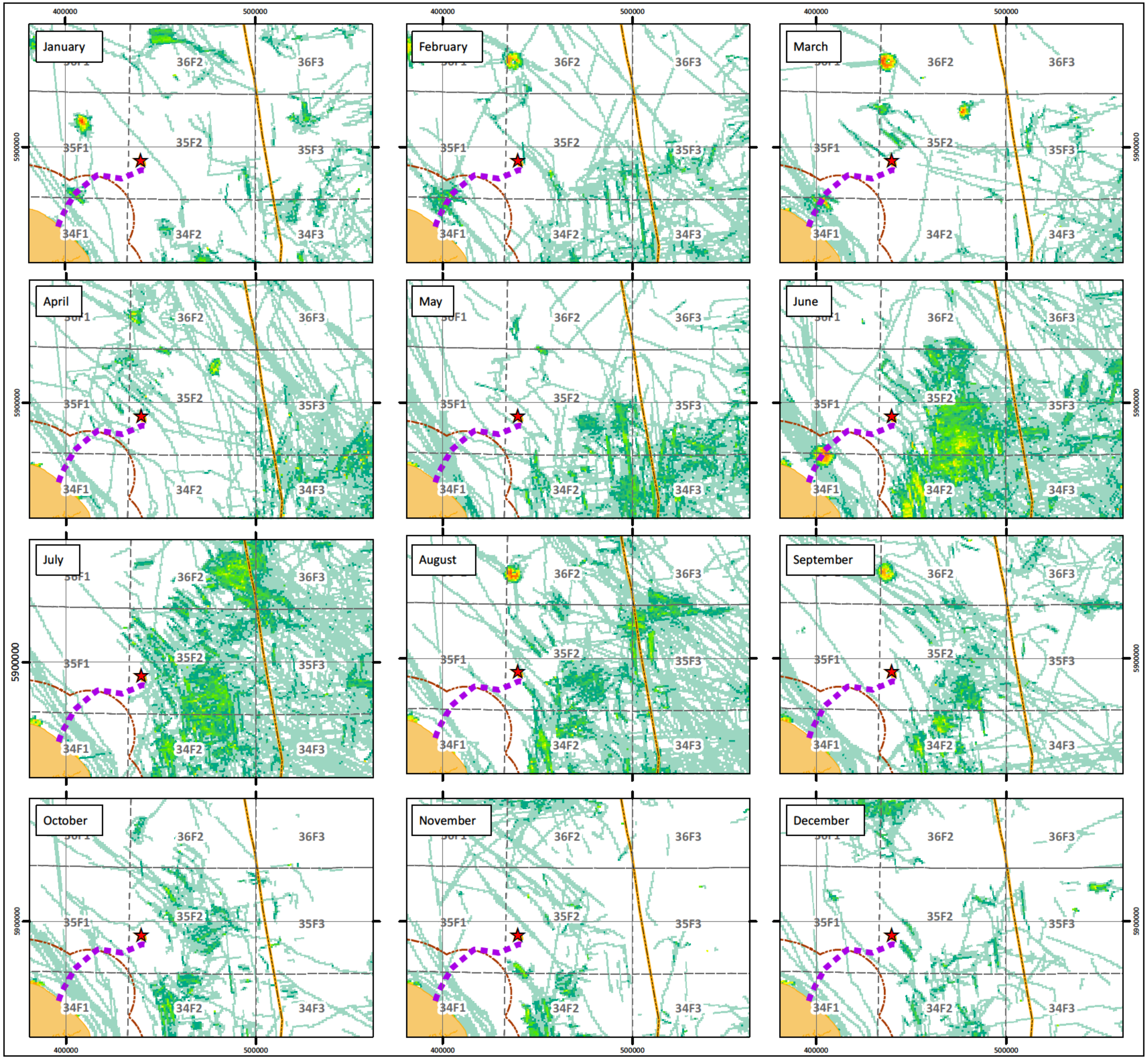
Compared to Blythe and Elgood, Southwark experiences the lowest volumes of in-field traffic with 887 vessel tracks passing through the 10 NM study area. These tracks are predominantly from vessels servicing the nearby Leman platforms. Safety vessels operating in the vicinity of the Proposed Development appear to be servicing the oil and gas infrastructure, particularly to the south of Southwark, whilst supply vessels service both offshore wind farms and oil and gas infrastructure (Xodus 2021b).

The VTS study revealed that the Southwark field was crossed by a lower number of fishing tracks compared to the Blythe and Elgood fields. The presence of fishing vessels does not necessarily indicate the presence of fishing activity in the study area and may represent vessels in transit. There are several vessel transits noted as actively fishing directly to the east of Blythe and Elgood, with fishing vessels seeming to actively avoid the Dudgeon and Dudgeon Extension wind farms.

However, fishing activity (Automatic Identification System (AIS) points from vessels with a status set to actively fishing) seems to be relatively higher in the Southwark field which exhibited a larger number of AIS points actively fishing, particularly to the south-east of Southwark and to the east of the Leman platforms (Xodus 2021b).

4.5.2.2 Navigational features

The Proposed Development is situated within relatively open waters. Within the 10 NM VTS study area surrounding Southwark, there are multiple surface infrastructure features including the Europa, Jupiter Ganymede, South Valiant, Vulcan 1 and various Leman platforms.



IOG SOUTHWARK ENVIRONMENTAL STATEMENT

SHIPPING ACTIVITY
2019 Monthty Vessel Densities
Fishing Vessels

Drawing No: P2371S3-SHIP-001	A

Legend

- Southwark Platform
- Southwark Pipeline
- Thames Pipeline
- ICES Rectangle
- 12nm Territorial Sea Limit
- EEZ Boundary

Vessel Density (Fishing Vessels)

Vessel Hours per km² (Log Scale)

100

10

0

N W E S

NOTE: Not to be used for Navigation

Date	03 March 2021
Coordinate System	WGS 1984 UTM Zone 31N
Projection	Transverse Mercator
Datum	WGS 1984
Data Source	UKHO; MarineRegions; EMODnet; OSOD; ESRI;
File Reference	J:\P2371\Mxd\P2371S3\07_SHIP\ P2371S3-SHIP-001.mxd
Created By	Chris Dawe
Reviewed By	Emma Storey
Approved By	Stuart McLaren

iog intertek

km 0 30 60 90 120

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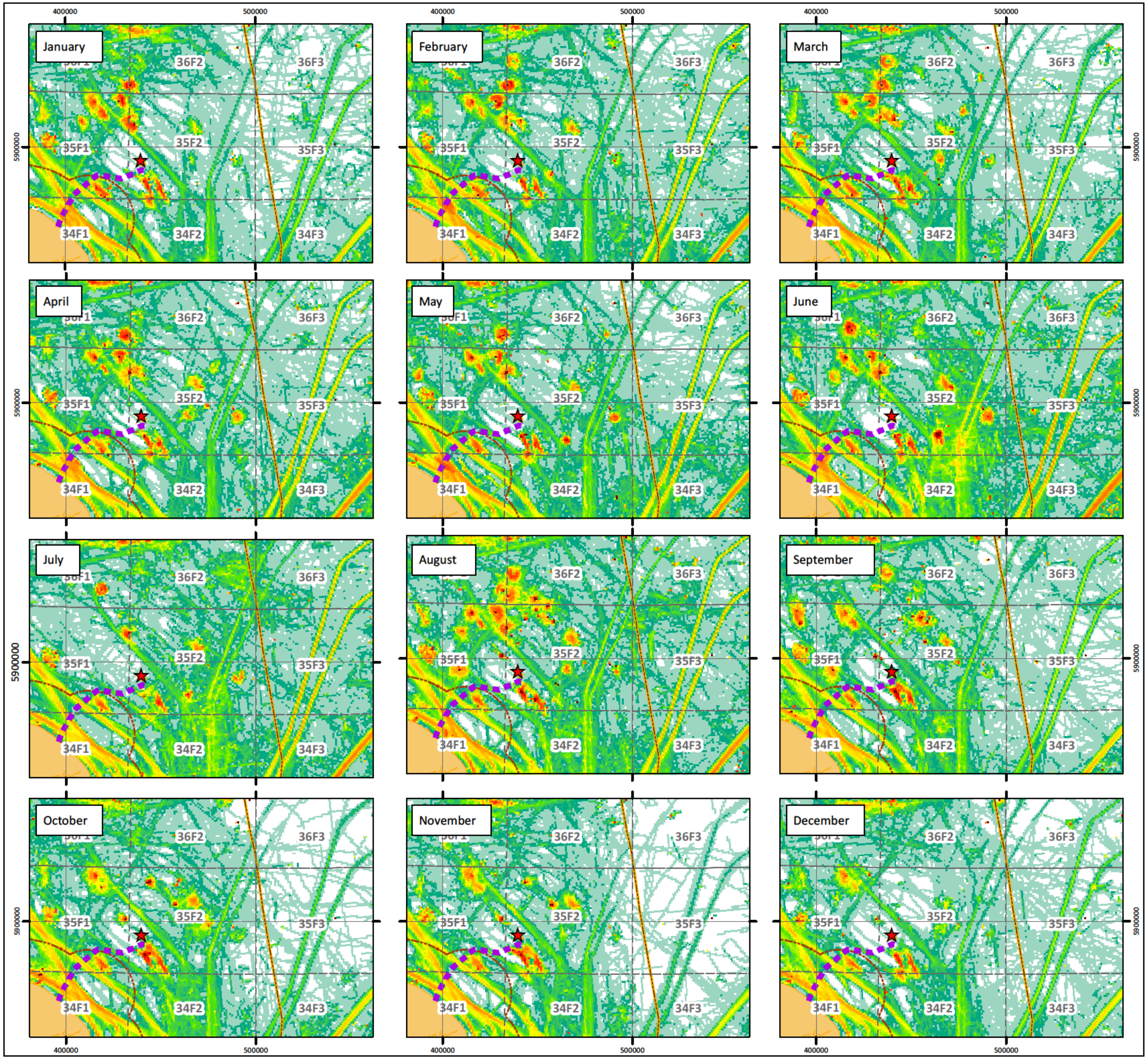

IOG SOUTHWARK ENVIRONMENTAL STATEMENT

SHIPPING ACTIVITY
2019 Monthly Vessel Densities
All Vessels

Drawing No: P2371S3-SHIP-002	A

Legend

- Southwark Platform
- Southwark Pipeline
- Thames Pipeline
- ICES Rectangle
- 12nm Territorial Sea Limit
- EEZ Boundary

Vessel Density

Vessel Hours per km² (Log Scale)

100

10

0

N E S W

NOTE: Not to be used for Navigation

Date	03 March 2021
Coordinate System	WGS 1984 UTM Zone 31N
Projection	Transverse Mercator
Datum	WGS 1984
Data Source	UKHO; MarineRegions; EMODnet; OSOD; ESRI;
File Reference	J:\P2371\Mxd\P2371S3\07_SHIP\P2371S3-SHIP-002.mxd
Created By	Chris Dawe
Reviewed By	Emma Storey
Approved By	Stuart McLaren

iog intertek

0 30 60 90 120 km

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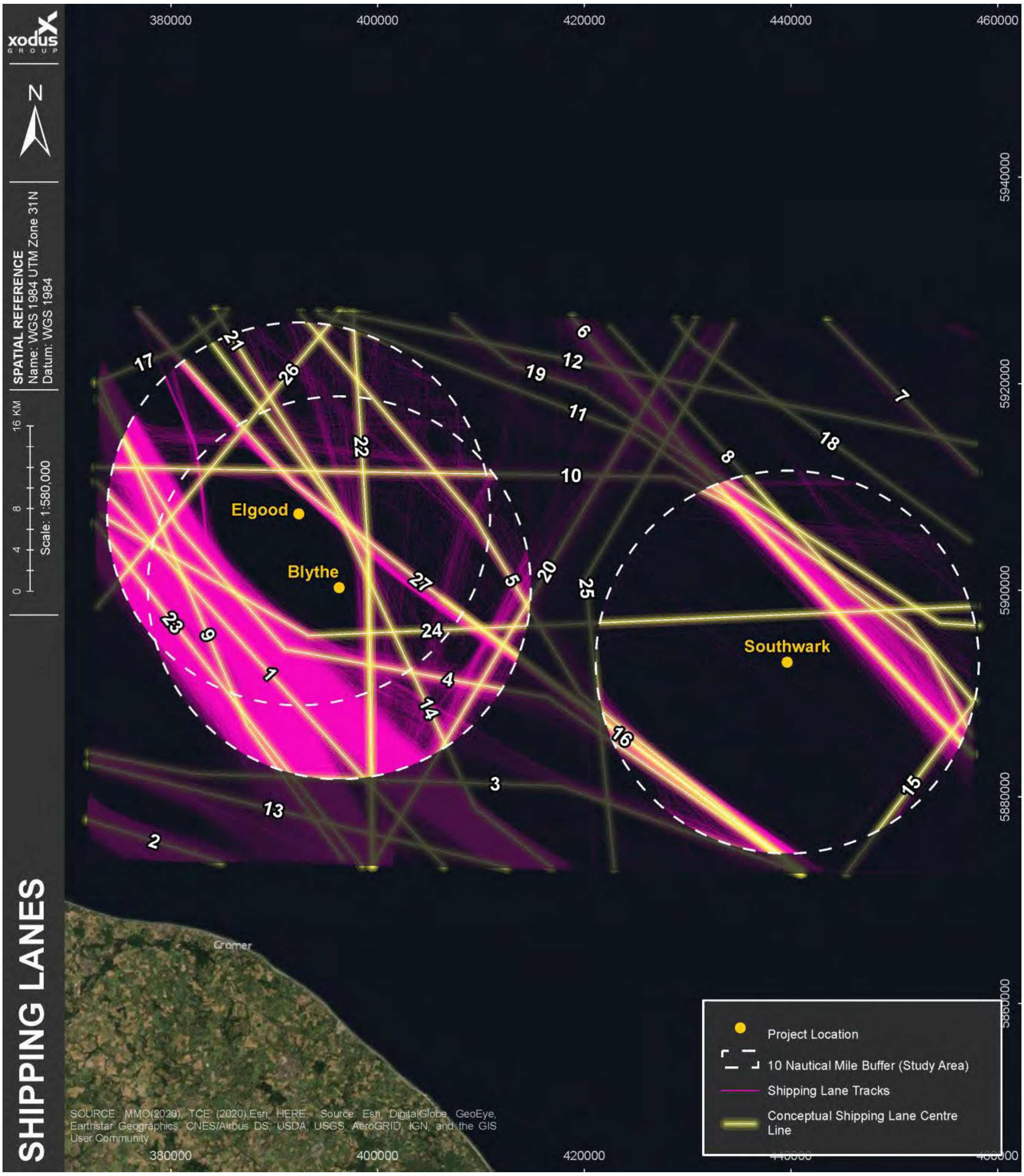
Figure 4-24 Shipping lanes identified by the VTS from processed track line data



Source: Xodus (2021b)

4.5.3 Other marine users

The SNS is a busy area of the North Sea with regards to the oil and gas industry and other marine users. There are several different sea users which are active in the region. Table 4-11 lists the closest instances of each type of seabed user occurring within 40km of the Proposed Development. Figure 4-25 (Drawing No: P2371S3-INFR-001-A) shows the marine infrastructure in the vicinity of the Proposed Development.

Table 4-11 Marine users

Marine user	Name	Distance (km)	Bearing (° True)
Pipeline	Leman G to Leman F (PL364)	2.45	209
Well	49/21-8A (CHRYSAOR PRODUCTION LIMITED - Abandoned Phase 3)	0.13	221
Platform	LEMAN G (SHELL)	2.43	209
Telecommunication cable	TAMPNET	18.61	90
Disposal site	HU142 - Ower Bank disposal site (closed)	0.41	248
Military Practice Area	Neatishead (Air Combat Training)	38.57	16
Sailing route	RYA route to Oostende	18.48	222
Windfarm	East Anglia North Tranche One West (Norfolk Vanguard West)	25.57	146
Aggregate dredging	Humber 3 (Area 484) (DEME Building Materials)	32.1	347

No sites of marine archaeological interests or aquaculture sites have been identified within 40km of the Proposed Development (Crown Estate 2021).

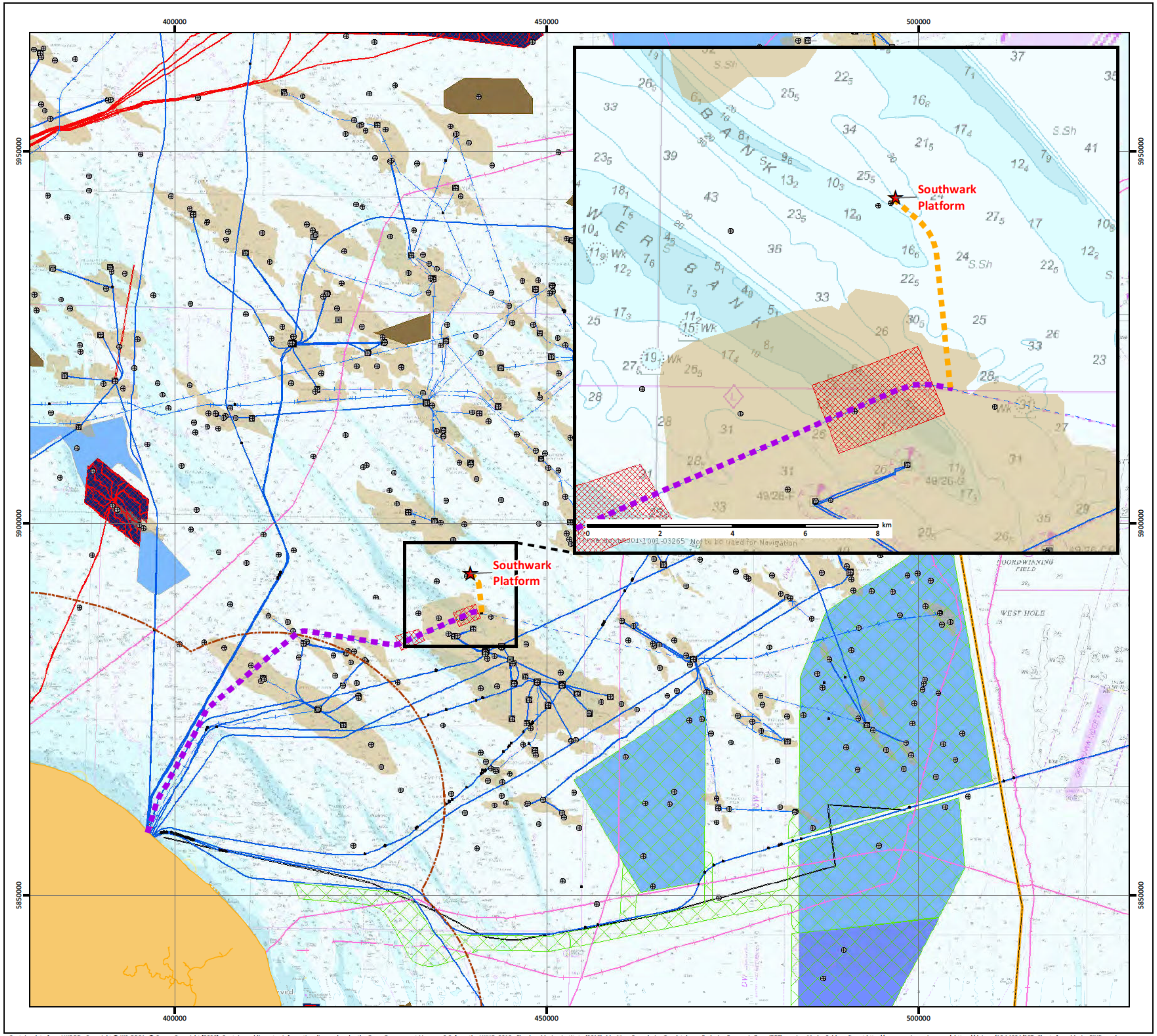
The oil and gas industry in the SNS is dominated by gas developments with a comprehensive network of installations (177 gas platforms in the SNS) and pipelines in Quadrants 43, 44, 47, 48 and 49. Gas pipelines serving the platforms of the SNS connect to terminals at Bacton, Theddlethorpe and Easington/Dimlington (DECC 2016). The closest platforms being the Leman platforms (2.4km to Leman G) operated by Shell and the Vulcan 1 platform (8.6km) operated by Chrysoar.

The Southern North Sea is traversed by ferry routes emanating from the north and travelling to mainland Europe, with the Hull to Rotterdam and Hull to Zeebrugge routes being the closest to the Proposed Development. Figure 4-26 (Drawing No: P2371S3-REC-001-A) shows the intensity of recreational yachting in the area as low.

4.5.4 Unexploded ordnance (UXO)

Offshore, most UXO encountered in the SNS is expected to be the result of wartime use, particularly associated with naval operations during both Word War I and World War II and with airborne operations during World War II (Cheong et al. 2020). UXO range in size from sub-kg size objects up to devices containing more than 700kg of high explosive (HE), e.g. mines, depth charges and torpedoes.

The Proposed Development is within an area which saw an extremely high level of wartime activity. This included attacks on coastal shipping routes, the laying of individual mines and minefields, and overflight by military aircraft. A desktop study of the potential for encountering UXO at the Southwark platform site (Ordtek 2021) indicated that the Southwark platform lies within an area where encounters with large UXO (projectiles, depth charges and torpedoes) is possible. Charge weights for these types of ordnance ranged up to 730kg but were typically around 250kg. It is considered likely that this reflects the situation along the pipeline route.



IOG SOUTHWARK ENVIRONMENTAL STATEMENT

INFRASTRUCTURE
Other Marine Uses

Drawing No: P2371S3-INFR-001 | A

Legend

- Southwark Platform
- Southwark Pipeline
- Thames Pipeline
- 12nm Territorial Sea Limit
- EEZ Boundary

Infrastructure
- Well
- Terminal
- Platform
- Subsurface Infrastructure

Cables
- Power
- Telecom
- Telecom (Disused)

Pipelines
- Proposed
- Active
- Abandoned
- Removed
- Hydrocarbon Field

Disposal Sites
- Open
- Closed
- Disused

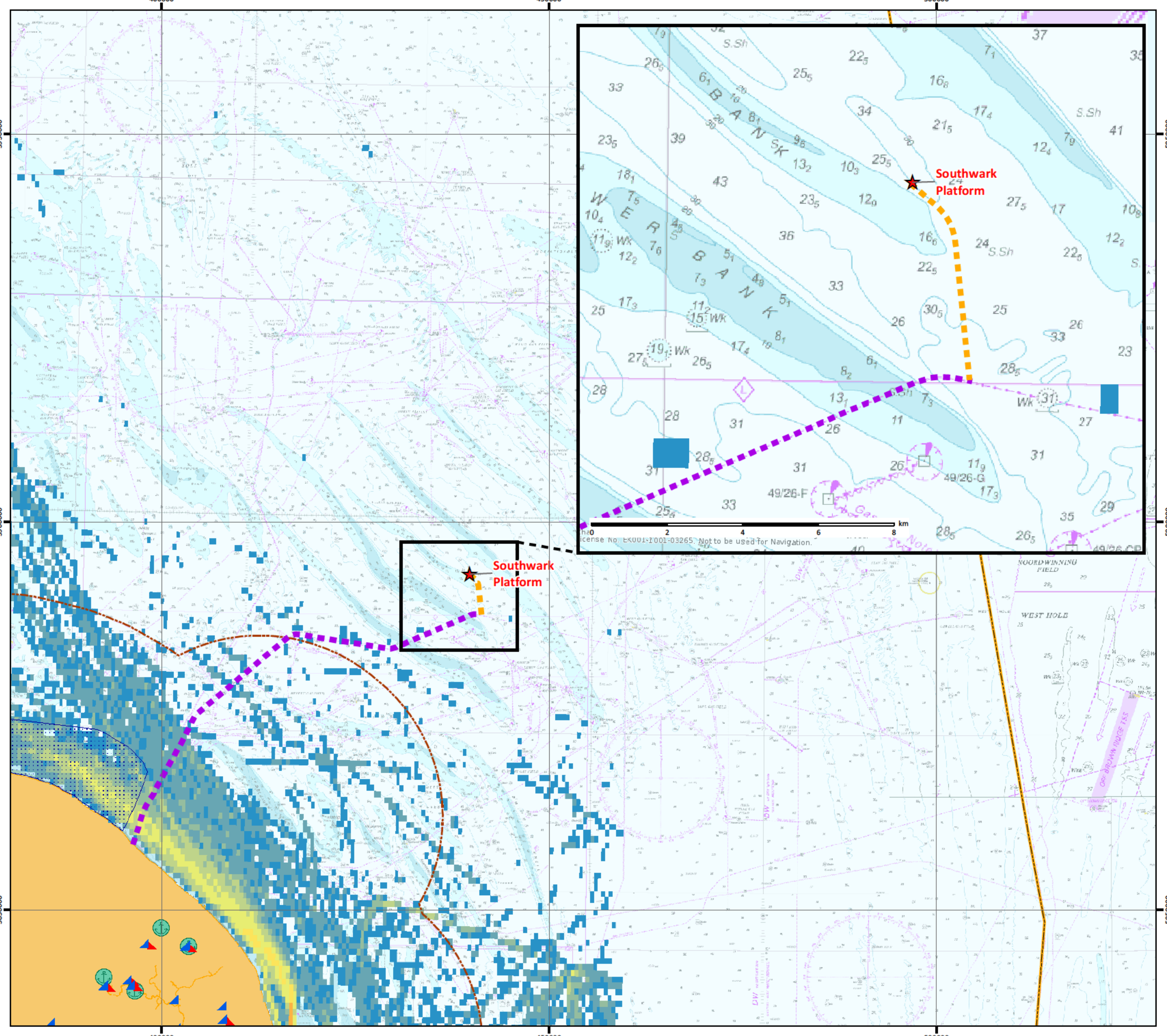
Marine Aggregates
- Aggregate Production

Offshore Windfarm
- Active/In Operation
- Consented
- In Planning

NOTE: Not to be used for Navigation

Date	03 March 2021
Coordinate System	ED 1950 UTM Zone 31N
Projection	Transverse Mercator
Datum	European 1950
Data Source	OGA; KISCA; TCE; UKHO; MarineRegions; MarineFind; ESRI; OSOD;
File Reference	J:\P2371\Mxd\P2371S3\08_INFR\P2371S3-INFR-001.mxd
Created By	Chris Dawe
Reviewed By	Emma Storey
Approved By	Stuart McLaren

0 5 10 15 20 km



IOG SOUTHWARK ENVIRONMENTAL STATEMENT

RECREATIONAL BOATING
RYA Coastal Atlas

Drawing No: P2371S3-REC-001 | **A**

Legend

- Southwark Platform
- Southwark Pipeline
- Thames Pipeline
- 12nm Territorial Sea Limit
- EEZ Boundary

RYA UK Coastal Atlas of Recreational Boating

- RYA Club
- RYA Training Centre
- Marina
- General Boating Area

AIS Intensity (Recreational Yachting)

- Low
- High

N S W E

NOTE: Not to be used for Navigation

Date	24 February 2021
Coordinate System	ED 1950 UTM Zone 31N
Projection	Transverse Mercator
Datum	European 1950
Data Source	RYA; UKHO; MarineRegions; MarineFind; ESRI; OSOD;
File Reference	J:\P2371\Mxd\P2371S3\10_REC\ P2371S3-REC-001.mxd
Created By	Chris Dawe
Reviewed By	Emma Storey
Approved By	Stuart McLaren

0 5 10 15 20 km

4.6 Natural evolution of the baseline

This description has been compiled using the Offshore Energy Strategic Environmental Assessment 3 (DECC 2016) and the Marine Climate Change Impacts Report Card 2020 (MCCIP 2020).

The baseline environment is not static and will exhibit some degree of natural change over time due to naturally occurring cycles and processes. Over the last 11,000 years seabed habitats around the UK have been subject to change associated with post-glacial trends in sea level, climate, and sedimentation. In the shorter term, seasonal, inter-annual and decadal natural changes in benthic habitats, community structure and individual species population dynamics may result from physical environmental influences (e.g. episodic storm events; hydroclimatic variability i.e. hot summers and cold winters; and sustained trends) and/or ecological influences such as reproductive cycles, larval settlement, predation, parasitism and disease.

The sandbank habitat surrounding the Proposed Development, changes on an annual basis, as evident from the survey data acquired by IOG and more widely by other bathymetric surveys. It is currently thought that the sandbanks are elongating, very slowly, in a north-easterly direction (JNCC 2017a). This elongation and migration is aided by the strong currents that the banks closer to shore are subject to, which are maintained by offshore sediment transport. These banks, as opposed to those further offshore which are found in areas of weaker currents, feature the best developed sandwaves in the area, which are in constant evolution and movement due to strong current conditions present. While the positioning of the sandbanks and waves themselves may change over time, due to the continual circulation of new sediment in the area new banks and waves will continue to form into the foreseeable future. It is predicted that over the lifetime of the Proposed Development, although there may be local changes to mobile bedforms, the overarching habitat type will not change.

The effects of climate change are predicted to affect various habitats and species in UK waters in different ways. For example, increasing sea surface temperatures are likely to result in fish species that are typically found in warmer waters (such as anchovy *Engraulis encrasicolus*) being found in greater numbers within the North Sea. Other species that may be affected include sandeel which may shift their distribution to deeper, colder waters further north. This shift could lead to reductions in population due to the lack of coarse sandy sediment habitat further north that sandeel are typically associated with (Ørsted 2018b). A reduction in population of important prey species in the North Sea, such as sandeel, could lead to reductions in available prey for seabird and marine mammal species, in turn resulting in shifts in distribution/reduction in these populations. In addition to these potential effects, it is expected that climate change will:

- Increase the number of invasive non-native species;
- Shift the distribution of habitats and species;
- Lead to a reduction in certain habitat and species (e.g. blue mussel, predicted to decline significantly in number by 2050 and set to be lost completely by 2100);
- Increase the risk of disease to species from new pathogens as their distributions shift; and
- Result in an increase in storms which could damage areas of high biodiversity.

Taken this information into consideration, it is expected that over the lifetime of the Proposed Development (18 years) habitats could be affected by shorter term seasonal events (i.e. storm events) but longer term effects as a result of climate change may also be observed.

Discussion with local fishermen has indicated that despite demersal fishing being the current dominant method of fishing in the region, static gear fishing and fishing for shellfish are predicted to increase in effort in the coming years. This is partly due to changes in the sediment composition of the seabed making the region less suitable for demersal fish species and more habitable for crustacean and shellfish species.

5. ENVIRONMENTAL HAZARDS, EFFECTS AND MITIGATION MEASURES

5.1 Environmental Impact Assessment (EIA) methodology

5.1.1 Introduction

The impact assessment has been carried out in three stages:

1. Definition of the existing baseline environment– see Section 4.
2. Identification of the activities that have the potential to impact the baseline environment.
3. Assessment of the significance of the impact. This has been based on the potential severity of the impact and the probability of the impact occurring. The assessment ensures that potential risks are considered and that activities will be carried out in accordance with all current legislation and good industry practice. The susceptibility of the Proposed Development to a natural disaster and/or climate change is also discussed within this Section.

The potential for transboundary and cumulative impacts has been assessed, both within the Proposed Development, or when combined with other external activities. This is discussed in Section 7. The potential impacts of an unplanned event are discussed separately in Section 6.

5.1.2 Impact assessment criteria

Potential environmental impacts have been categorised using severity classes adapted from the environmental risk assessment guidance produced by UK Offshore Operators Association (UKOOA) (1999) as presented in Table 5-1.

Table 5-1 Severity classification

Severity class		Criteria
1	Negligible	Change unlikely to be noticed against background variability.
2	Minor	Change within normal variability but could be noticed / monitored. Some users may need to modify behaviour.
3	Moderate	Localised effect but with full recovery back to existing variability. May contribute to cumulative impact. Nuisance potential to some users.
4	Major	Medium term (2 year) change in ecosystem or activity over a wide area with recovery to normal variability likely within 10 years.
5	Severe	Long term (10 year) change to ecosystem over wide area with low probability of recovery to normal range.

These potential impacts have been assessed using a risk matrix shown in Table 5-2, based upon International Standard BS EN ISO 17776:2002. This has been adapted for use by Intertek to provide the criteria for oil and gas operations.

Risk is a term in general usage to express the combination of the likelihood of a specific impact occurring and the severity of the consequences that might be expected to follow from it. For this assessment, the likelihood and severity of the impact is considered once standard mitigation inherent in the design of the operation is incorporated e.g. measures taken to ensure legal compliance.

The assessment considers the possibility that a receptor group may be exposed to several different potential impacts under each activity and that for each impact there may be different combinations of severity and likelihood e.g. low severity and high likelihood or high severity but low likelihood. Risk is scored according to the worst-case combination provided similar mitigation and controls apply to both.

Table 5-2 Risk matrix

Severe [5]	Severity	5-A	5-B	5-C	5-D	5-E
Major [4]		4-A	4-B	4-C	4-D	4-E
Moderate [3]		3-A	3-B	3-C	3-D	3-E
Minor [2]		2-A	2-B	2-C	2-D	2-E
Negligible [1]		1-A	1-B	1-C	1-D	1-E
		Likelihood				
		Very Low [A]	Low [B]	Medium [C]	High [D]	Very High [E]
		Plausible but no known occurrences in the industry	Plausible and believed to have occurred in the industry	Possible (known isolated occurrences in the North Sea region)	Probable (several known occurrences in the North Sea regions)	Very likely (expected to occur)

The coloured zones in Table 5-2 indicate broad risk acceptability and tolerability levels as follows in Table 5-3:

Table 5-3 Risk acceptability levels

(green)	**Acceptable:** Risks are accepted without further reduction other than the routine management process of continual improvement.
(orange)	**Tolerable:** Risks which are acceptable provided that the residual risk has been subject to feasible and cost effective mitigation.
(red)	**Unacceptable:** Risks cannot be justified under the current criteria.

Impacts are discussed in detail in Section 5.2 onwards.

5.1.3 Mitigation of potential impacts

Mitigation measures are the actions or systems that are used, or have been proposed, to manage the potential risks identified. They may take the form of reducing:

- The probability of a triggering event occurring;
- The probability of an event having an impact; and
- The severity of the potential impact.

Mitigation is an integral part of the Proposed Development. All the potential impacts identified from this project are subjected to either standard recognised good practice mitigation measures or to impact specific, feasible and cost-effective mitigation. The mitigation measures considered pertinent for each environmental and social issue are outlined in the individual technical sections.

Mitigation measures are discussed, in association with potential impacts, in Section 5.2 onwards.

5.1.4 Residual impact assessment

Where the initial impact assessment indicated that mitigation measures are required (i.e. a conclusion of tolerable or unacceptable risk is reached) the assessment is repeated taking into consideration good practice and proposed mitigation measures. This determines whether there is likely to be a significant residual impact following the implementation of mitigation.

Impacts assessed as unacceptable or tolerable after consideration of proposed mitigation measures will normally require additional analysis and consultation to discuss and further mitigate potential impacts. Where further mitigation is not possible a residual impact may remain.

5.2 Summary of impact assessment scores

The assessment is based on the Proposed Development programme outlined in Section 3, the Proposed Development footprint (see individual sections below) and on the environmental baseline described in Section 4. The scores applied during the initial assessment of the risk the activities pose to the environment are summarised in Table 5-4 below. Where the cells in Table 5-4 remain blank, there is not expected to be a pathway for an effect. All impacts considered in the initial risk assessment are **acceptable**.

Table 5-4 Risk matrix - summary of initial assessment results

	Environmental receptor											
Aspect	**Air quality**	**Water quality**	**Seabed sediment**	**Plankton**	**Benthos**	**Fish and shellfish**	**Seabirds**	**Marine mammals**	**Protected sites**	**Shipping**	**Commercial fisheries**	**Other marine users**
Subsea infrastructure												
Physical presence										2-C	2-C	2-C
Seabed disturbance			3-C		3-C	1-A			3-C		2-C	
Generation of atmospheric emissions	1-B											
Marine discharges		2-C	2-C		2-C	2-C	2-C		2-C		2-C	2-C
Generation of underwater sound - vessels				1-A		1-B		1-C	1-A			
Generation of underwater sound – UXO detonation (pre mitigation)				3-B		3-B		4-B	4-B			
Generation of underwater sound – UXO detonation (post mitigation)				3-B		2-B		3-B	3-B			
Human health and population	This aspect has been scoped out of the assessment due to the distance of the pipeline installation activities from human populations.											

5.3 Physical presence

5.3.1 Impact assessment

This assessment concluded that the risk posed to the environment by the physical presence of the Proposed Development is acceptable.

A temporary safety exclusion zone will be established around installation vessels for the duration of the operation (approximately 65 days, excluding hydrotesting and tie-ins which will be within existing 500m safety zones). The size of the exclusion zone will depend on the type of vessel. A standard 500m radii zone (area of 0.79km^2) will be used for most vessels with restricted manoeuvring capacity. If an anchored pipelay vessel is used anchors are likely to extend approximately 1km to the front and bank of the vessel and 500m to the sides, covering a total area of 2km^2. Other traffic in the region will be asked to remain outside of the anchor footprint, with anchor support tugs present to manage this exclusion area.

Fishing vessels may be displaced by the presence of the exclusion areas and installation activity between the Southwark platform and the Thames to Bacton pipeline (PL370) tie-in point locations as seabed preparation, pipelay and support vessels travel between the two. In addition, the pipeline may be exposed on the seabed between pipelay and trenching, creating a snagging risk. Guard vessels will be present to protect the pipeline for periods when it is exposed on the seabed prior to burial.

5.3.1.1 Commercial fisheries

The assessment of fisheries statistics indicated that demersal fisheries are the most important fishery in the vicinity of the Proposed Development. Fishing activity in the area is typically average compared to the neighbouring ICES rectangles, with more effort in ICES rectangle 36F1 and 35F1, similar effort in rectangle 34F2 and less effort in the remaining rectangles.

Fishing activity seems to be relatively higher in the Southwark field, compared to the Blythe and Elgood fields, which exhibited a larger number of AIS points actively fishing, particularly to the south-east of Southwark and to the east of the Leman platforms (Xodus 2021b). During installation works these passing vessels are expected to increase their clearance to the south.

There is potential that fishing vessels may be displaced from their fishing grounds due to the presence of a temporary exclusion zone around each of the seabed preparation, pipelay and support vessels.

The impact area of each of the seabed preparation and support vessels is between approximately 0.79km^2 and 2km^2 per vessel (depending on the vessels used). The areas affected by the installation vessels are therefore small and are of limited duration (up to 65 days). In addition, if the pipeline is exposed before burial, guard vessels will be present until the pipeline is buried, reducing the risk that fishing gear can become snagged. Once installation is complete there will be no further exclusion zones or disruption unless in the unlikely event that remedial works are required for upheaval buckling.

It is possible that fishing may be impacted through the introduction of potential snagging points for fishing nets and trawls. During installation the presence of guard vessels at times when the pipeline is exposed seeks to mitigate this risk. During operation, the pipeline will be buried with between 90-100% sediment coverage, therefore the snagging risk will be largely removed.

5.3.1.2 Shipping and navigation

The pipeline installation operations have the potential to disrupt shipping routes as the anchor initiation, pipelay, trenching and guard vessels each travel between the Southwark platform and the Thames to Bacton pipeline (PL370). 16 shipping lanes/established patterns of vessel movement were identified in the Southwark study area (10NM around the Southwark platform), by a desktop Vessel Traffic Survey (Section 4.5.2.1).

Most of the shipping lanes are located either northeast and southwest of the Proposed Development. These routes are predominantly from vessels servicing the nearby Leman platforms and none of the shipping lanes cross the pipeline route. Safety vessels operating in the vicinity of the Proposed Development appear to be servicing the oil and gas infrastructure, particularly to the south of Southwark, whilst supply vessels service both offshore wind farms and oil and gas infrastructure. Such vessels will typically pass a minimum distance of 1NM from ongoing offshore operations involving vessels restricted in their manoeuvrability. There is sufficient sea room for vessels to change passage without causing a significant nuisance to their routes.

5.3.2 Mitigation measures

Table 5-5 presents mitigation measures that will be adopted in the Proposed Development.

Table 5-5 Mitigation measures – physical presence

ID	Mitigation measures
M1	Project vessels will follow the international maritime organisation (IMO) standards to reduce the likelihood of collision i.e. will comply with Standard Marking Schedule. This includes requirements for navigation, lighting, obstruction lighting and beacons.
M2	Users of the sea will be notified of the presence and intended movements of the project vessels via the Kingfisher Fortnightly Bulletins, Notices to Mariners and very high frequency (VHF) radio broadcasts.
M3	Guard vessels will be utilised to prevent other none-project vessels entering the Proposed Development area during pipeline installation, and to protect the pipeline prior to burial.

5.3.3 Residual impact

Once pipeline installation is complete, the pipeline will be buried, and all installation and support vessels will be removed. Therefore, after the short-term impact during installation it has been assessed that there will be no residual impacts from the activities.

5.4 Seabed disturbance

5.4.1 Quantification of footprint

It is important to quantify the seabed footprint of Proposed Development activities to determine the extent of the impact on seabed habitats in the area. A seabed footprint will result from: anchor lay vessel (although it is unlikely that this will be used for pipelay), pipeline anchors, sandwave clearance, dredging and trenching, pipeline installation and tie-in, and contingency remediation works, as discussed below.

5.4.1.1 Project vessels anchors

There is potential that an anchored pipelay vessel may be used for pipeline installation. An anchor will also be used for pipeline initiation (see Section 3.2.2.3). The estimated seabed footprint of the anchors is 1,015m^2. This will be a temporary deposit.

5.4.1.2 Sandwave clearance, trenching and dredging

As detailed in Section 3.2.2.2, sandwave clearance will have a total seabed footprint of 374,220m^2. The trenching footprint will be within the same disturbance corridor as the sandwave clearance and is therefore not considered within the overall footprint.

At the Southwark platform and the Thames pipeline tie-ins, localised dredging will be undertaken as described in Section 3.5. The estimated seabed footprint from dredging activities is 1725m^2.

5.4.1.3 Pipeline installtion and tie-in

In order to protect the spool pieces at the pipeline tie-in locations (Southwark platform and Thames pipeline), an estimated 200 mattresses and 2900 grout/sand bags will be required. The seabed footprint from these deposits will be approximately 3928m^2.

5.4.1.4 Contingency rock remediation works

The requirement for remedial operations during the lifetime of the Proposed Development is dependent on the occurrence of upheaval buckling. Since it is not possible to predict where upheaval buckling will occur, it has been assumed that approximately 10% of the pipeline route may require remediation in the form of rock protection over the project lifetime, covering an area of 3000m^2.

The pipeline will be installed below mean seabed level therefore there is a high degree of confidence that rock remediation works for free-spans will not be required.

5.4.2 Impact assessment - North Northfolk Sandbanks and Saturn Reef SAC

This assessment concluded that the risk posed to the marine environment by the potential seabed disturbance of the Proposed Development is tolerable.

The Proposed Development is located within the North Norfolk Sandbanks and Saturn Reef (NNSSR) Special Area of Conservation (SAC). Therefore, the assessment has focused on potential impacts to the designated features of this site which includes:

- Annex I habitat- Sandbanks which are slightly covered by sea water all the time; and
- Annex I habitat - Reefs

A detailed description of these features is provided in Section 4.3.2.2.

The Haisborough, Hammond and Winterton SAC is located 15km southwest of the Proposed Development. Given the distance to this site and that direct effects from the installation will be localised, effects to this SAC are not considered further. In addition, it is not expected that the sediment plume created during sandwave clearance and trenching works will travel to this site. Displacement of sediments during trenching will be very localised with resuspended coarse sediments settling out within approximately 100m and resuspended fine sediments settling out within 1-2km of the pipeline route (Gooding et al 2020).

5.4.2.1 Proportion of NNSSR affected

The NNSSR SAC covers an area of 3,603.41km^2. Table 5-6 details the percentage of the site that will be affected by pipeline installation activities.

Table 5-6 Proportion of NNSSR SAC effected by pipeline installation and associated activities.

Aspect	Footprint km^2	% of SAC effected	Nature of footprint
Sandwave clearance, trenching and dredging	0.3760	0.01	Temporary
Anchoring (pipeline and if required anchor lay barge)	0.001015	0.00003	Temporary
Mattresses and grout/sand bag deposition bags at tie-in locations	0.003928	0.0001	Permanent - however, dependant on decommissioning
Indicative contingency rock remediation works	0.003	0.00008	Permanent - however, dependant on decommissioning
Temporary	**0.38**	**0.01**	-
Permanent	**0.007**	**0.0002**	-

5.4.2.2 Conservation objectives and associated impact

The conservation objectives for the NNSSR SAC are detailed in full in Section 4.3.2.2. JNCC's view on the qualifying features 'Annex I Sandbanks which are slightly covered by sea water all the time' and 'Annex I Reefs' is that they are both in an unfavourable condition.

For Sandbanks which are slightly covered by seawater all of the time the conservation objectives include the following attributes and objectives:

- Extent and distribution – restore;
- Structure and function – restore; and
- Supporting processes - maintain.

For reefs the conservation objectives include the following attributes and objectives:

- Extent and distribution - restore; and
- Supporting processes - restore.

5.4.2.3 Seabed disturbance from sandwave clearance, trenching and dredging

Background information

The comparative assessment undertaken for the Proposed Development concluded that sandwave clearance and burial of the pipeline to below mean seabed level represents the Best Practicable Environmental Option (BPEO).

The Proposed Development is located in a morphodynamically active environment with evidence of actively migrating sandwaves that are characteristic of the North Norfolk sandbank system. Given the mobility of sandwaves in the region it is not possible to estimate the exact locations of sandwave clearance activities. Therefore, the assessment assumes that pre-sweeping will be undertaken at any point along the pipeline route, from the Thames pipeline tie-in to the Southwark platform tie-in.

The proposed route crosses the sandwaves at varying angles, depending on the location along the route, meaning there is the potential for relatively large cross-sections of individual sandwaves to be levelled for transversal crossings, compared with perpendicular crossing sandwaves. It has been calculated that during sandwave clearance and trenching approximately 575,000m^3 of sediment will be disturbed; resulting in a seabed footprint of 374,220m^2.

The footprint of trenching will be within the footprint of sandwave clearance and will not create an additional disturbance footprint. The assessment assumes that controlled flow excavation (CFE), trailing suction hopper dredger (TSDH) or seabed excavators will be used to clear sandwaves to the mean seabed level. For trenching below the mean seabed level either CFE, jet trenching or a mechanical plough with backfill be used. The assessment considers all techniques and presents the worst-case impacts from each combination.

To aid the tie-in at the Southwark platform and Thames pipeline, localised dredging will be undertaken. This dredging is likely to be conducted using a CFE or diver operated suction dredger. The material dredged will be deposited within 100m of the dredged area. It is estimated that that dredging will remove approximately 3450m^3 of sediment and will result in a seabed footprint of 1750m^2.

During sandwave clearance, trenching and dredging the material moved will be deposited on the seabed near the pipeline corridor, constituting an additional seabed footprint. This will be in the form of mounds. It is not possible to estimate the seabed footprint from this deposited sediment, however this will be within 2NM of the Proposed Developed and this sediment will remain within the NNSSR SAC.

Impact assessment

This section considers each of the conservation attributes and targets for the sandbank feature (extent and distribution, structure and function and supporting processes) in turn. It assesses whether the project activities and associated impacts could hinder the achievement of the conservation objectives and therefore adversely affect the integrity of the European site.

The closest known occurrences of *Sabellaria spinulosa* are located 5-10km from the Proposed Development, therefore the impacts from sandwave clearance, trenching and dredging to Annex I Reef will not be considered further. The indirect effect from sediment plumes to Annex I Reefs is discussed in Section 5.4.2.4 below.

One of the criteria in the Comparative Assessment was to look at the temporal recovery of conservation objectives/ attributes (sediments and benthic communities). The CA concluded that based on the conservation objectives, the removal of sandwaves and subsequent burial of the pipeline below the mean seabed level was the best BPEO as this option minimised the impacts to the conservation objectives.

1110 Sandbanks which are slightly covered by sea water all of the time

Extent and distribution

Objective – Restore: 'Activities must look to minimise, as far as is practicable, changes in substratum and the biological assemblages within the site to minimise further impact on feature extent and distribution'

The seabed within the direct zone of the sandwave clearance, dredging and trenching will be temporarily disturbed. This disturbance is a one-off event, but the seabed along the pipeline route could be disturbed on two discrete occasions within approximately a 2-3-month period. The first occasion will be for sandwave clearance or dredging; which will include deposition of dredged sediment; and the second occasion will be trenching (and deposition of mounds) along the full length of the pipeline. Trenching will be undertaken within the footprint of the sandwave clearance corridor. This footprint represents 0.01% of the NNSSR SAC area.

The impacts to the seabed will vary depending on which of the three possible methods are used for the sandwave clearance (CFE, TSHD and seabed excavators) and trenching (CFE, jetting and ploughing). None of the methods will significantly change the composition of the substrate and dredged material will be repositioned close to the levelled area and still within the extent of the SAC therefore the extent and distribution of the habitat will be retained in the sandbank system.

CFE is a method proposed for both sandwave clearance and trenching. With CFE the majority of the levelled sediment would be pushed aside, creating mounds adjacent and along the length of the pipeline corridor. The size of the potential mounds are unlikely to be larger than the surrounding sand wave features, although they will have a different orientation to the features. During CFE, the larger grains of suspended sediments will settle out of suspension first, with the finer sediment remaining in suspension for longer. This natural sorting of sediment within the plume will mean that the sediment composition within the area of largest sedimentation will principally remain the same as within the levelled area.

The TSHD and the seabed excavator methods both involve dredging a slurry of sediment from the seabed and side casting it in proximity to the dredged area creating deposition mounds on the seabed. For TSHD this sediment may also be discharged from the hopper within 2NM of the Proposed Development. Although the mounds constitute an additional area of seabed disturbance to that of the levelled area, the method is more accurate than the CFE method and the disturbance to the seabed will be fairly localised.

Jet trenching is more accurate and targeted than CFE with simultaneous backfill during the operation. This method involves fluidisation of the seabed with sediment temporarily entrained in the water column. A large proportion of this would be deposited within the trench or immediately adjacent to it as particles settle out of suspension, with little impact on the extent and distribution of the designating feature.

If the plough method is used, a backfill run will be carried out immediately post-ploughing, meaning that any berms associated with the side-cast would only be present for a very short period of time, reinstating the seabed to its original state.

The methods used for sandwave clearance, dredging and trenching will cause a temporary and localised flattening of sandwave features (this is discussed further in the Structure and Function Section below) along with the subsequent deposition of mounds along the length of the pipeline corridor. However, all of the displaced sediment will remain within the local area and in time, the sediment mounds will winnow down, infilling the adjacent trench or being incorporated into the nearby sandwaves as part of the sediment transport regime. Therefore, the extent and distribution of the substrate would not significantly change following sandwave clearance.

The Proposed Development is within an area of actively evolving sandwaves, influenced by the tidal and wave conditions across the wider North Norfolk sandbank system and SNS. The sandwave bedforms located within the pipeline corridor are migrating, bifurcating and converging, as presented in Xodus (2021c) (Technical Appendix G), with significant differences in structure and form noted each year. Therefore, given that sediment removed during sandwave clearance and trenching will remain within the vicinity of the Proposed Development, this sediment will become quickly re-distributed by the sediment regime in the area and will not alter the extent of the sandwaves within the SAC.

Biological assemblages within the SAC which may be temporarily disturbed by the sandwave clearance, dredging and trenching are also expected to recover within the short term. The sandbanks of the NNSSR SAC are characterised by the biotopes A5.233: *Nephtys cirrosa* and *Bathyporeia* spp in infralittoral sand and A5.231: Infralittoral mobile clean sand with sparse fauna (Jenkins et al 2015). The species which inhibit these biotopes are short lived and widespread.

Both biotopes are very similar, characterised by well-sorted medium and fine sublittoral sands and occur in sediments subject to physical disturbance, as a result of wave action (and occasionally strong tidal streams). The mobility of the sediment leads to a sparse and species-poor community, with polychaetes (*Nephtys cirrosa*), and burrowing amphipods (*Bathyporeia spp*.) characterising the biotopes. Consequently, the species inhabiting these biotopes are adapted to high levels of disturbance. The species present must either be able to withstand mobility of sediments through physical robustness, mobility and ability to re-position within sediments such as *Nephtys cirrosa* and the mobile amphipods and/or are able to recover rapidly to population losses following severe erosion. Characterising species typically have opportunistic life history strategies, with short life histories (typically two years or less), rapid maturation and extended reproductive periods. For example, *Bathyporeia spp*. are short-lived, reaching sexual maturity within 6 months.

Nephtys cirrosa is a relatively long-lived polychaete with a lifespan of six to possibly as much as nine years. However, the genus has a relatively high reproductive capacity (matures at one year with females releasing between 10,000 and 80,000 eggs) and widespread dispersion during the lengthy (12 month) larval phase. It is therefore, likely to have a high recoverability following disturbance. Adults are mobile and capable of swimming and are therefore able to migrate in and out of the biotope.

This indicates the community might be considered ‘mature’ only a few days or weeks after a storm event, as the mobile species displaced from the biotopes and those from adjacent areas colonise the substratum via the surf plankton. Even following severe disturbances recovery would be expected to occur within a year. Biotope recoverability is therefore assessed as ‘high’ for any level of impact (Tillin et al 2019). The activities associated with the installation of the pipeline will result in a one-off localised disturbance along the length of the pipeline route. Given the high resilience of the species present, recovery from any loss of fauna will be achieved within a year and will not result in a reduction to the extent or distribution of the biological assemblages.

Conclusion: there will be no significant effect from sandwave clearance, trenching and dredging to the extent and distribution of the Annex I Sandbank habitat.

Structure and function

Objective – Restore: 'Activities must look to minimise, as far as is practicable, disturbance and changes to the sediment composition, finer scale topography and biological communities within the site'

Pre-sweeping of the sandwaves will temporarily change the morphology of the sandbank feature along the length of the pipeline, flattening it within the sandwave clearance corridor (approximately 60m wide). This will affect a very small proportion of the SAC (0.01%). Sandwaves and Sandbanks are naturally subject to variations in topography based on the dynamic nature of the environment and therefore may be subject to large fluctuations in height, evident by the changes in topography observed between the 2018 and 2020 survey data. Any localised changes in the topography of the sandbanks will be within the natural variation of topography experienced within the SAC. In addition, given the highly dynamic environment and mobile nature of the sandbank sediments, any disturbance will be localised and restoration of the sandwave features is predicted to occur in the medium-term (two to ten years).

This conclusion is supported by evidence of sandbank recovery following construction disturbance at the Racebank OWF (Ørsted 2018a and b). Racebank OWF is located approximately 78km to the NWN of the Proposed Development. Localised sandwave levelling was undertaken at 19 locations in 12 sites during construction of the export and array cables. Monitoring evidence is available as a series of bathymetric charts and interpretative reports from four surveys, namely; pre-levelling 2016, immediately post-levelling 2016, five months post levelling in 2017 (Ørsted 2018a) and a monitoring survey in 2018 (Ørsted 2018b).

The monitoring study for the Racebank OWF is applicable to the Proposed Development for the following reasons:

- Racebank OWF is located within an actively migrating sandwave system with continuing supply of mobile sediments;
- Its location within the SNS means it is subject to a similar tidal and wave regime to that of the Proposed Development; and
- The habitats and sediment composition is similar to the Proposed Development, comprising sandy sediments.

The most notable difference between the Racebank OWF and the Proposed Development is water depth. The Proposed Development lies in water depths of between 22 – 34m LAT, whilst Racebank lies in 4-14m LAT. This means that the Proposed Development is less likely to be subject to wave effects which could increase sediment mobility. However, conclusions can still be inferred noting that due to less frequent exposure to wave effects and so potentially overall lower rates of sediment mobility, recovery could be slower at the Proposed Development in comparison to that observed at Racebank OWF.

The Ørsted (2018c) monitoring evidence five-months following sandwave levelling, found that recovery of the sandwaves at Racebank OWF was influenced by the dimensions of the dredged area, and the degree of sediment mobility at the dredge location. A combination of shallow and deep dredging was undertaken. The below discussion focuses on the results for areas where deep dredging i.e. to the base of the sandwave, was undertaken as an appropriate comparison to works proposed for the Southwark pipeline. Shallower dredging was associated with faster rates of recovery.

The four sites (site 3 area D, site 8 areas J & K, site 11 array cable Z01 – A02 and site 12 array cable C06 – B05), all showed partial recovery of sand wave features five months post-levelling (Figures 5-1 to 5-4).

Dredging at site 3 and 8 resulted in the formation of two distinct local features separated by the dredged area. At site 3 and 8 although migration was observed post-levelling the migration direction was completely different to the underlying migration characteristics. The crest of one part was migrating into the dredged area whilst the crest of the other part was migrating further away.

At sites 11 and 12 the dredged areas showed signs of infilling and merging across the levelled area, with no migration of the sandwave feature. Although sandwaves had not completely reformed, there was a change in water depth indicating a shallowing of the seabed in the dredged area. The infill of the dredged area is believed to have formed from a supply of sediment from the unaffected sandwaves in the area, where images show a slight reduction in the crest high of the unaffected sandwaves.

Full recovery was observed at one of three adjacent sandwaves at site 11 where the sandwave had completely reformed. Bathymetry data shows that three sandwaves at this site appeared to be dredged to the base of the sandwaves. Recovery of the site 4-5 months post dredging appeared to have occurred in-situ, without a significant migration of the sandwave feature.

Sandwave recovery has occurred across the site but at different rates and by different mechanisms. The study concludes this varying trajectory of recovery will continue towards a new natural equilibrium in the medium to long term (months – years). It appears that the main mechanism for recovery is from sediment input from the surrounding unaffected sandwaves where the sandwave reforms in-situ within the levelled area. The other mechanism is related to the recovery associated with sandwave migration, where the adjacent sandwave crests and flanks migrate into the levelled area. Sandwaves reformed or partially reformed as a result of sandwave migration can be orientated in a different direction to sandwaves features.

The dimensions of the dredged area influences sandwave recovery. Levelling the seabed to the base of the sandwaves (as is proposed for the Southwark pipeline) was associated with slower recovery rates. This deeper dredging divides the sandwaves into two distant features which are more likely to locally evolve or migrate with different rates and directions to that of the main sandwave body (Ørsted 2018a). The sandwaves along the Proposed Development are known to naturally bifurcate and converge. Therefore, it is predicted that although there will be a local change in sandwave direction following levelling, recovery will still continue to a natural equilibrium in line with the sediment processes within the area.

Further bathymetric surveys carried out by Ørsted in 2018 (Ørsted 2018d) provided additional evidence of sandwave recovery post-levelling. Examples of this are illustrated in Figure 5-8 and 5-10 which shows the longitudinal profile of the sandwaves along two of the array cables for three time periods. The blue line shows the profile of the seabed prior to levelling, the green line shows the profile following levelling and the black line shows the seabed profile approximately two years following levelling. The black line indicates that two years after sandwave levelling although the sandwave profiles have changed, they have re-formed and sandwave heights are equivalent to those recorded prior to levelling.

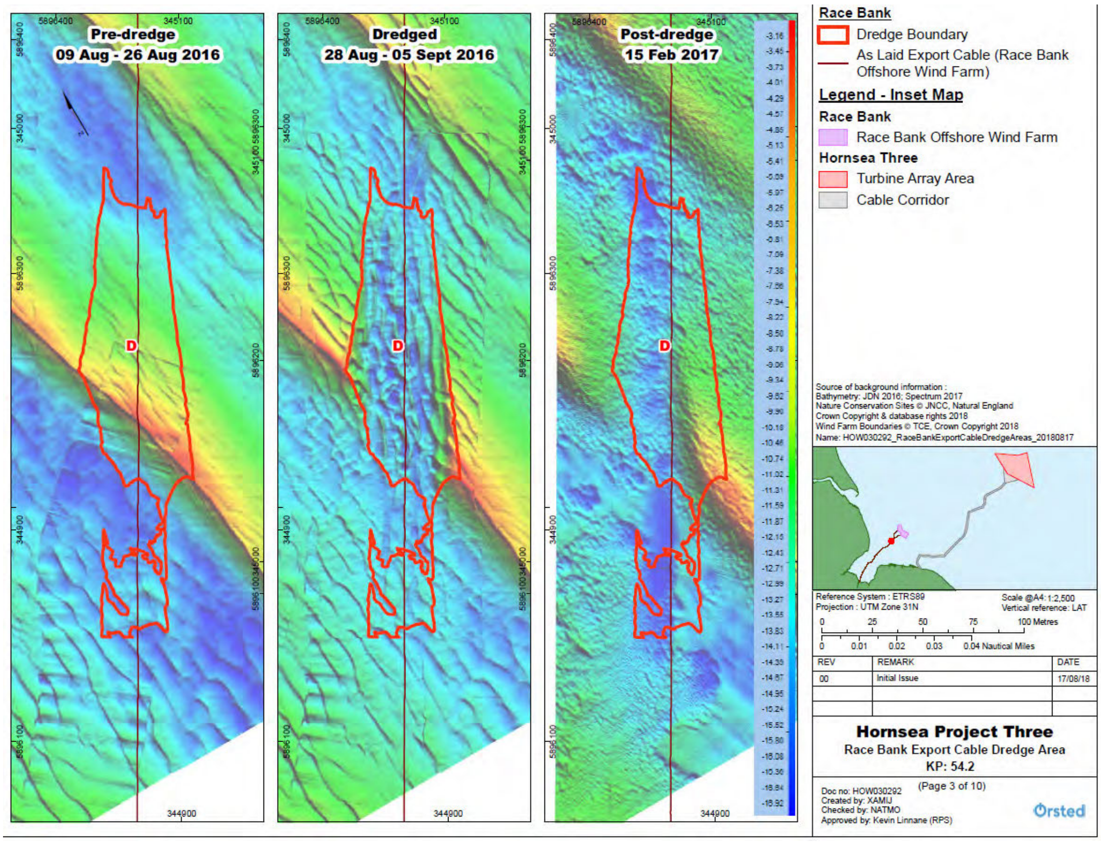
Figures 5-6 and 5-8 show the present the supporting bathymetric images, indicating a clear depression visible within the former sandwaves immediately after dredging. In 2018, two years following dredging, the sand waves have been restored.

The evidence presented for Racebank indicates that any change to the structure and function of the sandbanks within the NNSSR SAC as a result of the Proposed Development will be temporary. Partial recovery is predicted in the short-term (six months to two years) and given the deeper water depths full recovery is predicted within the medium-term (two to ten years).

The species inhabiting the two biotopes associated with the Inner bank are characteristic of mobile sediments and are adapted to the high levels of disturbance. The main species which define these biotopes are polychaetes (*Nephtys cirrosa*), and burrowing amphipods (*Bathyporeia spp*. As discussed above, these species are highly tolerant of disturbance and it is predicted they would recover from the pipeline installation disturbance within a year. Therefore, any changes in community structure will be localised and short term.

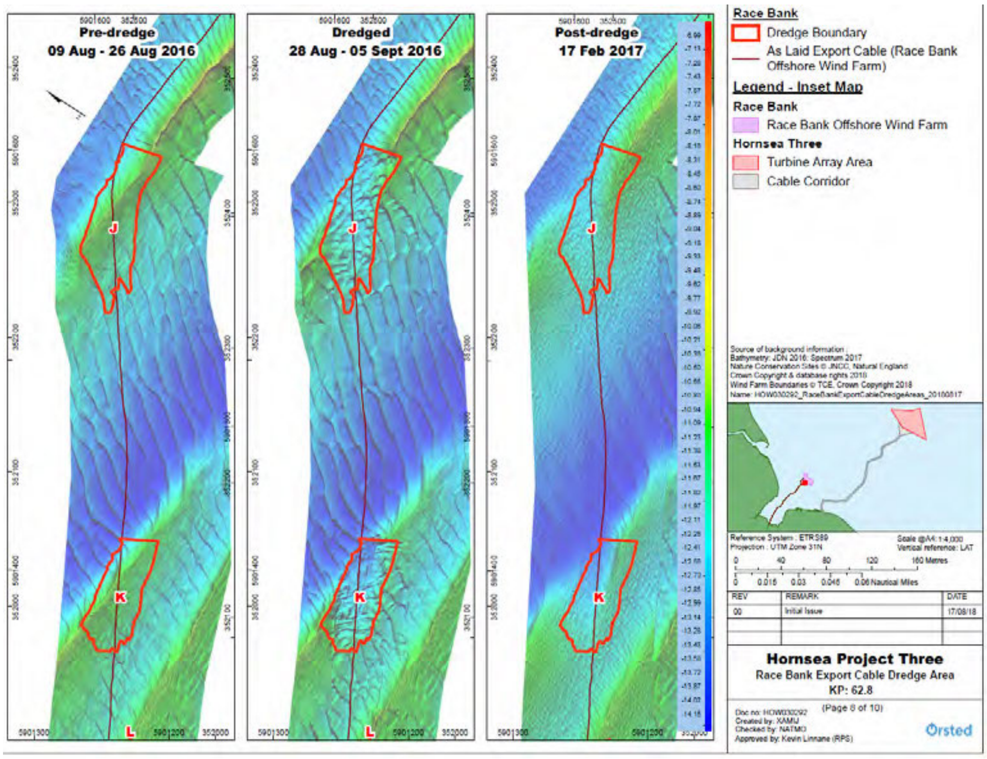
Conclusion: there will be no significant effect from sandwave clearance, trenching and dredging to the structure and function of the Annex I Sandbank habitat.

Figure 5-1 Bathymetry of Racebank export cable dredged area – Site D



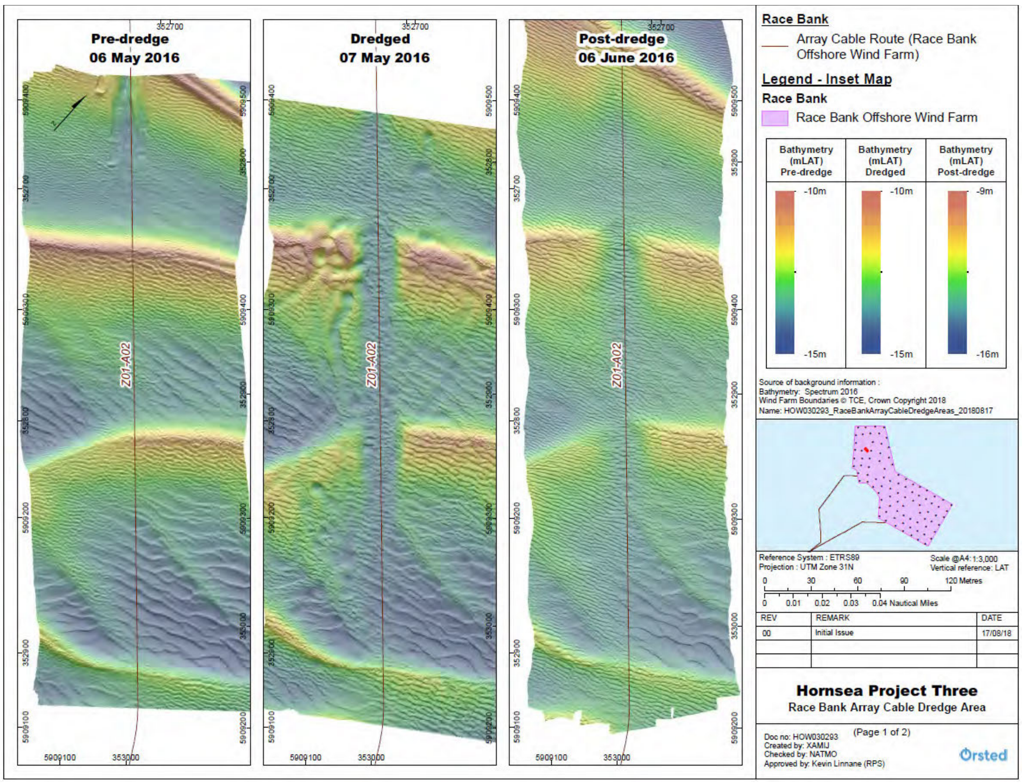
Source: Ørsted (2018c)

Figure 5-2 Bathymetry of Racebank export cable dredged area – Sites J & K



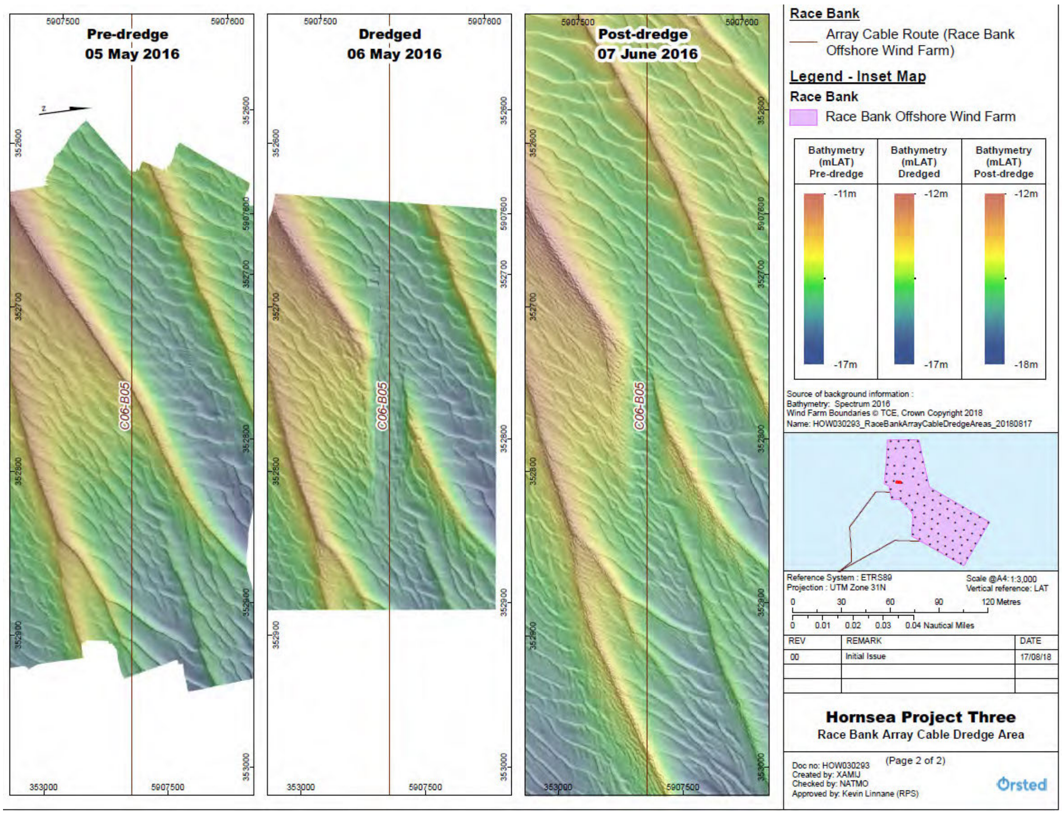
Source: Ørsted (2018c)

Figure 5-3 Bathymetry of Racebank dredged area – Array Cable Z01 – A02



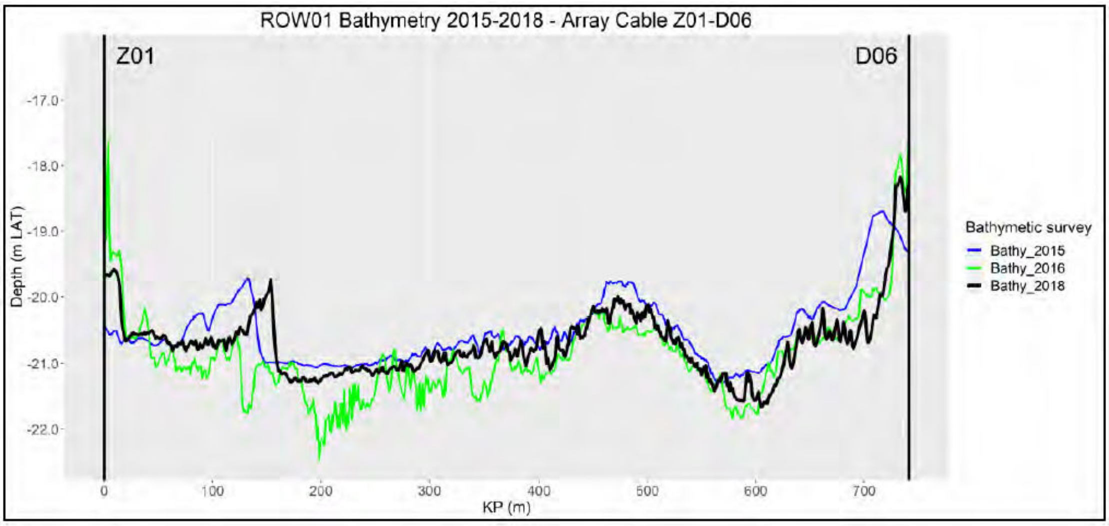
Source: Ørsted (2018c)

Figure 5-4 Bathymetry of Racebank dredged area – Array Cable C06 – B05



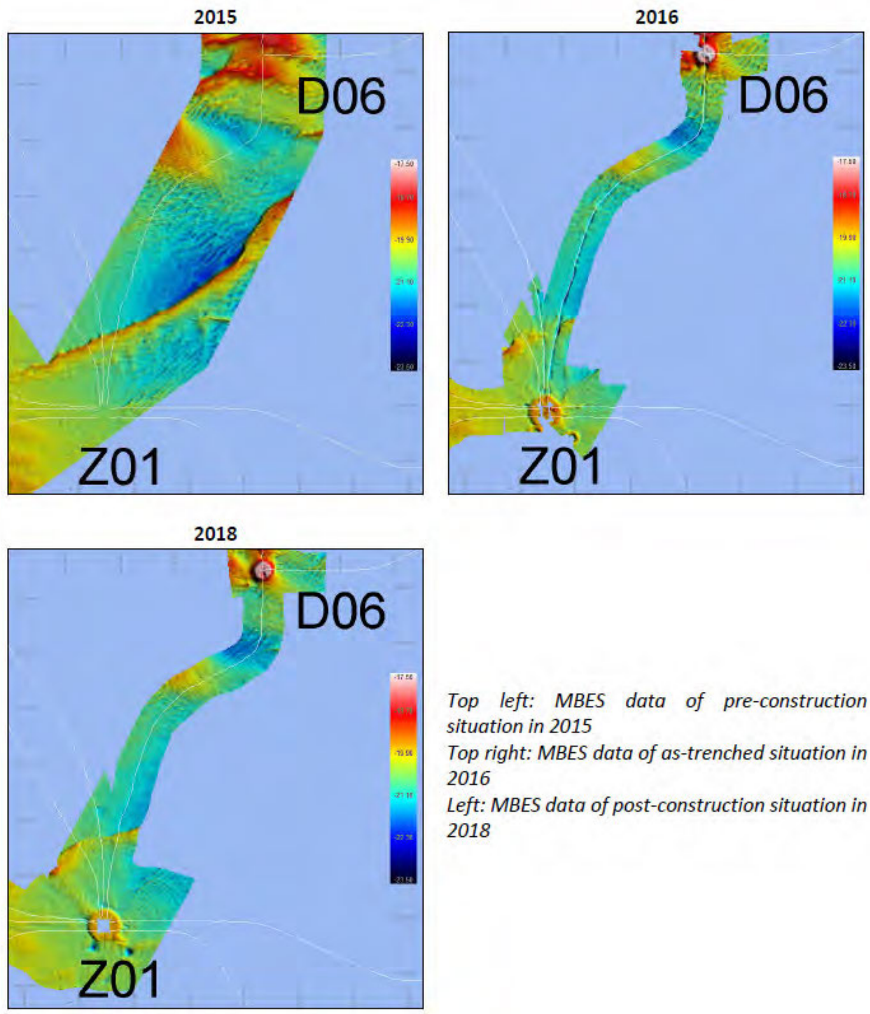
Source: Ørsted (2018c).

Figure 5-5 Longitudinal profile of MBES data along array cable Z01-D06



Source: Ørsted (2018d).

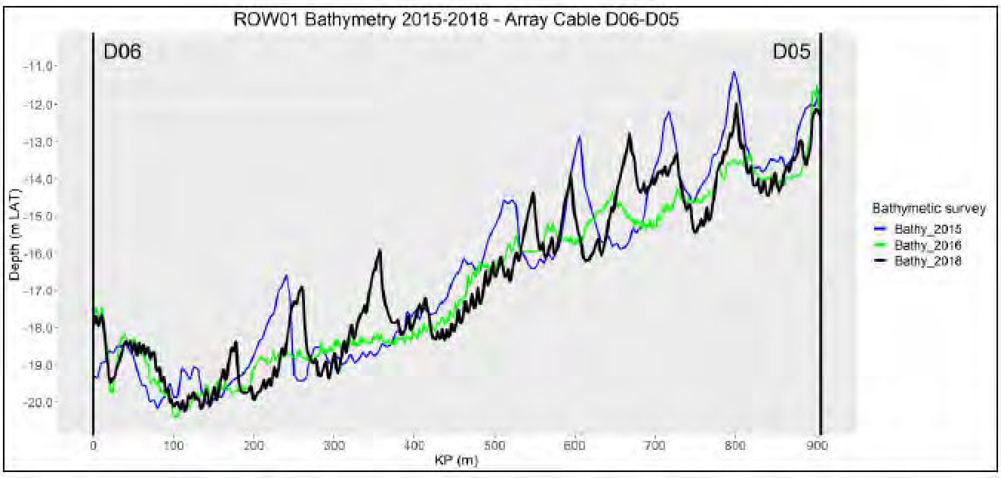
Figure 5-6 Images of MBES data along the entire length of array cable Z01-D06



Top left: MBES data of pre-construction situation in 2015
Top right: MBES data of as-trenched situation in 2016
Left: MBES data of post-construction situation in 2018

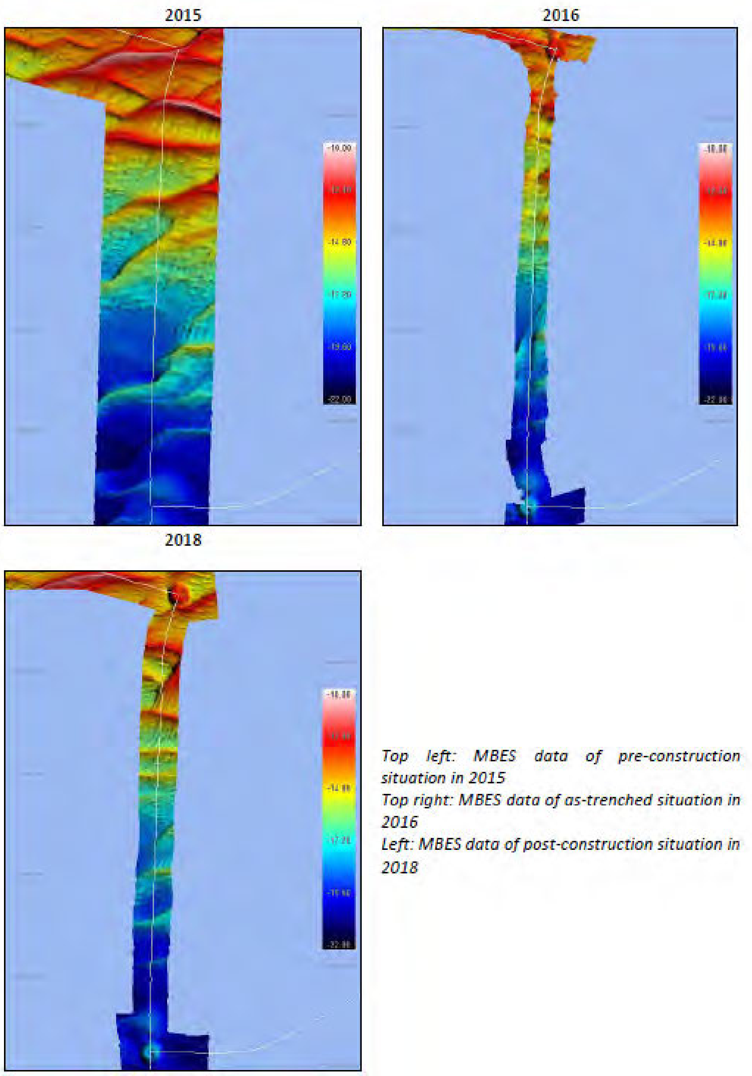
Source: Ørsted (2018d).

