5 ASSESSMENT OF POTENTIAL IMPACTS

Table 5.1 summaries the sources and potential environmental impacts identified during the ENVID which are discussed further in this section.

Table 5.1 Potential environmental impacts

Source of impact	Environmental Receptors	Section of this Document
Physical Presence	Benthic habitats and species; Other sea users: fishing vessels and shipping	5.1
Underwater noise	Marine mammals	5.2
Atmospheric Emissions	Air quality	5.3
Discharges to sea	Benthic habitats and species Marine biota and water quality	5.4
Accidental releases	Marine biota, water quality, protected sites, fishing industry, tourism.	5.5

5.1 Physical Presence

The physical presence of the drill ship, its support vessels and the drilling activities themselves have the potential to result in:

> Impacts to the seabed namely benthic habitats and species; and

> Interference with other shipping, navigation and fishing activities that may occur in the area.

Assessments of the potential impacts to these receptors are presented in Sections 5.1.1 and 5.1.2 below.

5.1.1 Seabed impacts to benthic species and seabed habitats

5.1.1.1 Potential impacts

The Project has the potential to disturb the seabed. The key activities that may interact with the seabed area are:

1. Spudding the well, cementing the 36" conductor pipe and installing the wellhead and BOP;
2. The deposition and settlement of drill cuttings and drilling muds onto the seabed; and
3. Severing the wellhead prior to well abandonment.

The above activities have the potential to lead to changes in the seabed habitat, which could have positive or negative impacts on the biota within the physical footprint of such activities, including:

> Direct loss of benthic species and seabed habitat; and

> Wider indirect disturbance to the benthic environment through the suspension and re-settlement of sediments.

The drilling of the single exploration well will be conducted using a floating drill ship which will maintain position using a DP system. As this ship will not use anchors to maintain position disturbance to the seabed from the use of equipment will therefore be limited to the use of the drill bit to drill the tophole sections, the cementing of the 36" conductor pipe and the installation of the wellhead and BOP, and the severing of the wellhead a minimum of 3 m below the seabed.

Note that the potential impact of the deposition of drill cuttings and drilling muds onto the seabed, including the results from the drill cuttings dispersion modelling, is discussed in Section 5.4. This section is therefore only concerned with the physical impacts to the seabed associated with the use of the drilling and well abandonment equipment as noted in items 1 and 3 above.

As discussed in Sections 3.2.3 the seabed in the Project location is comprised of very poorly sorted fine silt and is very homogenous surrounding the proposed well location. The deep water soft sediments support infaunal macrobenthic communities dominated by crustaceans and molluscs, with and a relatively sparse epifaunal community largely composed of burrowing epifauna such as polycheaes, anemones (Ceriantharia), crustaceans such as the Norwegian lobster (*Nephrops norvegicus*), and sea pens. Although 'sea pen and burrowing benthic megafauna communities' are listed in the OSPAR list of threatening and declining habitats and assessment of the communities observed by Fugro (2017c) determined it unlikely that the area fulfils the overall criteria required under OSPAR guidelines for this threatened and declining habitat. No other species or habitats of conservation importance or concern were observed during the recent surveys of the proposed Iolar well location (Fugro, 2017b, 2017c).

The area directly affected will be localised around the tophole location. The seabed disturbance described may also result in sediment suspension and re-settlement beyond the direct footprint of the drilling and well abandonment equipment but, given the scale and duration of seabed disturbance during the above activities, will be extremely limited in extent. The re-settlement of sediments may result in the smothering of epifaunal species (see Gubbay, 2003 for a review) with the degree of impact related to their ability to clear particles from their feeding and respiratory surfaces (e.g. Rogers, 1990). However, Defra (2010) states that impacts arising from sediment re-suspension are short-term (generally over a period of a few days to a few weeks). In addition, infaunal communities, which are dominant in soft sediments, are naturally habituated to sediment transport processes and are therefore less susceptible to the direct impact of temporarily increased sedimentation rates. Depending on the sedimentation rates, infaunal species and communities can also work their way back to the seabed surface through blanket smothering (Neal and Avant, 2008).

5.1.1.2 Mitigation measures

Nexen will take measures to reduce, where possible, the potential impacts of the Project on benthic habitats and species:

> A pre-spud ROV survey of well site to be undertaken to increase the likelihood that areas of high sensitivity will be avoided at the well site.

5.1.1.3 Residual impacts

The area of seabed potentially affected by the use of drilling or well abandonment equipment is assessed as being limited to approximately 10-20 m^2. Any sessile epifauna present in this area of deep-water soft sediment habitat, which could include seapens and burrowing anemones, and a proportion of the infauna (animals that burrow into the sediment or form tubes within it) such as polychaete worms may be lost.

Drilling activities may also result in sediment re-suspension and re-settlement around the edges of the direct footprint of the well. To estimate the area likely to be influenced by potential sediment suspension and re-settlement around activities causing seabed disturbance, it has been assumed that this is likely to occur within a radius of 10 m of the edge of the tophole of the well. On this basis, the area where an indirect residual impact may occur as result of sediment disturbance is estimated to amount to less than 500 m^2. The suspension and re-settlement of sediment plumes and resultant smothering of sediments and fauna will be localised and only temporary in nature. The Scottish Government FEAST - Feature Activity Sensitivity Tool (Marine Scotland, 2018) notes that burrowed mud can be largely tolerant to smothering by 5 cm of sediment. This is because burrowing species will be able to burrow through the additional layer of sediment in hours to days, to aid a relatively quick recovery. The sea pen *Pennatula phosphorea*, which is found around the Project location is able to withdraw rapidly into the sediment and appear to be able to recover from some smothering (Jones, 2008).

The potential impacts to seabed habitats and species from the deposition of drill cuttings and muds onto the seabed are assessed in Section 5.4, which indicates that the area of seabed potentially affected by such settlement will exceed that affected by disturbance of sediments as a result of the physical presence of the drilling equipment. Therefore, the impacts described here are not expected to be discernible compared to those assessed in Section 5.4.4.2.

The consequence of the impact is considered to be ‘**minor**’ and the frequency category ranked at **‘2’** (≤ 3 months duration). It is therefore considered that the residual significance level of impacts to seabed habitats and species is ranked as **‘negligible’** and considered to be ‘**not significant**’.

5.1.2 Interactions with other sea users

5.1.2.1 Potential impacts

During the Project, the presence of the drill ship and support vessels has the potential to interfere with other shipping, navigation and fishing activities that may occur in the area. This could result in loss of access to the area for other vessels on a temporary basis and increase the risk of vessel collisions.

VSP activities would take place from the drill ship itself and therefore no additional VSP survey vessel is anticipated to be used during the planned activities.

5.1.2.1.1 Increased vessel traffic and collision risk

The temporary physical presence of the drill ship and support vessels vessel has the potential to interfere with other sea users that may be present in the area, including increasing the risk of vessel collisions.

The Project is expected to start in April 2019 and last for approximately 100 – 150 days.

5.1.2.1.2 Temporary exclusion

Whilst the drill ship is on location, a 500 m radius safety exclusion zone will be maintained around it. The purpose of the temporary safety zone is to ensure the safety of all personnel involved in the Project and to minimise the risk of collisions between the vessels associated with the Project and other vessels in the area. As such, the 500 m exclusion zone (with an area of approximately 0.8 km^2) will exclude other sea users, including fisheries, for a maximum period of 150 days. It will not be maintained once the Project is complete and the well is abandoned.

5.1.2.1.3 Dropped objects

There is the possibility for objects to be accidentally lost overboard during the Project. If large enough, such objects can provide an uncharted obstacle that has the potential to damage fishing nets or fishing catch.

5.1.2.2 Mitigation measures

5.1.2.2.1 Increased vessel traffic and collision risk

A number of mitigation measures will be employed to minimise the impact of increased vessel traffic and collision risk resulting from the Project:

- Nexen will consult with relevant authorities and organisations as defined in the Rules and Procedures Manual, particularly the Sea Fisheries Protection Authority (SFPA) and the Sea Fisheries Policy Division, Department of Agriculture, Food and the Marine to minimise interference impacts resulting from the Project;
- A Notice to Mariners will be distributed by the Department of Transport, Tourism and Sport and a version of this will be run in selected local marine related publications;
- A vessel will operate on site for the duration of the Project;
- The drill ship and supply vessel will display SOLAS compliant lights and shapes and noise signals to alert other seafarers in the area;
- A 500 m safety zone will be maintained around the drill ship whilst on location; and
- Nexen will consider the use of a Fishing Liaison Officer (FLO) on board the standby guard vessel which will operate on site for the duration of the Project.

5.1.2.2.2 Temporary exclusion

To reduce the interference that the Project may have on other sea users in the region, Nexen has reduced the vessel requirements and the number of vessels days as far as practicable whist adhering to safety and emergency response requirements.

5.1.2.2.3 Dropped objects

The drilling contractor will have a dropped objects procedure which will be used for the Project to minimise any issues with dropped objects. This procedure will include the following mitigation measures as a minimum:

> The drill ship will have Safe Work Procedures to prevent dropped objects which will include (but not limited to):
  - Good housekeeping practices, with all wastes correctly stored
  - Storage of hazardous chemicals as per material safety data sheet (MSDS)
  - Lift planning for over-the-side lifting (including appropriate crane rigging and load ratings, crane operator and rigger training and competency requirements) all lifting equipment will be tested and certified;
  - A ship to ship transfer permit will be in place;
  - All deck items will be securely stowed;
  - Transfers of objects will use specialist equipment and consider environmental conditions;
  - Ongoing personnel awareness and training, and dropped object prevention programs (e.g. lanyards on hardhats, hand tools);
  - Safe working procedures to prevent dropped objects;
  - Procedures will be put in place to ensure that the location of any lost material is recorded and that significant objects are recovered – including ROV and boat recovery where practicable.
  - Ongoing personnel awareness and training, and dropped object prevention programs; and
  - Waste Management Plan

5.1.2.3 Residual impacts

5.1.2.3.1 Increased vessel traffic and collision risk

Although there will be an increase in the number of vessels in the area during the Project, these activities will only be of a relatively limited duration. As noted in the mitigation measures above, standard communication and notification procedures will be in place to ensure that all vessels operating in the area are aware of the activities, including the presence of the drill ship.

The Project is in an area of relatively low levels of shipping activity in comparison to other areas surrounding and to the west and south-west of Ireland. The vessels utilising the waters around the Project are primarily cargo vessels (see Section 3.5.6). There is an identified shipping route within 0.2 nm of the well location, which is used by a low (eight vessels) number of vessels per year (Anatec, 2018). However, there is amble sea room available for mariners of this route to temporarily and safely increase their clearance of the activities around the Project if required (Anatec, 2018).

Therefore, with the limited vessel requirements and the mitigation measures to be employed, there is little increase in the risk of vessel collision as a consequence of increased vessel activities from the Project. In addition, the Project is small and temporary, and there is ample sea room around the Project location for route adjustments through the Project duration. Through the implementation of the proposed mitigation the overall consequence of a physical presence impacts resulting from increased vessel traffic and collision risk as a result of the Project is '**minor**, with a frequency category ranked at **'2'** (≤ 3 months duration). It is therefore considered that the residual significance level of impacts resulting from increased vessel traffic and collision risk is ranked as **'negligible'** and considered to be '**not significant**'.

5.1.2.3.2 Temporary exclusion

As outlined in Section 5.1.2.1.2 vessels will be temporarily excluded from an area of approximately 0.8 km^2 around the drill ship as a result of the Project. Taking into account the localised and temporary nature of the access restrictions for a period of up to a maximum of 150 days posed by the Project and the low level of vessel traffic, the overall consequence of interference with fishing and shipping activity is considered to be is '**minor**, with a frequency category ranked at **'2'** (≤ 3 months duration). It is therefore considered that the residual significance level of impacts resulting temporary exclusion is ranked as **'negligible'** and considered to be '**not significant**'.