Figure 5-7 Longitudinal profile of MBES data along array cable Z01-D06



Source: Ørsted (2018d).

Figure 5-8 Images of MBES data along the entire length of array cable Z01-D06



Source: Ørsted (2018d).

Supporting processes

Objective – Maintain: 'Activities must look to avoid, as far as is practicable, impairing the hydrodynamic regime within the site and exceeding Environmental Quality Standards'.

Sandwave clearance activities will level an area of approximately 374,220m^2. Sediment disturbance associated with the sandwave clearance, dredging and trenching will result in short to medium-term, localised changes to the seabed topography. The deposition of cleared and trenched sediment will cause small mounds along the length the pipeline. These mounds may be in a different orientation to the sandwaves, however these mounds will not be large enough to effect sediment transport patterns in the area.

Sandwave and sandbank systems are naturally subject to variations in topography based on the dynamic nature of the environment and therefore are subject to fluctuations in height. In addition, given the highly dynamic nature of the environment to which the sandwaves are formed, winnowing of the deposition mounds and restoration of the sandwaves is predicted to take place in the medium term (2 - 10 years). No lasting changes to hydrodynamic processes are anticipated to occur as a result of seabed disturbance.

The Proposed Development will not contaminate sediments or lead to Environmental Quality Standards being exceeded.

Conclusion: there will be no significant effect from sandwave clearance, trenching and dredging to the supporting processes of the Annex I Sandbank habitat.

5.4.2.4 Indirect seabed disturbance resulting from sandwave clearance, trenching and dredging sediment plumes

Impact Assessment

This assessment focuses on the Annex I habitat reef. Since the biotopes associated with the sandbank habitat are characterised by species which can tolerate a high degree of disturbance, this impact is not considered further for the sandbank feature.

An indirect effect of the sandwave clearance, dredging and trenching is the generation of sediment plumes. Disturbed sediment will be suspended in the water column, with a varying period of suspension due to different sediment grain sizes. The plume will develop generally in line with the tidal flow with a narrower perpendicular spread. Coarser sediment is likely to quickly fall out of suspension (within <100m) and be deposited within the immediate vicinity of the clearance and trenching activities. Finer sediment particles will remain in suspension for longer, eventually being deposited over a wider extent but in thicknesses of <1mm. Of all the three methods considered for sandwave clearance and trenching, CFE will result in the greatest sediment plume.

This re-deposition of sediment can lead to smothering of sessile and low mobility species, such as filter feeders found in reef habitats, if deposition thicknesses are significant. The biogenic reef habitat found within the NNSSR SAC is formed by *Sabellaria spinulosa* which could be impacted by sediment plumes should they reach any patches of reef.

1170 Reefs

Extent and distribution

Objective – Restore: 'Activities must look to minimise, as far as is practicable, damaging the established i.e. high confidence reef within the site'

Data on the distribution of the SAC designating features indicates that the closest occurrence of *Sabellaria* reef is between 5 and 10km from the Proposed Development to the northwest.

It is not expected that the sediment plume created during sandwave clearance and trenching works will reach this *Sabellaria* reef in sufficient thicknesses to cause smothering. Displacement of sediments during trenching will be very localised with resuspended coarse sediments settling out within approximately 100m and resuspended fine sediments settling out within 1-2km of the pipeline route (Gooding et al 2020). The use of CFE and dredging will create a larger plume than trenching but evidence from the marine aggregate industry indicates that initial sedimentation of material discharged from the dredger is restricted to within a few hundred to 800m from the discharge chutes (Newell et al 1998, Hitchcock and Bell 2004, Duclos et al 2013). At greater distances, deposition thicknesses of fine fractions are undetectable against natural background variation. Therefore, the extent and distribution of species associated with the *Sabellaria* reef will not be impacted by the sediment plumes.

Conclusion: there will be no significant effect from sediment plumes to the extent and distribution of Annex I Reef habitat.

Supporting processes

Objective – Restore: 'Activities must look to minimise, as far as is practicable, disturbance to the hydrodynamic regime within the site and the habitats which support the reef within the site. Activities *must also look to avoid, as far as is practicable, exceeding Environmental Quality Standards for aqueous contaminants.*

Indirect seabed disturbance through a sedimentary plume would not have any effects on hydrodynamic processes. The sediments in the Proposed Development are not contaminated and therefore re-distribution of sediments within the SAC will not result in exceedance of Environmental Quality Standards.

Conclusion: there will be no significant effect from sediment plumes to supporting processes of Annex I Reef habitat.

5.4.2.5 Seabed disturbance from deposits

Background information
Seabed deposits will consist of the following:

- Temporary deposits – pipeline anchor and possibly anchors from anchored pipelay vessel, covering an area of approximately 1015m^2.
- Permanent deposits (although these may be removed at decommissioning) – concrete mattresses, grout/sand bags and contingency rock remediation, covering an area of approximately 6028m^2.

Impact Assessment
This assessment will focus solely on the impacts to Annex I feature - Sandbanks which are slightly covered by sea water all the time. The closest known occurrences of *Sabellaria spinulosa* are located 5-10km from the Proposed Development, therefore the impacts from seabed deposits to Annex I Reef will not be considered further.

1110 Sandbanks which are slightly covered by sea water all of the time

<u>*Extent and distribution*</u>

Objective – Restore: 'Activities must look to minimise, as far as is practicable, changes in substratum and the biological assemblages within the site to minimise further impact on feature extent and distribution.'

Temporary deposits

The anchors have the potential to cause direct loss and mortality of any sessile or low mobility species located beneath the footprint of the anchors and wires. However, their use will be a one-off event and their presence will be temporary. The worst-case footprint of anchors temporarily deposited on the seabed (pipeline anchor and potentially pipeline vessel anchors) is 1015m^2 which represents 0.00003% of the NNSSR SAC. Any impacts will be very localised and temporary, and given that the biotopes present in the NNSSR sandbanks are highly tolerant to disturbance, any impacts are not expected to be significant.

Permanent deposits

The introduction of grout/sand bags, mattresses and contingency rock remediation will be deposited in an area of sandy substrate. This would constitute a localised coarsening of these sediments and will effectively change the seabed sediment type to a hard substrate. This will reduce the extent of the habitat within the SAC by 0.0002%. Owing to the dynamic nature of the sandwave system, it is expected that overtime some of the external protection material may be buried by sand deposition. The extent that this occurs will depend on the local currents at each location and given the mobile nature of the sediments there is potential for re-exposure. This conclusion is supported by surveys undertaken by ConocoPhillips (reported in BEIS 2019c) which demonstrated that 63.7% of the surface laid Viking ED and GD pipelines (which lie in the NNSSR SAC) are now buried, although there has been exposure of previously buried pipelines as well.

The sandwaves within the NNSSR SAC are part of a large system of sandbanks. To cause a physical loss of the sandbanks i.e., reduce the extent, an impact would need to either remove sediment from the system or physical affect the transportation of sand. The Proposed Development will not remove sediment from the system and the permanent deposits will not physically affect the transportation of sand. This is evident from the information cited above showing that surface laid pipelines within the SAC are not affecting sediment mobility and sandwave migration, with sand waves continuing to migrate across the site.

The comparative assessment for the pipeline installation concluded that the proposed methods for installation provide the BPEO and take into consideration a sustainable approach to pipeline integrity management. Other installation options either would result in significantly higher quantities of permanent deposit or do not go far enough to ensure that rock remediation would not be required in future. The proposed solution offers the best feasible option and minimises the potential requirements for permanent deposits.

Conclusion: there will be no significant effect from temporary and permanent deposits to the extent and distribution of Annex I Sandbank habitat.

<u>*Structure and function*</u>

Objective – Restore: 'Activities must look to minimise, as far as is practicable, disturbance and changes to the sediment composition, finer scale topography and biological communities within the site'

Temporary deposits

The anchors have the potential to cause direct loss and mortality of any sessile or low mobility species located beneath the footprint of the anchors and wires. However, their use will be a one-off event and their presence will be temporary and localised (1015m^2). Therefore, a small loss of species beneath the footprint of the anchors will not affect the overall structure and functioning of the Annex I Sandbank habitat.

Permanent deposits

The Proposed Development is located within areas classified as EUNIS habitats A5.233: *Nephtys cirrosa* and *Bathyporeia spp* in infralittoral sand and A5.231: Infralittoral mobile clean sand with sparse fauna (Jenkins et al 2015). The deposit of concrete mattresses, grout/sand bags and rock remediation have the potential to change 0.0002% of the SAC habitat from sand to a hard substrate, which would lead to a reclassification of the biotope/EUNIS habitat within this very localised area.

The Marine Life Information Network (MarLIN) sensitivity assessment for A5.233 and A5.231 concludes that the sensitivity of the habitat to the pressure physical change (to another seabed type) is high. This is because a change to an artificial or rock substratum would alter the character of the biotope, from a mobile sand feature to an immobile rock feature, leading to biotope reclassification. Some of the external protection material may be buried by sand deposition, however there is also the potential for re-exposure (BEIS 2019c).

The presence of a permanent deposit may cause an obstruct to the sandwaves, inhibiting their natural mobility e.g. pinning them in place. The rate at which sandwaves move in the Proposed Development varies depending on the location but ranges between 14 and 26m per year (Xodus 2021c). At these rates of movement, it is unlikely that the small, localised deposits will affect the physical mobility of the sandwave features.

This conclusion is supported by studies undertaken at Scroby Sands OWF and of the Viking pipelines (reported in BEIS 2019), both positioned in sandbank systems. The studies indicate that the physical presence of the structures did not affect the overall sediment transport of the sandbank and the overall morphology of the sandbank has been maintained. The structures do not impede medium to large scale sand wave migration. Changes are noticed at a local scale, with scour and accretion evident immediately surrounding structures, but bedforms quickly re-establish away from the feature (BEIS 2019c).

In conclusion, the change will be very localised (0.0002% of the SAC) and will not affect the overall biological and physical functioning of the Annex I Sandbanks habitat. Furthermore, the species found along the Proposed Development are widespread and short lived. A very small loss of the habitat and associated species will not affect the overall community structure and functioning of the sandbank community.

Conclusion: there will be no significant effect from temporary and permanent deposits to the extent Structure and Function of Annex I Sandbank habitat.

Supporting processes

Objective – Maintain: 'Activities must look to avoid, as far as is practicable, impairing the hydrodynamic regime within the site and exceeding Environmental Quality Standards'. Standards are set out in the sites supplementary guidance

There is potential that the presence of concrete mattresses, grout/sand bags and contingency rock remediation could affect the sediment transport pathways over the sandbank system and inhibit their natural mobility. The movement of the sandbanks within the SAC is caused by the re-deposition of sand in a northerly direction predominantly as bedload (Xodus 2021c). Evidence from offshore wind farms (reported in BEIS 2019c) indicates that the physical presence of wind turbines does not affect sediment transport over a sandbank feature. Therefore, the small scale, low level obstruction of mattresses, grout/sand bags and contingency rock remediation will not affect the overall sediment transport processes within the SAC.

The presence of the permanent deposits may cause very localised changes in water flows which in turn could cause localised seabed scour. Typically, it is the action of waves on seabed sediments that causes the development of pits, troughs or depressions (i.e. scour) in the seabed sediments around the edges of any deposits. Where this modifies the seabed from its natural state it can affect sensitive receptors through habitat alteration.

Given the water depth at the Proposed Development (22-34m) the seabed is unlikely to be affected by wave energy[1] and therefore wave induced scour is unlikely around the deposits. This holds true even with the reduction in water depth caused by the height of the deposits.

The permanent deposits could also result in turbulent flow from acceleration or deceleration of tidal flow over the structures. The magnitude of turbulence created by deposits corresponds to the shape and size of the deposit. It is considered that hydrodynamic changes as a result of the low-profile deposits will be highly localised with turbulent flow present for several metres downstream of the deposits.

Scour will only occur in areas of sediment where bottom current either already exceeds the critical bedload parting velocity, or where deposits result in an increase in current velocity to above the critical bedload parting velocity. The type of sediment that the deposits lay upon can also have a large influence on the potential for scouring, with soft sediments like sand more prone to scour.

Studies have found that sand migration as a result of mega ripples appears to be impeded at a small scale in the immediate vicinity of gas platforms/ pipeline risers. Scour and accretion is evident at some platform/ pipeline riser base locations (BEIS 2019c). However mega ripples appear to quickly reform away from platforms and platform risers. It can therefore be drawn from this evidence that the permanent deposits will not affect the overall equilibrium of the feature and the supporting processes.

[1] The depth at which waves can affect seabed sediments is a function of the wavelength. Below a depth of half the wavelength, the water column is unaffected by wave energy. Wave lengths within the Proposed Development have been calculated as 1.0m assuming a depth of 22m and a worst-case wave speed of 7.1s.

Evidence set out above suggests that there is potential for localised scour around the permanent deposits. However, this localised scour will not affect the overall supporting processes of the SAC.

Conclusion: there will be no significant effect from temporary and permanent deposits to supporting processes of Annex I Sandbank habitat.

5.4.3 Impact assessment – Southern North Sea SAC

This assessment concluded that the risk posed to the marine environment by the potential seabed disturbance of the Proposed Development is tolerable.

The Proposed Development is located entirely within the Southern North Sea SAC. Therefore, the assessment has focused on potential impacts to the designating feature of this site, harbour porpoise. A detailed description of this feature is provided in Section 4.3.2.1.

5.4.3.1 Proportion of Southern North Sea SAC effected

The Southern North Sea SAC covers an area of 36,796km^2. Table 5-7 details the percentage of the site that will be affected by pipeline installation activities.

Table 5-7 Proportion of Southern North Sea SAC effected by pipeline installation and associated activities

Aspect	Footprint km^2	% of SAC effected	Nature of footprint
Sandwave clearance, trenching and dredging	0.3760	0.001	Temporary
Anchoring (pipeline and if required anchor lay barge)	0.001015	0.000003	Temporary
Mattresses and grout/sand bag deposition bags at tie-in locations	0.003928	0.000001	Permanent - however, dependant on decommissioning
Indicative contingency rock remediation works	0.003	0.000001	Permanent - however, dependant on decommissioning
Temporary	**0.38**	**0.001**	-
Permanent	**0.007**	**0.000002**	-

5.4.3.2 Conservation objectives and associated impact

The conservation objectives for the Southern North Sea SAC are detailed in full in Section 4.3.2.1. JNCC's view on the qualifying features of harbour porpoise is that the population is in a favourable condition.

For harbour porpoise the conservation objectives include the following attribute relevant to seabed disturbance:

- The condition of supporting habitats and processes, and the availability of prey is maintained.

As shown in Table 5-7 above, both the temporary and permanent footprints of the installation activities comprise a negligible area in relation to the overall Southern North Sea SAC, with both footprints combining to affect only 0.001% of the site. As such, the installation activities will have a negligible impact on the overall habitat of the SAC, and the condition of supporting habitats and processes, and the availability of prey will continue to be maintained.

5.4.4 Impact assessment - fish and shellfish

This assessment concluded that the risk posed to the environment from seabed disturbance is acceptable.

Immobile eggs, juveniles and shellfish present on the seabed around the proposed pipeline route will be subject to direct and indirect disturbance from smothering.

The Proposed Development is located within ICES rectangle 35F2. Marine Management Organisation (MMO) landing data between 2015 and 2019 for this rectangle indicates that the majority of fish species present are demersal (bottom dwelling). In addition, there is potential for bottom dwelling rays and sharks to be found, along with several commercial shellfish species. These species, which inhabit the seabed and demersal zone, are vulnerable to seabed disturbance. The loss or disturbance of habitat during operations will be localised, representing only a very small footprint of the wider region.

Atlantic herring and sandeel spawn within the ICES rectangle (35F1). However, the area within the Proposed Development has been considered as "unsuitable" for herring spawning habitat, with a more suitable herring spawning habitat identified 4.5km south west of the Proposed Development (Fugro 2018a). Given the large area of both Atlantic herring and sandeel spawning grounds in the SNS, localised disturbance from the Proposed Development is unlikely to affect these species at a population level.

The fish spawning or nursery grounds of other species known to overlap the Proposed Development also cover large areas, therefore the impacts from seabed disturbance is unlikely to affect any species on a population level.

The potential impacts to fish and shellfish from seabed disturbance caused by the Proposed Development is localised and is not expected to be significant.

5.4.5 Impact assessment - commercial fisheries

This assessment concluded that the risk posed to the environment from seabed disturbance is acceptable.

The Proposed Development is within an area of low to medium importance for demersal, pelagic and shellfish fisheries when compared with the rest of the UKCS. The Proposed Development will increase the oil and gas footprint of the area; however the seabed footprint is not expected to impact the wider population of fish species.

The seabed footprint created by the installation of the pipeline will be temporary. Sandwave clearance and trenching is expected to take up to 37 days to complete. The pipeline will be buried below the mean seabed level with the trench either naturally or mechanically backfilled. After backfill the final seabed profile will be a shallow depression over the pipelines due to the loss of finer sediments from displaced material through winnowing. However, given the Proposed Development is located within a natural evolving sandbank system this shallow depression will be a short-term feature, with a recovery expected within 6 months – 2 years. This minor short term and localised change in seabed profile is not expected to impact commercial fisheries.

The deposition of concrete mattresses at the tie-in locations and any contingency rock remediation works will represent localised discrete snagging hazards. Approximately 50% of the deposits will be within the 500m safety zone established around the Southwark Platform and therefore will not pose a risk to the fishing industry. The deposits at the Thames pipeline tie-in will not be within a safety zone, will be next a feature that is already marked on Admiralty and KIS-ORCA fishing awareness charts as presenting a snagging hazard to fishermen. Any locations of remedial rock protection will be notified to fishermen.

The burial of the pipeline will significantly reduce the snagging risk posed by the pipeline to the fishing industry. A very localised risk remains but this has been assessed as acceptable.

5.4.6 Mitigation measures

Table 5-8 presents mitigation measures that will be adopted in the Proposed Development.

Table 5-8 Mitigation measures – seabed disturbance

ID	Mitigation measures
M4	Concrete mattresses, grout/sand bags and rock remediation will only be employed where the integrity of the pipeline is at risk. Cover will be kept at the minimum required to ensure pipeline protection is adequate. Good industry practice will be used when deploying any pipeline protection.
M5	If a trailing suction hopper dredger is used, sediment will not be retained onboard but will be deposited within 2NM of the pipeline corridor, to ensure all sediment is retained in the local system.

5.4.7 Residual impact

It has been determined from the assessment that there will be no residual impacts from the activities.

5.5 Generation of atmospheric emissions

5.5.1 Impact assessment

This assessment concluded that the risk posed to the environment by the generation of atmosphere emissions is acceptable.

Table 5-9 presents the estimated atmospheric emissions arising from operations at the proposed development. Emissions will arise from pipeline installation and during remedial operations. Calculations use the emission factors recommended under the Environmental and Emissions Monitoring System (EEMS 2008), updated in the Department of Energy and Climate Change (DECC) guidance (DECC 2015).

5.5.1.1 Air Emissions

Air quality, as measured by concentrations of gases with the potential to cause environmental or human harm, other than through contribution to climate change i.e. carbon dioxide (CO_2), carbon monoxide (CO), nitrogen oxides (NO_x), nitrous oxide (N_2O), sulphur oxides (SO_x), methane (CH_4), and volatile organic compounds (VOC), is generally not considered a significant issue offshore, as there are no proximate receptors.

Greenhouse gases trap heat in the atmosphere and contribute to global warming. Global warming potential (GWP) is a relative measure of how much heat a greenhouse gas traps; usually expressed as CO_2 equivalent (CO_2-e). Greenhouse gases differ in their abilities to trap heat. Carbon dioxide is the dominant greenhouse gas and is therefore used as a reference (GWP value of 1) against which other gases are compared. The conversion factors used in Table 5-6 below to calculate CO_2-e are as given in Department for Environment, Food and Rural Affairs (Defra) (2015).

Table 5-9 estimates that approximately 57,389 tonnes carbon dioxide equivalent (CO_2-e) will be released from the Proposed Development during construction.

This scale of emissions represents a very small portion of UK wide greenhouse gas emissions (provisional estimates indicate emissions in 2019 totalled 435.2 million tonnes CO_2-e (Department for Business, Energy and Industrial Strategy [BEIS] 2020)).

There has been a general decrease in offshore emissions of carbon dioxide from the oil and gas industry since 2000. Factors such as a decline in production and produced water volumes over this period have been influential in reducing emissions (OGUK 2017).

EEMS data for offshore emissions from both fixed and mobile installations in the UKCS shows that the upstream oil and gas industry emitted 14.63 million tonnes of CO_2-e in 2018 (OGUK 2019). Estimated

CO_2-e atmospheric emissions from the Proposed Development would account for 0.4% of the total CO_2-emissions produced by the upstream oil and gas industry in the UKCS in 2018 (OGUK 2019).

This figure is negligible in comparison to the provisional 2019 UK wide emissions of 435.2 million tonnes of CO_2-e (BEIS 2020).

Table 5-9 Air emissions

Aspect	Fuel Use (t/d)	Days	Total Fuel Use/quantity flared (t)	Emissions (t)							
				CO_2	CO	NO_x	N_2O	SO_x	CH_4	VOC	CO_2-e
GWP Values				**1**			**298**		**25**		
Pipeline Installation, Tie-in and commissioning											
Pipeline installation vessel	54.32	65	3531	11299	55.4	208	0.78	3.53	0.64	7.06	11545.93
Sand wave clearance vessels	12.61	32	404	1291	6.3	24	0.09	0.40	0.07	0.81	1319.53
Trenching vessel	97.00	15	1455	4656	22.8	86	0.32	1.46	0.26	2.91	4757.94
Commissioning (leak testing)	27.16	38	1032	3303	16.2	61	0.23	1.03	0.19	2.06	3374.96
Pipe supply vessels (2 vessels)	15.52	65	1009	3228	15.8	60	0.22	1.01	0.18	2.02	3298.84
Guard vessel	0.485	65	32	101	0.5	2	0.01	0.03	0.01	0.06	103.09
Anchor handling vessels (4 vessels)	155.2	65	10088	32282	158.4	595	2.22	10.09	1.82	20.18	32988.37
Sub-Total	**-**	**-**	-	**56159**	**275.5**	**1035**	**3.86**	**17.55**	**3.16**	**35.10**	**57388.65**
Remedial operations											
Rock deposit vessel	54.32	6	326	1043	5.1	19	0.07	0.33	0.06	0.65	1065.78
Sub-Total	**-**	**-**	**-**	**1043**	**5.1**	**19**	**0.07**	**0.33**	**0.06**	**0.65**	**1065.78**

5.5.2 IOG's commitent to Net Zero 2050.

IOG's ambition is to be a safe and efficient developer and producer of high-value, low-carbon gas.

IOG appreciates that limiting climate change and transitioning to a more sustainable economy are critical challenges of our time. In that context, IOG recognise the importance of the UK's 2050 Net Zero target as part of global efforts to meet the goals of the 2015 Paris Accord. To achieve this target IOG has committed to eight targets within which IOG will evaluate their greenhouse gas emissions and put in place measures to mitigate their existing and projected emissions. IOGs Climate Change and Sustainability Policy and commitment is provided in full in Section 8.

IOG aims to contribute positively to the UK's energy transition by helping to supply stable and affordable energy to UK homes and businesses as part of a lower-carbon energy supply mix.

5.5.3 Decommissioning and recovery

Decommissioning activities may occur both at the end of and during the field life. During such activities it is likely that there will be emissions associated with necessary decommissioning vessel activity.

At the time of decommissioning the operator will likely carry out an energy balance assessment based on the Institute of Petroleum 'Guidelines for the Calculation of Estimates of Energy Use and Gaseous Emissions in the Decommissioning of Offshore Structures' (Institute of Petroleum, 2000) (or applicable guidance at the time). The assessment will include identification of all end points associated with decommissioning each structure and their associated energy use and resultant atmospheric emissions resulting from vessels, onshore transport for recovery/treatment/disposal, will be assessed and their environmental impacts determined.

Emissions associated with decommissioning activities are not assessed further at this time.

5.5.4 Mitigation measures

Table 5-10 presents the mitigation measures that will be adopted in the Proposed Development.

Table 5-10 Mitigation measures – atmospheric emissions

ID	Mitigation measures
M6	Practical steps to minimise emissions will be implemented, e.g. ensuring efficient operations and monitoring fuel consumption
M7	Project vessels employed will comply with the Merchant Shipping (Prevention of Air Pollution from Ships) Regulations 2008, which controls the levels of pollutants entering the atmosphere.

5.5.5 Residual impact

It has been assessed that there will be no significant residual impacts from the Proposed Development.

5.6 Marine discharges

5.6.1 Impact assessment

This assessment concluded that the risk posed to the environment from discharges to the marine environment is acceptable.

The safe installation and integrity testing of a pipeline requires use of chemicals. The majority of chemical discharges are of 'PLONOR' (posing little or no risk to the environment) chemicals. Chemical discharges of non-PLONOR chemicals (normally dosed into PLONOR carriers) are typically of quantities in the range of grammes to tens of kilogrammes).

All proposed chemical discharges must be risk assessed ahead of activities commencing as part of the chemical permitting process, and will be subject to the conditions set in the approved permit.

The discharge of chemicals to the marine environment has the potential for toxic effects on water column and benthic species and may in some very severe cases contaminate seabed sediments. Where required the risk associated with chemical discharges will be quantitatively assessed using either the Chemical Hazard and Risk Management (CHARM) model or the Osborne Adams Methodology (O&A). These will indicate if the chemicals have the potential for an adverse impact on the marine environment. Where possible, chemicals will be selected to ensure there is the lowest potential for adverse environmental impact.

5.6.1.1 Water column

Water column species are only likely to be vulnerable within a short distance of any discharge, as chemicals will be rapidly diluted and dispersed to below potentially toxic concentrations under the energetic conditions prevalent in the UKCS. Therefore, no significant impact is anticipated at population level.

5.6.1.2 Benthic community

Benthic fauna are potentially vulnerable to discharges which will enter the sediment (seabed discharges) as they may be unable to move or drift away from discharges.

The tidal current speeds in the region range from 0.46 to 0.88ms^{-1}, therefore any discharges are likely to be rapidly dispersed and any harmful effects will be highly localised. Where potentially toxic chemicals are used their impact is largely mitigated either by the small quantities in which they are applied or because pathway from source-to-receptor is extremely limited. Impacts on water quality are expected to be brief and localised. The environment will generally be able to rapidly assimilate the discharges and deal with them through natural bacterial action. Therefore, the risk posed by operations on the benthic community has been assessed as acceptable.

The potential impacts of a hydrocarbon release during pipeline installation operations at the Proposed Development are discussed in Section 6.

5.6.2 Mitigation measures

Table 5-11 presents mitigation measures that will be adopted in the proposed development:

Table 5-11 Mitigation measures – marine discharges

ID	Mitigation measures
M8	Chemical use and discharge will be monitored and kept to the minimum consistent with operational requirements.
M9	Where suitable alternatives are available and deemed fit for purpose, chemicals with lower potential for environmental impact will be utilised.
M10	Chemical storage and usage will be in accordance with the vessel's control of substances hazardous to health (COSHH) procedure. Material Safety Data Sheets (MSDS) will be carried for all hazardous substances.

5.6.3 Residual impact

It has been determined from the assessment that there will be no residual impacts from the activities.

5.7 Generation of underwater sound (vessels)

5.7.1 Impact assessment

This assessment concluded that the risk posed to the environment by the generation of underwater sound by vessels is acceptable.

The main environmental receptors potentially impacted by underwater sound are:

- Marine mammals.
- Plankton (including fish eggs and larvae); and
- Adult fish.

Underwater sound has the potential to modify behavioural patterns (e.g., causing avoidance behaviour) and in certain situations the pressure waves associated with the sound may cause physical injury and even mortality (Genesis Oil and Gas Consultants 2011).

5.7.1.1 Sound generation

The main sound sources during vessel operations at the Proposed Development will originate from machinery sound (e.g. use of thrusters on pipelay project vessels). Machinery sound generation is generally considered to be of relatively low intensity and near continuous, although some events will result in short term peaks in intensity.

Dynamically positioned subsea construction vessels are likely to emit sound at intensities of up to 190dB re: 1µPa @1m (rms) (Wyatt 2008), assumed to be broadband. The vessels will travel along the route of the proposed pipeline, therefore sound emitted during subsea construction will generally be transient and temporary. The generated sound signal is expressed as the sound pressure level (SPL). This is time independent i.e., it is generated continuously at this level; however, response to continuous sound is dependent on exposure time by the receptor.

Sound depletes as it propagates through water and the local oceanographic conditions will affect both the path of the sound into the water column and how much sound is transmitted. Attenuation can be calculated using the equation:

$$Sr = S - 15\log(r) - \alpha r/1000$$

Where:

- Sr = Sound at range r (m)
- S = Sound at 1m from the source
- r = distance from the source
- 15log(r) represents the spreading loss, in dB re 1m
- α = is the frequency related attenuation, $0.036*f^{1.5}$, where f is in kHz, in dB re 1m

Units of sound are dB re 1µPa or 1µPa^{2}s, which are equivalent for a 1 second transmission

This equation provides conservative estimates for sound attenuation as it does not take into consideration the conditions within the area, such as bathymetry, water depth or sediment type and thickness; all which increase attenuation.

The impacts of continuous sound on a sensitive organism are a function of the SPL at the receptor and of the exposure time. Injury criteria for exposure to continuous sound are therefore expressed as sound exposure levels (SEL), related to SPL as:

$$SEL\ (dB\ re 1\mu Pa^2 s) = SPL + 10\log(t)$$

Where: t is the exposure time in seconds.

This equation has the effect that a doubling of exposure time results in an increase of 3dB re SPL, while 24hrs continuous exposure result in an increase of 49dB re SPL.

5.7.1.2 Potential impacts on marine mammals

The risks to marine mammals from anthropogenic sound and vibration are well documented (e.g. DECC 2016). Both cetaceans and pinnipeds have evolved to use sound as an important aid in navigation, communication and hunting (Richardson *et al.* 1995). It is generally accepted that exposure to anthropogenic sound can induce a range of behaviour effects and, in extreme circumstances, permanent injury in marine mammals. Loud and prolonged sound above background levels may be considered noise and may have a negative effect on marine life. In marine mammals, this may mask communicative or hunting vocalisations, inhibiting social interactions and effective hunting.

It is an offence under the Conservation of Offshore Marine Habitats and Species Regulations 2017 to deliberately capture, injure, kill or disturb any wild animal of a European Protected Species (EPS). Disturbance of animals includes any disturbance which is likely:

a) To impair their ability –

i) To survive, to breed or reproduce, or to rear or nurture their young; or

ii) In the case of animals of a hibernating or migratory species, to hibernate or migrate; or

b) To affect significantly the local distribution or abundance of the species to which they belong.

All cetacean species are EPS and therefore causing injury or disturbance could be considered an offence.

For marine mammals exposed to continuous noise, Southall et al. (2019) provides thresholds at which permanent threshold shift (PTS) or temporary threshold shift (TTS) occur for different groups pf marine mammals, based on their auditory range. These groups are low-frequency cetaceans (LF); high-frequency cetaceans (HF); very-high frequency cetaceans (VHF); and phocid carnivores in water (PCW).

Thresholds (Table 5-12) at which the onset of auditory injury could occur, are given in terms of the SEL and take into account not only exposure time but also the auditory range of the marine mammal group (i.e., it is assumed that if an animal cannot hear the sound it will not have a significant impact). Southall et al. (2019) does not provide the duration for the SEL thresholds; however, NMFS (2016) specify 24-hour exposure for the same SEL threshold values and state that thresholds should be modified where exposure times are either less or greater than 24-hours.

Behavioural disturbance is more difficult to assess than injury and is dependent upon many factors related to the circumstances of the exposure (Southall et al. 2007, NMFS 2018). Disturbance may result in individuals moving away from the zone of disturbance and remaining at a distance until the activities have passed. There may also be changes in foraging, migratory or breeding behaviours; all factors that can affect the local distribution or abundance of a species. Introduced sound may also cause masking or disruption of the animal's own signals, whether used for communication, foraging or other purposes.

An animal's ability to detect sounds produced by anthropogenic activities depends on its hearing sensitivity and the magnitude of the noise compared to the amount of natural ambient and background anthropogenic sound. In simple terms, for a sound to be detected it must be louder than background and above the animal's hearing sensitivity at the relevant sound frequency. All sound produced by anthropogenic activities greater than 20 - 30dB above background is considered to have the potential for disturbance to sensitive marine mammals (Cato 2009). 140dB re 1 $\mu Pa^{-2}s$ (RMS) has been used as the disturbance threshold for continuous sound for all marine mammal species (Gomez et al. 2016, BOEM 2014, NMFS 2018).

Table 5-12 shows the distances at which the thresholds for the onset of auditory injury or disturbance could be exceeded for the various marine mammal groups. This assumes both that the sound is continuously generated and that the animal remains within range for 24 hours. Given that marine mammals are highly mobile, animals are unlikely to remain within range for a fraction of that time.

Table 5-12 Sound modelling results, pipelay vessel emitting 190dB re 1 μPa (broadband)

Hearing group	Auditory range	Common species present within the Proposed Development	Sources of sound impacting group	SEL (weighted) continuous sound (dB re 1 μPa²s) (Southall *et al*. 2019)		Distance from Source (m) where threshold is exceeded	
				PTS	**TTS**	**PTS**	**TTS**
LF cetaceans	7Hz-35kHz	No species identified	Vessel engine sound	199	179	-	5
HF cetaceans	150Hz-160kHz	White beaked dolphin	Dynamic positioning thruster operation	198	178	-	4.2
VHF cetaceans	275Hz-160kHz	Harbour porpoise		173	153	8.6	159.7
Pinnipeds, phocid carnivores (UK) in water (PCW)	50Hz-86kHz	Grey seal & harbour seal (unlikely to be present)	Vessel engine sound	201	181	-	2.9
All groups	Disturbance (NMFS 2018)			140		1708	

Source: Southall *et al.* (2019),

Although the results presented in Table 5-12 indicate that there is a potential that continuous noise could cause auditory injury, at the TTS level, to the most sensitive group (VHF cetaceans), animals will have to be present within the zone of influence for 24-hours for the onset of effects. Given the area is 160m from the installation vessel this is highly unlikely to occur.

For some activities the vessels may be stationary for extended periods, however, this will only require low thruster power to maintain position, with consequent low levels of transmitted sound. Use of thrusters at high power, associated with manoeuvring, will be short term; hence, as discussed above, sensitive species are unlikely to remain within the zone of influence for 24 hours.

Data from Reid *et al*. (2003) suggests that harbour porpoise are likely to be present, in low to moderate densities, peaking at high densities in July, whilst white beaked dolphin are present in low densities in January, April, May and October.

Table 5-12 indicates that disturbance may occur. Even at very low swim speeds (e.g. 0.5ms^{-1}) it would take cetaceans approximately 2 hours to swim the total 3.4km diameter zone where disturbance could be experienced. At greater swim speeds (which would be expected in the event of disturbance) exposure times would be correspondingly less, suggesting that actual exposure times are well below the 24-hours exposure time used in determining the thresholds given in Table 5-12. As a result, actual risk to marine mammals is very low.

5.7.1.3 Plankton, fish and shellfish

The thresholds used in the assessment are taken from Popper et al. (2014). These are specifically for fish which have swim bladders, as these are most sensitive to sound. The thresholds given for recoverable injury and TTS as a result of continuous noise are:

- Recoverable injury, 170 dB re 1 µPa^2s RMS (for exposure of 48 hours), exceeded at 22m from source.
- TTS threshold of 158 dB re 1 µPa^2s RMS for exposure of 12 hours, exceeded at 133m from the source.

As the species of plankton, fish and shellfish present in the Proposed Development are typical of the SNS (Section 4) no impacts at population level are expected.

5.7.1.4 Protected sites

The Proposed Development is within the Southern North Sea SAC, designated for the conservation of harbour porpoise. The Proposed Development lies in the area defined as the summer grounds but close the winter grounds (Section 4.3.2.1). It is accepted (JNCC 2019a) that:

Noise disturbance within an SAC from a plan/project individually or in combination is significant if it excludes harbour porpoises from more than:

1. 20% of the relevant area of the site in any given day, and

2. An average of 10% of the relevant area of the site over a season

As the disturbance zone is less than 0.1% of either the summer or winter grounds of the SAC any potential disturbance can be regarded as non-significant.

The conservation objectives of the North Norfolk Banks and Saturn Reef SAC are not considered vulnerable to noise.

5.7.2 Mitigation measures

The risk to plankton, fish, shellfish and marine mammals is assessed as acceptable therefore no mitigation has been proposed.

5.7.3 Residual impact

It has been determined from the assessment that there will be no residual impacts from the activities.

5.8 Generation of underwater sound (UXO detonation)

5.8.1 Background

It is unknown if a UXO detonation will be required within the Proposed Development. However, given the historic use of the region, a desktop study of the Southwark platform site (Ordtek 2021) indicates it is possible that a large UXO such as a projectile, depth charge or torpedo could be encountered.

The primary objective will be to avoid encountered potential UXO. A UXO survey of the pipeline route corridor will be undertaken to identify magnetic anomalies which could indicate the presence of UXO. These will be investigated to determine if they pose a risk to the installation operation. It is possible that a minor route-adjustment to the pipeline centreline could be made to avoid extensive anomalies although micro-routeing is not a feasible solution due to the inflexibility of the pipeline.

If visual inspection of the potential UXO confirms a UXO then, if it is safe to do so, the UXO will be removed. Only as a last resort will in-situ detonation be undertaken.

Should UXO be found which require clearance by detonation it is assumed that there would be a relatively large release of impulsive sound energy, creating high amplitude shock waves (von Benda-Beckmann et al. 2015). Peak source levels would depend on the quantity and nature of explosive material. At close range there would be risk of mortality as relatively small quantities of explosive can result in significant sound pressure levels, e.g. Richardson et al. (1995) reported that 0.5kg of TNT was associated with a peak pressure of 267dB re 1µPa @ 1m.

5.8.2 Impacts

An underwater explosion, such as UXO detonation, can cause physical injury such as crushing, fracturing, haemorrhages and rupture of body tissue, and/or permanent or temporary changes to hearing (i.e. onset of PTS or TTS) to animals in close proximity to the explosion. This blast trauma, resulting from the effects of the initial shock wave and rapid changes in pressure immediately following, can result in immediate or eventual mortality of the animal. However, most research including von Benda-Beckmann et al. (2015) into effects of underwater explosions, focuses on the sound levels that are high enough to cause hearing loss i.e. onset of PTS, as it is acknowledged that this is likely to occur at lower sound pressure levels than would cause the physical trauma injuries previously listed. The justification is that if mitigation can be proposed to avoid PTS level effects this will also effectively mitigate for blast injuries.

The UXO detonation, if required, will be an instantaneous event. Although animals in the wider area may display a startle reaction there will not be widespread or prolonged displacement or disturbance. In the event of the detonation of a UXO the Statutory Nature Conservancy Boards (SNCBs 2020) indicate that, in the absence of empirical evidence of harbour porpoise avoidance, a precautionary 26km effective deterrence range (EDR) should be used for high order detonation of UXOs. They also note that a single explosion would probably be of too short duration to cause widespread displacement.

As previously stated, the Proposed Development is within the summer area of the Southern North Sea SAC, the Primary Feature of which is the Annex II species harbour porpoise. A 26km radii zone of influence would cover 2124km^2. Assuming this area was entirely within the Southern North Sea SAC it would represent 5.75% of the total SAC area of 36,951km^2. As shown in Figure 5-12 (Drawing No: P2371S3-PROT-002) due to the position of the Proposed Development within the SAC, the 26km radii zone of influence will extend outside of the SAC. The maximum area affected within the SAC is therefore 1,640km^2 (detonation close to the Thames pipeline tie-in end), equivalent to 4.44% of the SAC.

As previously stated, noise disturbance within the SAC is significant if it excludes harbour porpoises from more than:

1. 20% of the relevant area of the site in any given day, and
2. An average of 10% of the relevant area of the site over a season

The Proposed Development lies close to the boundary of the summer and winter grounds, which measure 27,028km^2 and 12,696km^2 respectively. A UXO detonation therefore has the potential to affect both relevant areas. It is calculated, using a GIS that approximately 1577km^2 of the summer ground (detonation at Southwark platform tie-in end) and 136km^2 of the winter ground (detonation at Thames pipeline tie-in end) could be affected by the 26km EDR; equivalent to 5.83% and 1.07% of the relevant areas respectively.

The assessment concludes that the Proposed Development will not cause significant noise disturbance.

5.8.3 Mitigation measures

High order detonations of UXO results in one of the loudest sources of underwater noise and the risks to marine mammals are unacceptable unless project specific mitigation is implemented. There are three categories of noise mitigation which can be applied to UXO detonation, namely: noise abatement / reduction, spatial-temporal restrictions, and acoustic deterrents.

If UXO detonation is required, IOG will contract ordnance disposal contractors and will ensure that they comply with the JNCC guidelines for minimising the risk of injury to marine mammals from using explosives (JNCC 2010, or as updated). This includes requirements to ensure that there are no marine mammals in the direct vicinity of the detonation e.g. visual searches of an established mitigation zone, only commence operations during daylight hours and good visibility, and soft-start procedures. The guidance includes real time restrictions during the activity e.g. halting the activity temporarily in response to detection of marine mammals using visual or passive acoustic monitoring. Implementation of the guideline procedures will ensure that the risk of marine mammals being exposed to sound levels sufficient to cause blast injuries or the onset of PTS will be reduced to a negligible level.

If more than one UXO detonation is required, the Contractor shall seek to place the UXO together at one location so that one detonation can take place, or will programme the detonations so that the smaller charge is detonated first similar to a soft-start procedure.

With respect to noise abatement mitigation, IOG propose to use deflagration for all charge sizes. The deflagration process is described in Cheong et al. (2020) as “the UXO casing is penetrated by a shaped charge that generates insufficient shock to detonate. The explosive material inside the UXO reacts with a rapid burning rather than a chain reaction that would lead to a full explosion. Deflagration is a much less energetic process and anecdotal evidence has suggested that it is “quieter” than traditional high-order detonation.” Cheong et al. (2020) goes on to say that US test studies show that low-order detonation procedures are very effective in reducing blast effects with a yield reduction exceeding 97% in comparison to the equivalent high-order detonation. Cheong et al. (2020) reports the results of an experimental trial conducted in Limehillock Quarry, Scotland to study the acoustic characteristics of underwater explosions, including low order detonation by deflagration. The study observed a more than 20dB reduction in peak sound pressure levels (SPL) and sound exposure levels (SEL) between high-order detonations and low-order detonations of the same charge size. The data clearly showed that low-order detonations “offer a much lower amplitude of peak sound pressure than high-order detonations (by a factor of approximately 10 [in our trials])” Cheong et al. (2020). The study concluded that low-order deflagration is an effective mitigation measure.

In addition, IOG are also proposing the use of acoustic deterrent devices (Lofitech seal scarer or similar) and the augmentation of visual searches by passive acoustic monitoring to aid detection of marine mammals within the mitigation zone.

Implementation of the above mitigation will ensure that the risk of marine mammals being exposed to sound levels sufficient to cause blast injuries or the onset of auditory injury will be reduced to a negligible level.

Table 5-13 presents the mitigation measures that will be adopted in the Proposed Development.

Table 5-13 Mitigation measures – UXO detonation

ID	Mitigation measures
M11	A UXO survey will be undertaken along the pipeline corridor to identify anomalies. If any significant UXO is identified, the decision-making hierarchy taking into account environmental sensitivities, safety and technical considerations shall be: 1. Avoid 2. If the UXO cannot be avoided, undertake clearance to surface or move UXO outside the installation corridor. 3. If the UXO cannot be safely moved, clearance by on-site detonation
M12	If clearance by on-site detonation is the only feasible option, all charge sizes shall be detonated using deflagration (low order detonation).
M13	UXO clearance by deflagration shall comply with the JNCC guidelines for minimising the risk of injury to marine mammals from using explosives (JNCC 2010, or as updated), including: a. Establishment of a default 1km mitigation zone for marine mammal observation, measured from the explosive source and with a circular coverage of 360 degrees b. Provision of two trained marine mammal observers (MMO) to implement the JNCC guidelines

ID	Mitigation measures
	c. Provision of a Passive Acoustic Monitoring (PAM) to be operated by a suitably trained and experienced MMO to support visual observations. d. Commencement of explosive detonations only during daylight hours and good visibility e. Accurate determination of the amount of explosive required for the operation, so that the amount is proportionate to the activity and not excessive. f. If necessary, planning of a sequence of multiple explosive discharges so that, wherever possible, the smaller charges are detonated first to maximise the 'softstart' effect.
M14	Lofitech AS seal scarer (or similar) acoustic deterrent device will be used prior to UXO deflagration.

5.8.4 Residual impact

The proposed mitigation measures have proven successful for similar projects in the SNS and they are proven effective at reducing the magnitude of the effect by reducing the number of marine mammals exposed to noise levels that may cause injurious effects. The use of an acoustic deterrent device will marginally extend the length of time for disturbance level effects i.e. from instantaneous to brief (<1hr). However, this marginal increase in disturbance is outweighed by the benefits the acoustic deterrent devices provide in reducing the more significant risks of injury. As deflagration will be an instantaneous event, and with the implementation of the proposed mitigation there will be no residual effects.

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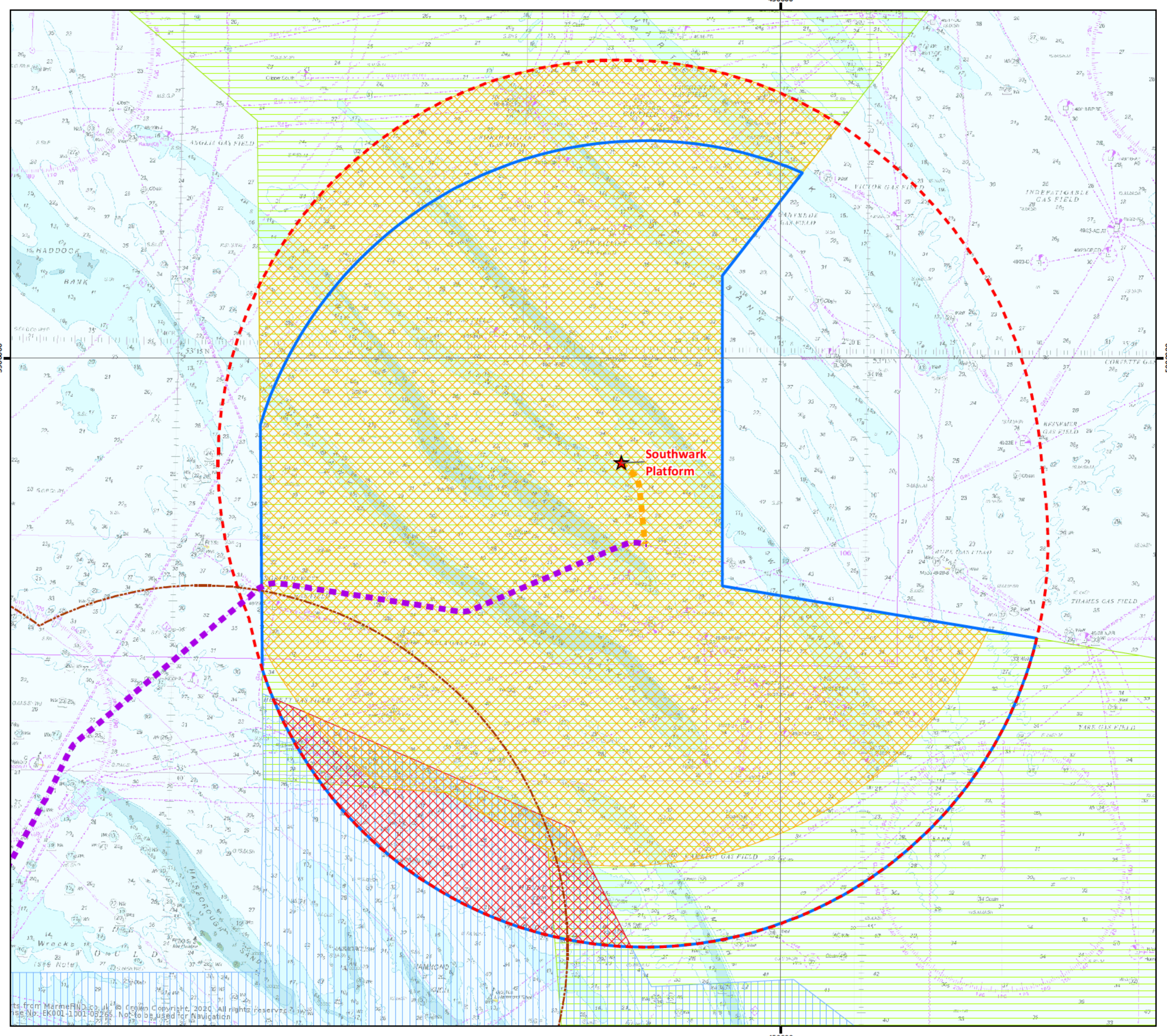

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IOG SOUTHWARK ENVIRONMENTAL STATEMENT

PROTECTED SITES
Southern North Sea SAC UXO Detonation Impact

Drawing No: P2371S3-PROT-002	A

Legend

- Southwark Platform
- Southwark Pipeline
- Thames Pipeline
- 12nm Territorial Sea Limit
- Southwark Pipeline 26km EDR

Maximum Impacted Area

- Total SAC (163960 ha)
- SAC Summer Grounds (157666 ha)
- SAC Winter Grounds (13599 ha)

Southern North Sea SAC

- Summer
- Winter

N W E S

NOTE: Not to be used for Navigation

Date	29 March 2021
Coordinate System	ED 1950 UTM Zone 31N
Projection	Transverse Mercator
Datum	European 1950
Data Source	OGA; JNCC; UKHO; ESRI; OSOD;
File Reference	J:\P2371\Mxd\P2371S3\06_PROT\ P2371S3-PROT-002.mxd
Created By	Chris Dawe
Reviewed By	Emma Storey
Approved By	Anna Farley

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5.9 Generation of waste

5.9.1 Impact assessment

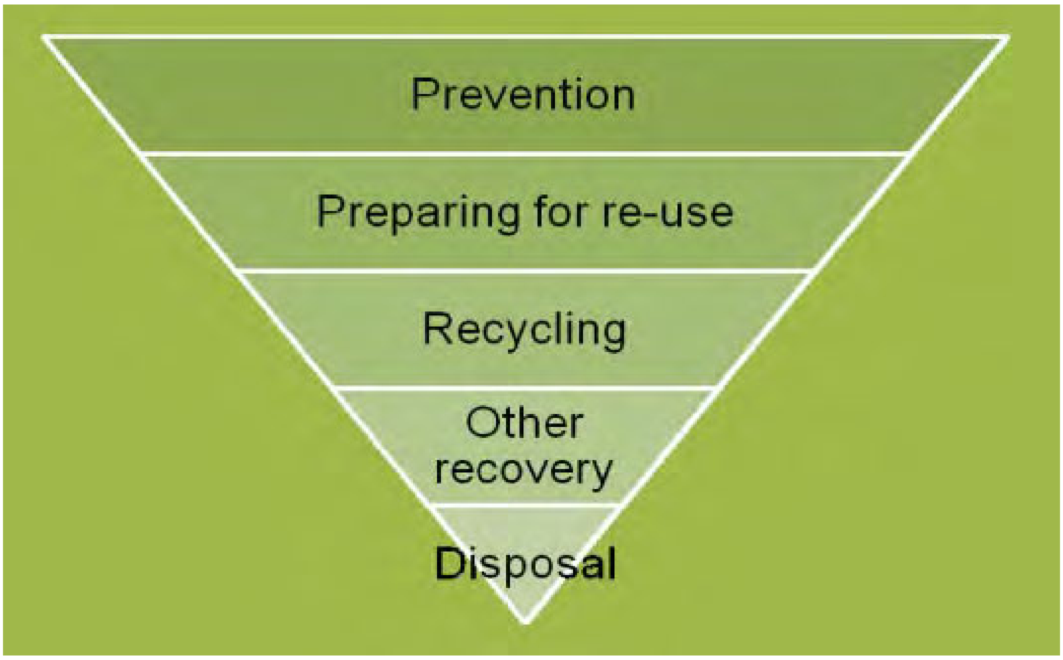
This assessment concluded that the risk posed to the environment from generation of waste is acceptable.

Waste will be generated during all phases of the Proposed Development. The intention is to minimise waste production and to manage all produced waste, by applying approved and practical methods and by adhering to a waste hierarchy shown in Figure 5-13.

Waste will only be disposed of to landfill if it cannot be prevented, reused/recycled or recovered (as per Figure 5-13). All waste streams generated will be managed via waste contracts. Procedures are in place to manage waste generated offshore and the associated controls required to manage the hazards associated with the transportation and disposal of waste from offshore sites and the processes, and verification activities, necessary to ensure legal obligations are satisfied.

Consent to transfer to the United Kingdom shore is not required but Duty of Care (under the Environment Protection Act 1990) makes it the waste producer's responsibility to ensure that waste is only transferred to an appropriately licensed carrier who should have a Waste Carrier Registration. Transfer of Controlled Waste requires a Transfer Note to be completed (or Consignment Note in the case of Special Waste). A Waste Transfer Note (WTN) is required to detail the type and quantity of waste, from whom and to whom the waste has been transferred, the category of authorised person to whom the waste has been consigned, relevant licence numbers, time, place and date of transfer. The waste hierarchy outlines the priority for waste handling (Figure 5-13).

Figure 5-10 Waste hierarchy



Source: Defra (2011)

5.9.2 Vessel waste

Waste is anticipated to be generated from vessels associated with the Proposed Development. Waste will be managed by the individual vessel in accordance with the International Convention for the Prevention of Pollution from Ships (MARPOL) requirements.

General waste, special/hazardous waste and chemical/laboratory waste generated on the pipelay vessel and any other project vessels will be segregated by personnel at the source of generation, and either manually handled to the appropriate labelled waste receptacle until transferred onshore for disposal and/or treatment or managed in accordance with the appropriate handling procedures.

All waste will be segregated in accordance with waste management procedures and waste management duty of care audits will be carried out, with completion of controlled waste transfer notes. All waste will be disposed of onshore via a licensed contractor.

5.9.3 Decommissioning phase

The waste generated as a part of the decommissioning phase of the Proposed Development will be a combination of both hazardous (special) and non-hazardous wastes. A decommissioning programme will be developed to identify, quantify and discuss available disposal options for waste resulting from the decommissioning activities. Where practicable, materials will be recycled or sold, and reused taking into account a waste hierarchy similar to that shown in Figure 5-13. It is intended that, if the infrastructure is recovered, it will be returned to shore and transferred to a decommissioning facility. The minimisation of waste is a factor considered at every stage of the Proposed Development. If appropriate, a comparative assessment will be undertaken at decommissioning to determine the Best Practicable Environmental Option (BPEO).

5.9.4 Mitigation measures

Table 5-14 presents mitigation measures that will be adopted in the Proposed Development .

Table 5-14 Mitigation measures – waste generation

ID	Mitigation measure
M15	Waste will be managed in line with waste management procedures, striving to reduce the amount of waste going to landfill (disposal). All waste will be correctly documented, transported, processed and disposed of in accordance with applicable legal requirements line with legislation and in an environmentally responsible manner.

5.9.5 Residual impact

It has been determined from the assessment that there will be no residual impacts from the activities.

5.10 Susceptibility to natural disaster and climate change

The probability of a major natural disaster (such as an earthquake or tsunami) occurring in UK waters which could impact the pipelay operation or pipeline use is extremely low (British Geological Survey 2020).

In the North Sea, the frequency of occurrence of a magnitude 4 natural seismic event is expected to be approximately every two years and that of a magnitude 5 event every 14 years (British Geological Survey 2020). These events will not cause a natural disaster or likely to result in significant damage to offshore infrastructure.

In August 2015, a magnitude 4.1ML (local magnitude) earthquake at a depth of 4km occurred in the Southern North Sea and was felt on nearby platforms and Sheringham on the Norfolk coast (DECC 2016). The event did not cause any damage to offshore oil and gas infrastructure.

Anthropogenic climate change is expected to increase the frequency of storm surge events in the North Sea toward the end of the century; however, this is not expected to affect the east coast of the UK, from which Southwark is located (Woth *et al*. 2006). Increases in storm surge frequency are therefore not expected to affect the pipelay operation or the integrity of the pipeline over its lifetime.

A literature review by Schrum *et al.* (2016) describes dynamic wave modelling of the future wave climate of the North Sea which shows a predicted increase in wave heights of an average of only 15cm per year. This is based on a doubling of carbon dioxide emitted for the period 2060-2089 compared with 1970-1999.

In addition, a study by Sterl *et al.* (2015) into the wind climate of the Southern North Sea under climate change scenarios concludes that global warming will not change the wind climate over the North Sea beyond the large range of natural climate variability that has been experienced in the past. Meteorological variations are therefore not expected to affect the pipelay operation or the integrity of the pipeline over its lifetime.

This demonstrates that any change to the environmental baseline brought about by climate change is unlikely to affect the Proposed Development during its lifetime.

5.10.1 Mitigation measures

Pipelines are designed to withstand seismic forces and vibrations with little or no damage while maintaining integrity. There is an extremely low likelihood of exceedance of the pipeline's integrity due to natural disasters or the effects of climate change during its lifetime.

5.11 Technical and data deficiencies

Technical information regarding the pipeline installation method has been provided in full by Subsea7, the subsea engineering contractors for the pipelay operations. In addition, recent survey data collated in 2018 has been utilised for the environmental baseline. This has been updated using the most recent pre-lay survey reports from 2020.

The operation is part of a standard offshore construction. Information is available within literature to assess the likely consequences of the development on the elements listed in Table 5-4 and assessed throughout Sections 5.3 to 5.10.

There are limitations in the data available to assess the effects of climate change specifically on offshore developments. The effects of climate change on the offshore environment within the SNS in general have been used to determine the possible effects on the pipeline installation and the lifetime of the pipeline.

6. UNPLANNED EVENTS

6.1 Introduction

It is possible that, during the lifecycle of a development, events may occur which result in unplanned releases of hydrocarbons (including fuels) or chemicals to the environment. While any release has the potential to impact the environment, the significance of the impact depends on numerous factors including (but not limited to) the quantity and properties of the substance released, metocean conditions at the time, and the sensitivity of the receptors. Releases of water-soluble chemicals and of insoluble solids denser than water generally present a low risk of harm as they tend to dilute and disperse rapidly to below potentially harmful concentrations in the marine environment. However, hydrocarbons will tend to form surface slicks, with the potential to cause harm to species such as seabirds and marine mammals and a risk of beaching on surrounding coastlines. Impacts on water quality and water column species (e.g. fish and plankton) and, in some very severe cases, sediments and associated benthic species may also occur.

The risks associated with releases of hydrocarbons were presented in the Blythe Hub Development ES Addendum – Southwark Field Development (IOG 2018), and at the request of OPRED have been reproduced in this section. It concluded that:

- A spillage of diesel, from the platform or service vessels, had the potential to impact the shoreline, with persistence on the water surface up to 14 days following the end of release.
- Condensate, whether released as a result of a well blowout or of pipeline failure would not reach the shoreline, with persistence on the water surface up to 3 days following the end of release.

Release of diesel was therefore considered by the Blythe Hub Development ES Addendum – Southwark Field Development to represent the worst case and is the basis of the Field Development Oil Pollution Emergency Plan (OPEP) which covers the drilling of wells and any operations within 500m of the Southwark platform.

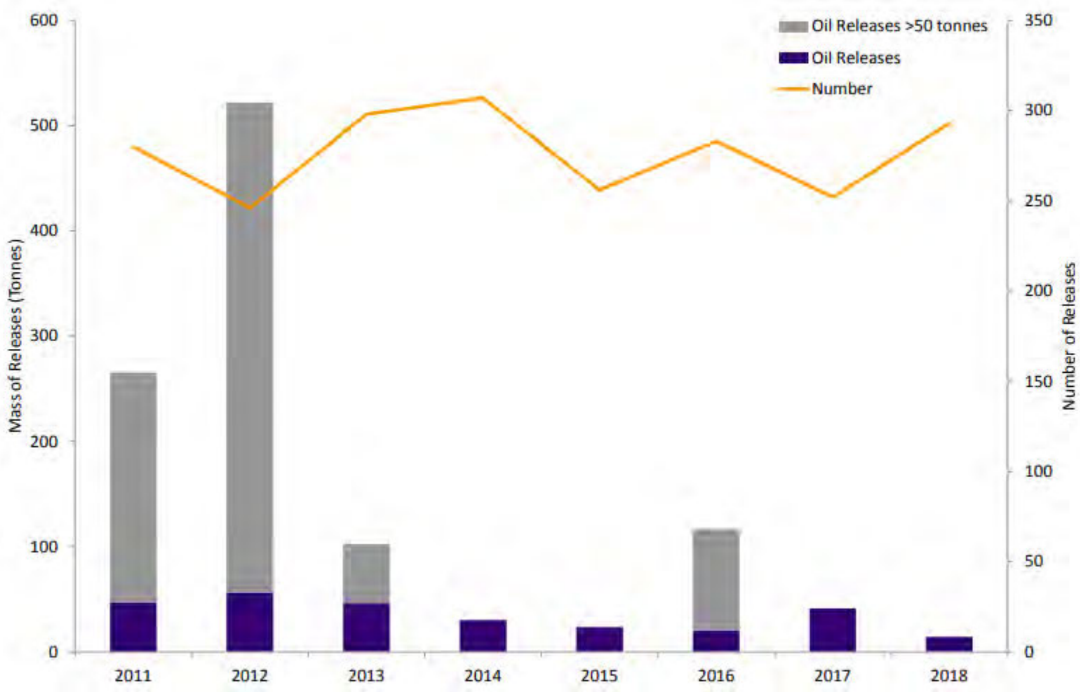
Unplanned releases from EPC Contractor vessels outside of the 500m zone around the Southwark platform, are the responsibility of the EPC Contractor, and are managed through the implementation of the individual vessels Shipboard Oil Pollution Emergency Plan (SOPEP). Oil spill modelling is not required under the SOPEP. The modelling results presented for a diesel spill within the 500m safety zone should therefore only be regarded as indicative for releases from vessels outwith the 500m safety zone.

The assessment provided in this section is based on unplanned events which would be the responsibility of the pipeline operator, ODE AM.

6.1.1 Frequency of unplanned oil releases on the United Kingdom Continental Shelf (UKCS)

Available information on hydrocarbon releases from oil and gas operations on the UKCS shows that, while the annual number of unplanned releases has remained close to constant between 2011 and 2019. the quantity released annually and the average spill size, have generally decreased (OGUK 2020). However, while rare, individual releases larger than 50 tonnes dominate the total releases during this period, as shown in Figure 6-1 (OGUK 2019).

Figure 6-1 Accidental oil release in the UKCS



Source: OGUK (2019)

6.1.2 Frequency of vessel collisions in the UKCS

The vessel traffic survey (VTS) undertaken for the Proposed Development (Xodus 2021b) estimated that, during the period 31/03/2019 and 30/03/2020, 3,943 vessels passed within 10NM of the Southwark field. Of these 887 were in-field traffic, largely associated with the Leman field to the south of the Southwark platform and 164 were fishing vessels. The associated annual collision risk frequency for the platform was assessed as 1.102E-03, in the absence of a guard vessel. While this study related to vessel-installation collisions, rather than vessel-vessel collisions, it suggests that the likelihood of a collision during the period of pipeline installation is very low (approximately 1E-05).

6.2 Release modelling

It is a regulatory requirement that all operators have an OPEP in place for offshore activities. The OPEP outlines the procedures to be followed and implemented in the event of a hydrocarbon release occurring within the 500m safety zone of an installation. Hydrocarbon release modelling is included within the OPEP. This is presented to advise the decision-making process if response action is required. By understanding the potential fate of hydrocarbon during worst case release scenarios, informed decisions can be taken to prevent impacts on sensitivity receptors.

Oil spill modelling provides information such as:

- Hydrocarbon (oil) trajectories following a release;
- Minimum arrival times for surface oil at points along the trajectories;
- The probability of surface oil reaching points along the trajectories; and
- The probability, and quantities, of oil crossing a median line or reaching a shoreline or entering a protected site.

This information is used in the assessment of the potential impacts of a release of oil on the receiving environment.

In the event of a hydrocarbon release occurring from a vessel outside of a 500m safety zone the vessel SOPEP will be followed.

6.2.1 Inventories

Table 6-1 shows the inventories of hydrocarbons which could be released in the event of an incident such as loss of containment from the Southwark platform or from a vessel servicing the platform or from the Southwark 24" pipeline (PL370). The unplanned event scenarios which could occur are:

- Release of diesel from vessel or platform.
- Release of hydrocarbons from a pipeline failure.

Diesel is an International Tanker Owners Pollution Federation (ITOPF) Group 2 hydrocarbon which will form surface slicks if significant quantities are released. The diesel inventory is based on the worst-case fuel load on a rig or vessel at the Southwark platform.

Southwark is primarily a gas field. While natural gas, as such, has little potential to cause harm to the marine environment, the associated gas condensate has the potential to form surface slicks; however, it is an ITOPF Group 1 hydrocarbon. This is considered non-persistent in the marine environment. The condensate inventory is based on the potential release due to pipeline failure. The potential for release during drilling (i.e. a blowout) is not considered in this addendum to the Environmental Statement (ES).

Table 6-1 Hydrocarbon inventory

Type	ITOPF Category	Site	Volume (m^3)	Release time	Modelled
Diesel	2	Platform/ Vessel	1,138	Instantaneous	Yes
Condensate	1	Pipeline	0.63	Instantaneous	Yes

6.2.2 Scenarios

While the Blythe Hub Development ES Addendum – Southwark Field Development (IOG 2018) included modelling of unplanned release scenarios for both diesel and condensate (Table 6-2), only results for the modelled diesel release are given here, as this represents the worst-case covered under the Field OPEP. This only covers diesel releases occurring within the 500m safety zone of the Southwark platform, as releases from vessels outwith this area will be subject to the vessel SOPEP. As shown in Table 6-1, diesel is present in considerably larger quantities, and is more persistent than (i.e. is in a higher ITOPF category than) condensate.

Table 6-2 Unplanned release scenarios

Scenario	Description of the unplanned release
1. Loss of utility hydrocarbon and/or fuel from platform support vessel	Unplanned release of utility hydrocarbons (lube and hydraulic oils) and/or fuel during bunkering or because of vessel impact or collision. A total loss of diesel fuel could be significant but varies depending on the vessel and associated inventories. The worst-case scenario at the Proposed Development would be a loss of the total diesel inventory from a vessel.
2. Loss of pipeline inventory or subsea release	An unplanned release from a pipeline may occur due to failure or accidental damage when operational. Releases of hydraulic oil from surface equipment and remotely operated vehicles (ROV) are possible during the pipelay operation.

6.2.3 Modelling parameters

Stochastic modelling has been conducted using the SINTEF oil spill contingency and response (OSCAR) modelling package. In a stochastic simulation, a release trajectory is repeatedly run with a start date that is within the period covered by the available wind and/or hydrodynamic data. This results in a series of possible trajectories, with probabilities of surface oiling at any point based on the number of trajectories which pass through that point. Thus, the plot shows only where oil could be found, not the area which will be subject to oiling, in the event of a release.

For the selected worst-case scenario, 150 trajectories were run for each of the four seasons to create stochastic results. This approach allows enough simulations to adequately model the variability in the wind speed and direction in the area identified within the simulation. Running multiple release simulations during a single season should provide a reliable prediction of the oil pathways and oiling probabilities for a release starting during that season and extending into subsequent seasons.

In alignment with the requirements as stipulated by the Department for Business Energy and Industrial Strategy (BEIS) Guidance (BEIS 2019), the results of the modelling were analysed to determine:

- The probability of a visible surface oil with a minimum thickness threshold of 0.3µm, displayed to >10%;
- Time of arrival and probability >1% of crossing any UKCS median line; and
- Time of arrival and probability >1% of shoreline contamination along the UK and adjacent coastlines respectively.

The modelling parameters are presented in Table 6-3.

Table 6-3 Modelled scenarios

Scenario Parameters								
Loss from well / FPSO / rig / other	Rig/vessel			**Instantaneous loss?**		Yes		
Worst case volume	1,138.35m^3			**Will the well self-kill?**		N/A		
Flow rate	N/A			**If yes then when?**		N/A		
Justification for predicted worst case volume		Maximum diesel inventory of jack-up drilling rig (ENSCO 92 used as a proxy)						
Location								
Release source point	Latitude	53° 9' 36.900" N WGS84		**Longitude**		002° 6' 58.176" E WGS84		
Installation / Facility name	Southwark			**Quad / block**		Block 49/26, Southern North Sea		
Hydrocarbon Properties								
Hydrocarbon name	Diesel							
Assay available	No	**Was an analogue used for release modelling?**				Yes		
	Name	**ITOPF category**	**Specific gravity**	**API**	**Viscosity (cP (at temp °C))**	**Asphaltene content (%)**	**Wax content (%)**	**Pour point (°C)**
Hydrocarbon	Diesel	2	0.843	36.4	3.9	-	-	-36
Metocean Parameters								
Air temperature	2-15 °C		Sea Surface Temperature			7 - 14°C		
Wind data	Data period:		2 years' (2012 – 2013)					
Wind data reference	UK Oil & Gas European Centre for Medium-Range Weather Forecasts (ECMWF) wind data							

Current data	Data period:	2 years' (2012 – 2013)	
Current data reference	UK Oil & Gas (Shelf daily currents)		
Modelled Release Parameters			
Surface or subsurface	Surface	**Depth**	0m
Release duration	1 hour	**Instantaneous?**	Yes
Persistence duration	6.83 days	**Release rate**	1,138.35 m3/hour
Total simulation time	15 days	**Total release**	1,138.35 m^3
Oil Spill Modelling Software			
Name of software	OSCAR	**Version**	9.0.1.

6.2.4 Modelling results

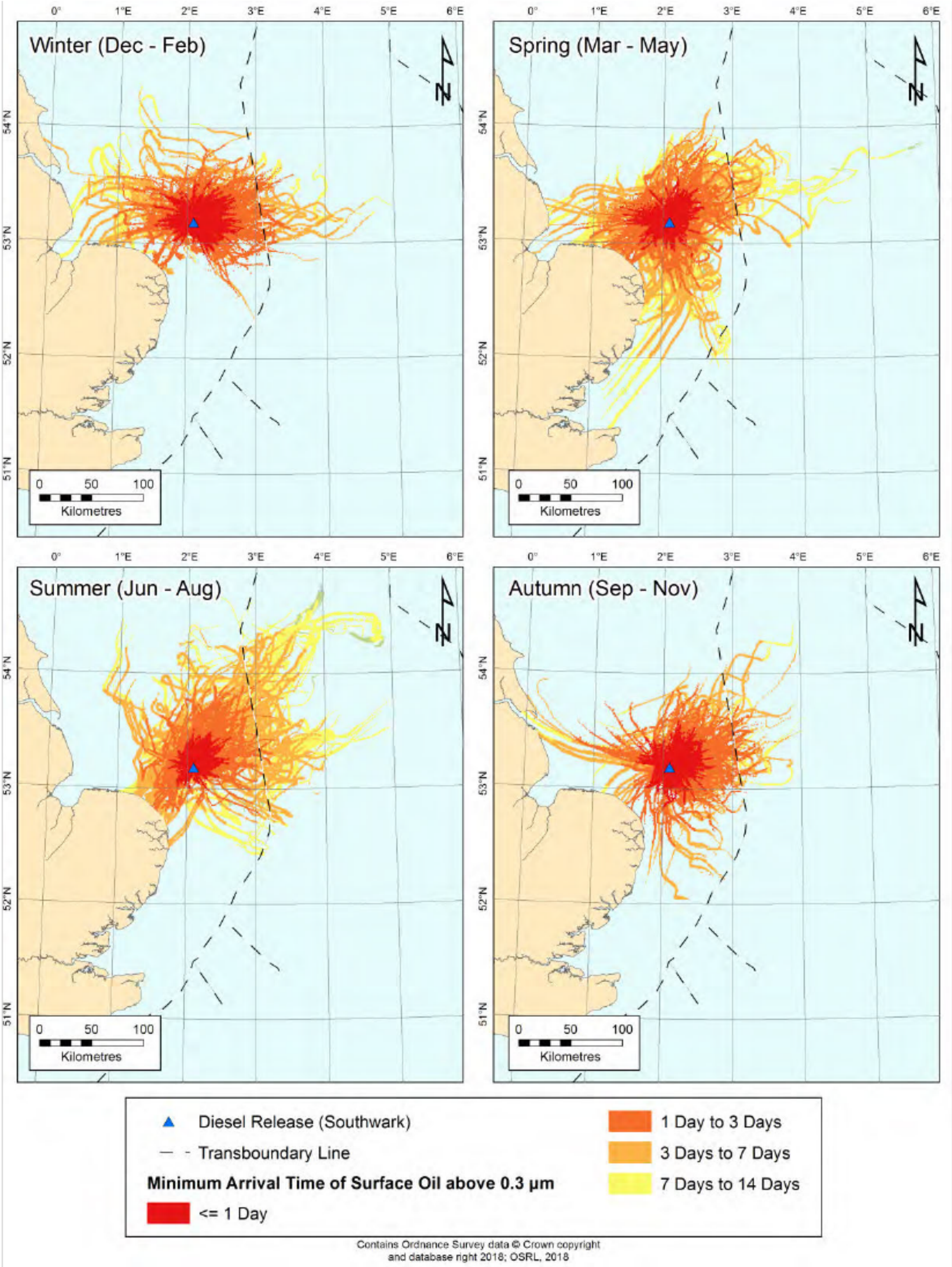
Table 6-4 shows the results of the diesel spill modelling, while the stochastic modelling results in Figure 6-3 show travel times for oil on the sea surface and Figure 6-4 shows the probability of oil contaminating the sea surface (IOG 2018). The modelling shows that hydrocarbons could potentially travel in any direction, although travel in a north easterly direction appears slightly more likely than travel in other directions. Beaching and/or crossing the median line is predicted to occur following a diesel release, as modelled. During summer months the area which could experience oiling is smaller than during winter months, because of generally lower wind speeds.

Table 6-4 Diesel release modelling results

Sensitivity	**Factor**	**Season**			
		Dec - Feb	Mar - May	Jun - Aug	Sep - Nov
Median line crossing					
UK/Netherlands	Probability (%)	30	18	51	28
	Time (days)	1.42	2.17	2.00	1.50
Landfall					
UK	Probability (%)	10	24	13	7
	Time (days)	2.17	1.67	2.58	2.37
	Mass beaching (tonnes)	551	520	649	566
	Volume beaching (m^3)	654	617	770	671

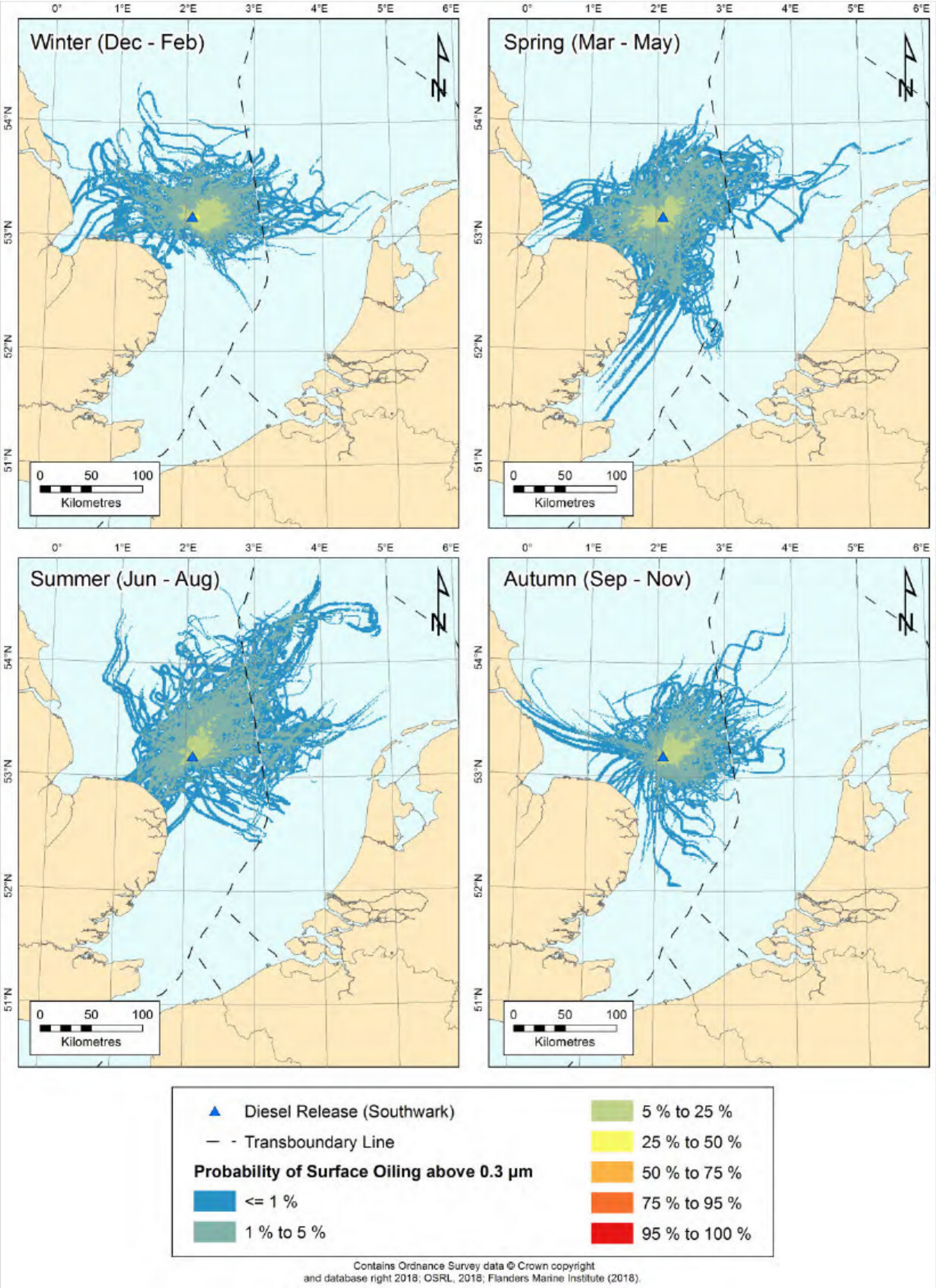
Source: IOG (2018)

Figure 6-2 Diesel release – Surface oiling arrival time



Source: IOG (2018)

Figure 6-3 Diesel release – Probability of surface oiling



Source: IOG (2018)

6.3 Environmental impacts of a hydrocarbon release

6.3.1 Summary of impact assessment of potential releases

The scores applied during assessment of the risk an unplanned event poses to the environment are summarised in Table 6-5. These scores have been derived considering the oil release modelling outlined in Section 6.2 above and the probability of a release of the modelled magnitude occurring. The risk assessment methodology is provided in Section 5.1. The assessment for key sensitive receptors is discussed below.

Table 6-5 Risk matrix – summary of assessment results (unplanned events)

	Environmental receptor											
Aspect	**Air quality**	**Water quality**	**Seabed sediment**	**Plankton**	**Benthos**	**Fish and shellfish**	**Seabirds**	**Marine mammals**	**Protected sites**	**Shipping**	**Commercial fisheries**	**Other marine users**
Unplanned events	1-A	1-A		2-A		2-A	4-A	3-A	3-A	1-A	2-A	

6.3.2 Plankton, fish and shellfish

Unplanned releases of hydrocarbons have the potential to cause toxic harm to plankton and fish communities (Beyer *et al*. 2016). In general, lighter refined petroleum products such as diesel and gasoline are more likely to mix in the water column and are therefore more toxic to marine life. However, they tend to evaporate quickly and do not persist long in the environment as soluble components are readily biodegradable. Direct effects, including mortality, to plankton and fish larvae have been recorded following major oil spills; however, these are considered unlikely to cause impacts at population level (IPIECA 2015).

As identified in Section 4 of this ES Addendum, the Proposed Development is located within the nursery grounds of eleven species, nine of which also spawn in the area. The spawning and nursing grounds of these species are extensive and are not limited to the area of the North Sea potentially affected by the extent of oiling from a diesel release scenario.

Therefore, in the highly unlikely event of a hydrocarbon release from an unplanned event at the Proposed Development it is expected to have a minor impact on the plankton and fish community at population level. The assessment concluded that a release poses an **acceptable** risk to plankton and fish.

6.3.3 Seabirds

Seabird sensitivity refers to susceptibility to surface pollutants, specifically hydrocarbons, following breeding and during moulting at sea. Section 4 of this ES Addendum indicates that seabird sensitivity to oiling within the area potentially affected by an unplanned release of hydrocarbons is extremely high during the period November to April.

The modelled diesel release has the potential to impact seabirds within the area of any slick generated. As this includes areas where seabird vulnerability is extremely high, the impact is potentially major; however, the probability of such a spill occurring is very low. As a result, the assessment concluded that the risk is **tolerable**.

6.3.4 Marine mammals and marine reptiles

The distribution of marine mammals and marine reptiles in the Potential Development area is discussed in Section 4 of this ES addendum. Harbour porpoise (*Phocoena phocoena*) and Atlantic white-beaked dolphin (*Lagenorhynchus albirostris*) have been regularly observed in the Proposed Development, with the former present at moderate to high density during June and July, while other species of cetacean have been reported as occasional visitors. Two species of pinniped, common or harbour seal (*Phoca vitulina*) and grey seal (*Halichoerus grypus*), occur in low density within the Proposed Development, but densities increase towards the coastline.

The effects of oil spills on marine mammals are discussed by Helm *et al*. (2015). Accidental releases of hydrocarbons present a risk to cetacean and pinniped species in the locality of the release, due to their toxic nature and ability to clog up breathing passages (blow holes). As marine mammals must surface to breathe, they may inhale vapours from hydrocarbon slicks or sheen and their eyes and skin may also be vulnerable. Impacts as a result of loss of insulation are not expected as cetaceans and adult grey and harbour seal rely on blubber (rather than fur) for insulation. In general, exposure to oil is likely to be most problematic for species in restricted habitats or those with restricted ranges. Many cetacean species found in offshore or open coastal waters are highly mobile and have a wide range, so their contact with released oil may be relatively brief (Helm *et al*. 2015).

While marine turtles are potentially vulnerable to oil (IPIECA 2015), they only occur in the North Sea as occasional visitors, as it is outside their normal range (DECC 2016). As a result, any impacts at population level will be negligible.

While there is potential for moderate impacts on marine mammals in the event of an unplanned release of hydrocarbons, the likelihood of such an event is very low. It is therefore concluded that the potential for an accidental release of hydrocarbons during the Proposed Development poses an **acceptable** risk to marine mammals and a negligible risk to marine reptiles.

6.3.5 Protected sites

A number of protected sites (as discussed in Section 4 of this ES Addendum) may be affected by a potential hydrocarbon release from the Proposed Development:

- The Proposed Development is within the North Norfolk Sandbanks and Saturn Reef Special Area of Conservation (SAC) (designated for the Annex I habitats: Sandbanks which are slightly covered by sea water all the time and Reefs) (as discussed in Section 4). An unplanned release of hydrocarbons may result in an increase in toxic dissolved hydrocarbons in the water column within the SAC. The designated features of the North Norfolk Sandbanks and Saturn Reef SAC are primarily on the seabed; therefore the conservation objectives of the SAC will not be impacted.
- The Proposed Development is within the Southern North Sea SAC, designated for the Annex II and European Protected Species (EPS) Harbour porpoise, as discussed in Section 4. Assuming the entire release volume (Table 6-3) formed a slick of 0.3µm thickness, the area covered would be 3,790km^2. This constitutes 10.3% of the total area (36,796km^2) of the SAC; however, any impacts on harbour porpoise within this area will be short term due to the nature of the released hydrocarbon. In addition, the probability of a release of this magnitude is very low. Therefore, the conservation objectives of the SAC will not be impacted.
- The closest Special Protection Area (SPA) to the Proposed Development is the Greater Wash SPA, designated for the protection of breeding populations of Sandwich tern, common tern and little tern, which is located 34km to the southwest. The presence of diesel on the sea surface or beaching within the SPA is possible, though extremely unlikely as it would require both a triggering event and adverse weather conditions. However, as diesel is not persistent in the marine environment,

any impact on the conservation objectives of the SAC, through impacts on seabirds, will be short term.

Although there is a potential for impacts on species for which the Southern North Sea SAC and the Greater Wash SPA are designated, the probability of such impacts occurring is very low. As a result, a release poses an **acceptable** risk to the conservation objectives of the protected sites. Mitigation is primarily through prevention of a release of diesel occurring, rather than though treatment following such a release.

6.3.6 Other users

A major oil spill would be likely to impact shipping and commercial fishing through imposition of exclusion zones within the affected area. However, modelling indicates that the duration of any slick following a spill would be short term, with any slick formed dissipating within 14 days, with the risk of a spill occuring being very low. The risk to both shipping and commercial fishing is therefore **acceptable**.

There are no aquaculture sites located within 40km of the proposed development and hence there is limited potential for aquaculture sites to be impacted by an unplanned release from the proposed development.

6.3.7 Major Environmental Impact

Some scenarios for unplanned events can have the potential to result in a Major Environmental Incident (MEI). The Offshore Installations (Offshore Safety Directive) (Safety Case etc) Regulations 2015 (SCR) Regulation 2 (SCR 2015 Reg. 2) defines a MEI as "*an incident which results, or is likely to result, in significant adverse effects on the environment in accordance with Directive 2004/35/EC of the European Parliament and of the Council on environmental liability with regard to the prevention and remedying of environmental damage*".

The Environmental Liability Directive (EC Directive 2004/35/EC) defines environmental damage as:

> *"a) damage to protected species and natural habitats, which is any damage that has significant adverse effects on reaching or maintaining the favourable conservation status of such habitats or species. The significance of such effects is to be assessed with reference to the baseline condition;*
>
> *b) water damage, which is any damage that significantly adversely affects the ecological, chemical and/or quantitative status and/or ecological potential, as defined in Directive 2000/60/EC* [Water Framework Directive], *of the waters concerned; and*
>
> *c) land damage, which is any land contamination that creates a significant risk of human health being adversely affected as a result of the direct or indirect introduction, in, on or under land, of substances, preparations, organisms or micro-organisms."*

Where 'damage' is defined as "*a measurable adverse change in a natural resource or measurable impairment of a natural resource service which may occur directly or indirectly*".

SCR 2015 Reg. 2 defines a major accident as:

> *(a) an event involving a fire, explosion, loss of well control or the release of a dangerous substance causing, or with a significant potential to cause, death or serious personal injury to persons on the installation or engaged in an activity on or in connection with it;*
>
> *(b) an event involving major damage to the structure of the installation or plant affixed to it or any loss in the stability of the installation causing, or with a significant potential to*

cause, death or serious personal injury to persons on the installation or engaged in an activity on or in connection with it;

(c) the failure of life support systems for diving operations in connection with the installation, the detachment of a diving bell used for such operations or the trapping of a diver in a diving bell or other subsea chamber used for such operations;

(d) any other event arising from a work activity involving death or serious personal injury to five or more persons on the installation or engaged in an activity on or in connection with it; or

(e) any major environmental incident resulting from any event referred to in paragraph (a), (b) or (d),

Thus, an MEI requires a triggering event which constitutes a major accident.

During the Project Development there is potential for a worse case release of up to 1,138m^3 of diesel as the result of a major accident (i.e. vessel collision resulting in severe damage to the vessel with a significant potential to cause death or serious personal injury to personnel), which could potentially result in an MEI. There is also a potential for a release of up to 0.63m^3 condensate through pipeline failure; however, this is not considered as representing potential for an MEI.

Diesel is an ITOPF Group 2 hydrocarbon, which is considered non-persistent. The volume of oil released could cover an area of up 3790km^2 (assuming an average depth of 0.3µm); however, the surface slick would rapidly break up through natural weathering processes, decreasing the area impacted. For diesel the predominant weathering processes will be evaporation and dissolution.

Impacts of a worst-case diesel spill would be:

Seabirds - The potentially impacted area only represents a small proportion of the range of any seabird present in the SNS and the surface oil will be non-persistent. As a result, impacts on seabird populations will not be significant.

European Protected Species (EPS) - This area only represents a small proportion of the range of any cetacean species found within the SNS, while marine reptiles are outside their range. As a result, there will not be a significant impact on EPS.

Protected sites - The maximum area for the slick represents 10.3% of the total surface area of the Southern North Sea SAC 14.0% of the northern summer area (in which the Project Development lies) and 29.9% of the southern (winter) area. However, modelling suggests that oil is unlikely to enter the winter zone during the winter months (Figure 6-3) and therefore the conservation objectives of the site will not be impacted. With the exception of the Southern North Sea SAC, the conservation objectives of fully marine SACs are not vulnerable to surface slick formation. Beaching of diesel within coastal SACs is not expected to impact the conservation objectives of the receiving sites as such impacts will be short term, due to the nature of the oil. Diesel could enter the Greater Wash SPA; however, any impacts on bird populations within the SPA will be short term and the conservation objectives of these sites will not be impacted. It is concluded that hydrocarbons will not persist within these protected sites for long enough to cause a severe regional impact and will not lead to long term/irreversible damage to the sites and their supporting habitats.

An event leading to a Major Environmental Incident (MEI) (e.g., a collision leading to total fuel loss from the vessel inventory over 1 hour) is possible. However, this will not affect the conservation objectives of protected sites and European Protected Species, nor is it likely to result in a significant adverse effect. Therefore, if a worst-case release occurred this will not constitute an MEI. In addition, the probability of such an event occurring is very low and therefore the risk is **acceptable**.

6.4 Mitigation

Operations are conducted in such a manner as to minimise the risk of hydrocarbon and chemical spillage and pollution. Risk assessment processes are used to identify potential risks, their severity, and identify barriers to prevent those risks from materialising. Where residual risks remain, management and mitigation measures are put in place to reduce the likelihood and extent of any potential unplanned releases.

In the event of an unplanned release occurring within the 500m safety zone of an installation, the installation operators OPEP will be applied. Outwith a 500m safety zone an unplanned release from a vessel will result in the vessel's SOPEP being applied.

There are two key levels of mitigation for hydrocarbon releases - prevention and control. Table 6-6 demonstrates the measures that will be implemented to minimise the risks of unplanned releases.

Table 6-6 Mitigation measures

Mitigation measure	Summary of controls
M16	**Spill prevention** - All operational personnel, whether in the direct employ of IOG, the Installation and Pipeline Operator or appointed contractors will be made aware of existing environmental protection procedures and the crucial importance of hydrocarbon containment and Asset Integrity. The risk of a release is addressed on a day-to-day basis by IOG employees and contractors following good practice, collision avoidance and fuel handling and transfer procedures. Every effort will be made to prevent such releases. It is noted that most releases occur during offshore fuel transfer operations (bunkering), which are not expected to occur during this operation. If they are required IOG & the Installation and Pipeline Operator require vessel contractors to take the following measures: The connection between the fluid transfer hose and the supply vessel will be a self-sealing, dry-break hose connection. Preference will be given to carrying out external fluid transfers during the hours of daylight. If operational reasons dictate that external fluid transfer are carried out during the hours of darkness, then they will be subject to documented risk assessment which will include environmental and safety considerations. Fluid transfer during hours of darkness will not commence without provision of sufficient illumination to allow the entire length of the transfer hose to be visually monitored from the installation. If operational reasons dictate that simultaneous external fluid transfers of more than one hydrocarbon liquid product is required, it will not take place until a full documented risk assessment has been made. Integrity of the pipeline is ensured by application of corrosion protection measures and regular monitoring and maintenance.
M17	**Control** - In line with the Merchant Shipping (Oil Pollution Preparedness, Response and Co-operation Convention) (Amendment) Regulations 2015 and the Offshore Installations (Emergency Pollution Control) Regulations 2002 an approved OPEP will be in place for the project. This will cover response measures to be taken to protect the environment in the event of a release. As discussed in the preceding section, this OPEP provides detailed hydrocarbon release scenarios to enable the determination of appropriate offshore actions. In addition, it outlines reporting and training requirements for mitigating accidental spillage throughout all phases. A three-tier response system will be operated, based on the following key factors: hydrocarbon type and properties, potential quantities released, metocean and metrological data, environmental and economic sensitivities and the response capability. ▪ Tier 1 is a local response, geared at the most frequently anticipated oil release. ▪ Tier 2 is a regional response for a less frequently anticipated oil release where external resources and assistance in monitoring and clean-up will be required. ▪ Tier 3 is a national response for very rarely anticipated oil releases of major proportions which will potentially require national and international resources to assist in protecting vulnerable areas and in the clean-up.

Mitigation measure	Summary of controls
	The response strategy available following a release will be aerial surveillance Any releases including sheens, will be reported to the statutory authorities using the PON1 reporting system. For larger releases, a comprehensive range of back-up resources is available to IOG through oil spill providers. All contractors vessels will have an approved SOPEP in place.

6.5 Residual impact

Residual impacts, in the unlikely event of a major incident occurring, remain potentially serious to some receptors. Mitigation measures and adherence to legal requirements are intended to reduce the likelihood of such an event occurring, reducing the risk to vulnerable receptors to an acceptable level.

7. IN-COMBINATION, CUMULATIVE AND TRANSBOUNDARY IMPACTS

7.1 Introduction

In accordance with the Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020, the assessment has given consideration to in-combination and cumulative impacts.

The definitions of these types of impact overlap, without agreed and accepted definitions. For the purposes of this assessment, the definitions proposed by the European Commission (1999) have been used.

In this assessment, the term 'in-combination impacts' refers to impacts upon receptors from different activities within the same project. The way in which the EIA has been conducted e.g. by looking at the impacts of project activities on receptors, means that intrinsically it has already considered in-combination impacts. For example, Section 5 assesses the impact of different pathways of disturbance of seabed habitats i.e. deposit of infrastructure; all activities which in-combination have the potential to impact habitats in an additive manner. In-combination impacts are therefore not discussed further in this section.

The term 'cumulative impact' refers to the impacts upon receptors arising from the Proposed Development when considered alongside other past, present, or reasonably foreseeable projects, plans or licensed activities, that may result in an additive impact with any activities of the Proposed Development.

The term 'transboundary' refers to the moving, or having effect, across a boundary or boundaries.

7.2 Identification of relevant plans and projects

The assessment of cumulative impacts requires identification of activities (proposed, consented or active) which have impacts which could interact with those of the Proposed Development. These include:

- Other oil and gas developments;
- Wind farm developments;
- Marine renewable energy projects (e.g. tidal and wave power);
- Aggregate extraction and dredging disposal sites; and
- Other marine users (i.e. marine archaeological sites, commercial fishing, or shipping).

In the absence of an agreed search range (distance from the Proposed Development) it is proposed to use the 40km radius used as a search area for sensitive features in the Offshore Petroleum Regulator for Environment and Decommissioning (OPRED) Portal Environmental Tracking System (PETS) as a search distance for relevant projects and plans. The search area is illustrated in Figure 7-1 (Drawing No: P2371S3-INFR-003). As Section 5 concluded that for the Proposed Development, the greatest distance a potential impact may affect receptors is 26km (i.e. marine mammal disturbance in the event of an un-mitigated UXO detonation) the 40km provides a conservative search area.

Figure 7-1 (Drawing No: P2371S3-INFR-003) illustrates that within 40km of the Proposed Development, a total of 818 wells have been drilled. Of this total, 19 were drilled between 2010 and 2019 with the closest being approximately 19.5km south east of the Southwark platform tie-in. In addition, there are two wind farm leases and three windfarm cable leases within the search area. The closest windfarm is the East Anglia North Tranche One West (Norfolk Vanguard West) located 25.5km southeast of the Proposed Development. The closest wind farm cable array is the consented Hornsea Three Transmission Asset 23.5km northeast of the Proposed Development. This six cable power export array is expected to impact 4.23km^2 of seabed within the North Norfolk Sandbanks and Saturn Reef SAC (Orsted 2018).

The nearest aggregate site, Humber 3 (Area 484) licensed by DEME Building Materials Ltd, is located 32.1km to the north of the Proposed Development.

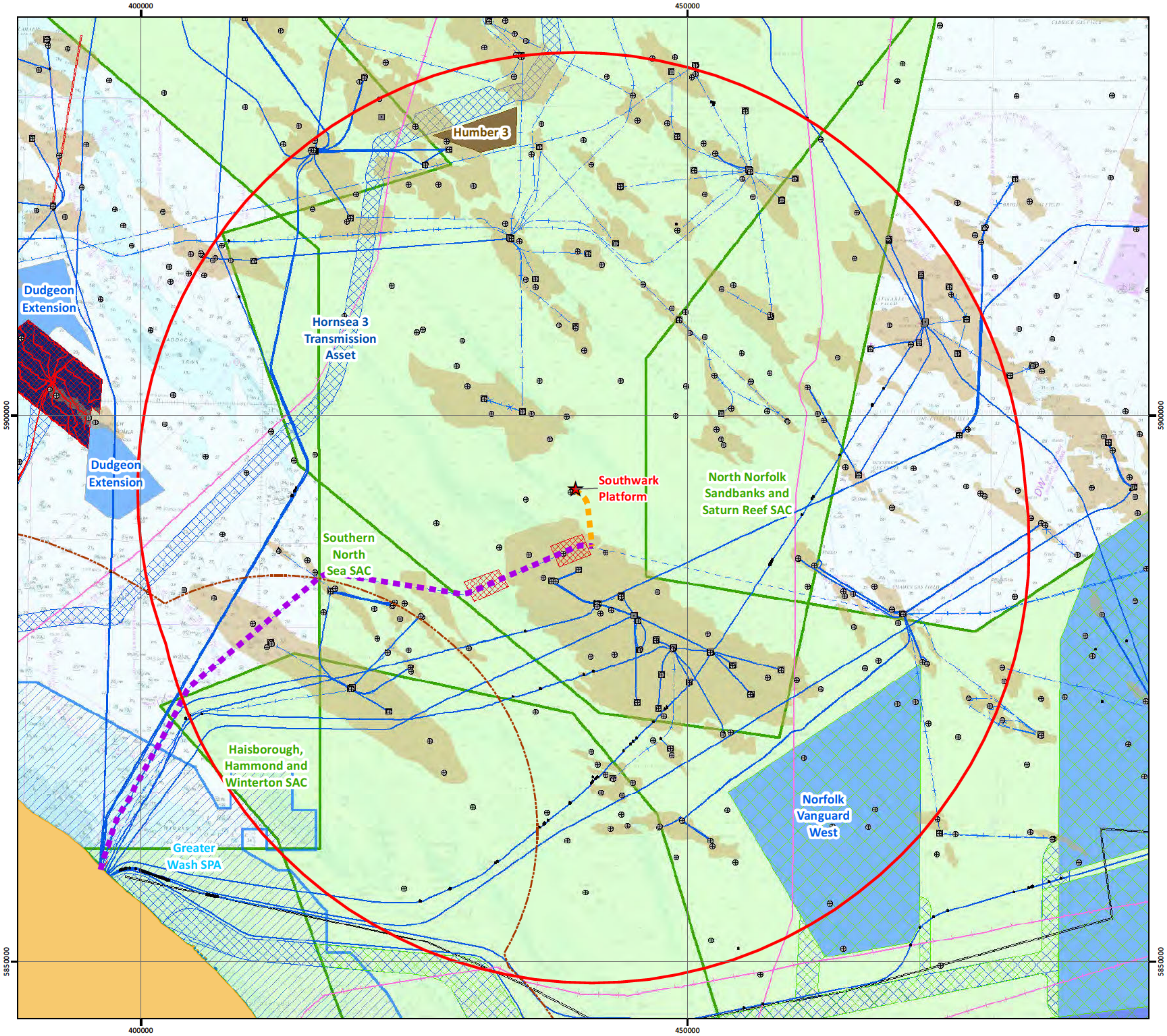
As search of the Defra data download service (https://environment.data.gov.uk/DefraDataDownload) identified that the Marine Management Organisation (MMO) have awarded several Marine Licences within 40km of the Proposed Development. These were for survey activities e.g. core or benthic grab samples, which have all been completed.

There are no sites of marine archaeological interest, aquaculture sites or any other projects or plans within 40km of the Proposed Development, which could have the potential to interact with the impacts caused by the pipeline.

IOG SOUTHWARK ENVIRONMENTAL STATEMENT

INFRASTRUCTURE
Relevant Plans and Projects within 40km

Drawing No: P2371S3-INFR-003 | **A**



Legend

- Southwark Platform
- Southwark Pipeline
- Thames Pipeline
- Southwark Pipeline 40km Buffer
- 12nm Territorial Sea Limit
- SAC
- SPA

Infrastructure
- Well
- Terminal
- Platform
- Subsurface

Cables
- Power
- Telecom
- Telecom (Disused)

Pipelines
- Proposed
- Active
- Abandoned
- Removed
- Hydrocarbon Field

Disposal Sites
- Open
- Closed
- Disused

Marine Aggregates
- Aggregate Production

Offshore Windfarm
- Active/In Operation
- Consented
- In Planning
- Export Cable Agreement

N E S W

NOTE: Not to be used for Navigation

Date	30 March 2021
Coordinate System	ED 1950 UTM Zone 31N
Projection	Transverse Mercator
Datum	European 1950
Data Source	OGA; KISCA; TCE; UKHO; MarineRegions; MarineFind; ESRI; OSOD; JNCC
File Reference	J:\P2371\Mxd\P2371S3\08_INFR\ P2371S3-INFR-003.mxd
Created By	Chris Dawe
Reviewed By	Emma Storey
Approved By	Anna Farley

iog intertek

0 5 10 15 20 km

7.3 Summary of impact assessment

The scores applied during assessment of the risk that cumulative and transboundary impacts pose to the environment by the planned activities are summarised in Table 7-1 below. The risk assessment methodology is provided in Section 5.

Table 7-1 Risk matrix – summary of assessment results (cumulative and transboundary)

Impact	Environmental receptor											
	Air quality	Water quality	Sediment	Plankton	Benthos	Fish and shellfish	Marine birds	Marine mammals	Protected sites	Shipping and navigation	Commercial fisheries	Other marine users
Cumulative	1-B	1-B	2-B	1-B	2-B	2-A	2-A	2-A	3-A	1-B	2-B	1-B
Transboundary	1-A	1-A										

Note: Unplanned events have not been summarised here, see Section 7.3.2.8

7.3.2 Cumulative impacts

7.3.2.1 Physical presence

The Proposed Development will occur within a well-developed oil and gas area and will present a modest increase in physical presence of vessels and offshore oil and gas activity. During the period while the pipeline is being laid, the Proposed Development has the potential to further restrict fishing activity and navigation (Section 5.2.1.1). However, due to the temporary nature of the pipelay operation it is not anticipated that the Proposed Development will have a significant cumulative impact on fishing and navigation in the area.

7.3.2.2 Seabed disturbance

Permanent disturbance

Section 5.3 estimated that the permanent footprint of the Proposed Development will be approximately 0.02km^2, (including the trenched area and pipeline protection). Including the Thames pipeline, there are approximately 15km of existing pipeline within 5km of the Proposed Development, assumed to have a total footprint of approximately 0.06km^2 (i.e. extending an average of 2m either side of the pipelines, to allow for sections where there is pipeline protection). There are no recently (<10 years) drilled wells within this area, other than those associated with the Southwark field itself. Thus, the total cumulative footprint of the Proposed Development and pre-existing developments represents less than 0.1% of the seabed within 5km of the Proposed Development, decreasing if a wider area is taken into consideration. As the pipeline will be buried, any perturbations in seabed dynamics are expected to be restricted to within a few metres of the protected sections and are therefore not expected to interact with other projects in the region in a cumulative manner.

It is therefore concluded that the cumulative impact on sediment structure and the benthos will be acceptable.

Within the North Norfolk Sandbanks and Saturn Reef SAC there are:

- 1379km of pipeline, of which 45km is untrenched. Assuming an average permanent impact zone extending 0.5m either side of surface pipeline and 1m either side of trenched pipeline (to allow for protection of exposed sections) the total permanent impacted area is indicatively 2.71km^2.

- 74 platforms. While the actual seabed impact of these is limited to the area of the leg base on the seabed an average area beneath the platform of 2500m^2 (i.e. 50m x 50m) has been assumed, giving a total impacted area of 0.185km^2.
- A section of the Hornsea Three Transmission Asset array with an estimated permanent footprint of 4.23km^2 (Orsted 2018)
- 597 wells, each assumed to have a seabed footprint of 10m^2, resulting in a total footprint of 0.006km^2

The total footprint of these assets, as estimated above, is 7.13km^2, representing less than 0.2% of the total area of the North Norfolk Sandbanks and Saturn Reef SAC. As the largest impact on seabed movement is likely to be the result of linear features on the sediment surface, the cumulative impact on the conservation objectives of the North Norfolk Sandbanks and Saturn Reef SAC is expected to be minor. These impacts are sufficiently separated that there is unlikely to be any interaction between the sites. The potential overall cumulative impact on the sediment, benthos and conservation objectives of the North Norfolk Sandbanks and Saturn Reef SAC is therefore acceptable.

Temporary disturbance

While the area of temporary disturbance associated with pipelay and other operations is considerably larger than the area permanently impacted, such disturbance is not expected to result in cumulative impacts, except where operations are close together in time and space. Construction of the East Anglia North Tranche One West (Norfolk Vanguard West), located 25.5km southeast of the Proposed Development is not expected to commence until 2023, and the Hornsea Three cable array, which may commence construction in 2021, is 23.5km distant, although within the North Norfolk Sandbanks and Saturn Reef SAC. Thus, no direct interaction between the developments is anticipated. Operations such as trenching and pre-sweeping of sand waves will result in short-lived changes to sandbank bedforms through temporary and local re-distribution of naturally mobile sediments. Such repositioning of sand within the active environment of the SNS and North Norfolk Sandbanks and Saturn Reef SAC is not expected to cause a cumulative impact on sediment dynamics or on the conservation objectives of the SAC.

Any potential for interaction with the seabed disturbance due to fishing is not assessed.

7.3.2.3 Greenhouse gas emissions

The greatest contributions to greenhouse gas from this area are likely to be from drilling of the proposed Elgood, Blythe and Southwark wells (anticipated to be of the order of 12,550 tonnes CO_2 equivalent per well); noting that both Elgood and Blythe lie further than 40km from Southwark. Operations to commission the associated infrastructure (e.g. pipelines) at Elgood, Blythe and Southwark will contribute a small additional amount of greenhouse gases where vessels are used. This work will take place over approximately two years with first gas at Elgood and Blythe expected in Q3 2021 and the installation of the Southwark pipeline scheduled for 2022. However, assuming all emission occur during the same year they represent <0.003% of total UK greenhouse gas emissions (based on 2018 figures, ONS 2020)

7.3.2.4 Air pollutants

Air pollutant emissions combined with the emissions emitted from other projects in the area have the potential to result in an increased impact on the air quality in the region. Given the distance of the Proposed Development to landfall (52km) and the UK/Netherlands Exclusive Economic Zone (EEZ) boundary (65km), it is anticipated that emissions will undergo rapid dispersion and dilution under prevailing meteorological conditions, it is unlikely that the Proposed Development will significantly contribute to cumulative effects of atmospheric pollutants on air quality.

7.3.2.5 Marine discharges

Chemical discharges associated with the Proposed Development and other operations within the 40km search area will be rapidly diluted and dispersed. Interactions could only occur in the case of near simultaneous (within 24 hours) discharges in close proximity to each other. As such, no cumulative impacts are anticipated.

7.3.2.6 Generation of underwater noise

The Proposed Development is located within an area which was subjected to considerable wartime activity, including minelaying and other munitions use. As a result, there is a potential that UXO could be present along the pipeline corridor. If clearance activities are unsuccessful, a UXO may be detonated in-situ, with an estimated disturbance zone of 26km^2 for marine mammals. If wind farm piling is in progress or another UXO detonation is planned on a different project within the Southern North Sea SAC there is the potential that a cumulative impact could occur.

- Construction of the East Anglia North Tranche One West (Norfolk Vanguard West), located 25.5km southeast of the Proposed Development is not expected to commence until 2023, and the Hornsea 3 windfarm, which may commence construction in 2021 is more than 52km distant.
- Although mitigation measures (e.g. deflagration) will be in place, detonation of the full charge is possible during UXO clearance and therefore presents the worst-case.
- It is possible that a UXO detonation, resulting from activities such as bottom trawling, could occur at any point within the Southern North Sea SAC. Although, the risk of co-incident detonation is very low. If it were to occur it could impact up to 7.85% of the summer ground and up to 16.73% of the winter ground. The worst-case impact areas arising from UXO detonation from the Southwark Proposed Development (Section 5.8.2) are 5.83% of the summer ground and 1.07% of the winter ground. The maximum impact area from a co-incident detonation is therefore 17.90% of the winter grounds. Based on the criteria for significant disturbance from underwater noise discussed in Section 5.7.1.4, this impact area is below the 20% threshold and considered not to have a significant impact on the conservation objectives of the Southern North Sea SAC.
- Wind farm development, requiring piling, within the Southern North Sea SAC would result in a conservative similar 26km Effective Disturbance Range (EDR) to that from UXO detonation (JNCC, NE and DAREA 2020). A UXO detonation, co-incident with a wind farm piling operation would therefore not have a significant impact on the conservation objectives of the Southern North Sea SAC.
- The overall impact of co-incident, high intensity impulsive sound on marine mammals, fish and seabirds is therefore assessed as minor (i.e. zones of disturbance could overlap). In all cases the likelihood of a co-incident event occurring is very low.

Impacts due to construction and other vessels are considerably shorter range; however, vessels associated with the Proposed Development will contribute to the overall background noise of the SNS during the operation. As sound sensitive species are expected to have habituated to relatively high noise levels any change in the cumulative impacts of vessel movements either within the 40km search area or on the conservation objectives of the Southern North Sea SAC is expected to be negligible.

Overall, noise levels created from the Proposed Development are assessed to have an acceptable risk of causing a cumulative impact on marine species in the area or on the conservation objectives of the Southern North Sea SAC.

7.3.2.7 Generation of waste

The cumulative impact of waste generated during the Proposed Development is anticipated to arise from the waste that will be disposed of to landfill. However, as discussed in Section 5.7, it is anticipated that only waste generated during the Proposed Development that cannot be prevented, reused/recycled or recovered would be disposed of in landfill. Procedures are in place to manage waste generated offshore and the associated controls required to manage the hazards associated with the transportation and disposal of waste from offshore sites and the processes, and verification activities, necessary to ensure legal obligations are satisfied. There are no significant cumulative impacts associated with the waste generated during the Proposed Development.

7.3.2.8 Unplanned events

The Proposed Development is within a well-developed area of the North Sea. There is the potential for the impacts associated with an accidental hydrocarbon release from the Proposed Development to act cumulatively with an accidental release from another nearby offshore installation. It is very unlikely that a single or simultaneous event would occur. However, whilst unlikely, a cumulative impact may also occur from non-simultaneous events, given that shoreline contamination may persist over a longer period. Therefore, the probability of a cumulative impact from an accidental hydrocarbon release is low.

7.3.2.9 Mitigation measures

It is considered that the Proposed Development will not result in any significant cumulative impacts. Therefore, no additional mitigation measures, other than those outlined in Section 5.7.6, have been proposed.

7.3.3 Transboundary impacts

The Proposed Development is located approximately 65km from the UK/Netherlands Exclusive Economic Zone boundary. Therefore, any associated air quality impacts resulting from the Proposed Development are unlikely to be measurable at the EEZ boundary. Similarly, emissions from the Proposed Development will rapidly disperse under prevailing meteorological conditions with no detectable variation from the background at the EEZ boundary, therefore emissions are not expected to cause a significant transboundary impact.

Planned marine discharges are also not expected to cause a significant transboundary impact. The environment is sufficiently dynamic to encourage adequate dispersion of any permitted discharges. Subsea installation of the Proposed Development will take place in UK waters therefore there will be no transboundary impacts resulting from noise, seabed disturbance and physical presence; the disturbance zones will not reach the EEZ boundary (see Section 5.6 – Generation of underwater noise, Section 5.3 Seabed disturbance and Section 5.2 – Physical presence).

As discussed in Section 6, a diesel release is the worst-case risk associated with the unplanned release of hydrocarbons for the Proposed Development. Diesel spill modelling at the Proposed Development indicates that this scenario is likely to result in oil crossing the EEZ boundary, both at the surface and within the water column, but oiling of international shorelines will not occur given the type of hydrocarbons present. Due to the nature of the expected hydrocarbons the Proposed Development will not add to the existing risk of transboundary effects. In the event of an unplanned release crossing the EEZ boundary, international cooperation will be necessary; this will be addressed within the oil pollution emergency plan (OPEP[1]).

7.3.3.1 Mitigation measures

It is considered that the Proposed Development will not result in any significant transboundary effects. The OPEP will address international cooperation in the event of an unplanned release, although none are expected to occur. Therefore, no additional mitigation measures, other than those outlined in Section 6, have been proposed.

[1] [1] Note there will be an Offshore OPEP (tier 1 response) and an Onshore OPEP (tier 2/3 response)

8. ENVIRONMENTAL MANAGEMENT

8.1 Environmental Management System

IOG recognises the critical importance of maintaining effective environmental management processes in the development and operation of UK Continental Shelf offshore fields, and in maintaining their licence to develop the Blythe field. IOG's Environmental Management System (EMS) was verified on 5th June 2020 by a third-party external verifier.

Overall responsibility and accountability for environmental practice and compliance rests with the IOG Chief Executive Officer (CEO), and the Board. Leadership and commitment in all health, safety and environmental (HSE) aspects of IOG activities are major factors in ensuring that company values, policies and performance expectations are fulfilled. Each IOG line manager is responsible for ensuring that IOG policies and expectations are adhered to in the conduct of all activities within their respective areas of responsibility, and individuals engaged by IOG are personally responsible for their conduct in respect of environmental care and compliance.

IOG recognises the recommendations of The Convention for the Protection of the Marine Environment of the North-East Atlantic (the OSPAR Convention) for all operators controlling the operation of offshore installations on the UK Continental Shelf to have in place an Environmental Management System (EMS) designed to:

- Achieve the general objectives of the OSPAR Offshore Strategy;
- Achieve the environmental goals of the prevention and elimination of pollution from offshore sources and of the protection and conservation of the maritime area against other adverse effects of offshore activities; and
- Maintain continual improvement in environmental performance.

The IOG EMS:

- Is implemented at a strategic level, being driven by the CEO as an integral part of the corporate aspirations and growth of the IOG enterprise;
- Is designed to deliver and manage compliance with environmental laws and regulations on an ongoing basis, including a register of environmental legislation which describes the key requirements of each piece of legislation relevant to IOG's activities as a licence operator on the UK Continental Shelf. This includes UK legislation, industry guidelines and other standards as well as European Union and other international requirements such as OSPAR and the International Convention for the Prevention of Pollution from Ships (MARPOL). Through the use of compliance tracking and commitment registers, IOG is able to detect potential non-compliance and initiate corrective action in a timely manner;
- Delivers suitable resource management; through the office of the IOG HSE Manager, supporting line management in the discharge of their environmental responsibilities and reporting directly to the CEO on environmental matters;
- Incorporates performance metrics that are developed according to each aspect of the particular operation, and with a view to meeting the clear public reporting requirements as administered by the Department for Business, Energy and Industrial Strategy.

A commitment register has been developed to address the different aspects of the Proposed Development. During the implementation of the Proposed Development, objectives and targets will also be used to set goals for continuous improvement and development in performance to follow the commitments set out in the register. Environmental Management is an ongoing process that will continue beyond implementation of the mitigation measures identified during this Environmental Statement Addendum to strive for continuous improvement and to meet changing regulatory requirements.

Contractors are expected to demonstrate a high level of health, safety, security and environment commitments and to have systems in place for managing HSE and plant integrity.

8.2 IOGs Climate Change and Sustainability Policy and Commitment to Net Zero 2050.

IOG's ambition is to be a safe and efficient developer and producer of high-value, low-carbon gas.

IOG appreciates that limiting climate change and transitioning to a more sustainable economy are critical challenges of our time. In that context, the importance of the UK's 2050 Net Zero target as part of global efforts to meet the goals of the 2015 Paris Accord, is recognised.

IOG aims to contribute positively to the UK's energy transition by helping to supply stable and affordable energy to UK homes and businesses as part of a lower-carbon energy supply mix.

To help achieve this, IOG is committed to:

- Identify and evaluate the existing and projected Scope 1 and 2 greenhouse gas emissions from our sanctioned development assets and ongoing corporate activities.
- Evaluate the efficacy of methods to mitigate or offset these existing and projected emissions.
- Implement the most effective methods as far as reasonably practicable.
- Use these emissions projections and mitigation methods to calculate a meaningful corporate Carbon Neutrality target for future adoption.
- Derive appropriate benchmarks from the emissions analysis and integrate these into future investment decisions, along with any other relevant market factors.
- Collaborate with relevant partners, associations and industry bodies as part of a wider industry effort to mitigate emissions and help meet the UK's Net Zero target.
- Embed a mindset of sustainability, responsibility, strong ethics and respect for people and the environment throughout our management decisions, operations and investments.
- Communicate effectively and clearly to relevant stakeholders on progress and performance on the objectives set out herein.

IOG considers these commitments as essential elements of a robust strategy and good corporate citizenship, in the context of collective efforts to mitigate climate change. The Board of Directors has assigned executive responsibility to the CEO for the implementation of this policy, which will be continually reviewed and revised in light of future changes in relevant public information, government policy and scientific progress.

9. CONCLUSIONS

9.1 Approach to EIA

This ES addendum has been prepared to address the requirements of the Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020 (S.I. 2020/1497) (the "EIA Regulations").

The following methodology was applied to assess the possible impacts of the proposed development:

- Describe the existing baseline environment (physical, biological and socio-economic) of the area.
- Identify activities within the Proposed Development which have the potential to impact the baseline environment.
- Determine the risk posed to the environment by considering the severity of impact and the likelihood of occurrence; and
- If necessary, re-assess impacts post-implementation of mitigation measures to determine residual impact.

9.2 Baseline environmental description

The Proposed Development lies in the Southern North Sea (SNS) off the north Norfolk coast. The Proposed Development lies on the flanks of the Inner Bank, one of the main banks in the North Norfolk Sandbank system. The main physical feature of the route are the sandwaves and megaripples that occur throughout. Comparing 2018 and the 2020 survey data, it appears that the sandwaves are travelling in a northerly direction at a rate of 14-25m / year. It also appears that the sandwaves have grown in height and there is also evidence of bifurcating and converging sandwaves, which all confirm an active and dynamically evolving environment.

The superficial sediments consist of sand, gravelly sand, and sandy gravel and may be classified as the European Nature Information System (EUNIS) habitat 'Deep circalittoral sand' (A5.27). Water depth along the proposed pipeline route ranges from approximately 22m to 34m. It is reported that sediments generally support a macrofauna community largely dominated by annelids and arthropods, with the remainder including echinoderms and other phyla with a sparse epifaunal community.

Eleven fish species have been identified as spawning and nursing in the Proposed Development. The likelihood for presence of juveniles within the first year of their life near the Proposed Development is low for all species. Harbour porpoise and Atlantic white-beaked dolphin are commonly occurring in the Proposed Development, in low to high densities depending on season. Other sightings in the region include bottlenose dolphin, common dolphin, Sowerby's beaked whale, Northern bottlenose whale, minke whale and humpback whale. Seabird sensitivity to oil pollution in the Proposed Development is extremely high from November through to February, very high from March to April and low from June to September.

The Proposed Development lies within the Southern North Sea Special Area of Conservation (SAC) and the North Norfolk Sandbank and Saturn Reef SAC. Other European sites within 40km are Haisborough, Hammond and Winterton SAC and Greater Wash Special Protection Area (SPA), 15km and 34km distant respectively.

The Proposed Development is within an area of low fishing vessel density all year round, typically targeting demersal fisheries, with sufficient sea room available for passing vessels to safely navigate around the proposed operations.

9.3 Potential hazards, effects and mitigation measures

The potential effects to the environment from the Proposed Development were identified and assessed; this was done for planned activities and unplanned releases. Activities assessed included physical presence; seabed footprint; generation of atmospheric emissions; marine discharges; generation of underwater noise; generation of waste and unplanned releases.

The assessment has been based on the potential severity and likelihood of an impact using the criteria described in Section 5.1.2. The assessment rated the risk to the environment as acceptable, tolerable or unacceptable. The assessments assume that activities will be carried out in accordance with all current legislation and good industry practice.

Risks posed to the marine environment from the physical presence of the installation vessels, generation of atmospheric emissions, marine discharges, the generation of underwater sound from vessels and the generation of waste have been assessed as acceptable.

The risk posed to the Southern North Sea SAC from the generation of underwater sounds from UXO detonation has been assessed as tolerable. Mitigation has been proposed which lowers the scoring of the residual effect, however this is still assessed as tolerable. The risk posed to the North Norfolk Sandbanks and Saturn Reef SAC from seabed disturbance has been assessed as tolerable. However, the EIA concluded that the Proposed Development will not hinder the achievement of the conservation objectives of these sites and therefore will not adversely affect the integrity of the European sites.

If an unplanned release of hydrocarbons occurred, a very low probability, the modelling in the Blythe Hub Development ES Addendum – Southwark Field Development shows that hydrocarbons could potentially travel in any direction, although travel in a north easterly direction appears slightly more likely than travel in other directions. Beaching and/or crossing the EEZ boundary is predicted to occur following a diesel release, as modelled. During summer months the area which could experience oiling is smaller than during winter months, because of generally lower wind speeds.

The assessment did not identify any unacceptable environmental risks from an unplanned release and concluded an acceptable or tolerable risk to the environment. An acceptable risk to plankton, fish and shellfish, marine mammals, protected sites in the event of a worst-case unplanned release was identified. Owing to the extremely high seabird sensitivity to oiling in November through to February, the risk to seabirds was assessed as tolerable.

An event leading to a Major Environmental Incident (MEI) (e.g., a collision leading to total fuel loss from the vessel inventory over 1 hour) is possible. However, this will not affect the conservation objectives of protected sites and European Protected Species, nor is it likely to result in a significant adverse effect. Therefore, if a worst-case release occurred this will not constitute an MEI. In addition, the probability of such an event occurring is very low and therefore the risk is acceptable.

The impacts resulting from the Proposed Development have the potential to act cumulatively with impacts from past, present or reasonably foreseeable projects, plans or licensed activities in the area. Activities assessed for cumulative effects include seabed disturbance (temporary and permanent), generation of underwater noise, increased activity in the region, generation of atmospheric emissions and marine discharges. It was concluded that the Proposed Development would not contribute to a significant cumulative impact.

The Proposed Development is approximately 64.5km to the west of the UK/Netherlands EEZ boundary. Greenhouse gas emissions, planned marine discharges, and underwater noise will not reach the EEZ boundary. The unplanned release of hydrocarbons could result in oil crossing the EEZ boundary, both at the surface and within the water column, but oiling of international shorelines will not occur given the type of hydrocarbons present. In the event of an unplanned release crossing the EEZ boundary, international cooperation will be necessary; this will be addressed within the oil pollution emergency plan (OPEP).

Mitigation measures identified in this EIA are listed below:

ID	Mitigation measures
M1	Project vessels will follow the international maritime organisation (IMO) standards to reduce the likelihood of collision i.e. will comply with Standard Marking Schedule. This includes requirements for navigation, lighting, obstruction lighting and beacons.
M2	Users of the sea will be notified of the presence and intended movements of the project vessels via the Kingfisher Fortnightly Bulletins, Notices to Mariners and very high frequency (VHF) radio broadcasts.
M3	Guard vessels will be utilised to prevent other none-project vessels entering the Proposed Development area during pipeline installation, and to protect the pipeline prior to burial.
M4	Concrete mattresses, grout/sand bags and rock remediation will only be employed where the integrity of the pipeline is at risk. Cover will be kept at the minimum required to ensure pipeline protection is adequate. Good Industry practice will be used when deploying any pipeline protection.
M5	If a trailing suction hopper dredger is used, sediment will not be retained onboard but will be deposited within 2NM of the pipeline corridor, to ensure all sediment is retained in the local system.
M6	Practical steps to minimise emissions will be implemented, e.g. ensuring efficient operations and monitoring fuel consumption
M7	Project vessels employed will comply with the Merchant Shipping (Prevention of Air Pollution from Ships) Regulations 2008, which controls the levels of pollutants entering the atmosphere.
M8	Chemical use and discharge will be monitored and kept to the minimum consistent with operational requirements.
M9	Where suitable alternatives are available and deemed fit for purpose, chemicals with lower potential for environmental impact will be utilised.
M10	Chemical storage and usage will be in accordance with the vessel's control of substances hazardous to health (COSHH) procedure. Material Safety Data Sheets (MSDS) will be carried for all hazardous substances.
M11	A UXO survey will be undertaken along the pipeline corridor to identify anomalies. If any significant UXO is identified, the decision-making hierarchy taking into account environmental sensitivities, safety and technical considerations shall be: 1. Avoid 2. If the UXO cannot be avoided, undertake clearance to surface or move UXO outside the installation corridor. 3. If the UXO cannot be safely moved, clearance by on-site detonation
M12	If clearance by on-site detonation is the only feasible option, all charge sizes shall be detonated using deflagration (low order detonation).
M13	UXO clearance by deflagration shall comply with the JNCC guidelines for minimising the risk of injury to marine mammals from using explosives (JNCC 2010, or as updated), including: a. Establishment of a default 1km mitigation zone for marine mammal observation, measured from the explosive source and with a circular coverage of 360 degrees b. Provision of two trained marine mammal observers (MMO) to implement the JNCC guidelines c. Provision of a Passive Acoustic Monitoring (PAM) to be operated by a suitably trained and experienced MMO to support visual observations. d. Commencement of explosive detonations only during daylight hours and good visibility e. Accurate determination of the amount of explosive required for the operation, so that the amount is proportionate to the activity and not excessive. f. If necessary, planning of a sequence of multiple explosive discharges so that, wherever possible, the smaller charges are detonated first to maximise the 'softstart' effect. g. if the UXO identified is greater than 10kg then a soft-start procedure shall be used whereby charges of 50g, 100g, 150g, and 200g will be deployed at 5 minute intervals with a further 5 minute interval before the detonation of the UXO

ID	Mitigation measures
M14	Lofitech AS seal scarer (or similar) acoustic deterrent device will be used prior to UXO deflagration.
M15	Waste will be managed in line with waste management procedures, striving to reduce the amount of waste going to landfill (disposal). All waste will be correctly documented, transported, processed and disposed of in accordance with applicable legal requirements line with legislation and in an environmentally responsible manner.
M16	**Spill prevention** – All operational personnel, whether in the direct employ of IOG, the Installation and Pipeline Operator or appointed contractors will be made aware of existing environmental protection procedures and the crucial importance of hydrocarbon containment and Asset Integrity. The risk of a release is addressed on a day-to-day basis by IOG employees and contractors following good practice, collision avoidance and fuel handling and transfer procedures. Every effort will be made to prevent such releases. It is noted that most releases occur during offshore fuel transfer operations (bunkering), which are not expected to occur during this operation. If they are required IOG & the Installation and Pipeline Operator require vessel contractors to take the following measures: ▪ The connection between the fluid transfer hose and the supply vessel will be a self-sealing, dry-break hose connection. ▪ Preference will be given to carrying out external fluid transfers during the hours of daylight. If operational reasons dictate that external fluid transfer are carried out during the hours of darkness, then they will be subject to documented risk assessment which will include environmental and safety considerations. ▪ Fluid transfer during hours of darkness will not commence without provision of sufficient illumination to allow the entire length of the transfer hose to be visually monitored from the installation. ▪ If operational reasons dictate that simultaneous external fluid transfers of more than one hydrocarbon liquid product is required, it will not take place until a full documented risk assessment has been made. ▪ Integrity of the pipeline is ensured by application of corrosion protection measures and regular monitoring and maintenance.
M17	**Control –** In line with the Merchant Shipping (Oil Pollution Preparedness, Response and Co-operation Convention) (Amendment) Regulations 2015 and the Offshore Installations (Emergency Pollution Control) Regulations 2002 an approved OPEP will be in place for the project. This will cover response measures to be taken to protect the environment in the event of a release. As discussed in the preceding section, this OPEP provides detailed hydrocarbon release scenarios to enable the determination of appropriate offshore actions. In addition, it outlines reporting and training requirements for mitigating accidental spillage throughout all phases. A three-tier response system will be operated, based on the following key factors: hydrocarbon type and properties, potential quantities released, metocean and metrological data, environmental and economic sensitivities and the response capability. ▪ Tier 1 is a local response, geared at the most frequently anticipated oil release. ▪ Tier 2 is a regional response for a less frequently anticipated oil release where external resources and assistance in monitoring and clean-up will be required. ▪ Tier 3 is a national response for very rarely anticipated oil releases of major proportions which will potentially require national and international resources to assist in protecting vulnerable areas and in the clean-up. The response strategy available following a release will be aerial surveillance. Any releases including sheens, will be reported to the statutory authorities using the PON1 reporting system. For larger releases, a comprehensive range of back-up resources is available to IOG through oil spill providers. All contractors vessels will have an approved SOPEP in place.

9.4 Environmental management

IOG recognises the critical importance of maintaining effective environmental management processes in the development and operation of UK Continental Shelf offshore fields, and in maintaining their licence to develop the Blythe field. IOG's Environmental Management System (EMS) was verified on 5th June 2020 by a third-party external verifier.

The IOG EMS is designed, amongst other objectives, to deliver and manage compliance with environmental laws and regulations on an ongoing basis, including a register of environmental legislation which describes the key requirements of each piece of legislation relevant to IOG's activities as a licence operator on the UK Continental Shelf. This includes UK legislation, industry guidelines and other standards as well as European Union and other international requirements such as OSPAR and the International Convention for the Prevention of Pollution from Ships (MARPOL). Through the use of compliance tracking and commitment registers, IOG is able to detect potential non-compliance and initiate corrective action in a timely manner.

Environmental Management is an ongoing process that will continue beyond implementation of the mitigation measures identified during this Environmental Statement Addendum to strive for continuous improvement and to meet changing regulatory requirements.

Contractors are expected to demonstrate a high level of health, safety, security and environment commitments and to have systems in place for managing HSE and plant integrity.

IOG's ambition is to be a safe and efficient developer and producer of high-value, low-carbon gas. IOG appreciates that limiting climate change and transitioning to a more sustainable economy are critical challenges of our time. In that context, IOG recognise the importance of the UK's 2050 Net Zero target as part of global efforts to meet the goals of the 2015 Paris Accord.

To achieve this target IOG has committed to eight targets within which IOG will evaluate their greenhouse gas emissions and put in place measures to mitigate their existing and projected emissions.

IOG aims to contribute positively to the UK's energy transition by helping to supply stable and affordable energy to UK homes and businesses as part of a lower-carbon energy supply mix.

9.5 Overall conclusion

It is concluded that the Proposed Development can be completed without causing any unacceptable risks to the environment.

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APPENDIX A

Policy & Legislation Framework

A.1 POLICY AND LEGISLATION FRAMEWORK

This Environmental Statement (ES) Addendum has been prepared to address the requirements of the Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020 (S.I. 2020/1497) (the "EIA Regulations").

In addition, other relevant international, United Kingdom (UK) and local legislation, policy and agreements have also been considered as part of the impact assessment process. These may require consent or approval in their own right. While the list is not exhaustive, the following sections detail the main policies, laws and guidelines relevant to the activities considered by this ES Addendum.

Permits, consents and licenses required to carry out the activities detailed in the Project Description (Section 3) will be applied for as necessary.

A.1.1 Marine Planning

A.1.1.1 East Offshore Marine Plan

The Proposed Development is located in the area covered under the East Offshore Marine Plan. The East Offshore Marine Plan area covers the marine area from 12 nautical miles out to the maritime borders with the Netherlands, Belgium and France, a total of approximately 49,000 square kilometres of sea. The area is predominantly open, shallow water supporting oil and gas platforms and commercial activities such as shipping, aggregate extraction and fishing.

The Proposed Development has been assessed against the East Offshore Marine Plan objectives (see Table A-1) and the Oil and Gas Marine planning policies (Table A-2).

Table A-1 Proposed Development assessed against East Offshore Marine Plan objectives

East Offshore Marine Plan objective	Applicable	Assessment
Objective 1: To promote the sustainable development of economically productive activities, taking account of spatial requirements of other activities of importance to the East marine plan areas.	✓	This development is in favour of sustainable development.
Objective 2: To support activities that create employment at all skill levels, taking account of the spatial and other requirements of activities in the East marine plan areas.	✓	The development will provide jobs and tax revenues to the economy.
Objective 3: To realise sustainably the potential of renewable energy, particularly offshore wind farms, which is likely to be the most significant transformational economic activity over the next 20 years in the East marine plan areas, helping to achieve the United Kingdom's energy security and carbon reduction objectives.		Not applicable
Objective 4: To reduce deprivation and support vibrant, sustainable communities through improving health and social well-being.		Not applicable
Objective 5: To conserve heritage assets, nationally protected landscapes and ensure that decisions consider the seascape of the local area.	✓	There are no known wrecks or heritage sites near the Proposed Development.

East Offshore Marine Plan objective	Applicable	Assessment
Objective 6: To have a healthy, resilient and adaptable marine ecosystem in the East marine plan areas.	✓	The potential for impacts on the marine ecosystem has been assessed in the EIA (Section 5).
Objective 7: To protect, conserve and, where appropriate, recover biodiversity that is in or dependent upon the East marine plan areas.	✓	The potential for impacts on the biological environmental has been assessed in the EIA (Section 5).
Objective 8: To support the objectives of Marine Protected Areas (and other designated sites around the coast that overlap, or are adjacent to the East marine plan areas), individually and as part of an ecologically coherent network.	✓	The potential for impacts on the Marine Protected Areas has been assessed in the EIA (Section 5).
Objective 9: To facilitate action on climate change adaptation and mitigation in the East marine plan areas.	✓	Emissions will be monitored with a view of long-term reductions and IOGs NetZero commitments.
Objective 10: To ensure integration with other plans, and in the regulation and management of key activities and issues, in the East marine plans, and adjacent areas.	✓	Cumulative impacts have been assessed as part of the EIA (Section 7).
Objective 11: To continue to develop the marine evidence base to support implementation, monitoring and review of the East marine plans	✓	Management practices are formed on the most recent and sound data and regularly reviewed to ensure compliance with policy.

Table A-2 Proposed Development assessed against oil and gas marine planning policies

East offshore Marine Plan Oil and Gas policies	Applicable	Assessment
Oil & Gas 1: Proposals within areas with existing oil and gas production should not be authorised except where compatibility with oil and gas production and infrastructure can be satisfactorily demonstrated.	✓	The development has been designed with existing oil and gas production in mind and makes uses of existing pipeline infrastructure.
Oil & Gas 2: Proposals for new oil and gas activity should be supported over proposals for other development.	✓	This development is for new oil and gas activity.

A.1.1.2 Marine Strategy Regulations 2010

The European Union's Marine Strategy Framework Directive (MSFD) (2008/56/EC) was adopted by the EU on 15th July 2008 and transposed into UK legislation by the Marine Strategy Regulations 2010 (*SI 2010/1627*). The aim of the Marine Directive (2008/56/EC) is to protect more effectively the marine environment across Europe.

The Commission produced a set of detailed criteria and methodological standards to help Member States implement the Marine Directive. These were revised in 2017 leading to the new Commission Decision on Good Environmental Status (GES). The MSFD outlines 11 high level descriptors of GES in Annex I of the Directive. The Proposed Development is aligned with all these descriptors.

A.1.2 Strategic and Environmental Impact Assessment

A.1.2.1 Environmental Assessment of Plans and Programmes Regulations 2004

In the UK, the European Union's SEA Directive is implemented through the Environmental Assessment of Plans and Programmes Regulations 2004. Although the SEA Directive was not incorporated into UK law until 2004, SEAs have been carried out by the Department for Business Energy & Industrial Strategy (BEIS) (formerly DTI, BERR and DECC) since 1999. BEIS and its predecessors undertook a sequence of oil and gas strategic environmental assessments (SEAs) considering various areas of the UK continental shelf (UKCS) (SEA areas 1 – 8). More recently offshore energy SEA (OESEA, OESEA2, OESEA3) consider the entire UKCS for oil and gas and renewable energy.

The SEA Directive applies to a range of public plans and programmes, both offshore and onshore, including energy. Under the Directive it is mandatory for plans and programmes to be prepared for agriculture, forestry, fisheries, energy, industry, transport, waste/water management, telecommunications, tourism, town & country planning or land use. These must set the framework for future development consent of projects listed in the EIA Directive; or have been determined to require an assessment under the Habitats Directive (EC Directive 1992/43/EC).

The Proposed Development lies within Regional Sea 2 according to the OESEAs.

A.1.2.2 Offshore Oil and Gas Exploration, Production, Unloading and Storage (Environmental Impact Assessment) Regulations 2020

Under these regulations consent is required for offshore hydrocarbon-related activities. Consent is granted by the Oil and Gas Authority (OGA) but is also subject to agreement by the Secretary of State.

There are criteria which outline activities that do and do not require submission of an ES. If an ES is required the activity involves the extraction of hydrocarbons for commercial purposes >500 $tonnes.day^{-1}$ (oil)/ $500,000m^3day^{-1}$ (gas); pipelines of >800mm diameter and >40km in length; geological storage of carbon dioxide (CO_2); or installation for the capture of CO_2. These are classed as Schedule 1 projects.

The original Southwark development was subject to an ES Addendum in 2018, however the Southwark 24" pipeline requires a new ES Addendum due to the revised installation method required to ensure stability and integrity of the pipeline. Post-submission of the ES, any changes that do not exceed the thresholds listed above can be sought within a Screening Direction.

BEIS provide guidance on the content of ESs prepared under the Regulations. The latest guidance (dated December 2020) has been used to inform this ES Addendum.

A.1.3 Protected species and sites

A.1.3.1 Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001 (as amended)

These regulations require the Secretary of State to undertake a Habitats Regulations Assessment (Appropriate Assessment) if the proposed activities, whether on their own or in combination with any other plan or project, are likely to have a significant effect on a Natura 2000 site (i.e. Special Area of Conservation, Special Protection Area). In addition, UK Government policy (ODPM Circular 06/2005) states that sites designated under the Convention on Wetlands (Ramsar, Iran 1971) known as the "Ramsar Convention" are also included under the definition Natura 2000. The appropriate assessment is carried out against the site's conservation objectives. Information to inform the appropriate assessment to be undertaken by OPRED is provided in Section 4 and Section 5 of the EIA Addendum.

A.1.3.2 Conservation of Offshore Marine Habitats and Species Regulations 2017

The Regulations aim to protect marine species and birds in the UK offshore area (12 nautical mile limit to the end of the Exclusive Economic Zone) by preventing environmentally damaging activities. They create offences that ensure certain activities in the offshore marine environment can be managed.

Of particular note to the Proposed Development is that the regulations make it an offence to deliberately disturb wild animals of a European Protected Species in such a way as to be likely (a) to impair their ability (i) to survive, breed, or rear or nurture their young; or (ii) in the case of animals of a hibernating or migratory species, to hibernate or migrate or b) to affect significantly the local distribution or abundance of that species. Assessment of the generation of underwater noise from project activities is included in Section 5.6.

A.1.3.3 Convention for the Protection of the Marine Environment of the North East Atlantic (Oslo Paris Convention) (OSPAR) 1992

This is the main legislative instrument regulating international cooperation, concentrating on provisions to protect the marine environment through the use of best available techniques, best environmental practice and where appropriate clean technologies.

The OSPAR Biological Diversity and Ecosystems Strategy sets out that the OSPAR Commission will assess which species and habitats need to be protected. The OSPAR List of Threatened and/or Declining Species and Habitats has been developed to fulfil this commitment. The list includes (but is not limited to) ocean quahog; dog whelk; flat oyster; lesser black-backed gull; black-legged kittiwake; Roseate tern; European eel; basking shark; common skate; spotted ray; cod; sea lamprey; thornback skate / ray; salmon; harbour porpoise; deep-sea sponge aggregations; maerl beds; blue mussel beds; *Sabellaria spinulosa* reefs; and sea-pen and burrowing megafauna communities.

Species that appear on the list that are found within the Proposed Development have been identified within the environmental baseline (Section 4).

A.1.3.4 UK Post-2010 Biodiversity Framework

The UK biodiversity action plan (UK BAP) was the UK Government's initial response to the international treaty, Convention on Biological Diversity (CBD) 1992 (which set out commitments for maintaining the world's ecological biodiversity). The UK's initial response described the biological resources and provided detailed plans for the protection of these resources. It listed priority species and habitats that were identified as being the most threatened and required conservation action under the UK BAP.

In July 2012 the UK Post-2010 Biodiversity Framework was published, succeeding the UK BAP. Much of the work carried out under the UK BAP is now focused at a country level, e.g., England, Wales, Scotland and Northern Ireland. The resources collated under the UK BAP were used to draw up statutory lists of priority species and habitats. The framework sets out the priorities for UK-level work to support the CBD's Strategic Plan for Biodiversity 2011-2020 and its five strategic goals and 20 'Aichi Biodiversity Targets' (agreed October 2010), and the EU Biodiversity Strategy (launched May 2011). It shows how the work of the four UK countries work at a UK level to achieve the biodiversity targets and strategy, and how this work is to be implemented and provides for annual reporting on progress. UK BAP species are identified and considered within the environmental baseline and EIA of this ES Addendum (see Section 4 and 5, respectively).

A.1.4 Atmospheric emissions

A.1.4.1 Greenhouse Gas Emissions Trading Scheme Regulations 2012 (as amended)

The regulations (S.I. 2012 No 3038) implement the EU Emissions Trading Scheme (EU-ETS) Directive (2003/87/EC) in the UK. This establishes a scheme for greenhouse gas emissions trading. The regulations require that an installation with a combustion plant that on its own or in aggregate with another combustion plant of a rated thermal input exceeding 20MW (th) must be registered under the EU-ETS. The Proposed Development comprises of a subsea infrastructure tied back to an existing producing installation. Therefore, the Proposed Development does not require registration under the EU ETS.

A.1.4.2 Energy Act 1976 and Petroleum Act 1998

These acts govern the flaring and venting of both hydrocarbon and inert gas from licensed areas. Consents to vent are required for all Category 4 (unignited vents).

A.1.5 Chemical discharges

A.1.5.1 Offshore Chemicals Regulations 2002 (as amended)

These regulations (and all subsequent amendments) apply the OSPAR Convention 2000/2 decision to implement a harmonised mandatory control system for the use and discharge of chemicals by the offshore oil and gas industry. Under these regulations Operators are required to apply to the Secretary of State for a Chemical Permit to cover the use and discharge of chemicals during all offshore oil and gas activities.

A.1.6 Hydrocarbon and produced water discharges

A.1.6.1 Convention for the Protection of the Marine Environment of the North East Atlantic (Oslo Paris Convention) (OSPAR) 1992

OSPAR Recommendation 2012/5 requires member states to implement a risk-based approach (referred to as RBA) for the management of produced water discharges from offshore installations. The approach is a method of prioritising mitigation actions on those discharges and substances that pose the greatest risk to the environment. All UK offshore installations that have a permit to discharge produced water are included in the UK implementation programme. There is no significant produced water anticipated from the Proposed Development.

A.1.6.2 Offshore Petroleum Activities (Oil Pollution Prevention and Control) Regulations 2005 (as amended)

The OPPC Regulations are designed to encourage operators to reduce the quantities of hydrocarbons discharged during offshore operations. Discharges to sea are prohibited unless in strict accordance of the terms of an Oil Discharge Permit. Operators must identify all planned oil discharges to relevant waters and apply for the appropriate permits ahead of activities commencing. Term permits (permits restricted by date) will be sought to cover any necessary hydrocarbon discharges during pipeline installation activities.

A.1.7 Transboundary

A.1.7.1 Convention on Environmental Impact Assessment in a Transboundary Context (Espoo) 1991

The Convention lays down a general obligation to States to notify and consult each other on all major projects under consideration that are likely to have a significant adverse environmental impact across boundaries.

A.1.8 Unplanned events

A.1.8.1 International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC) 1995

The Convention on OPRC primary objectives are to facilitate international cooperation and mutual assistance in preparation for and responding to a marine pollution event.

Parties to the OPRC are required to establish measures for dealing with pollution incidents, either nationally or in co-operation with other countries. Ships and operators of offshore installations are required to have an OPEP or similar arrangements which must be co-ordinated with national systems for responding promptly and effectively to oil pollution incidents. In the UK obligations under the Convention are transposed into legislation by the Merchant Shipping (Oil Pollution Preparedness, Response and Co-operation Convention) (Amendment) Regulations 2015.

A.1.8.2 Merchant Shipping (Oil Pollution Preparedness, Response and Co-operation Convention) Regulations 1998 (as amended)

The OPRC Regulations, implement the provisions of the Offshore Safety Directive (2013/30/EU) relating to the oil pollution aspects of internal emergency responses plans. They require all Operators of offshore oil and gas installations and pipelines to have an approved OPEP in place before activities commence. The OPEP sets out arrangements for responding to incidents which cause or may cause marine pollution by oil, with a view to preventing such oil pollution or reducing or minimising effect. This will include reference to international cooperation arrangements.

A.1.8.3 Offshore Installations (Emergency Pollution Control) Regulations 2002

The EPC Regulations give the Government power to intervene in the event of an incident involving an offshore installation where there is or there may be a risk of significant pollution, or where an operator has failed to implement proper control and preventative measures. These Regulations apply to chemical and oil spills.

A.1.8.4 Offshore Installations (Offshore Safety Directive) (Safety Case etc.) Regulations 2015

These Regulations, together with the OPRC regulations, implement the Offshore Safety Directive. They are intended to provide for management and control of major accident hazards and environmental incidents arising from major accidents. The regulations establish the Offshore Safety Directive Regulator (OSDR) as Competent Authority. They act to integrate safety and environmental protection within an operation safety case.

A.1.9 Other licensing requirements

A.1.9.1 Marine and Coastal Access Act 2009

The Act has introduced a marine licensing system that covers offshore activities which are the responsibility of Offshore Petroleum Regulator for Environment and Decommissioning (OPRED) but which are not currently controlled under the Petroleum Act 1998, the Energy Act 2008 or exempted under the Marine Licensing (Exempted Activities) (Amendment) Order 2013. Generally, this relates to decommissioning activities, the depositing or removal of materials and the use of explosives. All activities to be undertaken during the Proposed Development discussed in this ES Addendum are covered by the Petroleum Act 1998.

APPENDIX B

Consultation

B.1 STAKEHOLDER MEETING MINUTES

Stakeholder meetings have been held between IOG and the Department for Business, Energy and Industrial Strategy (BEIS); Joint Nature Conservation Committee (JNCC); National Federation of Fishermen's Organisations (NFFO); VisNed and Rederscentrale at the following times, to discuss the Southwark Pipeline Installation.

- 13th August 2020 – JNCC
- 20th August 2020 – BEIS
- 11th February 2021 – BEIS and JNCC
- 17th February 2021 – NFFO, VisNed and Rederscentrale

Meeting minutes are provided below.

B.1.1.1 JNCC – August 2020

Time	1300-1400	
Date	13th August 2020	
Location	n/a Microsoft Teams	
Attendees	IOG	- Mark Yates - Ian Pollard - Rebecca Gay - Nigel D'Arcy
	Joint Nature Conservation Committee (JNCC)	- Hannah Hood - Becky Hitchin
	Intertek Energy and Water Consultancy Services (Intertek)	- Anna Farley - Nathalie De Groot

Summary

The Southwark Pipeline Stakeholder Engagement meeting was set up as an early engagement between IOG and JNCC to discuss the Southwark Pipeline Environmental Statement. In particular, the focus was on potential pipeline protection methods (i.e. rock deposit and trench/dredge and burial) and on the Habitats Regulations Assessment (HRA) process. A copy of the slides presented during the call has been distributed with these minutes.

Points made:

1. IOG provided a quick overview of the IOG assets and described the key elements of the Southwark Pipeline: a 24" pipeline of approximately 6km long connected to the existing Thames pipeline. The pipeline will facilitate gas export from the Southwark platform to the onshore Bacton facility. The pipeline is located in the Southern North Sea (SNS) SAC and the North Norfolk Sandbanks and Saturn Reef (NNSSR) SAC.
2. Intertek invited JNCC to provide their view and most up to date guidance on rock deposit/protection in a SAC with sandbank features.
3. JNCC explained that rock protection is generally considered to have an adverse effect on sandbank features. Additionally, placing permanent deposits are considered more problematic compared to deposits that will be removed at the end of operational life (decommissioning). As in the latter case the effects will be temporary, even if long term.
4. JNCC mentioned that Natural England is planning to organise a workshop on sandbanks within NNSSR before the end of the year and would like operators to join. IOG would be welcome to join if interested.
5. JNCC indicated that they would be publishing a NNSSR report in early September that could be beneficial to IOG for use while writing the ES.

6. IOG expressed that they found this meeting very clear and helpful. IOG are very grateful to JNCC for the time and the information that was provided.
7. JNCC stated that they appreciated the opportunity, as they prefer to talk upfront and work together on challenging issues. JNCC recommended speaking to Ørsted, as well as other Oil and Gas operators (e.g. Chrysoar) that are active within the SNS site.
8. IOG concluded that the key takeaway from the meeting was to look at the project holistically. IOG will also consider the example of Hornsea windfarm (Ørsted), whilst being mindful of the differences between the projects.
9. Intertek and IOG informed JNCC that the next stage of the project development would be a IOG comparative assessment workshop with the IOG engineering team and appointed engineering contractors to feedback the discussion points from this meeting and from a similar engagement meeting with OPRED.
10. Intertek and IOG proposed to re-engage with JNCC to discuss in further detail the Southwark pipeline design and Environmental statement and the outcomes of the comparative assessment in a few weeks' time.

General Questions Raised

Question	Answer
What are JNCC's thoughts on pipeline protection methods? Are there any showstoppers or things that JNCC does not want to see within a SAC?	In general, rock protection is seen as having an adverse effect on the NNSSR site features. Additionally, permanent deposits are seen as worse than temporary deposits.
What is JNCC's view on fronded mats, which would become buried?	JNCC mentioned that the potential use of fronded mats is worth looking into. There is also an example of an operator that used fins on a pipeline, which in theory will help the pipeline to self-bury. In the example provided by JNCC, one pipeline self-buried and one did not.
What does unfavourable condition mean in the context of sandbank features?	A key point that would be considered is the extent of the impact incurred. An 'unfavourable condition' of the site would mean less sandbanks within the site as a consequence of the deposit, whereas the conservation goal is to have more sandbanks. In the case of the NNSSR site, an increase in non-sandbank features has occurred, following deposits from various industries within the site. Therefore, the proposed pipeline will have a likely significant effect, especially when considering the cumulative effects of other developments within the site (~200 projects)
For the appropriate assessment, what would be required? Would there be a requirement for modelling?	The best practice example of an appropriate assessment is provided by the Hornsea project, (Ørsted), available on the PINS website. JNCC did not state that modelling would be required for this ES as requirements vary from project to project but would be happy to advise once further project details have been determined. In practice, the appropriate assessment needs to provide a clear and concise outline or "story" of project and the associated impacts anticipated.
Did the Hornsea project go through the IROPI (Imperative Reasons of Overriding Public Interest) process?	Yes, it did. However, this was because of ornithology and not because of sandbanks

What is considered 'clear evidence' in terms of baseline data and post installation effects? Will the survey results provide sufficient evidence or will over time monitoring be required?	This depends on the quality of the data. JNCC confirmed they would be happy to have a look at IOG's data to confirm whether the quality of the data would be acceptable for the purposes of the assessment.
Is there any additional monitoring of the site that could be used for the assessment?	There is a new NNSSR monitoring report expected to be published in September 2020. This report incorporates the 2017 survey data.
What is the view of JNCC on pre-sweeping and sand wave shaving?	It is seen as temporary disturbance. Ørsted recently produced a useful monitoring report on Rosebank sandbank. This report includes photographs before, during and 6 months after sandwave shaving. The report shows what happens and indicates that after six months the site, although not fully recovered, shows signs of recovering and moving towards recovery.
Is there any specific mitigation recommended around sweeping?	It is recommended to keep the sediment within the site and, as there are different sediment types within the site, keep it within the same sediment type.
Sand wave recovery also means that the pipeline will be buried over time. What is JNCCs position regarding spanning, trenching, or rock deposit during the operational lifetime of the pipeline?	In the Hornsea project 6% remediation in the form of rock deposit was assumed. Hereby, it was recommended to minimise the difference in 'grainsize' between the rock deposit and the background sediment. It is appreciated that the Hornsea is different because the remediation was related to a cable, whereas this project is a pipeline. This is project is the first time a new pipeline will be installed within the site.
What were the minimum water depths encountered on the Hornsea project?	Water depths of below 15m were observed with the shallowest depths observed at sandwave crests at depths of 5m
What are JNCC's preferences for the HRA, a standalone document or incorporated into the ES?	JNCC does not have a preference for either, as long as the reporting is concise and to the point without repetition of information.
What level of detail would be expected in the HRA?	As above JNCC prefers concise documents, that outline the project as a whole and any potential impacts.
It is recognised that the HRA can be an iterative process, would JNCC be open to reviewing the HRA before the ES submission?	Yes. JNCC is open to early engagement and would be able to provide an early review of the HRA.
As the Hornsea Project was IROPI because of the ornithology, are there any example cases of IROPI process because of sandbank features?	Not yet. Although, Ørsted have put together a draft compensation package as part of their consent for Hornsea that is worth looking at. However, in this package sandbanks were compensated with reefs. This is contrary to guidance where compensatory measures should be like for like, i.e. sandbank for sandbank and reef for reef.
If a permanent rock structure is covered with a fronded mat, or sand is deposited over the top, would this be classed as recovery or mitigation?	This would most likely be seen as mitigation. JNCC has not fully considered this yet, but would probably take into account the whole three dimensional structure rather than just the top.

Would the outputs of the comparative workshop, including the rationale on the options considered, provide useful information to include in the assessment?	Yes, JNCC would recommend that the outcome of the CA workshop is fed into the ES, to provide grounds for why a specific option has been selected.
Would dredging and burying be more preferable than rock deposit?	In general, rock deposit is considered a 'difficult' topic. Additionally, anything deposited permanently will be considered worse for the site integrity than deposits that would later be removed.
With regards to the engagement meeting with JNCC, do JNCC know if their position on the rock protection/deposits and trenching/dredging would be different to the position of OPRED?	JNCC refrained from commenting on the position of OPRED and advised to verify this with OPRED.
What would be a reasonable timeframe for the review of a document?	Typically, one month to review a document. Quick queries could be addressed in a shorter timeframe.

Actions

1. JNCC to provide the recommendations which were provided to Ørsted for the Hornsea Offshore Wind Project concerning sweeping.
2. IOG/Intertek to review the PINS website. This details all of the consultation with Ørsted and could be very beneficial to IOG.
3. IOG/Intertek to ask Ørsted for the sand wave monitoring report. If unable to obtain this from Ørsted, JNCC can assist with this request.
4. IOG to speak with Ørsted and other oil and gas operators that are active within the North Norfolk site.
5. Intertek to schedule a follow-up meeting with JNCC in a few weeks' time to discuss the outcomes of the comparative assessment and next steps with the Environmental Statement. .

B.1.1.2 BEIS – August 2020

Time	0930-1030	
Date	20th August 2020	
Location	n/a Microsoft Teams	
Attendees	Department for Business, Energy & Industrial Strategy (BEIS)	- Anna Buckingham
	Independent Oil and Gas (IOG)	- Mark Yates - Rebecca Gay - Nigel D'Arcy
	Intertek Energy and Water Consultancy Services (Intertek)	- Anna Farley - Nathalie De Groot
	Subsea 7	- Ken Hope - Gavin Leishman

Summary

The Southwark Pipeline Stakeholder Engagement meeting was set up as an early engagement between IOG and BEIS to discuss the Southwark Pipeline Environmental Statement (ES). In particular, the focus was on potential pipeline protection methods (i.e. rock deposit and trench/dredge and burial) and on the Environmental Statement preparation and engagement process. A copy of the slides presented during the call has been distributed with these minutes.

Points made:

1. IOG opened the meeting with introductions and confirmed the agenda. IOG mentioned that the project had a stakeholder engagement meeting with JNCC on the 13th of August 2020.
2. BEIS confirmed receipt of the JNCC stakeholder engagement minutes of meeting and made the following comments:

   a. Firstly, BEIS explained that it is not IOG's responsibility to produce a Habitats Regulations Assessment (HRA). This will be done by BEIS, based on the information provided in the ES.

   b. Secondly, BEIS referred to the potential use of fronded mattresses and clarified that all plastic materials (and thus fronded mattresses) must be removed at time of decommissioning.
3. IOG described the Southwark Pipeline as a fundamental part of infrastructure for Phase 1 of IOGs developments. This underpins the importance of the ES preparation and engagement plan.
4. IOG outlined the project's strategy of multiple early engagement sessions and a comparative assessments workshop.
5. BEIS advised a lessons-learned session on the Blythe and Elgood Environmental Statement would be beneficial. BEIS explained that a new ES is required for the 24" pipeline, because the worst case had not been presented previously.
6. Intertek explained that given that the pipeline crosses the North Norfolk Sandbanks Special Area of Conservation (SAC), a robust discussion of alternatives would be required for all the possible installation method options. Therefore, the project proposed to organise a comparative assessment workshop. The workshop will investigate all potential installation methods and consider environmental, engineering and commercial aspects to determine the best solution for the pipeline; noting this may be a combination of techniques to address site specific conditions. The aim of the comparative assessment workshop is to provide a robust justification for the selected option. BEIS supported IOGs decision to undertake the comparative assessment workshop and thought it would be an extremely useful tool for the ES. See question 1.
7. IOG provided a quick overview of the IOG assets and described the key elements of the Southwark Pipeline: a 24" pipeline of approximately 6km long connected to the existing Thames pipeline. The pipeline will facilitate gas export from the Southwark platform to the onshore Bacton facility. The pipeline is located in the Southern North Sea (SNS) SAC and the North Norfolk Sandbanks and Saturn Reef (NNSSR) SAC.
8. Intertek stated that the aim of this stakeholder engagement meeting is to get a better feeling of BEIS position on the pipeline installation methods and that this information will be used to provide feedback to the engineering team.
9. Intertek explained that the method of installation has not been determined yet, and that the options could potentially include rock deposits to protect berms or shaving of parts of the sandbank tops to prevent free-spanning.
10. BEIS mentioned that it would be worth speaking with oil and gas operator ENI (both environmental and engineering teams) and offered to help facilitate a discussion if required.
11. IOG confirmed to have been in touch with ENI and considers the sharing of experiences extremely useful.
12. The use of fronded mattresses was discussed. IOG mentioned that the use of mattresses of any kind might not be possible in particular areas of the project. There is potential issues in keeping the mattresses in place due to the prevailing metocean conditions (movement of sediment). This is in contrast to projects further north, were the current effects are not as strong and mattresses would be more stable.
13. Intertek confirmed to take on board the recommended approach towards demonstrating that the pipeline installation methods will not have a significant effect. An example of what the impacts assessment will investigate includes whether introducing rock into the benthic environment creates a steppingstone for other species to colonise, or whether it will be covered in sand relatively quickly.