5.1.2.3.3 Dropped objects

The mitigation measures described in Section 5.1.2.2.3 will reduce the likelihood of objects being dropped onto the seabed. In the unlikely event that a significant object is dropped, Nexen will endeavour to recover it where possible. As a result, there are likely to be no residual issues associated with the presence of debris on the seabed and the overall consequence of a physical presence impacts resulting in dropped objects from the Project is **'minor**, and frequency category ranked at **'3'** (An event that could occur within lifetime of 10 similar facilities and has occurred at similar facilities). It is therefore considered that the residual significance level of impacts resulting from dropped objects is ranked as **'minor'** and considered to be '**not significant**'.

5.2 Underwater Noise

Underwater sound is generated by natural sources such as rain, breaking waves and marine life, including whales, dolphins and fish (termed ambient sound). Human use of the marine environment adds additional 'unwanted' sound from numerous sources including shipping, oil and gas exploration and production, aircraft and military activity.

Many species found in the marine environment (including marine mammals) use sound to understand their surroundings, track prey and communicate with members of their own species. Some species, mostly toothed whales, dolphins and porpoise, also use sound to build up an image of their environment and to detect prey and predators through echolocation.

Exposure to natural sounds in the marine environment may elicit responses in marine species; for example, harbour seals have been shown to respond to the calls of killer whales with anti-predator behaviour (Deecke *et al.*, 2002). In addition to responding to natural sounds, marine species such as fish and marine mammals may also respond to man-made noise. Whilst there is a lack of species-specific information collected under controlled or well-documented conditions, enough evidence exists for marine mammals to suggest that sound may have a potential biological impact and that noise from man-made sources may affect animals to varying degrees depending on the sound source, its characteristics and the susceptibility of the species present (e.g. Nowacek *et al.*, 2007).

In addition to potential behavioural impacts of noise, marine mammals exposed to an adequately high sound source may experience a temporary shift in hearing ability (termed a temporary threshold shift; TTS) (e.g. Finneran *et al.*, 2005). In some cases, the source level may be sufficiently high such that the animal exposed to the sound level might experience physical damage to the hearing apparatus and the shift may not be reversed; in this case there may be a permanent threshold shift (PTS) (Southall *et al.*, 2007).

The potential noise sources associated with the Project include:

- Drill ship (utilising DP and drilling);
- Drilling standby vessel; and
- VSP.

This section assesses the potential impacts from the proposed activities above on marine mammals, including cetaceans and pinnipeds (seals).

5.2.1 Potential impacts

5.2.1.1 Injury to marine mammals

Sound propagation calculations (as described in Section 5.2.1.3) allow the received noise level at different distances from the source to be determined. To determine the potential consequence of these received levels on any marine mammal which might experience such noise emissions it is necessary to relate the levels to known or estimated potential impact thresholds. A number of thresholds or methods for determining thresholds exist (e.g. the dB_{ht} method described by Nedwell *et al*., 2007 and Southall *et al*., 2007) and each has advantages and disadvantages. The DAHG guidance (NPWS, 2014), alongside other guidance such as that from the UK JNCC and Marine Scotland (JNCC, 2017, Marine Scotland, 2014), recommends using the injury criteria proposed by Southall *et al.* (2007), which are based on a combination of linear (i.e. un-weighted) peak pressure levels and mammal hearing weighted (M-weighted) sound exposure levels (SEL). The M-weighting function is designed to represent the bandwidth for each group within which acoustic exposures can have auditory impacts. The categories include low-, mid- and high-frequency cetaceans (including whales, dolphins, and porpoises) and pinnipeds in water (including seals, walruses and similar animals).

Based on current knowledge of functional hearing in marine mammals, Southall *et al*. (2007) defined five distinct, functional hearing categories. Species known to be found within the region of the Project (see Section 3.3.5) have been classed into the groups as follows:

> **Low-frequency cetaceans**: Sei whale, blue whale, minke whale and fin whale; with an estimated hearing range of 7 hertz to 22 kilohertz;

> **Mid-frequency cetaceans**: Risso's dolphin, short-beaked common dolphin, white-beaked dolphin, striped dolphin, bottlenose whale, beaked whales, Atlantic white-sided dolphin, bottlenose dolphin, false killer whale, killer whale, long finned pilot whale and the sperm whale with an estimated hearing range of 150 hertz to 160 kilohertz; and

> **High frequency cetaceans**: harbour porpoise; with an estimated hearing range of 200 hertz to 180 kilohertz.

> **Pinnipeds in water**: harbour seal and grey seal; with an estimated hearing range of 75 hertz to 75 kilohertz.

The injury criteria proposed in Southall *et al*. (2007) are for three different types of sound. These sound types include:

> **Multiple pulsed sound** (i.e. sound comprising two or more discrete acoustic events per 24 hour period, such as impact piling and VSP);

> **Single pulse sound** (i.e. a single acoustic event in any 24 hour period, such as an underwater explosion); and

> **Continuous sound** (i.e. non-pulsed sound such as continuous running machinery, vessels or drilling).

In relation to the potential noise sources from the Project, VSP is considered to be a multi-pulse source type and drilling and vessel operations are non-pulse or continuous source type.

The relevant criteria proposed by Southall *et al.* (2007) for assessing the potential for permanent threshold shift due to multiple and single pulse sounds are considered to be an un-weighted peak pressure level of 230 dB re 1 μPa and an M-weighted SEL of 198 dB re 1 $\mu Pa^2 s$ for all cetaceans. The criteria for pinnipeds are an un-weighted peak pressure level of 218 dB re 1 μPa and an M-weighted SEL of 186 dB re 1 $\mu Pa^2 s$. These injury criteria values are derived from values for onset of TTS with an additional allowance of +6 dB for peak sound and +15 dB for SEL to estimate the potential onset of PTS. Southall *et al.* (2007) states that these thresholds represent suitable levels for a precautionary approach.

For continuous sound, the relevant criteria proposed by Southall *et al.* (2007) are an un-weighted peak pressure level of 230 dB re 1 μPa and an M-weighted SEL of 215 dB re 1 $\mu Pa^2 s$ for all cetaceans. The criteria for pinnipeds are an un-weighted peak pressure level of 218 dB re 1 μPa and an M-weighted SEL of 203 dB re 1 $\mu Pa^2 s$.

It is important to note that the above criteria were developed using a precautionary approach, meaning that:

> The criteria do not take into account the potential for recovery in hearing between subsequent pulses or days of exposure, and are therefore likely to overestimate hearing damage caused by time varying exposure;

> The M-weighting curves are heavily generalised, in that they emphasise the frequency range at which each hearing classification is deemed to be most sensitive. In reality, the hearing threshold audiograms for individual mammal species will not adhere to this shape, but will instead comprise a much narrower "trough" shape, showing peak sensitivity somewhere in the range identified by the hearing group classification and decreasing sensitivity with increasing and decreasing frequency about this "trough"; and

> The peak pressure difference between TTS and PTS was arbitrarily taken to be 6 dB for pulsed sound, compared to 15 dB for continuous sound, meaning that the pulsed sound criteria are potentially very precautionary.

The criteria for use in assessing the likelihood of injury as a result of the Project as outlined in NPWS (2014) are summarised in Table 5.2.

Table 5.2 Marine mammal criteria for onset of PTS injury (per 24 hr period)

Marine Mammal Group	Type of Sound	Injury Criteria	
		Peak pressure, dB re 1 μPa	SEL, dB re 1 μPa^2s (M-weighted)
Low-frequency cetaceans	Single or multiple pulses	230	198
	Non-pulses (e.g. continuous sound)	230	215
Mid-frequency cetaceans	Single or multiple pulses	230	198
	Non-pulses (e.g. continuous sound)	230	215
High-frequency cetaceans	Single or multiple pulses	230	198
	Non-pulses (e.g. continuous sound)	230	215
Pinnipeds in water	Single or multiple pulses	218	186
	Non-pulses (e.g. continuous sound)	218	203

5.2.1.2 Disturbance to marine mammals

Beyond the area in which injury may occur, the impact on marine mammal behaviour is the most important measure of a potential impact of underwater noise.

Behavioural reactions to acoustic exposure are generally more variable, context-dependent, and less predictable than the effects of noise exposure on hearing or physiology. This is because behavioural responses to anthropogenic sound are dependent upon operational and environmental variables, and on the physiological, sensory, and psychological characteristics of exposed animals. It is important to note that the animal variables may differ (greatly in some cases) among individuals, of a species and even within individuals depending on various factors (e.g. sex, age, previous history of exposure, season, and animal activity). However, within certain similar conditions, there appears to be some relationship between the exposure Received Level (RL) and the magnitude of behavioural response. Southall *et al*. (2007) graded the severity of context-specific behavioural responses to noise exposure, as follows (refer to Table 5.3 for detailed description):

> Relatively minor and/or brief, score 0-3;

> A higher potential to affect feeding, reproduction, or survival, score 4-6; and

> Considered likely to affect these life functions, score 7-9.

Table 5.3 Southall *et al*. (2007) Behavioural disturbance scale

Response Score	Corresponding Behaviours in free-ranging Subjects
0	• No observable response.
1	• Brief orientation response (investigation / visual orientation).
2	• Moderate or multiple orientation behaviours; • Brief or minor cessation/modification of vocal behaviour; • Brief or minor change in respiration rates.
3	• Prolonged orientation behaviour; • Individual alert behaviour; • Minor changes in locomotion speed, direction, and/or dive profile but no avoidance of sound source; • Moderate change in respiration rate; • Minor cessation or modification of vocal behaviour (duration < Duration of source operation).
4	• Moderate changes in locomotion speed, direction, and/or dive profile but no avoidance of sound source; • Brief, minor shift in group distribution; • Moderate cessation or modification of vocal behaviour (duration more or less equal to the duration of source operation).
5	• Extensive or prolonged changes in locomotion speed, direction, and/or dive profile but no avoidance of sound source; • Moderate shift in group distribution; • Change in inter-animal distance and/or group size (aggregation or separation); • Prolonged cessation or modification of vocal behaviour (duration > duration of source operation).
6	• Minor or moderate individual and/or group avoidance of sound source; • Brief or minor separation of females and dependent offspring; • Aggressive behaviour related to sound exposure (e.g. Tail/flipper slapping, fluke display, jaw clapping/gnashing teeth, abrupt directed movement, bubble clouds); • Extended cessation or modification of vocal behaviour; • Visible startle response; • Brief cessation of reproductive behaviour.
7	• Extensive or prolonged aggressive behaviour; • Moderate separation of females and dependent offspring; • Clear anti-predator response; • Severe and/or sustained avoidance of sound source; • Moderate cessation of reproductive behaviour.
8	• Obvious aversion and/or progressive sensitisation;

Response Score	Corresponding Behaviours in free-ranging Subjects
	• Prolonged or significant separation of females and dependent offspring with disruption of acoustic reunion mechanisms; • Long-term avoidance of area (> source operation); • Prolonged cessation of reproductive behaviour.
9	• Outright panic, flight, stampede, attack of conspecifics, or stranding events; • Avoidance behaviour related to predator detection.

The more severe the response on the scale, the lower the amount of time that the animals will tolerate it before there could be significant negative effects on life functions, which would constitute a disturbance under the relevant regulations.

The United States (US) National Marine Fisheries Service guidance (NMFS, 2005) sets the Level B harassment threshold[5] for marine mammals at 160 dB re 1 µPa (rms) for impulsive noise and 120 dB re 1 µPa (rms) for continuous noise. The value for impulsive sound sits in the upper-mid range for disturbance impacts identified in Southall *et al*. (2007) and consequently this criterion has been used (in lieu of more suitable up to date criteria) for assessing onset of potentially strong behavioural reaction in this assessment, although it should be borne in mind that this value is possibly over-pessimistic. The value for continuous sound sits roughly mid-way between the range of values identified in Southall *et al*. (2007) but is lower than the value at which the majority of mammals responded at a response score of 6 (i.e. once the received rms sound pressure level is greater than 140 dB re 1 µPa). Taking into account the paucity and high level of variation of data relating to onset of behavioural impacts due to continuous sound, it is recommended that any ranges predicted using this number are viewed as probabilistic and possibly over-precautionary. The criteria proposed for use in assessing the spatial extent of marine mammal disturbance is summarised in Table 5.4.