14. IOG (Mark Yates) concluded that a lot of useful information was covered in the meeting and that this information gave a good overall context for the ES process.
15. BEIS commented that the level of engagement was really appreciated.
16. IOG (Nigel D'Arcy) found it good to hear that the difficulty of the location was recognised and appreciated in the discussion.
17. Subsea 7 was appreciative of opportunity to be included in the discussion which provided them with key information to consider.

General Questions Raised

Question	Answer
Is BEIS onboard with the proposed strategy towards the ES of early engagement and a comparative assessment workshop?	BEIS expressed that they were certainly in favour of early engagement. After the 'comparative assessment workshop' was defined, BEIS agreed that the workshop would provide a thorough selection process and would help to reveal IOGs thought process. Additionally, BEIS also proposed a lessons-learned session on the Blythe and Elgood Environmental Statement. In this session, BEIS would like to provide their perspective on what happened previously as this would help to solidify IOGs understanding of the requirements of the Environmental Impact Assessment process.
Given that BEIS will carry out the HRA. What is the preference for relevant information to be presented? For example, on other (cables) projects, Intertek has produced a standalone 'shadow' HRA.	BEIS does not have a preference. BEIS does not see a particular benefit in producing a shadow HRA as BEIS will need to consider all the evidence provided in the ES, without being biased by the format in which the information is presented by the operator. However, BEIS would not be opposed to a shadow HRA either if this would help to structure all the information for the project's own assessment.
Does BEIS have any objections against rock deposits (within the SAC)?	BEIS explained that the regulator is not in a position to determine how an operator must install pipeline, as they are not involved in the engineering studies that underpin this decision. How to install a pipeline is up to the operator, but this must be justified with engineering reasons as well as environmental considerations. It was discussed that the disadvantages of rock deposits are that these introduce another substrate to the benthic environment and that these impacts are considered permanent. Whereas mattresses that can be recovered are considered to have temporary impacts.
BEIS asked: Did JNCC say they would object to rock dumping in the stakeholder engagement meeting?	Intertek responded that JNCC has provided the project with information on what JNCC would generally consider with respect to rock dumping, but that JNCC's position on this would be determined on a case-by-case basis.
Is BEIS aware of any examples of the use and removal of fronded mattresses?	In the past BEIS has not always been aware whether mattresses used were fronded or not. BEIS is aware of a company in Dundee that did a pilot study on placement and recovery of fronded mattresses. This company has found a way to remove mattresses that have degraded with time, this might be worth investigating so that the

	commitment to remove all mattresses at end of lifetime can be made. If IOG thinks degradation of a mattress might be an issue in its removal at decommissioning, then they should have an inspection and maintenance regime in place that removed the mattresses and replaced them before they became to degraded.
BEIS asked: Given the high mobility environment, would the project wish to use fronded mattresses?	IOG and Subsea 7 confirmed they have not crossed this option off the list but given the environmental conditions it could be very difficult. From a technical viewpoint, rock dumping would be considered easier in this environment. In case of the Blythe pipeline, IOG proposed substitution of rock dumping with mattresses at the pipeline crossings. However, the 24” pipeline is very different, and the use of mattresses may not be possible due to the mobile conditions observed in the NNSSR SAC. IOG indicated that on recent project work (intelligent pigging campaign) they discovered a mattress from another operator that had been moved by the currents to the IOG Thames pipeline location.
With regards to the HRA, are there examples of projects where a significant effect was concluded resulting in going through the (Imperative Reasons of Overriding Public Interest) IROPI process?	This has never been the case and BEIS would prefer not to go down that route. If such an outcome would be likely, BEIS would not approve the ES.
In terms of approval, what are the risks of the use of rock deposits?	That depends on the quantity. But it is important that the worst case is covered. There are examples of other operators that needed to ask to increase the quantity of rock deposits. The answer to that would be no or a new ES would be required.
Would a ‘worst case’ scenario be for just the installation phase or would it be useful to include a maintenance campaign prediction?	The worst case should just include the worst case of all planned activities including maintenance.
Does BEIS have a preference for either rock dumping or sand shaving?	That depends on the technical requirements, bearing in mind the environmental conditions of the location. However, the regulator is not in a position to propose the installation method. See question 3.
Would BEIS foresee any requirement for modelling, to demonstrate the effect rock deposits or trenching might have on the environment?	BEIS did not explicitly discuss modelling and instead explained that a description of the regime of currents would be useful to demonstrate that the installation method will not have a significant effect. For example, it would be worth showing that the sediments are so mobile that installing pipeline and protection theoretically should not interfere with the environment.

Actions

1. IOG to obtain the contact details of the ENI engineering department to liaise with
2. IOG to speak with ENI engineering department contact
3. IOG to give BEIS (Anna Buckingham) a call in a few weeks' time to discuss the outcomes of the comparative assessment and next steps with the Environmental Statement.

B.1.1.3 BEIS and JNCC – February 2021

Time	1000-1115	
Date	11th February 2021	
Location	n/a Microsoft Teams	
Attendees	Department for Business, Energy & Industrial Strategy (BEIS)	- Anna Buckingham
	Joint Nature Conservation Committee (JNCC)	- Hannah Hood - Becky Hitchin
	Independent Oil and Gas (IOG)	- Mark Yates - Ron Doherty - Katrina Ross
	Intertek Energy and Water Consultancy Services (Intertek)	- Anna Farley - Kerri Gardiner - Nathalie De Groot
	Subsea 7	- Andy Robb - Ken Hope - Gavin Leishman

Summary

The third Southwark Pipeline Stakeholder Engagement meeting follows the initial early engagement, which took place in August 2020, between IOG and BEIS and JNCC to discuss the Southwark Pipeline Environmental Statement (ES). This third meeting was set up to discuss the outcomes of IOGs Comparative Assessment (CA) workshop which was held on the 29th January 2021. A copy of the slides presented during the call has been distributed with these minutes.

Points made:

1. **1. Introductions & Consultation Objectives**

   Mark Yates (MY) opened the meeting reflecting that this was the 3rd stakeholder engagement meeting, with previous engagement meetings held in August 2020. MY stated that the objective of today was to update BEIS and JNCC on the outcomes of the successful CA workshop which was held on the 29th January 2021. MY mentioned the meeting would also present the next steps of the ES timeline.
2. All attendees of the meeting were introduced.
3. Anna Farley (AF) presented the agenda and mentioned that each of the agenda points would be supported by ppt slides. AF stated that attendees should feel free to interrupt for questions or clarifications at any time during this presentation. AF reiterated that the objective of the meeting was to present the outcomes of the CA workshop and to verify whether BEIS and JNCC would agree with the CA conclusions.
4. Project overview

   AF presented a brief overview of the project and its location within the North Norfolk Sandbanks and Saturn Reef (NNSSR) Special Area of Conservation (SAC). The profile showing the sandwaves along the route produced by Subsea7 was also presented.
5. **2. Technical Options**

AF mentioned that the feedback from the previous consultation meetings (with JNCC and BEIS) was used by Subsea 7 in producing their Technical Options Report. The 7 options that were identified in this report were presented.

6. 3. CA Workshop Objectives & Process

   AF explained that the objective of the CA workshop was to identify the Best Practicable Environmental Option (BPEO), the spread of scores: to find out whether there was an option that was clearly preferred and the sensitivities around the scores: to test whether the BPEO conclusion was robust.

7. AF explained the process of the CA workshop included the following steps: verifying of technical options, to ensure the right options are identified. Reviewing the screened out options to confirm this decision was correct. Verifying suitability of the range of feasible options and a comparative assessment of the feasible options.

8. 4. Assessment Criteria

   AF presented the eight assessment criteria, which were formulated around the conservation objectives of the (NNSSR SAC) site, developed by Xodus (as the environmental consultancy supporting Subsea 7 on this project) and as agreed with IOG and Intertek.

9. AF checked whether BEIS and JNCC were happy with the level of detail provided in the presentation thus far and both confirmed.

10. 5. Options Screened Out and Justifications

    AF explained that the technical options report had screened out options 1, 2, 4 & 7 based on technical and feasibility grounds and that the CA workshop confirmed this decision. Reasons for screening out these options were summarised as follows:

11. Option 1 no seabed preparation – would result in unacceptable free spans.

12. Option 2 local re-route – would not be able to avoid the sandwaves, the project has also separately discounted a global re-route in technical note. AF also noted that re-routing the 24” pipeline would not be as simple as re-routing a cable.

13. Option 4 concrete mattresses – too many mattresses would be required making this option technically unfeasible. Additionally, due to the high sandwaves a couple of mattresses would need to be stacked leading to stability and safety concerns. This is also something not done before (on this scale).

14. Option 7 self-burial – would lead to free spans before self-burial, resulting in pipeline fatigue. This is also unproven technology.

15. Andy Robb (AR) – added that the 24” concrete armoured pipeline would indeed not be as flexible as cable and that bends in pipeline would be at a scale of 100m (radius).

16. AF confirmed whether BEIS and JNCC agreed it was sensible to scope out the aforementioned options. Both agreed and were glad to hear the mattresses option was not taken forward.

17. 6. BPEO & CA Conclusions

    AF stated that of the options that were taken forward (3, 5 and 6) the CA workshop concluded that the BPEO was option 6 (Sandwaves levelled to mean seabed level across the width of the pipe lay corridor and trenching to below the mean seabed level).

18. AF remarked that on the scoring, there were a small number of scores were the CA workshop participants disagreed initially. Consensus was reached by discussing the scoring and testing the rationale.

19. MY added that in his view having both Xodus and Intertek, as environmental consultancies, discussing, testing and reaching an agreement on the scoring led to a thorough and robust outcome of the workshop.

20. AF further explained that the CA workshop concluded the following:

    - The rock infill option scored the worst across all the environmental criteria and was therefore quickly discounted.

- Different weighting systems of the scores were tested, including linear and exponential, but changing the scoring system did not change the BPEO.
- Changing the weighting of individual criteria – for example giving the criterium 'new substrate' double weight, was also tested. However, it was found that this did not really change the BPEO, unless the weighting was pushed to unrealistic values (making one of them 4 times more important).
- Within Option 6 (BPEO) all sub options had a very similar score, with exception the sub options using Controlled Flow Excavation (CFE). CFE was identified as slightly worse because this method is not so directional and therefore creates greater sediment plumes.

21. AF stated that the project team would like to include all sub options including those with CFE to give Subsea7 the widest range of possible tools for seabed preparation.

22. AF opened the floor for any queries. There were no queries.

23. HH mentioned that it was good to see different weightings were applied in the CA process. HH requested that the scoring be provide in the ES. AF explained that the plan is to include all 7 options that were considered in the alternatives section of the ES and to provide the CA report which includes the scoring as an addendum to the ES. This was agreed to be appropriate.

24. AF explained that now the BPEO has been identified, Subsea 7 will be working out the technical requirements for this option. In the meantime, Xodus has commenced a study to look at sediment mobility in order to predict how the sediment moves within the site to inform the worst case sediment that needs to be moved. Current estimate of the sediment to be moved ranges from 60 000 – 100 000 m3.

25. AF clarified that there will be no sediment moved out of the (NNSSR SAC) site.

26. 7. Race Bank: evidence of recovery from pre-sweeping

AF presented evidence from the Race Bank windfarm on signs of recovery after pre-sweeping – the sandwave recovery analysis report obtained from Ørsted has good imagery of the bathymetric from pre sweeping, during dredging and afterwards. The data shows that within 2 years, nearly complete (75%) recovery) recovery was reached.

27. AF explained this is the type of information the project team is planning to use to support the environmental impact assessment and asked whether BEIS and/or JNCC are aware of any additional useful information (either concerning Northern Norfolk Sandbanks or similar environments).

28. AB advised to engage with Chrysoar with regards to their decommissioning activities and agreed to facilitate contact with them (through Angela Flower, Environmental Advisor at Chrysoar).

29. AF asked whether they would likely have any survey data available. AB stated to be unsure the status of the survey data availability.

30. BH mentioned to be aware of post activity survey data for rock dumping from Chrysoar but was also unsure about survey data regarding sandwave levelling.

31. BH stated that the Race Bank data presented indeed shows the potential for recovery in some cases (not all cases as evidenced by one of the pre and post survey image sets). BH also mentioned that it is known that there will be differences in the pre and post sweep sandwaves, but that was unsure on what the significance of this was. For example, post clearance sand waves tend to show more bifurcation than before. Suggested a joint email approach to Dayton Dove at BGS to determine if he can provide more insight.

32. AF summarised the plan to include the following in the ES: any pictorial evidence of sandwave recovery and prediction of how the sandwaves are likely to be moving.

AB inquired about findings from IOG surveys that supported the notion that the sandwaves had changed from one survey to another.

33. KR answered that there is data from a seabed survey from 2018 for the pipeline route and from 2020. Comparing both data sets showed a difference in height of the sandwaves and also where the sandwaves are. This data was used in the CA to show that the sandwaves are highly mobile.

34. AF mentioned that the 2018 data covers a wider survey corridor, whereas the 2020 survey was focused on the pipeline centre line, but that the difference between both surveys has indeed shown changes in sandwaves.

35. AB stated that showing both survey data sets in the ES would be useful to demonstrate that IOG has been monitoring and will continue to monitor the sandwaves on the site.

36. AF mentioned that Subsea7 will base the detailed technical engineering on current data available, but that because of the high mobility of the sandwaves the project will have to do another survey immediately ahead of installation to confirm the status of the seabed at that moment in time. Therefore, the ES will include contingency (e.g. 20% (number made up for illustrative purposes) contingency for the amount of sediment to be moved) based on the Xodus sandwave mobility study.

37. AR confirmed recommending a pre-sweep survey.

38. Discussion: Controlled Flow Excavation (CFE)

AF moved to the discussion of CFE as a seabed preparation method. AF explained that with this method, potentially a greater area will be disturbed. Although, it will retain sediment in same location and within sandwave system.

39. AF mentioned that this method is not the preferred method from a technical perspective, but the project would like to keep as wide a range of tools as possible and therefore include this as the worst case. AF therefore asked whether BEIS and/or JNCC has any specific concerns.

40. AB – had no feedback on this method at the moment but could run it past colleagues internally to get more information on this topic.

41. HH recognised that the CFE sub option even with the additional impact was better than the other seabed preparation options and appreciated the rationale to keep this method as an option. HH recommended to provide a comparison of the seabed footprint and impact on the site for each potential option in the ES.

42. AF confirmed that the plan is to include a table that provides the seabed footprint and volumes of sand to be moved in the Project Description of the ES to make the differences between the sub options clear.

43. AF inquired whether any new data with respect to Sabellaria within the NNSSR SAC was yet available. BH responded that a new monitoring report was available and that HH should be able to direct to this information.

44. 9. ES Next steps

AF presented the ES timeline and the next steps. She explained that at this moment in time, the pre-ES consultation is starting to overlap with the ES data gathering stage. AF mentioned that the project has scheduled a consultation with NFFO for next week and is looking to submit the ES in the middle of May 2021.

45. AB mentioned that under the new regulations, developers are allowed to submit a draft version of the ES, which will not go out for public consultation and will just be reviewed within the BEIS department.

46. AF inquired how this would affect the determination period.

47. AB responded that it would slow things down, but potentially eliminates the frequency of further information required and that she could provide additional information on this process if required.

48. AF proposed to take this away and think about this and whether it would be quicker.

49. AB provided more information from the new guidance and explained that – Developers are allowed to submit a near final draft version of the ES to BEIS for informal review, before commencing the formal engagement process. If a draft was to be submitted, BEIS Admin would acknowledge receipt and the BEIS manager (i.e. AB) would intend to review the draft and provide comments within 30 days (or advise of an

alternative date to expect comments if not feasible). This is a discretional process and developers can also choose to submit via the traditional method, although this carries a risk of more iterations for additional data request.

50. AF inquired whether the draft route could run parallel with the process of obtaining discretional advice from JNCC.

51. AB agreed to check whether this would legally be allowed.

52. AB also mentioned that before the formal ES could be submitted to BEIS, the application for consent from the pipeline works authority (PWA) needed to be launched and formally recognised.

53. 10. Wrap-up

AF moved to wrap up of the meeting and asked if any of the attendees had any further comments or thoughts.

54. AB mentioned that any pre-sweeping activities (e.g. a pre-sweeping survey), if taking place prior to a pipeline number from OGA was received, this would need to be covered under a marine license (through the PETS system).

55. HH and BH confirmed no further questions.

56. AF added the remark that in selecting the BPEO the project team really looked at the sustainability of the seabed preparation options and thought about the life cycle of the pipeline when comparing all options. In this respect, the selected option significantly reduces any requirement for future rock remediation.

57. AB stated that she really appreciated the level of engagement with the project.

58. MY concluded that it was a great session and that from IOG's perspective we covered all the bases in the meeting.

Actions

9. IOG will include CA results in ES
10. BEIS to arrange introduction to Chrysoar
11. BEIS to feedback whether the review of draft ES process could legally run parallel to JNCC Discretionary Advice process.
12. Intertek to draft email for JNCC to send to Dayton Dove (BGS)
13. JNCC to provide link to NNSSR SAC Monitoring Report

B.1.1.4 NFFO, VisNed, Rederscentrale – February 2021

Time	10:30-11:30	
Date	17th February 2021	
Location	n/a Microsoft Teams	
Attendees	Independent Oil and Gas (IOG)	- Mark Yates – mark.yates@iog.co.uk - Ron Doherty – ron.doherty@iog.co.uk - Katrina Ross – Katrina.ross@iog.co.uk - Phil McIntyre – phil.mcintyre@iog.co.uk
	Marine Space Fisheries Liaison Officer	- Damien Kirby – damien.kirby@marinespace.co.uk
	Intertek Energy and Water Consultancy Services (Intertek)	- Anna Farley - anna.farley@intertek.com - Kerri Gardiner – kerri.gardiner@intertek.com
	NFFO	- Ian Rowe – ian.rowe@nffo.org.uk
	Belgian fisheries – Rederscentrale	- Jasmine Vlietinck – jasmine.vlietinck@rederscentrale.be

	VisNed – represent Dutch fishermen	- David Russ – dras@visned.nl

Summary

Points made:

1. 1. Introductions & Consultation Objectives

   Mark Yates (MY) opened the meeting, providing an agenda and objective of the meeting.

   All attendees of the meeting were introduced.

2. 2. Southwark overview and fisheries context

   Overview:

   MY presented a brief overview of IOG and their assets and the current status of activities within the Blyth and Southwark fields. MY went onto to discuss how the Southwark pipeline fits into the overall development. MY provided an overview of the ES process to date and why this ES addendum is required.

3. Fisheries in the region:

   Katrina Ross (KR) provided an overview of fisheries in Southwark and the surrounding area. Main points noted: fisheries dominated by demersal fisheries (predominantly coastal, both for mobile and static gears) and effort is low. KR asked if anybody had any questions.

   Ian Rowe (IR) advised that static gear is dominant in the area and Southwark is mainly fished by Belgian and Dutch vessels. He advised that fishing grounds in the area are constantly evolving, many fisheries are being pushed out by other developments, particularly wind. IR advised that this should be captured within the ES.

4. 3. CA Workshop overview

   Anna Farley (AF) discussed the seabed profile along the Southwark route and how it is dominated by migrating sand waves.

5. AF advised that IOG commissioned Subsea 7 as EPC contractor to undertake a review of options for seabed preparation and installation. AF discussed the 7 candidate seabed preparation, installation and protection options for the pipeline with associated sub options.

6. AF explained that the objective of the CA workshop was to identify the Best Practicable Environmental Option (BPEO), the spread of scores: to find out whether there was an option that was clearly preferred and the sensitivities around the scores: to test whether the BPEO conclusion was robust.

7. AF explained the process of the CA workshop included the following steps: verifying of technical options, to ensure the right options are identified. Reviewing the screened out options to confirm this decision was correct. Verifying suitability of the range of feasible options and a comparative assessment of the feasible options.

8. 4. CA Assessment Criteria

   AF presented the eight assessment criteria, which were formulated around the conservation objectives of the North Norfolk Sandbanks and Saturn Reef (NNSSR) Special Area of Conservation (SAC) site, developed by Xodus (as the environmental consultancy supporting Subsea 7 on this project) and as agreed with IOG and Intertek.

9. 5. Options Screened Out and Justifications

   AF explained that the technical options report had screened out options 1, 2, 4 & 7 based on technical and feasibility grounds and that the CA workshop confirmed this decision. Reasons for screening out these options were summarised as follows:

   Option 1 no seabed preparation – would result in unacceptable free spans.

Option 2 local re-route – would not be able to avoid the sandwaves, the project has also separately discounted a global re-route in technical note.

Option 4 concrete mattresses – too many mattresses would be required making this option technically unfeasible.

Option 7 self-burial – would lead to free spans before self-burial, resulting in pipeline fatigue. This is also unproven technology.

10. 6. BPEO & CA Conclusions

AF stated that of the options that were taken forward (3, 5 and 6) the CA workshop concluded that the BPEO was option 6 (Sandwaves levelled to mean seabed level across the width of the pipe lay corridor and trenching to below the mean seabed level).

11. AF further explained that the CA workshop concluded the following:

- The rock infill option scored the worst across all the environmental criteria and was therefore quickly discounted.
- Different weighting systems of the scores were tested, including linear and exponential, but changing the scoring system did not change the BPEO.
- Changing the weighting of individual criteria – for example giving the criterium 'new substrate' double weight, was also tested. However, it was found that this did not really change the BPEO, unless the weighting was pushed to unrealistic values (making one of them 4 times more important).
- Within Option 6 (BPEO) all sub options had a very similar score, with exception the sub options using Controlled Flow Excavation (CFE). CFE was identified as slightly worse because this method is not so directional and therefore creates greater sediment plumes.

12. AF opened the floor for any queries. There were no queries and IR said everything was clear.

13. 7. Race Bank: evidence of recovery from pre-sweeping

AF presented evidence from the Race Bank windfarm on signs of recovery after pre-sweeping – the sandwave recovery analysis report obtained from Ørsted has good imagery of the bathymetric from pre sweeping, during dredging and afterwards. The data shows that within 2 years, nearly complete (75%) recovery) recovery was reached.

14. AF then opened the floor for any queries:

15. IR advised that he was happy to see that concerns raised in the original ES and Addendum had been taken into consideration, not only from a fisheries perspective but also from a pipeline integrity perspective, particularly associated with the potential for fishing vessels to snag the pipeline.

16. David Ras (DR) asked if any free spans are expected to occur and will any remediation be required. AF advised that it cannot be guaranteed that free spans will not occur, however given that IOG are burying the pipeline below the level of sand wave mobility then there is more confidence that this method will prevent free spans than any other method assessed. AF advised that burial below mean surface level is the most sustainable in terms of long-term strategy for the pipeline and it will minimise the risk of free spans. AF advised that Xodus has commenced a study to look at sediment mobility in order to predict how the sediment moves within the site and where the seabed is likely to lie during installation.

17. DR asked if there will be any post installation monitoring to pick up free spans and will these be communicated to the fishing industry. Ron Doherty (RD) advised surveys will be carried out routinely. IR advised that it would be good if any free-spans are communicated via the Kingfisher Bulletin. AF advised standard mitigation for communication to the fisheries industry will be in place and if there is any serious risk from free-spans then it is likely that this will be communicated.

IR asked that the ES considered the evolution of fishing grounds in the area. AF noted this as an action for Intertek to capture in the ES Addendum.

18. Damien Kirby (DK) asked if there will be a change in sediment composition following installation of the pipeline. AF advised that any sand removed during installation will be retained within the wider sandbank system and in the locality of the sand waves with no significant changes in composition.

19. 9. ES Next steps

    AF presented the ES timeline and the next steps.

20. 10. Wrap-up

    AF moved to wrap up of the meeting and asked if any of the attendees had any further comments or thoughts. – No further comments were raised.

Actions
14. IOG will consider the evolution of fishing grounds in the area within the ES

B.1.2 Actions addressed in the ES

The following table outlines how the actions raised in consultation are addressed in the ES.

Action	Response
5. Intertek to schedule a follow-up meeting with JNCC in a few weeks' time to discuss the outcomes of the comparative assessment and next steps with the Environmental Statement.	A follow up stakeholder engagement meeting was held on 11th February to present the results of the Comparative Assessment workshop
8. IOG to give BEIS (Anna Buckingham) a call in a few weeks' time to discuss the outcomes of the comparative assessment and next steps with the Environmental Statement.	
9. IOG will include CA results in ES	The Comparative Assessment process and results are described in Section 2 of the ES Addendum. The final report from the CA Workshop is include as an Appendix to the ES Addendum.
11. BEIS to feedback whether the review of draft ES process could legally run parallel to JNCC Discretionary Advice process.	IOG discussed with BEIS and decided not to submit a draft, due to the extent of consultation that has preceded that submission of the ES Addendum. The first submission to BEIS will be the final submission.
13. JNCC to provide link to NNSSR SAC Monitoring Report	The NNSSR SAC Monitoring Report has been used as a reference throughout the environmental baseline chapter (Section 4) of the ES Addendum.
14. IOG will consider the evolution of fishing grounds in the area within the ES	This has been considered in Section 4 of the ES Addendum

APPENDIX C

Technical Note – Calculation of Dredged Volume for 24” Route (Subsea7 2021b)

Independent Oil and Gas PLC

Blythe and Vulcan Satellite Hubs Development

Technical Note - Calculation of Dredged Volume for 24" Route

ET1077-SRV-00296

001-GEN-SS7-U-RP-0282

Originator:	Adrian Mitchell					
Checker:	Lee Morrice					
Approver:	Gavin Leishman					
00	**Issued for Review**	**09.03.2021**	**AMITC**	**AROBB**	**GLEI**	
Rev.	Reason for Issue	Issue Date	Prepared by	Checked by	Approved by	Client Approval

subsea 7

Technical Note

Project:	IOG Blythe Vulcan	Prepared:	Adrian Mitchell
Client:	IOG	Checked:	Lee Morrice
Subject:	Calculation of dredged volume for 24” route	Doc No.	ET1077-SRV-00296
Date:	08/03/21	Revision:	00

1. INTRODUCTION

This technical note is presented to describe the process used to arrive at the volumetric calculation results for the IOG 24” pipeline route from the mechanical connector at the Thames 24” trunk line to the Southwark platform. The results are presented as calculated, no contingency values have been added.

2. DATA SOURCES

There are two sources of seabed bathymetry used in the calculation which are the client supplied Fugro digital terrain model from 2018 and the Skandi Acergy 24” pre-lay survey from 2020. Both datasets are reduced to LAT.

A TIN model was created which is a design shape of the desired trench in relation to the seabed bathymetry. This TIN (triangulated irregular network) model was created using the 24” design route centreline increased in various depth values to a level beneath the seabed by KP range for pipeline stability (see drawing ET1077-DR-AA-11001). This data was supplied by pipeline analysis. A lateral flat corridor was extended out either side of this deeper centreline by 15m to create a 30m flat bottom section. Slope sections of 25° were then added on either side to go from the flat bottom section up to the seabed level. These slopes are approximately 15m wide at each side making the corridor approximately 60m in width.

The TIN model and seabed bathymetry was submitted to Xodus for calculation of the predicted migration of sand waves in the area in 2022 as the proposed date for the installation of the 24” pipeline. These shifted sand waves were returned as various updated seabed bathymetry models based on max, min and average expected movement (ref. L-100699-S00-TECH-001 - 24" Southwark Pipeline Morphological Assessment). These were loaded into EIVA NaviModel. The TIN model was added and the software asked to calculate the total volume of material above the TIN model. This was repeated for each shifted sand wave model.

Please note that there is a short section of 750m at the Southern end of the route where the 24” design centreline is outside the bounds of the 2018 seabed bathymetry. For this section, the Skandi Acergy 2020 survey data was used and this was not shifted to predicated sand wave locations in 2022.

The results are presented below:

Bathymetry correction approach	Total Calculated Volume (m^3)	Prediction Description
Block shift	**367200**	Block shift of full 2018 bathymetry based on the minimum migration rate.
Block shift		Block shift of full 2018 bathymetry based on the maximum migration rate.
Block shift	**367200**	Block shift of full 2018 bathymetry based on the average minus one standard deviation migration rate.
Block shift		Block shift of full 2018 bathymetry based on the average plus one standard deviation migration rate.
Block shift	**383300**	Block shift of full 2018 bathymetry based on the average migration rate.
Mobile Bed Slope 1	**372000**	Shift of the mobile seabed using the average migration rate. The mobile seabed was determined from the estimated slope of the underlying immovable geology.
Mobile Bed Slope 1	**372100**	Shift of the mobile seabed using the average minus one standard deviation migration rate. The mobile seabed was determined from the estimated slope of the underlying immovable geology.
Mobile Bed Slope 1	**378600**	Shift of the mobile seabed using the average plus one standard deviation migration rate. The mobile seabed was determined from the estimated slope of the underlying immovable geology.
Mobile Bed Slope 1	**N/A**	Shift of the mobile seabed using the maximum deviation migration rate. The mobile seabed was determined from the estimated slope of the underlying immovable geology.
Mobile Bed Slope 1	**371500**	Shift of the mobile seabed using the minimum deviation migration rate. The mobile seabed was determined from the estimated slope of the underlying immovable geology.
Mobile Bed Slope 2	**369000**	Shift of the mobile seabed using the average migration rate. The mobile seabed was determined from a refined estimate of the slope of the underlying immovable geology.
Mobile Bed Slope 2	**382000**	Shift of the mobile seabed using the average plus one standard deviation migration rate. The mobile seabed was determined from a refined estimate of the slope of the underlying immovable geology.
Mobile Bed Slope 2	**370200**	Shift of the mobile seabed using the average minus one standard deviation migration rate. The mobile seabed was determined from a refined estimate of the slope of the underlying immovable geology.
Mobile Bed Slope 2	**N/A**	Shift of the mobile seabed using the maximum deviation migration rate. The mobile seabed was determined from a refined estimate of the slope of the underlying immovable geology.
Mobile Bed Slope 2	**N/A**	Shift of the mobile seabed using the minimum deviation migration rate. The mobile seabed was determined from a refined estimate of the slope of the underlying immovable geology.

Various screenshots are provided below to illustrate the process described.

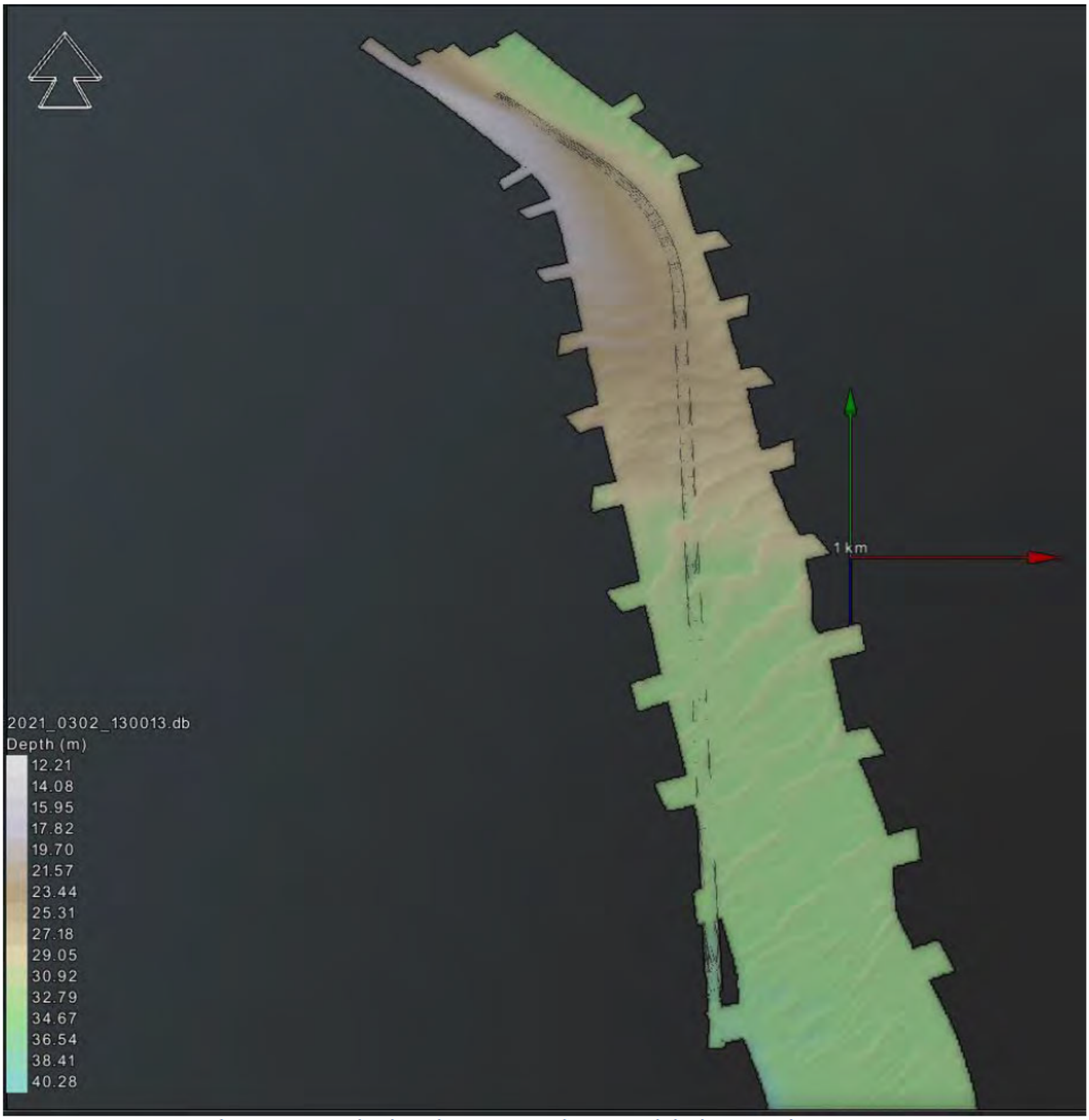


Figure 1 – Seabed Bathymetry and TIN Model Along Design Route

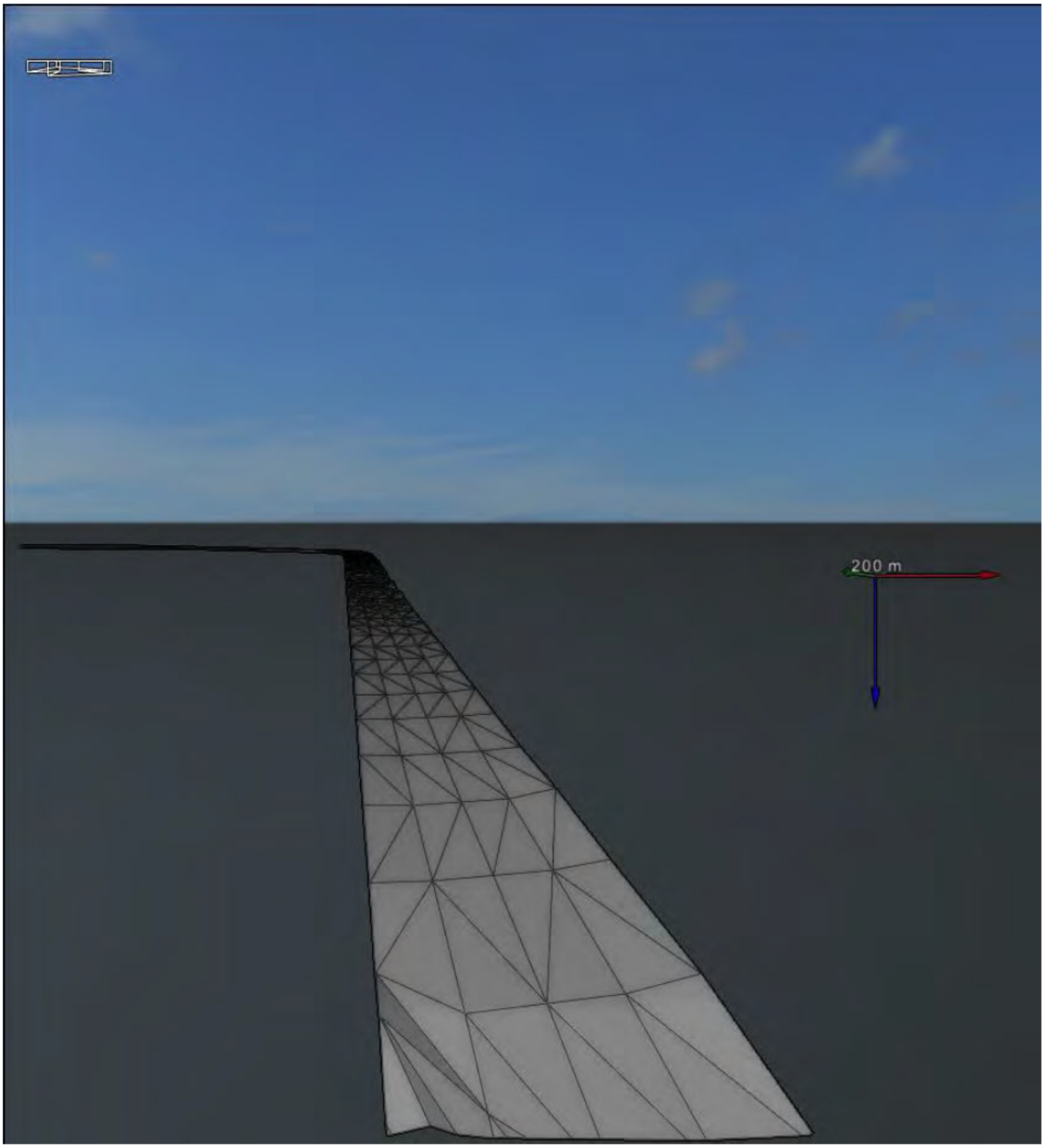


Figure 2 – TIN Model Along Design Route

APPENDIX D

Southwark 24” Pipeline Comparative Assessment

Final Report (Intertek 2021)

Total Quality. Assured.

INDEPENDENT OIL AND GAS (IOG) LIMITED

Southwark 24" Pipeline Comparative Assessment

Final Report

P2371_R5224_Rev1 | 9 February 2021

Intertek Energy & Water Consultancy Services
Exchange House, Station Road, Liphook, Hampshire GU30 7DW, United Kingdom

DOCUMENT RELEASE FORM

Independent Oil and Gas (IOG) Limited

P2371_R5224_Rev1

Southwark 24" Pipeline Comparative Assessment

Final Report

Authors

Nathalie De Groot, Alistair Bird

Project Manager	Authoriser
pp. Kerri Gardiner	Anna Farley

Rev No	Date	Reason	Author	Checker	Authoriser
Rev 0	05/02/2021	Draft for comments	NDG	ALF / AB	ALF
Rev 1	09/02/2021	Final	NDG	ALF	ALF

EXECUTIVE SUMMARY

As part of the wider Phase 1 development, Independent Oil and Gas Limited (IOG) have conducted a Comparative Assessment (CA) of the potential seabed preparation, installation and protection options for the installation of the 24" Southwark Pipeline. The CA was conducted to compare and assess all technically feasible options across eight environmental criteria following a robust assessment process. The objective of the process was to identify and that the option taken forward to prepare the seabed, install and protect the pipeline is the Best Practicable Environmental Option (BPEO).

The CA workshop was attended by experienced project development, pipeline engineering, geotechnical specialists together with environmental consultants and subject matter experts from IOG, Subsea 7, Intertek and Xodus. This CA report forms a record of the process and collective judgment of the workshop participants with regards to the BPEO.

During the workshop it was concluded that, subject to confirmation that a global re-route is not feasible, the **BPEO is Option 6: Dredged to mean sea level and then trench to below mean sea level.**

The BPEO conclusion proved to be resilient against a variety of weightings that were applied to the rankings and the effect of changing the weighting given to individual criteria.

Follow-up actions that were identified during the CA workshop are as follows:

Action ID	Action	Responsible party	Deadline
INTK_1	Progress the study for global re-routing.	Intertek and IOG	TBC
SUB_1	Subsea 7 to reissue report to modify table Report update: tweaks, finalise report to accommodate changes to the table. Delete percentages of capex cost, so that not traceable to contract value. Not needed as input.	Andy Robb	ACTIONED 03/02/2021
SUB_2	Subsea 7 forward copy of final slides	Andy Robb	ACTIONED 08/02/2021
AB_1	Send screen grab of revised scores to workshop attendees	Alistair Bird	ACTIONED 01/02/2021
XOD_1	Xodus to go back to the report and make the slight tweaks to the scores to align the report with the outcome of the CA workshop. Provide asterix to show which scores have been amended after CA. If report going to public domain, caveats that footprints are indicative (in case that they are different than ES)	Marten Meynell	05/02/2021
SUB_3	Subsea 7 to set up a kick-off meeting with IOG, Intertek and Xodus to kick off data gathering phase of the ES and discuss inputs required from Subsea 7.	Andy Robb	ACTIONED Meeting held on 03/02/2021 Further meeting planned for 12/02 to discuss outcome from 11/02 mtg with BEIS and JNCC.
XOD_2	Xodus to produce a proposal for the sandwave predictive scope, exact requirements to be confirmed at the ES data gathering kick-off meeting.	Anna Chaffey	ACTIONED 05/02/2021
INTK_2	Intertek to produce a draft comparative assessment report and send out for review to workshop attendees. This report will feed in to slide packs for stakeholder consultations.	Nathalie de Groot, Anna Farley and Alistair Bird	ACTIONED 05/02/2021

CONTENTS

GLOSSARY

BEIS
Department for Business, Energy and Industrial Strategy

BPEO
Best Practicable Environmental Option

CA
Comparative Assessment

CAPEX
Capital Expenditure

CFE
Controlled Flow Excavation

EIA
Environmental Impact Assessment

ES
Environmental Statement

IOG
Independent Oil and Gas Limited

JNCC
Joint Nature Conservation Committee

MSL
Mean Sea Level

NFFO
National Federation of Fishermen's Organisations

NNSSR
North Norfolk Sandbanks and Saturn Reef

OPEX
Operating Expenses

OPRED
Offshore Petroleum Regulator for Environment and Decommissioning

SAC
Special Area of Conservation

TSHD
Trailing Suction Hopper Dredging

1. INTRODUCTION

1.1 Purpose

The purpose of this document is to present the Comparative Assessment (CA) of the seabed preparation options for the installation of the 24" Southwark Pipeline. It describes the project background, the seabed preparation options considered, the CA methodology used and the conclusions from the CA process.

The CA workshop was carried out on the 29th of January 2021. Details of the agenda, participants and minutes are provided in Appendix A. The CA workshop was attended by representatives of the project team from IOG, Intertek, Subsea7, and Xodus.

1.2 Background

As part of the Southwark field development, IOG intends to install a 6 km 24” export gas pipeline from the new Southwark platform to a tie-in to the existing Thames 24” pipeline.

The Southwark pipeline is located within the North Norfolk Sandbank and Saturn Reef (NNSSR) Special Area of Conservation (SAC) and Southern North Sea SAC. Respective designations are:

NNSSR SAC:

- Annex I habitat – Sandbanks which are slightly covered by seawater all the time; and
- Annex I habitat – Reefs.

Southern North Sea SAC:

- Annex II species, harbour porpoise

Offshore Petroleum Regulator for Environment and Decommissioning (OPRED) approval of an Environmental Statement (ES) Addendum for the pipeline was secured in April 2020.

Survey data acquired in May 2020 (Subsea7 2021 - Appendix B) showed that, since the previous survey in March 2018, sandwaves have moved in a north or north-west direction up to 50m, with smaller sandwaves travelling less than larger ones. Crests have increased in places by 1m. Subsea 7 have indicated that these changes mean that the seabed preparation required to facilitate the pipeline installation described in the approved ES addendum are no longer appropriate. Consequently, a new ES Addendum needs to be prepared. Intertek are engaged by IOG to prepare the addendum.

Given the environmental sensitivity of the site, it is particularly important the new environmental impact assessment (EIA) reported in the ES Addendum demonstrates careful consideration of potential impacts of the development and appropriate choice of techniques. During early consultation with OPRED, IOG committed to carry out a CA of pipeline seabed preparation and installation options. The objective was to inform further consultation and the selection of techniques to be employed.

IOG have contracted Subsea 7 to engineer, procure and construct the pipeline, and within this scope to carry out a feasibility study of installation options: ‘Seabed Preparation Options for Installation of 24" Southwark Pipeline’ report prepared by Subsea7 (Ref 1). This includes an initial environmental appraisal of the options based on environmental criteria which have been previously agreed with IOG.

1.3 Technical options

The Subsea 7 Technical Options Report (Ref 1) provided the starting point for the CA workshop, and established:

1. Seven candidate seabed preparation, installation and protection options for the pipeline, with associated sub options, as follows:

Option	Description
1	No seabed modification, pipeline installed on as-found seabed;
2	Re-route pipeline;
3	Rock infill between sandwaves;
4	Concrete mattress infill between sandwaves;
5	Sandwaves levelled to mean seabed level across the width of the pipe lay corridor, using the following methods:
	a) Controlled flow excavation (CFE);
	b) Trailing suction hopper dredging (TSHD); and
	c) Seabed excavators.
6	Sandwaves levelled to mean seabed level across the width of the pipe lay corridor and trenching to below the mean seabed level as follows:
	a) CFE to the mean seabed level, with trenching using CFE;
	b) CFE to the mean seabed level, with trenching using jetting;
	c) CFE to the mean seabed level, with trenching using a mechanical plough;
	d) TSHD to the mean seabed level, with trenching using CFE;
	e) TSHD to the mean seabed level, with trenching using jetting;
	f) TSHD to the mean seabed level, with trenching using a mechanical plough;
	g) Seabed excavator to the mean seabed level, with trenching using CFE;
	h) Seabed excavator to the mean seabed level, with trenching using jetting; and
	i) Seabed excavator to the mean seabed level, with trenching using a mechanical plough.
7	Pipeline self-burial

2. A set of eight previously agreed environmental criteria to be used for the assessment (see Appendix Table B-1) and associated scheme against which criteria are ranked (Appendix B, and B-2).
3. An assessment of the technical feasibility of each option (including safety, CAPEX, OPEX and project risk considerations).
4. An environmental appraisal matrix which evaluates each of the options against each criteria using the ranking scheme.

Technical feasibility considers whether the options provides technically acceptable installation and operational performance. This includes consideration of safety, CAPEX, OPEX costs, the main project risks, the viability of installation and operational structural integrity.

Ref 1 screens out options from further consideration as follows:

Option	Reasons for screening out
1	No seabed modification, pipeline installed on as-found seabed; judged not feasible on the basis that the pipeline will fail at outset since unacceptable freespans are formed between sandwaves immediately following laydown.
2	Local re-route pipeline; also judged not feasible because much of the re-routed pipeline will remain subject to the environmental loads which render Option 1 not feasible. *
4	Concrete mattress infill between sandwaves; Considered not feasible as this would require 22,500 mattresses, taking approximately 3.75 years to install. The extent of stacking required also raises stability and safety concerns.
7	Pipeline self-burial. Considered not feasible due to combination of: ▪ Presence of unacceptable freespans immediately following laydown (similar to option 1). ▪ Depth of self-burial unlikely to be enough for the sand wave heights (localised heights up to 4m) ▪ Impact on fatigue life over the period before self-burial achieved and/or sections which remain unburied. ▪ New unproven technology, would require research and trials with no guarantee of success in the timescales required for the project (i.e. <9 months).

***Notes:** A global re-route has been discounted in a separate technical note (in prep). It is noted that local re-routing as part of the detailed design process for other options should be considered. Any local re-route of the final pipeline route would be minimal and would be done in response to a pre lay survey shortly before installation. As such, it would not change the seabed preparation method and should be considered to be more of an operational optimisation.

2. COMPARATIVE ASSESSMENT METHODOLOGY

2.1 Context

The aim of the CA workshop was to be able to demonstrate that the techniques used to prepare the seabed, install and protect the pipeline are the Best Practicable Environmental Option (BPEO).

The specific outputs of the workshop are as follows:

- BPEO
- Spread of scores for comparative purposes (i.e. to show whether an option is clearly preferred, or is one within a group having very similar scores)
- Sensitivities around the outcome (i.e. to show what would need to change in order to select different options)

These outcomes will be used as input to:

- Stakeholder consultation with OPRED, Joint Nature Conservation Committee (JNCC) and National Federation of Fishermen's Organisations (NFFO)
- The Environmental Statement's (ES) - Project Justification and Alternatives Chapter

  Guidance from the Department for Business, Energy and Industrial Strategy (BEIS) on the content of an ES: "*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*."
- Further engineering and design

  Which will inform ES Project Description - for EIA purposes the best case and worst-case estimates are needed.

The EIA will then assess the potential impacts of the selected option in full (on a worse case basis), in order to get the pipeline installation permit.

2.2 Workshop Process

The CA workshop was broken down into three stages:

1. Verification of Technical Options Report outputs:
   - Conclusions concerning screening out of options (Options 1, 2, 4 and 7)
   - Suitability of scoring process
2. For technically feasible options (Options 3, 5 & 6), review of criteria scores, to establish/confirm:
   - Whether a range of ranking is applicable to reflect differences between 'Best estimate' and 'Worst Case' rankings
   - Extent of uncertainty concerning individual scores
   - Meeting agreement of the scores
3. Comparative Assessment of feasible options, to examine overall score sensitivity to:
   - Potential adjustments to scores identified above

- Changes to the weight given to each rank (see Appendix B, Table B-3)
- Change to the relative weights given to environmental criteria

2.3 Verification of the Technical Options Report

Participants, who had the opportunity to review the report in advance, confirmed the report conclusions (described in Section 1.3), with minor changes to summary table and verified the choice of environmental criteria and ranking scheme. The CA workshop noted that the Option of a global re-route (where the tie-in point can be moved) was outside of the Options report and will be addressed separately.

During the CA workshop the rationale for screening out Options 1, 2, 4 and 7 was confirmed and it was agreed that Option 3, 5 and 6 were taken forward for further consideration in the workshop.

3. WORKSHOP FINDINGS

3.1 Option Scoring

The Subsea 7 Technical Options Report (Ref 1) provided the starting point for option scoring. It was confirmed that the scoring undertaken to date was based around worst case assumptions. The session focused on testing underlying assumptions and establishing agreement for the scores. Discussions tested:

- That scoring between options was on merit and not relative to other options / sub-options
- That scoring did not double count potential impacts between criteria
- Whether options allowed for a best case and worst-case assessment score
- The justification behind the score to establish consensus

Where there was any doubt e.g. as to potential effects, a precautionary approach was taken and effect assumed (as an upper value if a range was judged appropriate).

Figure 2-1 provides the results of the review. Participants had opportunity in advance of the workshop to review scores and were invited to identify scores for further discussion. Cells highlighted in green were discussed and consensus reached that the scores should not be changed. Scores highlighted in blue were changed during the workshop after discussion.

Figure 3-1 Comparative Assessment Scores

No.	Description	Criteria		3: Rock	5: Removal to MSL			6: Dredge to MSL, Trench to below MSL								
		Even			5A: Controlled Flow Excavation (CFE)	5B: Trailing Suction Hopper Dredging	5C: Seabed Excavators	6A: Controlled Flow Excavation + CFE	6B: Controlled Flow Excavation +	6C: Controlled Flow Excavation +	6D: Trailing Suction Hopper Dredging	6E: Trailing Suction Hopper Dredging	6F: Trailing Suction Hopper Dredging	6G: Seabed Excavators + CFE	6H: Seabed Excavators + Jetting	6I: Seabed Excavato + Plough
1	Direct disturbance	12.5%	L	3	3.0	3.0	3.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
			H	3	3.0	3.0	3.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
2	Recovery of conservation objectives	12.5%	L	5	4.0	4.0	4.0	3.0	2.0	2.0	3.0	3.0	2.0	3.0	3.0	2.0
			H	5	4.0	4.0	4.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
3	Sediment plume	12.5%	L	2	3.0	2.0	2.0	4.0	3.0	3.0	3.0	2.0	2.0	3.0	2.0	2.0
			H	2	3.0	2.0	2.0	4.0	3.0	3.0	3.0	2.0	2.0	3.0	2.0	2.0
4	Sediment composition	12.5%	L	1	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
			H	1	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
5	New substrates	12.5%	L	5	3.0	3.0	3.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
			H	5	3.0	3.0	3.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
6	Seabed morphodynamics	12.5%	L	5	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
			H	5	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
7	Commercial fisheries	12.5%	L	5	4.0	4.0	4.0	3.0	2.0	2.0	3.0	2.0	2.0	3.0	2.0	2.0
			H	5	4.0	4.0	4.0	3.0	2.0	2.0	3.0	2.0	2.0	3.0	2.0	2.0
8	Operational intervention (scour/spans)	12.5%	L	5	4.0	4.0	4.0	3.0	2.0	2.0	3.0	2.0	2.0	3.0	2.0	2.0
			H	5	4.0	4.0	4.0	3.0	2.0	2.0	3.0	2.0	2.0	3.0	2.0	2.0

3.2 BPEO – Comparative Analysis

To establish the BPEO, the scores were tested for sensitivity. This was undertaken in two ways; by adjusting the weighting applied to score ranking; and by adjusting weighting assigned to individual criteria.

Prior to any testing the rock-infill option (option 3) is considered not environmentally acceptable, it scores in the highest impact ranking against 5 of the criteria: recovery of conservation objectives, introduction of new substrates, impact on seabed morphodynamics, impact on commercial fisheries and likelihood of further operational intervention. The options were therefore dropped from the comparative assessment (although still represented in the figures below).

Criteria were scored on a 1 to 5 scale, 5 being the highest impact. Noting that a score of 5 has a considerably higher impact than 5 times that of a score of 1. This method is referred to as linear scoring. Alternative scoring methods were tested to determine if they changed the overall ranking of the options being assessed. These included Square, Cubic, Exponent (2^{R-1}), Exponent (e^{R-1}), and Exponent (10^{R-1}) (Appendix B-3). Figure 3-2 provides the results of the assessment. Colour shading indicates relative ranking of options and sub-options, demonstrating that the scoring methodologies have little effect on the ranking of options.

Figure 3-2 Comparison of scoring methodologies

Description	Criteri A		3: Rock	5: Removal to MSL			6: Dredge to MSL, Trench to below MSL								
	Even			5A: Controlled Flow Excavation (CFE)	5B: Trailing Suction Hopper Dredging	5C: Seabed Excavators	6A: Controlled Flow Excavation + CFE	6B: Controlled Flow Excavation +	6C: Controlled Flow Excavation +	6D: Trailing Suction Hopper Dredging	6E: Trailing Suction Hopper Dredging	6F: Trailing Suction Hopper Dredging	6G: Seabed Excavators + CFE	6H: Seabed Excavators + Jetting	6I: Seabed Excavator + Plough
Linear		L	3.9	3.3	3.1	3.1	3.0	2.5	2.5	2.9	2.5	2.4	2.9	2.5	2.4
		H	3.9	3.3	3.1	3.1	3.0	2.6	2.6	2.9	2.5	2.5	2.9	2.5	2.5
Square		L	17.4	11.0	10.4	10.4	9.5	6.8	6.8	8.6	6.8	6.1	8.6	6.8	6.1
		H	17.4	11.0	10.4	10.4	9.5	7.4	7.4	8.6	6.8	6.8	8.6	6.8	6.8
Cubic		L	82.6	38.5	36.1	36.1	31.5	19.8	19.8	26.9	19.8	17.4	26.9	19.8	17.4
		H	82.6	38.5	36.1	36.1	31.5	22.1	22.1	26.9	19.8	19.8	26.9	19.8	19.8
Exp (2)		L	10.9	5.3	5.0	5.0	4.5	3.3	3.3	4.0	3.3	3.0	4.0	3.3	3.0
		H	10.9	5.3	5.0	5.0	4.5	3.5	3.5	4.0	3.3	3.3	4.0	3.3	3.3
Exp (e)		L	35.5	11.6	11.0	11.0	9.4	6.1	6.1	7.8	6.1	5.5	7.8	6.1	5.5
		H	35.5	11.6	11.0	11.0	9.4	6.6	6.6	7.8	6.1	6.1	7.8	6.1	6.1
Exp (10)		L	6263.9	426.3	415.0	415.0	302.5	156.3	156.3	190.0	156.3	145.0	190.0	156.3	145.0
		H	6263.9	426.3	415.0	415.0	302.5	167.5	167.5	190.0	156.3	156.3	190.0	156.3	156.3

To test whether weighting affected the ranking the Exponent (e^{R-1}), scoring method was used. Seven tests were agreed:

1. Make Criteria 8 (operational intervention) twice as important as other criteria
2. Make Criteria 5 (new substrate) twice as important as other criteria
3. Make both Criteria 5 and 8 twice as important as other criteria
4. Make Criteria 7 (commercial fisheries) twice as important as other criteria
5. Make Criteria 7 four times as important as other criteria
6. Make Criteria 1 (direct disturbance) twice as important as other criteria
7. Make Criteria 1 four times as important as other criteria

Overall scores, assuming even weighting to each criteria are provided in Figure 3-3. On a best estimate basis, options 6F and 6I (dredging to mean sea level (MSL) by either suction trailing hopper or seabed excavator followed by ploughing to below MSL) represent BPEO. However, ploughing and jetting are considered to have a similar worst-case performance (options 6E, 6F, 6H and 6I).

Figure 3-3 BPEO analysis

	Best Estimate		Worst Case	
Pipeline installation option	Score	Rank	Score	Rank
5A: Controlled Flow Excavation (CFE)	11.6	12	11.6	12
5B: Trailing Suction Hopper Dredging	11.0	10	11.0	10
5C: Seabed Excavators	11.0	10	11.0	10
6A: Controlled Flow Excavation + CFE	9.4	9	9.4	9
6B: Controlled Flow Excavation + Jetting	6.1	3	6.6	5
6C: Controlled Flow Excavation + Plough	6.1	3	6.6	5
6D: Trailing Suction Hopper Dredging + CFE	7.8	7	7.8	7
6E: Trailing Suction Hopper Dredging + Jetting	6.1	3	6.1	1
6F: Trailing Suction Hopper Dredging + Plough	5.5	1	6.1	1
6G: Seabed Excavators + CFE	7.8	7	7.8	7
6H: Seabed Excavators + Jetting	6.1	3	6.1	1
6I: Seabed Excavator + Plough	5.5	1	6.1	1

Figure 3-4 demonstrates that the effect of changing the weighting (Tests 1-6) was found not to significantly influence the BPEO conclusions. To investigate the circumstances under which dredging to MSL (Option 5) might be considered BPEO the direct disturbance weighting (criteria 1) was increased by a factor of 4 (Test 7). This levelled up the scores between Options 5 and 6. However, an increase of this magnitude to the weighting of Option 1 is not considered justifiable and it can therefore be concluded that Dredging to MSL cannot be considered BPEO.

Overall, and with the exception of use of CFE, all sub options for dredging to MSL followed by trenching to below MSL yielded similar scores such that, within the accuracy of the assessment, any could be considered to represent BPEO. Recognizing that detailed engineering is yet to be done and that it is possible that choice of seabed preparation technique may be limited by market availability of equipment, it is recommended that CFE is not yet dropped from further consideration.

Figure 3-4 Weighting sensitivity

A				5: Removal to MSL			6: Dredge to MSL, Trench to below MSL								
Even			3: Rock	5A: Controlled Flow Excavation (CFE)	5B: Trailing Suction Hopper Dredging	5C: Seabed Excavators	6A: Controlled Flow Excavation + CFE	6B: Controlled Flow Excavation + Jetting	6C: Controlled Flow Excavation + Plough	6D: Trailing Suction Hopper Dredging + CFE	6E: Trailing Suction Hopper Dredging + Jetting	6F: Trailing Suction Hopper Dredging + Plough	6G: Seabed Excavators + CFE	6H: Seabed Excavators + Jetting	6I: Seabed Excavator + Plough
Exp (e)															
	L	Score	35.5	11.6	11.0	11.0	9.4	6.1	6.1	7.8	6.1	5.5	7.8	6.1	5.5
		Rank		12	10	10	9	3	3	7	3	1	7	3	1
	H	Score	35.5	11.6	11.0	11.0	9.4	6.6	6.6	7.8	6.1	6.1	7.8	6.1	6.1
		Rank		12	10	10	9	5	5	7	1	1	7	1	1
Criteria 8 - twice as important	L		37.6	12.5	12.0	12.0	9.2	5.7	5.7	7.8	5.7	5.2	7.8	5.7	5.2
				12	10	10	9	3	3	7	3	1	7	3	1
	H		37.6	12.5	12.0	12.0	9.2	6.2	6.2	7.8	5.7	5.7	7.8	5.7	5.7
				12	10	10	9	5	5	7	1	1	7	1	1
Criteria 5 - twice as important	L		37.6	11.1	10.6	10.6	8.7	5.7	5.7	7.2	5.7	5.2	7.2	5.7	5.2
				12	10	10	9	3	3	7	3	1	7	3	1
	H		37.6	11.1	10.6	10.6	8.7	6.2	6.2	7.2	5.7	5.7	7.2	5.7	5.7
				12	10	10	9	5	5	7	1	1	7	1	1
Criteria 5 & 8 both twice as important	L		39.3	12.0	11.5	11.5	8.5	5.4	5.4	7.3	5.4	4.9	7.3	5.4	4.9
				12	10	10	9	3	3	7	3	1	7	3	1
	H		39.3	12.0	11.5	11.5	8.5	5.9	5.9	7.3	5.4	5.4	7.3	5.4	5.4
				12	10	10	9	5	5	7	1	1	7	1	1
Criteria 7 - twice as important	L		37.6	12.5	12.0	12.0	9.2	5.7	5.7	7.8	5.7	5.2	7.8	5.7	5.2
				12	10	10	9	3	3	7	3	1	7	3	1
	H		37.6	12.5	12.0	12.0	9.2	6.2	6.2	7.8	5.7	5.7	7.8	5.7	5.7
				12	10	10	9	5	5	7	1	1	7	1	1
Criteria 7 - four times as important	L		40.7	13.9	13.5	13.5	8.8	5.1	5.1	7.7	5.1	4.7	7.7	5.1	4.7
				12	10	10	9	3	3	7	3	1	7	3	1
	H		40.7	13.9	13.5	13.5	8.8	5.6	5.6	7.7	5.1	5.1	7.7	5.1	5.1
				12	10	10	9	5	5	7	1	1	7	1	1
Criteria 1 - twice as important	L		32.4	11.1	10.6	10.6	10.6	7.6	7.6	9.2	7.6	7.1	9.2	7.6	7.1
				12	9	9	11	3	3	7	3	1	7	3	1
	H		32.4	11.1	10.6	10.6	10.6	8.1	8.1	9.2	7.6	7.6	9.2	7.6	7.6
				12	9	9	11	5	5	7	1	1	7	1	1
Criteria 1 - four times as important	L		27.8	10.4	10.0	10.0	12.3	9.9	9.9	11.2	9.9	9.5	11.2	9.9	9.5
				9	7	7	12	5	5	10	3	1	10	3	1
	H		27.8	10.4	10.0	10.0	12.3	10.3	10.3	11.2	9.9	9.9	11.2	9.9	9.9
				9	5	5	12	7	7	10	1	1	10	1	1

4. CONCLUSION

The CA workshop, which was attended by experienced project development, pipeline engineering, geotechnical specialists together with environmental consultants and subject matter experts from IOG, Subsea 7, Intertek and Xodus drew the following conclusions.

1. The Technical Options Report (Ref 1) is considered to provide an appropriate selection of seabed preparation options for pipeline installation and the report's recommendations for those considered technically feasible for inclusion in the CA workshop were considered sound: Rock infill, Sandwave levelling to MSL, Sandwave levelling to MSL and trenching to below MSL. Environmental assessment criteria established within the Options Report are also considered appropriate.
2. With a small number of minor adjustments, the eight environmental impact criteria provided with the Option Report were confirmed. For a small number of Option/Criteria combinations a distinction can be made between a best estimate and worst case scores (respectively identified as "L" and "H" scores). The Option Report is to be re-issued with these adjustments included (and identified).
3. Rock-infill option is considered not environmentally acceptable, scoring in the highest impact ranking against 5 of the criteria: recovery of conservation objectives, introduction of new substrates, impact on seabed morphodynamics, impact on commercial fisheries and likelihood of further operational intervention. The option was therefore dropped from the comparative assessment.
4. Overall scores, assuming even weighting to each criteria are provided in Table 2-2 above. On a best estimate basis, options 6F and 6I (dredging to MSL by either suction trailing hopper or seabed excavator followed by ploughing to below MSL) represent BPEO. However, ploughing and jetting are considered to have a similar worst-case performance (options 6E, 6F, 6H and 6I). A variety of weightings were applied to the rankings and none we found to affect the overall result.
5. The effect of changing the weighting given to individual criteria was also considered, and found not to significantly influence overall BPEO conclusions. Changes considered included:
    a. individually doubling the weightings given to: direct disturbance, new substrates, commercial fisheries and Operational interventions
    b. doubling the weightings to both new substrates and Operational intervention
6. To investigate the circumstances under which dredging to MSL (Option 5) might be considered BPEO the direct disturbance weighting was increased by a factor of 4. This levelled up the scores between Options 5 and 6. An increase of this magnitude to the weighting of Option 1 is not considered justifiable and it can therefore be concluded that Dredging to MSL cannot be considered BPEO.
7. Overall, and with the exception of use of CFE, all sub options for dredging to MSL followed by trenching to below MSL (Option 6) yielded similar scores such that, within the accuracy of the assessment, any could be considered to represent BPEO. Recognising that detailed engineering is yet to be done and that it is possible that choice of seabed preparation technique may be limited by market availability of equipment, it is recommended that CFE is not yet dropped from further consideration.

Subject to confirmation that a global re-route is not feasible, the **BPEO is Option 6: Dredged to mean sea level and then trench to below mean sea level.**

REFERENCES

1 Seabed Preparation Options for Installation of 24" Southwark Pipeline ET1077-ENG-00240, Subsea 7, Date 25 January 2021

2 Comparative Assessment Workshop – January 2021 Terms of Reference, P2371_R5216_Rev1_FINAL CA ToR, Intertek, Date 28 January 2021

APPENDIX A

Comparative Assessment Workshop

A.1 ATTENDEES

Table A-1 List of attendees

Organisation	Name	Role
IOG	Mark Yates	Head of HSE
IOG	Ron Doherty	Pipeline and Subsea Manager
IOG	Ian Pollard	HSE Consultant
IOG	Phil McIntyre	Pre-Development Assets Manager
IOG	Katrina Ross	Environmental Advisor
Intertek Associate (5x5)	Alistair Bird	CA Chairman
Intertek	Anna Farley	Southwark Pipeline EIA Lead
Intertek	Nathalie De Groot	CA Scribe
Subsea 7	Andy Robb	Assistant Project Manager
Subsea 7	Gavin Leishman	Project Engineering Manager
Subsea 7	Ken Hope	Project Director
Subsea 7	Craig Peters	Senior Pipeline Engineer
Subsea 7	Lee Morrice	Senior Geotechnical Engineer
Xodus	Marten Meynell	Project Manager (EIA Delivery Lead and Principal Environmental Consultant)
Xodus	Nichola Lacey	Benthic Ecology Subject Matter Expert
Xodus	Anna Chaffey	Marine Physical Processes Subject Matter Expert
Xodus	Jon Ashburner	Linear Infrastructure and Routing Environmental Specialist

A.2 AGENDA

Table A-2 CA Workshop agenda

Item		Comments
1	Introduction	
13:00 to 13:20	▪ Opening remarks (IOG) ▪ EIA context/Post workshop program (Intertek) ▪ Objectives /Workshop process (5by5)	
2	Option Report Review (SS7/Xodus)	
13:20 to 13:50	Brief description of report outputs (Subsea7/Xodus): ▪ Options considered ▪ Options screened out & justification ▪ Recap on ranking and environmental criteria	Participants will have had opportunity to review the report in advance of the workshop
3	Option Scoring Review (Xodus/All)	
13:50 to 14:50	▪ Feasible options scores review	Xodus introduce scores for each option. Meeting will seek to agree consensus on the scores and identify anywhere ranges need to be considered (e.g. Best Estimate vs Worst case). Differences of opinion to be recorded.
Short break		
4	BPEO - Comparative analysis (5by5/All)	
15:00 to 16:30	▪ Sensitivity to ranking ranges / uncertainties ▪ Sensitivity to scoring scale ▪ Sensitivity to weighting	Series of sensitivity evaluations to determine resilience of BPEO conclusions. Identify what would need to change to arrive at a different BPEO. Capture issues to address during consultation
5	Conclusions / wrap up (5by5/All)	
16:30 to 17:00	▪ Agree conclusions ▪ Actions / recommendation	▪ BPEO conclusions ▪ Uncertainties ▪ Priorities for consultation ▪ Timelines for actions

A.3 MINUTES

Time	1300-1700
Date	29th January 2021
Location	n/a Microsoft Teams

Summary

The purpose of the Comparative Assessment workshop is to be able to demonstrate that the techniques used to prepare the seabed, install and protect the 24" Southwark pipeline (hereafter referred to as 'the pipeline') are the Best Practicable Environmental Option. The EIA will then assess the potential impacts of the selected techniques (on a worse case basis).

ID	Points made:
	<u>Introductions</u>
1	Anna Farley (AF) opened the workshop, presented the agenda and stated the workshop 'rules' regarding interaction (especially as the meeting was held via video conference) and what would happen in case of disagreement.
2	Mark Yates (MY) thanked all who have contributed to the project so far and the preparation of the CA workshop. MY acknowledged the significance of the CA workshop in terms of unlocking Phase 1 by enabling the EIA submission to get the pipeline installation permit for the Southwark 24" that will connect the Southwark Development to the existing 24" Thames pipeline.
	<u>Session 1: Introduction</u>
3	AF explained the context of the workshop and what will happen to the results. She explained that the outputs of the workshop will be a report outlining: the Best Practicable Environmental Option (BPEO), spread of scores for comparative purposes and sensitivities around the outcome.
4	The outputs of the workshop will be used as input to: stakeholder consultation with statutory stakeholders OPRDED, JNCC and NFFO; the project justification and alternatives chapter of the ES and the BPEO will be taken forward for further engineering and design.
5	AF presented the timeline of the post workshop programme. It was announced that the stakeholder engagement with OPRED and JNCC shall take place on the 11th of February and that consultation with NFFO will be confirmed. Data gathering for the ES with Subsea7 will take place in the weeks following this workshop. The aim is to submit the ES to the regulator in middle of May.
6	Alistair Bird (AB) presented the workshop objectives and process. AB stated that the Subsea 7 options review report provided the starting point for the workshop and described the workshop process to confirm the outcomes of the option report, review scores for each options / criteria combination and compare the overall scores for each option.
7	Ken Hope (KH) noted that not option 5 but option 7 (as presented on the slides) was screened out. This was agreed.
8	AB summarised the overall objective of the CA workshop as: to find a resilient BPEO, check how far the scoring, ranking and weightings need to change to get a different one and how realistic such changes are.

	Session 2: Option Report Review
9	The options report review was presented by Andy Robb (AR) from Subsea7 and Marten Meynell (MM) and Anna Chaffey (AC) from Xodus.
10	AR stated that the main installation challenge of the approximately 6.7 km long pipeline is the dynamic environment present along the entire route with significant sandwaves (>4m) and a highly mobile seabed.
11	Because of this dynamic environment, the pipeline would fail if we did not do anything (i.e. in terms of seabed preparation to protect the pipeline) and this is therefore not technically feasible.
12	AC provided an overview of the environment and explained that the sandwaves follow a NW trend and may move up to 14m a year.
13	AR explained that the options review identified 7 options for the installation of the pipeline and these were discussed in terms of technical feasibility:
14	**Option 1** – Do nothing, does not meet objectives.
15	**Option 2** – Re-route. It was clarified that this option only covered a local re-route. A global re-route was not investigated, as the global re-route will be covered in a separate assessment this was not included in today's scope. The local re-route option was screened out on the basis that the pipeline would still be located within the same dynamic environmental system and that it would not be possible to miss the sandwaves with this option.
16	**Option 3** - Rock infill. This option aims to fill the troughs between peaks of sandwaves to obtain a (partially) flat surface for the pipeline to be installed on. Because the pipeline would still be in the dynamic environment, the OPEX for this option is unknown as free spanning can occur over time. Therefore, the project would need to constantly monitor for that.
17	**Option 4 –** Would aim to achieve the same objectives as option 3 but using mattress instead of rock. Because this option would require the placement of approximately 22500 mattresses with a DSV (i.e. Diving Support Vessel) this would be both a concern from a safety point of view as well as prohibitively expensive. Additionally, there would still be the risk of free spanning with unknown OPEX. Therefore, this option is considered not viable.
18	**Option 5** – This option would aim to remove the sandwaves, by cutting down to mean sea level. The pipeline would still be in the dynamic environment with the risk of free spans and unknown OPEX, but this is a known technique.
19	**Option 6** – Comprises temporarily removing sandwaves along the route and burying pipeline below mean sea level. Because the pipeline will be buried (i.e. protected from the dynamic environment) this option carries the lowest possible risk for OPEX.
20	**Option 7** - Pipeline self burial. This option is considered high risk as there is no clear certainty that pipeline will be buried. R&D would be required and the option carries a high degree of uncertainty on cost and schedule.
21	AB queried the colours of the presented options table why was option 2 coloured red as it was screened out. It was agreed it should be red.
22	AF queried whether option 2 – re-route could be combined with another option an whether this could change the assessment (i.e. change it to green). AR clarified that option 2 re-route assumed no seabed manipulation. As it would not be possible to re-route and miss sand waves.
23	Jon Ashburner (JA) pointed out the difference between a local re-route and route refinement (i.e. route optimisation). Any option will have a level of route refinement, which will take

	place at the further stages of engineering and design. There is potential to optimise route for all options and find a slightly better route with less environmental disturbance, but it will not be possible to completely avoid the sand waves. Hence, it was agreed to keep option 2 red.
24	AF queried why for option 7, the CAPEX box was coloured red. AR answered that this was because of the high risk to schedule and cost and that this was seen as a showstopper . It was agreed to keep this box in red.
25	AR summarised that the Options – 3, 5 and 6 were carried forward, with Option 6 being the preferred option from a technical feasibility point of view. All participants agreed.
26	AC explained how the environmental appraisal of the different options was carried out and that all options were considered individually (rather than comparatively).
27	AC stated that the primary environmental impact on all options was considered to be the loss or damage to the qualifying interest feature: annex 1 sandbanks slightly covered by seawater at all times (sandwaves).
	<u>Session 3: Option Scoring Review</u>
28	AB shared his Excel table with the screened in options and scoring from the options review report as a starting point and it was agreed with the participants to progress only options screened in (options 3, 5 and 6).
29	AB mentioned that the spreadsheet was designed to be able to cope with integers (i.e. half scores), in case this would be required.
30	KH queried why the ranking was set at scenario B, rather than A (even ranking) to start with. AB agreed and switched to A.
31	MM explained that 8 different environmental criteria were looked at for all options by Xodus and that the scoring was based around worst case assumptions.
32	AB queried whether there would be a need to include a best case for some option/criteria combinations. AB explained that in a situation when best case and worst case would be equally likely, the assessment would be based around the worst case. But when best case is more likely, and worst case is still not unacceptable then there would be added value to capture the both cases.
33	AF provided an example where this could be the case, namely when comparing option 5 and 6 within criteria 1. Hereby, Option 5 scores a 3 (meaning moderate change to habitat species) whereas Option 6 scores 4 (meaning major or regional change). How can Option 5, which also includes a significant amount of seabed levelling have less of an impact than option 6, which is considered to cause major impact/significant change?
34	AC explained the scoring is not relative and the reasoning for option 6 scoring higher was that trenching would be along entire route, and therefore would have a greater potential for affecting reefs away from the sandwaves.
35	AF queried whether there is double counting between Criteria 1 and 2.
36	AC clarified that criteria 1 looks at the physical disturbance (spatial impact), whilst criteria 2 concerns the recovery potential – (temporal aspect)
37	AF queried whether the difference between Option 5 to Option 6 is truly going from local to regional? It is a big jump from ranking 3 to 4. Justification provided for the scoring and agreement reached.
38	With respect to Criteria 1 (direct) and criteria 3 sediment plume (indirect) AC explained the scoring is/has to be conservative because we don't know if there are Sabellaria present. But they are more likely between sandwaves.

39	AB revisited the discussion on the value of having a best estimate along the worst case.
40	In the precautionary, conservative case all participants were comfortable with all sub options within option 6 scoring 4 against criteria 1.
41	AB queried whether there is justification for a possible best case? All participants concluded it would be best in this case to keep low and high scores the same.
42	AB queried whether it is possible to apply micro-routing to avoid patches of Sabellaria, would it be picked up by the geophysical survey?
43	NL explained that Sabellaria can exist solitary and finding solitary Sabellaria in the survey would not mean there would be a significant impact on this species. Sabellaria can also form aggregations on the seabed, which stabilises seabed. By forming a calcified crust on the seabed, this allows more complex ecosystems to establish. These aggregations would be picked up by side scan/sonar surveys.
44	The participants concluded that the scoring probably can't go to a lower realistic case (micro-routing would be limited as the 24"concrete covered pipeline would not be as flexible compared to for example cables)
45	AR queried whether the survey that picks up on Sabellaria needs to be completed at a certain time?
46	NL explained that Sabellaria are presented during the whole year, so the survey can be done at any time of year.
47	AB queried how important a drop down video survey would be to capture Sabellaria.
48	JA explained that if no camera survey was done, you have to take a conservative view point on the potential impact on Sabellaria. i.e. if geophysical survey identified potential anomalies, this should be interpreted as Sabellaria. Otherwise you can disconfirm no Sabellaria with camera if you find something that might be Sabellaria on scan/sonar.
49	AF stated that Sabellaria are ephemeral (i.e. can be very extensive at one time and then later not present at all). Therefore, it is important to carry out the survey as close to installation as possible.
50	Discussion also noted that pipeline was not as flexible as cables and micro-routeing as such is not feasible. Routeing would only be able to decide which side of corridor to lay within rather than avoiding specific patches of habitat.
	Option 6B and 6C – criteria 2 recovery of conservation objectives
51	AF queried why Option 6B and 6C scored 2 (meaning no effect) against criteria 2. How can the dredged area have no effect on sandwaves? Would have thought there would be a short term, reversible effect.
52	JA explained the reasoning was based on that in option 6 the pipeline will be buried. In option 5 and 3 pipeline will remain on surface over lifetime of pipeline.
53	AB stated that if there was a short term, reversible effect the score should be 3.
54	AF queried what evidence supports no effect.
55	JA explained the scoring intended to capture burial will greatly increase habitat recovery.
56	AF queried why there is a difference between sub options within option 6 scoring 2 and 3 against criteria 2? Is this because jetting back-fills quicker, so greater recovery of conservation objectives.
57	AF stated that in this case the scoring would be a relative comparison, rather than actual comparison.

58	AB proposed an optimistic case with no material effect, scoring 2 and a worst case of 2.5 to capture that.
59	JA cautioned against not ruling out tools at this moment in time, AB clarified that, if anything, this change levels up between tools.
60	AB asked AF whether 2.5 would be more defendable than 2. AF stated she preferred 2.5 to 2, as this score would be recognising there is an effect.
61	AB stated that this scoring change shouldn't change the BPEO, but that it would make it easier to be able to defend our position in consultation with stakeholders. AB asked whether Xodus would be happy to amend the score.
62	AC responded and pointed out that a scoring of 2.5 for one of the sub-options would make the scoring relative, so it would be better to put the worst case at 3.
63	AF agreed this would lead to an easier dialogue with JNCC: to cover range.
	Option 6A Controlled flow excavation + CFE - criteria 3 Sediment plume
64	AF queried the reasoning behind option 6A – scoring 4 for criteria 3 and why this was considered a whole level higher than the other options.
65	JA clarified that this scoring for 6A on criteria 3 captures the fact that of all technologies, CFE creates most plumes.
66	AF asked whether criteria 3 considered the plume as well as indirect effects of the plume? It was confirmed this was correct.
67	Nichola Lacey (NL) stated criteria 3 covered extent of the plume and impact of plume and that recovery time was split out and covered under criteria 2.
68	AB queried how the impacts on criteria 3 compare to natural background levels? Like storm event. AC explained that the potential impacts can be well above background levels, but there is uncertainty.
69	AF confirmed to be comfortable with the scores and with option 6A scoring 4 against criteria 3.
	Option 3 Rock infill – criteria 5 New substrates
70	AF queried why option 3 scored 5 against criteria 5.
71	AB queried whether criteria 2 was needed. JA clarified – criteria 2 just concerns temporal / recoverability, whereas physical impact on conservation objectives are captured under the other criteria.
72	AF confirmed to be comfortable with the scoring.
	Option 6 Dredge to MSL, Trench below MSL– criteria 5 New substrates
73	AB queried why option 6 scored 2 and not 1 against criteria 5 due to the short term localised exposure.
74	Craig Peters (CP) explained that with any option, there will be some exposure at the ends of the pipeline, which cannot be entirely buried. This is common to all the options.
75	The participants agreed that's why option 6 can't score a 1 against criteria 5.
	Option 6 Dredge to MSL, Trench below MSL– criteria 7 Commercial fisheries
76	Lee Morrice (LM) queried why jetting scored worse than ploughing. Is it because jetting provides some form of cover? What is the likelihood of areas that remain exposed?
77	AB queried further whether there is a real difference between plough and jetting?

78	The participants agreed to amend the score so that jetting and ploughing score the same, because no real difference plough and jetting.
	Option 5 vs Option 6 - criteria 5 New substrate
79	AB asked about the rationale for the difference between option 5 versus option 6 against criteria 5.
80	AC explained that the scoring has not considered the total volume of rock, but rather the low medium high risk needing remedial work. For a well buried pipeline (Option 6), the probability of the pipeline area becoming exposed during lifetime of pipeline lower than for (Option 5). However, in either case not as much rock likely required as option (3) .
	<u>10 minute break</u>
	<u>Session 4: BPOE – Comparative Analysis</u>
81	AB showed the effect of different ranking (e.g. linear, exponential, logarithmic etc.) on the outcomes. The scoring had surprisingly little impact and the BPEO proved to be resilient against different ranking methods.
	Next the weighting of the different criteria was tested. The following scenarios were explored:
	Criteria 8 Operational intervention – twice as important
82	AF proposed changing criteria 8 in relative importance, given the fact that both OPRED and JNCC have stressed that the chosen solution should be sustainable one.
83	AB summarised that even if the significance of criteria 8 was doubled, it doesn't make much difference.
	Criteria 5 New substrates – twice as important
84	AF proposed to test the sensitivity of doubling criteria 5, knowing JNCC's position on man-made structures on the seabed.
	Doubling made no difference.
	Both criteria 5 New substrates and criteria 8 Operational intervention – twice as important
85	AC proposed, if our primary drivers are related to statutory consultants' concerns, to try increase relative importance of changing both 5 and 8.
	This had no effects on the ranking.
	Criteria 7 Commercial fisheries – more important
86	AB proposed to test an extreme position on the fishing (i.e. make it significantly more important).
	This had no effect.
	What weighting does change the BPEO?
87	JA noted that changing weighting would only have an effect if scores were juxtaposed between options.
88	It was concluded that to break the decision between option 5 and 6 (i.e. make option 5 better than option 6), making criteria 1 – 4 times as important as the other criteria was required. Even then, option 6 would still come out still as the best option with exception of sub options using CFE.
89	Hence, the decision between 5 and 6 is very resilient, and the argument for the best option between sub options as well. CFE gives weaker performance because of the direct impacts (criteria 1).

90	JA stated the importance of not completely ruling out CFE at this stage, to be able to consent as large tool kit as possible as long as it doesn't significantly increase consenting risk.
91	AR aligned with that view to keep flexibility where possible.
	Session 5: Conclusion and Wrap-up
92	AB summarised that the CA workshop concluded that: • There is a clear demarcation between Option 5 and 6. With option 6 being clearly the BPEO and therefore Option 5 will probably ruled-out in the EIA. • Within Option 6, all sub-options are worth keeping at this stage, although the sub-options with CFE are resulting in the largest environmental impact (especially on criteria 1). Sub options will be revisited at stage of detailed engineering. • The BPEO is very resilient and insensitive to different weightings various stakeholders might apply to this. • Changing the weighting of the criteria makes remarkably little difference to the outcome. The only manipulation that makes a difference is increasing the weighting of criteria 1 to more than 4 times, which was considered extreme.
93	MY thanked the workshop attendees for their input and confirmed to be happy with the result that was achieved today, especially given the challenges of running this workshop remotely.

Actions

Action ID	Action	Responsible party	Deadline / Actioned
INTK_1	Progress the study for global re-routing.	Intertek and IOG	TBC
SUB_1	Subsea 7 to reissue report to modify table Report update: tweaks, finalise report to accommodate changes to the table. Delete percentages of capex cost, so that not traceable to contract value. Not needed as input.	Andy Robb	ACTIONED 03/02/2021
SUB_2	Subsea 7 forward copy of final slides	Andy Robb	ACTIONED 08/02/2021
AB_1	Send screen grab of revised scores to workshop attendees	Alistair Bird	ACTIONED 01/02/2021
XOD_1	Xodus to go back to the report and make the slight tweaks to the scores to align the report with the outcome of the CA workshop. Provide asterix to show which scores have been amended after CA. If report going to public domain, caveats that footprints are indicative (in case that they are different than ES)	Marten Meynell	05/02/2021
SUB_3	Subsea 7 to set up a kick-off meeting with IOG, Intertek and Xodus to kick off data gathering phase of the ES and discuss inputs required from Subsea 7.	Andy Robb	ACTIONED Meeting held on 03/02/2021 Further meeting planned for 12/02 to discuss outcome from 11/02 mtg with BEIS and JNCC
XOD_2	Xodus to produce a proposal for the sandwave predictive scope, exact requirements to be confirmed at the ES data gathering kick-off meeting.	Anna Chaffey	ACTIONED 05/02/2021
INTK_2	Intertek to produce a draft comparative assessment report and send out for review to workshop attendees. This report will feed in to slide packs for stakeholder consultations.	Nathalie de Groot, Anna Farley and Alistair Bird	ACTIONED 05/02/2021

APPENDIX B

Scoring

B.1 ENVIRONMENTAL SCORING

Each option will have a total environmental score evaluated based on the weighted summation of scores against each of eight agreed environmental criteria. Environmental criteria and associated ranking tables are given in Tables B-1 and B-2 (taken from Ref 1). The assigned ranks will be converted to criteria scores according to alternative scales given in Table B-3.

Each criteria will have an assigned weighting, the sum of the weightings adding up to 1. In the 1st instance all criteria will have equal weight.

Table B-1 Environmental Criteria

Criteria	Description
1	**Area and volume of direct disturbance (sediments and benthic communities):** This evaluates the relative footprint, area and volume of disturbance or loss of existing habitat, including the potential for direct impact on designated qualifying features and supporting benthic habitats and communities that may occur within the area. This includes consideration of the areas buried or sediment removed as part of bed levelling that would result in change to the designated qualifying features. The extent and composition of new substrate provision is accounted for in Criteria 5.
2	**Temporal recovery of conservation objectives/ attributes (sediments and benthic communities):** This evaluates the potential for recovery of existing habitat, including designated qualifying features and supporting benthic habitats and communities that may occur within the area, following direct disturbance as described above. Recovery potential may be over short term or long-term timescales or assessed as a permanent loss of habitat.
3	**Development, extent and persistence of a sediment plume:** This evaluates the potential for a sediment plume to be developed as part of the seabed preparation and installation works for the various options. It accounts for the relative extent, duration and concentration of any plume, with the potential for indirect impacts on designated qualifying features, including Annex I *S. spinulosa* reef, and supporting benthic habitats and communities, and sediment deposition over the plume extent.
4	**Changes to sediment composition:** It is noted within the NNSSR SAC site assessment and Conservation Objectives (JNCC, 2010; 2017) that different sediment grain sizes are characteristic to different locations within the SAC. This criteria therefore evaluates the potential for localised sediment composition changes in proximity to the installation works or for sediment to be redistributed elsewhere within the NNSSR SAC, with potential impacts on the sediment composition (size, texture and sorting). This does not include the introduction of any rock substrate, for which impacts are considered in Criteria 5.
5	**Introduction of new substrate:** This evaluates the potential for new material to be introduced into the NNSSR SAC during installation works. It includes consideration of the permanence, volume and scale of the introduced substrate.
6	**Changes to the seabed morphodynamic regime:** The sandwaves are an integral part of the function of the sandbanks within the NNSSR SAC, with connectivity to the hydrodynamic and sediment transport processes. This criteria evaluates the potential for changes to the form of sandwaves and the hydrodynamic and sediment transport regime due to the installation works and during the operation of the pipeline. It includes consideration of changes caused both directly and indirectly, with the potential impacts on the recoverability of the sandwaves in line

Criteria	Description
	with the morphodynamic processes occurring across the North Norfolk sandbank system.
7	**Impacts on commercial fisheries:** This considers potential impacts to commercial fisheries including exclusions from the project area and introduction of snagging risks, accounting for the low fishing intensity in the area.
8	**Potential for and magnitude of scour development and free span, necessitating the need for remedial works:** This evaluates the potential for the development of scour and free span, including the possible scale of any scour necessitating the need for remedial works and active intervention during the operation of the pipeline. Any remedial works are most likely to include the use of rock. Therefore, this criteria also includes consideration of protection and stabilisation measures, along with the permanence of the measure.

Table B-2 Environmental Ranking

Ranking (Best to Worst)	Assessment
1	▪ Effects unlikely to be discernible or measurable. ▪ No contribution to cumulative effects. ▪ No noticeable stakeholder concern and only limited public interest. ▪ No increase in snagging risk.
2	▪ No effect on the conservation objectives and attributes of nationally/internationally protected sites, habitats or populations. ▪ Minor/local change in habitats or species which can be seen and measured but is at same scale as natural variability or localised change in a habitat or species beyond natural variability with recovery expected in the short-term (<2 years) following cessation of potential impact or activity. ▪ Negligible contribution to cumulative effects. ▪ Issues that might affect individual people or businesses or single interests at the local level. Some local public awareness and concern. ▪ Potential increase in snagging risk along localised areas of the pipeline, resulting from unplanned events (e.g. scour) over the operational lifetime of the asset.
3	▪ Short term but reversible effect on the conservation objectives and attributes of nationally/internationally protected sites, habitats or populations. ▪ Moderate/local change in a habitat or species beyond natural variability with recovery likely within the short (<2 years) to medium (2-10 years) following cessation of activities, or localised degradation with recovery over the long-term (>10 years) following cessation of potential impact/activity. ▪ Minor contribution to cumulative effects. ▪ Regional concerns at the community or broad interest group level. ▪ Likely increase in snagging risk along sections of the pipeline resulting from unplanned events (e.g. scour) over the operational lifetime of the asset.

Ranking (Best to Worst)	Assessment
4	▪ Long term but reversible effect on the conservation objectives and attributes of nationally/internationally protected sites, habitats or populations. ▪ Major/regional (widespread) potential impact on the quality or availability of habitat/wildlife and where recovery may take place over the long term (>10 years) and involve significant restoration effort. ▪ Moderate contribution to cumulative effects. ▪ Well established and widely held areas of concern, including perception of threat to the regional environment. ▪ Inherent increase in snagging risk along sections of the pipeline for the lifetime of the asset resulting from installation method.
5	▪ Permanent effect on the conservation objectives and attributes of nationally/internationally protected sites, habitats or populations at local to regional scales. ▪ Major/regional (widespread) potential impact on the quality or availability of a habitat and/or wildlife with no recovery expected or irreversible alteration (permanent). ▪ Major contribution to cumulative effects. ▪ Well established and widely held areas of concern, including perception of threat to the national environment. ▪ Inherent increase in snagging risk along the length of the pipeline for the lifetime of the asset resulting from installation method.

Criteria are ranked on a 1 to 5 scale, 5 being the highest impact. Noting that a score of 5 has a considerably higher impact than 5 times that of a rank of 1, weightings need to be applied to the score. Candidate weightings are tabled below.

Table B-3 Conversion of ranking to criteria score

Ranking	Linear	Square	Cubic	Exponent (2^{R-1})	Exponent (e^{R-1})	Exponent (10^{R-1})
1	1	1	1	1	1	1
2	2	4	8	2	2.7	10
3	3	9	27	4	7.4	1,000
4	4	16	64	8	20.1	10,000
5	5	25	125	16	54.6	100,000

Note that level 5 is deemed unacceptable and will result in rejection of an option. As a sense check, Table B-4 below identifies the lowest unacceptable scores with 8 criteria. With the exception of the last two cases, an option scoring the mid case (3) against all criteria would have a higher score than an option deemed unacceptable by having a score of 5 with all others scoring 1. Natural exponent will be used as a starting point since this option has the lowest unacceptable score (i.e. 1 at Rank 5 and 7 at Rank 1) with a similar result to all Ranked 3.

Table B-4 Lowest unacceptable scores

	Linear	Square	Cubic	Exponent (2^{R-1})	Exponent (e^{R-1})	Exponent (10^{R-1})
Min unacceptable	12	32	132	23	62	100,007

APPENDIX E

Seabed Preparation Options for Installation of 24” Southwark Pipeline (Subsea7 2021a)

Independent Oil and Gas PLC

Blythe and Vulcan Satellite Hubs Development

Seabed Preparation Options for Installation of 24" Southwark Pipeline

ET1077-ENG-00240

001-GEN-SS7-Y-RP-0228

Originator:	Andy Robb					
Checker:	Gavin Leishman					
Approver:	Ken Hope					
1	**Issued for Use**	**25.01.2021**				
Rev.	Reason for Issue	Issue Date	Prepared by	Checked by	Approved by	Client Approval

REVISION RECORD SHEET

Revision	Issue Date	Purpose	Description of Updated/Modified Sections (if any)
A	15.12.2020	Issued for IDC	N/A (First Issue)
B	18.12.2020	Issued for Client Review	Incorporated IDC Comments.
01	25.01.2020	Issued for Use	Incorporated Client Comments. Added mechanical plough options for product trenching below mean seabed level.

TABLE OF CONTENTS

1. EXECUTIVE SUMMARY

Seven options were identified for seabed preparation in preparation for installation of the 24" Southwark gas export pipeline. The technical, safety, cost and environmental implications of each option are presented for all seven options. Three options have been assessed as being technically viable and will be carried forward to a comparative assessment workshop. The aim of the workshop will be to identify the Best Practical Environmental Option. The options carried forward for comparative assessment are listed below:-

- Option 3 – Rock in-fill between sand waves;
- Option 5 – Sandwaves removed, Pipe laid on Seabed;
- Option 6 – Sandwaves removed, Pipe trenched below seabed;

The environmental appraisal methodology used within this document involved developing the criteria and ranking, which were both used to complete the appraisal based on the potential environmental impacts of the different options. The criteria were developed on the basis of the following:

- The conservation objectives and supplimentary advice for the qualifying interest features within the North Norfolk Sandbanks and Saturn Reef (NNSSR) Special Area of Conservation (SAC);
- Stakeholder concerns raised during consultation;
- The known morphodynamic properties of the sandbank system within the SAC; and
- The installation method and likely operational requirements of the different options.

The ranking used to evaluate the environmental criteria were developed to account for the varying degrees of risk to the conservation objectives of the qualifying interest features and potential impacts to the wider supporting habitats and users. In accounting for the potential risk, the ranking considered the spatial extents and temporal longevity of any impacts. The completed appraisal then assessed the scale and magnitude of the potential environmental impact from the different options and sub-options based on the installation method and perceived risk to the respective environmental criteria. The environmental appraisal scores were then assigned to each option and sub-option as a basis to compare the potential for, and magnitude of, environmental impacts.

2. INTRODUCTION

2.1 Project Overview

Independent Oil and Gas PLC (IOG) operate the Blythe Hub and Vulcan Satellite Hubs Development, a future gas development located in Blocks 48 and 49 of the North Sea approximately 40 kilometres East of Bacton Gas Terminal, Norwich. The field location is shown in Figure 1.1**.**

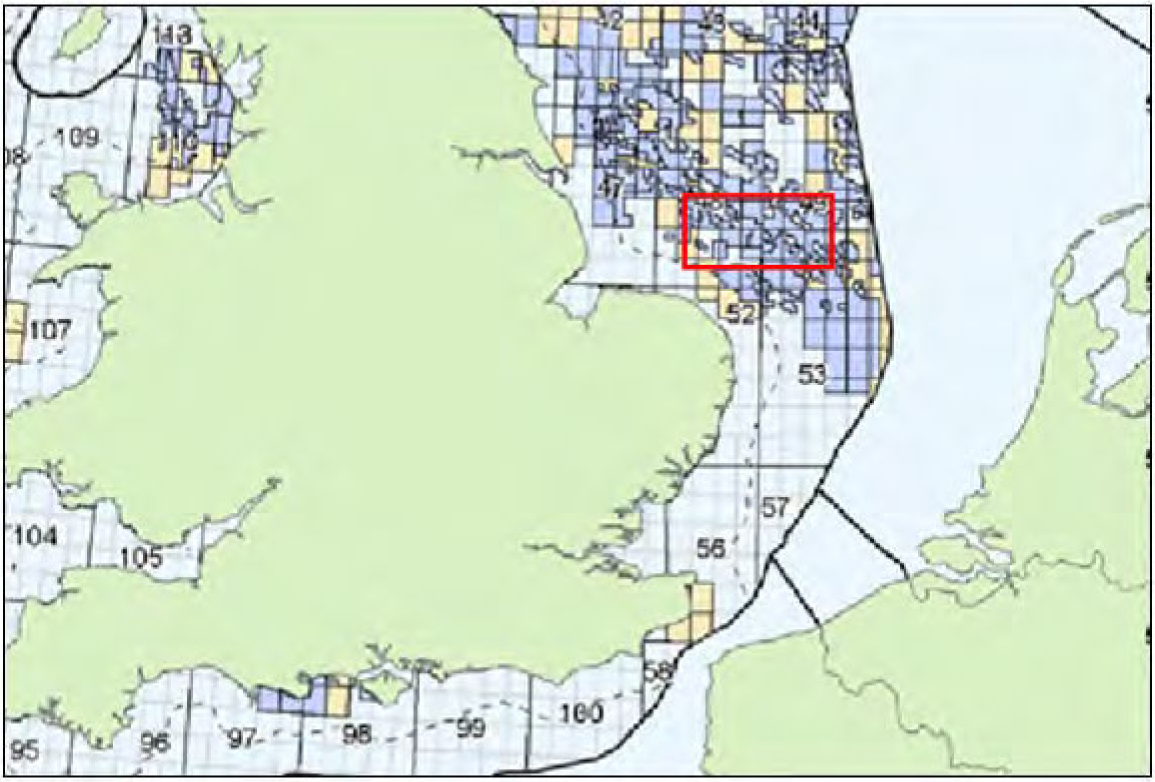


Figure 1.1 – Field Location

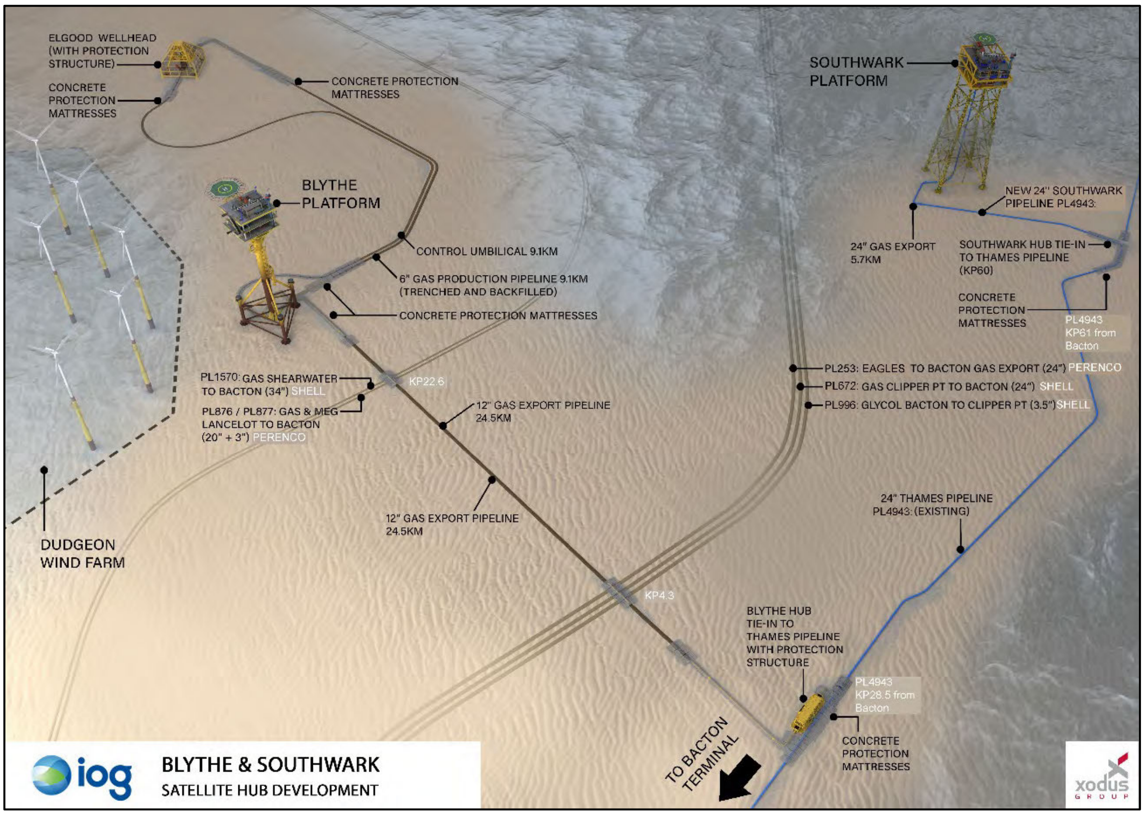


Figure 1.2 – Blythe and Vulcan Field Layout

The Blythe and Vulcan Satellite Hubs Development project shall be complete, ready for operation no later than 1st September 2021.

2.2 Scope

The objective of this document is to present the problem and potential solutions around the seabed route for the 24" Southwark Gas Export Pipeline. This document will be used to support a comparative assessment to be performed by COMPANY, COMPANY's specialist environmental advisors and CONTRACTOR. The aim of that Comparative assessment will be to select the best practicable environmental option (BPEO).

2.3 Cost and Schedule Statements

Note that all statements made regarding cost and schedule are provided to display an order of magnitude relative to each option. While they are based on evidence that Subsea 7 has access to (i.e. previous tendered prices), they are not all market tested nor are they indicative of future costs relating to the market availability of that technology timed, which would need to coincide with a pipelay campaign.

Note, costs have been provided for the application of a technology, it does not account for any changes to the base scope itself, i.e. UXO Survey, Pre-lay Survey or laying of the pipeline etc.

In addition, the costs do not provide a comparison of total expenditure, TOTEX, i.e. CAPEX and OPEX costs combined.

2.4 Definitions

Table 1.1 presents the abbreviations used within this document.

Abbreviation	Definition
BFP	Backfill Plough
BPEO	Best Practicable Environmental Option
CAPEX	Capital Expenditure
CDV	Cutter Dredging Vessel
CFE	Controlled Flow Excavation
CWC	Concrete Weight Coating
DP	Dynamic Positioning
DOL	Depth of Lowering
DSV	Diving Support Vessel
FPROV	Fall Pipe Remote Operated Vehicle
FPV	Fall Pipe Vessel
MSBL	Mean Seabed Level
OOS	Out of Straightness
OPEX	Operating Expenditure
ROV	Remote Operated Vehicle
ROVSV	Remote Operated Vehicle Support Vessel
SAC	Special Area of Conservation
SIMOPS	Simultaneous Operations
TSHD	Trailing Suction Hopper Dredger
TSV	Trenching Support Vessel
UHB	Upheaval Buckling
UXO	Unexploded Ordnance
VMP	V-Mechanical Plough
WROV	Work Class Remote Operated Vehicle
3LPP	Three Layer Polypropylene

Table 1-1 – Abbreviations and Definitions

2.5 References

Ref.	Description
1	DNVGL-RP-F105, Free Spanning Pipelines, June 2017

Table 1-2 - References

2.6 Hold Points

Table 1.3 presents the HOLD points within this revision of the document.

Section	HOLD Point

Table 1-3 – HOLD Points

2.7 Methodology

The methodology involved the identification of a number of technical solutions which were itemised, reviewed for environmental impact, technical viability, project risk, this included, the identification of high-level CAPEX costs and OPEX cost considerations.

2.8 Scope for Determining Environmental Criteria

The identification of environmental assessment criteria has been informed by the range of options identified by Subsea 7 (2020) for the installation of the 24" NB Southwark pipeline from the new Southwark platform to a connection point on the Thames Pipeline.

To date seven main options and associated sub-options have been identified as follows:

1. No seabed modification, pipeline installed on as-found seabed;
2. Re-route pipeline;
3. Rock infill between sandwaves;
4. Concrete mattress infill between sandwaves;
5. Sandwaves levelled to mean seabed level across the width of the pipe lay corridor, using the following methods:
   a) Controlled flow excavation (CFE);
   b) Trailing suction hopper dredging (TSHD); and
   c) Seabed excavators.
6. Sandwaves levelled to mean seabed level across the width of the pipe lay corridor and trenching to below the mean seabed level as follows:
   a) CFE to the mean seabed level, with trenching using CFE;
   b) CFE to the mean seabed level, with trenching using jetting;
   c) CFE to the mean seabed level, with trenching using a mechanical plough;
   d) TSHD to the mean seabed level, with trenching using CFE;
   e) TSHD to the mean seabed level, with trenching using jetting;
   f) TSHD to the mean seabed level, with trenching using a mechanical plough;
   g) Seabed excavator to the mean seabed level, with trenching using CFE;
   h) Seabed excavator to the mean seabed level, with trenching using jetting; and
   i) Seabed excavator to the mean seabed level, with trenching using a mechanical plough.
7. Pipeline self-burial.

2.8.1 Understanding Stakeholder Requirements

Early engagement with the statutory consultee, JNCC and the Regulator, BEIS, was completed by IOG and Intertek to discuss the Southwark Pipeline Environmental Statement (ES). The meetings were conducted on 13th August (IOG, 2020a) and 20th August (IOG, 2020b) respectively.

During the meetings, it was noted a comparative assessment was welcomed by the BEIS to investigate the potential installation methods, considering the environmental, engineering and commercial aspects, in order to determine the best solution for the pipeline installation.

The key points that were discussed and are of relevance to this scope centred around the use of seabed remediation methods (e.g. rock, concrete mattresses) as well as the use of sandwave pre-sweeping to aid installation. The information documented in the meeting minutes was reviewed to ensure that the concerns raised by the statutory stakeholders were adequately considered and applied in developing the assessment criteria.

3. SITE AND PIPELINE DESCRIPTION

3.1 Installation Site

The route of the Southwark Gas Export Pipeline leaves the Southwark Platform on a South East heading then turns South towards the tie-in point on the Thames Pipeline. The pipeline route is approximately 6km in length. The seabed in this region is characterised by large sand waves and mega-ripples which present challenging conditions for pipeline installation. Seabed modification works are required before the pipeline can be installed to mitigate the effect of the sand waves and mega-ripples.

The pipeline route is located within the Southern North Sea Special Area of Conservation (SAC), North Norfolk Sandbanks SAC and Saturn Reef SAC. It is therefore important that the environmental impact of seabed modification works carried out to facilitate pipeline installation are kept to a minimum.

The sand waves at the installation site are known to be mobile, this is evidenced by the changes in seabed topography observed between route surveys carried out in 2018 and 2020.

As a whole the pipeline route is located in a morphodynamically active environment with evidence of actively migrating sandwaves that are characteristic of the North Norfolk sandbank system. Bathymetric information from the 2018 and 2020 surveys, indicate that the sandwaves are actively evolving with migration rates of over 10 m/year for the largest sandwaves. In the wider area covered by the 2018 survey, there is also evidence of bifurcating and converging sandwaves, associated with steep asymmetric profiles, which all support the conclusion of an active and dynamically evolving environment.

The sand waves have been observed to move in a generally Northern direction. This movement makes it more difficult to determine the extent of the seabed modification works required for pipeline installation since the exact nature of the sand waves will not be known until shortly before construction.

The pipeline route is also constrained by shallow water towards the Northern end which would restrict access for pipeline installation vessels.

3.2 Pipeline Parameters

The Southwark Gas Export Pipeline is planned to be installed in Q3/Q4 2021. The pipeline has a steel outside diameter of 24" and is coated with 3LPP anti-corrosion coating and concrete weight coating. Table 2.1 presents the pipeline parameters.

Parameter	Unit	Value
Pipeline Length	km	5.667
Pipeline Design Life	Years	15
Pipeline Steel Outside Diameter	mm	609.6
Pipeline Steel Material Grade	-	API 5L X65 PSL2 MO
Manufacturing Process	-	DSAW
Pipeline Coating Material	-	3LPP + CWC
Pipeline 3LPP Coating Thickness	mm	3.2
Pipeline 3LPP Coating Density	kg/m^3	900
Concrete Weight Coating Thickness	mm	100 and 120
Concrete Weight Coating Density	kg/m^3	3040

Table 2-1 – 24" Gas Export Pipeline Parameters

3.3 Environmental Setting

3.3.1 Regional and Site Understanding

3.3.1.1 Bathymetry

The Vulcan Satellites Hub Development is located in the Southern North Sea (SNS), a relatively shallow area of the North Sea; water depths across the site are typically 20 m to 30 m (IOG, 2018). Across the NNSSR SAC, the sandbank crests deepen with increasing distance offshore, with those of the Indefatigables being the deepest. However, there is more consistency across all the sandbanks in terms of the depths of the troughs, thereby indicating steeper and more asymmetric profiles in the sandbanks closer to the coast. At the Well Bank, close to the proposed new 24” NB Southwark pipeline, crests were on average at a depth of 15 m and the troughs averaged a depth of 35 m (Jenkins *et al*., 2015).

The pipeline at the Southwark platform (KP 0) is located in water depth of 29.1 m LAT. It then passes through an area of sandwaves, becoming shallower. The shallowest point along the pipeline (KP 2.089) reaches a depth of 24.1 m LAT in another area of sandwaves. Ultimately, the pipeline route enters deeper water to 34.2 m LAT at the point of tie-in at KP 62 of the Thames to Bacton 24” pipeline (PL370; Fugro, 2018).

3.3.1.2 Tidal Regime

The tidal range of the SNS generally ranges between 2 and 5 m, increasing towards the south and coast (Jones *et al*., 2004). Further offshore and northeast of the 24” NB Southwark pipeline, within the Hornsea 3 offshore wind farm (OWF), the mean spring tidal range is around 2 m increasing to approximately 5 m at the coast (Ørsted, 2018). The tidal flow in proximity to the 24” NB Southwark pipeline is broadly aligned with the coast, with a south-easterly flood flow and a north-westerly ebb flow (HR Wallingford, 2002; Ørsted, 2018).

Tidal measurement associated with a tidal diamond west of the NNSSR SAC (53°19.0'N 1°25.4'E), indicate mean current speeds of up to 0.88 m/s during spring tides and 0.46 m/s during neap tides. The overall residual current is 0.049 m/s, flowing northeast and associated with the ebb tide (Hydrographer of the Navy, 2008 cited in IOG, 2018).

Observed and modelled data associated with the nearby Hornsea 3 OWF suggest current speeds of up to 0.7 m/s east of the NNSSR SAC and increasing to between 0.8 and 1.0 m/s in the location of the Southwark pipeline (Ørsted, 2018). Elsewhere within the NNSSR and associated with Broken Bank, mean spring and neap current speeds were 1.6 m/s and 1 m/s respectively. Complex and variable flow patterns and current speeds are expected associated with the sandbank features within the NNSSR SAC, with evidence for circulation patterns around the sandbanks (Collins *et al*., 1995). The Norfolk sandbanks system is also located in water, which is considered permanently and well mixed, with evidence for stratification further offshore (Ørsted, 2018).

3.3.1.3 Wave Regime

Across the NNSSR SAC, the wave regime mainly comprises locally generated wind waves generated within the SNS, associated from the prevailing direction from the southwest. This area is also be susceptible to swell waves propagating in from the Atlantic and into the North and Southern North Seas. Observed data from the Hornsea 3 OWF recorded the 90th percentile significant wave height as being 1.7 m to 1.9 m in summer (with periods of 5.8 s and 6.6 s respectively) and 2.5 m and 2.7 m in winter (with periods between 6.6 s and 7.1 s respectively), comprising both locally generated and swell waves (Ørsted, 2018). Similar wave properties are expected to occur in the vicinity of the 24" NB Southwark pipeline.

3.3.1.4 Seabed Sediment and Geology

Sediments within the SNS are indicative of relict glacial, fluvial and coastal processes. Regional seabed sampling suggests that the seabed around the Vulcan Satellites Hub Development consists of Holocene sand, coarse sand and gravels (JNCC, 2010; 2017; IOG, 2018), where the thickness of the Holocene layer varies between 6 m and 11 m along the pipeline (Fugro, 2018). The sandbanks in proximity to the 24" NB Southwark pipeline principally comprise medium sand ranging between 280 µm at the crest to approximately 430 µm in the trough (Jenkins *et al.*, 2015), where the composition was >80% sand (JNCC, 2017). Other sediment grains include gravels, with low occurrence of silts.

Off the east coast of Norfolk, the underlying offshore geology is made up of an upper cretaceous fine-grained limestone. This layer covers a lower cretaceous layer of mainly sandstones and mudstones (DECC, 2016), which is also present along the proposed pipeline route (Fugro, 2018).

3.3.1.5 Sediment Transport

The 2002 SNS Sediment Transport Study indicates the concentration of suspended particulate matter within the Norfolk sandbanks area is 4-8 mg/l in summer and 8-16 mg/l in winter (HR Wallingford, 2002). More recent quantification puts the concentration of suspended particulate matter in the area at 1.1-2 mg/l in summer and 9.1-10 mg/l in winter (Limpenny *et al.*, 2011), particularly at the southern reaches of the sandbank system, where the 24" NB Southwark pipeline is located.

Occasional storm surge induced currents over the North Norfolk sandbanks area does cause sand to be transported in directions other than those caused by the tidal currents alone (Flather, 1987 cited in JNCC, 2017). This is expected to contribute to the transport of sand oblique to the tidal currents and towards the northeast, contributing to the sandbank's natural progression in this direction (Caston and Stride, 1970; Collins *et al.*, 1995). It has been suggested that the sediment is transferred between sandbanks heading offshore, with the sandbanks acting as 'stepping stones' (Collins *et al.*, 1995).

The localised movement of sand resulting in the migration of sand features in this area may magnify small irregularities in the sandbanks generating an 'S' shaped bank surrounded by ebb and flood channels (Caston, 1971).

3.3.1.6 Seabed Bedforms

The NNSSR SAC is a representative example of the Annex I feature 'Sandbanks which are slightly covered by sea water all the time' and is considered to represent the most extensive system of open shelf ridge sandbanks in the UK (Graham *et al.*, 2001 cited in JNCC, 2017). Evidence suggests that the more southern sandbanks within the SAC are moving in a northerly direction (Jenkins *et al.*, 2015). Additionally, the sandbanks are of a northwest to southeast orientation and are slowly becoming elongated in a north-easterly direction (JNCC, 2017).

The sandbanks within the NNSSR SAC have asymmetrical profiles; the steeper slopes (which are up to 7°) face away from the coast (Caston, 1979; Collins *et al.*, 1995). The Fugro (2018) geophysical report of the proposed route of the new 24" NB

Southwark pipeline identified bedforms (including sandwaves and megaripples) with gradients of up to 18° in places.

The area around the Vulcan Development is highly mobile, in particular at the location of the proposed new 24” NB Southwark pipeline.

3.3.2 Environmental Protected Sites

The proposed 24” NB Southwark pipeline corridor is entirely located within two designated sites namely:

- The NNSSR SAC, which is designated for the conservation of:
  - Annex I habitat – Sandbanks which are slightly covered by seawater all the time; and
  - Annex I habitat – Reefs.
- The Southern North Sea SAC, which is designated for Annex II species, harbour porpoise (*Phocoena phocoena*).

3.3.2.1 North Norfolk Sandbanks and Saturn Reef SAC Site Description

The NNSSR SAC is designated under the European Commission Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora ‘Habitats Directive’ transposed into UK law as The Conservation of Offshore Marine Habitats and Species Regulations 2017. The designation under the Habitats Directive necessitates that activities do not have an adverse impact on the Conservation Objectives and attributes of the qualifying interest features that constitute the designation. Based on information presented in the JNCC mapper for the NNSSR SAC (JNCC, 2020), in addition to the 24” NB Southwark pipeline overlapping the sandwaves and Inner Bank, there is the potential for high confidence reef habitat in the area of the proposed pipeline.

The Conservation Objectives for the NNSSR SAC (JNCC, 2017) Sandbanks which are slightly covered by seawater all the time and Reefs are for features to be in a favourable condition, ensuring site integrity to be achieved by maintaining or restoring:

- The extent and distribution of the qualifying habitats in the site;
- The structure and function of the qualifying habitats in the site; and
- The supporting processes on which the qualifying habitats rely.

Associated with the broad ecological aims of the Conservation Objectives for this site are attributes which directly inform the characteristics and properties of the qualifying features. As such, the attributes for the Annex I sandbanks slightly covered by seawater all the time and Annex I reefs are closely linked the Conservation Objectives and include:

- The physical extent and distribution of the qualifying feature;
- The structure and function which considers the physical presence of the features and ecological processes they support. This attribute encompasses:
  - Bedform morphology (from sandbanks through to mega-ripples and mounds), and linkages to the hydrodynamic regime;
  - Sediment composition and distribution; and
  - The presence of key species supporting the habitat structure, particularly the *Sabellaria spinulosa* (*S. spinulosa*) and other characteristic communities.
- The supporting processes, which enable the functions (ecological processes) and principally comprises the hydrodynamic regime (at varying scales) and

elements related to the water and sediment quality, with respect to environmental quality standards (EQS).

The site characterisation (JNCC, 2017) notes that potential changes to the attributes of the qualifying features can directly influence the overall site condition and status. For this reason, it is proposed that the attributes associated with the Conservations Objectives of the qualifying features are used to inform the environmental assessment criteria.

3.3.2.2 Southern North Sea SAC Site Description

The Southern North Sea SAC is also designated under the Habitats Directive, via The Conservation of Habitats and Species Regulations 2017 within 12 nautical miles (NM), and The Conservation of Offshore Marine Habitats and Species Regulations 2017 between 12 NM out to 200 NM or the UK Continental Shelf. As the 24” NB Southwark pipeline corridor is within 12 NM, it is entirely covered by the inshore regulations.

The area is designated for its importance to harbour porpoise in both the summer and winter months, where sightings and modelled data both showed elevated densities of usage by the species all year round (JNCC, 2019). However, the pipeline is mainly located within the summer grounds. Therefore, the Conservation Objective associated with the site and interest features is to ensure the integrity of the site is maintained, ensuring the following:

- Harbour porpoise is a viable component of the site;
- There is no significant disturbance of the species; and
- The condition of supporting habitats and processes, and the availability of prey is maintained.

For the Southern North SAC, there are no further attributes associated with the Conservation Objectives for the Annex II harbour porpoise. There is, however, a recognition of the pressures on the species with the potential to impact the condition and status of the feature and site (JNCC, 2019). The pressures that are of particular relevance to this scope and which are therefore relevant in informing the environmental assessment criteria are:

- Contaminants, with associated effects on the water and prey and bioaccumulation of contaminants;
- Anthropogenic underwater noise, resulting in injury, mortality and disturbance leading to behavioural changes; and
- Death or injury by collision.

It is recognised that the introduction of anthropogenic underwater noise is a concern with respect to the harbour porpoise qualifying feature for the Southern North Sea SAC. There will however be no discernible difference in the noise generated between the various installation options being considered. Another pressure on the qualifying feature is the potential for injury or death by collision. However, there will again be no discernible difference between the various options. For the above reasons, consideration of impacts to the harbour porpoise qualifying feature are not developed further into an environmental assessment criteria as part of this scope.

4. PIPELINE INSTALLATION AND SEABED INTERVENTION OPTIONS

4.1 Options Identification

Table 3.1 presents the potential options which have been identified for pipeline installation and seabed modifications. Descriptions of each option are presented in Section 3.2 to 3.8.

Option	Method
1	No seabed modification, pipeline installed on as-found seabed.
2	Re-Route pipeline.
3	Rock infill between sand waves.
4	Concrete mattress infill between sand waves.
5	Sand waves removed to local mean seabed level across the width of the pipe lay corridor.
6	Sand waves removed to local mean seabed level across the width of the pipe lay corridor then pipeline installed and trenched below local mean seabed level.
7	Pipeline self-burial.

Table 3-1 – Identified Options

The environmental considerations and assumptions associated with seabed preparation works and pipeline installation for each option and sub-option are summarised below along with the potential environmental impacts associated with the works. These have aided the development of the environmental criteria presented in Appendix D and are used to directly inform the environmental appraisal of each of the installation options.

4.2 No Seabed Modification

4.2.1 Description

This option comprises the installation of the pipeline on the as-found seabed along the proposed route with no seabed modification. Pipeline installation on an uneven seabed will cause sections of the pipeline to be out of contact with the seabed, these are known as pipeline free spans. Assessment of these free spans is required to establish if pipeline installation on the unmodified seabed is technically feasible. Details of this assessment are presented in Appendix A.

4.2.2 Technical

- This option is not technically feasible since the pipeline is exposed to environmental loads which severely reduce the pipeline's fatigue life, in some areas reducing the fatigue life to days or weeks (see Appendix A).

4.2.3 Safety

- Pipeline would fail during operation due to over utilisation and fatigue induced damage.
- Large free spans would present a hazard to fishing activity and other users of the sea.
- UXO clearance certificate required.

4.2.4 Environmental

This installation approach does not entail any seabed preparation and involves laying the pipeline directly on the seabed. During installation, any impacts are expected to be direct and therefore localised to within the footprint of the pipeline and would mainly relate to the pipeline laying on the seabed. Potential environmental impacts in relation to this installation method include the following:

- Direct impact to the designated qualifying features and environmental features of conservation importance would be limited to those located within the footprint of the pipeline, namely Sandbanks which are slightly covered by sea water all the time and *Sabellaria spinulosa* aggregations. It is noted that areas of high reef potential are located ~5-15 km from the proposed route (JNCC, 2020), however the Environmental Baseline Survey only recorded small patches of *S. spinulosa* which were not extensive enough to classify as reef structures (IOG, 2019);
- The pipeline would replace the underlying surface sediment with a novel hard substrate, however it is expected that this would be fully removed during decommissioning, returning the substrate type to its original state;
- There is a significant risk of scour and free spans necessitating remedial works over the operational life of the plan. Even from installation, free spans are expected due to the steep asymmetric profiles of the present sandwaves and the properties of the pipeline. There is also the high potential for the development of scour due to the non-cohesive nature of the sediment, the prevailing sediment transport regime with the blockage effect of the pipeline generating localised turbulence that leads to scour. The presence of free spans either from installation or as a result of additional scour would necessitate significant levels of intervention and remedial work through the introduction of rock placement which would permanently replace the existing sandy sediment habitat with a novel hard substrate; and
- The surface laid pipe and the likely high number of free spans would present a significant snagging risk to fishers along the full length of the pipeline,

however the fishing activity in the region is low in the context of the wider North Sea.

4.2.5 CAPEX

- No additional CAPEX required for seabed modification prior to pipeline installation.

4.2.6 OPEX

- Cost of replacing the pipeline after failure.
- Additional decommissioning cost for removal of failed pipeline.

4.3 Re-Route Pipeline

4.3.1 Description

This option involves changing the route of the pipeline to avoid large sand waves therefore reducing or removing the need for seabed modification. The scope of this document is limited to local re-routing within the surveyed area (2018 & 2020 surveys). The pipeline end locations (Southwark Platform and Thames Pipeline Tie-In) are considered fixed points.

4.3.2 Technical

- The current pipeline route is considered optimal based upon the data available from surveys carried out in 2018 and 2020 (see Appendix B section B.1).
- There is little scope for re-routing due to the presence of sand waves either side of the route.
- The route is further constrained by shallow water (<15m) at the Northern end which limits access for pipe-lay vessels.
- Seabed modification works would likely be required along the new route considering the available survey data.
- Potential increase in seabed area disturbed if route length is longer than the original proposal.
- The risk of future free spans requiring remedial work is considered high.

4.3.3 Safety

- Standard offshore pipelay operations, no additional safety concerns.
- Additional UXO surveys and certificates required.

4.3.4 Environmental

This option entails locally modifying the proposed pipeline route within the extents of the 2018 survey and again laying the pipeline, in order to avoid large sandwaves and remove the need for seabed modification. There is little scope for avoiding the designated qualifying interest feature, i.e. sandbanks and associated sandwaves, as the sandwaves occur on either side of the proposed pipeline route and cover a large area. Therefore, the environmental impacts of this option would be the same as those described for Option 1: No seabed modification, in Section 4.2.4.

4.3.5 CAPEX

- Increased CAPEX requirement for any increase in route length.
- Additional survey required to support pipeline detailed design considering new route.
- Additional pre-lay survey required before pipeline installation.
- Additional UXO surveys required.

4.3.6 OPEX

- Regular surveys of the exposed pipeline will be required to monitor the effect of seabed movement on pipeline free spans. If unacceptable free spans develop then remedial works will be required.
- Free span remedial works will most likely involve rock installation since concrete mattresses cannot be installed underneath an existing pipeline. No current technology is available for the removal of rock from the seabed therefore any rock installed would be a permanent deposit.
- Any increase in pipeline length would increase decommissioning costs.

4.4 Rock Installation between Sand Waves

4.4.1 Description

This option comprises subsea rock installation between sand waves to create a smooth profile for the installation of the pipeline to mitigate against premature pipeline failure. Figure 3.1 presents a typical arrangement of rock infill between sand waves.

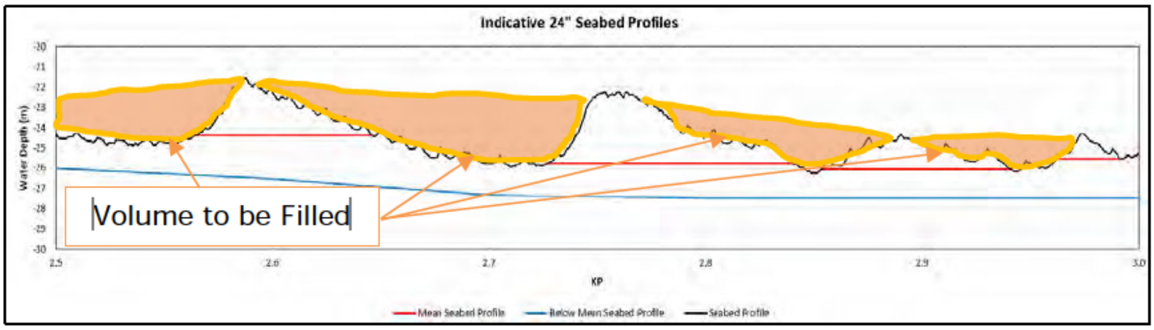


Figure 3.1 – Typical Arrangement of Rock Infill

4.4.2 Technical

- Approximately 125,000m^3 of rock required to be installed.
- Seabed surface area covered with rock is approximately 80,000m^2.
- Rock installation would be required along almost all of the pipeline route based upon the vertical seabed profile (see Appendix C).
- Offshore operations not particularly weather sensitive.
- No current technology available for the removal of rock from the seabed. Any rock installed would be a permanent deposit.
- Future free span remedial works due to sand wave / rock berm movement would require additional rock to be deposited on the seabed. The risk of future free spans requiring remedial work is considered high.

4.4.3 Safety

- Standard offshore pipelay and rock installation operations, no additional safety concerns.
- UXO clearance certificate required.

4.4.4 Environmental

With this option, it is assumed that a rock berm would be installed between the crest of successive sandwaves, in order to create a flat and relatively uniform surface upon which the pipeline would be laid. The top of the rock berm would need to have a minimum width of 10 m to enable for the lateral movement of the pipeline over its lifetime, with a base width of around 25 m. As it would not be possible to remove the rock used in this option, it is considered here as a permanent substrate. Although the width of the rock berm may be fixed, the length of each rock berm section would be dictated by the sandwave wavelength. It is noted that in the area surrounding the pipeline, the present sandwaves vary in length along the crest, ranging between tens and hundreds of metres in length. Therefore, in some case the width of the berm may be along the full length of some sandwaves. Potential environmental impacts in relation to this installation method include the following:

- The installation of a rock berm would result in the direct and permanent loss of designated qualifying features, including 'Sandbanks which are slightly covered by sea water all the time' and any *S. spinulosa* aggregations within the footprint of the rock berm;

- Rock installation between the sandwave crests would permanently replace the sandy habitat within the footprint of the berm along almost the full length of the pipeline based upon the vertical seabed profile. This would equate to a loss of approximately 80,000 m^2 of sandy habitat and associated communities within the sandbank feature and represents the introduction of 125,000 m^3 of new substrate into the NNSSR SAC that is not representative of the baseline sediment type;
- The fact that the rock berm may be present along a significant proportion of the length of an individual sandwave, means that there is the potential to pin whole or sections of the affected sandwaves in place. This would immediately change the form of the present sandwaves, with onward disruption to the hydrodynamic and sediment transport regimes locally and over a wider area, with effects on the sediment connectivity across the North Norfolk sandbank system;
- The deposition of the rock substrate on to the seabed is only likely to cause minimal sediment disturbance, which would be both localised to the berm footprint and have a short duration. Therefore, there is not considered to be any significant impacts associated with the generation of sediment plumes, as the areas of high potential *S. spinulosa* reef occur at distances of >5 km from the pipeline route; and
- The rock berms and surface laid pipe would present a snagging risk along the full length of the pipeline. It is assumed that formation of free spans would be less frequent compared to sandy substrate installation methods and would be determined by the degradation rate of the rock berms.

4.4.5 CAPEX

- Additional CAPEX for the charter of a subsea rock installation vessel and installation time.
- The cost of rock installation is expected to be approximately £7.7m.

4.4.6 OPEX

- Regular surveys of the exposed pipeline will be required to monitor the effect of seabed movement on pipeline free spans. If unacceptable free spans develop then remedial works will be required.
- Free span remedial works will most likely involve rock installation since concrete mattresses cannot be installed underneath an existing pipeline. No current technology is available for the removal of rock from the seabed therefore any rock installed would be a permanent deposit.
- No additional decommissioning cost in excess of usual pipeline decommissioning is expected assuming that rock is a permanent deposit.

4.5 Concrete Mattress Installation between Sand Waves

4.5.1 Description

This option comprises the installation of concrete mattresses between sand waves to create a smooth profile for the installation of the pipeline to mitigate against premature pipeline failure.

4.5.2 Technical

Figure 3.2 presents a typical sand wave location along the Southwark Pipeline Route and the potential volume which would have to be filled with concrete mattresses to create an acceptable profile for pipeline installation. The pipeline may displace laterally up to 10 x pipeline outside diameter during its operational life therefore the top width of the mattress stack must accommodate this movement in addition to pipeline installation tolerances.

- Considering standard concrete mattress dimensions (6m x 3m x 0.5m), approximately 22,500 concrete mattresses would be required along the pipeline route.
- There are approximately 20 locations along the pipeline route this type of intervention is required. Concrete mattresses would cover a seabed area of approximately 130,000m².

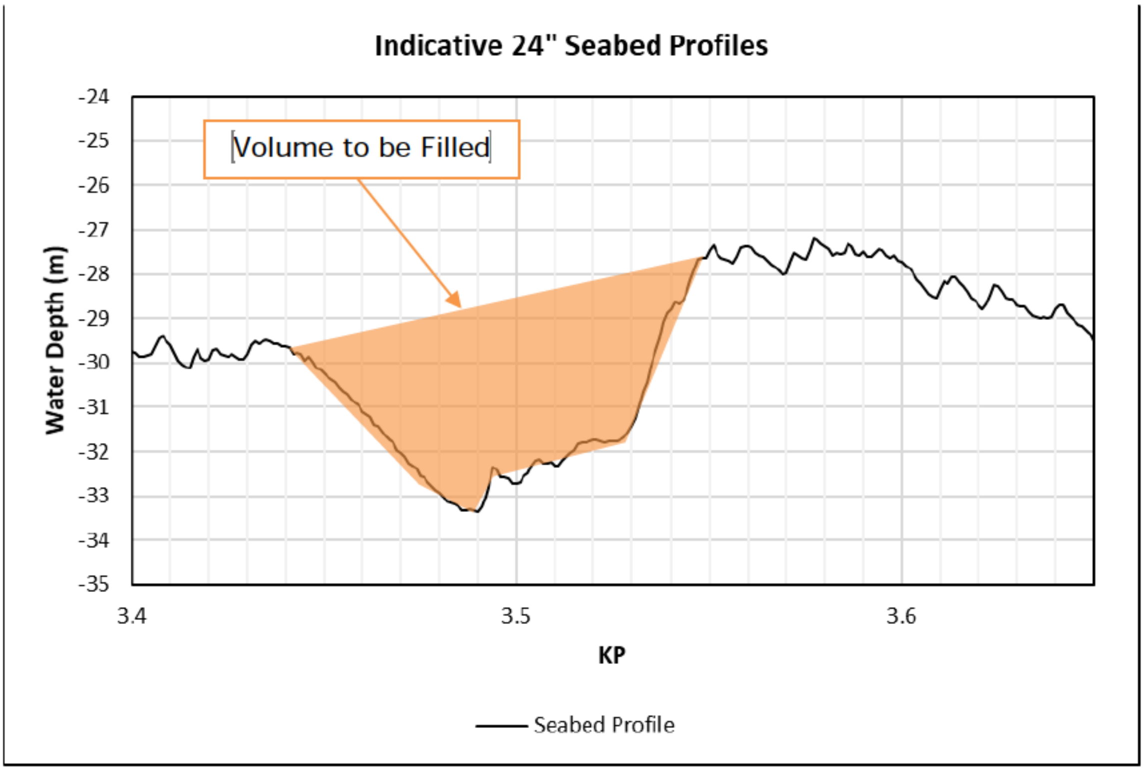


Figure 3.2 – Possible Location of Concrete Mattresses

In addition to the quantity of mattresses the following technical points can be considered:

- Concrete mattress installation is more sensitive to weather and tidal conditions than other seabed modification options.
- The removal of concrete mattresses at the end of pipeline operational life is a difficult operation. Due to deterioration of the mattress over time they would likely have to be recovered in baskets which is a time consuming and costly process.
- It is likely that some of the concrete mattresses will self-bury over time and will be impossible to recover. These would have to be considered permanent seabed deposits.

4.5.3 Safety

- Standard offshore pipelay operations, no additional safety concerns.
- The stacking of concrete mattresses more than 2 high is unusual and presents the risk of instability and collapse. CONTRACTOR has concerns about how this arrangement of mattresses can be installed and decommissioned safely.
- The large volume of mattresses to be installed and the repetitive nature of the work increases the chance of a safety incident. The risk is further increased by tidal conditions and poor subsea visibility in this field.
- UXO clearance certificate required.

4.5.4 Environmental

This option follows that described for the rock infill between sandwaves, with the exception of concrete mattresses being used instead of rock infill. The environmental impacts described for the rock infill option in Section 3.4.4 are also applicable here, with the exception of a larger footprint of direct impact. With this method, the minimum and maximum corridor width along the pipeline route ranges between 50 and 78 m, equating to an approximate area of 130,000m^2. This constitutes a much larger footprint of direct impact and loss of designated qualifying features and supporting habitat, compared with Option 3. Although theoretically mattress protection can be considered as a non-permanent measure, due to the safety risks inherent in removing approximately 22,500 mattresses from the environment during decommissioning, it is considered as a permanent measure with respect to the proposed works.

4.5.5 CAPEX

- Additional CAPEX required for a DSV / ROVSV campaign to install concrete mattresses ahead of pipelay. Considering an installation rate of 1 hour per mattress and a typical vessel cost of £120k per day, this equates to an approximate installation cost of £188 million. This includes vessel mobilisation and transit.
- Additional CAPEX is also required for procurement of the concrete mattresses, this cost is currently around £500 per mattress (£11.3 million estimated total for route length).
- For clarity, mattress lay for these quantity of mattresses would give an overall duration of 3.7 years to complete (prior to pipelay).

4.5.6 OPEX

- Regular surveys of the exposed pipeline will be required to monitor the effect of seabed movement on pipeline free spans. If unacceptable free spans develop then remedial works will be required.

- Free span remedial works will most likely involve rock installation since concrete mattresses cannot be installed underneath an existing pipeline. No current technology is available for the removal of rock from the seabed therefore any rock installed would be a permanent deposit.
- Significant costs associated with the removal of concrete mattresses at end of pipeline operational life. These costs will be higher than for installation due to the difficulties of recovering potentially deteriorated mattresses.
- Costs for onshore disposal of concrete mattresses recovered during decommissioning.

4.6 Sand Wave Removal to Mean Seabed Level

4.6.1 Description

This option comprises the removal of sand waves to mean seabed level within the extents of the pipeline lay corridor to create a smooth profile for the installation of the pipeline to mitigate against premature pipeline failure. The removal of sand waves could be carried out using the following methods:

- Controlled flow excavation.
- Trailing suction hopper dredging.
- Seabed excavators.
- Jet trenching.

Descriptions of each of these methods are presented in Appendix B. Indicative vertical seabed profiles showing the removal of sand waves to mean seabed level are presented in Appendix C.

4.6.2 Technical

- Estimated volume of seabed material relocated from pipeline route is 60,000-100,000m^3.
- The estimated seabed area disturbed is approximately 60,000m^2.
- Jet trenching not a feasible solution due to the height of the sand waves along the pipeline route, some in excess of 4m. The maximum achievable trench depth by jetting is around 1.5m.
- Controlled flow excavation and trailing suction hopper dredging are less sensitive to weather conditions than concrete mattress installation.
- Trailing suction hopper dredging will produce a more accurate seabed profile than controlled flow excavation.
- Trailing suction hopper dredging can be configured to side-cast recovered material back into the locality.
- Seabed excavators cannot operate on steep seabed slopes therefore may have difficulty working within the sand waves.
- The risk of future free spans requiring remedial work is considered medium.

A full list of technical advantages and disadvantages for each method is presented in Appendix B.

4.6.3 Safety

- Standard offshore pipelay operations, no additional safety concerns.
- Seabed modification works are standard offshore operations for known SUPPLIERS, no additional safety concerns.
- Seabed preparation will need to be carried out just before pipeline installation. SIMOPS therefore required for pipelay and seabed preparation support vessels.
- UXO clearance certificate required.

4.6.4 Environmental

This option assumes the crest and body of the larger sandwaves are levelled to a reference mean seabed level (Appendix C) along the pipeline corridor and the pipe is laid directly on the seabed at the mean seabed level. With this method, no burial or backfill of the pipeline within the levelled area is carried out once the pipeline has been laid. The pipeline would therefore largely remain exposed over its operation, aside from any natural burial that may occur due to sandwave migration or natural sedimentation.

Based on information from the indicative vertical seabed profiles (Appendix C), only limited and short sections of the pipeline route would require sandwave levelling to the mean seabed level, equating to a footprint area of about 60,000 m^2. The corridor width requiring levelling across each sandwave is between 30 and 40 m depending on the sandwave height, while the sandwaves along the pipeline have lengths varying between tens and hundreds of metres. The proposed route crosses the sandwaves at varying angles, depending on the location along the route, meaning there is the potential for relatively large cross-sections of individual sandwaves to be levelled for transversal crossings, compared with perpendicular crossing sandwaves.

This method assumes that no sediment will be lost from the North Norfolk sandbank system, as material would be deposited locally to the levelled area and thereby within the extents of the morphological connectivity between the sandbanks within the NNSSR SAC.

The sandwave levelling to mean seabed level is to be completed using one of three methods, which comprise sub-options that are evaluated as part of this environmental appraisal:

- Controlled Flow Excavator (CFE);
- Trailer Suction Hopper Dredging (TSHD); and
- Seabed excavator.

The environmental impacts common to each of the sub-options or sandwave levelling methods are as follows, whereas additional environmental impacts that may be relevant to a particular sub-option are discussed in the respective section below.

- The sandwave levelling will entail a clearance of designated qualifying features and supporting habitats within the corridor footprint. Indicative area requiring clearance along the full length of the pipeline is estimated to be 60,000 m^2, with a sediment volume of between 60,000 - 100,000 m^3 being displaced, although the amounts would vary for each sandwave, depending on the size and orientation of the feature with respect to the pipeline route. The different clearance methods do have varying degrees of accuracy, which would influence the footprint of any direct impacts, therefore this consideration will be addressed further in each sub-section in relation to the respective sub-options;
- Sandwave levelling can be considered to have a direct but temporary impact due to the potential recovery of the designated qualifying features at varying timescales. Although the levelling may lead to a physical change of the intersected sandwaves, this would only result in a temporary alteration to the morphology and localised modification of the hydrodynamic and sediment transport regime. In time, infilling and recovery of the sandwaves are expected in line with processes that occur across the North Norfolk sandbank system, with little impact on the long-term morphodynamic regime. Information from studies completed in relation to the Race Bank – Docking Shoal and the Haisborough sandbank systems showed a potential for sandwave recovery following levelling activities for cable installation, due to the ideal hydrodynamic conditions and sediment availability. As similar conditions are available across the North Norfolk sandbank system, sandwave recovery can again be expected to occur;
- Sandwave levelling will result in the direct temporary loss of any *S. spinulosa* aggregations within the footprint of the excavation operations. Recolonization of the sandy sediment, and as such recovery of the baseline communities

along the excavated corridor, would be expected over time following cessation of seabed preparation and pipeline installation activities;
- For all the levelling methods considered for this option, the deposited sediment is to be kept in the vicinity of the levelled area, therefore, there is unlikely to be any change to the sediment composition associated with the seabed levelling works;
- Surface installation of the pipeline in areas not requiring sandwave levelling would result in the direct and medium to long-term loss of designated qualifying features, including any *S. spinulosa* aggregations and the sandy sediment communities within the pipeline footprint. However, recovery of communities and habitats would be expected following removal of the pipeline at decommissioning or if sandwaves developed over the pipeline during the lifetime of the project;
- *S. spinulosa* reefs are resilient against natural burial events however reefs are sensitive to damage from siltation events caused by the blocking of feeding apparatus by fine sediment (silt), which are known to occur but at very low percentages. The known areas of reef are located >5 km from the pipeline route, however, as the burden (i.e. magnitude, duration, burial depth) of the sediment plume settlement is unknown, a low level of damage and disturbance cannot be discounted if a significant plume is generated. Short term recovery would be likely due to larval dispersal allowing the establishment of new reefs elsewhere;
- Surface installation of the pipeline will result in a long-term introduction of new hard substrate in a soft sediment environment along the full length of the pipeline route. This is considered a long-term impact until full pipeline removal at decommissioning;
- The surface laying of the pipeline in non-cohesive and mobile sediment environment, means there is the potential for scouring to occur resulting in free spans along sections of the pipeline route over its operational life. The developed scour and spans have the potential to be considerably large, should these occur within the troughs of some of the sandwaves present along the route. These would most likely result in the installation of rock berms as a remedial measure, leading to the introduction of a permanent substrate.
- Surface laying of the pipeline constitutes a long-term snag risk for fishing activities along the full extent of the pipeline for the lifetime of the development. However, pipeline sections are likely to get buried and exposed over the operational life in relation to the recovery and ongoing migration of the sandwave features. Nonetheless, the potential for scour and free spans further compounds the snag risk where and when they are present.

The impacts associated with the varying instruments used to carry out the seabed levelling are considered in the following sections.

4.6.4.1 Sandwave levelling using controlled flow excavation (CFE)

This method involves blowing sediment away along the proposed sandwave levelling corridor. Based on available information from the NNSSR SAC, the sediment along the route is likely to comprise gravel, sand and silt of varying grain sizes, which will be taken into suspension as part of the levelling process, although the period in suspension would vary for the different sediment grain sizes.

The additional or different environmental impacts which are associated with this method are as follows:

- As this method is RELATIVELY LESS accurate compared with the other levelling methods and the area being levelled can be influenced by the seastate, the duration required to achieve the target depth and levelled corridor is likely to be longer. Therefore, the total area of direct disturbance and impact to sediments and benthic communities, including the area covered by the levelling and displaced sediment, is likely to be marginally larger compared with other methods. This is despite the additional footprint of the sediment spoil mounds associated with the dredging/excavation sub-options.

- A larger volume of sediment is likely to be disturbed resulting in greater suspended sediment concentrations associated with a plume over a wider extent. Depending on the duration and direction of the sediment plume, there is an increased risk of damage, disturbance and loss to *S. spinulosa* reef habitats in the vicinity from this method.
- With this method, the bulk of the levelled sediment would be pushed to the side only slightly influencing the seabed depths on either side of the dredged area. With respect to the generated plume, the largest grains would settle out first with the finer sediment remaining in suspension for longer. This natural sorting of sediment within the plume would mean that the sediment composition within the area of largest sedimentation would principally remain the same as within the levelled area.

4.6.4.2 Sandwave levelling using trailer suction hopper dredging (TSHD)

This method involves applying suction to the seabed along the proposed sandwave levelling corridor and dredging a slurry of sediment and water from the seabed. With respect to the proposed sandwave levelling works, it is assumed that no spoil would be retained in the TSHD hopper, and instead would be continuously side cast in proximity to the dredged area during active dredging. The deposition of the dredged sediment would constitute an additional area of seabed disturbance to that of the levelled area.

Sandwave levelling using a TSHD is considered to be more accurate, as the drag head of the dredger can be directly targeted on the seabed. The dredging of the seabed by slowly moving the drag head over the seabed will generate seabed disturbance that would be fairly localised to the area being levelled and by itself is unlikely to develop a significant sediment plume. The mode of operation and how the sediment is returned to the seabed will however have the greatest influence on the development of a sediment plume.

The additional or different environmental impacts which are associated with this method are as follows:

- The area of direct impact to sediments and benthic communities associated with this method would comprise both the area being levelled through dredging and the seabed adjacent to the levelled area, where there the dredged material would be deposited. Even with the additional deposition footprint, the total area of disturbance is still considered to be smaller compared with that of the CFE method.
- The drag head is unlikely to develop a large plume during the dredging process due to the sediments that characterise the study area. However, plume development associated with the continuous side-casting and release of sediment adjacent to the dredge area is expected. Larger plume extents can be expected with sediment release at increasing distance from the seabed, so the largest plume extents are likely to occur with sediment release from the sea surface. The assessment completed as part of this appraisal assumes sediment release in proximity to the seabed with the use of a down-pipe.
- Assuming a worst-case plume generated from deposition of sediment from the sea surface, there is a risk of impact to nearby areas of *S. spinulosa* reef. As described above, recovery would be likely following cessation of installation activities. Due to the accuracy of the TSHD method, the plume concentration

and duration would be expected to be less than for CFE. However, disturbance to qualifying habitats cannot be entirely discounted as there is still the potential for as of yet unknown *S. spinulosa* aggregations within the proposed corridor.
- The continuous side casting adjacent to the dredge area would result in the introduction of deposition mounds on the seabed resulting in the complete burial and loss of supporting habitats. Although the side-casting may widen the area of potential disturbance, this is likely to be similar or smaller to the area of disturbance associated with the less accurate CFE method. This would constitute a long-term impact with recolonization by sediment communities expected following cessation of activities.

4.6.4.3 Sandwave levelling using seabed excavators

This method involves using a mobile tracked vehicle to dredge the seabed, via cutting application or high-pressured jetting, and using a suction hose to excavate a slurry of sediment. The excavated material is then deposited in a soil heap adjacent to the equipment. This method does not entail a surface release, instead the dredged material is carried through a pipe along the seabed and released away from the excavated area. Deposition of any excavated sediment would constitute an additional area of seabed disturbance.

As this method involves cutting and high-pressure jetting, there is the potential for the development plumes both in relation to the seabed excavation works as well as the release of excavated sediment. However, due to the sectional and limited extent of the seabed requiring levelling, the developed plume is likely to be similar to the TSHD sub-option being considered. Therefore, the other environmental impacts described for the TSHD sub-option (Section 3.6.4.2) are also applicable here.

4.6.5 CAPEX

- Additional CAPEX required for the chartering of seabed modification equipment spreads and support vessels to be in field alongside pipeline installation.
- The cost of this sand wave removal option is dependent on the technology employed and is estimated to be between £2.9m to £7.4 million (GBP).

4.6.6 OPEX

- Regular surveys of the exposed pipeline will be required to monitor the effect of seabed movement on pipeline free spans. If unacceptable free spans develop then remedial works will be required.
- Free span remedial works will most likely involve rock installation since concrete mattresses cannot be installed underneath an existing pipeline. No current technology is available for the removal of rock from the seabed therefore any rock installed would be a permanent deposit.
- No additional decommissioning cost expected above what is required for standard pipeline decommissioning.

4.7 Sand Wave Removal and Trenching Below Mean Seabed Level

4.7.1 Description

This option comprises the removal of sand waves to mean seabed level within the extents of the pipeline lay corridor. The pipeline would be installed on the seabed then trenched below mean seabed level. The removal of sand waves to mean seabed level could be carried out using the following methods:

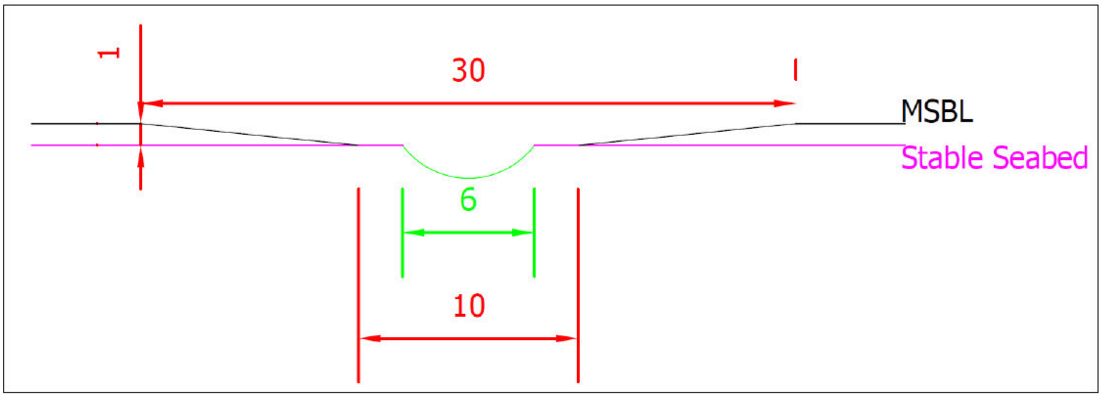
- Controlled flow excavation.
- Trailing suction hopper dredging.
- Seabed excavators.
- Jet trenching.

Trenching of the pipeline below mean seabed level after installation could be carried out using the following methods:

- Controlled flow excavation.
- Jet trenching.
- Mechanical plough and backfill.

Descriptions of each of these methods are presented in Appendix B. Cross sections of the proposed solutions are presented in Figure 3.3 and Figure 3.4. Indicative vertical seabed profiles showing the removal of sand waves to mean seabed level and target trench depth are presented in Appendix C.

Sandwave levelling using CFE/TSHD/Seabed Excavators and trenching below seabed level via CFE/Jet Trencher



Sand Wave Clearance

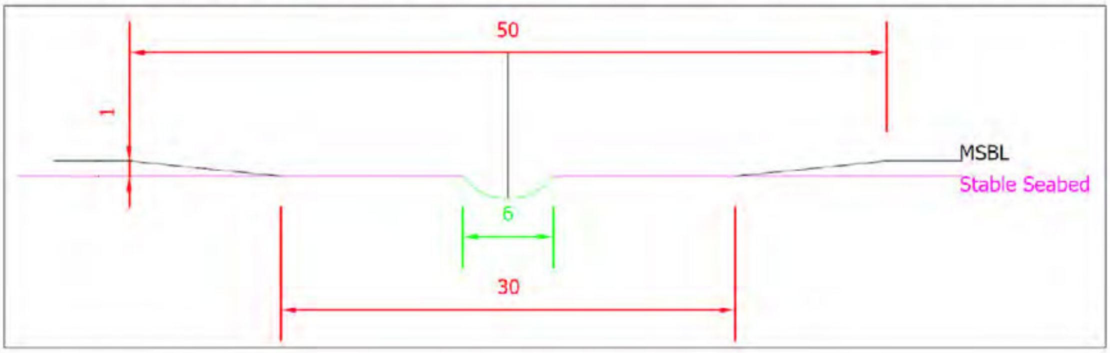
- **30m** sand wave clearance TOP width;
- **10m** sand wave clearance BASE width;
- Based on a **1.0m** height, noted TOP width shall vary subject to clearance height;
- Based on pipeline planned lay route at 90degrees to sandwave approach;
- All dimensions in meters.

Product Trenching

- **6.0m** max. width;
- **1.5m** target trench depth;
- All dimensions in meters.

Figure 3.3 – Proposed Cross Section of Sand Wave Removal and Trenching by Jetting / CFE

Sandwave levelling using CFE/TSHD/Seabed Excavators and trenching below seabed level via **Mechanical Plough and Backfill**



Sand Wave Clearance

- **50m** sand wave clearance TOP width;
- **30m** sand wave clearance BASE width;
- Based on a **1.0m** height, noted TOP width shall vary subject to clearance height;
- Based on pipeline planned lay route at 90degrees to sandwave approach;
- All dimensions in meters.

Product Trenching

- **6.0m** max. width;
- **1.6m** target trench depth;
- All dimensions in meters.

Figure 3.4 Proposed Cross Section of Sand Wave Levelling and Trenching by Mechanical Plough and Backfill

4.7.2 Technical

Removing sand waves to mean seabed level:

- Estimated volume of seabed material relocated from pipeline route is dependant upon the method used for post-lay trenching. For jet trenching, approximately 235,000m^3 of material will be removed, for mechanical ploughing 263,000 m^3 will be removed.
- Jet trenching not a feasible solution due to the height of the sand waves along the pipeline route, some in excess of 4m. The maximum achievable trench depth by jetting is around 1.5m.
- Controlled flow excavation and trailing suction hopper dredging are less sensitive to weather conditions than concrete mattress installation.
- Trailing suction hopper dredging will produce a more accurate seabed profile than controlled flow excavation.
- Controlled flow excavation displaces material locally whereas trailing suction hopper dredging requires material transport to another location for disposal.
- Seabed excavators cannot operate on steep seabed slopes therefore may have difficulty working within the sand waves.

Trenching of pipeline below mean seabed level after installation:

- Jet trenching provides simultaneous trenching and backfilling. Mechanical ploughing would require two passes with an interim mobilisation.
- Mechanical plough has a larger footprint therefore requires sand wave removal to mean seabed level over a larger area.
- For mechanical ploughing and backfilling, the minimum target trench depth shall be 1.6m to allow sufficient trench wall interaction with the BFP front skids for stability.
- Potential issues with mechanical plough handling of a pipeline of this size and weight, will dictate further detailed engineering analysis.
- If using a mechanical plough, then the pipeline field joint coating must be suitable for passing through plough roller boxes and thus may need further engineering.

A full list of technical advantages and disadvantages for each method is presented in Appendix B.

The risk of future free spans requiring remedial work is considered low.

4.7.3 Safety

- Standard offshore pipelay operations, no additional safety concerns.
- Seabed modification works are standard offshore operations for known SUPPLIERS, no additional safety concerns.
- Seabed preparation will need to be carried out just before pipeline installation. SIMOPS therefore required for pipelay and seabed preparation support vessels.
- UXO clearance certificate required.

4.7.4 Environmental

This option entails first sandwave levelling to the mean seabed level along sections of the pipeline route as per Option 5 and the associated sub-options. The pipe is then laid on the seabed along the route, including within the pre-cut levelled areas, after which the entire length of the pipeline route would be trenched to a depth of around 1.5 m, below the mean seabed level, within which the pipeline will lie. The additional activity of excavating a trench to below mean seabed level is to be completed using either CFE, jetting or mechanical plough. Due to the combination of levelling and trenching methods, there are a total of nine sub-options associated with Option 6, which are summarised in Table 3-2.

Table 3-2 Option 6 sub-options and installation method

Sandwave levelling method	Trenching method
Controlled Flow Excavator (CFE)	CFE
	Jetting
	Mechanical plough
Trailer Suction Hopper Dredging (TSHD)	CFE
	Jetting
	Mechanical plough
Seabed excavator	CFE
	Jetting
	Mechanical plough

For the trenching operations along the full length of the pipeline, a maximum trench corridor width of 6 m is expected accounting for the varying sandwave heights that may occur along the route. Immediately following pipeline trenching using CFE or jetting, some proportion of the disturbed sediment in the immediate vicinity of the trench would quickly settle over the pipeline to provide a degree of burial and protective overburden. It is expected that the amount of sedimentation would be larger in relation to the jetting method. With the use of the mechanical plough it is proposed that the excavated sediment would be initially side-cast, with a separate backfill run carried out to return the excavated sediment over the pipeline, thereby providing some additional protection, while accelerating the return of the seabed to its original state. For this environmental appraisal it is assumed that the backfill run is carried out immediately post-ploughing, meaning that any berms associated with the side-cast would only be present for a very short period of time.

As only sections along the pipeline route are to be levelled with this option, the environmental impacts encapsulating those previously discussed for sandwave levelling to mean seabed level (Option 5, Section 3.6.4) are applicable. An additional footprint of environmental impact is to be expected with this option associated with the trenching works along the full length of the pipeline, although limited impacts are anticipated with respect to the operation of the pipeline. The description of the environmental impacts for the sub-options will therefore only focus on those associated with the trenching works, noting that the impacts discussed in Section 3.6.4 are also relevant.

Additional environmental impacts that can be expected with this option are as follows:

- The trenching operations will entail a clearance of designated qualifying features and supporting habitats within the corridor footprint along the full length of the pipeline, constituting a direct impact to these features. Although the works have a direct impact, these can be considered to be temporary due to the potential for recovery of the features at varying timescales. As trenching is to occur along the entire route, it will result in the removal of sections of smaller sandwaves, any *S. spinulosa* aggregations and the supporting habitats within the footprint of the trenching operations. However, recolonisation of the sandy sediment, and as such recovery of the baseline community composition, along the pipeline corridor would be expected over time following cessation of seabed preparation and pipeline installation activities. With respect to the sandwave features, studies have demonstrated the potential for sandwave recovery following trenching works.
- The levelled and trenched sandwaves and seabed are again considered to have a limited impact on the long-term morphodynamic regime that occurs across the wider

North Norfolk sandbank system. Localised changes in the morphology in individual sandwaves, will likely result in the localised but temporary modification of the hydrodynamic and sediment transport regime, ultimately leading to the infilling and recovery of the affected sandwaves.