Table 5.4 Marine mammal criteria for onset of disturbance

Type of Sound / Criteria Metric	Effect	Criteria
Single pulses		
Peak sound pressure level, dB re 1 µPa	Potential strong behavioural reaction[6]	224
SEL, dB re 1 µPa²s		183
Multiple pulses		
RMS sound pressure level, dB re 1 µPa	Potential strong behavioural reaction[7]	160
	Low level marine mammal[8]	140
Continuous sound		
RMS sound pressure level, dB re 1 µPa	Potential strong behavioural reaction	140
	Potential mild- strong behavioural[9]	120

5.2.1.3 Noise sources and sound propagation calculations

Increasing the distance from the noise source usually results in the level of noise getting lower, due primarily to the spreading of the sound energy with distance, analogous to the way in which the ripples in a pond spread after a stone has been thrown in. The way that the noise spreads (geometrical divergence) will depend upon several factors such as water column depth, pressure, temperature gradients, and salinity, as well as surface and bottom conditions. Thus, even for a given locality, there are seasonal variations to the way that sound will

[5] *Level B Harassment is defined as having the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioural patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering but which does not have the potential to injure a marine mammal or marine mammal stock in the wild.*

[6] *Based on criteria adopted from Southall et al. 2007 for behavioural effects due to single pulsed sound*

[7] *Based on Federal Register (2005) Level B harassment criterion for pulsed sound.*

[8] *Based on HESS (1997) criterion for onset of mild behavioural disturbance due to pulsed sound.*

[9] *Based on Federal Register (2005) Level B harassment criterion for continuous sound*

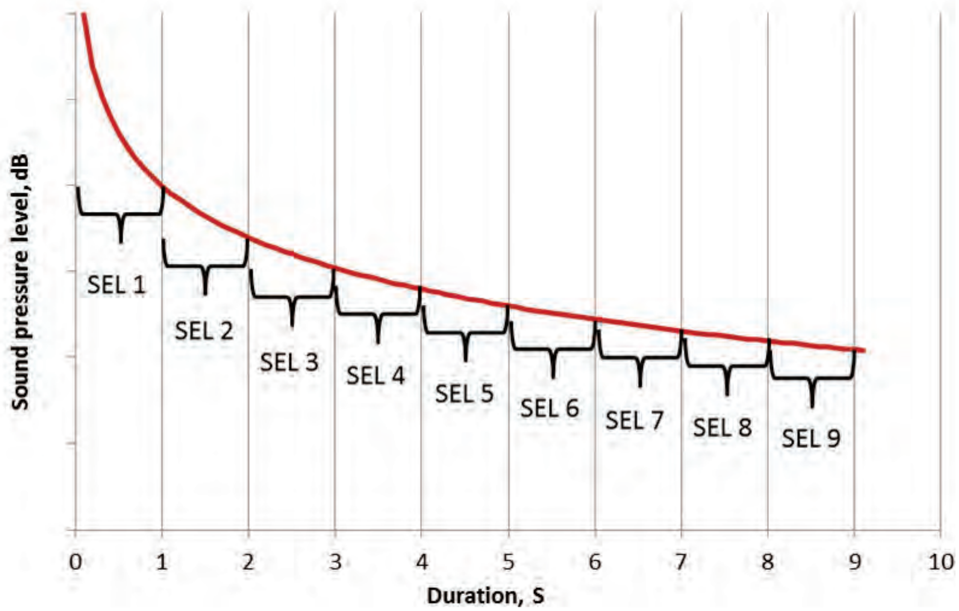
propagate. However, in simple terms, the sound energy may spread out in a spherical pattern (close to the source) or a cylindrical pattern (much further from the source) or somewhere in between, depending on several factors.

Sound propagation calculations for this assessment was carried out using the Xodus SubsoniX noise calculation tool, which implements the sound propagation model developed by Rogers (1981). The Rogers sound propagation model is a semi-empirical, range dependent propagation model which is based on a combination of theoretical considerations and extensive experimental data. Consequently, unlike purely theoretical sound propagation models, the calibration for the Rogers model is built into the calculations itself and it has subsequently been successfully benchmarked against other sound propagation calculations (e.g. Etter 2013, Toso *et al*., 2014, Schulkin and Mercer, 1985) and has been used previously in underwater noise assessments for tidal and wind energy developments (e.g., Dawoud *et al.*, 2015). The calculation tool uses several concepts including:

> Refractive cycle, or skip distance;
> Geometric divergence;
> Deflection of energy into the bottom at high angles by scattering from the sea surface;
> A simplified Rayleigh two-fluid model of the bottom for sand or mud sediments; and
> Absorption of sound energy by molecules in the water.
> The calculation tool takes into account the following parameters:
> Third-octave band source sound level data;
> Source directivity characteristics.
> Discreet range (distance from source to receiver);
> Water column depth and sediment layer depth;
> Sediment type (sand/mud); and
> Sea state

As well as calculating the sound pressure levels at various distances from the source, it is also necessary to calculate the SEL for a mammal using the relevant M-weightings (hearing characteristic) taking into account the amount of sound energy to which it is exposed over the course of a day. In order to carry out this calculation, it has been assumed that a mammal will swim away from the noise source at an average speed of 1.5 ms^{-1}. The calculation considers each 1-second period of exposure to be established separately, resulting in a series of discrete SEL values of decreasing magnitude (Figure 5.1). As the mammal swims away, the noise will become progressively quieter; the cumulative SEL is worked out by logarithmically adding the SEL to which the mammal is exposed as it travels away from the source. This calculation was used to estimate the approximate minimum start distance for a marine mammal in order for it to be exposed to sufficient sound energy to result in the onset of potential injury. It should be noted that the sound exposure calculations are based on the simplistic assumption that the animal will continue to swim away at a fairly constant relative speed. The real world situation is more complex and the animal is likely to move in a more complex manner. Swim speeds of marine mammals have been shown to be up to 5 ms^{-1} (e.g. cruising minke whale 3.25 ms^{-1} (Cooper *et al*. 2008), harbour porpoise up to 4.3 ms^{-1} (Otani *et al*. 2000) and grey seals up to 3.5 ms^{-1} (Gallon *et al*., 2007)). The more conservative swim speed of 1.5 ms^{-1} used in this assessment allows some headroom to account for the potential that the marine mammal might not swim directly away from the source, could change direction or does not maintain a fast swim speed over a prolonged period.

Figure 5.1 Conversion of continuous noise sources into discrete 1-second windows



The noise sources and noise data used in the sound propagation calculations for this assessment Project are summarised in Table 5.5.

Further information on the inputs and assumptions made in determining the noise source data used in the calculations are provided in Appendix B.

Table 5.5 Summary of noise sources and data used in the sound propagation calculations

Activity	**Data source**	**Peak sound pressure level dB re 1 µPa**	**SEL dB re 1 µPa^{2}s**	**RMS sound pressure level, dB re 1 µPa**
Drill ship (including thrusters)	Kyhn *et al.* (2011)	187	184 (1s)	184
Drilling support and standby vessel	Austin & McGillivray (2005)	191	188 (1s)	188
VSP[10]	Sercel G-Gun II 250	226	220	

5.2.1.4 Sound propagation calculation results

The results of the sound propagation calculations as the radii of the potential injury zones and behavioural change zone for the different situations, sources and thresholds are summarised in Table 5.6.

[10] The sounds propagation calculations assumed that the VSP would come from a separate vessel. However, VSP is planned to be undertaken from the drill ship. Therefore, the noise level from the drill ship is expected to be much less than that from a vessel, and therefore the calculations represent a conservative assessment.

Table 5.6 Sound propagation calculation results

Activity	Radius of effect (m)			
	Low-frequency cetacean	Mid-frequency cetacean	High-frequency cetacean	Pinnipeds in water
SEL radius of potential injury zone (moving mammals are assumed to move with a speed of 1.5 ms^{-1})				
Continuous noise: Drilling / DP / support vessel	0*	0*	0*	4
VSP	25	9	7	77
VSP + soft start	6	3	2	21
Estimated range for onset of disturbance				
Continuous noise: Drilling / DP / support vessel.	590 m (strong behavioural disturbance)			
VSP	2,795 m			

* Threshold not exceeded.

5.2.2 Mitigation measures

5.2.2.1 Continuous noise sources

None of the continuous noise sources (drilling DP and support vessel) have been identified as likely to produce significant levels of noise to cause injury to cetaceans.

There is a possibility that the continuous noise sources could result in injury to pinnipeds within 4 m of the sound source. The number of seals expected to be encountered is likely to be very low, and few, if any animals, would be expected to be found in the Project area across the whole Project period as it is so far from the coast (and numbers potentially impacted are not presented). This combined with the very small zone of potential injury to seals, no mitigation measures for any of these activities is proposed.

5.2.2.2 VSP

In order to mitigate potential impacts to marine mammals associated with the VSP activities associated with the Project, Nexen will adhere to the most recent guidance produced by the NPWS - Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters (NPWS, 2014). The mitigation measures to be adopted during the VSP are in line with NPWS (2014) guidance and are summarised below:

- A qualified and experienced marine mammal observer (MMO) shall be appointed to monitor for marine mammals and to log all relevant events using standardised data forms;
- Sound-producing activities shall only commence in daylight hours where effective visual monitoring, as performed and determined by the MMO, has been achieved. Where effective visual monitoring, as determined by the MMO, is not possible, the sound-producing activities shall be postponed until effective visual monitoring is possible;
- As the water depth is >200 m pre-start-up monitoring shall be conducted at least 60 minutes before the activity is due to commence. Sound-producing activity shall not commence until at least 60 minutes have elapsed with no marine mammals detected within the 1000 m Monitored Zone by the MMO.
- Pre-Start Monitoring shall subsequently be followed by a Ramp-Up Procedure (where possible) which should include continued monitoring by the MMO. Airguns utilised in VSP generally fire for approximately two minutes and then stop for 5 – 10 minutes before repeating the pattern. To ensure that marine mammals

are given the opportunity to move away from the airguns as they commence firing, energy would be slowly increased to the maximum level over a period of 40 minutes, in a process called ‘soft-start’.

> If there is a break in sound output for a period of 5-10 minutes (e.g., due to equipment failure, shut-down), MMO monitoring must be undertaken to check that no marine mammals are observed within the Monitored Zone prior to recommencement of the sound source at full power.

> If there is a break in sound output for a period greater than 10 minutes (e.g., due to equipment failure, shut-down or station change) then all Pre-Start Monitoring and a subsequent Ramp-up Procedure (where appropriate following Pre-Start Monitoring) will be undertaken.

5.2.3 Residual impacts

5.2.3.1 Likelihood of injury to marine mammals

As outlined in Section 5.2.1.3 the assumption that the mammal would stay stationary during a period of VSP activity is considered to be unrealistic. A more realistic assumption is that, upon hearing the onset of the activity, the mammal would move away from the sound source, hence the first pulse would provide the highest ‘dose’ of sound, with each subsequent pulse contributing less to their exposure as they move away from the source. Swim speeds of the species most likely to be observed in the area have been shown to be up to 5 ms^{-1} (e.g. cruising minke whale swims at a speed of 3.25 ms^{-1}, (Cooper *et al.,* 2008), harbour porpoise up to 4.3 ms^{-1}, (Otani *et al*., 2000)). In order to take a conservative approach, the predicted exposures of marine mammals moving away from the sound source have been calculated using a slow swim speed of 1.5 ms^{-1}. This also takes into account the mammal swimming away off axis, for the few cases where a mammal is moving in the same direction of vessel travel. Table 5.6 shows that the zone of potential injury from VSP with the implementation of the soft start procedure (as outlined in Section 5.2.2.2) for high frequency cetacean species is 6 m, 3 m for mid-frequency cetaceans, 2 m for low-frequency cetaceans and 21 m for pinnipeds.