- Seabed preparation works along the full length of the pipeline are likely to generate seabed disturbance resulting in sediment plumes that would spread beyond the extent of the works. The extent, concentration and duration of these plumes would vary in relation to the method and timing of the works. Depending on the scheduling of the levelling and trenching operations, there is the potential for plumes of the individual activities to coalesce, thereby increasing the plume concentration and duration over a wider extent.
- *S. spinulosa* reefs are generally resilient against natural burial events however reefs are sensitive to damage from siltation events caused by the blocking of feeding apparatus by fine sediment (silt). The known areas of reef are located >5 km from the pipeline route, however, as the burden (i.e. magnitude, duration, burial depth) of the sediment plume settlement is unknown, a level of damage and disturbance cannot be discounted. Short term (<2 years) commencement of recovery would be likely due to larval dispersal allowing the establishment of new reefs elsewhere.
- For the CFE and jetting trenching options, the pipeline would be partially covered immediately post trenching by the natural settlement of the disturbed sediment. It is not expected that the full amount of disturbed sediment would settle back within the trench and over the pipeline. However, any deposited material would provide some initial protection, with the presence of over-burden reducing the potential for scour occurring and free spans developing. It is noted that the amount of sediment which resettles within the trench would be larger for the jetting method, than for CFE, whereas a backfill run for all the methods would increase the over-burden. For the mechanical plough it is proposed that a backfill run would be completed thereby providing a larger depth of cover, greatly reducing the potential for scour and free spans.
- Open trenching without active re-burial constitutes a snag risk for fishing activities along the full extent of the pipeline. Following natural infilling immediately after trenching, the risk would be reduced if sufficient depth is achieved. Therefore, due to the likely partial burial of the pipeline along most of the route, the long-term snag risk for fishing activities is considered to be reduced compared with other surface laid methods.

4.7.4.1 Trenching below seabed level via CFE

On reaching the mean seabed level using a method as considered in Section 3.6, this method entails using the CFE method for the trenching operations to create an approximately 1.5 m deep trench within which the pipeline would lie, with some sedimentation occurring over the pipeline within the trench. Additional environmental impacts with this method are as follows:

- The lower accuracy of a CFE means a larger footprint may be disturbed during trenching resulting in a direct impact to the sediment and benthic communities over a larger area compared with other methods.
- The lower accuracy of a CFE would in turn result in a longer duration of works thereby contributing to a larger plume over a wider extent.
- Depending on the direction and duration of the sediment plume, damage and disturbance to nearby areas of high confidence *S. spinulosa* reef cannot be discounted. Short term recovery would be likely due to larval dispersal allowing the establishment of new reefs elsewhere.
- The use of CFE for trenching would entail blowing sediment to the sides of the trench potentially creating mounds adjacent and along the full length of the pipeline trench. The size of the potential mounds are unlikely to be larger than the surrounding features, although they would have a different orientation to

the features. In time, the sediment mounds would winnow down, infilling the adjacent trench or be incorporated into the nearby sandwaves as part of the sediment transport regime.

- The size, extent and natural processes resulting in the displaced sediment mounds is unlikely to cause any blockage effects (temporary or permanent) to the hydrodynamic or sediment transport regime.
- A build-up of sediment along the trench margins would potentially cause a temporary loss of sediment communities along the full length of the pipeline in association with the area of disturbance. Recolonization of the mounds would be expected in the short term (<2 years) following cessation in activities.

4.7.4.2 Trenching below seabed level via jetting

On reaching the mean seabed level using a method as considered in Section 3.6, this method entails using the jetting method for the trenching operations to create an approximately 1.5 m deep trench within which the pipeline would lie, with sedimentation occurring over the pipeline within the trench. Jetting is a more accurate and targeted method, with simultaneous backfill during operation, so there is likely to be a larger volume of sedimentation and therefore thicker over-burden. The amount of over-burden deposited over the pipeline with this approach would be larger than that for CFE, but still less than that for a mechanical plough, due to the active backfilling associated with the plough method.

As the greater proportion of the route would be trenched through jetting, a plume is still likely due to the fluidisation and disturbance of the seabed. However, the plume is expected to be smaller compared to the plume resulting from the use of CFE, as described in Section 3.7.4.1. The differences in environmental impact associated with this methods are as follows:

- As the jetting method involves fluidisation of the seabed, sediment is temporarily entrained, a large proportion of which would be deposited within the trench or immediately adjacent to it. The sedimentation associated with this method would therefore be larger than for the CFE method. The deposition is likely to result in the natural sedimentation and sorting of the material. Where this occurs adjacent to the trench, it would result in an asymmetric low mound. In time the deposited material would be winnowed down returning to the background seabed depths, without any impacts on the hydrodynamic and sediment transport regime.
- Due to the potential smaller plume extents associated with jetting, the damage and disturbance to nearby areas of high confidence *S. spinulosa* reef is less likely than for CFE trenching, although it cannot be altogether discounted. However, there is the potential for plumes of the individual activities to coalesce, thereby increasing the plume concentration and duration over a wider extent. As such, disturbance and damage to nearby high confidence reef habitats cannot be discounted.
- With the jetting method, a large proportion of the disturbed material would be retained within the trench or deposited immediately adjacent to it. In the instance material is deposited adjacent to the trench, this would cause the burial and temporary loss of sediment communities along the full length of the pipeline. Recolonization of the mounds would be expected to commence in the short term (<2 years) following cessation in activities.

4.7.4.3 Trenching below seabed level via ploughing

This method entails reaching the seabed level using a method as considered in Section 3.6, after which a mechanical plough is used to excavate the seabed to below the seabed level. With the use of a plough trenching tool, a wider sandwave levelling corridor width will be required, at between 50 and 60 m (compared with 30 – 40 m for the CFE or jetting trenching methods (Section 3.6)).

On the basis of the plough trenching tool, the additional or different environmental impacts that can be expected in addition to that described in Section 3.6.4 are as follows:

- Due to the wider levelled width required for the plough trenching tool, there will be a relatively larger area of direct impact to the sediment and benthic communities across the sandwave levelled areas.
- There will also be a longer period of disturbance associated with the sandwave levelling, resulting in a marginally larger plume that would cover a wider extent, thereby resulting in partial increases in the sediment concentration and duration. In terms of the levelling impacts along sections of the pipeline, there is a greater potential damage and disturbance to nearby areas of high confidence *S. spinulosa* reef. Short term recovery would be likely due to larval dispersal allowing the establishment of new reefs elsewhere.
- During trenching, the use of the plough will likely create berms of excavated material immediately adjacent to the trench, although these are assumed to be present for a short-period of time between the plough trenching and backfill run. Depending on the volume of material removed these could have heights that are considerably greater than the surrounding seabed. As the proposed method is to replace the excavated material over the laid pipeline and reinstate the seabed to its original state, there is unlikely to be any blockage effects to the hydrodynamic regime. In time the slightly raised profile associated with the reburial of the pipeline would be winnowed down to the surrounding seabed.
- As the plough trenching tool involves cutting into the seabed and not fluidising the sediment, the plume generated through the trenching operations would be considerable smaller than the CFE and jetting trenching methods, with much smaller impact extents.
- As this method involves side-casting material which would only be present as a berm adjacent to the trench for a very short-period of time, the environmental impacts can be considered to be limited. Side-cast sediment will be located within the footprint of disturbance caused by the plough skids and thus do not represent an additional impact.

4.7.5 CAPEX

- Additional CAPEX required for the chartering of seabed modification equipment spreads and support vessels to be in field alongside pipeline installation.
- The cost of this option is dependent on the technology selected, it ranges between £5m to £10m (for clarity this incorporates the cost of clearing the sandwaves and the cost of the subsequent pipe burying operation).

4.7.6 OPEX

- Through life survey requirements are likely to be less for a buried pipeline compared to the exposed option. The risk of future free spans developing and requiring mitigation is significantly reduced therefore the risk of permanent deposits being required (rock) is also reduced.
- No additional decommissioning cost expected above what is required for standard pipeline decommissioning.

4.8 Pipeline Self Burial

4.8.1 Description

The option involves attaching an external fin to the pipeline during installation which, when installed on the seabed, will disrupt water flow over the pipeline causing suspended sediment to drop and bury the pipeline.

4.8.2 Technical

- CONTRACTOR has no recent experience with the use of this method.
- Depth of self-burial achieved is highly unlikely to be enough to mitigate the larger sand waves which have heights in excess of 4m.
- Pipeline fatigue damage due to free spans may be exceed allowable limits before the pipeline self-buries.
- Self-burial would have to be considered in combination with one of the sand wave removal options (sections 3.6 and 3.7).
- The risk of future free spans requiring remedial work is considered medium.

4.8.3 Safety

- The installation of pipeline fins is not a standard operation for CONTRACTOR's pipelay vessels therefore presents an increased risk.
- UXO clearance certificate required.

4.8.4 Environmental

Following initial surface lay, the pipeline will present a snag risk to fishing gear along the full length of the pipeline, as for the other surface lay options considered. A potential solution to enhance self-burial is the addition of a spoiler. A spoiler consists of two parts: a template and a fin. The template is fastened to the pipe and the fin protrudes upward (Bijker, 2000). The addition of a spoiler to a pipeline increases both the scour depth beneath a pipeline and downstream of a pipeline. The presence of the spoiler hinders localised flow over the top of the pipe which accelerates scour underneath allowing the pipeline to lower into the scour hole (Chiew, 1992; Bijker, 2000). Typically, self-burial of a pipeline (without a spoiler) requires a seabed of 20% silt. A spoiler would allow self-burial to occur in seabed sediments of up to 40-50% silt (Bijker, 2000).

More recent hydraulic model experiments conducted under ideal steady flow conditions similarly found the asymmetrical pressure dynamics as a result of using a spoiler increased the overall downward force on the pipeline. In the laboratory experiments, the use of spoilers was found to enhance self-burial under the steady current (Lee *et al*., 2019). However, evidence for use of spoilers to enhance self-burial in the marine environment, more characteristic to unsteady flow, is presently unavailable, with limited proof of its success. A review of the potential environmental impacts of this option is therefore based on empirical evidence.

- Direct impact to the designated qualifying features and environmental features of conservation importance would be limited to those located within the footprint of the pipeline, including the potential for *S. spinulosa* aggregations within the pipeline corridor. However, following burial, the sandy sediment habitat and associated communities will be replaced and can recolonise. This is assessed as a medium to long-term impact as the time required for full pipeline burial is unknown.
- The pipeline would replace the underlying surface sediment with a novel hard substrate until full burial is achieved. Once buried, the pipeline would have

limited ecological connectivity and would not constitute an ongoing ecological impact.

- Assuming this option is used with no seabed modification, even from installation, free spans are expected due to the steep asymmetric profiles of the present sandwaves and the properties of the pipeline. In this instance, remedial works including the use or rock berms may be required, which would lead to the introduction of a permanent rock substrate.
- For the pipeline sections directly on the seabed, the presence of the fins may potentially reduce the risk of free spans by generating scour holes which the pipeline sinks into. Nonetheless, there is a high potential for remedial works over the operational life of the pipeline through the introduction of rock placement and/ or mattresses which would replace the existing sandy sediment habitat with a novel hard substrate.
- The high number of free spans occurring would also present a significant snagging risk to fishers. It is also likely that the external fin, as a vertical extension from the top of the pipeline, will pose an additional snag risk prior to burial, particularly for gears such as beam trawls. The intention of the spoiler is to be light and flexible allowing easy mounting prior to the pipeline installation. In addition, the spoiler is able to withstand interaction with fishing gear owing to its flexibility; it should be pushed aside and spring back into position. Bevelled edges further minimise the potential for interaction with gears (Bijker, 2000). Over time, if a sufficient depth of burial above the external fin is achieved along the full length of the pipeline, the snag risk may be removed.

4.8.5 CAPEX

- Additional CAPEX for procurement of pipeline fins approximately £1.8m (GBP).
- Slower lay speed during pipeline fabrication therefore increased vessel time and associated cost.
- Testing and qualification programme required to build confidence in this method before deployment offshore.
- Self-burial would have to be considered in combination with one of the sand wave removal options (sections 3.6 and 3.7).

4.8.6 OPEX

- Regular surveys of the pipeline will be required to monitor the progress of pipeline self-burial. If the pipeline fails to self-bury and unacceptable free spans develop then remedial works will be required.
- Free span remedial works will most likely involve rock installation since concrete mattresses cannot be installed underneath an existing pipeline. No current technology is available for the removal of rock from the seabed therefore any rock installed would be a permanent deposit.
- No additional decommissioning cost expected above what is required for standard pipeline decommissioning.

5. SUMMARY

Options for seabed preparation for installation of the 24" Southwark Gas Export Pipeline have been presented and described. A summary of these options are presented in Table 4-1, presented on the next page (incorporating environmental score, CAPEX, OPEX and high level risk details).

In consideration of the options presented in this report, the information indicates that the overall lower risk option for the pipeline installation is the removal of the sand waves and subsequent burial of the pipe below the mean seabed level, i.e. option 6.

The technologies as outlined in option 6 are considered viable, however each technology has its own unique advantages and disadvantages and therefore with associated differing degrees of risk to project economics and the associated schedule.

Consequently, all technologies identified in options 6 should be considered against the lens of market availability upon scope sanction.

Further engineering will develop the best suited technology solution for the project which accommodate project schedule.

However, recognising that the comparative assessment workshop needs to evaluate all technically feasible options, the 3 options recommended to be carried forward into the Comparative Assessment Workshop are Options 3, 5 and 6.

Further discussion around the justification for the environmental appraisal scoring is provided in Appendix E. Yellow cells in the environmental appraisal scoring matrix in Appendix E present aspects that are "showstoppers" from an environmental consenting perspective.

For clarity, with regards to the scores identified within Table 4-1 relating to the Environmental Performance. It should be noted that a low score indicates an improvement on overall Environmental Performance.

Option	Method	Environmental Score (Unweighted)	Mtl Deposited	Sandwave Removal	Pipeline Below MSBL	Progress to CA Workshop	Technical Fesability	CAPEX Cost	% of CAPEX cost	OPEX Risk (uncosted)
1	Pipeline on seabed, on sand waves	23	-	-	-	-	Very High; Pipe fails due to faituge;	£0	0%	Not viable
2	Re-Route pipeline	23	-	-	-	-	Re-routed to miss sand waves;	Unknown	0%	Unknown
3	Rock infill between sand waves	31	X	-	-	X	Flat surface for pipeline to sit on; OPEX costs are unknown, due to migrating sands creating Freespans.	£7.7m	HOLD	Unknown
4	Concrete mattress	32	X	-	-	-	Flat surface for pipeline to sit on; Prohibitively expensive; OPEX costs are unknown, due to migrating sands creating Freespans. Requires 22,500 mattresses Installation campaign of >3.75 years	£188m	HOLD	Unknown
5	Sand waves removed Pipe laid on seabed		-	X	-	X	Sandwaves removed. Dynamic soils still exist. Risk of freespanning diminished, but still exists; OPEX costs are unknown, due to migrating sands creating Freespans.			Unknown
5a	Controlled Mass Flow Excavation	26						£5m	HOLD	
5b	Trailing Head Suction Hopper	25						£3m	HOLD	
5c	Seabed Excavator	25						£7.5m	HOLD	
6	Sand waves removed, Pipe trenched		-	X	X	X	Project risk lower; Established trenching technologies; More certainty on schedule; Low risk of freespanning occuring;			Relatively low cost
6a	CFE + Controlled Mass Flow Excavation	24						6.3m	HOLD	
6b	CFE + Jetting	20						£7m	HOLD	
6c	CFE + Plough	19						£8.2m	HOLD	
6d	THSH + Controlled Mass Flow Excavation	23						£4.3m	HOLD	
6e	THSH + Jetting	20						£5m	HOLD	
6f	THSH + Plough	18						6.2m	HOLD	
6g	Seabed Excavater + Controlled Mass Flow Excavation	23						£8.7m	HOLD	
6h	Seabed Excavater + Jetting Pipeline	20						£9.4m	HOLD	
6i	Seabed Excavater + Ploughing / Backfill Pipeline	18						£10.6m	HOLD	
7	Pipeline self-burial	22	-	X	-	-	Requires option 5; High risk to schedule since untested solution; Unknown schedule exposure to engineer solution Untested technology; High degree uncertainty on costs;	£4.8m	HOLD	Unknown

Table 4-1 – Summary of Seabed Preparation Options

NOTE:- A low Environmental Score, indicates a better environmental performance.

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APPENDIX A.

PIPELINE FREE SPAN ASSESSMENT

FREE SPAN ASSESSMENT METHODOLOGY

The flow of water around a free spanning section of pipeline can cause the pipeline to move due to vortex induced vibration. This vibration causes fatigue damage to the girth welds between the individual pipes joints which form the pipeline. Excessive fatigue damage to these welds could cause a loss of pipeline integrity.

The occurrence of vortex induced vibration in a pipeline free span in dependent upon the relationship between the structural natural frequency of the free spanning section of pipeline and the flow velocity around the pipeline. The flow velocity is the combination of wave and current action. Generally, as the length of a free span increases, the natural frequency reduces, therefore the free span experiences vortex induced vibration at slower flow speeds. For a known set of environmental conditions, longer free spans will experience greater fatigue damage than shorter free spans.

Where multiple pipeline free spans exist close to one another the vibration behaviour is connected. These free spans are said to be interacting. Interacting free spans have a lower structural natural frequency than isolated free spans and therefore experience greater fatigue damage.

A preliminary on-bottom roughness assessment has been carried out in accordance with DNVGL-RP-F105. Finite element analysis is carried out using Abaqus 2016 to model the pipeline resting on the seabed. Pipeline free span data is extracted from the analysis results file, this data includes free span lengths, gap heights, water depths and mode shapes for in-line and cross-flow vibration. This data is used to carry out free span fatigue damage assessment using DNVGL FatFree. The output from this assessment is a maximum allowable exposure time for each free span.

The free span fatigue damage assessment has considered the pipeline empty on the seabed in the month of September. This is the least onerous condition considering available monthly environmental data, therefore if span fatigue damage is unacceptable for this case then seabed intervention work is recommended at the predicted span location before the offshore installation operation.

FREE SPAN ASSESSMENT RESULTS

The results of the preliminary free span fatigue damage assessment are presented in Figure A.1, each marker represents an individual free span. The results presented show the most critical free spans along the pipeline route, shorter free spans with longer fatigue life also exist but have been omitted for chart clarity. The results show that the allowable exposure time for several free spans is less than 1 day. These free spans are long and are interacting with other spans. It can therefore be concluded that installation of the pipeline on this seabed profile is not technically feasible without pre-lay seabed preparation.

It is important to note that the results presented are based upon a preliminary assessment which considers seabed survey data from Q2 2020. Due to the mobile nature of the seabed the vertical profile will have changed before the pipeline is installed in Q3/Q4 2021. This assessment will be updated during the detailed design stage of the project when updated survey data is available.

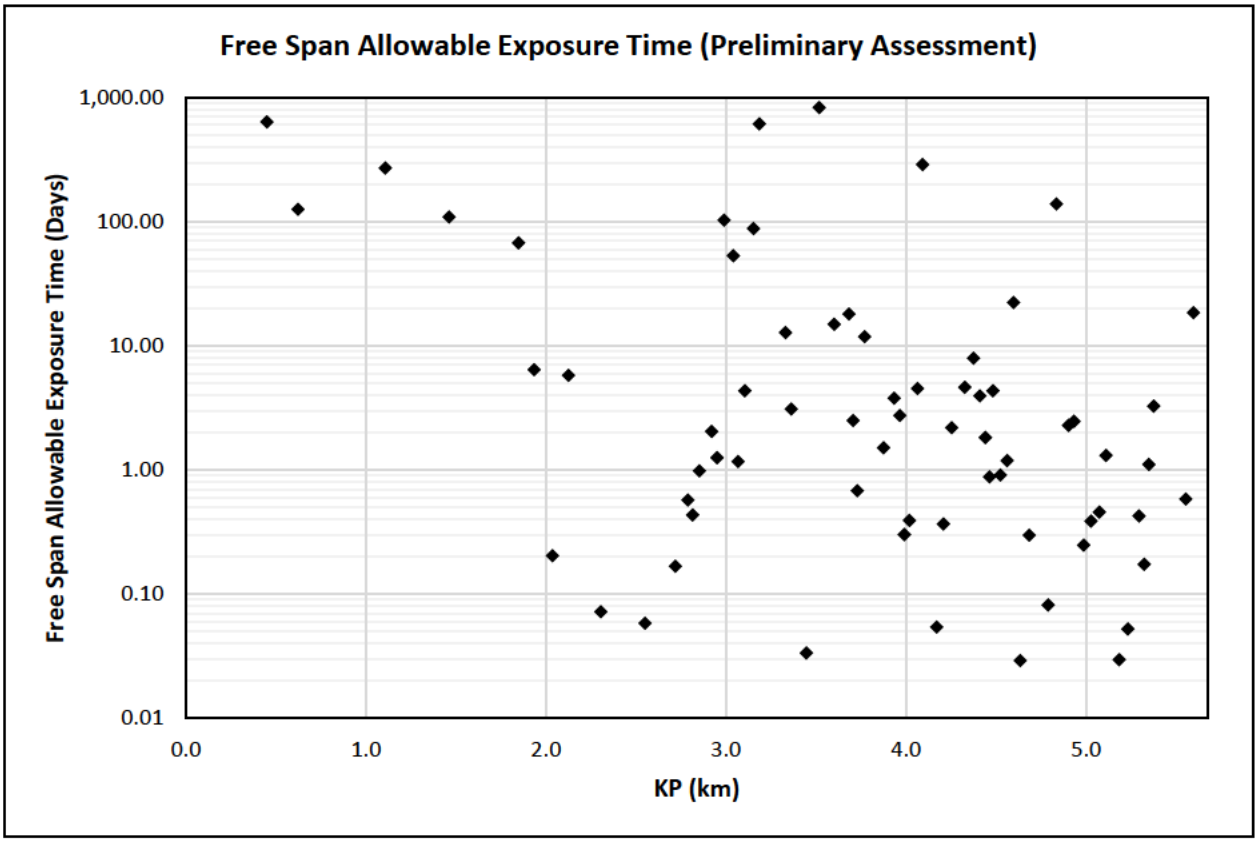


Figure A.1 – Free Span Allowable Exposure Time, Preliminary Assessment (KP 0 at Southwark Platform End of Route)

APPENDIX B.

DESCRIPTIONS OF SEABED MODIFICATION METHODS

RE-ROUTE PIPELINE

This option involves changing the route of the pipeline to avoid large sand waves therefore reducing or removing the need for seabed modification. The pipeline end locations (Southwark Platform and Thames Pipeline Tie-In) are considered fixed points.

The available survey data for the area close to the proposed pipeline route is presented in Figure B.1 to Figure B.3. Colours are used to present water depths within these figures with red being shallower water and blue deeper water. Sand waves are identified by the sharp changes in colour which generally run across the pipeline route.

The following constraints must be considered when re-routing the pipeline:

- Availability of seabed survey data (2018 and 2020 surveys).
- Pipeline end points are fixed.
- Shallow water at the Northern section of the route which may limit / prohibit access for pipelay vessels.
- Minimum pipeline radius limit for changes in heading (approx. 1800m).

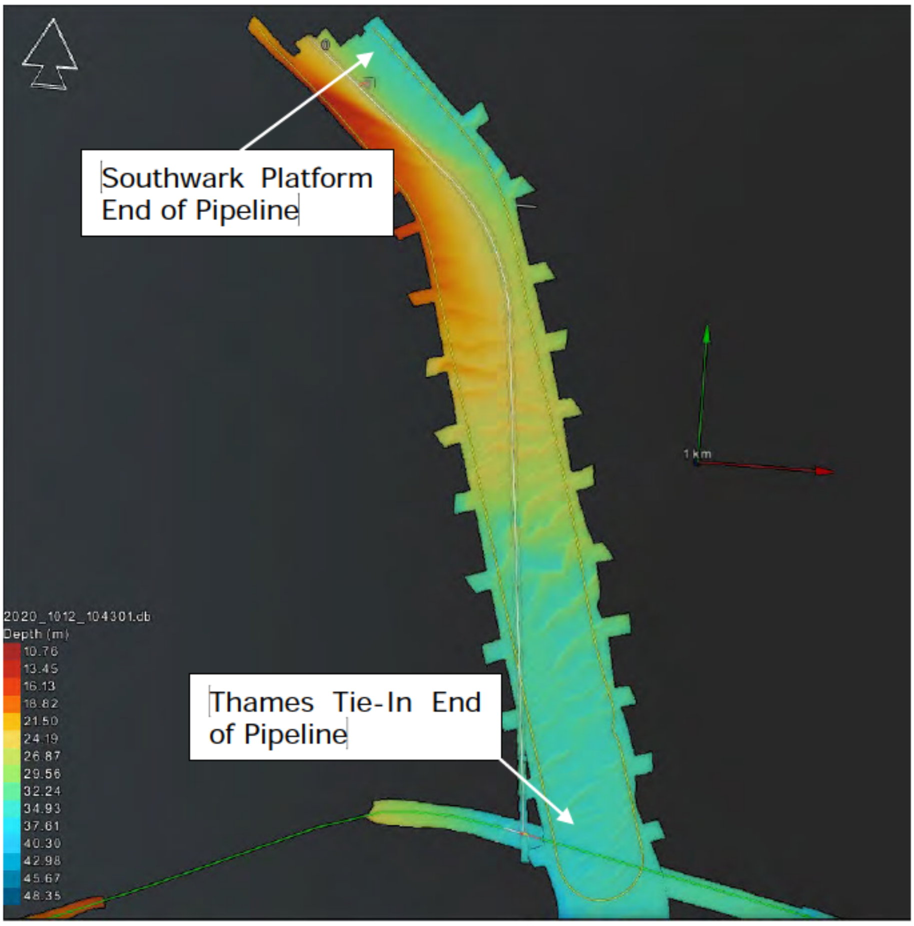


Figure B.1 – Extents of Survey Data

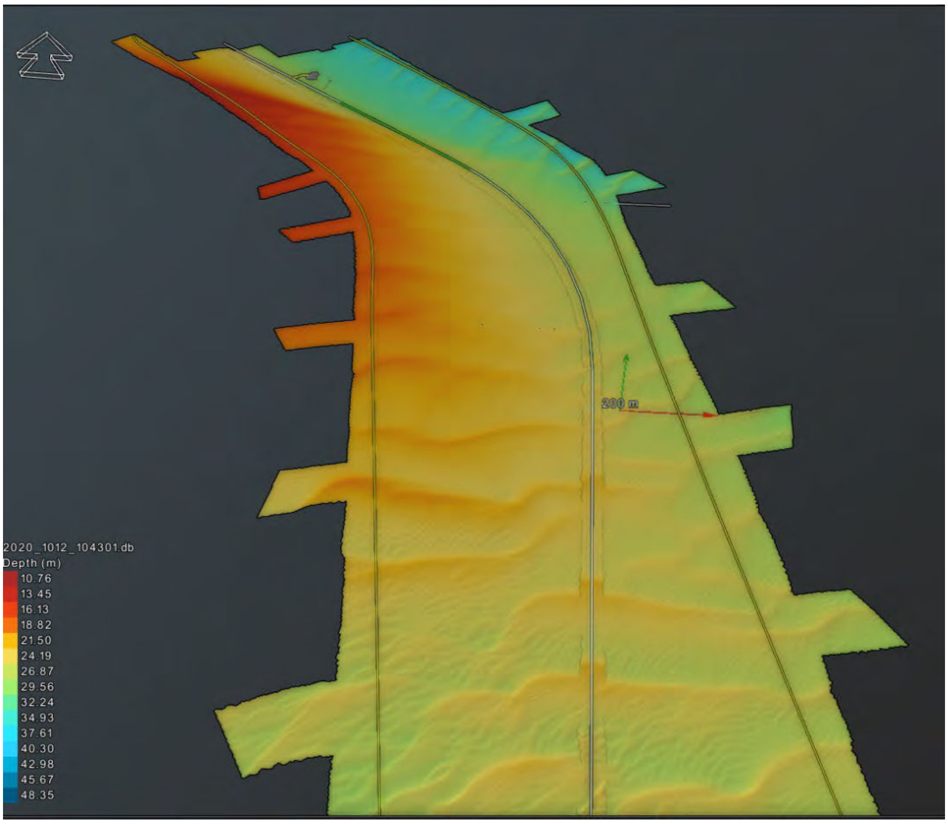


Figure B.2 – Survey Data for Northern Section of Route

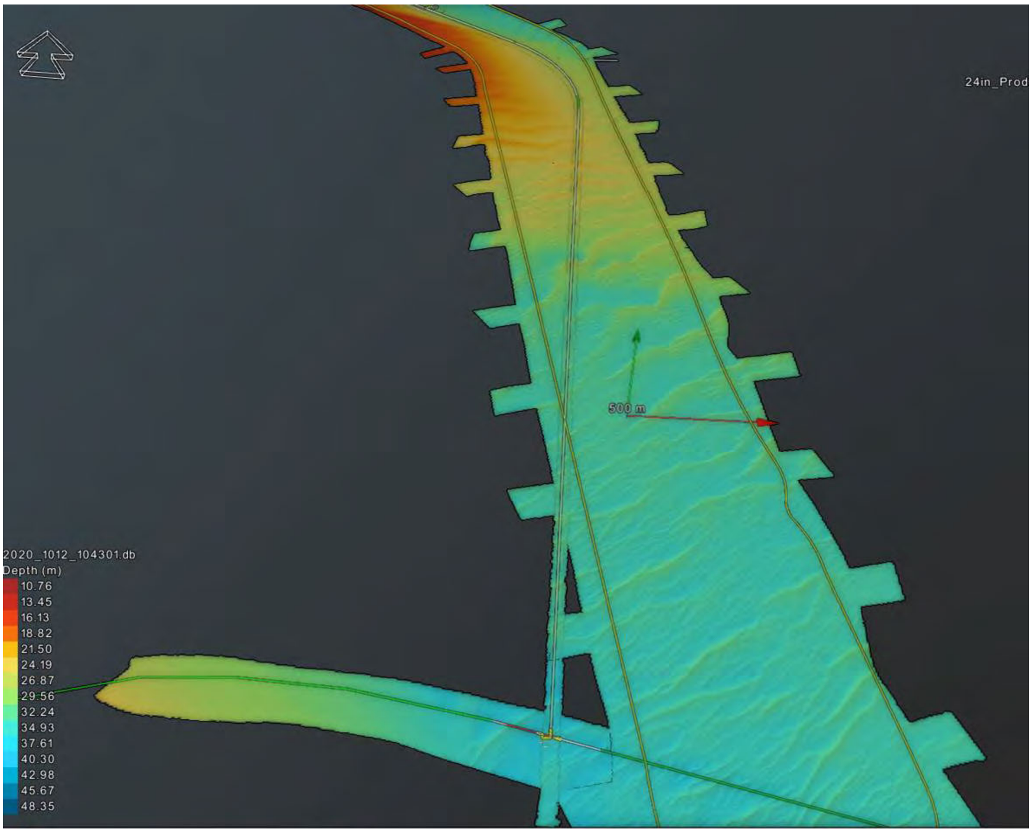


Figure B.3 – Survey Data for Southern Section of Route

SUBSEA ROCK INSTALLATION

Subsea rock installation is provided by utilising a dedicated fallpipe vessel (FPV) to load, transport and install engineered rockberms for a variety of protection and mitigation methods. These vessels typically hold between 4,500te to 33,500te of rock material and deploy rock to the seabed using a series of either rigid pipe sections or flexible buckets lowered through a moonpool in the centre of the vessel or via a fixed inclined chute at the side of the vessel.

The rate of rock installation depends on several parameters such as vessel tracking speed, speed of the rock feeding conveyor belts, fallpipe offset height above MSBL and the applied vertical/horizontal installation tolerances. Positioning of the fallpipe is controlled by the fallpipe ROV (FPROV) situated at the bottom of the fallpipe string. The FPROV has a suite of survey equipment which performs the pre-dump, intermediate and post-dump surveys to confirm the installed rock is as per requirements.

For rock installation in between sand wave troughs, a designed rock berm can be installed to the required height and width to provide a level foundation prior to product lay. Installed rock in these locations can also prevent future sand wave marching by locking them in place.

FPV’s can operate in water depths between 20m to 1,600m and are DP class II vessels. For shallower water depths, side stone dumping vessels can be utilised instead which consists of a hydraulic or tilting system to push rock off the side of the vessel directly above the target location.

UK/Norway rock installation Supplier’s include Van Oord, Deme Group, Jan De Nul and Boskalis.

Figures B.4 and B.5 present typical rock installation operations. Advantages and disadvantages of rock installation are presented in Table B.1.

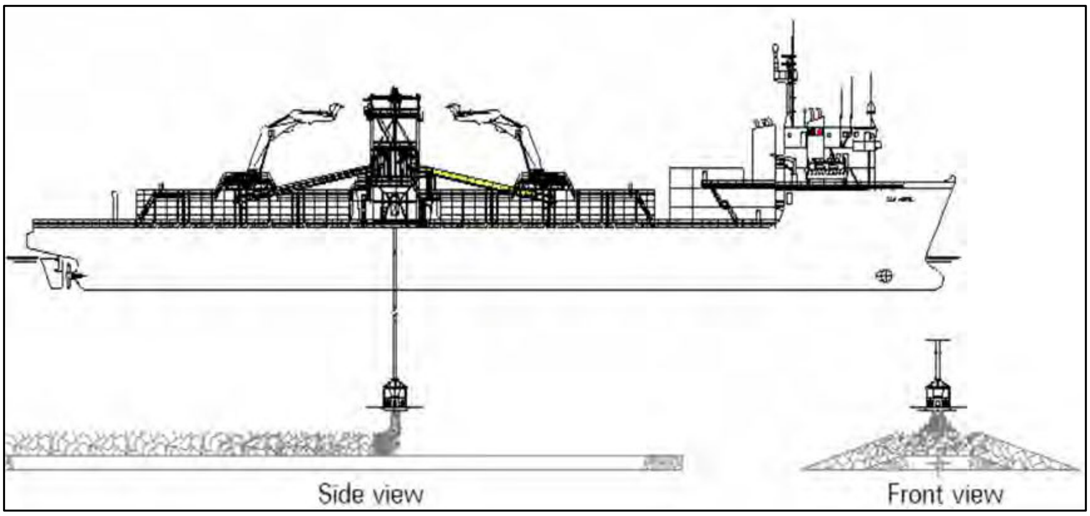


Figure B.4 – Typical Rock Installation Operation

Figure B.5 – Rock Installation Vessel (Van Oord)

Subsea Rock Installation	
Advantages	**Disadvantages**
• Ability to vary the rock installation rate to suit recently surveyed seabed profiles. • Supplier can analyse the seabed in real time with 3D software to accurately monitor installation progress and adjust performance. • Rock installation de-risks the seabed as no interaction is required. Method requires only limited knowledge of soil conditions. Can operate in both relatively deep water and shallow water areas. • Rock can be installed in zero visibility using sonar and positioning equipment. • FPV can operate in high sea states of up to 4.5m Hs and can weather vane as not heading restricted. • Minimal suspended soil sediment and turbidity in water column. • High vessel availability on the market.	• Rock cannot be removed during decommissioning. • Rock installation accuracy can be affected by subsea current strength/direction. • Rock installation in shallow water (<20m) with a side stone dumper is less accurate compared to an FPV. • Risk of overdumping and/or washout in shallow water depths. • Risk of rockberm instability in areas with seabed mobility and high currents. An engineered rock grade may be required. • Potential for high noise levels which may disturb subsea habitats/life. • Several vessel passes are likely to create a suitably high and wide stable base in between sand waves. • If a large amount of rock tonnage is required, re-load trips must be performed. This increases overall schedule duration. • Rock tonnage amount permitted to install is subject to acceptance by the relevant governing bodies. • Mobilisation and operational costs are considerable.

Table B.1 - Rock Installation Method Evaluation

CONCRETE MATTRESS INSTALLATION

Concrete mattresses comprise multiple individual concrete blocks which are connected with polypropylene rope to form a rectangular mattress. Typical concrete mattress dimensions are 6m length x 3m breadth x 0.15-0.5m height.

Concrete mattresses are installed using a specially designed handling frame attached to the crane of an offshore construction vessel. A suite of survey equipment is installed on the mattress handling frame to monitor the position and orientation of the mattress during installation. After the mattress has been landed on the seabed the lift rigging is released by an ROV or divers.

UK suppliers of concrete mattresses include SPS and Pipeshield.

Figure B.6 presents concrete mattress installation from a vessel crane. Advantages and disadvantages of concrete mattress installation are presented in Table B.2.

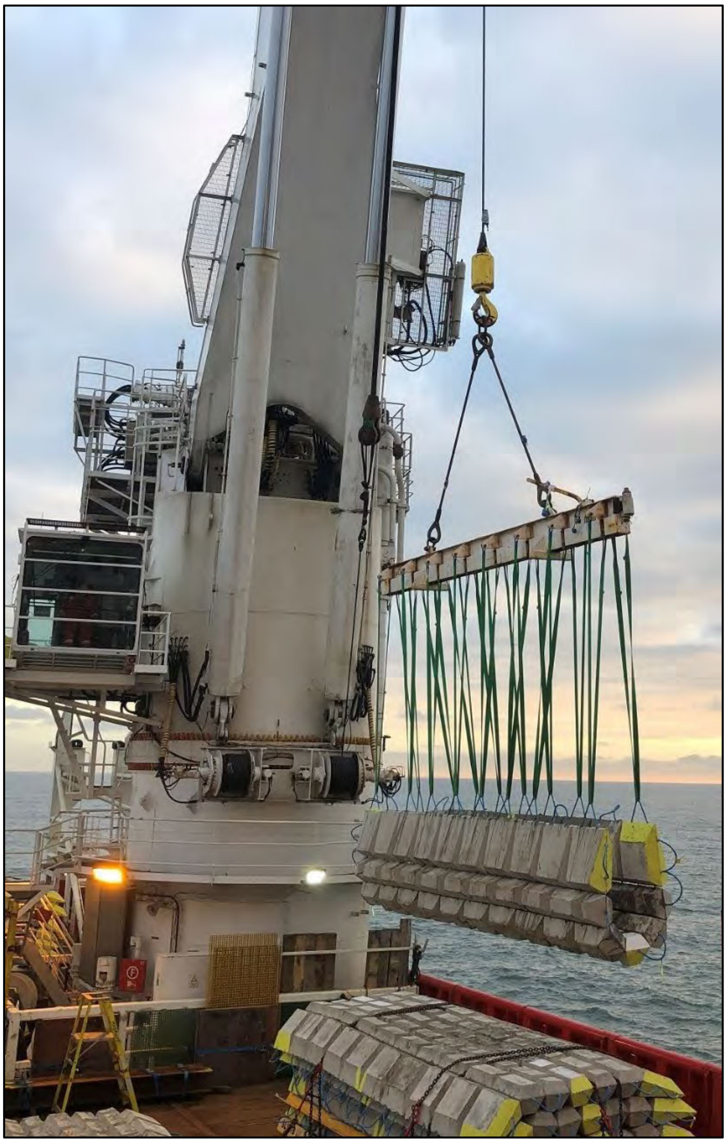


Figure B.6 – Concrete Mattress Installation

Concrete Mattress Installation	
Advantages	**Disadvantages**
• CONTACTOR vessels have extensive experience installing concrete mattresses. • Mattress design can be adjusted to suit project requirements (thickness, density, shape of edge blocks). • Theoretically recoverable at the end of life, though technology is not field proven. • Not limited by water depth.	• Installation is highly sensitive to weather and tidal currents. • Stacks of multiple mattresses are known to be unstable. • Mattresses may be dislodged through interaction with fishing gear. • Fronded mattresses introduce plastic into the environment.

Table B.2 – Concrete Mattress Installation

CONTROLLED FLOW EXCAVATION

Controlled Flow Excavators (CFE) tools utilise an impeller to generate a large column of water which is expelled directly below the tool. They direct a low volume high pressure water flow vertically downwards towards the seabed; opposed to the historical mass flow technology which provides a high volume at low pressure. Subsea deployment is either from a dedicated LARS or suspended from a vessel crane.

CFE tools are positioned directly above the required excavation area and will fluidise non-cohesive material blowing it away within the area of influence or will weaken and break up cohesive soil material. Typical flow rates range from 2,000ltrs/s to 10,000ltr/s and jetting pressure between 1-2bar.

Vessel tracking speed, CFE tool height and pressure settings can influence the clearance corridor and depth achieved in a single pass; typically 2m to 3m wide depending on specific CFE tool utilised. Excavation rates vary between 700m^3/hr to 1000m^3/hr in non-cohesive soils and 50m^3/hr to 300m^3/hr in cohesive soils. Increased rates can be achieved by introducing additional jetting attachments.

Only CFE equipment spread and personnel are typically provided by the Supplier with no dedicated vessel included. UK CFE Supplier's include Rotech, James Fishers, Seatools and DeepC.

Figure B.7 presents a typical CFE tool. Advantages and disadvantages of CFE tools are presented in Table B.3.

Figure B.7 – Typical CFE Tool (Rotech)

Controlled Flow Excavation Method	
Advantages	**Disadvantages**
• Non-contact method of excavation providing high levels of safety for sensitive products. • Ability to continuously vary the power supplied to propeller, MSBL height offsets and vessel speed to instantly to maximise results. • Real-time sonar imaging of the excavation progress achieved. Instant feedback provides operators a chance to review and adjust performance. • Can be used with a high-pressure jetting system to increase clearance capabilities. • No need to dispose material excavated. • Tool can be utilised from a small, economical and cost effective vessel. • Minimal deck space and power/utility requirements for the operating spread. • Tool can be deployed via a dedicated LARS or vessel crane.	• Not typically suited for accurate applications where precision is required. A wider trench profile then desired may be created. • Erratic clearance profiles may be obtained based on vessel movement and environmental conditions experienced. Potential issues for UHB/OOS sensitive products. • Multiple passes likely required to achieve clearance specification (width and depth). • Tool is sensitive to high currents and shallow water which may affect tool performance/stability. Suitable water head required on pump system. • Difficult to control soil dispersion. Soil heaps may build up within clearance corridor. • No visibility during excavation, typically relying on survey equipment for positioning. • Multiply surveys of seabed profile may be required to monitor excavation progress.

Table B.3 – CFE Method Evaluation

TRAILING SUCTION HOPPER DREDGERS

Trailing Suction Hopper Dredgers (TSHD) operate by deploying either one or two suction pipe/s connected to drag heads to the seabed which applies a suction pressure to excavate seabed sediments within the area of influence. A slurry of sediment and water is pumped through the suction pipes back up into the vessel hopper.

The passive drag head is kept in contact with the seabed at all times by hydraulic system that compensates for swell and tidal variations. No additional power is applied at the head and material to be excavated is scoured by hydraulic currents induced at the drag head.

They are primarily used for dredging loose material such as sand, clay or gravel. The disturbed material is dredged to and transported up the suction pipe/s and stored in hopper, where dredged material settles out of suspension and the water drains off through a controllable overflow system. Settlement of material is dependent on grain size and therefore timings for various sediments can differ.

Once the vessel storage capacity is reached, the TSHD will either:

- Relocate to the pre-defined disposal site in field to discharge the dredged material via opening hopper bottom doors or the rainbowing technique.
- Relocate to a pump ashore catchment facility or another storage barge where the sediment will be discharged through a floating pipeline

TSHD are typically utilised in loose non-cohesive soils or soft clay soil conditions, which are readily influenced by a passive drag head system. The vessel performs several passes to achieve the required dredging depth and width.

Sediment storage capacities range from 2,500m^3 to 50,000m^3 with a working water depth of between 20m to 100m.

UK TSHD Supplier's include Deme Group, Boskalis, Van Oord and Jan De Nul.

Figure B.8 presents a typical TSHD. Advantages and disadvantages of TSHD are presented in Table B.4.

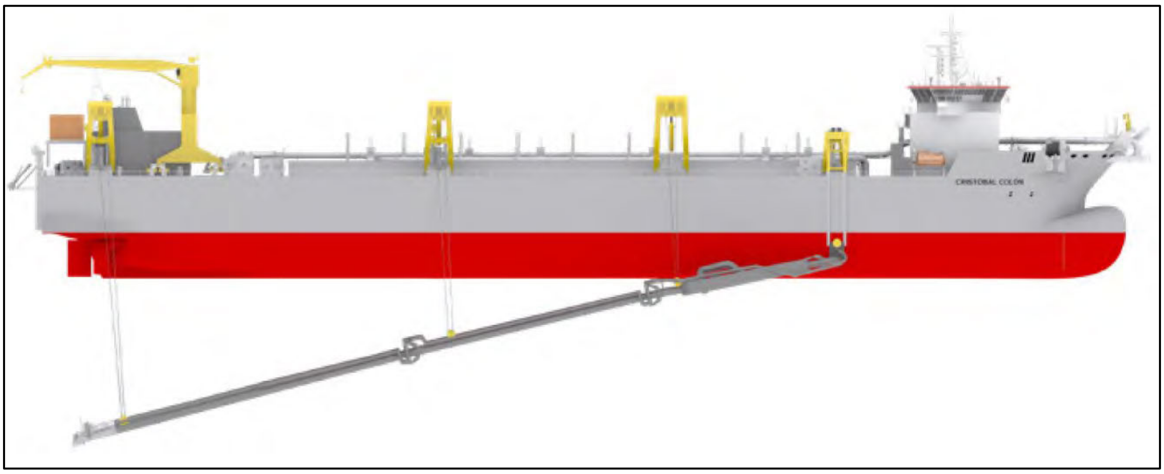


Figure B.8 – Typical TSHD (Deme Group)

Trailing Suction Hopper Dredger Method	
Advantages	**Disadvantages**
• TSHD suitable for excavation of both cohesionless and cohesive sediments. • The dredged load may be pumped ashore as reclamation. • Not restricted by subsea currents or adverse weather compared to other forms of excavation. • TSHDs operate without the requirement to anchor, they can move freely. • Can operate in both deep water and shallow water areas. • Relatively high production rates; depending on type of material and environmental conditions. • Minimal suspended soil sediment and turbidity in water column. • High vessel availability on the market.	• The final excavation profile may not be precise, with a large area dredged. • Localised dredging may still be required to compensate for infill prior to product installation or to remove soil heaps created. • Technique not particularly suited to removing thin soil layers only, a large area is affected. • Several vessel passes are likely to create a suitable wide clearance corridor. • TSHD vessels typically do not have DP capabilities. • Mobilisation and operational costs are considerable. • A specialised dredging permit may be required for sediment disposal.

Table B.4 – TSHD Method Evaluation

CUTTER DREDGING VESSEL

Cutter Dredge Vessels (CDV) operate under the same principles as a TSHD but with an active drag head/s instead, which uses power to drive cutting teeth/rotating wheel or high pressure water jets to excavate the material and aid in forming the solid/water slurry. This slurry of sediment and water is pumped through the suction pipes back up into the vessel hopper.

CDVs are typically utilised in firm to hard cohesive soils or soft rock which require active influence by mechanical interaction, although can be adapted for very dense non-cohesive material. The cutting heading can be optimised for various soil conditions:

- Flared chisels for peat, sand and soft clay;
- Narrow chisels for over-consolidated sand and firm clay;
- Teeth with picks for soft rock.

The vessel must remain stationary by means of spud cans or anchors, with the suction pipe slewing across the required dredging width. Vessel power capacities range from 1,500kW to 45,000kW with a working water depth of between 10m to 50m.

UK CDVs Supplier’s include Deme Group, Boskalis, Van Oord and Jan De Nul.

Figures B.9 and B.10 present a typical CDV vessel and cutting drag head. Advantages and disadvantages of CDV are presented in Table B.5.

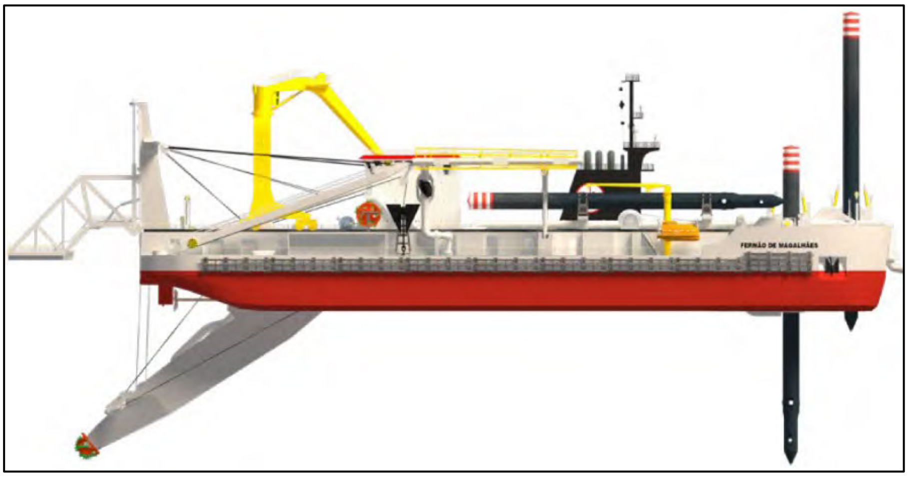


Figure B.9 – Typical CDV (Jan De Nul)

Figure B.10 – IHC Cutting Drag Head

Cutter Dredger Vessel Method	
Advantages	**Disadvantages**
• CDV's are suitable for excavation of hard cohesive sediments and some forms of weak rock types. • Precise final excavation profiles can be achieved as the CDV operation is highly controlled. • Not restricted by subsea currents. • Minimal suspended soil sediment and turbidity in water column. • High vessel availability on the market.	• The vessel must remain stationary by means of spud cans or anchors during dredging operation. Therefore, requires sufficient soil capacity for spud can penetration and a large footprint for an anchor pattern. Additional time is also required for vessel set-up and relocation along the clearance route. • Adverse weather can affect operations. Reduced working limitations compared to other forms of excavation due to heading restrictions when moored. • CDV's can typically only operate in shallow water depths up to 50m. • Mobilisation and operational costs are considerable. • A specialised dredging permit may be required for sediment disposal.

Table B.5 – CDV Method Evaluation

SEABED EXCAVATORS

Seabed excavators are highly mobile tracked vehicles with a soil dredging system installed and controlled via an extendable arm which directs the suction hose end. Loose non-cohesive soil is dredged through the suction hose, with the soil being educted at the rear of tool to a designated disposal area. A suite of survey/sonar equipment is installed to provide accurate positioning and visual aid to monitor dredging progress.

Suction hose sizes usually vary from 4 to 20” apertures with an outreach of between 5m to 20m. Certain subsea exactors are also capable of slewing it’s undercarriage to increase the dredging reach zone. Typical dredging rates of between 5m^3/hr to 40m^3/hr can be achieved based on soil type/strength.

Stiff cohesive soils are broken up by utilising a bespoke cutting application or high-pressured jetting nozzles attached to the suction hose end. General configurations for increased cutting capabilities include:

- Ripper teeth for overconsolidated soil types up to 150kPa soil;
- Cutting head/chain for increased soil dislodging +150kPa;
- High pressures nozzles for increased soil fluidisation.

UK/Norway CFE Supplier’s include Scanmudring, Deep-C and WeSubsea.

Figures B.11 and B.12 present subsea excavators. Advantages and Disadvantages of subsea excavators are presented in Table B.6.

Figure B.11 – Subsea Excavator on Deck (Scanmachine)

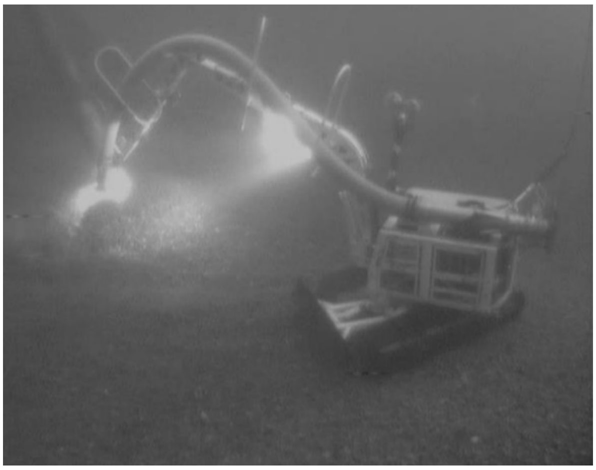


Figure B.12 – Subsea Excavator Subsea (Scanmachine)

Seabed Excavator Method	
Advantages	**Disadvantages**
• Capable of relocating offset the launch/recovery point to worksites independent of ROV support. • Additional tooling can be installed for specific soil types/strengths to improve efficiencies. • Certain seabed excavators can reconfigure it's dredging capability subsea without the need for recovery, where stiffer sediments are experienced. • Seabed excavators are capable of dredging via an extended suction hose for hard to access locations. • Tools can operate in zero visibility using sonar and positioning equipment. • Supplier can analyse the seabed in real time with 3D software to accurately monitor dredging progress. • Subsea excavators can usually be reconfigured and utilised for other subsea applications with customised attachments e.g. cable gripper, rockdump levelling, grabber bucket and diamond wire cutter. • Seabed excavators typically generate low noise and vibration levels, which reduces environmental impact.	• Not typically suited for accurate applications where precision is required. • Dredge/eduction system is prone to clogging with large lumps of clay/cobbles. • Tool performance/stability may be affected by high subsea currents. • Tracked seabed excavators may struggle tracking over undulating seabed and steep gradients (>20°). • Requires a suitably rated vessel crane to launch/recover subsea excavator. Typically, a heave compensated vessel crane is specified by the Supplier. • A large deck footprint to accommodate the dedicated equipment spread is required. An umbilical chute requires to be installed for safe umbilical deployment. • A team of x6 offshore personnel is required to support 24 hours operations. • Multiple surveys of seabed profile may be required to monitor dredging progress achieved. • The dredged/educted soil heap will build up at the designated disposal area which may require a permit.

Table B.6 – Seabed Excavators Method Evaluation

JET TRENCHING

Traditional jet trenchers can be set-up to perform sand wave and mega ripple clearance through non-cohesive sediments. This application is targeted at critical free-span correction.

The deployable jetting swords are lowered and raised accordingly along with pump pressure settings to achieve a smooth trench profile. This can either be achieved along the entire product route in a continuous pass or at predetermined locations of high seabed gradients. Clearance widths can range between 2m to 4m with trenching speeds of 150-400m/hr depending on soil condition and required clearance depth.

Figures B.13 and B.14 present survey data images which show the use of jet trenchers. Advantages and disadvantages of jet trenching are presented in Table B.7.

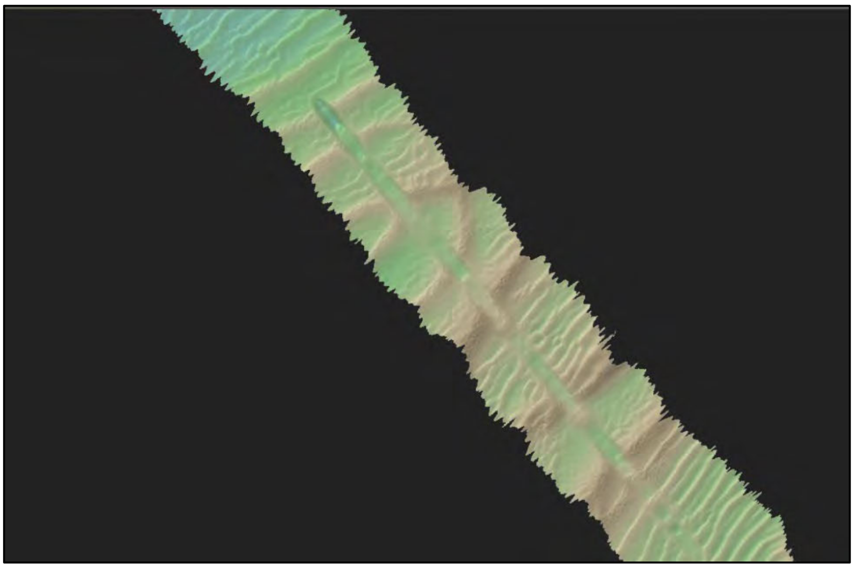


Figure B.13 – Post Sand Wave Clearance GeoTIFF (T1500 Tool – Helix Offshore)

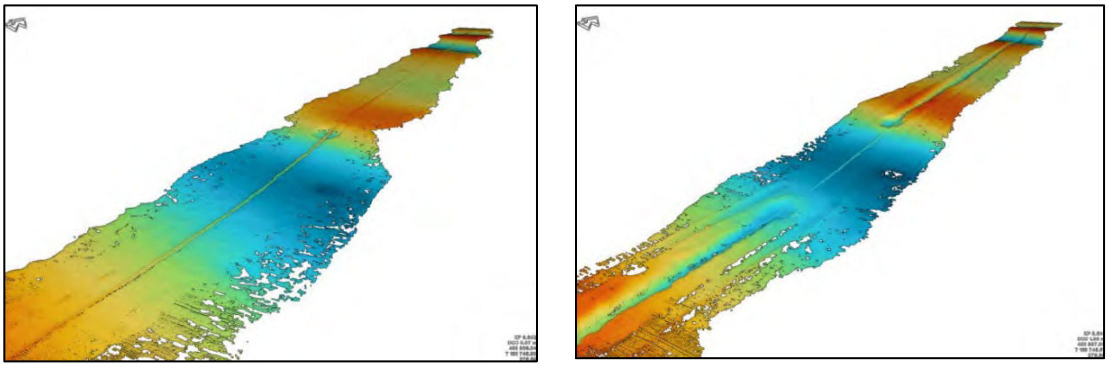


Figure B.14 – Pre and Post Sand Wave Clearance DTM Grab (Q1400 Tool – Global Marine)

Jet Trenching Method	
Advantages	**Disadvantages**
• Main trenching of the product can be executed directly after the sand wave clearance scope is complete, utilised from a single vessel. Potential cost and time savings. • Non-contact method of excavation providing high levels of safety for sensitive products. • Ability to continuously vary the jetting power and height of jetting swords. • A smooth accurate profile is created.	• Careful jetting sword configuration and operational control is required. • Trench depth limitations due to the tracks remaining on MSBL, unable to clear a wide corridor; only the area in-between the internal tracks can be cleared. • Not a standard operating procedure requires expertise and knowledge of soil conditions. Limited Suppliers with track records available. • If only performing sand wave clearance, then operationally will be costly.

Table B.7 – Jet Trenching Method Evaluation

MECHANICAL PLOUGH AND BACKFILL

A mechanical plough is towed by a Trench Support Vessel (TSV) and creates an open "V" shaped trench in the seabed. Technically ploughing is a plausible solution for means of lowering the product below an established stable seabed post-sand wave clearance, with seabed gradients becoming suitable for pitch and roll limitations.

During ploughing operations, spoil heaps are deposited on the seabed either side of the trench. Generally, these spoil heaps are redeposited back in the trench on top of the product using a separate mechanical backfill plough due to known environmental restrictions and potential risk to fishing gear interaction if left. Therefore, a separate backfill pass is included as part of the solution. The backfill plough is designed to operate inside a fully developed trench, with the forward skids, positioned in a fixed V shape, supported by the trench walls. Relatively reduced ploughing speeds can be predicted compared to jet trenching or CFE methods, especially in areas where there are localised increased fines content in the dominated sand sediments. Note a trenching assessment along the proposed route has not been performed to determine predicted ploughing speeds and/or required bollard pull at this stage.

The following non-exhaustive list of technical aspects and risks require to be assessed further to ensure a mechanically ploughed and backfilled solution remains feasible:

- Specialised anchor handling vessel availability and suitability;
- Stress analysis assessment of the pipeline during 4 phases of ploughing operation: product loading, transition in/out, normal ploughing and emergency recovery;
- Integrity checks of the pipeline and field joints during ploughing operations.
- Soil condition review to ensure suitability for ploughing;
- Water depth limitations of the plough/s.
- Potential for limited DOL achieved across the sand wave shoulder troughs if seabed is not levelled sufficiently / accurately.

Ploughing Operations Method Statement

Plough Deployment

Before launching the VMP, a safe location will be identified at least 50m away from any surface/subsea infrastructure. The VMP will be deployed using the stern mounted A-frame on the support vessel, see Figure B.15. During deployment and lowering of the VMP to seabed, the online survey team will monitor the position of both the VMP and TSV. The WROV will provide visual assistance during the final alignment and landing sequence.

Figure B.15 – Over-boarding VMP

When the plough is fully immersed, a full systems function test will be carried out and recorded. When all systems are confirmed operational, lowering is continued to the pre-determined safe location. At 20m above the seabed the lowering is paused and the passive heave compensator engaged in “Load Balance” mode. This smooths the wave-induced motion at the plough, and the plough is then lowered onto the seabed.

Touchdown of the VMP on the seabed will be monitored by WROV, ‘winch payout’ indicator, altimeter, profilers, seabat multibeam echosounders and, where possible, onboard cameras. With the plough on the seabed, the heave compensator is switched to “Taut Wire” mode.

The function and setup of the profiling sonar heads is now checked. If the buoyancy is to be used the tanks are filled at this stage. With the sonar checks completed and the buoyancy tanks filled to the required volume, the heave compensator is switched to “Load Balance” mode. This mode gives the best response from the heave compensator but needs precise setup for the weight of the plough.

The plough is lifted to 6-10m above the seabed. The plough shares are opened ready for landing over the pipeline. As the vessel and plough approach the pipeline the plough profiling sonar, video cameras, and the ROV are used to monitor the altitude of the plough in relation to the pipeline, fine heading alignment adjustments are made with the plough thrusters and horizontal position is controlled by vessel movements. In the event that buoyancy is not required, the plough can be deployed over the pipeline, without the need to land off-pipeline first. However, this will be down to the discretion of the Offshore Manager.

Loading of Pipeline

The plough is landed astride the pipeline at the chosen initiation position. Touchdown of the plough on the seabed will be monitored by ROV, altimeter, profilers and depending upon visibility, the onboard cameras. The lift wire will then be disengaged and recovered. The TSV bridge will be informed that the plough has landed and is ready to commence operations.

Figure B.16 – Landing VMP

The pipeline will be lifted into the plough using the fore and aft pipeline lift grabs. With the pipeline safely enclosed in the roller boxes the grabs will be disengaged and lifted completely out of the way of the pipeline.

Figure B.17 – Loading pipeline into VMP

Ploughing

The bridge will be informed that the VMP is ready to commence operations and the TSV will proceed to the offset distance to achieve the required tow wire layback whilst continually paying out on the tow pennants and VMP umbilical. When the required layback has been achieved the brake will be applied to the tow winch and the umbilical winch will be placed in the constant tension setting.

Figure B.18 – Ploughing with VMP

The TSV will be instructed to move ahead. As the tow tension increases the front skids will be raised to allow the share to descend into the seabed to the required depth. The operators will attempt to close the share in the first 25m of the transition. A constant update of position, KP, and the distance cross course from the product design route will be displayed on the helmsman screen located in the control cabin.

The position of the VMP will be monitored by use of USBL responders which are integrated with the surface navigation system to provide absolute positioning.

During trenching operations the depth of trench reading from the aft profiling sonars will be continually recorded. Data from the VMP logger electrical and hydraulic telemetry will be recorded. Selected channels will be output to screens on the bridge, and in the VMP control cabin. These selected channels include, but are not restricted to tow force, skid height, pitch & roll angles and instantaneous speed.

Upon reaching the end of full trench depth location, the start and end of transition will be displayed on the navigation display. Trenching operations will end typically 100-50m from the end of the design route, subject to pipeline stress analysis during VMP handling.

The towing speed will be progressively reduced as the VMP approaches the designated start of transition to ensure that the operation is carried out in a controlled manner, the VMP skids will be lowered to produce the designed transition.

The relevant navigation, VMP control and profile data will be recorded until completion of transition. The TSV will be brought to an all stop and then manoeuvred slowly astern, towards the VMP, whilst the product is unloaded and the tow wires and umbilical are recovered. The WROV will be used to monitor the tow wire touch down to mitigate the risk of snagging any subsea structures or features.

Plough Recovery

Upon completion of transitioning out the TSV will be manoeuvred into the recovery position and the docking bullet lowered and latched in to the VMP, assisted by the WROV.

The VMP will then be lifted 6-10m above seabed under surveillance from the WROV. To ensure the safety of subsea assets, the TSV will locate 50m from all subsea and surface infrastructure before finally recovering the plough to deck.

The plough will be recovered to the surface, docked securely into the ‘A’ frame scissor frame and placed on the aft deck.

Backfilling Operations Method Statement

BFP Deployment

Backfilling operations will commence from the point at the end of the transition zone where the pipeline has reached full depth, thus the full transition length will remain uncovered.

Figure B.19 – Backfill plough

The launch of the plough varies slightly from the VMP launch philosophy in that the BFP is launched in reverse and rotated 180 degrees in the water column to achieve forward orientation.

A deck mounted tugger winch and pennant hold back wire steadies the plough during launch and controls the rotation whilst the tow wire will be used to rotate the plough during the launch. Once the plough is fully rotated to the operational orientation, in-water checks will be carried out.

Once all in water checks are complete the steadying pennant is disconnected from the tugger wire and secured to the BFP umbilical, the spoil blades and skids will be extended to their operational position.

The TSV, winch and launch line movements will locate the BFP at the end of the VMP transition zone to commence backfilling.

Backfilling

On successful landing within the trench profile, the launch line will be released and recovered to the ship. The tow pennants and control umbilical will be paid out until the layback length is reached at which point the brake will be applied to the tow winch and the umbilical winch will be placed in the constant tension setting.

The vessel will then move ahead, increasing the tow tension whilst the BFP operators manoeuvre the skids within the trench to maintain an optimum backfilled profile behind the plough.

The spoil blade height is maintained by skid adjustment to ensure that they skim the natural seabed and return only cut spoil to the trench. The sonar profilers mounted on the front of the BFP indicate the height of the spoil heaps in front of the plough. The aft mounted profilers will monitor the resultant seabed profile after the passage of the BFP and will be used to adjust the skid height where required.

Backfill Plough Recovery

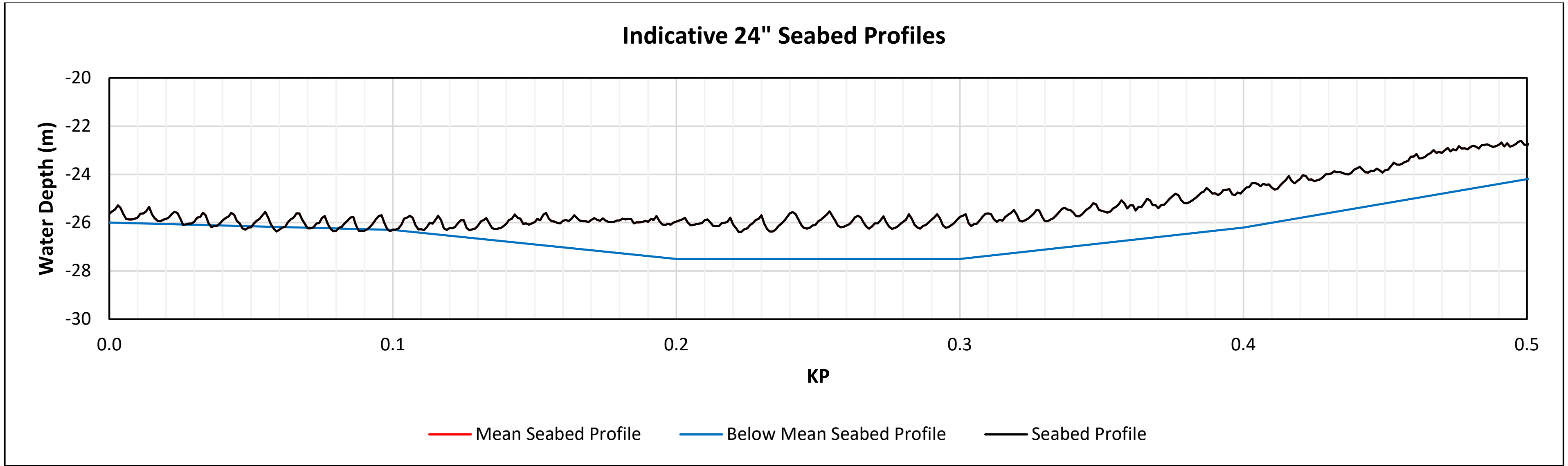
On approach to the end of the full depth trench, the tow tension and speed will be reduced towards the start of the transition zone. On completion of backfilling, the vessel will be backed up whilst recovering the tow pennants and umbilical. The lift line and docking bullet will be lowered and latched into the BFP which will then be raised from the seabed and offset a safe distance from the pipeline prior to recovery.

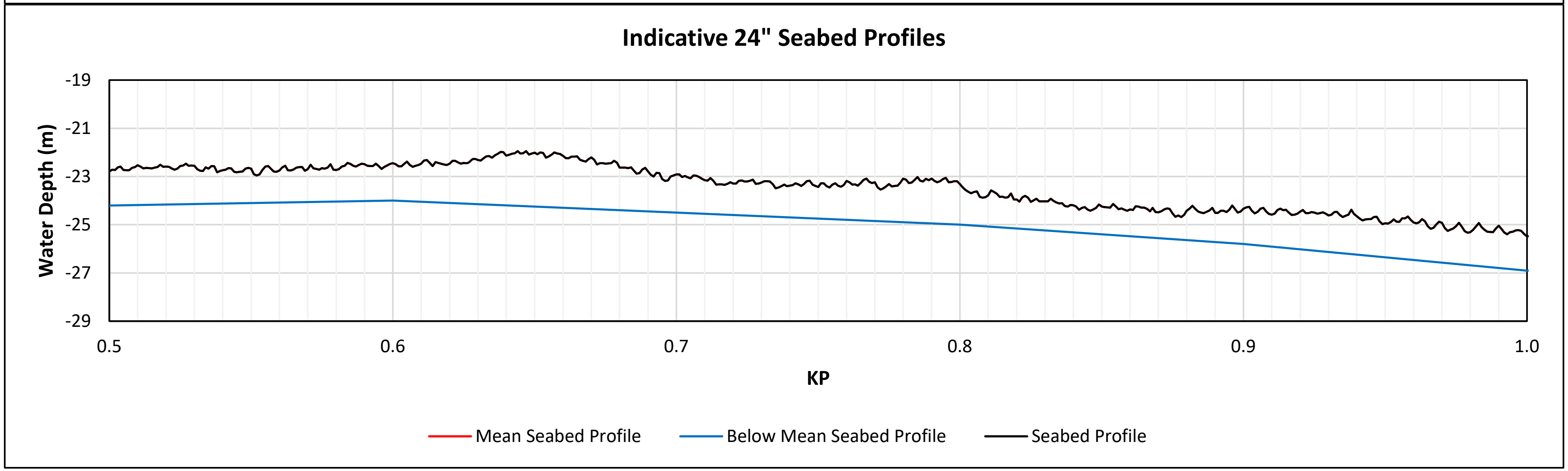
The BFP will be raised until 10m below the water surface at which point the alignment pennant is disconnected from the umbilical and connected to the tugger winch. The tugger winch will be utilised to rotate the plough 180 degrees, before it is raised and brought inboard.

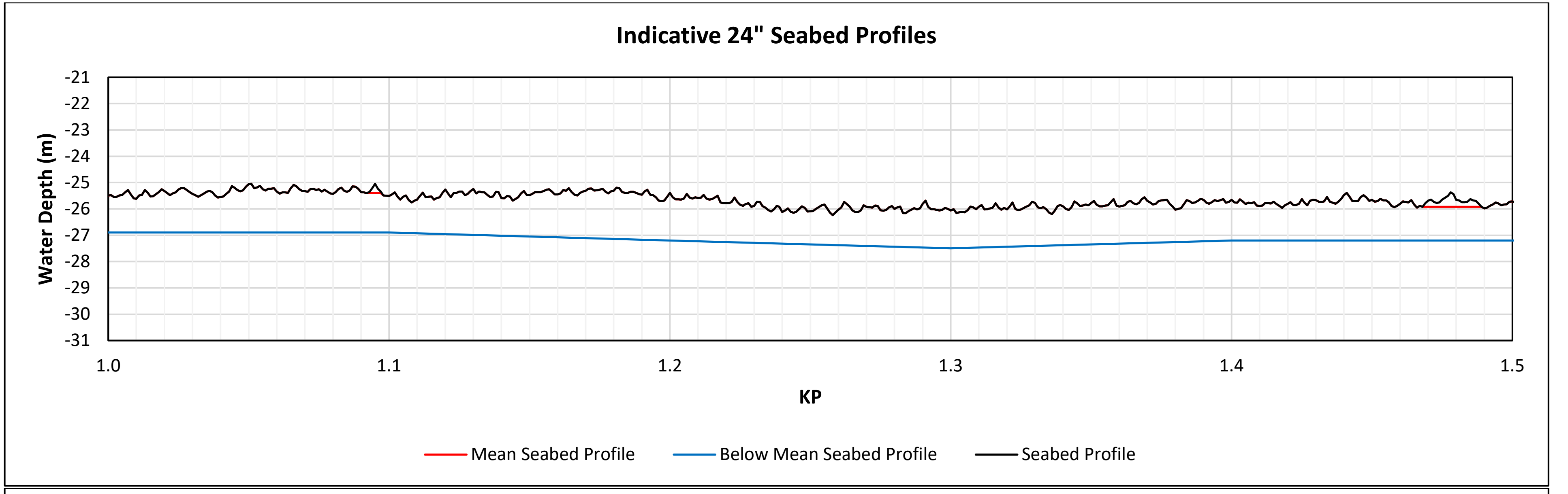
APPENDIX C.

INDICATIVE VERTICAL SEABED PROFILES

The following figures present indicative seabed profiles for the 24” pipeline route. KP 0 is at the Southwark Platform end of the route.