The possibility of injury to marine mammals from the VSP is significantly reduced (effectively eliminated) with the use of a 1,000 m Monitored Zone, since the start-up of the sound source would not occur until the visual monitoring showed that the area was clear of marine mammals. There is, therefore, expected to be no residual negative impact through injury to marine mammals arising from VSP activities from the Project. Table 5.6 shows that the zone of potential injury from the continuous noise sources to cetaceans resulting from the drill ship, drilling or support vessel or any combination of these activities operating concurrently, assuming marine mammals move away from the source of the noise at onset, does not occur for all cetacean species.

Table 5.5. shows there is a potential zone of injury of 4 m to pinniped species resulting from the combination of continuous noise sources. The number of seals expected to be encountered is likely to be very low, and few, if any animals, would be expected to be found in the Project area across the whole Project period as it is so far from the coast (over 200 km). This combined with the very small zone of potential injury to seals (4 m from source) and the short duration of the activities, the residual negative impact to pinnipeds is expected to be minor and not significant.

5.2.3.2 Disturbance to marine mammals from noise

To understand the residual impact on animals that may be experiencing some disruption to normal behaviour, it is important to consider a number of factors including the size and location of the potential disturbance zone (larger areas mean a greater potential to interact with a greater number of animals) and length of time for which the sound source will be present (the longer the period the greater potential to have significant effects). Behavioural changes such as moving away from an area for short periods of time, reduced surfacing time, masking of communication signals or echolocation clicks, vocalisation changes and separation of mothers from offspring for short periods, do not necessarily imply that detrimental effects will result for the animals involved (JNCC, 2010). Temporarily affecting a small proportion of a population would be unlikely to result in population level effects and would not considered as non-trivial disturbance (i.e. would not be significant disturbance). In contrast, affecting a large proportion may be considered non-trivial disturbance (i.e. could be significant disturbance).

Based on the sound propagation calculations, the radius of the zone for the onset of behavioural change effects will be approximately:

> 590 m from the sound source for the continuous noise sources of drilling / DP / drilling support vessel. equating to an approximate area of 1.09 km^2

> 2,795 m from the source array for VSP equating to an approximate area of 24.5 km^2.

Behavioural changes such as moving away from an area for short periods of time, reduced surfacing time, masking of communication signals or echolocation clicks, vocalisation changes and separation of mothers from offspring for short periods, do not necessarily imply that detrimental effects will result for the animals involved (JNCC, 2010). Therefore, the zone of behavioural change will not be a zone from which animals are necessarily excluded, but rather one in which normal behaviour might be affected across a range of potential responses, from a simple noticing of the sound, to a startle response and return to normal behaviour, through to exclusion from an area.

To determine the likelihood of impact in terms of actual number of animals, it is possible to calculate the number of animals likely to experience some sort of behavioural impact using local density and population estimates. Density estimates from the area covering the West of Ireland and Celtic Seas are not well understood for many species, but estimates from SCANS-II (detailed in JNCC, 2010 and Hammond *et al*., 2013) and Cetacean Offshore Distribution and Abundance in the European Atlantic II (CODA) survey results (detailed in JNCC, 2010) provide regional density estimates for some of the species most regularly found in vicinity of the Project. The number of seals expected to be encountered is likely to be very low, and few, if any animals, would be expected to be found in the Project area across the whole Project period as it is so far from the coast (and numbers potentially impacted are not presented).

To understand how the number of animals that might be affected might constitute a non-trivial disturbance offence, it is important to understand what proportion of the population this number represents. Temporarily affecting a small proportion of a population would be highly unlikely to result in population level effects, thus not considered as being qualifying as non-trivial disturbance. In contrast, affecting a large proportion may be considered non-trivial disturbance. Determining this proportion is in itself not a simple task since it is not clear how North East Atlantic marine mammal populations act at a local level. For example, minke whales are likely to make use of the entire North East Atlantic, so the population can be viewed as one, whilst other species may display more local fidelity and be viewed as a series of sub-populations.

The Statutory Nature Conservation Bodies of the UK (SNCBs, 2013) note that marine mammals of almost all species found in UK waters are part of larger biological populations whose range extends into the waters of other States and/or the High Seas. In order to obtain the best conservation outcomes for many species, it is necessary to consider the division of populations into smaller management units. This requires an understanding of the geographical range of populations and sub-populations, in order to provide advice on impacts at the most appropriate spatial scale. The output of the SNCB exercise investigating how marine mammal populations may act (SNCBs, 2013) is the determination of Marine Mammal Management Units (MMMU) for species including bottlenose dolphins, common dolphins, harbour porpoise, white-beaked dolphin Atlantic white-sided dolphin and minke whale. These MMMUs and associated population estimates can be interpreted in the context of the potential disturbance zones to consider the potential for a significant impact to occur.

The number of individual animals potentially affected for species known to be present in the Project area (Atlantic white-sided dolphin, white beaked dolphin, bottlenose dolphin, common dolphin, harbour porpoise, striped dolphin, pilot whale sperm whale, minke whale and fin whale) is shown in Table 5.7. The numbers have been calculated for the criteria relative to the type of noise emission.

Considering the percentages of the populations affected in Table 5.7, it is clear that, whilst the presence of these species in the potential disturbance area at the time of the Project cannot be ruled out, the number of individual animals that are likely to exhibit some form of change in behaviour for the period in which they encounter sound from the Project is so small that it would be largely undetectable against natural variation and would have no effect at the population level. Of those individuals that are potentially present in the disturbance area there is a very low likelihood of these individuals remaining within the Project area for the whole duration and given the relatively short duration of the Project (100 - 150 days) any change in their behaviour for the period in which they encounter sound from the Project will also be so small that it would also be largely undetectable against natural variation and would have no lasting effect at the population level.

For species not listed in Table 5.7 due to lack of sightings information (e.g. killer whale, blue whale, beaked whales), densities and population estimates would be expected to be lower than those in Table 5.7 and the percentage of population affected would be lower. Therefore, the overall magnitude of the impact on these species is thus considered to be similar.

Through the implementation of the proposed management and mitigation the overall consequence of underwater noise impacts to marine mammals as a result of the Project is considered to be '**minor**', and the frequency category ranked at **'3'** (Intermittent emission or activity). It is therefore considered that the residual significance level of underwater noise impacts to marine mammals is ranked as **minor** and considered to be '**not significant**'.

Table 5.7 Estimated number of animals experiencing behavioural changes as a result of the Project

Species	Density estimates[11] per km²	Marine mammal population estimate[12]	VSP		Continuous noise Drilling / DP / drilling support vessel.	
			Maximum number of animals predicted to be in the behavioural change impact zone at any one time[13]	Percentage of reference population potentially affected	Maximum number of animals predicted to be in the behavioural change impact zone at any one time[15]	Percentage of reference population potentially affected
Atlantic white side / white-beaked dolphin[14]	0.052	85,188	1.274	0.0011495516	<1	0.000066535
Bottlenose dolphin	0.0099	11,923	<1	0.002034303	<1	0.000090506
Common dolphin	0.015	51,800	<1	0.000709459	<1	0.000031564
Harbour porpoise	0.074	104,695	1.81	0.001731697	<1	0.0001077043
Striped dolphin	0.16	85,585	3.92	0.004746625	<17	0.000211176
Pilot whale	0.056	83,441	1.37	0.001644276	<1	0.000073153
Sperm whale	0.003	2,424	<1	0.003032178	<1	0.000134901
Minke whale	0.013	23,163	<1	0.001375038	<1	0.000061175
Finn whale	0.1	7,523	2.45	0.032566795	<1	0.00144889

[11] Density estimates from JNCC Hammond *et al.* (2013) and JNCC (2010).
[12] Population density estimates from SNCB (2013) management unit within which the Project sits, CODA estimates from JNCC (2010). For Atlantic white-sided & white-beaked dolphins, management unit population estimates of 69,293 & 15,895 respectively have been given combined since density estimates are for both species combined.
[13] Calculated as the density estimate x behavioural change area.
[14] JNCC (2010) presents the SCANS-II abundance estimates for these two species as a combined value, due to difficulty in distinguishing the two species in the field. When considering either of the two species individually, the values provided are there therefore an over-estimate.

5.3 Atmospheric Emissions

5.3.1 Potential impacts

The drill ship and support vessels will be required to be present for the duration of the Project. The main atmospheric emissions associated with the Project are the products of fossil fuel combustion by the drill ship and associated vessels, including:

- Carbon dioxide;
- Methane;
- Nitrous oxide;
- Sulphur oxides;
- Nitrogen oxides;
- Carbon monoxide; and
- Non-methane volatile organic compound(s).

In the event of a well kick situation, gas could be released accidentally from the well into the water column. Some of this gas may eventually be released into the atmosphere at the sea surface.

The potential impacts of the main atmospheric emissions are summarised in Table 5.8.

Table 5.8 Potential environmental impacts associated with atmospheric emissions (Defra, 2011)

Gaseous Emissions	Environmental Impact
Carbon dioxide (CO_2) Direct greenhouse gas	CO_2 is a greenhouse gas, meaning that it inhibits the radiation of heat into space. An increase in global greenhouse gas concentrations may increase temperatures at the earth's surface.
Methane (CH_4) Direct greenhouse gas	Implication in global climate change and contribution to regional-level air quality deterioration through low level ozone production. The indirect impacts of these emissions are the impacts of low level ozone, which is detrimental to health and can cause damage to vegetation, crops and ecosystems.
Nitrous oxide (N_2O) Direct greenhouse gas	N_2O is a greenhouse gas, meaning that it inhibits the radiation of heat into space. An increase in global greenhouse gas concentrations may increase temperatures at the earth's surface.
Carbon monoxide (CO) Air quality and indirect greenhouse gas	Deterioration in air quality - at elevated levels CO can have direct impacts upon human health (asphyxiant).
Oxides of nitrogen (NO_X) Acidification gas and indirect greenhouse gas	The direct impact of NO_X emissions is the formation of photochemical pollution in the presence of sunlight. Low level ozone is the main chemical pollutant formed, with by-products that include nitric and sulphuric acid and nitrate particulates. The impacts of acid formation include contribution to acid rain and dry deposition of particulates. The indirect impacts of acid deposition are damage to buildings and vegetation, and a contribution to the acidification of soils and lakes.
Sulphur oxides (SO_X) Acidification gas	Precursor to acid rain and atmospheric particulates. Can result in respiratory illnesses and disease at elevated levels.
Non-methane volatile organic compounds (NMVOCs)	Significant greenhouse gas and can react with NO_2 in the atmosphere to form ozone in the lower atmosphere.

Gaseous Emissions	Environmental Impact
Air quality and indirect greenhouse gas	Deterioration of local air quality.
Particulate matter (PM)	Formation of low level ozone through photochemical reactions with sunlight.

Atmospheric emissions, with potential impacts on natural ecosystems and human well-being, may potentially result in impacts at a local, regional, transboundary and global scale.

Local, regional and transboundary issues include the potential generation of acid rain from NO_X and SO_X released from combustion, and the human health impacts of ground level NO_2, SO_2 (released from combustion) and ozone (generated via the action of sunlight on NO_X and VOCs).

On a global scale, concern with regard to atmospheric emissions is now increasingly focused on global warming and climate change. The Intergovernmental Panel on Climate Change (IPCC) in its fourth assessment report states that *'Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations (GHG).'* Climate change projections included in the IPCC report for Europe and Africa forecast a temperature increase of between 2.3°C and 5.3°C in the period from 2080 to 2099. GHG includes water vapour, CO_2, CH_4, N_2O, ozone and chlorofluorocarbons. The most abundant GHG is water vapour followed by CO_2. IPCC (2007) reports a 35% increase in CO_2 concentrations compared to pre-industrial concentrations and states that the combustion of fossil fuels is the primary contributor.

The IPCC and the US Climate Change Program have researched the environmental impacts of climate change and indicated that impacts may include:

- Increased frequencies of heat waves, droughts and fires;
- Coastal flooding as a result of rising sea levels caused by melting of ice caps, glaciers and polar ice sheets;
- Severe hurricane activity and increased frequency of severe precipitation;
- Infectious disease migration into new regions;
- Loss of wildlife habitats; and
- Increased levels of ground level ozone causing heart and respiratory illnesses (IPCC, 2007).

Therefore, consideration has been given to all potential sources of atmospheric emissions associated with the Project.

5.3.1.1 Quantification of emissions

Generation of power on-board the drill ship during the Project will result in the emission of various combustion gases. The Project is planned to start in April 2019 and last for approximately 100 – 150 days. It has been assumed that the drill ship and vessels will be on location for maximum of 150 days. For the atmospheric emission calculations, it has been assumed that drilling operations will be continuous for the period that the drill ship is on site.

Atmospheric emissions from the Project are related to:

- Fuel consumption by the drill ship and supply/support vessels; and
- Unplanned release of gas to the atmosphere during well control operations

No planned well testing is anticipated.

5.3.1.2 Fuel consumption

The vessels which will be presented during the Project include:

- Drill ship;

- A standby vessel; and
- Three supply vessels.

In addition, helicopters will be used five times a week to transport freight and personal to the drill ship from Kerry airport. They will also be used in the event of an emergency situation.

In order to calculate atmospheric emissions, the vessel estimated activity quantities have been used in conjunction with Institute of Petroleum Guidelines (IP, 2000) and EEMS emission factors (EEMS, 2008).

A summary of predicted fuel use and the subsequent atmospheric emissions for the Project detailed above is provided in Table 5.8.

5.3.1.3 Well control operations

In the event of a well kick situation, gas could be released accidentally from the well into the water column. Some of this gas may eventually be released into the atmosphere at the sea surface. A well kick could be 100 bbl at a maximum pressure of 690 barg. The composition of the gas in the reservoir is expected to be composed of methane (a greenhouse gas), ethane and propane. Therefore, in the event of an unplanned well kick this could also potentially result in the emission of greenhouse gases into the atmosphere.

5.3.2 Mitigation measures

A number of mitigation measures will be employed to minimise the impact of atmospheric emissions resulting from the Project:

- Practical steps to limit the release of atmospheric emissions during the Project will include advanced planning to enable efficient operations and fuel utilisation and well maintained and operated power generation equipment.
- The contractors will comply with the MARPOL Convention 73/78 Appendix VI on atmospheric emissions: no emissions of ozone depleting substances, content of sulphur in fuel oil not exceeding 3.5% m/m, and no incineration of garbage containing more than traces of heavy metals;
- All vessels and the drill ship will comply with the Merchant Shipping (Prevention of Air Pollution from Ships) (Amendment) Regulations 2014; and
- Nexen will verify that drill ship contractor procedures align with the relevant Nexen Engineering requirements which cover all aspects of primary and secondary well control for floating drilling operations.

5.3.3 Residual impacts

The Project will generate approximately 40,192 tonnes of CO_2. Whilst there may be locally elevated concentrations of the gases detailed in Table 5.9, the dispersive nature of the exposed offshore environment means that these will be short-lived. In addition to potential local impact, emissions of CO_2 will contribute to global warming and ocean acidification, whilst emissions of SO_2 and NOx can result in acidifying effects and the formation of ground-level ozone. However, there is unlikely to be a direct, demonstrable effect of the emissions arising from the Project since they will be negligible in a national or global context.

With respect to an accidental well kick, in the worst-case scenario up to 4.5 tonnes of methane could be released subsea. It is expected that some of this would dissipate and be absorbed into the water column. However, assuming that all the gases reach the sea surface and are released to the atmosphere, such amounts could equate to approximately 114.85 tonnes of CO_2 equivalent. As with the combustion emissions, the dispersive nature of the exposed offshore environment means that these additional emissions to the atmosphere will be short-lived and that there is unlikely to be a direct, demonstrable effect since they will be negligible in a national or global context.

Through practical steps to limit the release of atmospheric emissions during the Project, Nexen will minimise the environmental risks associated with atmospheric emissions from the Project. Therefore, given the dispersive nature of the exposed offshore environment and the distance of the Project to shore, the overall consequence of adverse environmental impact through atmospheric emissions associated with the Project is ‘**minor**’ with the frequency ranking of **‘2**’ (≤ 3 months duration). It is therefore considered that the residual significance level as result of atmospheric emissions is ranked as **‘negligible’** and ‘**not significant.**

Table 5.9 Atmospheric emissions from the Project

Activity	Source	Details			Atmospheric emissions (tonnes)							
	Vessels	Duration[15]	Fuel use (tonnes/day)	Total fuel use (tonnes)	CO_2	CH_4	N_2O	SO_x	NOx	CO	NMVOC	$CO_{2\text{-}e}$[16]
DP drill ship on location	IceMAX	150 days	50	7,500	24,000.00	0.83	1.65	0.10	273	62.25	9.00	24,528.83
Support shipping	Standby vessel	150 days	1.7	255	808.35	0.05	0.06	3.06	15.05	4.00	0.61	826.70
	Supply vessels (x3)	450 days	10	4,500	14,265.00	0.81	0.99	54.00	265.5	70.65	10.80	14,588.91
Transport personnel and freight	S92 helicopter transporting personnel (5 1 hour 15 minute return flights from Kerry per week)	22 days	0.7838 tonnes one-way trip	34.49	110.36	0.18	0.43	0.01	00	00	0.03	247.76
				Total	**39,183.71**	**1.86**	**3.13**	**57.16**	**553.55**	**136.91**	**20.44**	**40,192.20**

[15] These days do not account for the travel time of vessels reaching the Project area.
[16] "Carbon dioxide equivalent ($CO_{2\text{-}e}$) is a term for describing different greenhouse gases in a common unit. For any quantity and type of greenhouse gas, $CO_{2\text{-}e}$ signifies the amount of CO_2 which would have the equivalent global warming impact.

5.4 Discharges to Sea

5.4.1 Introduction

During the Project drilling activities, there will be a number of potential drilling discharges to sea, including:

> Drilling mud and cuttings;
> Cement and cement additives;
> Clean-up chemicals; and
> Plug and abandonment chemicals.

These discharges may lead to potential impacts to the seabed or water column through the following mechanisms:

> Increased suspended solids in the water column;
> Settlement of cuttings, muds and cement on the seabed that may:
  - Alter the seabed topography and sediment habitat due to the introduction of different sediment particle sizes, which can affect oxygen movement within the sediment;
  - Bury or partially cover the benthic communities where deposition is high; and
  - Impair the feeding and respiratory systems of benthic organisms due to deposition of fine particles and increased concentrations of suspended particles near the seabed.
> Potential impacts from the muds and chemical additives used in the drilling operations.

Those discharges associated with vessel operations (sewage, drainage, etc.) are considered to have a minor environmental impact and are therefore not considered further in this section. They will be controlled in line with the Merchant Shipping (Prevention of Oil Pollution) Regulations 1996 which implements MARPOL Annex 1 in the UK and controls oily discharges from any vessel activity (e.g. machinery space drainage), and the Merchant Shipping (Prevention of Pollution by Sewage and Garbage from Ships) Regulations 2008 which is in place for sewage treatment and discharges.

5.4.1.1 Discharge types

5.4.1.1.1 Drilling programme

As outlined in Section 2, the first two sections of the Iolar exploration well (36'' and 26'') will be drilled before a marine riser is installed. This means that all drilling fluids, rock cuttings and residual cement returns from these sections will be discharged directly onto the seabed in the immediate vicinity of the exploration well. These sections will be drilled using seawater and pre-hydrated bentonite sweeps a type of WBM, so that the associated discharges at the seabed will consist of cuttings and poly beta-hydroxybutyrate (PHB).

The deeper sections (20'', 17½'', 12¼'' and 8½'') will be drilled using OBM. The mud will be pumped downhole and then circulated back to the surface via the annulus (the space between the drill stem and the wall of the bore hole) and through the BOP stack and the marine riser back to the drill ship. The mud and cuttings from these sections will then be skipped and shipped to the shore for treatment and recycling/disposal. Therefore, none of the OBM from the deeper sections are to be discharged to sea.

Table 5.10 provides an estimate of the amounts of cuttings and WBM that will be generated/used and subsequently discharged into the sea, as was modelled to inform this ERA. It is worth noting that what was modelled is now less that what is expected from the current well design, and therefore the values presented in Table 5.10 and assessed in this section are a conservative, worst case estimate of the likely impact.

Table 5.10 Cuttings and mud generation and discharge volumes

Section	Discharge point	Cuttings discharged (te)	Type of drilling mud
42"	Seabed	941	WBM
26"	Seabed	2,168	WBM

The specific chemicals and additives used during drilling will be dependent upon the mud composition, which in turn will be determined by the down-hole conditions encountered whilst drilling. All chemicals will be selected on their technical specifications as well as for their potential environmental impacts, which will be assessed using the CHARM risk assessment model. The results of this process are submitted in a PUDAC, 60 days prior to planned operations in line with the Rule and Procedures Manual. Additional chemicals will be stored on the drill ship to deal with any contingencies such as stuck drill pipe or loss of circulation.

5.4.1.1.2 Cementing

Steel casings will be installed in the proposed exploration well during the drilling operation to provide structural strength and isolate unstable formations and different formation fluids. Each casing will be cemented into place to form an effective seal between the casing and the formation and to prevent the migration of formation fluids to the seabed.

During the cementing phase, a number of chemicals are added to the mix water (used to form the cement composition) so that the final cement has the necessary physiochemical (e.g. corrosion resistance, viscosity, pore size etc.) and mechanical properties (e.g. tensile and compressive strength) to achieve the desired performance.

Cementing operations may involve small discharges of cement when cementing the top hole sections (drilled without a marine riser in place) back to the surface. During the subsequent cement jobs there will be no cement returns to seabed or surface. When cleaning up the cement unit after each of the cementing operations is completed, an additional quantity of heavily diluted residual cement slurry will be discharged to sea. The quantity will be included in the PUDAC application which will be applied for prior to the commencement of the drilling operations.

5.4.2 Potential impacts

5.4.2.1 Potential seabed impacts

Particulate material deposited on the seabed during drilling of the top hole sections (because there is no riser in place) may form a localised "cuttings pile" at the seabed around the entry point. The material deposited will be a mixture of cuttings (i.e. removed from the well), drilling mud (bentonite – a clay material) and some cement with associated chemicals.

Burial of benthic organisms may result in mortality depending on the depth of cuttings deposition. Filter feeding organisms (for example hydroids and bryozoans) that rely on suspended particles as a source of food may be more vulnerable to the potential smothering impacts of the drilling discharges than deposit-feeding organisms that rely on the deposition of suspended material. More mobile species may be able to avoid unfavourable conditions.

Feeding structures may become clogged with increased suspended solids in the water column just above the seabed and therefore feeding would be temporarily limited. Due to the short term nature of drilling activities the increased suspended solids loading is not expected to be long term. There is potential impact to the composition of the benthic community in the immediate vicinity of the drilling location.

After deposition, the particulate material in the cuttings pile is subject to re-distribution due to seabed currents. It is anticipated that recovery of the seabed will start immediately following cessation of drilling due to bioturbation and recolonisation of smothered sediments as species move back into the disturbed area.

In addition to potential impacts associated with deposition of material to the seabed, potential impacts associated with drilling chemicals need to be considered. Barite consists of barium sulphate, an insoluble, chemically inert mineral powder that normally contains measurable concentrations of several trace metals. Barium is considered biologically unavailable, of low toxicity and is unlikely to have a measurable impact on the benthic fauna (Jenkins *et al.,* 1989, Hartley, 1996; Starczak *et al*., 1992). The potential environmental impact of other trace metals will depend on their concentration in the WBM cuttings, which in turn depends partially on the geological source of barite. Neff (2008) found that metals associated with drilling mud barite are virtually unavailable to marine organisms that might come into contact with discharged drilling fluids.

5.4.2.2 Potential water column impacts

As described in Section 5.4.1 both the physical and chemical impacts of drilling discharges to sea can result in potential impacts to the seabed and to the water column. Discharges to the water column have the potential to affect fish, planktonic organisms and organisms living at or near the seabed. Organisms affected could experience interference with feeding, respiration and migration.