Indicative 24" Seabed Profiles
Water Depth (m)
-21
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-26
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-28
-29
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-31
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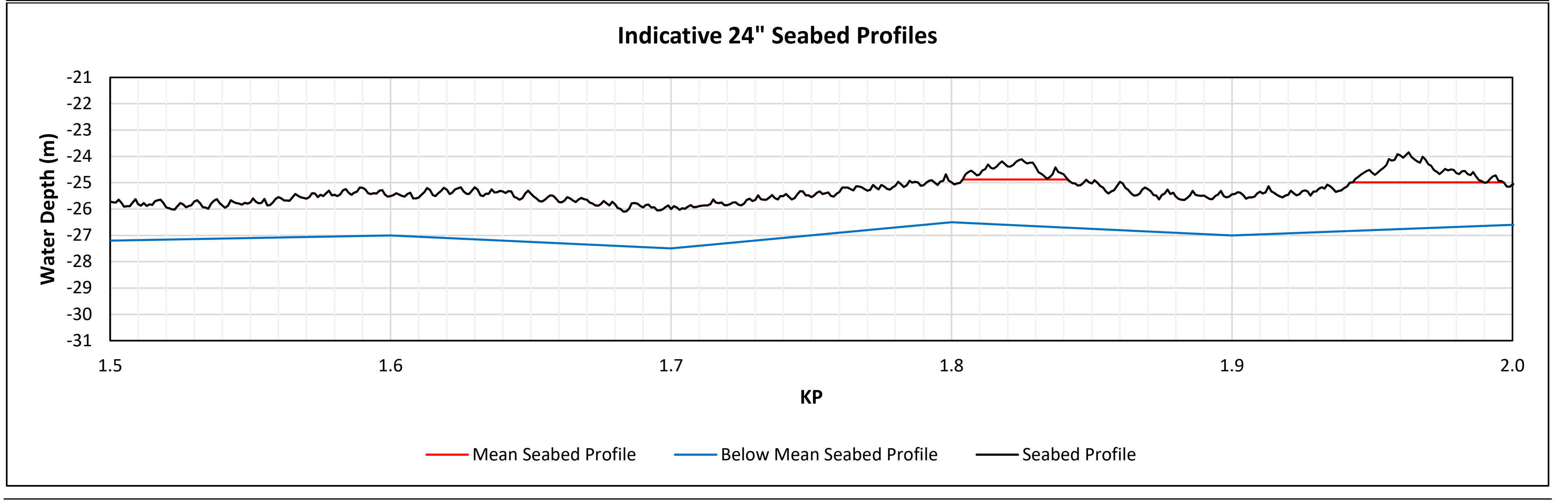
1.2
1.3
1.4
1.5
KP
Mean Seabed Profile
Below Mean Seabed Profile
Seabed Profile



Indicative 24" Seabed Profiles
Water Depth (m)
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-26
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-29
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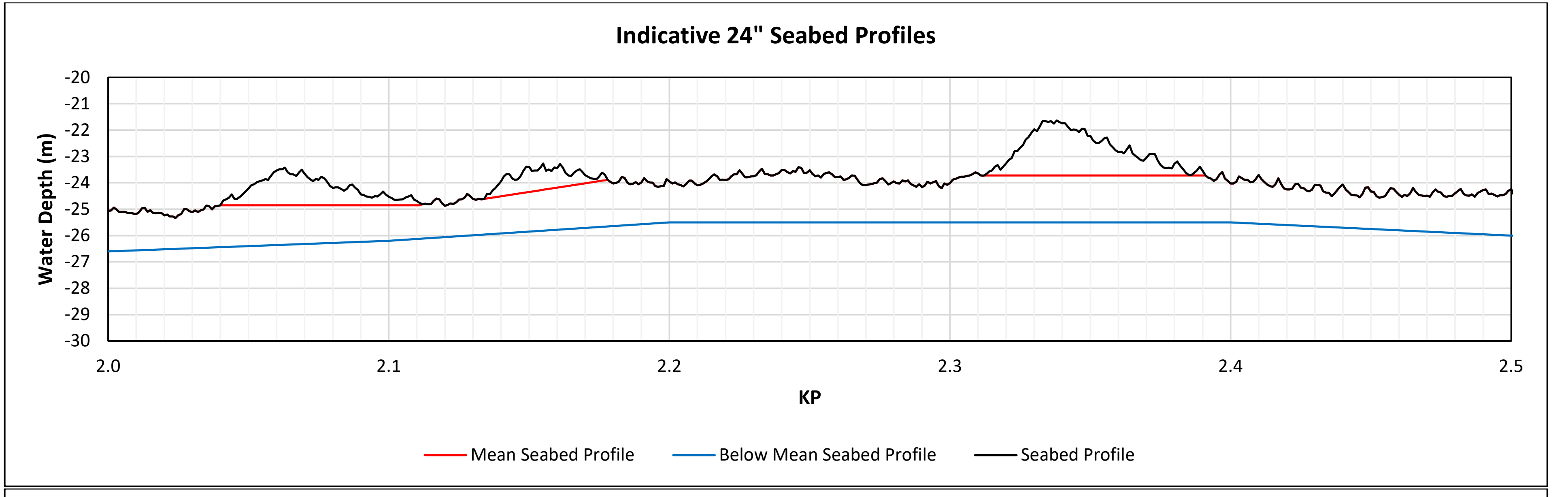
1.8
1.9
2.0
KP
Mean Seabed Profile
Below Mean Seabed Profile
Seabed Profile


Indicative 24" Seabed Profiles
Water Depth (m)
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2.0
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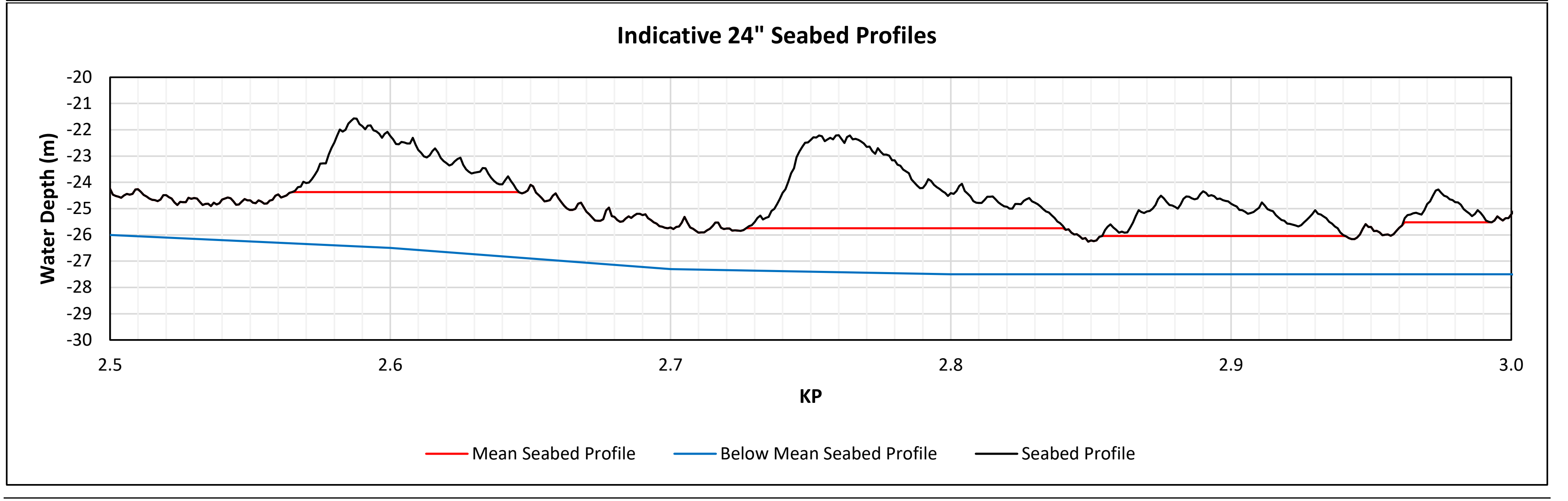
KP
Mean Seabed Profile
Below Mean Seabed Profile
Seabed Profile


Indicative 24" Seabed Profiles
Water Depth (m)
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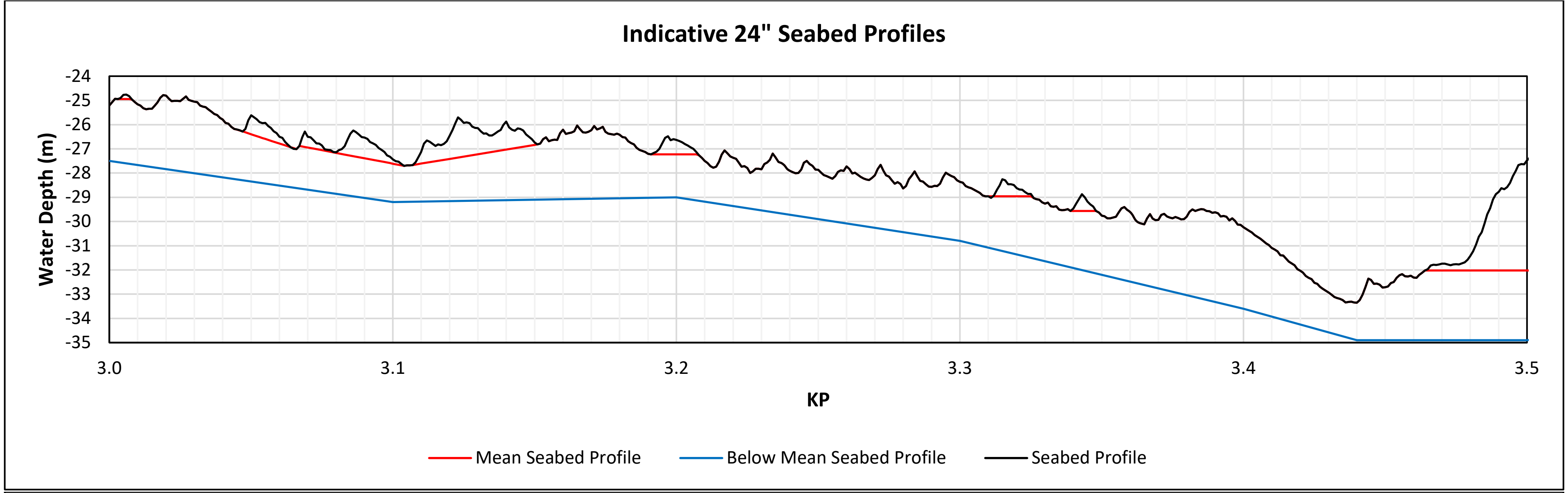
2.9
3.0
KP
Mean Seabed Profile
Below Mean Seabed Profile
Seabed Profile



Indicative 24" Seabed Profiles
Water Depth (m)
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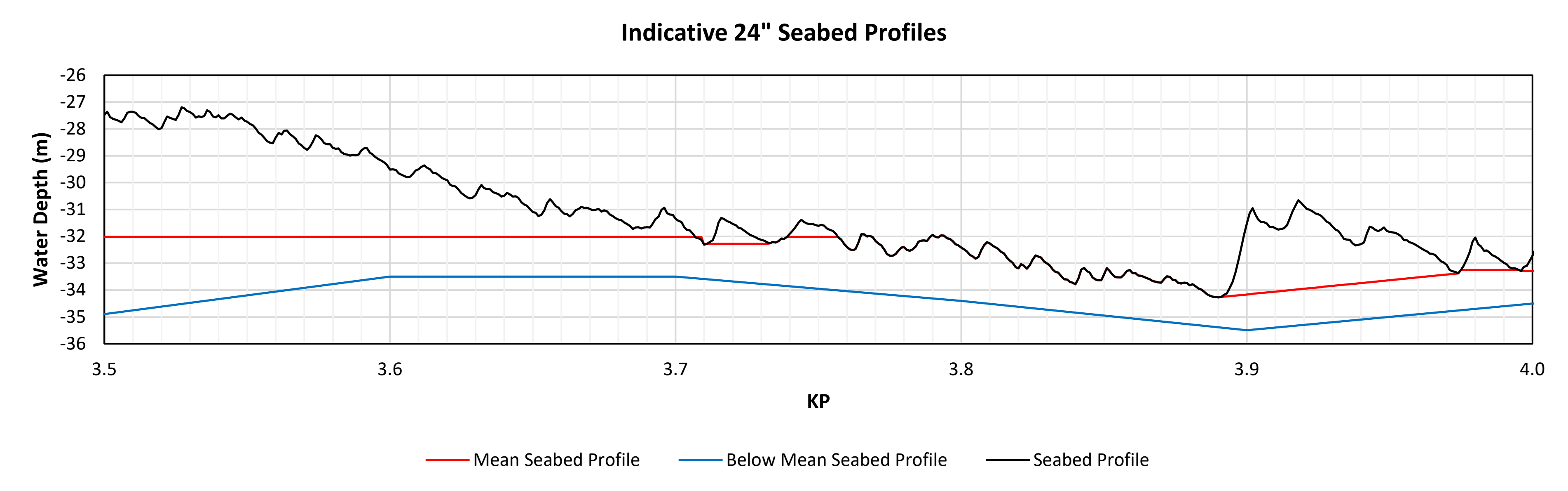
3.4
3.5
KP
Mean Seabed Profile
Below Mean Seabed Profile
Seabed Profile



Indicative 24" Seabed Profiles
Water Depth (m)
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-28
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-30
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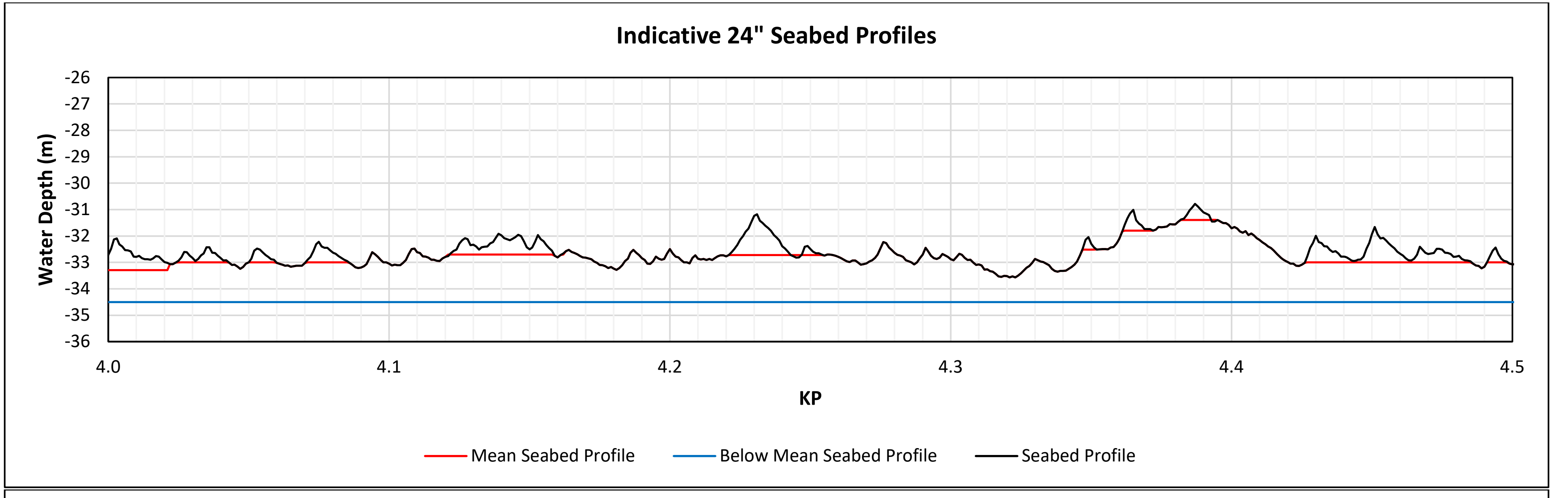
-32
-33
-34
-35
-36
3.5
3.6
3.7
3.8
3.9
4.0
KP
Mean Seabed Profile
Below Mean Seabed Profile
Seabed Profile



Indicative 24" Seabed Profiles
Water Depth (m)
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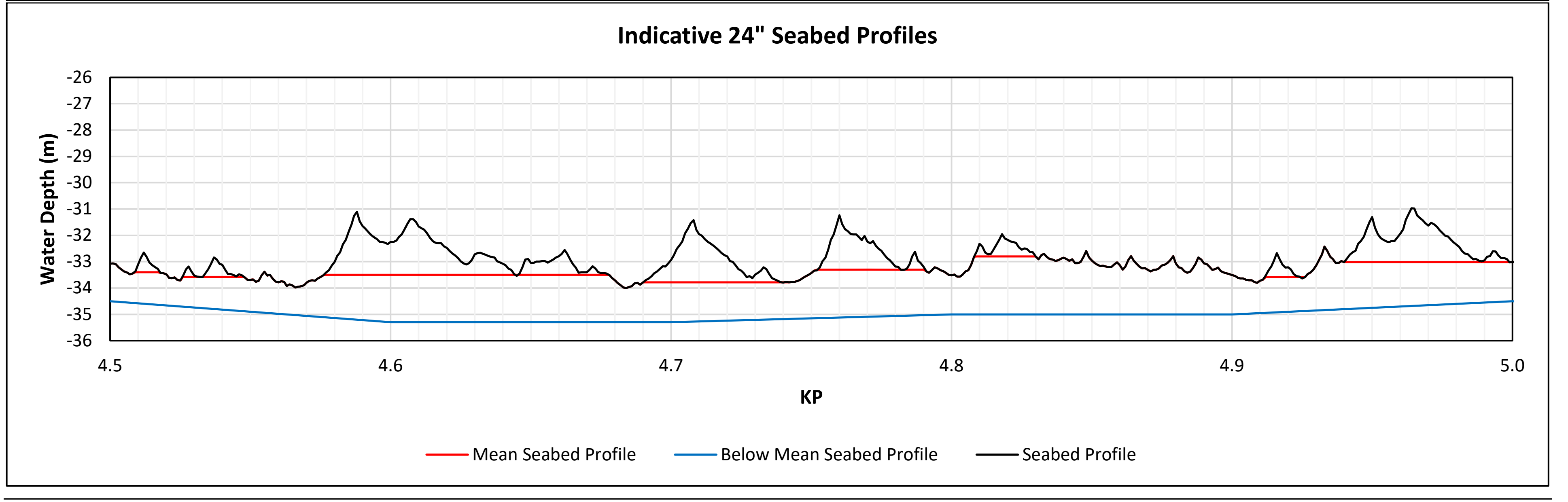
4.5
KP
Mean Seabed Profile
Below Mean Seabed Profile
Seabed Profile



Indicative 24" Seabed Profiles
Water Depth (m)
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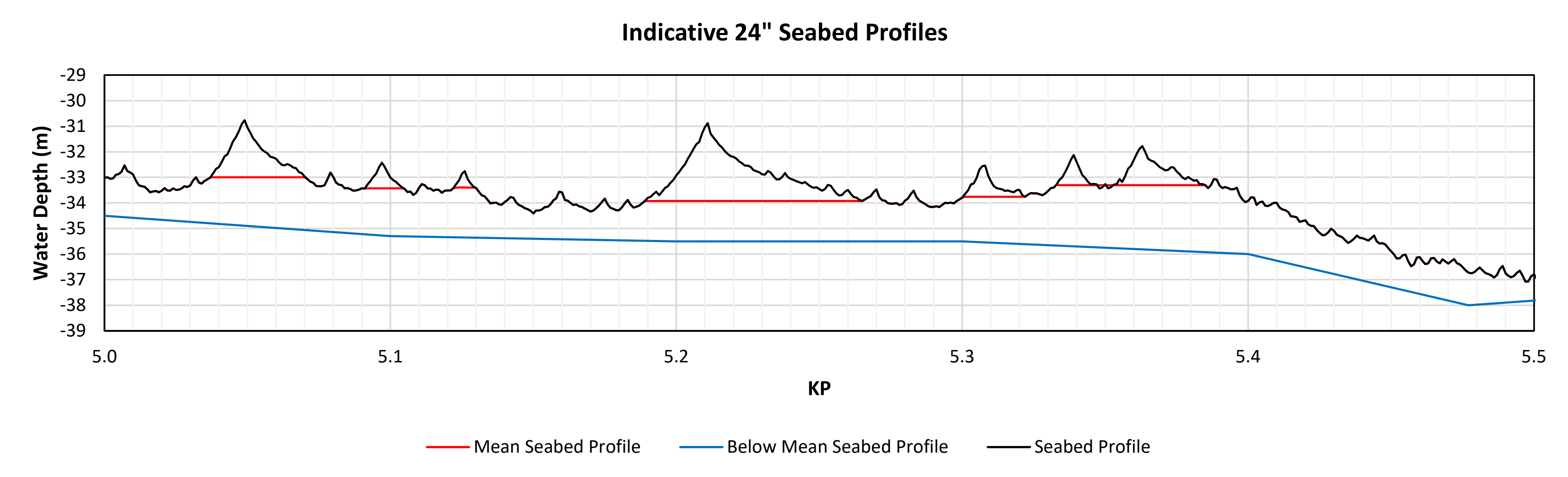
KP
Mean Seabed Profile
Below Mean Seabed Profile
Seabed Profile



Indicative 24" Seabed Profiles
Water Depth (m)
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-34
-35
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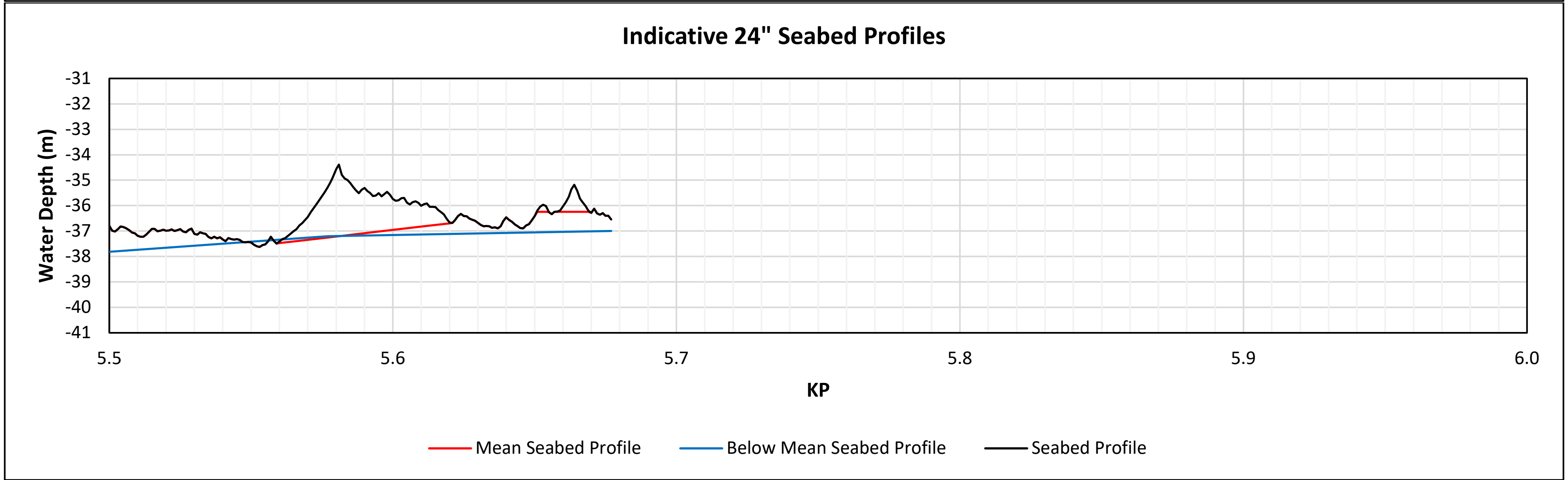
-38
-39
5.0
5.1
5.2
5.3
5.4
5.5
KP
Mean Seabed Profile
Below Mean Seabed Profile
Seabed Profile



Indicative 24" Seabed Profiles
Water Depth (m)
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-32
-33
-34
-35
-36
-37
-38
-39
-40
-41
5.5
5.6
5.7
5.8
5.9
6.0
KP
Mean Seabed Profile
Below Mean Seabed Profile
Seabed Profile

APPENDIX D.

ENVIRONMENTAL APPRAISAL CRITERIA

In light of the objectives of the comparative assessment and the developed understanding to date, environmental assessment criteria to support an initial appraisal of options have been developed based on the following:

- The attributes associated with the Conservation Objectives of the designated sites and qualifying features and the potential impacts to these;
- Concerns presented by the statutory stakeholders during engagement regarding the Southwark Pipeline Environmental Statement;
- An understanding of the physical environment and seabed morphodynamic characteristics, including the likely changes to the physical environment over the operational life of the pipeline;
- Consideration of impacts to other sea users; and
- Consideration of the various installation options currently being deliberated.

From the review of all available information, 8 environmental assessment criteria are proposed. These are presented below, along with a very brief justification on the relevance of the criteria. It is expected that the following environmental criteria will primarily be assessed qualitatively, providing comparisons between the different installation options being considered. The majority of the developed criteria relate to the assessment of potential impacts associated with seabed preparation and installation activities, whilst others relate to consideration of impacts associated with the operation and maintenance of the pipeline over the development's lifetime, and subsequent decommissioning of the pipeline.

1. **Area and volume of direct disturbance (sediments and benthic communities):** This evaluates the relative footprint, area and volume of disturbance or loss of existing habitat, including the potential for direct impact on designated qualifying features and supporting benthic habitats and communities that may occur within the area. This includes consideration of the areas buried or sediment removed as part of bed levelling that would result in change to the designated qualifying features. The extent and composition of new substrate provision is accounted for in Criteria 5.
2. **Temporal recovery of conservation objectives/ attributes (sediments and benthic communities):** This evaluates the potential for recovery of existing habitat, including designated qualifying features and supporting benthic habitats and communities that may occur within the area, following direct disturbance as described above. Recovery potential may be over short term or long-term timescales or assessed as a permanent loss of habitat.
3. **Development, extent and persistence of a sediment plume:** This evaluates the potential for a sediment plume to be developed as part of the seabed preparation and installation works for the various options. It accounts for the relative extent, duration and concentration of any plume, with the potential for indirect impacts on designated qualifying features, including Annex I *S. spinulosa* reef, and supporting benthic habitats and communities, and sediment deposition over the plume extent.
4. **Changes to sediment composition:** It is noted within the NNSSR SAC site assessment and Conservation Objectives (JNCC, 2010; 2017) that different sediment grain sizes are characteristic to different locations within the SAC. This criteria therefore evaluates the potential for localised sediment composition changes in proximity to the installation works or for sediment to be redistributed elsewhere within the NNSSR SAC, with potential impacts on the sediment composition (size, texture and sorting). This does not include

the introduction of any rock substrate, for which impacts are considered in Criteria 5.

5. **Introduction of new substrate:** This evaluates the potential for new material to be introduced into the NNSSR SAC during installation works. It includes consideration of the permanence, volume and scale of the introduced substrate.
6. **Changes to the seabed morphodynamic regime:** The sandwaves are an integral part of the function of the sandbanks within the NNSSR SAC, with connectivity to the hydrodynamic and sediment transport processes. This criteria evaluates the potential for changes to the form of sandwaves and the hydrodynamic and sediment transport regime due to the installation works and during the operation of the pipeline. It includes consideration of changes caused both directly and indirectly, with the potential impacts on the recoverability of the sandwaves in line with the morphodynamic processes occurring across the North Norfolk sandbank system.
7. **Impacts on commercial fisheries:** This considers potential impacts to commercial fisheries including exclusions from the project area and introduction of snagging risks, accounting for the low fishing intensity in the area.
8. **Potential for and magnitude of scour development and free span, necessitating the need for remedial works:** This evaluates the potential for the development of scour and free span, including the possible scale of any scour necessitating the need for remedial works and active intervention during the operation of the pipeline. Any remedial works are most likely to include the use of rock. Therefore, this criteria also includes consideration of protection and stabilisation measures, along with the permanence of the measure.

Table 3 1 defines the ranking proposed to be used for the environmental assessment criteria. For each proposed option (and sub-option), each of the 8 environmental criteria will be qualitatively evaluated in relation to the potential environmental impact and assigned a score between 1 and 5; the lower the score, the more favourable the assessment. Whereby a score of 5 is considered to be a showstopper to achieving consent.

The scoring system can be adapted if required, to conform to the scoring system to be used in the comparative assessment.

Ranking (Best to Worst)	Assessment
1	• Effects unlikely to be discernible or measurable. • No contribution to cumulative effects. • No noticeable stakeholder concern and only limited public interest. • No increase in snagging risk.

2	• No effect on the conservation objectives and attributes of nationally/internationally protected sites, habitats or populations. • Minor/local change in habitats or species which can be seen and measured but is at same scale as natural variability or localised change in a habitat or species beyond natural variability with recovery expected in the short-term (<2 years) following cessation of potential impact or activity. • Negligible contribution to cumulative effects. • Issues that might affect individual people or businesses or single interests at the local level. Some local public awareness and concern. • Potential increase in snagging risk along localised areas of the pipeline, resulting from unplanned events (e.g. scour) over the operational lifetime of the asset.
3	• Short term but reversible effect on the conservation objectives and attributes of nationally/internationally protected sites, habitats or populations. • Moderate/local change in a habitat or species beyond natural variability with recovery likely within the short (<2 years) to medium (2-10 years) following cessation of activities, or localised degradation with recovery over the long-term (>10 years) following cessation of potential impact/activity. • Minor contribution to cumulative effects. • Regional concerns at the community or broad interest group level. • Likely increase in snagging risk along sections of the pipeline resulting from unplanned events (e.g. scour) over the operational lifetime of the asset.
4	• Long term but reversible effect on the conservation objectives and attributes of nationally/internationally protected sites, habitats or populations. • Major/regional (widespread) potential impact on the quality or availability of habitat/wildlife and where recovery may take place over the long term (>10 years) and involve significant restoration effort. • Moderate contribution to cumulative effects. • Well established and widely held areas of concern, including perception of threat to the regional environment. • Inherent increase in snagging risk along sections of the pipeline for the lifetime of the asset resulting from installation method.

5	• Permanent effect on the conservation objectives and attributes of nationally/internationally protected sites, habitats or populations at local to regional scales. • Major/regional (widespread) potential impact on the quality or availability of a habitat and/or wildlife with no recovery expected or irreversible alteration (permanent). • Major contribution to cumulative effects. • Well established and widely held areas of concern, including perception of threat to the national environment. • Inherent increase in snagging risk along the length of the pipeline for the lifetime of the asset resulting from installation method.

APPENDIX E.

ENVIRONMENTAL APPRAISAL MATRIX

No	Environmental Criteria – Description	Option 1 No Se bed Modi ca ion – Score	Option 1 – Justification	Option 2 Re Route P peine – Score	Option 2 – Justification
1	A ea and volume o di ect d stu ban e sed ments a d ben hic ommuni i s)	2	Di e t dis u bance would be l m t d o he imm diae oo p nto he pipeine The e would be a loss o qu li yng in eest eau s (Annex I andban s nd Ann x I *S sp nolu a*) nd uppo ing h biats w th n he oo p nt a ong he u l len th o the pi el ne	2	The e is l tle cope o void ng the d si nat d qu li ing in eest eau es hus envi onmen al mpa ts as pe Op ion 1 Di e t di tu bance wou d be l mi ed o the imm diae oo p nt o he p peine
2	T mpo al ecove y o con e va ion ob ec iv s tt but s	4	The e would be a ong tem oss o s abed hab tas ncuding any qu li yng in eest spe i s a ong the ll engh o he pip l ne S abed hab tas would be expe t d o eco e to ba el ne cond t ons o lowng he mov l o the p peine at d comm ss oning	4	The e would be a long em oss o eabed hab t ts ncuding ny qu li ing nte est spe ies alo g he u l l ngth o he ipeine Se bed abi a s wou d be xpec ed to cove to bas l ne ondi io s ol owing he emova o the p pel ne at de ommi sio ing
3	De elopment ex ent nd pe ss t nce o a sed m nt plume	1	Th s me hod wou d ent il min m l se bed is u b nce o de elopment o as diment pl me Any d s u b nce wo ld be du ng he pe iod o in tal p pe ay A soc a ed e ecs would be vey loc l sed to t e p peine and t mpo a y qu cky e u n ng to wi hin bac g ound ediment oncent t on ev ls	1	This me hod wou d nta l m n mal eab d d s u ban e o dev lopment o as diment plume Any d stu ban e wou d be du ing he pe od o in tal p pel y As oci t d e cs wo ld be ey ocai ed to the p pel ne and t mpo ay qui kly e u n ng to w t in bac g ound s diment con ent a ion eve s
4	Chan es to sed ment compos t on	1	No hange n s diment compos t on is exp c ed w th th s m thod as t does not nvo ve the emova l o d pos to sand o gav l along he pip l ne ou e o l ewhe e n he NN SR SAC	1	No ch nge in sed m nt compos t on s expe t d wi h th s me hod as t does not in ol e the emo al o depo ito and o g vel long hep peine oute o es whe ein he NNS R SAC
5	I t oduc ion o new ubst a e	3	The nt oduc ion o new ubst a e is imi ed o that o the pi el ne wh ch woud ons i ute a long em int odu ton o had subst te w th covey to ba el ne cond t ons ol owing mo al o hep peine at d comm ss oning	3	The int odu t on o ew su stae s l m t d o hat o he pip l ne whi h wou d con t tue a ong tem nt oduc ion o had ubst a e w th e ovey to bas l ne ondi io s o lowng emov l o the p pel ne at de ommi s oning
6	Chan es to the s abed mo phod nam c gime	2	The p esen e o the su ce l id pipe new ll sult n long tem but m no and loc l sed e e ts on the mo phod namic gime ncuding ch nges o cou and depos ion a und the sset	2	The p sence o he su a e ad p peine wil e ult n ong tem but mino nd ocai ed e e ts on he mo phodyn m c e ime nclu ing cha ges to s ou and depos t on a ound the a set
7	Impa ts on comme c al she es	5	Al hough sh ng in ens ty s low a su a e ad p peine wil esu t in nce sed sna gi g sk houg out the l etme o he as et a ong the u le tento the o te nag ing skwi l be m dia ed o lowng u l mov l o the p peine at d comm ss oning	5	Al hough sh ng nt ns ty is ow a u ace ad p pel ne wil sult n inc ea ed snag ing sk th oughout he li tmeo he ss t a long he u l ex ent o he ou e Sn gg ng sk wil be med ae d o lowi g ull emoval o the pi el ne at de ommi sion ng
8	Po ent al o and m gni ude o s ou dev lopment and ee sp n ne ess t ng the ne d o meda wo s	5	The e is a s gni cant i ko cou and ee sp ns nece s taing emedi l wo ks o e the ope a iona l i e o t e p an ven om in tal t on ee sp ns a ee pec ed due to the s eep as mmet c p o i e s o the p es nt sandwa es and the p ope i s o the p pel ne he e s a so the hi h po en i l o he deve opment o sou due to the non cohe iven tu e o the sed ment he p va l ng sed m nt t anspo t g me wi h he blo kage e ect o he pipe ne gene t ng oc l sed tu bul nce th t l ads to scou The p ese ce o ee spans i he om in t l at on o as a e ult o ddi ion l scou wou d n ces i ae igni c ntle es o in e ven ion and m dial wo k Snce t is not pos ib e to in tal conce e mat ess to spe t vey bene th an x st ng pip l ne m dial ptons a e ik ly o be l mi ed o ock pl cement Th s wou d pe manen ly epac e t e xi t ng sandy s diment hab t t wi h a nov l had sub tate	5	The e is a si ni ant isko s ou and ee sp ns n ce si ai ng em dia wo ks ove the opeat onal i eo the p an E en om ins al t on ee spans a e exp c ed due o hest ep asymmet ic p o l so the p sent andwa s nd he p ope i s o he pip l ne The e is al o he high po ental o the d ve opm nt o scou ue o he non- ohes ve na u e o he sed m nt he p e ai ng ediment t nspo t gime w h he bo c agee cto t e p peine gene a ing ocai ed u bulen e that e ds o cou The p sen e o e spans e the om ins al t on o s a esu t o add t onal cou would ne ess t es gni cant ev ls o in e ven ion and emed al wo k Snce it s not poss b e o ns al conce e mat es e et speci e y be neah n e i t ng p peine emed al op ions a e l key to be l m t d o ock pla ement his wou d pe m nen ly p l ce the e is i g andy sed m nt hab ta w th a novel had subst te
		23		23	

No	Description	Option 3 Rock n ll etwe n andwav s – Score	Option 3 – Justification	Option 4 Conce e M tt e s n i l betw en andwa s – Score	Option 4 – Justification
1	A ea and volume o di ect d stu ban e sed ments a d ben hic ommuni i s)	3	A o k bem wou d e equi d be ween the c e to suc ess ve s ndw ves The wid h o he ock be m o tp int w th n he tough betwe n he sandwa e e tu es s es ima ed o be a ound 25 m a soc a ed w th an es ima ed olume o 125 0 0m o ock he la em nt o he o k em wou d nta l compl t ly bu ing he uali ing nte e t e tu es and uppo ing h biats w th n he toughs w th a oo p nt o app ox ma e y 80 000m The u ace aid p pel ne would a so bu y any sed ments a d hab ats a ong the ull p peine oute eng h nclud ng any qua i yng in e st eau es andban s nd *S pinu osa* gg eg t ons	4	Matt ss in t l at on wou d be equi ed be ween the c e to suc ess ve s ndw ves The min mum nd max mum co do w d h o he mat e s ootp nt a long he pip l ne ou e anges b twe n 50 and 78 m he p a em nt o the mat ess p ote t on wou d nta l comp et ly bu ying he quali ing nte e t e tu es and suppo t ng habi a s w th n the tou hs wi h a ootp int a ea o ppo imat ly 130 000m The su a e ad p peine wou d a so bu y any edimen s and abi a s long he u l pip l ne ou e engh nclu ing any quai yng in eest eau s andban s nd *S sp nulosa* agg e at ons
2	T mpo al ecove y o con e va ion ob ec iv s tt but s	5	his wil con t tu e a pe manent oss o qua i y ng in eest eau s nd uppo ing hab ats he o k bems	5	Th s wil cons i ute a pe m nent oss o qua i y ng nte st atu es and suppo t ng hab t ts n he oo p nt o the ock bems
3	De elopment ex ent nd pe ss t nce o a sed m nt plume	2	eab d d stu ban e wou d be imi ed to the ay ng o the p peine and in tal t on o ock esu ing in min ma deve opment o a sed m nt plume uspend d s diment wou d be h gh y loc l sed to t e ns al aion ac vi i s	2	S abed di tu bance wou d be imi ed o the l yng o he pip l ne and ns al a i n o matt ss s su t ng n m nimal de el pment o a ed ment pume Su pended sed m nt wou d be hi hly ocai ed o he in ta at on c iv tes
4	Chan es to sed ment compos t on	1	No chan e n sed m nt com osi ion s xpec ed wi h his me hod as it do s ot inv lve he mov l o depo ito s nd o ga el a ong the p peine o teo e sewhe e in the NNSSR AC	1	No hange n ediment ompo i ion is e pec ed w th his m thod s t does not nvo ve he emoval o depos to sand o gav l a ong he pip l ne ou e o l ewhe e n the NN SR SAC
5	I t oduc ion o new ubst a e	5	his method en a ls he nt oduc ion o a la ge olume o new ock sub t ate a ong the p peine oute incud ng he pot nt al o ock gad ngs hat a e not cha ac e is c o he ediment w th n he NN SR Cu ent e hnolo ies wou d not l ow the emoval o ock so his s cons de ed a pe manent d posit	5	Th s m thod en ai s the nt oduc ion o a la ge vo ume o uni o m had subst a e a ong he p peine ou e th t is not cha cte st c o the NNSSR ba el ne envi onment The is k o sa e y is e pec ed to p vent mat ess mo al at d comm ss oning so h s s cons de ed a pe manent d posit
6	Chan es to the s abed mo phod nam c gime	5	he ns al ai n o a ock bem betwe n andwav s would c ea e l nea eau s a ge y pep ndicu a o he o en at on o the s ndw ve atu es a ong a si ni i ant l ngh o he oute The sa dw ves a e al gn d wi h e pect o he t dal p oce ses he e o e t e ock bem wou d empo a ly p n he andwave c e ts as oc at d w th the ock bem n ime and n i he s deo the bem he andwave eau s ae ik ly o coni ue o mg te as s pa te nd d s inct e tu es howe e the e wou d be onside bly sma le d pend ng on he andwave engh n e a ion to the be m wid h Nonethe ess hep sen eo he o k bem wou d ont nue to modi y he shape and ongo ng m g at on p ope tes as abo e and h ogh he dis up ion o the ocal h d od namic gme a ound hesandwa es and andban s Th s in tu n wou d nte upt the s diment upply owa ds he no th and west nc uding he poten al ede o o he andban s w th n he NN SR	5	The ns al a ion o m tt sses b tween s ndw ves wou d c ate in a au es a gey pe pend cu a o he o ent t on o he sandwa e e tu es a ong a igni c nt len th o the oute The sandwa es a e l gned wi h esp ct to he id l p o es es he e o e the ock bem wou d empo a i y pin the s ndwave c es s ass ci ted wi h he o k bem In t me nd on e the s deo the be m the s ndwave a ues a e l key to con inue o mig a e as sepa a e and d st nct eau s howeve hese wou d be con ide ab y sma l e ending on the s ndwave l ngh n e at on o the be m wid h Nonet el ss he p e ence o he mat es es wou d con i ue o modi y the hape and ongo ng mig t on p ope tes as above nd h ou h he is up ton o the oca l h dodyn m c e ime a ou d he andwav s and s ndbanks Th s n u n would nte u t the s diment supp y towa ds the no th and w st ncl ding the po en i l e de o o he s ndbanks wi h n he NNS R
7	Impa ts on comme c al she es	5	A th ugh i hing nt nsi y is ow a su ace l id pip l new ll e ult n nc eas d nagg ng i k houghout he i eimeo the a set long he ull xent o he oue Addi onal y he ns a la ion o a e ock bems at he gh s sim la o he sandwave c st and be ween andwav s wil con t tu e a igni ca t and pe manen inc ea e in snag ing isk s nce u ent echno ogy would not allow the emo al o he bem u ng d comm ss oning	5	A thou h is ing in en i y s low a su ce la d pipe i e w ll esu t in i c ased sn ggng isk h ou hout the i eime o the as et a ong the ull xt nt o the oute Addi ion l y t e nst l a ion o conce e mat e ses the ghts s mi a to he andwave c e t and etwe n s ndwaves wil l cons i ute a s igni cant nd pe manent nc ease n nag ing sk as sa ety con e ns a e e pec ed to p e ent he emoval o them tt sses du ing d commi s oning
8	Po ent al o and m gni ude o s ou dev lopment and ee sp n ne ess t ng the ne d o meda wo s	5	n he lon -em he equi m nt o emedi l wo ks a soc a ed w th th s m thod is ons de d o be h gh Th s is ba ed n he oten i l in tab l yo he o k-bem o e t e ope tonal i eo he pip l ne he i ey ntoducion o ed scou a soc a ed w th the bem nd he al e ed shape and m g aion cha ac eis i so the s ndw ve and as ess d hang s o he hyd odynamic nds diment t nspo t e ime oc l y a ound ea h ock bem nd c o s he sandw ves a ong the p pel ne ince t is not po sib e to in tal concee mat es e spec i e y b neah n xi t ng pipeine med al op ions a e lk ly to be imi ed to ck pla ement his would pe m nen ly pl ce the e is ing andy sed m nt h biat wi h a no el had ubst a e	5	n he long tem the equi ement o m dial wo ks as oc at d w th th s me hod is con ide ed to be hi h Th s bas d on the po en ial egad a ion o ea h mat ess ove the ope a ion l i e o he pipeine the ik ly nt oduc ion o edge cou as oc at d w th the bem and the l e d hape and m g ton ha ce s ics o he sandwa e and ss ssed ch nges o he hyd o ynamic and sed ment t an po t egme oca l y a ound each matt ss p l e and acoss he andwav s along he pipe i e S nce it s not poss b e o ns al conce e matt ss s eto peci ely ben a h an e is ing p peine emed al op ions a e l key to be imi ed to o k p ac m nt Th s would pe ma ent y e la e he ex s ing s ndy ed ment hab at wi h a nov l had sub t a e
		31		32	

Op ion 5 S ndwave Removal – Sub options

No	Description	5A Cont olled low ex ava ion C E – Score	5A – Justification	5B T ailing Suc ion Hoppe D edging – Score	5B – Justification	5C S abed Ex av to s – Score	5C – Justification
1	A ea and volume o di ect d stu ban e sed ments a d ben hic ommuni i s)	3	[illegible]	3	[illegible]	3	he a ao d ect mp ct to se iments nd ben h c ommuni i s asso i ted wi h his me hod wou d omp i e bo h the a ea be ng e el ed th ough d dging nd he eab d dja ent o he le el ed a ea whe e the e the d edg d ma e al wou d be depo i ed E en w th the add ional d pos ton ootp nt he o al a ea o di tu bance s st ll ons de d o be sma le compa d w th tha o the C E meth d The co do wid h equi ng e el ing c o s each s ndw ve would nge betw en 30 - 40 m whe eas he sandwa es a ong he p pe ine ha e len ths va y ng be w en ens and hund eds o m tes he p opos d oute c os es the s ndwaves t va yi g ngl s dep nding on the oca ion a ong the o te hus he e is the po en ial o el t ve y la ge c oss se t ons o ind v dual s ndwaves o be ev l ed compa ed w h a sma le ec ion o the a ge lon e s ndw ves and pe pend cu a c os ings ndwaves The oo p int o d s u ba ce e ul ing om andwave eve l ng is nt c pat d o be app ox m te y 60 00 m2 w th ind ca i e ed ment olume o be w en 60 000 - 100 000m3 being d sp aced he eab d d s u ban e e ul ing om he su a e ay o he p peine wou d be l mi ed o he pip l ne oo p nt
2	T mpo al ecove y o con e va ion ob ec iv s tt but s	4	[illegible]	4	[illegible]	4	Med um sho t tem eco e y o ediment h bi a s nd c mmuni i s in lud ng the andwave ea u s would be exp ct d ol owing c ssai n i le e l ng c iv t es ow ve he e wou d ea ong tem but eve s ble oss o hab t t in su a e ad p peine ootp int w th cove y o low ng pipe i e emoval
3	De elopment ex ent nd pe ss t nce o a sed m nt plume	3	[illegible]	2	[illegible]	2	As his meth d nvol es cu t ng and h gh p ssu e je t ng he e is the po en ial o he d ve opm nt plumes bo h n e at on o the s abed ex ava ion wo s s w ll as he e ea e o xc va ed ed ment Howeve due o he sec onal l mi ed xent o t e ct v ty the d ve oped plume is l k ly to be l ss compa d w th othe opt ons being onsi e d he x ent o ndi ect mp cts ssoc a ed w th t e p ume w ll c mpa a i ely sma l and he eby duc ng po en i l impac s on he *S sp nulo a* e communi ies n he vi in ty w th cove y poss ble n he sho t tem
4	Chan es to sed ment compos t on	2	[illegible]	2	[illegible]	2	he me hod w ll d s u b sed ment o va y ng s zes wi hin the c os -s ct on o a andwave his wi l l key sult n coa se ediment b ing depo i ed on he seab d mmed a ely dja ent o he le el ed co do due to the va y ng ll v lo i ies o di e ent g an iz s In ddi ion the e s he pot nt al o the depo i ion o ne m te al ove a w de a a which may not cha cte st c l y omp i e ine ediment due to the du a ion and conc nt at on o he plume ove a wide ex ent Howeve n ime the hyd odynam c eg me c o s the andwav s nd NNSSR wi l ac to ed st bute a d so t he ediment n ne w th the na u al ediment eg me
5	I t oduc ion o new ubst a e	3	[illegible]	3	[illegible]	3	he nt oduc on o n w subs ate s im ted to hat o he p pe ine wh ch would cons tu e a ong te m i t oduct on o had sub t a e wi h eco e y o b se ine co di ions o low ng emoval o he pip l ne at dec mmis ion ng
6	Chan es to the s abed mo phod nam c gime	3	[illegible]	3	[illegible]	3	his method en a ls po ent a ly eve l ng la ge s c ions o ndiv dual andwav s w th l m ed ccu acy howeve the ev l ed a a w ll onst t te only ocai ed sec io s o he sandwa es Non the ess the e is he pote tal to i t oduce chan es to the o m o he l vel d andwav s whi h may in lude c ea ing wo d s inct ea u es th t m g tes pa t ly wi h on oing ch nges o he hyd o ynamic and se iment t an po t eg me w th e pect o he ev l ed sandwa es n ime he e s the po ent al o in l ing o he ev l ed a a and eco e y o t e a ges sandwa es as s ndwaves c o s he NN SR a e na u al y bi u at ng nd onve gi g he p e ence o he u ace aid p pel ne wi l al o esu t n ong tem but mino nd oca sed e e ts on he mo phodyn m c e ime nclu ing cha ges to s ou and depos t on a ound the a set
7	Impa ts on comme c al she es	4	[illegible]	4	[illegible]	4	he ipe ine w ll be su ce la d at MS w th n he l ve l d co do and as such wi l ni i l y cons i ute an nc ase o sn gg ng sk a ong he u l ex ent o he ou e It s l key hat du ing he li e ime o the sset se t ons o the p peine wi l be bu ed by n tu al ediment t nspo t p o ess s educ ng the sk o sn gg ng in th se a as howe e o he ec ions wi l ik ly m in expo ed es l ing in an inc ased sn gg ng i k th oughout he i e ime o the a set A eas su je t to scou p oduc ng ee spa s w ll c nst tu e an
8	Po ent al o and m gni ude o s ou dev lopment and ee sp n ne ess t ng the ne d o meda wo s	4	[illegible]	4	[illegible]	4	he ipe ine w ll be su ce la d at MS howeve th s is s i l wi hin a mob le s diment eg me As s ch he na u al eab d movement nd s ndwave mig a ion has the po en ia to esu t n ee pan o ma ion du ing the i e o the a set ince t is not po sib e to in ta l onc ete mat ess s et o peci i ely ben a h an e is ing p peine emed al op ions a e l key o be imi ed to o k la em nt Th s wou d ons i ute a pe m nent in oduct on o new ubst a e at ough o ly in lo a is d s c ions o he ou e
		26		25		25	

No	Description	6A Cont o l d ow xca a ion + C E – Score	6A – Justification	6B Cont o l d ow xca a ion + e t ng – Score	6B – Justification
1	A ea and volume o di ect d stu ban e sed ments a d ben hic ommuni i s)	4	On e ching he me n eabed l vel by means o a C E th s me hod ent i s c at ng a deepe t en h long t e ull ou e engh The ootp in o dis u bance a soc at d w th the s ndwave l ve l ng wo ld be na ogous to th t o 5A The e would a so e he add t onal mpa t as oci t d wi h the t en hing wo s long he u l len th o the p peine ute h ou h he u e o C E The a cu acy o a C E means a la ge oo p nt m y be d s u b d du ing t nching esu t ng n a di e t impact o he sed m nt and ben hic commu i ies ove a la ge a a ompa ed wi h the me hods	4	On ea hing t e mean s abed l vel by means o a C E h s me hod nta s c e t ng a d epe tench a ong the ull oute engh The otp int o d s u b nce as oci ted wi h he sandw ve le el ng wou d be a alo ous to that o 5A The e wo ld al o be he ddi ion l impac asso i ted wi h he t ench ng wo ks a ong the ull engh o the p pel ne ou e as oci t d wi h je t ng The ac u cy o j t ing means a smal e oo p nt may be dis u b d du i g t nch ng but the po en ial o ow l e dep si ion l mounds dja ent o he t ench would cau e n add t onal d s u ban e to the s diment and ben hic communi i s long he ull en th o the p peine
2	T mpo al ecove y o con e va ion ob ec iv s tt but s	3	Th s would en ail empo a y di tu ban e o lo s o ny benth c commun t es h bi ats nd qua i y ng in eest ea u s pes nt a ong the t en hed o ido long he u l pipe ne ou e nclu ing any *S pinu osa* ommuni i s hat comp se he NNS R SAC o low ng su ci nt na u al n l o the t en h as umed o be in he ho t em) the s diment hab ats and commu i ies wou d be e pec ed to e olon se wi hin the t nch ootp int	2	Th s wou d nt il em o a y di tu bance o oss o any b nth c commun t es hab t ts and qua i ying nte e t atu es p esent long he le el ed a ea and t enched co do a ong the ull p pe ine oute incudi g ny *S sp nulo a* commun t es that omp i e he NN SR SAC Howeve et ing p ov des s mu t neous t ench ng and back l ing As su h s diment co e wi l be imme ia e y va l ble abo e he pip l ne p omot ng hab tat eco e y
3	De elopment ex ent nd pe ss t nce o a sed m nt plume	4	S abed p pa t on wo ks a ong the u l engh o he pip l ne a e ik ly to g ne tes abed d stu ban e e ul ing in s diment p um s hat wou d sp e d be ond he ex ent o he wo s The owe ac u cy o a C E u i i ed bo h o ev l ing and t ench ng wou d n u n esu t in a lon e du t on o wo ks the by ont ibu ing o a a e p ume ove a w de e tent Dep nding on the di e t on nd du a ion o the ediment p ume s gni cant dama e nd d stu ban e o nea by a as o hi h con dence *S pinu osa* e c nnot be dis ount d Sho t e m ec ve y wou d be i ely due o a al d spe sal l ow ng the e t bl shment o new e s e sewhe e	3	Se bed p epa a on wo ks along he u l l ngth o he p peine a e l key to gene a e se bed di tu bance esu t ng in sed m nt plumes hat would sp ead be ond he ex ent o he wo ks Due to the po en ial m l e pl me ex en s asso i ted wi h e t ng he d m ge and di tu bance o n a by a e s o igh con id nce *S sp nul sa* ee s le s i ey han o C E t ench ng l hough it annot be a tog the dis ount d Howeve he e s the pot nt al o plumes o he ind vid al ac i i i s o oa esce the eby nc eas ng the p ume con ent a ion and du t on o e a w de xt nt As su h di tu bance a d dama e o n a by h gh con id nce ee hab ta s canno be d sc unted equi ng sho t tem eco e y
4	Chan es to sed ment compos t on	2	The me hod w ll d stu b sed m nt o va y ng i es w th n the c oss se t on o a andwave and a ong the t en h co ido Th s w ll i ely esu t in coa se sed m nt be ng d pos ted on he eab d mmed at ly ad ac nt to the a ea o a t v ty due to the a ing all elo i i s o di e nt gain s zes In add t on he e is the po en ial o he d pos t on o ine ma e al ove a w de a a whi h may not cha a te st ca ly omp i e ine ediment due to the du at on and oncent t on o the plume ove a w de e tent Howeve n ime the hyd odyn m c e ime c oss the s ndw ves and NNSSR wi l act o ed st bute and so t the s diment n ine wi h he na u l sed m nt e ime	2	The m thod wi l di tu b ediment o aying s z s w th n he c ss sec i n o a s ndw ve and al ng he t ench co do his wi l ik ly su t in coa se ed ment eing de osi ed on the s abed immedi te y ad ace t to the a ea o a t vi y due to the va y ng ll v loc ies o di e e t g in s zes n addi ion he e s the po ent al o the d posi ion o ine mate al ove a w de a ea which may not cha ac e i t ca ly comp se ine s diment due o the du t on nd oncent t on o he plume ove a wide ex ent Howeve in ime he hyd odynamic eg me c o s he sandw ves and NN SR w ll ct to edi t ibu e and so t he sed m nt in l ne wi h he natu al ediment eg me
5	I t oduc ion o new ubst a e	2	The nt oduc ion o new subst te is imi ed to th t o the p pel ne wh ch wou d cons i ut a long em int odu t on o had subs ate w th ecove y o ba e ine cond t ons o low ng nau l in i l o he t nch	2	The in oduct on o new ubst a e is l mi ed o hat o he pip l ne whi h wou d cons i u e a ong te m nt oduc ion o had sub t a e wi h eco e y o b se ine c ndi ions o low ng back l ing o he t nch du ng jet t nch ng and nau l sed m nt depos ton
6	Chan es to the s abed mo phod nam c gime	3	n ad i ion to the e c s d sc ib d o C E l ve l ng (Op ion 5) the C E t nching ct v ty would en a l blow ng ed me t to the s des o he t nch poten al y c a ing mo nds ad ac nt and a ong he u l l ngh o he t ench he ize o he pot nt al mounds a e un ik ly o be a e th n he su ound ng e tu es l hough they wou d h ve a di e ent o ien a ion to he ea u es n ime he ed me t mounds would winnow down in i l ng he dj cent t nch o e nco po ted nto the nea by s ndw ves as pa t o he ed ment t an po t eg me The s diment mounds c at d du ing t nching a e unl k ly to c use any b ock ge e ec s (empo a y o pe m nen) to the hyd odyn m c o sed m nt t anspo t eg me	3	The j t t ench ng wou d nta l lu dis ng the s abed wi h edimen a ion occu ng a ong the t e ch ma g n c a ing mo nds dj cent and a ong the ull engh o the t en h The s ze o the po en ial mounds a e unl key to be a ge han the su ounding ea u s a thou h hey would have a di e nt o en at on to the a u es In t me the s diment moun s wou d w nnow down n l ing he dj cent t nch o e nco po ted i to the nea by sandwa es as pa t o the ediment t nspo t e ime The s diment mounds c ea ed du ng t ench ng a e u l key o cause a y b ock gee e ts tempo a y o pe manen) to the hyd odynamic o ediment t nspo t e ime
7	Impa ts on comme c al she es	3	o low ng natu al n l o the p e- ut t ench nd on e u i ien cove s ach ev d the p pel ne wi l not p sent a sn g sk to comme c al ishes Snag isk wi l be l m t d o he sho t medium du a ion equi ed o u i ient atu al n ll nd ny un lann d ven s e g s ou)	2	J t ing wi l su t in simu tan ous back l ing o he t nch howe e the d pth o cove ach ev d w ll be sub e t to the ocal s abed cond t ons As such j t ing wi l p o ide some m t ga on o nagg ng sk immedi te y o low ng ins al t on and th s w ll be u he duced by na u al n l ng o he sho t m dium e m
8	Po ent al o and m gni ude o s ou dev lopment and ee sp n ne ess t ng the ne d o meda wo s	3	The u e o C E to t ench the p peine is un i ely o p ov de su i i nt back i l ng o s diment co e ove the p pel ne on he compl t on o ns al a ion Wh en tu al s dimen t an po t p oc sses a e exp ct d o esu t n n l ing o he t ench ove ime ove he majo ty o the oute the e is he poten al th t the open t en h may su t in loc l sed s ou xpos ng the pi el ne and equ ing m dia ion hough ock pla ement	2	J t ing wi l su t in simu tan ous back l ing o he t nch howe e the d pth o cove ach ev d w ll be sub e t to the ocal s abed cond t ons Natu al ediment t nspo t gimes a e exp ct d o ont nue to in i l the t e ch inc as ng he dep h o ove o e ime The combin t on o b cki l ng du ng in tal t on nd n tu al in ll wi l s gni can ly duce the isk o xposu es and ee sp ns o cu ng
		24		20	

No	Envi onmen al C te ia — De c ption	6C Cont o led ow E cav ton + P ough — Sco e	6C Ju ti ca ion	6D Tai ing uct on Hoppe D edg ng + C E — S o e	6D Jus i ca ion
1	A ea and volume o di ect d stu ban e sed ments a d ben hic ommuni i s)	4	On ea hing he me n s abed l vel by means o a C E th s me hod en a ls c ea ing a de pe ten h a ong the ull oute eng h The ootp int o d stu ban e sso ia ed w h he andwave ev l ing would be ana ogous o hat o 5A he e wou d lso be the ad i ional mpact as oc at d w th the ten hing wo s long he u l len th o t e p peine o te as oc at d wi h a p ough W th a plo gh t nch ng me hod a wide andwave ev l ing co do a ais qui ed he eby e ul ing n a a e a eao di tu ban e In add t on the ex av ted m te al wi l be depos t d a ja ent o he ten h cons i ut ng an addi onal a ea o di tu bance a beit nly sho t- te m s he m te i l would be e ns a ed du i g he back ll un	4	On ach ng the mean se bed e el by m ans o a TSHD in s de- as ing mode his method ent i s c at ng a deepe t ench a ong he u l ute l ngh The oo p nt o d stu ban e asso i ted wi h he sandwa e e el ing wou d be an lo ous o hat o 5B The e wou d l o be he add t onal mp ct as oc at d w th the ten hing wo s long he u l len th o the pipe ne oute h ou h he use o C E The lowe ccu acy o a C E means a la e t enc ing o tp int may be di tu bed e ul ing n a di ct mpa t ove a age a ea compa ed w th o he methods The bulk o he C E t ench d mate al wou d be m ved to the ma ins and ad ac nt to the t nch in add t on to the s de ca ted m te al om he ev l ed a as
2	T mpo al ecove y o con e va ion ob ec iv s tt but s	2	Th s wou d ent il empo a y di tu bance o oss o ny b nth c commun t es h bi a s nd qu li y ng in e est ea u s p e ent a ong the l vel d a ea and ten hed o ido long he u l pipe ne ou e in lud ng any *S sp nu osa* c mmuni i s th t comp se the NNSSR SAC Howeve a ba k ll lough n wi l be condu ted post t nch ng wh ch wi l pla e emoved s dimen s o e he p pe As such sed ment hab t t would be imm dia e y aval ble o colon z t on p omot ng hab tat cove y	3	Depend ng on he th ckn ss o the de osi ion o e cav t d mate al th s wou d e ult n ei he a empo a y dis u bance o he b nth c commun t es o a lai e y hin l ye o depos t on hat was ap dly di pe sed by w te mov m nt o a empo a y loss o commun t es wi hin the dep si ion a ea which would ecove th ough colon z t on o a th ck so l heap ol owing nau l in i l o the t nch t e ediment h bi as nd commun t es would be expe t d o eco oni e w th n he t ench ootp int
3	De elopment ex ent nd pes st nce o a sed m nt plume	3	Due to the w de ev l ed w d h equi ed o he plou h t nch ng ool and the ow a cu cy o the C E me hod the e wi l a so be a onge pe iod o d stu ban e ince se plume gene a on Howeve as he p ough t en hing t ol invo v s ut ing nto the s abed and not uid s ng the sed ment he plume gene a ed th ough the t nching ope a i ns wou d be cons de ab e m l e th n o he t nching me hods wi h much sma le m act e te ts The e tent o indi e t impac s as oci t d wi h the plume wi l compa at v ly smal and he eby duc ng po en i l impac s on he S sp nulo a ee commun t es in the v c ni y w th e ove y poss ble n he sho t te m	3	Seab d p epa a ion wo s long he ul len th o the p peine a e l key o gene a e seab d dis u bance su t ng n sed m nt plumes th t would sp ead beyond the xt nt o the wo ks Due o the pot nt al o ge a e p ume ex en s as oci ted wi h C E t ench ng he e s pote t al o am ge and dis u bance o nea by a eas o h gh con iden e S sp nulo a ee Depend ng on he di ec ion and du t on o he sed m nt plume ign ic nt damage and dis u bance to nea by a eas o h gh con iden e S sp nulo a ee cannot be d scoun ed Sho te m cove y would be l key due to la va dispe al a low ng he es ab ishment o new ees el ewhe e
4	Chan es to sed ment compos t on	2	The method wi l di tu b ed ment o va ying iz s w th n he c oss- se t on o a andwave and a ong the t en h co ido Th s w ll i ely esu t in coa se sed m nt be ng d pos ted on the s abed imm dia e y adj cent to t e a ea o ct v ty due to he a ing all eoci i s o di eent g an s zes In add t on he e s the po en ial o t ed pos t on o ine m te al ove a w de a a whi h may not cha a tei t caly comp ise ine sed ment ue o he du t on nd c ncent a on o he plume ove a wide ex ent How ve in t me he hyd odynamic eg me ac oss he san w ves and NN SR w ll ct o ed st ibu e and so the se iment in l ne wi h he natu al ediment eg me	2	The m thod wi l dis u b s diment o a ings zes wi h n he c o s- ec ion o a sandwa e and long he t ench co do his wi l l key sult n oa se s diment b ing depo i ed on the s abed imm dia e y adj cent o he a ea o aci i y ue o he va y ng a l ve oc tes o di eent g an si es n ddi ion the e s he pot nt al o the depo i ion o nem tei l ove a wide a ea wh ch m y n t cha ac e is i al y comp se ne sed m nt due o he du a ion and con ent a ion o he p ume o e a wide xent H w ve in t me he hyd dynamic eg me ac oss he sandwa es and NNS R w ll a t to dis ibu e nd o t he sed m nt in l ne w th he n tu al s diment eg me
5	I t oduc ion o new ubst a e	2	The nt oduc ion o new ubst a e is imi ed o that o the pi el ne whi h wou d con t tu e a ong te m nt oduc ion o ha d ubst a e w th cove y to ba el ne cond t ons o low ng he back ll p ough un nd nau l sed m nt depos t on	2	The int odu t on o n w sub tae s l m t d o hat o he pipe ne whi h wou d cons i ute a l ng e m int odu t on o ha d sub tate wi h eco ey o b se ine cond t ons o low ng n tu al n ll o he t ench
6	Chan es to the s abed mo phod nam c gime	3	In add t on to the e cts de c ibed o C E le el ing Opt on) the use o the p ough du ing t ench ng wi l l key c ate be ms o exc va ed ma e i l immedi te y ad ace t to the t en h Depend ng on he vo ume o mate al mo ed he e ould have h igh s th t a e co side ab y la ge ge a e th n the u oundings abed As he p opo ed me hod s to condu t a b ck i l pl ugh un hese be ms wi l be l vel d so the e is un ik ly o be any bl cka e e ec s to the hyd odyn m c eime n ime he sig t y a sed p o le as oc at d w th the bu al o he pip l ne wou d be w nnow d down o he su ound ng se bed	3	In add t on o he e e ts desc bed o SHD e el ing Opt on 5) he C E t ench ng aci i y wou d ent il b owings diment o he sid s o the t en h po en ia ly c e t ng mounds adj cent nd long the ull en th o the t en h The s zeo the po en ia mounds a e unl key to be la ge han the su ounding ea u s a thou h hey would have a di e nt o en at on o the atu es In t me the s diment mounds wou d w nnow down n l i g the ad ac nt t ench o be in o po a ed in o he nea by andwav s as pa o the s diment t anspo t gime he ed men mounds c ea ed du ng t ench ng a e un key o ause any bloc age e c s t mpo a y o emane t) o he hyd o ynamic o s diment t an po t e ime
7	Impa ts on comme c al she es	1	o low ng c ive n ll o hep -cut ench du ng in tal ton ct v tes the p peine wi l not p esen a nag sk to comme c al i hes	3	ol owing nau al in i l o he p e cutt nch and once su cent co e is chi ved he pipe ne w ll not p es nt as nag isk o ommeci l shes Sn g sk w l be imi ed to t e sho du a ion equi ed o u i ient atu al n ll nd ny unp ann d e en s eg s ou)
8	Po ent al o and m gni ude o s ou dev lopment and ee sp n ne ess t t ng the ne d o med a wo s	2	The p pel ne would ac i ely ove ed mmed a e y po t t ench ng by the use o he ack i l p ough The p ese ce o ove-bu den edu es the po ent al o scou ccu ng and e spans de elop ng	3	The use o C E o t en h he pip l ne s unl key to p o ide su cent ba k lingo sed m nt cove ove he pipe i e on t e omp e ion o in tal ton Wh le nau l sed m nt t anspo t p ces es a e xpec ed to su tin in i l ng o the te ch o e ime o e the ma o ty o he ou e he e s the po ent al hat he open t nch may esu t in oca i ed scou expo ing he p peine a d equi ing emed at on th ough ock p ac ment
		19		23	

No	De c ption	6E Tai ng Suc ion Hoppe D ed ing + J ting — Sco e	6E Ju ti ca ion	6F Ta ing S ion Hoppe Dedging + Plough — Sco e	6F Ju ti ca ion
1	A ea and volume o di ect d stu ban e sed ments a d ben hic ommuni i s)	4	On ea hing t e mean s abed l vel by means o a TSHD n s de ca t ng mode his me hod en ai s c ea ing a deepe t ench a ong the ull oute eng h The otp int o d s u b nce as oc at d wi h the sa dw vel vel ng wou d e nalo ous to th t o 5B The e would a so be the add t onal mp ct as oc a ed w th the t nching wo ks al ng he u l l ngth o he pip l ne ou e th ough the use o et i g The a cu cy o j ting means a smal e oo p nt may be dis u ed du i gt nch ng but the po en ial o ow l e dep si ion l moun s dja ent o he t ench would cau e n add t onal d s u ban e to the s diment and ben hic communi i s long he ul len th o the p peine	4	[illegible]
2	T mpo al ecove y o con e va ion ob ec iv s tt but s	3	Depe ding on the th c ness o he d pos ton o xca a ed ma e ial th s would sult n e the a empo a y di tu bance o he ben hic commun ies o a el t vey th n aye o depo i ion th t w s ap dly d spe sed by wate mo em nt o a empo a y lo s o commun t es wi hin t ed pos t on a ea whi h wou d eco e th ough co oni at on o a th ck so l heap How ve j ting p ovi es simu tan ous t ench ng and b ck i l ng As such sed ment cove wi l be immed a e y val ble abo e he pip l ne p omot ng habi at cove y	2	[illegible]
3	De elopment ex ent nd pes st nce o a sed m nt plume	2	Se bed p epa t on wo ks along he u l l ngth o he p peine a e l key to gene a e se bed di tu bance esu t ng in sed m nt plumes hat would sp ead be ond he ex ent o he wo ks Al hough a plume wou d st ll e ene a ed n e a ion to the bed p epa at on aci i i s the ccu acy and tag t d nau e o he m thods would a so m an a sho e du t on o wo ks es l ing in he m l e plume ex ent du ton nd d nsi y th n o C E Howeve he ench ng does employ u dis t on o he sed m nt a ong he u l p pel ne ou e and so ndi e t di tu bance o n a by S pinu osa ees m plume sed m nta ion cann t be nti ly di coun ed	2	[illegible]
4	Chan es to sed ment compos t on	2	The method wi l di tu b ediment o a ying s z s w th n he c ss sec i n o as ndw ve and a ong he t ench co do his wi l ik ly su t in coa se ed ment eing de osi ed on the s abed immedi te y ad ace t to the a ea o a t vi y due to the va y ng ll v lo i ies o di e ntg an s zes n addi ion he e s the po ent al o the d posi ion o ine mate al ove a w de a a which may not cha ac e i t caly comp ise ine s diment due o the du ton nd oncent ton o he plume ove a wide ex ent Howeve in ime he hyd odynamic eg me c o s he sandw ves and NN SR w ll ct o edi tibu e and so t he sed ment in l ne wi h he natu al ediment eg me	2	[illegible]
5	I t oduc ion o new ubst a e	2	The i t oduct on o new ubst a e is l mi ed o that o he pip l ne whi h wou d cons tu e a ong te m nt oduc ion o ha d su st a e wi h eco ey o b se ine c ndi ions o low ng back l ing o he t nch du ng jet t nch ng and nau l sed m nt depos ton	2	[illegible]
6	Chan es to the s abed mo phod nam c gime	3	The j t t ench ng wou d nta l lu dis ng the s abed wi h edimen a ion occu ng a ong the t nch magn c aing mo nds dj cent a d a ong the ull engh o he t en h The s ze o the po en ial mounds a e unl key to be la ge han the su ounding ea u s a thou h hey would have a di e nt o en at on to the ea u es In t me the s diment mou ds wou d w nnow down n ling he dj cent t ncho e nco po ted nto the nea by sandw ves as pa to the ediment t nspo t e ime The ediment mounds c ea ed du ng t ench ng a e u l key o cause a y b oc age e e ts tempo a y o pe manen) to the hyd odynamic o ediment t nspo t gime	3	[illegible]
7	Impa ts on comme c al she es	2	J ting wi l su tin simu tan ous back l ing o he t nch howe e the d pth o cove ach e ed w ll be sub e t to the ocal s abed cond t ons As such j ting wi l p vide some m tg t on o naggng skimmedi tey o lowing ins al ton and th s wi l be u he duced by nau al n l ng o he sho t m dium em	1	[illegible]
8	Po ent al o and m gni ude o s ou dev lopment and ee sp n ne ess t t ng the ne d o med a wo s	2	J ting wi l su tin simu tan ous back l ing o he t nch howe e the d pth o cove ach e ed w ll be sub e t to the ocal s abed cond t ons Natu al ediment t nspo t gimes a e exp ct d o ont nue to in i l the t nch inc as ng he dep h o ove o e ime The combin t on o b ck i l ng du ng in tal t on nd n tu al in ll wi l s gni can ly duce the isk o xposu es and ee sp ns o cu ng	2	[illegible]
		20		18	

No	De c ption	6G [illegible] — Sco e	6G Ju ti ca ion	6H eab d E ca ato s + Je t ng — S o e	6H Jus i i a ion
1	A ea and volume o di ect d stu ban e sed ments a d ben hic ommuni i s)	[illegible]	[illegible]	4	On ach ng the mean se bed e el by m ans o a TSHD in s de- as ing mode his method ent i s c at ng a deepe t ench a ong he u l o te l ngth The oo p nt o d stu ban e asso i ted wi h he sandwa e e el ing wou d be an log us o hat o 5C The e wou d l o be he add t onal mp ct as oc at d wi h the t en hing wo s long he u l len th o the pipe i e oute h ou h he use o j ting The ac u a y o je t ng m ans a m l e oo p nt m y be d s u b d du ing t en hing but the po ent al o low e e depo i iona mounds ad ac nt to the t nch wou d ause an addi i nal di tu bance o he sed m nt and ben hic commun t es a ong the ull eng h o the pi el ne
2	T mpo al ecove y o con e va ion ob ec iv s tt but s	[illegible]	[illegible]	3	Depend ng on he th ckn ss o the dep si ion o e cav t d mate al th s wou d e ult n ei he a empo a y dis u bance to he b nth c commun t es o a lai ely hin l ye o depos t on hat was ap dly di pe sed by w te mov me t o a t mpo a y loss o commun t es wi hin the depo i ion a ea which would cove th ough colon z t on o a th ck so l heap Howe e je t ng p o id s imul aneous t nching nd b ck i l ng As uch sed m nt cove w ll be mmed a ely a a lab e above he ipe ine p omo i g h bi at e ove y
3	De elopment ex ent nd pes st nce o a sed m nt plume	[illegible]	[illegible]	2	As o he SHD+ e t ng ench ng opt on a thou h a plume would s i l be gene a ed in e a ion to the b d p epa a ion ac i i ies the a cu acy and ta g ted na u e o he m thods wou d al o mean a sho te du a ion o wo s su t ng n the sma le p ume xt nt du a i n and den i y han o C E How ve the t nching do s mp oy uid sa ion o he ed men along he u l pip l ne ou e nd o ndi ect is u b nce to nea by S s inu osa e s om p ume edimen a ion cannot be en i e y dis ount d
4	Chan es to sed ment compos t on	[illegible]	[illegible]	2	The m thod w l dis u b s diment o va ings zes wi hin he c o s- ec ion o a sandwa e and long he ench co do his wi l l key e ult n oa se s diment b ing depo i ed n the se bed imm dia e y adj cent o he a ea o aci i y d e o he va y ng a l ve oc t es o di eent g an i es n ddi ion the e s he pot nt al o the depo i ion o nem te i l ove a wide a ea wh ch m y no cha ac e is i al y comp se ne sed m nt due o he du a i n and con ent a ion o he p ume o e a wide xent How ve in t me he hyd o ynamic eg me ac oss he sandwa es and NNS R w ll a t to dist bu e nd o t he sed m nt in l ne w th he n tu al s diment eg me
5	I t oduc ion o new ubst a e	[illegible]	[illegible]	2	The int odu t on o n w sub tae s l m t d o hat o he pipe ne whi h would cons i ute a lo g em int odu t on o ad sub tate w h ecove y o ba e ine cond t ons o low ng b cki l ng o the t e ch du i g et t e ching and natu al ediment d pos ton
6	Chan es to the s abed mo phod nam c gime	[illegible]	[illegible]	3	The je t ench ng would en a l uid s ng these se bed w th s dimen at on occu ng along the t en h ma in c e t ng mounds ad a ent and a ong he u l l ngh o he t ench he si e o the pot nt al mounds a e un i e y o be a ge han the su ound ng atu es al hough th y wou d ave a di e ent o ent t on o he atu es n t me he sed ment mounds would winn w down in i l ng the ad a ent t en h o be nco o a ed in o he nea by sandwa es as pa t o the s diment t an po t eg me The s diment mounds c at d du ng t ench ng a e un i ely o ause any b ock ge e ec s (empo a y o pe m nen) to the hyd o ynamic o s diment t a spo t e ime
7	Impa ts on comme c al she es	[illegible]	[illegible]	2	Je t ng wi l e ult n imul ane us b ck i l ng o the t en h howeve the dep h o cove ach ev d wi l be sub ect o he lo al se bed cond t ons As uch je t ng wi l p o ide some m t ga ion o sn gg ng skimm dia e y o lowi g ns al a ion nd his w ll be u he edu ed by n tu al n l ing o he sho med um e m
8	Po ent al o and m gni ude o s ou dev lopment and ee sp n ne ess t t ng the ne d o med a wo s	[illegible]	[illegible]	2	Je t ng wi l e ult n imul ane us b ck i l ng o the t en h howeve the dep h o cove ach ev d wi l be sub ect o he lo al se bed cond t ons N tu al s diment t an po t e imes a e xpe ted to con inue o n l the t en h ince sing he depth o co e ove ime The combinai n o b ck i l ng du ng ns a la i n and na u l in i l wi l s gni i an ly edu e the sk o e posu es and ee spans oc u ing
		23		20	

No	De c ption	6I Se bed Exc va o + Plou h — co e	6I Ju ti ca ion	Option 7 Pi el ne Sel Bu al — co e	Option 7 usti ca on
1	A ea and volume o di ect d stu ban e sed ments a d ben hic ommuni i s)	4	On ea hing the mean s abed le el by m ans o a TSHD in s de ca t ng mode his me hod en ai s c ea ing a deepe t ench a ong the ull oute eng h The o tp int o d s u b nce as oci t d wi h the san w ve le e l ng wou d be nalo ous to th t o 5C The e w uld al o be the add t onal mp ct a soc a ed w th the t en hing wo ks alo g he u l l ngth o he pip l ne ou e h ough he use o a plo gh W th a plou h t nching me hod a w de andwave eve ing co do a a is qui ed the eby esu t ng in a la ge a a o dis u ance n addi i n he xc va ed ma e ial w ll be depos ed dja ent o he t ench onst t ng n ddi ion l a a o dis u ance lb it on y sho t te m as he ma e i l wou d be e ns at d du ing he ack i l un	2	The ni i l su ace ay o t e p pe ine wou d esu t in a loss o ediment nd b nth c commu i ies wi h n he oo p nt o the p peine
2	T mpo al ecove y o con e va ion ob ec iv s tt but s	2	The depo i ion o a soi heap at he ide o he ench and subse uent in l ing o he t ench wi l con t tu e a ho t e m dis u ance ow ve a back i l p ough un w l be condu ted post t nchi g wh ch w ll ep ace emoved sed m nts ove the p pe As uch sed m nt hab t t wou d be mmed a ely va lab e o ec lon za ion p omot ng h bi at cove y	3	o low ng bu al the san y ediment h bi at and a soc at d ommuni i s nclud ng the qua i y ng in e st ea u e *S pinu osa* ommuni i s ost om he oo p nt o the p pel ne wi l be ep ac d nd eco oni ed Th s is a ses ed as a ho - e m di tu bance
3	De elopment ex ent nd pes st nce o a sed m nt plume	2	As o he TSHD Plough t en hing op ion s he plou h t nching ool in ol es cu t ng in o he se bed and not uid si g he sed m nt he plume gene a ed th ough the t ench ng ope a ions would be cons de ab e m l e th n o he t nching me hods wi h mu h ma le impact xents The ex ent o ndi e t impac s as oci ted wi h he plume wi l compa t ve y sm ll the eby duci g po en i l impac s on he *S sp nulo a* e communi ies n he vi in ty w h cove y poss b e n he sho t te m	1	Th s me hod wo ld ent il min mal se bed dis u ance o de elopment o a ediment p ume ny d s u b nce would be du ng the pe iod o in ial p pe ay A soc a ed e ec s would be ve y lo al sed to he p pe ine a d empo a y qu ck y e u ning to wi hin ba kg ound ediment oncent t on ev ls
4	Chan es to sed ment compos t on	2	The m thod wi l di tu b ediment o a ings z s w th n he c o s sec ion o a sa dw ve and al ng he t ench co do his wi l ik ly su t in coa se ed ment b ing dep si ed on the s abed immedi te y ad acen to the a ea o ac vi y due to the va y ng ll v loc ies o di e e t g in s zes n ddi ion he e s the po ent al o the de osi ion o ine mate al ove a w de a ea which may not cha ac e i t ca ly comp se ine s diment due o he du t on nd c ncent a on o he plume ove a wide ex ent Howeve in ime he hyd odynamic eg me ac o s he sandwa es and NN SR w ll ct to edi tibu e and so t he sed m nt in l ne wi h he natu al ediment eg me	1	No hange n s diment c mpos ion is e pec ed w th th s m thod s t does not nvo ve he emoval o d pos t o sand o g av l a ong he pip l ne ou e o el ewhe e n he NN SR SAC
5	I t oduc ion o new ubst a e	2	The in oduct on o new ubst a e is l m ed o hat o he pip l ne whi h wou d cons i u e a ong te m i t oduct on o ha d sub ta e wi h eco e y o b se ine co di ions o low ng the ba k ll p ough un and atu al s diment d posi i n	3	The nt oduc ion o new ubst a e is imi ed to th t o the p pel ne wh ch wou d con t tu e a ho t o med um te m nt oduc ion o ha d ubst a e p o to na u l bu al Once u y bu i d the n uence o new u ace ha d subst te on he lo al en i onm nt wi l be u ly em ved
6	Chan es to the s abed mo phod nam c gime	3	In add t on o he e e ts de c bed o eab d e ca ato e el ing Opt on 5) he use o the plou h du ing t nching w ll ik ly c ea e be ms o e cav t d mate al mmed at ly ad ac nt to the t nch Dep nding on the vo ume o ma e ial emoved th se cou d h ve hei hts hat a e ons de bly a e ge a e han the su ound ng se bed As the p opos d meth d s o condu t a b ck i l plou h un t ese be ms wi l be l vel d so he e is un ik ly to be any blo ka e e ec s to the hyd odyn m c eg me In t me he sigh ly a sed p o i e ass ci ted wi h he ebu i l o the p pe ine would be winnowed down o he su ound ng se bed	4	The p es nce o the su ce l id pip l ne nd ddi ion l ve t cal in wi l su t in long e m but s gni cant oc l sed e e t on he mo phodyn m c eg me in lud ng chan es to scou and depo i ion a ound he ass t s pe i s des gn unc ion How ve once he p peine s bu ied h s e ect wou d be educ d
7	Impa ts on comme c al she es	1	o low ng ct ve n ll o he p e cut t nch du ng ins al t on a t v t es he pipe i e w ll not p sent a s ag sk to comme c al is es	4	The su ce l id pip l ne nd sso ia ed spo l e s and ns w ll ni i l y p e ent a s gni cant sn gg ng sk o ow ng suc ess ul s l-bu i l the p pel ne i sel m y be xpe ted to each a evel o ove u i ient o edu e he sna g ng i k o the medium e m How ve as the he ght o he ve t cal in is un nown it s conse v t ve y ssumed th t the n w ll p e ent a sn g i k o he i e ime o the a set
8	Po ent al o and m gni ude o s ou dev lopment and ee sp n ne ess t t ng the ne d o med a wo s	2	The pi el ne w uld ac i ely co e ed mmed a ely po t t ench ng by the use o he lough The p sen e o ove-bu den educ s he pot nt al o scou o cu ng nd e pans dev lop ng	4	The su ce s o h s me hod t ma n ain ng a su i i nt le el o ove bu den is unkn wn As su h th s me hod is con e at v ly as es ed s h v ng he pot nt al o scou d veopm nt and ee sp n nec ss ta i g he need o emed al wo s long he u l pipe ne oute o e he i e ime o the a set
		18		22	

APPENDIX F

Southward Pipeline Morphological Assessment

(Xodus 2021)

Southwark Pipeline Morphological Assessment

24" Southwark Pipeline Morphological Assessment

Independent Oil & Gas PLC

Assignment Number: L100699-S00
Document Number: L-100699-S00-TECH-001

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24" Southwark Pipeline Morphological Assessment

L100699-S00

Client: Independent Oil & Gas PLC
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CONTENTS

1 INTRODUCTION

1.1 Study Background

A new 24” Nominal Bore (NB) pipeline (24” Southwark pipeline) is to be installed as part of the Independent Oil and Gas (IOG) Blythe and Vulcan Satellite Hubs Development, to connect the new Southwark Platform with the existing 24” Thames Pipeline (at KP 62). The new 24” Southwark pipeline will be approximately 5.8 km long with water depths along its route varying between 22 m and 35 m. The new 24” Southwark pipeline route is located entirely within the North Norfolk Sandbanks and Saturn Reef (NNSSR) Special Area of Conservation (SAC) which is designated for the conservation of Annex I habitats “sandbanks which are slightly covered by seawater all the time” and “reefs”. The seabed in the North Norfolk sandbank system is characterised by large sandwaves and mega-ripples which present challenging conditions for pipeline installation.

An Environmental Statement (ES) had previously been approved for the Vulcan Satellites Hubs Development, which included the 24” Southwark pipeline route. Following a survey in May 2020, it was identified that the sandwaves along the proposed pipeline corridor, prohibited the proposed pipeline installation without seabed preparation works. The Vulcan Satellites Hubs Development ES however did not adequately account for any seabed preparation works as part of the installation of the 24” Southwark pipeline, which were necessary due to the present sandwaves. For this reason, the 24” Southwark pipeline installation could not proceed under the approved Vulcan Satellites Hubs Development ES. An ES Addendum is therefore required to document and assess the potential impact of any proposed seabed preparation works required to facilitate 24” Southwark pipeline installation. IOG PLC have retained Intertek to prepare an ES Addendum, which is to include information on the required works to support a revised 24” Southwark pipeline installation date of July 2022.