Potential water column impacts are likely to be short term and localised which aligns with the findings published from potential impact studies for drilling such as the 1,000 fold dilution that is expected within 10 minutes of discharge (Neff, 2005) and the dose-related risk and effect assessment model (DREAM) related research (e.g. 2006 TNO report regarding the potential environmental impact on the water column of weighting agents in drilling mud). In addition, Alldredge *et al*. (1986) have shown that primary production in the vicinity of drilling platforms is not impacted by drilling discharges. Increased suspended solids, especially near the seabed, may result in direct irritation to certain types of marine organisms, abrading protective mucous coatings and increasing their susceptibility to parasites and infections, as well as affecting growth, reproduction and feeding.

5.4.3 Mitigation measures

Nexen procedures for chemical management, as well as specific regulatory controls, will be in place to prevent or reduce the potential environmental impacts. A number of mitigation measures will be applied to the Project to limite, where practicable, the potential environmental impacts of drilling discharges.

- All OBM will be skipped and shipped for onshore treatment and disposal, and not routinely discharged overboard;
- Cementing procedures will be in place to minimise the quantities of cement prepared and used, consistent with safe practices, and to minimise the amount of unused cement discharged;
- Chemicals will be selected in line with Nexen’s chemical selection policy, reducing where possible the use of chemicals carrying substitution notifications and other product warnings;
- The management of drilling fluids, drill cuttings, cementing fluids and subsea control fluids will be consistent with all appropriate Nexen Engineering Standards, Operating Standards, Procedures; and
- Environmental risk assessment as part of PUDAC approval process, and identification of measures to reduce risk, will be carried out to obtain approval for chemical use prior to drilling operations commencing as outlined in the PAD Rules and Procedures Manual (PAD, 2014).

5.4.4 Residual impacts

5.4.4.1 Drilling discharge modelling overview and assumptions

An assessment of the potential impacts from the drilling of the proposed exploration well was conducted with the aid of the ParTrack module within Sintef’s Dose-related Risk and Effect Assessment Model (DREAM) (included in Marine Environmental Modelling Workbench (MEMW) version 9) (Xodus, 2018). This software tool has been designed to support rational management of environmental risks associated with operational discharges of complex mixtures. Each component in the mixture is described by a set of physical-chemical-toxicological parameters. As hydrocarbons constitute a significant fraction of many industrial releases, DREAM incorporates a complete surface slick model, in addition to the processes governing pollutant behaviour in the water column.

Whilst the results of modelling cannot be directly substituted for observed impacts occurring during a real situation, modelling is a useful tool to help assess the risk of potential impacts and to inform project decision making. The earliest possible spud date for the exploration well is the 1st April 2019 and as such the design of the well and drilling programme was at an early stage at the time this modelling work was conducted. The model was run to cover drilling of the top two sections (36" and 26") which will be drilled riserless with WBM and cuttings discharged at the seabed. The model was set up to simulate the drilling and casing of all sections. When drilling a new section, the new discharge was set to commence six hours after the previous discharge.

The well bore wash-out rate was set to the model default value of 10% for both sections. particulates in the discharge (cuttings, barite and bentonite) were set up using the model default values. The chemical additives in the mud were input to the model according to their Cefas templates (a chemical registration system for chemicals used offshore, administered by Cefas).

5.4.4.1.1 Environmental impact factors (EIFs)

EIFs for the water column and sediment were calculated for the drilling discharges to inform the assessment of the potential impacts of the drilling programme. EIFs are a measure of risk to the biota in the marine environment. They are calculated using the PEC/PNEC approach, where the predicted environmental concentration (PEC) of a contaminant is divided by the predicted no effect concentration (PNEC); the highest concentration at which no environmental impact is predicted. A result of >1 indicates there is likely to be an environmental impact.

The PNEC values within the ParTrack model have been calculated using laboratory toxicity tests of a range of contaminants on a range of species. The PNEC for each substance has been defined within the model as the concentration at which the no observed effect concentration (NOEC) was exceeded in 5% of tests. In other words, the PNEC for any given chemical within the model would be expected to have an impact on 5% of all species tested. PNECs for non-toxic stressors such as burial and oxygen depletion, which are relevant to benthic biota, have also been calculated from experimental data.

The PEC for each contaminant is determined within the model using a number of calculations to simulate the behaviour of contaminants in the water column. Processes including dilution, partitioning, degradation and deposition into the sediment are simulated in order to generate a PEC for each contaminant over time. EIFs for the sediment compartment are more complex, incorporating toxicity of contaminants, but also processes such as oxygen depletion, change in median grain size and burial effects.

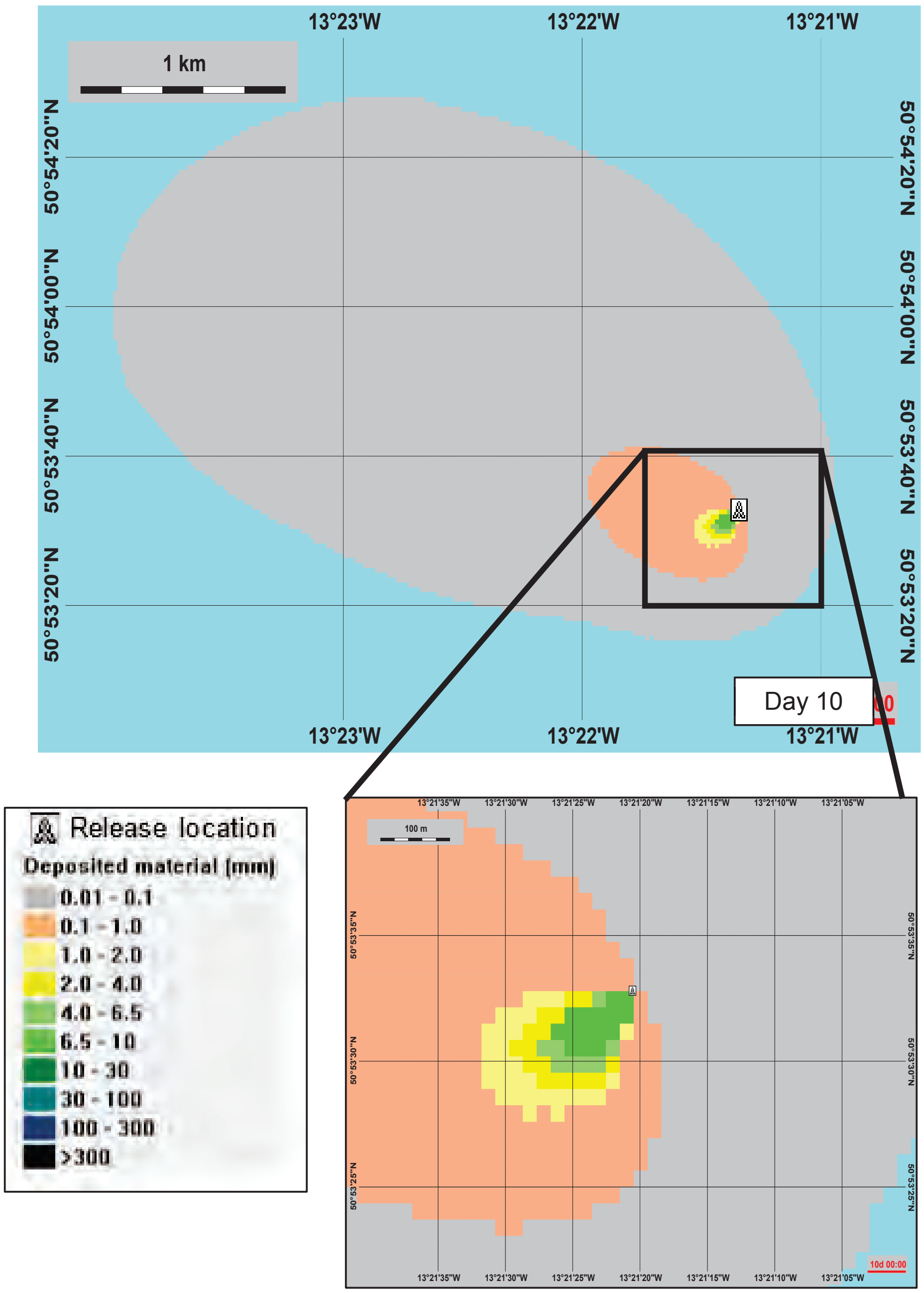
An EIF of 1 in the water column is equivalent to a 5% risk of impact to all species in 100,000 m^3 of water, and for sediment in 0.01 km^2 (1 hectare) of seabed.

5.4.4.2 Residual seabed impacts

Cuttings deposition on the seabed was modelled (Xodus 2018) and a summary of the results are presented here. Figure 5.2 displays the thickness of the cuttings pile along an approximate north east to south west direction and predicts that the cuttings nearest the well will be around 2,350 mm thick. Around 20 m south west of the discharge location, the thickness decreases to 80 mm and is then followed by another accumulation peak about 45 m south west of the discharge location around 280 mm thick. Overall there is a decrease in deposited material thickness with distance from the discharge location, such that within approximately 80 m the thickness has decreased to less than 15 mm. The model predicts that deposited material thickness peaks at approximately 40 minutes following drilling.

The sediment risk (EIF) is predicted to be zero. This coincides with the model prediction that the deposition arising from the drilling further than 20 m from the well is less than 10 mm and therefore below any thresholds for the burial of benthic organisms (TNO, 1994).

Figure 5.2 Predicted deposited material on the seabed at 10 days (Xodus, 2018)



Considering the relatively limited area over which benthic habitats and species have the potential to be impacted and that the sediment risk EIF value predicted to be zero, the overall consequence of the residual environmental impact on the seabed as a result of discharges associated with drilling the Iolar well is considered to be '**negligible**' with a frequency category on '**1**' (One off event or activity of ≤ 10 days duration). It is therefore considered that the residual significance level as result of discharges to sea resulting in impacts to the seabed is ranked as **'negligible'** and '**not significant**'.

5.4.4.3 Residual water column impacts

The drill cuttings dispersion modelling output showed that the size and extent of the plume in the water column with concentrations greater than 0.1 ppb to be limited to within 26 km of the point of release (Figure 5.3). The discharge plume peak concentration is predicted to remain at depth, below 1,900, depth of the water column as a result of the deep-water column and because discharges occur both at the seabed and at the sea surface (Figure 5.4).

The development of the water column EIF values over time is presented in Figure 5.5, while the contributions of the various components in the discharge to the maximum EIF are shown in Figure 5.6 (Xodus, 2018).

These figures show that the largest contributors to the risk are the barite (59%), bentonite (35%), and biocide (6%). These three contributors make up 85 - 100% of the impact for the duration of the discharge. After 4.25 days, the EIF has returned to zero.

Figures 5.3 to and 5.6 show that the water column impact is transient and very short-lived with the magnitude of the impact dependent primarily on the currents dispersing the drilling discharge, and thus reducing the volume of water impacted. It should be noted that this modelling was based on conservative (worst-case) assumptions for the quantities of mud and cuttings discharged, the toxicity of the components in the mud, and the timing and duration of the drilling programme. This modelling therefore represents an upper limit for the drilling using this preliminary well design, and any water column impact that occurs during the actual drilling is expected to be less than that predicted by the model.

Water column residual impacts relate to both the physical and chemical effects predominantly experienced by planktonic species. Considering the relatively limited area over which the water column is modelled to be affected and the transient nature of this effect (4.25 days), the discharge of cuttings from the Project is not considered to represent a significant residual impact to the water column.

Potential water column impacts are likely to be short term and localised, which aligns with the findings published from drilling impact studies such as the 1,000 fold dilution that is expected within 10 minutes of discharge (Neff, 2005) and the DREAM-related research regarding the potential environmental impact on the water column of weighting agents in drilling mud (TNO, 2006). As the suspended particulates from the lower well sections in the model are spatially restricted in the deeper water column, it is unlikely that there will be any significant residual impact on zooplankton feeding as these will generally be located higher in the water column.

Considering the characteristics of the potential impact, the mitigation measures detailed above, and the likely quick recovery, the potential consequence due to discharge of cuttings to the water column associated with the Project is therefore considered to be '**minor**' with a frequency category ranking at **'2'** (≤ 3 months duration). It is therefore considered that the residual significance level of impacts to the water column as result of discharges to sea is as **'negligible'** and considered to be '**not significant**'.

Figure 5.3 Water column impact at 3 hours, 12 hours, 4 days, 5 days, 10 days and the maximum (Xodus 2018)

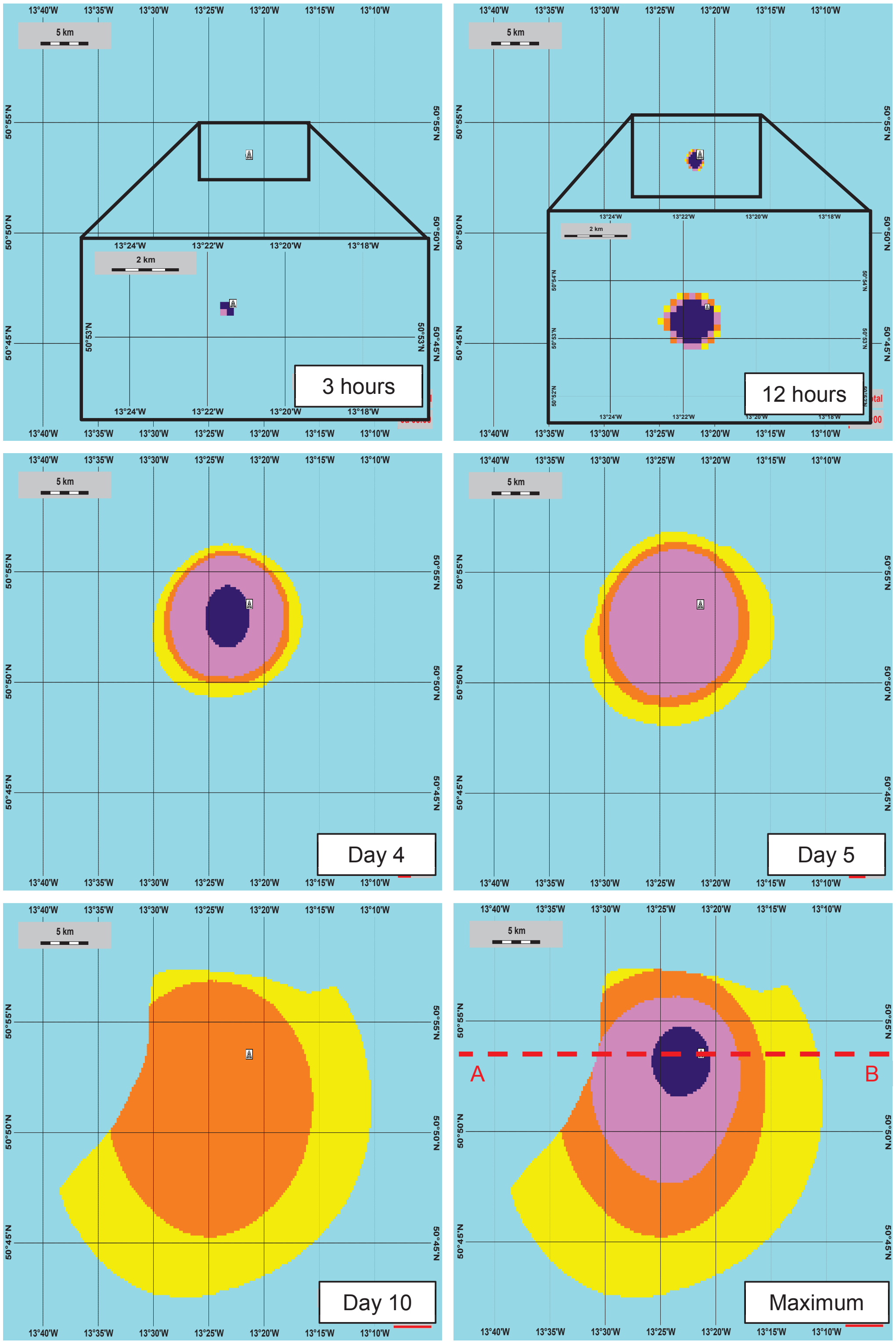


Figure 5.4 Water column total EIF transect (Xodus 2018)

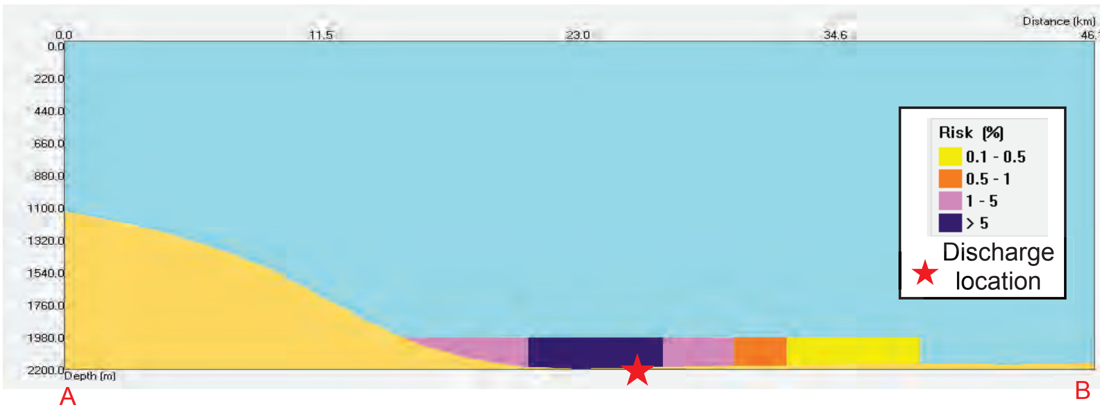


Figure 5.5 Development of water column impact (Xodus 2018)

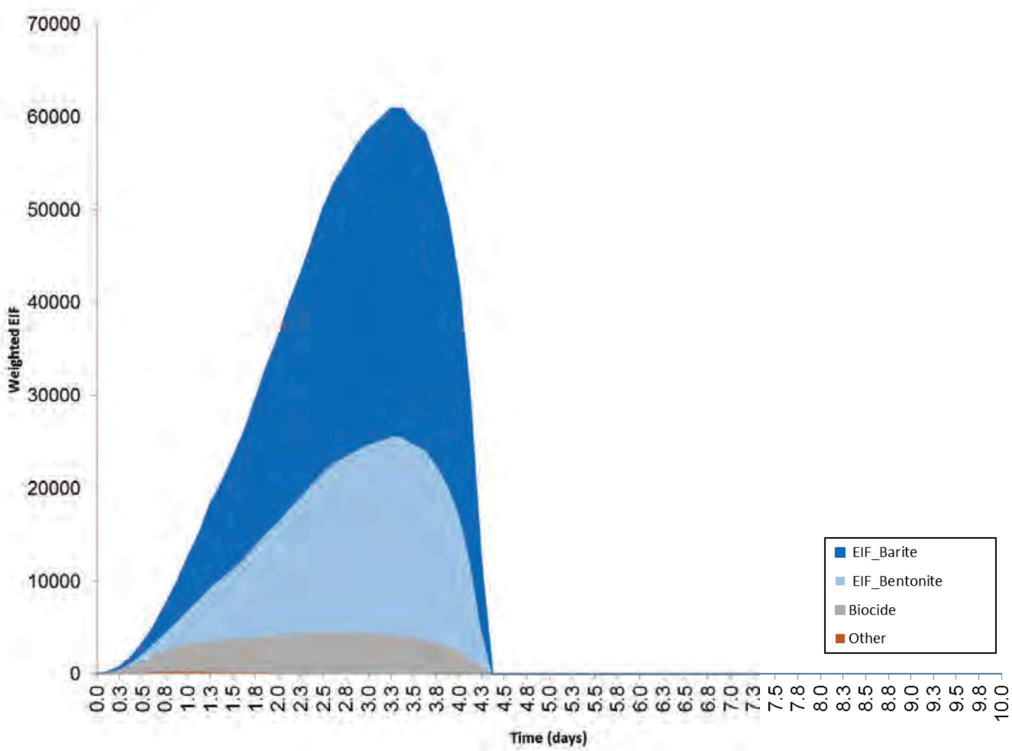
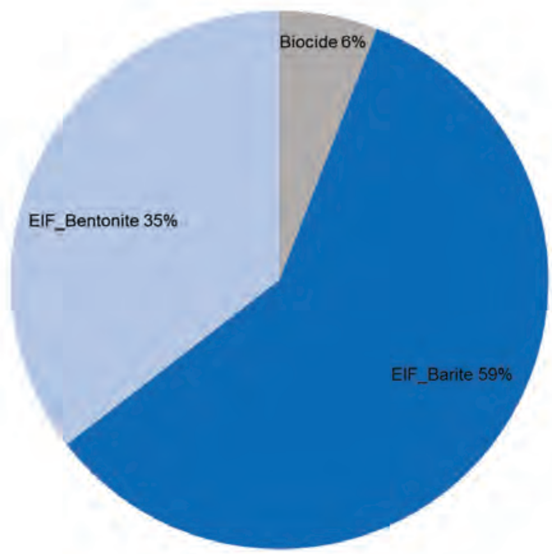


Figure 5.6 Weighted contribution to maximum risk to water column (Xodus, 2018)



5.5 Accidental Releases

5.5.1 Introduction

All marine activities, including exploration drilling, carry with them some risk of accidents, which may occur due to procedural weaknesses, human error, equipment failure or extreme natural conditions. The risk of accidental hydrocarbon releases is thus inherent in all offshore oil and gas activities, and is an area of public concern that may have potentially significant impacts on water quality, flora, fauna and other users of the sea. A summary of potential accidental release scenarios relevant to the proposed operations and historical trends in accidental event frequency is presented in Section 5.5.2.

Three categories of accidental event were identified that could occur during the Project and have the potential to cause potentially significant environmental impacts:

- Accidental release of fuel or chemicals from vessel decks or during bunkering;
- Loss of containment of fuel storage tanks (marine diesel) due to vessel collision; and
- Loss of well integrity resulting in a well blowout and release of crude oil.

Nexen has conducted a detailed risk assessment (see Section 4 and Appendix A supported by project-specific oil spill modelling (Section 5.5.4) in order to identify measures that will reduce the likelihood of an accidental release occurring, and that will mitigate the impacts in the event of an incident (Section 5.5.5).

The extent of environmental impacts in the event of an accidental release is not correlated simply to the size of the release but is also influenced by a number of other factors including: the distribution pattern of the released material on the sea surface and in the water column, the physico-chemical properties of the release such as its propensity to dissolve, partition or emulsify, its buoyancy in the water column and its weathering behaviour, and the potential for the released material to reach sensitive environmental receptors. The sensitivity of many receptor groups will vary over time and space, for example, individual migratory seabird species may be very sensitive during the period that they are present but will be completely insensitive during the period while they are not present.

When assessing the potential for impacts on coastal receptors it is also necessary to consider the likelihood that a release, once it has occurred, will reach the receptors, providing connectivity and a potential for impacts to occur. Without this connectivity, there can be no impact. The expected sensitivity of environmental receptors is summarised in Section 5.5.4.2.

The residual potential environmental impacts (that is, with mitigation measures being taken into account) in the unlikely event of an accidental release of hydrocarbons or chemicals have been assessed in Section 5.5.6. Potential for cumulative impacts is discussed in Section 5.6 and transboundary impacts in Section 5.7.