The 24” Southwark pipeline corridor is located in a morphodynamically active environment with evidence of actively migrating sandwaves that are characteristic of the North Norfolk sandbank system. Sandwaves are typically found on the slopes of sandbank formations and they are particularly well developed across the sandbank system, including those proximal to the 24” Southwark pipeline corridor. The sandwave crests are typically aligned perpendicular to the sandbank crest, and bathymetric information from surveys completed in 2018 and 2020 initially indicated that the sandwaves are actively evolving with average migration rates of up to 14 m/year. In the wider area covered by the 2018 survey, there is also evidence of bifurcating and converging sandwaves, associated with steep asymmetric profiles of up to 18°, which all confirm an active and dynamically evolving environment.

Owing to the seabed preparation works which are necessary prior to pipeline installation, information on the likely area and volume of sediment disturbance associated with the works is required as part of the ES Addendum for the 24” Southwark pipeline. The migratory nature of the sandwaves means that sediment disturbance volumes estimated from the present bathymetry are unlikely to be representative for an installation in 2022, as required by the ES Addendum. Therefore, an understanding of the migration properties of the sandwave bedforms with respect to the pipeline corridor by the installation period in 2022 is required, from which sediment disturbance volumes can be estimated. Subsea 7 initially approached Xodus to provide support in completing a morphological assessment of the sandwave bedforms to provide further information on the following:

> Sandwave migration affecting the 24” Southwark pipeline corridor between the 2018 survey and the present; and

> Likely locations of sandwaves along the pipeline route up to the present, and an estimated installation date of July 2022 as a worst case.

The morphological assessment will be used by Subsea 7 to inform technical aspects of the seabed preparation and pipeline installation; including calculating estimates of the likely area and volume of disturbance along the entire pipeline route as required the ES Addendum. IOG has now directly contracted Xodus to carry out the morphological assessment, in order to provide Subsea 7 with the results to calculate the area and volume of sediment disturbance as part of the seabed preparation works, to ultimately inform the ES Addendum.

1.2 Study Scope

Given the requirement to provide Subsea 7 with the understanding to ultimately inform the ES Addendum with the potential area and volume estimates of seabed disturbance from the seabed preparation works, the objectives of this morphological assessment are as follows:

> Identify and describe the properties of the sandwaves within the study area and which intersect the 24" Southwark pipeline corridor;

> Calculate the migration characteristics of the sandwave bedforms within the study area, particularly those that intersect or are likely to intersect with the 24" Southwark pipeline corridor; and

> Predict the position of the sandwave bedforms that are likely to intersect the 24" Southwark pipeline corridor by the assumed installation date of July 2022, as a worst case.

The results of the study and the predicted future position of the sandwave bedforms are to be used by Subsea 7 to determine the appropriate method of pipeline works and installation. This in turn will enable the calculation of estimates of the likely area and volume of disturbance required along the pipeline corridor to input into the ES Addendum.

1.3 Overview of Methodology

A summary of the morphological assessment approach is as follows:

> Characterise the environmental setting within which the North Norfolk sandbank and sandwaves are located, in terms of the tidal and wave regime and the forcing mechanisms that control the bedform evolution;

> Identify the occurrence of storm events for a period preceding and overlapping the 2018 and 2020 bathymetry information to evaluate the contribution of these events to the sandwave evolution;

> Determine the spatial translation of the bedforms where information is available;

> Determine the properties (height, wavelength, asymmetry) and migration characteristics of sandwave bedforms that are relevant to the 24" Southwark pipeline corridor;

> Based on the calculated sandwave migration characteristics, predict the future position of the sandwave bedforms up to July 2022 as a worst case; and

> Provide a statement on the level of uncertainty associated with the developed predictions.

1.4 Study Area

The proposed study area is the region covered by the 2018 bathymetry within the North Norfolk sandbank system. The study area is intentionally much wider than the 24" Southwark pipeline corridor in order to detect and account for sandwave bedforms present outside the corridor but with the potential to migrate in.

1.5 Data

The datasets applied to the study and their respective relevance is summarised in Table 1, while the extents of the applied bathymetry data are illustrated in Figure 1.

Table 1 Datasets applied in the study.

Data	Parameters and description	Applicability
Bathymetry		
2018 Southwark pipeline bathymetry (Fugro, 2018)	The Southwark pipeline geophysical survey was conducted by Fugro Ltd between the 5-12th February 2018. The route survey corridor covered an area of 5.854 km long and 600 m wide between Southwark and the Eastern Vulcan Tie-in Option (at KP 62). Bathymetric data was acquired using single beam and multibeam echo sounders. Water depths are quoted relative to Lowest Astronomical Tide (LAT) and are considered accurate to ± 1% of depth. The bathymetry data was reduced using observed Global Navigation Satellite System (GNSS) tides and corrected to LAT using vertical offshore reference frame (VORF).	This dataset forms the primary source of information to complete the morphological assessment and provides the best recent coverage of the study area.
2020 revised Southwark pipeline route bathymetry	A pipeline route survey was completed in 2020 and provides a very limited 50 m view of the pipeline corridor. Accuracy information is unknown but is assumed to be similar to that of the 2018 dataset.	This dataset forms another primary source for the study, although it does not provide the same coverage.
1991 Broken Bank to North Haisborough survey (UKHO, 1991)	The bathymetry data was accessed using the UK Hydrographic Office (UKHO) Admiralty Maritime Data Solutions Marine Data Portal under the Open Government Licence. Bathymetry data was used from the 1991 survey which covered a large area subdivided into Blocks. Bathymetry data for Blocks 3-10 contributed to the assessment.	This dataset was used to provide a regional context to the study area, including the location of the pipeline in relation to Inner Bank and the wider North Norfolk sandbanks.
Tidal		
Cromer tidal gauge data (BODC, 2021)	Tidal data was accessed from the British Oceanographic Data Centre (BODC). The nearest tidal gauge to the North Norfolk sandbanks is located along the Norfolk coast at Cromer on the end of Cromer Pier (1.30164E, 52.93436N; WGS84). The tidal gauge recorded data on both a primary and secondary channel. Data was used between 2017 and present to	This dataset is used to provide information on the tidal conditions preceding the 2018 survey and up to the recent 2020 survey, as well as an understanding of the conditions which would have influenced sandwave movement within that period.
Wave		
Blakeney Overfalls and Happisburgh buoy data (Channel Coastal Observatory, 2021)	Wave data was accessed from the Channel Coastal Observatory. Data was utilised from buoys at two locations along the Norfolk coast to infer wave conditions within the North Norfolk sandbanks: Blakeney Overfalls (1.09883E, 53.0588N; WGS84) and Happisburgh (1.54767E, 52.82700N; WGS84). The buoy at Blakeney Overfalls was located in an approximate water depth of 23 m (Chart Datum (CD)). The Happisburgh buoy was located in approximately 10 m (CD) of water.	Similar to the tidal information, these datasets are used to provide information on the wave conditions preceding the 2018 survey and up to the recent 2020 survey, as well as an understanding of the conditions which would have influenced sandwave movement within that period
Clipper and Sean Papa	Data for buoys located at the oil and gas platforms Clipper (operated by Shell) and Sean Papa (operated by ONE-	

buoy data (Cefas WaveNet, 2021)	Dyas) was accessed using the Centre for Environment, Fisheries and Aquaculture Science (Cefas) WaveNet online database. Though not available for public download, wave data was visualised over the 2017 to 2020 period.	

The reference frames used in this study are:

- European Datum 1950 (ED50) Universal Transverse Mercator (UTM) 31 North, which is the spatial reference frame for the wider Blythe and Vulcan Hubs Development project; and
- LAT vertical reference frame.

No correction was required for the 2018 and 2020 bathymetries. The 1991 UKHO bathymetry was projected to the same ED50 UTM31N spatial reference frame applicable to the project. No vertical correction was applied to the dataset, as the information was not directly used to inform any height or steepness estimates, instead it was only used to provide context of the wider North Norfolk sandbank system and high-level understanding of the nearby Inner Bank.

1.6 Assumptions

A number of assumptions based on the morphological understanding of the study area were applied in developing the predictions of future changes, which include:

- The assessed bedform features across the study area are situated on and move across the underlying immobile geology;
- The study is based on the understanding of morphological behaviour represented in the bathymetric datasets, which are related to varying environmental conditions, particularly between 2017 and 2020, where the bathymetric surveys capture a static snapshot of the bedform state with respect to the environmental forcing. Therefore, the future occurrence of environmental conditions beyond the observed envelope, may result in large changes and reworking of the present bedforms at all scales;
- Morphological bedforms may exhibit cyclical patterns of behaviour over much longer timescales than may be represented in the available data. Therefore, predictions of future change would likely under-estimate these patterns; and
- Typically, determination of the mobile part of the seabed for which the migration could be calculated for was based on a geotechnical model of the sediment unit. This approach also limits the influence of the slope of the underlying geology in determining the changes to seabed depths. However, this information is not available for this study. Therefore, the mobile sediment layer is estimated based on assessment on the changes in seabed contours between the 2018 and 2020 bathymetry dataset.

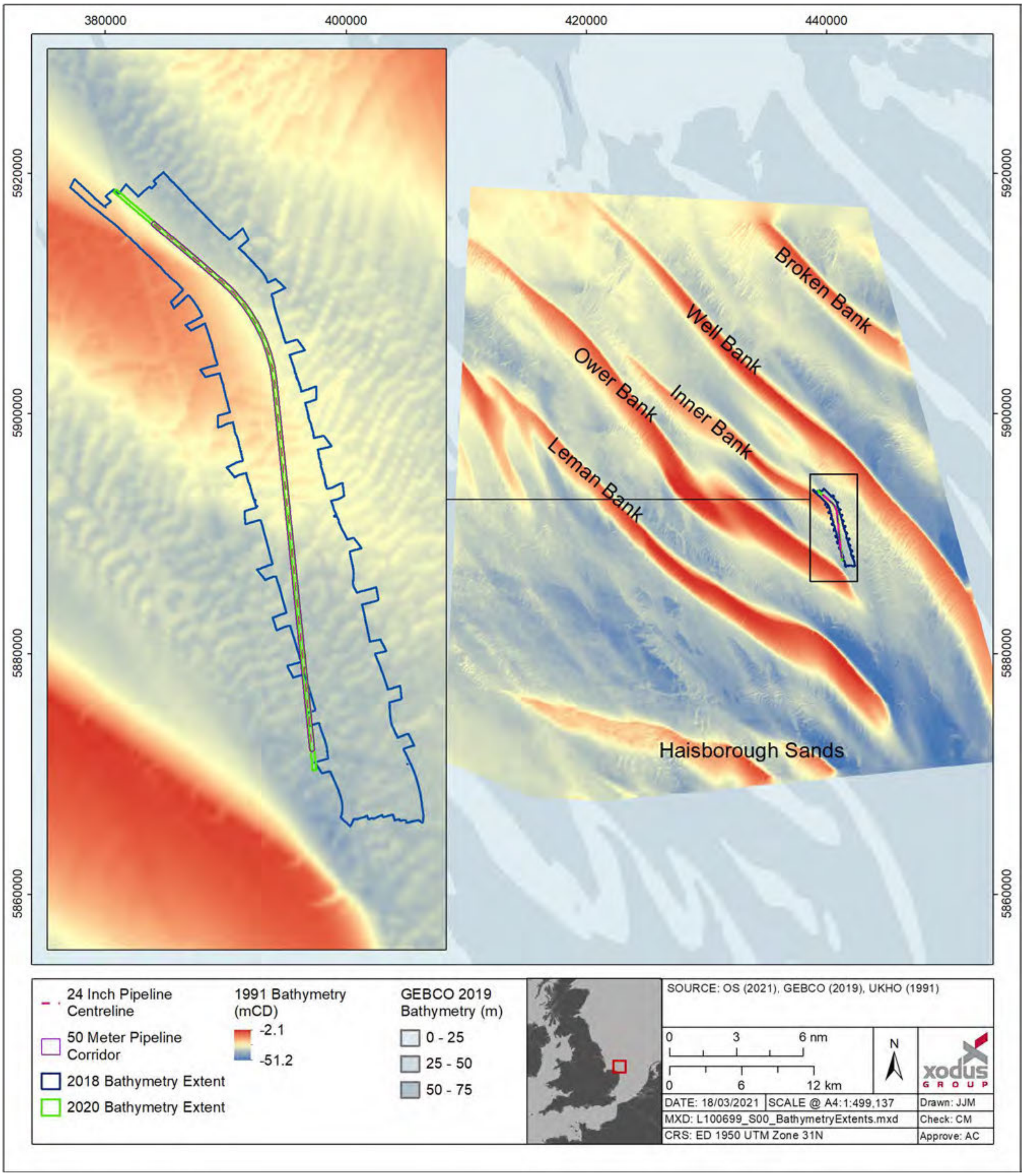

Figure 1 Bathymetry data extents used in the study.

2 BASELINE UNDERSTANDING

2.1 North Norfolk Sandbank System

The North Norfolk Sandbank system is located within the Southern North Sea (SNS), which is a relatively shallow area of the North Sea and associated with a number of morphological bedform features. The North Norfolk sandbanks are key examples of tidally controlled open shelf linear bedform features characteristic of sediment rich environments as illustrated in Figure 2. The sandbank system is located within an environment that is conducive to the active maintenance of the larger bedforms as well as smaller features superimposed over the sandbanks, due to the current speeds, water depths and sediment availability (Kenyon *et al.* 1981; Kenyon and Cooper, 2005).

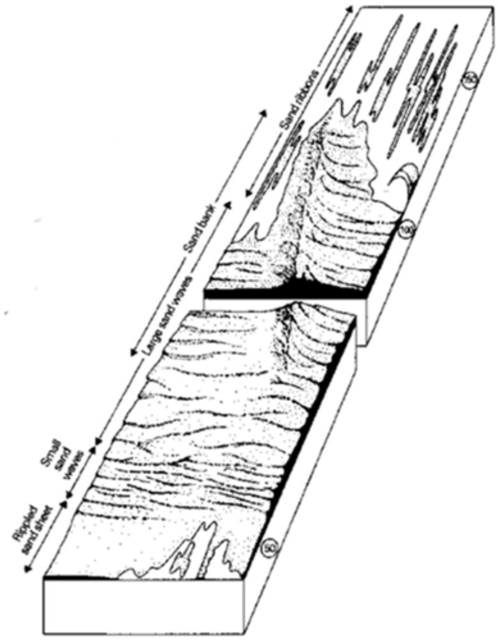

Figure 2 Characteristic morphological bedforms in areas of abundant sediment.

The North Norfolk sandbanks extend from about 40 km off the coast of Norfolk out to approximately 110 km offshore (Collins *et al*., 1995). The sandbank system includes the following sandbanks: Leman, Ower, Inner, Well, Broken, Swarte and four outer sandbanks which are collectively called the Indefatigables, part of which are illustrated in Figure 1. The crests of the sandbanks are in water shallower than 20 m, and the flanks of the sandbanks extend into waters up to 40 m deep (JNCC, 2008). The crests of the Indefatigables are deeper than those of the nearshore sandbanks (Inner, Well and Leman), however the troughs are comparable (Jenkins *et al*., 2005), thereby indicating steeper and more asymmetric profiles in the sandbanks closer to the coast. Superimposed on the sandbanks are sandwaves, which are best developed on the inner sandbanks, while the outer sandbanks have smaller sandwaves, if any at all (Collins *et al*., 1995).

The North Norfolk sandbanks are considered to represent the most extensive system of open shelf ridge sandbanks in the UK (Graham *et al*., 2001 cited in JNCC, 2017). The sandbanks have asymmetrical profiles, whereby the steeper slopes (up to 7°) are towards the east and northeast (Caston, 1970; Collins *et al*., 1995). However, the outermost sandbanks of the sandbank system have lower slopes and are considered to be moribund (Kenyon and Cooper, 2005). Each sandbank within the system is also wider in the south than in the north (Kenyon and Cooper, 2005). Initially, the sandbanks were thought to be parallel to tidal currents in the area however it is now understood that the orientation of the sandbanks is oblique to the peak currents with regional influence of the Coriolis effect (Kenyon *et al.* 1981; Kenyon and Cooper, 2005).

In the North Norfolk Sandbank system, using data from the Well, Broken and Swarte Banks, Besio, *et. al.,* (2006) found that sandbank crests formed and aligned to the mean tidal current over time. The movement of the sandbanks appears to be mainly in a northeast direction. Rates in the literature vary from 1-16 m/year

(Cooper, *et. al.*, 2008). Over time, the sandbanks have also extended to the northwest and southeast, becoming elongated (JNCC, 2017; Kenyon and Cooper, 2005). Recent evidence within the NNSSR SAC suggests that the more southern sandbanks within the SAC and in proximity to the proposed project are moving in a northerly direction (Jenkins *et al.*, 2015).

2.2 Inner Bank and Sandwaves in Proximity to the 24" Southwark Pipeline Corridor

The 24" Southwark pipeline corridor passes the southeastern corner of the Inner Bank which lies between the Ower Bank and the Well Bank (Figure 1). The sandbank has a crest alignment approximately northwest to southeast, with a minimum crest depth at around 10 mLAT (Holmes and Wild, 2003) and a maximum depth of more than 32 mLAT off the eastern flank. A comparison of depth contours associated with the sandbanks between the 1991 UKHO and 2018 bathymetries does suggest that the sandbank has moved to the northeast during this period at distances of up to 60 m along the eastern flank of Inner Bank (Figure 3). The estimated lateral translation of the sandbank margin is much larger than any expected spatial inaccuracy associated with the 1991 bathymetry, thereby confirming the migration of the sandbank in that direction. The identified migration direction and potential rate is in line with the general understanding of the sandbanks within the North Norfolk sandbank system, which are estimated to migrate to the northeast at an approximate rate of about 1 m/year. More precise estimates on the lateral translation of the Inner Bank sandbank are not available at present, as the UKHO bathymetry is provided to Chart Datum (CD) and this has not been corrected to LAT, although it is noted the variance between the two vertical datums is only on the order of around centimetres. Further work would be required to confirm the migration rate of the sandbanks feature.

The sorting of sediments on Inner Bank is considered to be variable. On the southwest flank, the seabed sediments constitute well sorted medium sands compared to well sorted fine sands on the crest and the northeast flank. The mean grain size gradually reduces across the sandbank towards the northeast and towards the offshore (Holmes and Wild, 2003). With regards to the connectivity between the Inner, Ower and Well Bank, trends in grain size indicate that sand is being transported between these sandbanks. This is consistent with the understanding of a net offshore sand transport pathway between the troughs which separate the North Norfolk sandbanks (Holmes and Wild, 2003). It also supports the concept of the sandbanks as offshore stepping stones as considered further in Section 2.5.

Superimposed on Inner Bank and its southeastern flank are sandwave and megaripple bedform features, with the sandwaves having wavelengths of hundreds of metres and heights of up to 5 m. The sandwaves associated with the sandbank and identified in relation to the 24" Southwark pipeline corridor, were surveyed in 2018 and found to have local gradients of up to 18° (Fugro, 2018). A comparison of the available bathymetry between 2018 and 2020 demonstrates that there is consistent migration towards the north within this time frame, with the crests of the sandwaves moving by a notable distance within the period (Figure 4). These sandwaves are representative of the pattern of modern sand transport around the sandbanks which is influenced by environmental conditions, such as tidal currents and the local wave regime.

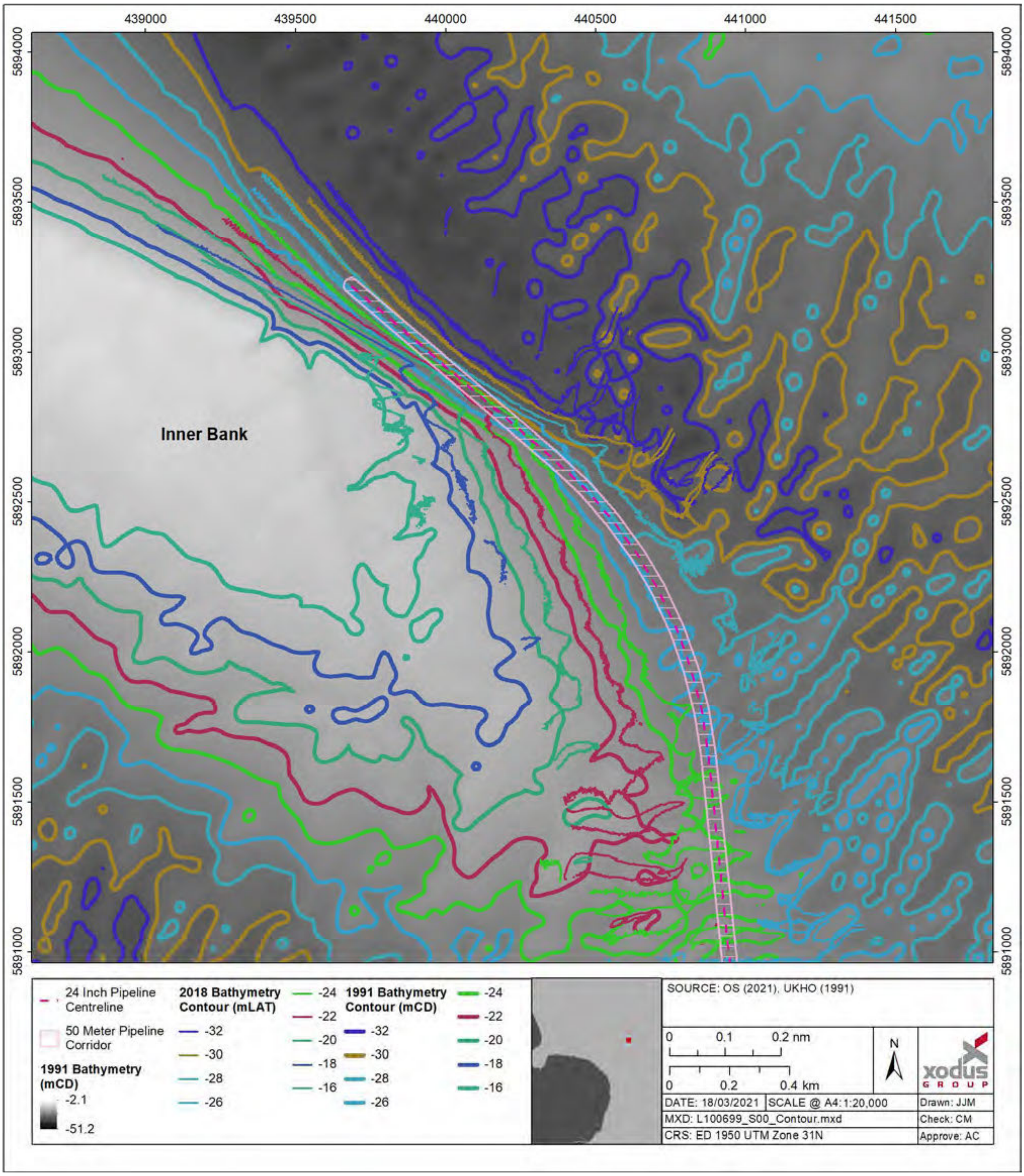

Figure 3 Movement of Inner Bank depth contours between 1991 and 2018.

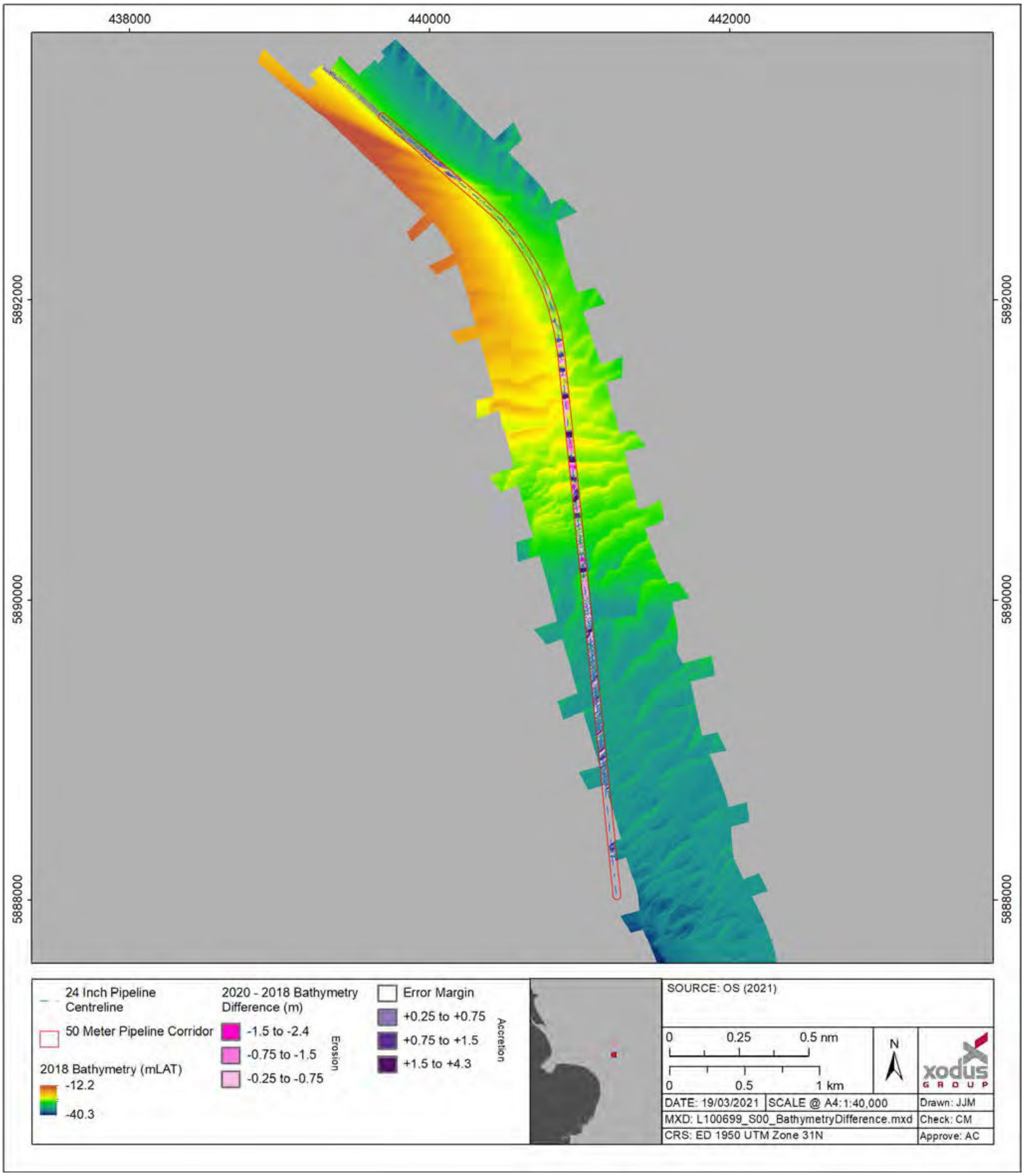

Figure 4 **Bathymetry difference between 2018 and 2020 illustrating the sandwave migration along the entire pipeline corridor.**

2.3 Tidal Properties

2.3.1 Regional Properties

The tidal range of the SNS generally ranges between 2 m and 5 m, increasing towards the south and coast (Jones *et al*., 2004), which is also characteristic for the area surrounding the 24” Southwark pipeline corridor (Ørsted, 2018). Information from the ABPmer Renewables Atlas (ABPmer, 2017) along the 24” Southwark pipeline corridor indicates a mean spring and neap tidal range of around 2.4 m and 1.2 m respectively, which is in line with observations from the nearby Hornsea Three Offshore Wind Farm (OWF) (Ørsted, 2018). The tidal flow in proximity to the 24” Southwark pipeline corridor is broadly aligned with the coast, with a southeasterly flood flow and a northwesterly ebb flow (HR Wallingford, 2002; Ørsted, 2018).

Tidal measurements associated with a tidal diamond west of the NNSSR SAC (53°19.0'N 1°25.4'E), indicate mean current speeds of up to 0.88 m/s during spring tides and 0.46 m/s during neap tides. The overall residual current is 0.049 m/s, flowing northeast and associated with the ebb tide (Hydrographer of the Navy, 2008 cited in IOG, 2018).

There are a number of OWFs in the wider area surrounding the 24” Southwark pipeline corridor, which indicate mean spring current speeds ranging between 0.7 m/s and 1.0 m/s across the region, with a rotating north-south alignment with increasing distance offshore (Ørsted, 2018; Vattenfall, 2019). Across the same area, maximum current speeds of 1.2 m/s are known to occur (Vattenfall, 2018a), while in proximity to Broken Bank (further offshore from the 24” Southwark pipeline corridor), mean spring and neap current speeds were recorded to be about 1.6 m/s and 1 m/s respectively (Collins *et al*., 1995). Current speeds in proximity to the 24” Southwark pipeline corridor obtained from the Renewables Atlas indicate peak spring and neap current speeds of 0.9 m/s and 0.5 m/s respectively, which are generally consistent with the ranges identified at the nearby OWFs. A complex pattern of tidal flow and current speeds does exist and is associated with the sandbank features within the North Norfolk sandbanks, with evidence for circulation patterns around the sandbanks (Collins *et al*., 1995).

2.3.2 Tidal Characteristics Between 2017 and 2020

Information on the tidal properties between 2017 and the present was reviewed in order to provide some context for any sandwave variability that may have occurred over that period in proximity to the 24” Southwark pipeline corridor. Tidal observation data was not available for any offshore location, therefore information from the tidal gauge at Cromer was used as a proxy to inform on the occurrence of any surge events.

Figure 5 shows the monthly mean tidal elevation between 2017 and 2020 at Cromer, which illustrates a cyclical tidal pattern with annual peaks towards the latter part of the year. It shows that the monthly tidal elevations are consistent throughout the three-year period, with minimal events observed that could affect the tidal elevation.

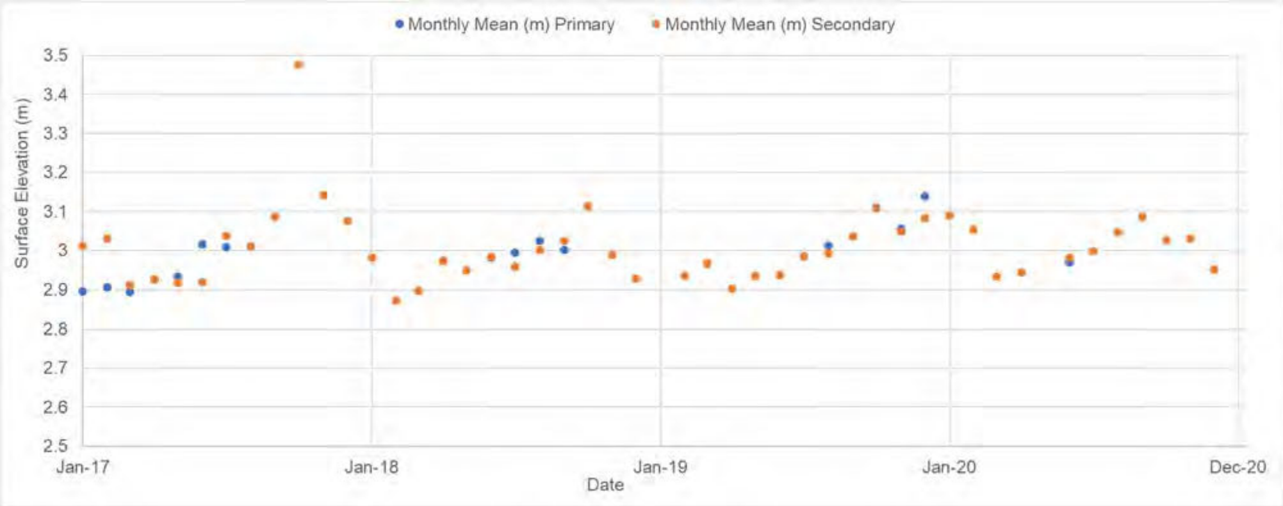

Figure 5 **Monthly mean tidal elevation between 2017 and 2020.**

Closer examination of surge events was completed by evaluating the occurrence of both positive and negative surge events across the same observation period (Figure 6). Although a number of surge events were identified, these were typically of ±0.5 m at the coast, and in a number of instances the occurrence of positive and negative events was roughly coincident (Figure 6). The information also indicates that such events occur throughout the year, with similar frequency between the years, but with the occurrence of moderately larger events in the winter of 2019/2020 (Figure 6).

In the offshore area, in proximity to the 24" Southwark pipeline corridor, these events are likely to be associated with changes to the current speeds and may contribute to the evolution of the offshore bedforms, due to variances in the residual current speeds. The marginally larger events identified in the winter of 2019/2020 may further contribute to migration of the sandwaves superimposed on the North Norfolk sandbanks.

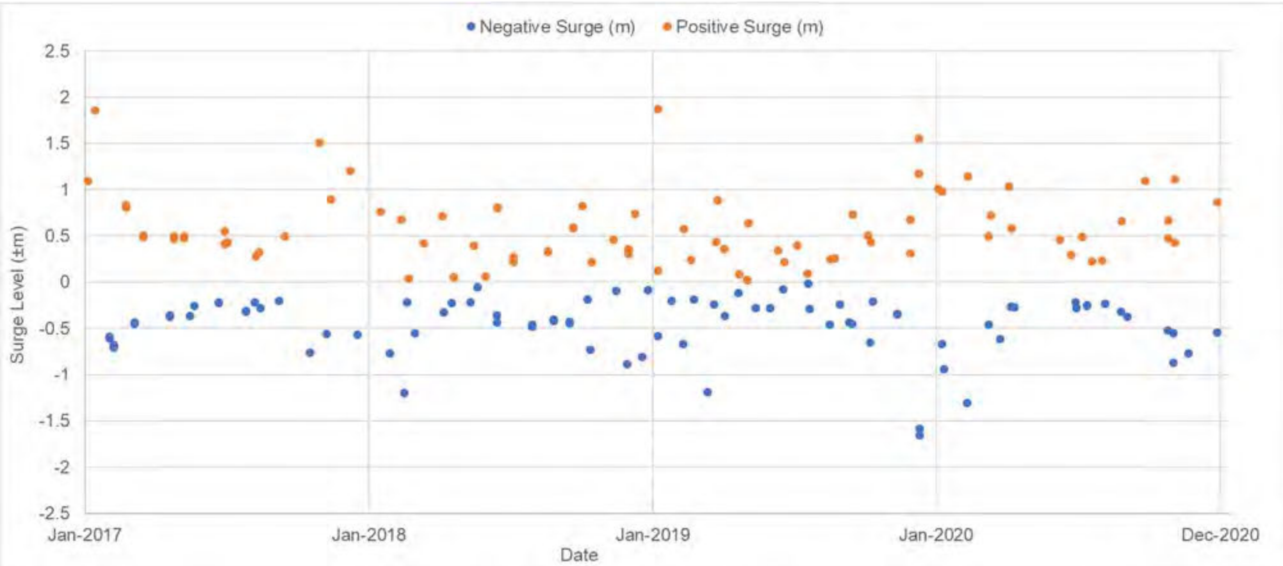

Figure 6 **Positive and negative surge occurrences between 2017 and 2020 at Cromer.**

2.4 Wave Properties

2.4.1 Regional Properties

Across the NNSSR SAC, the wave regime mainly comprises locally generated wind waves generated within the Southern North Sea, associated from the prevailing wind direction from the southwest. This area is also susceptible to swell waves propagating in from the Atlantic and into the North and Southern North Seas. Observed data from the Hornsea Three OWF recorded 90th percentile significant wave heights (Hs) as being 1.7 m to 1.9 m in summer (with periods of 5.8 s and 6.6 s respectively) and 2.5 m and 2.7 m in winter (with periods between 6.6 s and 7.1 s respectively), comprising both locally generated and swell waves (Ørsted, 2018).

The maximum 1 in 1-year return period significant wave height, immediately inside the northern boundary of Norfolk Boreas, is predicted to be 5.2 m. The predicted maximum 1 in 50-year significant wave height at the same location is 9.2 m (Vattenfall, 2019). Seastates hindcast data in the vicinity of the 24” Southwark pipeline corridor shows the majority of waves come from the south or northwest (Figure 7). Larger waves (>4 m) tend to arrive from the northwest, more so than from the south (Figure 7, ABPmer, 2018).

Waves within the Norfolk Boreas OWF, and within the 24” Southwark pipeline corridor, follow the dominant regional wave climate in that most waves arrive from the south or northwest. Waves can, however, approach from all directions and there is a small, but notable, proportion that arrives from the north-northeast (Figure 7).

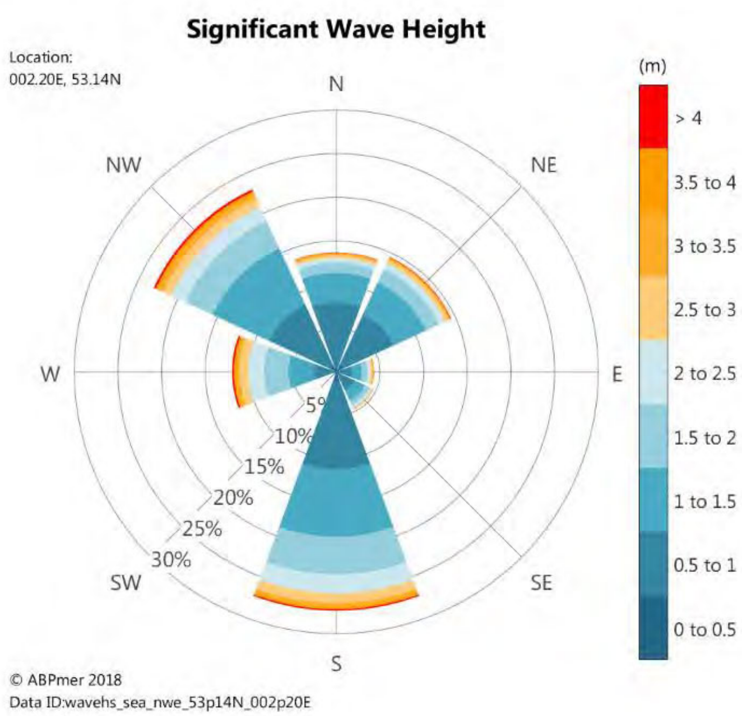

Figure 7 Wave rose of significant wave height within the 24” Southwark pipeline corridor (ABPmer, 2018).

2.4.2 Wave Characteristics Between 2017 and 2020

Information on the wave properties between 2017 and the present was reviewed in order to again provide some context for any sandwave variability that may have occurred over the same period. Although a time series of detailed wave observations was unavailable from an offshore location, information was nonetheless available in the form of graphs; which were applied and supplemented by available time series data from coastal locations.

Figure 8 shows the Hs at the Clipper platform (operated by Shell) which is approximately 40 km northwest of the 24” Southwark pipeline corridor and was available as a graph download from the Cefas WaveNet data portal (Cefas WaveNet, 2021). The wave trends at Clipper align with the significant wave heights identified at the Hornsea Three OWF (1.7 m to 1.9 m in summer and 2.5 m and 2.7 m in winter; Section 2.4.1). As per Figure 7, a very small percentage of the waves are greater than 4 m, typically the Hs at Clipper was between 1.25 and 2.5 m (Figure 8). Thus, the wave regime presented in Figure 8 is likely to be an accurate representation of the conditions within the 24” Southwark pipeline corridor. A review on the occurrence of Hs across the years demonstrates a consistent pattern with increased activity and higher Hs in relation to winter months, although waves with Hs of over 2 m frequently occur during the year (Figure 8).

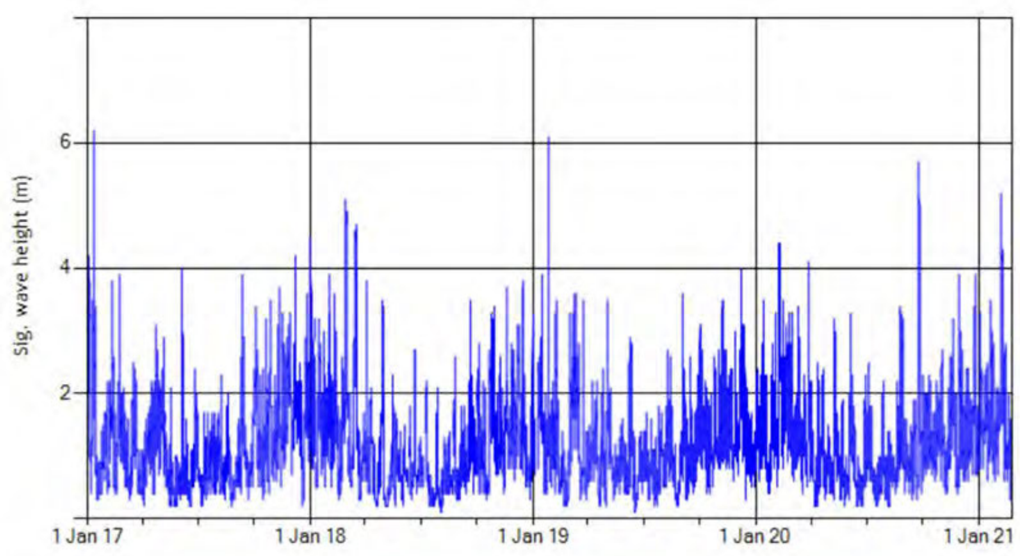

Figure 8 Significant wave height at the Clipper platform between 2017 and 2021 (Cefas WaveNet, 2021).

Further offshore, wave data has also been captured at the Sean Papa platform (operated by ONE-Dyas) and is shown in Figure 9. Located approximately 50 km due east of the 24” Southwark pipeline corridor the buoy data shows a significant wave height that is marginally higher overall and with increased frequency of larger Hs. However, the overall trend in the data between 2017 and January 2021 shows consistency in both the seasonal patterns and, at a higher resolution, similarity to individual smaller-scale fluctuations observed in the wave regime at Clipper (Figure 8).

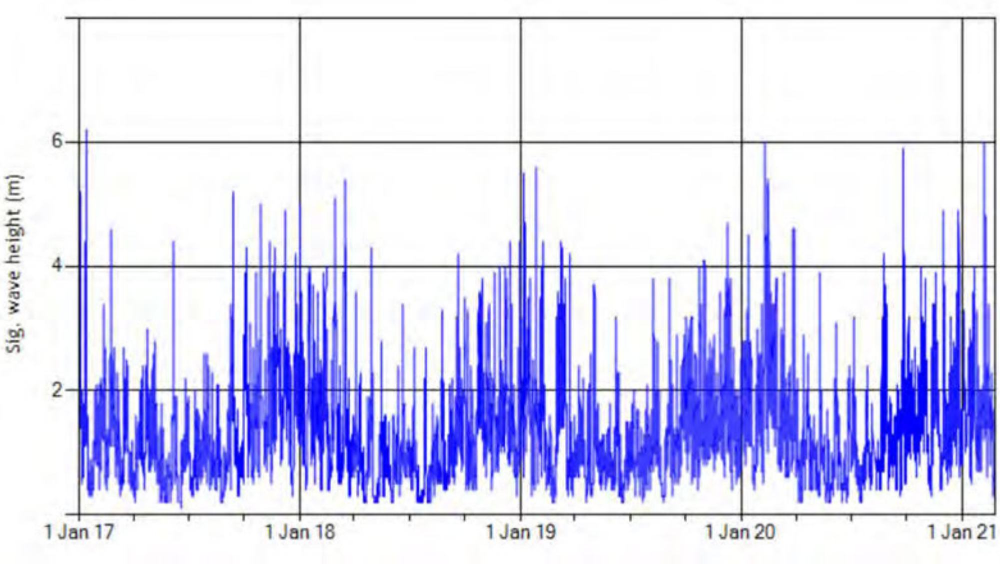

Figure 9 Significant wave height at the Sean Papa platform between 2017 and 2021 (Cefas WaveNet, 2021).

2.5 Sediment Transport Properties

Modes of sediment transport in the marine environment are through bedload or sediment in suspension, where the rates of the latter can be informed by the characteristic suspended sediment concentrations. Observations of suspended sediment concentrations across the Norfolk sandbanks from satellite monitoring indicates a range of between 1–2 mg/l and 9–10 mg/l in the summer and winter months respectively (Limpenny *et al.*, 2011), which is lower than modelled as part of the Southern North Sea Sediment Transport Study (HR Wallingford, 2002). The relatively low suspended sediment concentrations in the region suggests that the transport of sediment in suspension is the less dominant mode, with more transport occurring through bedload, which is also more likely due to the sediment grain sizes across the region.

Evidence of the sediment transport across the Southern North Sea and locally in proximity to the 24" Southwark pipeline corridor is through the movement of the sandwave and sandbank bedforms. Sediment transport across the study area is primarily in relation to the tidal currents, although occasional storm surge induced currents over the North Norfolk sandbanks causes sand to be transported in directions other than those caused by the tidal currents alone (Flather, 1987 cited in JNCC, 2017). The contribution from surge events is expected to contribute to the transport of sand oblique to the tidal currents and towards the northeast, resulting in the natural progression of the sandbank bedforms in this direction (Caston and Stride, 1970; Collins *et al.*, 1995), which has also been observed for Inner Bank (Section 2.2, Figure 3). It has been suggested that the sediment is transferred between sandbanks heading offshore, with the sandbanks acting as 'stepping stones' (Collins *et al.*, 1995). As introduced in Section 2.2, the analysis of the grain size supports this sandbank connectivity, particularly between Inner, Ower and Well Bank (Holmes and Wild, 2003).

Knaapen, *et. al.,* (2005), quantified the difference between the rate of migration of a number of different bedform sizes in the Dutch Southern North Sea. Generally, the movement of sandwaves superimposed on sandbanks was faster on the sandbank flanks than in the trough. In addition, there was a difference in the migration rate in relation to the seasons, with instantaneous rates of 0.014 m/hour associated with high-energy storm events. The overall residual transport rate, as derived from the long-term migration of the sandwaves, was 19 m/year (Knaapen, *et. al.,* 2005). Although not completely analogous of the North Norfolk sandbanks system, this shows the variability in bedform migration according to the seasonality of environmental conditions and the location of smaller bedforms on a larger sandbank. Comparatively closer, a sandwave study conducted within the offshore export cable corridor for the Norfolk Vanguard and Boreas OWF (Vattenfall, 2018b) through the Haisborough, Hammond and Winterton SAC, determined that sandwave migration rates varied between 5 and 30 m/year, with both northerly and southerly migrating sandwaves present. The sandbanks associated with the Haisborough, Hammond and Winterton SAC form the inshore part of the North Norfolk system and are likely to demonstrate processes that occur on the offshore banks in proximity to the 24” Southwark pipeline corridor. Although not directly observed in the available bathymetry around Inner Bank, there is the potential for reversals in the sandwave migration direction in relation to the North Norfolk sandbanks accounting for the known circulation around the large sandbank bedforms (Collins *et al.*, 1995; Kenyon and Cooper, 2005; Cooper, *et. al.*, 2008).

3 ANALYSIS

Given the general understanding of the tidal, wave and sediment transport regimes across the study area and the wider region, the morphological assessment focussed on evaluating the sandwave properties within the study area in order to predict future changes and the context for these changes.

3.1 Methodology

The objective of the study was to predict the potential position of the sandwave bedforms by the 2022 installation date. The applied analyses involved determining the sandwave properties, in terms of wavelength, asymmetry and migration rate prior to estimating the potential future migration of the sandwaves and their position by the 2022 installation date.

The alignment of the sandwave crests across the study area were determined from the seabed slope calculated for the 1991, 2018 and 2020 bathymetries. The calculated slope confirmed that the sandwaves were aligned approximately northeast to southwest, (Figure 10), with an associated migration direction perpendicular to the crest alignment, to the northwest. This also agrees with the general understanding of the sandwave bedforms across the North Norfolk sandbank system (Sections 2.1 and 2.2).

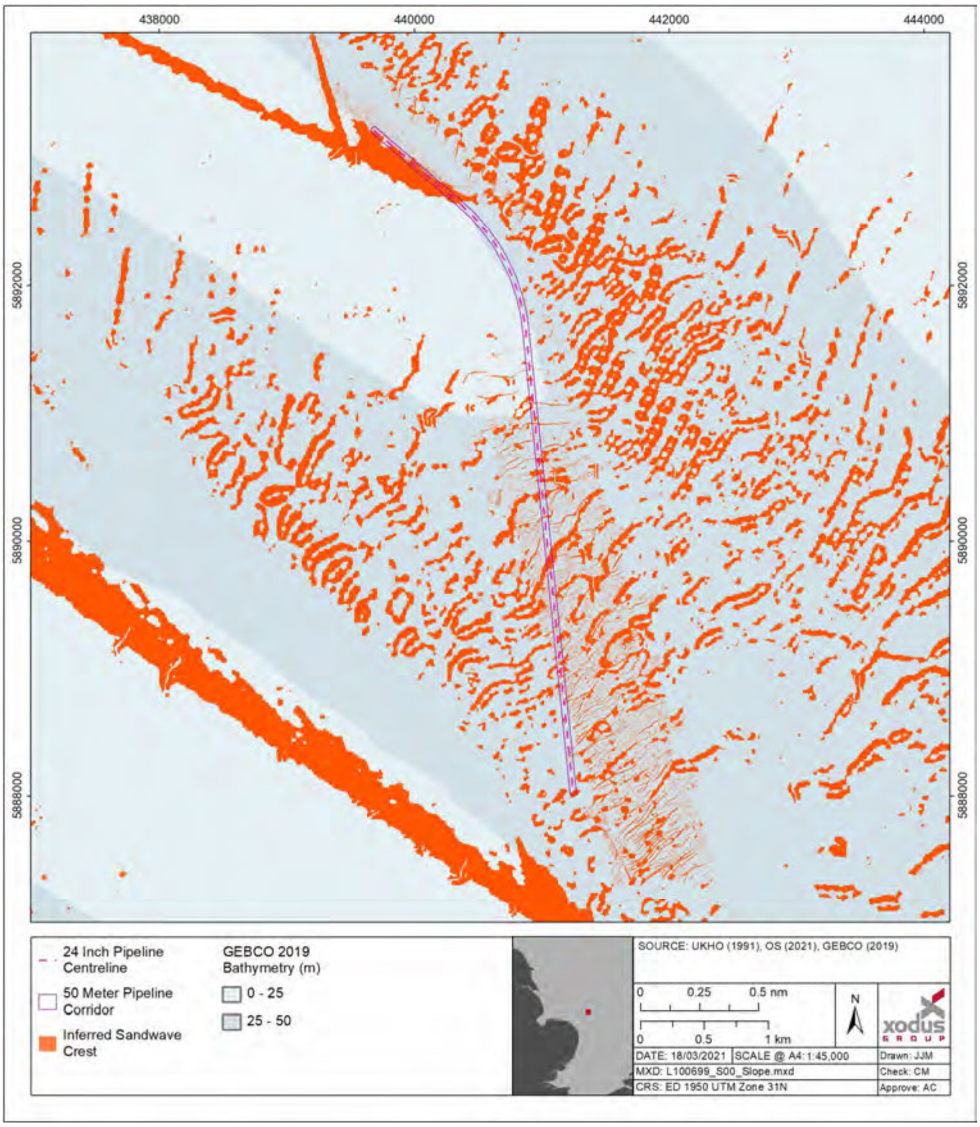

Figure 10 Sandwave crests determined from the seabed slope.

3.1.1 Sandwave Properties

To inform the sandwave properties, analysis transects were extracted across the 2020 and 2018 bathymetry extents, where the transects were orientated perpendicular to the dominant crest alignment. Due to the limited coverage of the 2020 bathymetry separate transects were obtained to determine the sandwave dimensions and migration as illustrated in Figure 11a and Figure 11b respectively. The sandwave analysis transects were created in order to capture multiple sandwaves along a single transect, and also to identify different sections of the same sandwave across the study area (Figure 11a). Shorter, but more frequent migration analysis transects were applied to capture multiple sandwave features, where there was overlapping information between the 2018 and 202 bathymetries (Figure 11b).

Using the extracted data from the sandwave analysis transects (Figure 11a) ,the sandwave wavelength was determined as the distance between sandwave crests, while the height was calculated as the elevation of the crest relative to the level of the adjacent troughs after removing the influence of any underlying slope.

The sandwave asymmetry (an indicator of the sandwave migration direction) was calculated as the ratio of the length of the slopes (measured from crest to trough) either side of the respective crest.

$$Asymmetry = \frac{\left(Crest - Trough_{before}\right) - \left(Trough_{after} - Crest\right)}{Wavelength}$$

For the assessment of the sandwave dimensions, fourteen sandwave features were identified and evaluated across five analysis transects (Figure 11a, sandwave 15 was not represented in the analysis transects), the results of which are presented and discussed in Section 4.1. The sandwave dimensions were calculated at multiple locations along the length of the assessed features and were labelled in relation to the both the analysis transects (A to E) and sandwave number (1 to 14).

The sandwave migration rates were calculated to investigate the rate at which the sandwave bedforms were moving and the potential future position of the bedforms at the proposed 2022 pipeline installation date. To estimate the rate, the depths and the crest position of the assessed sandwaves were extracted from the migration analysis transects (Figure 11b) from both the 2018 and 2020 bathymetries. The movement of the sandwave crests along the chainage between the surveys was then used to indicate the direction and rate of bedform migration (Figure 12).

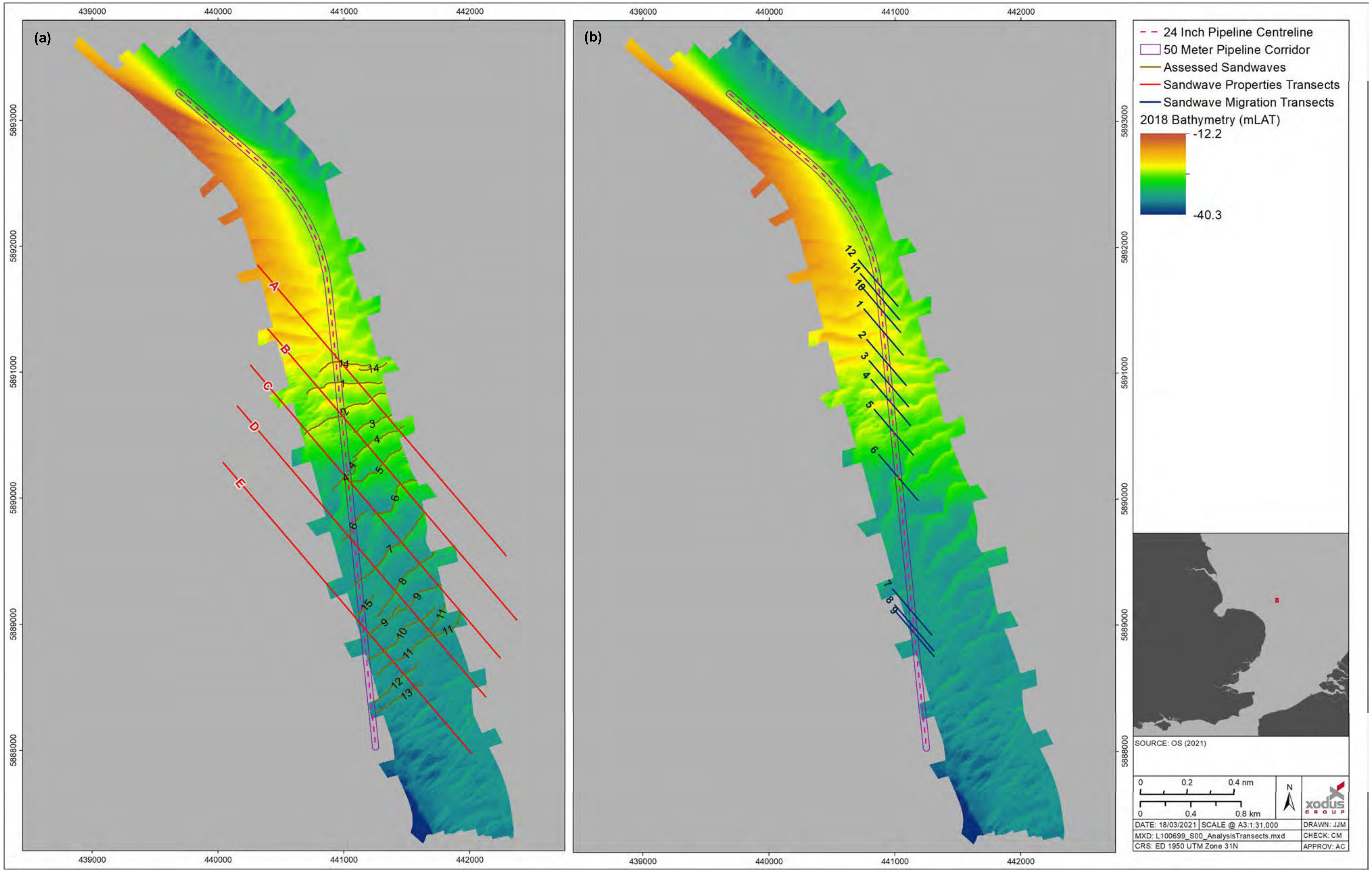

Figure 11 Applied analysis transects (a) to calculate the sandwave properties and (b) to calculate the migration rates.

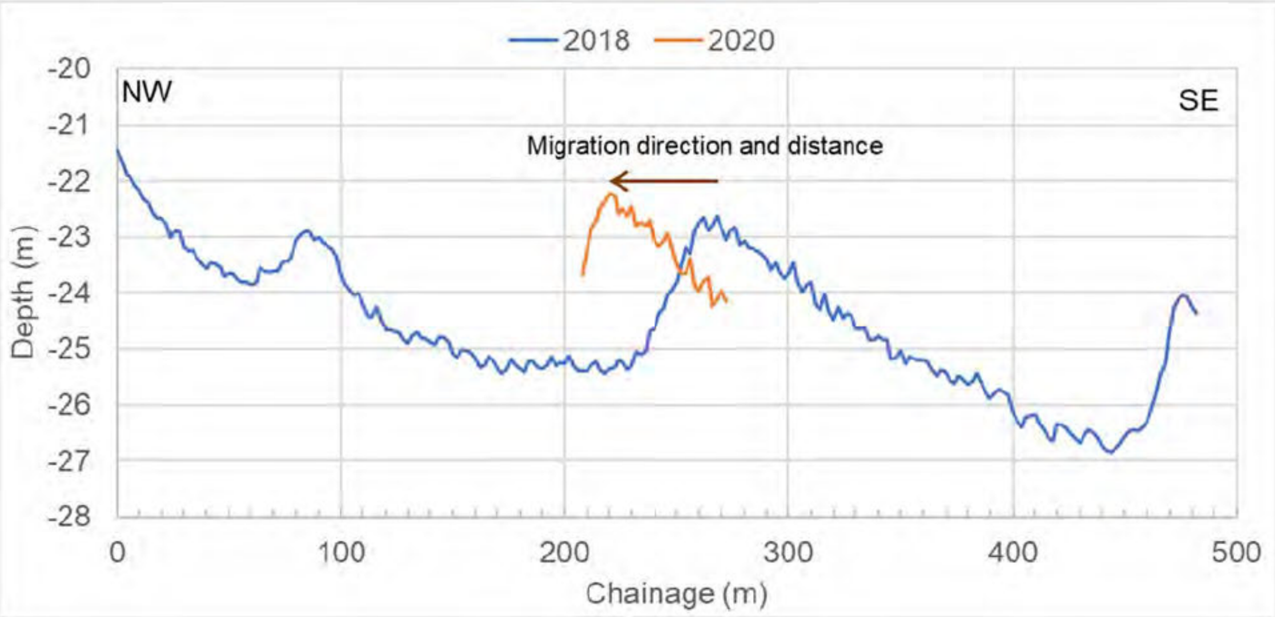

Figure 12 Analysis of sandwave migration along an analysis transect.

3.1.2 Future Sandwave Position

The potential future position for the sandwaves within the study area was calculated as the migration rate multiplied by the number of years between the baseline year (2018) and the prediction year (2022), equating to a total of four-years. The baseline bathymetry was then adjusted by the calculated migration distance and direction, to reflect the potential position of the sandwave bedforms at the prediction time step.

For this study, three bathymetry adjustment methods were applied, which involved a block shift of the entire bathymetry or the spatial translation of what was considered to be the mobile seabed. The latter employed an assumption of what is considered to be the underlying geological slope as a representation of the immovable seabed. Typically, the estimation of the mobile sediment horizon would entail an interpretation of the Holocene sediment unit, typically informed by a geotechnical ground model. As this data was unavailable, the depth of the immobile bed was estimated based on an assessment of depth contours from the 2018 and 2020 bathymetry dataset (Section 1.6).

3.2 Uncertainty

To validate the estimated migration rate, the sandwave positions and bathymetric surface were calculated for the year 2020 and compared with the available 2020 bathymetry. The accuracy of the prediction versus the observed was compared using error estimates including the root mean square error (RMSE). The error assessment was determined based on the entire surface, whereby lower RMSE estimates were representative of a better prediction across the area covering the 2020 bathymetric survey.

Table 2 Calculated error estimates for different migration and bathymetric adjusted scenarios.

Bathymetry Adjustment	Migration rate	Mean Squared Error	Root Mean Squared Error
Block shift	Average	0.518	0.720
	Average -1 standard deviation	0.302	0.550
	Average +1 standard deviation	0.650	0.806
	Minimum	0.319	0.565
	Maximum	0.921	0.960

Bathymetry Adjustment	Migration rate	Mean Squared Error	Root Mean Squared Error
Mobile Bed Slope 1	Average	0.246	0.496
	Average -1 standard deviation	0.353	0.594
	Average +1 standard deviation	0.379	0.616
	Minimum	Not calculated	Not calculated
	Maximum	Not calculated	Not calculated
Mobile Bed Slope 2	Average	0.235	0.484
	Average -1 standard deviation	0.321	0.567
	Average +1 standard deviation	0.394	0.628
	Minimum	Not calculated	Not calculated
	Maximum	Not calculated	Not calculated

In light of the calculated error estimates, an additional qualitative assessment has been completed to support the developed interpretations. Generally, predictions of future morphological behaviour are associated with an inherent level of uncertainty, with respect to:

> The quality and coverage of the datasets used to inform the analysis, which can in turn influence subsequent predictions and calculations; and

> The consistency and reliability of historical morphological behaviour represented and observed in the dataset, which are used to calculate the migration rates and future sandwave position.

A qualitative method has therefore been used for assessing the uncertainty associated with the understanding of morphological change in relation to the data underpinning the identified behaviour. The quality of the available 2018 and 2020 bathymetry is excellent. However, only the 2018 data is able to provide the coverage to adequately understand the presence, extent and properties of sandwaves, thereby resulting in a medium uncertainty for the data quality. Only two bathymetry datasets were available to determine the morphological behaviour. However, the behaviour was assessed across multiple sandwaves along the pipeline corridor, which provides additional confidence in the identified pattern; resulting in a medium uncertainty for the understanding of the morphological behaviour. On the basis of the above, an overall medium uncertainty level is determined and associated with the interpretations of the sandwave location and extent for 2022.

4 RESULTS

4.1 Sandwave Dimensions

Results on the calculated properties including the wavelength, asymmetry and height are set out in Table 3. These relate to the assessed bedform features identified along the sandwave analysis transects illustrated in Figure 11a. Sandwaves considered to be on Inner Bank include sandwaves 1 to 4 and 14, while sandwave 5 to 7 are transitioning off the sandbank and 8 to 13 are inferred to be off the sandbank (Figure 11a).

Sandwave wavelengths across the study area range approximately between 100 m to 250 m, with the largest wavelengths occurring in relation to sandwaves transitioning off Inner Bank (Table 3, Figure 11a). Sandwave heights range approximately between 0.5 m to 7 m, with the majority having heights 2 m to 3 m. The sandwaves all have a consistent asymmetry to the northwest, associated with a steepness in the same direction and are all interpreted to be actively migrating due to the calculated asymmetry measures (Table 3). Where multiple analysis transects intersect the same sandwave along its length, the sandwaves are assessed to have similar properties (Table 3). The calculated asymmetry and direction of the sandwaves present within the study area are in line with the general understanding of the sediment transport direction of sand in relation to tidal currents across the region (Section 2).

4.2 Sandwave Migration

An average migration rate of about 13 m/year was calculated with an associated standard deviation of approximately ±8 m/year for the assessed period between 2018 and 2020 (Table 4). The minimum and maximum rates within the same period were 4 m/year and 26 m/year respectively (Table 4). The estimated rate is within the range identified in relation to the nearby Haisborough, Hammond and Winterton sandbank system and characteristic to the wider sandwave bedform migration across the Southern North Sea (Section 2.5).

The 1991 UKHO bathymetry was not used to determine the migration rates, because based on the average migration and the characteristic wavelength, between one and three sandwaves could have migrated through the corridor between the 1991 and 2018 bathymetries. It was therefore not possible to directly pinpoint which sandwave feature was represented in the respective bathymetries.

Generally, faster rates were observed to occur in relation to the sandwaves located on the flank of Inner Bank, associated with transects 2, 3 and 4 (Figure 11b, Table 4). Slower rates occurred with the sandwaves that were further south of the bank, associated with transects 7, 8 and 9 (Figure 11b, Table 4). Due to the varying migration rates, the estimates of the future sandwave migration were calculated based on the average rate, along with the plus and minus one standard deviation.

Table 3 Calculated sandwave dimensions.

Sandwave Observation	Wavelength (m)	Asymmetry	Height (m)	Sandwave Observation	Wavelength (m)	Asymmetry	Height (m)	Sandwave Observation	Wavelength (m)	Asymmetry	Height (m)
A14	224	0.65	3.01								
A1	158	0.51	2.5	B1	138	0.61	1.74				
A2	184	0.61	2.61	B2	164	0.72	1.92	C2	470	0.70	6.76
A3	132	0.58	2.25	B3	158	0.43	3.05				
A4*	132	-	1.97	B4	168	0.50	3.40	C4	402	0.62	5.24
B5	224	0.66	3.33								
B6	224	0.83	4.45	C6	300	0.57	3.27	D6	216	.31	1.18
C7	252	0.47	3.37	D7	234	0.61	3.07				
C8	200	0.44	2.95	D8	152	0.33	3.36				
C9*	200	-	3.37	D9	144	0.36	2.21	E9	166	0.72	2.22
D10	152	0.21	2.99	E10	118	0.59	2.71				
D11	150	0.40	2.77	E11	142	0.51	2.08				
E12	152	0.38	4.52								
E13	146	0.44	2.20								

*: Assessment of the sandwave properties is based on the preceding sandwave due to extent of the bathymetric data.

Table 4 Calculated sandwave migration rate.

Migration Transect	Rate per year (m/year)	Migration Transect	Rate per year (m/year)
1	14	7	5
2	24	8	4
3	26	9	5
4	21	10	N/A
5	N/A	11	12
6	9	12	8
Statistics		**Rate per year (m/year)**	
Average		12.8	
Standard Deviation (±)		7.8	
Maximum		26	
Minimum		4	

The observed sandwave migration relates to the tidal and wave conditions during the preceding period, with the potential occurrence of larger surge events over the winter of 2019/2020 (Section 2.3, Figure 6) contributing to the observed migration rates. Without the additional bathymetric datasets, it was not possible to precisely confirm if the assessed rates were faster due to the occurrence of the events. The calculated rates are nonetheless within the range that is known to occur over the wider North Norfolk sandbank system (Section 2.5).

Given the estimated migration rates, the potential migration extent of sandwaves that would intersect the 24" Southwark pipeline corridor between the 2018 bathymetry and the 2022 installation date, is illustrated in Figure 13. Based on the sandwave positions in relation to the lateral migration distance for varying rates, Figure 13 shows that sandwave bedforms would move into the pipeline corridor that were not present in 2018 and less so in 2020. In addition, for a number of sandwave features, only the "tails" or margins of the sandwave were within the pipeline corridor in 2018, but by the 2022 installation date a larger part of these sandwaves are likely to migrate into the pipeline corridor. The introduction of additional and/or a larger proportion of the sandwave features, will act to increase the potential sediment volume that would be disturbed during the seabed preparation and trenching works.

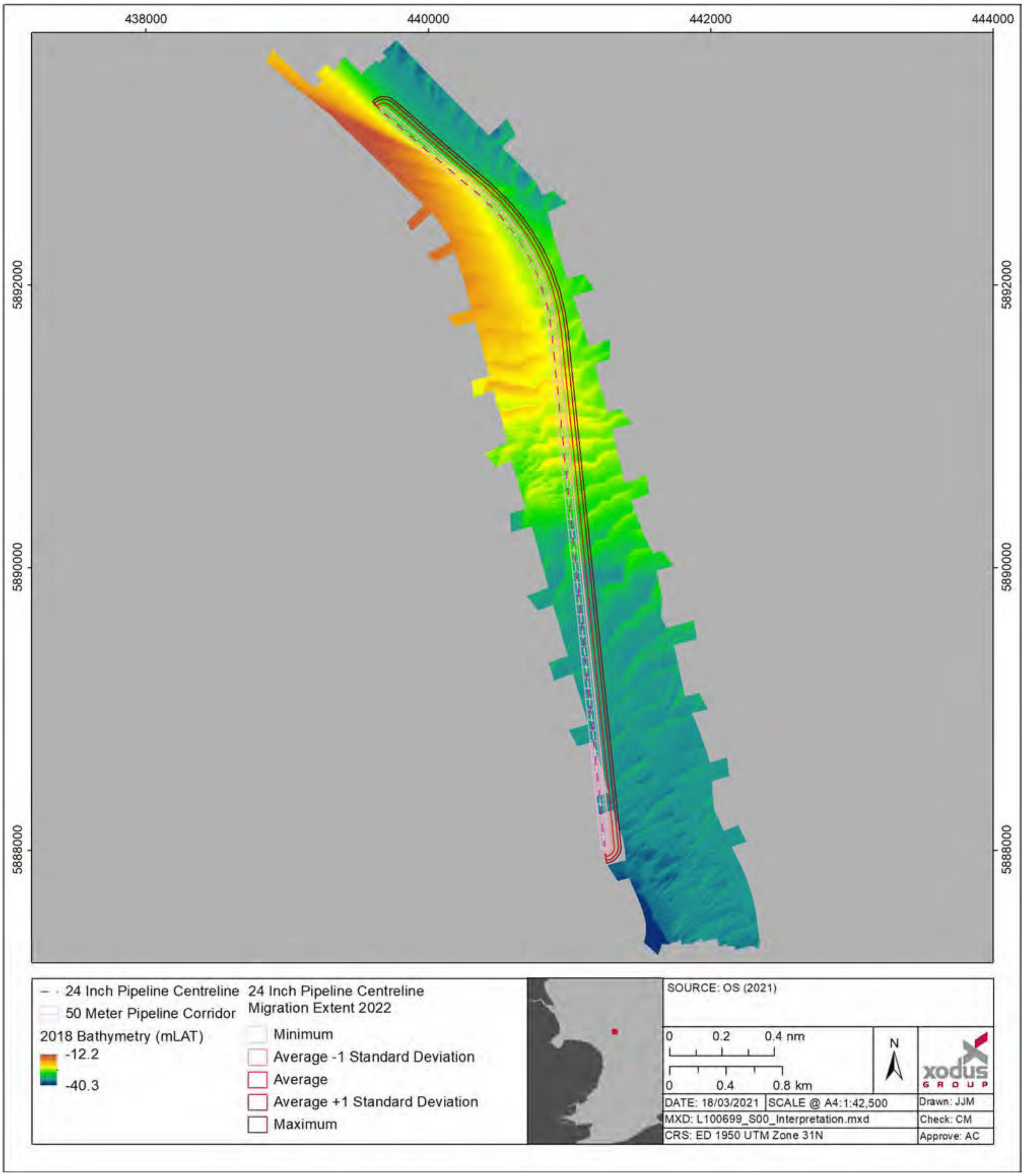

Figure 13 Potential migration extents for the different migration scenarios.

4.3 Future Sandwave Position

The predicted future sandwave positions for the applied bathymetry adjustment methods, based on the average migration rate, are illustrated in Figure 14. The results all indicate that sandwaves that were to the east of the pipeline corridor in 2018 would migrate within the corridor by 2022. For the sandwaves that were located within the corridor in 2018, although these sandwaves also migrate, the main body of the sandwaves will be still present within the corridor. The results show that due to the introduction of new sandwave bedforms into the corridor, there is likely to be an increase in the sediment volume requiring disturbance. The 2022 bathymetry was predicted on the basis that the representative tidal and wave pattern and magnitude observed between 2017 and 2020 (Sections 2.3.2 and 2.4.2), will continue to occur up to the 2022 installation date.

The predicted seabed change is associated with a medium level of uncertainty, due to the calculated RMSE and the data and morphological behaviour properties, as described in Section 3.2.

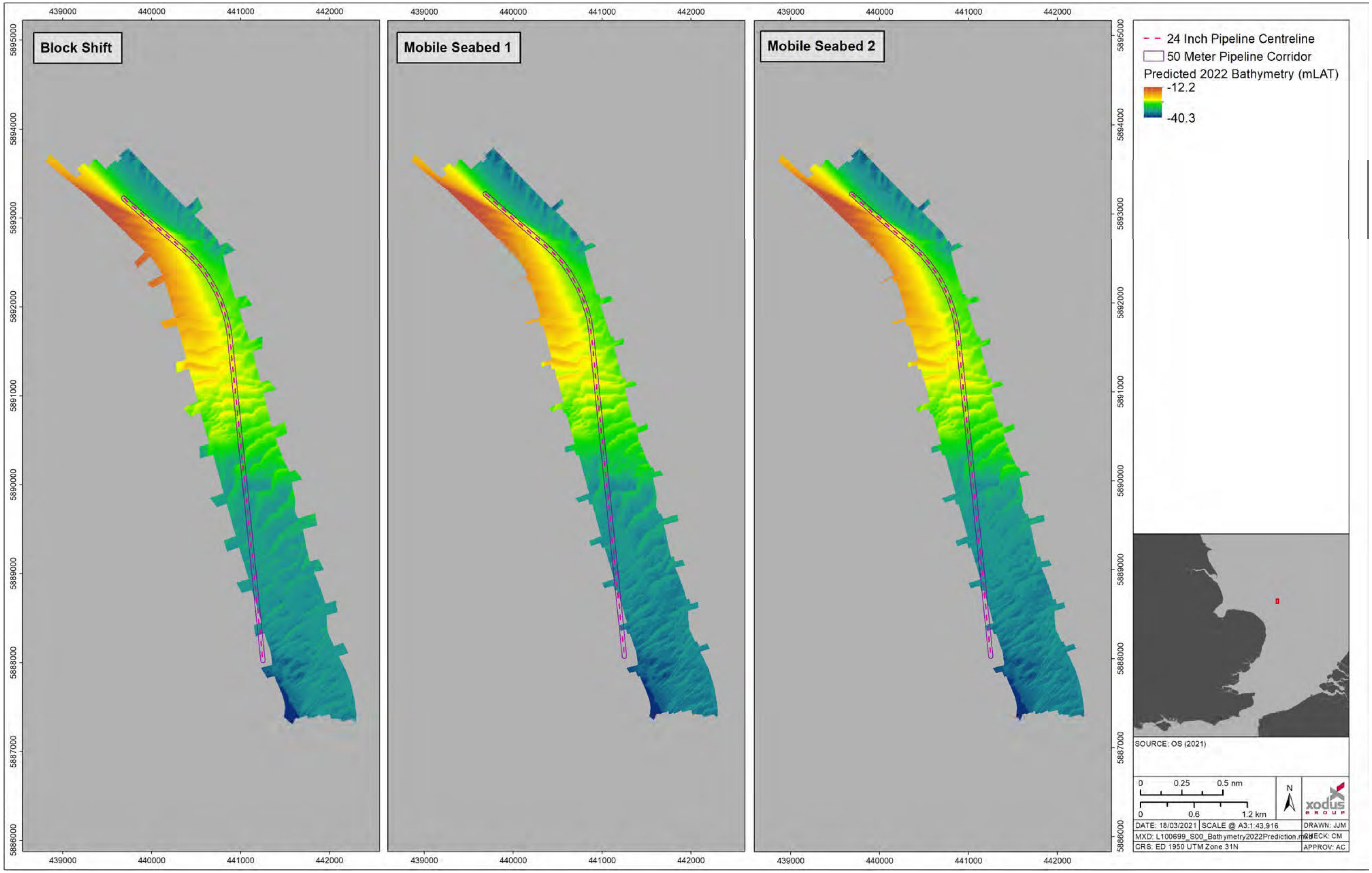

Figure 14 Future sandwave positions, based on the average migration rate for the block shift and mobile seabed bathymetry adjustment methods.

5 CONCLUSIONS

5.1 Summary

The 24” Southwark pipeline corridor is entirely located within the North Norfolk Sandbank system and is in proximity to dynamic and actively evolving sandwave bedforms, with steep asymmetric profiles. The dynamic sandwaves are known to evolve in relation to the tidal and wave conditions across the wider North Norfolk sandbank system and Southern North Sea (Collins *et al.*, 1995; HR Wallingford, 2002; Kenyon and Cooper, 2005; Cooper, *et. al.*, 2008). Information on the environmental forcing conditions for the period between 2017 and 2020 demonstrates patterns, frequencies and magnitudes that are mostly consistent across the years, apart from the occurrence of moderately larger surge events over the winter of 2019/2020 (Sections 2.3.2 and 2.4.2). The dynamic characteristics of the sandwaves in proximity to the 24” pipeline corridor coupled with ongoing environmental forcing conditions into the future as observed in the preceding period, means there is the potential for the features to migrate into the proposed pipeline corridor by the proposed installation date in 2022.

Part of the requirement of the ES Addendum for the 24” Southwark pipeline necessitates information on the potential sediment displacement volume associated with the seabed preparation works. A morphological assessment on the sandwave migration in and through the 24” Southwark pipeline corridor has therefore been completed, in order to enable ongoing volumetric calculations of the potential sediment disturbance. The outputs of this study, in terms of the predicted seabed for 2022 for various sandwave migration scenarios, are therefore to form direct inputs into further work by Subsea 7.

The assessment of sandwave properties confirmed the presence of steep asymmetric profiles consistently orientated to the northwest (Section 4.1) with evidence of migration in the same direction at an average rate of around 13 m/year (±8 m/year). Marginally faster migration rates were identified for sandwaves at shallower depths on the flanks of Inner Bank, compared to those further southeast of the sandbank (Section 4.2). This is consistent with understanding from elsewhere within the Southern North Sea (Knaapen, *et. al.,* 2005). The present sandwaves that intersected or had the potential to intersect the 24” Southwark pipeline corridor had wavelengths of between 100 m and 200 m, and heights approximately between 2 m and 3 m (Section 4.1). The sandwaves are themselves superimposed on the crest and flanks of Inner Bank, with this study identifying the potential for the migration of the large scale bedform towards the northeast at varying rates along the eastern flank of the sandbank (Section 2.2).

The assessment on the potential sandwave migration extent by 2022, showed that there was the potential for the introduction of sandwave features into the 24” Southwark pipeline corridor, given the consistent and ongoing patterns of the tide and wave forcing. The movement of sandwaves into the pipeline corridor by the installation data would directly result in an increase in the volume of sediment disturbance associated with the bed preparation works. The predicted potential migration was assessed to have a medium uncertainty due to the data availability and coverage of the bathymetry data, although the calculated error statistic indicated the predicted migration was representative of properties along the entire corridor. With this in mind a qualitative contingency of around 50% is suggested in applying the volume calculations within the ES Addendum for discussion with the Regulators and statutory advisers. It is the case however, that a comparison of the volume estimates for the varying migration scenarios, once completed, may act to reduce this contingency factor down if necessary.

5.2 Recommendations

On completion of the 24” Southwark pipeline morphological assessment scope, the following recommendations have been identified:

> This study scope only briefly considered the migration potential for Inner Bank. The migration of the sandbank is unlikely to impact the pipeline along the corridor once laid and buried. There is however the potential for interaction with the Southwark platform over the operation life of the platform. To understand this potential, a more detailed assessment on the properties of the sandbank, including its crest position and any changes across its entire extent would be recommended; and

- Due to the variable nature of the forcing environment, and if necessary, for the bed preparation and pipeline installation equipment, a geophysical survey should be completed closer to the proposed installation date to confirm the sandwaves present and their steepness in order to better inform the upcoming works.

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