5.5.2 Sources and likelihood of occurrence of hydrocarbon spills

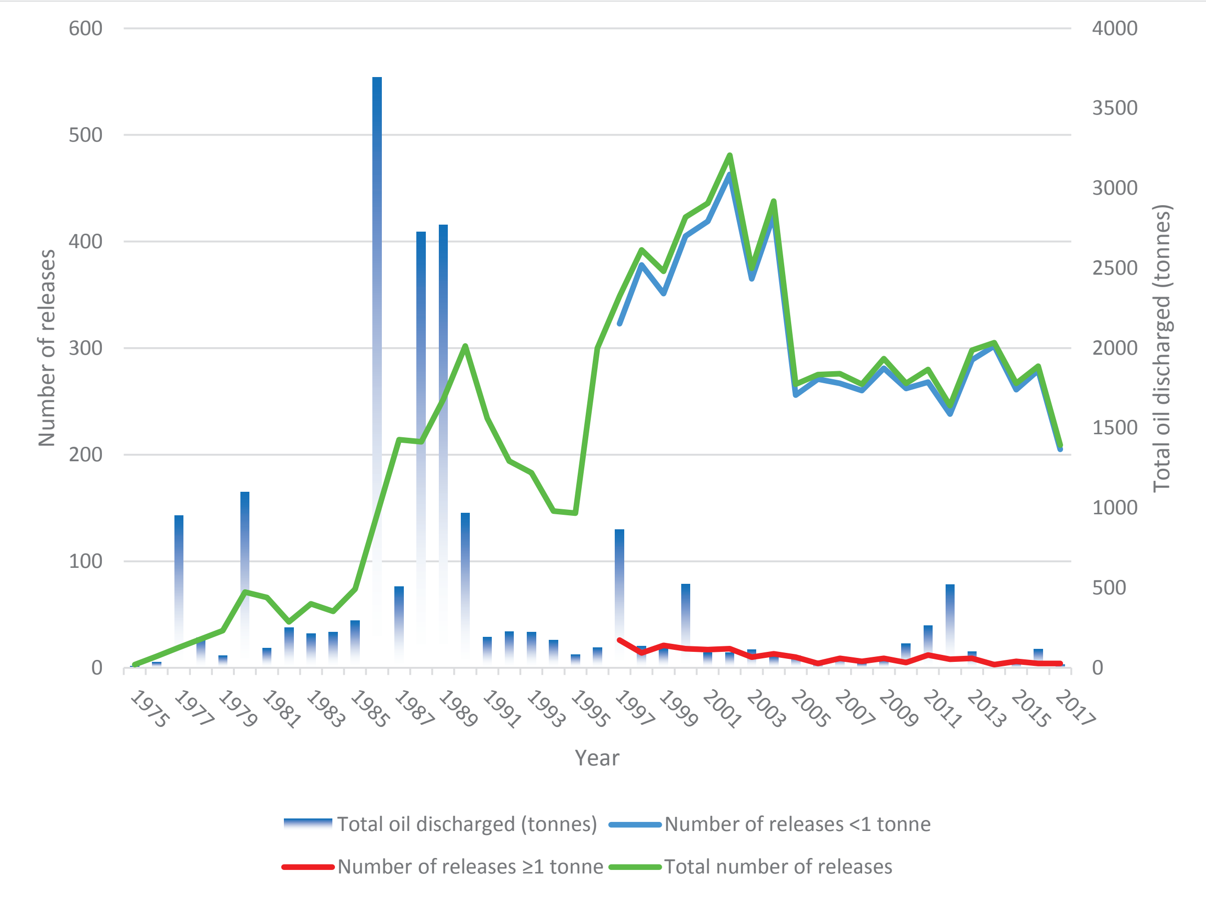
To put the accidental event scenarios relevant to the Project into context, the section below presents data on historical spill events which have occurred on the UK Continental Shelf (UKCS). These data are considered useful to support the risk assessment due to the relatively large number of wells drilled in the UKCS and the similar regulatory and safety standards in place in Ireland and the UK. Information is also used from the SINTEF Offshore Blowout Database which summarises worldwide blowout and well release incidents.

5.5.2.1 Overview

Review of UKCS historical oil spill data (presented in Figure 5.7) shows that between 1975 and 2017 a total of 18,678 tonnes of oil was accidentally released from 9,583 individual events. The total volume of oil released per year has been on a declining trajectory since a peak in 1986. The total number of spill events per year is also declining from a peak in 2002. The majority of spills from offshore oil and gas operations involve less than one tonne of oil. Spills of greater that one tonne have been declining in frequency since the start of the available data series in 1997, although there were three unusually large spill events between 2010 and 2012, reflected in the higher “Total oil discharged” columns for those years in Figure 5.7.

The United Kingdom Offshore Operators Association (UKOOA) (now Oil & Gas UK (OGUK)) reports that between 1975 and 2005, 46% of UKCS accidental release records related to crude oil, 18% to diesel, and the other 36% to other hydrocarbons such as condensates, hydraulic oils, oily waters and unknown types of hydrocarbon (UKOOA, 2006).

Figure 5.7 Total number of UKCS accidental hydrocarbon releases and amounts released (TINA Consultants Ltd., pers. comm., 2013; BEIS, 2018a; BEIS, 2018b; National Archives 2012a; National Archives 2012b; BP, 2016)



5.5.2.2 Blowouts and well releases

Primary well control is the practice of maintaining a hydrostatic pressure in the wellbore greater than the pressure of the hydrocarbons in the producing formation being drilled (formation pressure), but less than the fracture pressure (the pressure at which the rock adjacent to the wellbore will begin to fracture). The wellbore hydrostatic pressure is maintained and adjusted by varying the density of the drilling fluid being injected into the well. If the hydrostatic pressure is allowed to fall below the producing formation pressure, the well will begin to flow, that is, hydrocarbons will enter the wellbore from the formation and begin to displace the fluid in the wellbore towards the surface. This constitutes a failure of primary well control.

In the event that primary well control fails, secondary well control is initiated by closing valves on the wellhead (known as blowout preventers or BOPs) to prevent uncontrolled flow of material out of the well. Secondary well control is completed by mixing a heavier fluid on the drilling platform and injecting this into the wellbore under controlled conditions, simultaneously circulating the material that has intruded into the wellbore out of the well to the platform where it can be contained and processed. Once secondary well control is successfully completed, drilling may resume if appropriate.

If secondary well control fails, for example due to a failure of the BOP, or due to extremely high pressure fracturing the well casing at some point below the BOP, a well blowout may occur at the surface or underground. A surface blowout constitutes an uncontrolled flow of formation hydrocarbons from the reservoir to the surface (note the release may occur at the seabed or from the infrastructure at the sea surface) and may lead to release of hydrocarbons to the environment. An underground blowout is when hydrocarbons entering the wellbore cause the wellbore pressure to exceed the fracture pressure at another level in the well, allowing hydrocarbons to flow from the producing formation into the wellbore, and then back into the weaker formation. There may be no release to the environment under these circumstances.

A well release, as opposed to a blowout, is an incident where hydrocarbons flow from a well when flow was not intended, but flow is subsequently stopped by the use of the barrier system that was available on the well at the time the incident started (during drilling operations this would be the BOP). Well releases may also result in release of hydrocarbons to the environment, but because they are stopped using the equipment that is already in place on the well, these events tend to be rapidly resolved and any release to the environment can be expected to be small.

Blowouts are extremely rare events in modern drilling (DTI, 2001), although deep water HP/HT exploration wells such as the Project are the more challenging wells to drill because the HP/HT environment is more challenging to control, and conditions in exploration wells are less predictable than development wells in previously explored formations. Table 5.11 shows the historical frequency of drilling blowouts and well releases for various types of well drilled to North Sea standards. Deep water HP/HT exploration wells have a blowout and well release frequency approximately one order of magnitude greater than normally pressured exploration wells and HP/HT development wells, and two orders of magnitude higher than normally pressured development wells. The historical frequency of incidents is still low however, equating to one blowout per 667 wells drilled, and one well release per 83 wells drilled.

Table 5.11 Historical frequency of blowouts and well releases (per well drilled) for various types of well in >200 m water depth (IOGP, 2010)

Well type	Pressure regime	Historical frequency per well drilled (IOGP, 2010)[17]		Number of wells drilled per incident	
		Blowout	Well release	Blowout	Well release
Exploration	Normal	2.5×10^{-4}	2.0×10^{-3}	4,000	500
	HP/HT	1.5×10^{-3}	1.2×10^{-2}	667	83
Development	Normal	4.8×10^{-5}	3.9×10^{-4}	20,833	2,564
	HP/HT	3.0×10^{-4}	2.4×10^{-3}	3,333	417

The likelihood of a blowout is considered remote according to the definitions in Section 4.3, and the likelihood of a well release is considered unlikely. Nevertheless, as the consequences from a hydrocarbon release of any nature is potentially significant, Nexen will implement rigorous measures to reduce the potential for a failure of well control during the Project and ensure an effective response should an incident occur.

5.5.2.3 MODU spills

The proposed exploration well will be drilled from a MODU (in this case a drill ship). Potential accidental releases from MODUs (excluding blowouts discussed above) may include fuel, drilling muds, small accidental oil and chemical releases and hydraulic fluids.

The most notable UK blowout from a MODU was in 1988 when an explosion led to a fire on a semi-submersible rig drilling a high pressure high temperature field in the central North Sea. Historical data for frequency of blowouts from MODUs on the UKCS between 1990 and 2007 is presented in Table 5.12. The data do not show the severity of each event or whether the blowout led to an oil spill. However, the data do provide an indication of overall frequency of blowouts on the UKCS. The frequency of blowouts declined by almost an order of magnitude from the period 1990-1999 to 2000-2007.

[17] Based on SINTEF international data for wells in water >200 m (OGP, 2010)

Table 5.12 Blowout frequency per unit per year on UKCS (OGUK, 2009)

Type of facility	Period					
	1990 to 1999		2000 to 2007		1990 to 2007	
	Number	Frequency per year	Number	Frequency per year	Number	Frequency per year
MODU	13	0.020	3	0.0066	16	0.014

The information presented in Table 5.13 are based on data submitted to the UK Department of Energy and Climate Change (DECC)[18] for the period 2001 to 2007. During this period, MODUs operating in the UKCS completed a total of 172 operation years. No accidental releases greater than 100 tonnes were recorded in the UKCS between 2001 and 2007 and the majority of accidental releases recorded were less than 1 tonne.

The most common cause of accidental releases from MODUs was drilling operations (42%); of these releases 94% were less than 1 tonne. The second most common cause was maintenance/operational activities (27%); 97% of these releases were also less than 1 tonne.

Review of PON1 data recorded between 2007 and 2017 confirms no releases of >100 tonnes have occurred in the intervening years (BEIS, 2018a; 2018b) and that the majority of MODU accidental releases remain <1 tonne.

Table 5.13 Number of accidental releases from MODUs, based on UKCS historical data by release size and source during the period 2001 to 2007 (TINA Consultants Ltd pers. Comm., 2013)

Accidental release cause	<1 kg	1 to <10 kg	10 to <100 kg	0.1 to <1 tonnes	1 to <10 tonnes	10 to <100 tonnes	All accidental releases[i]
Maintenance/operational activities	10	14	4	5	1	0	**35**
Bunkering	2	9	2	9	0	0	**22**
Subsea releases	1	3	3	1	2	1	**12**
Drilling	12	6	15	15	2	1	**54**
Remote Operated Vehicle (ROV) associated	1	3	1	0	0	0	**5**
Other production	0	0	0	1	0	0	**1**
All accidental releases[ii]	**35**	**42**	**40**	**42**	**8**	**2**	**179**

[i] *Includes accidental releases of unknown size.*

[ii] *Includes accidental releases of unknown cause and accidental releases that could not be categorised.*

The total number of accidental releases from MODUs between 1990 and 2007 in the UKCS, and the frequency of releases per operational year is shown in Table 5.14. The frequency of incidents per operational year decreased by approximately 30% during the period 2000 to 2007 compared to the period 1990 to 1999.

[18] The UK government body that records accidental releases within the UKCS. In July 2016 DECC became part of the Department for Business, Energy & Industrial Strategy (BEIS).

Table 5.14 Number of accidental releases from MODUs on the UKCS from 1990 to 2007 and frequency per operational year (OGUK, 2009)

Type of facility	Period				1990 to 2007 (total)	
	1990 to 1999		2000 to 2007			
	Number	Frequency per year	Number	Frequency per year	Number	Frequency per year
MODU	160	0.246	78	0.172	238	0.215

Apart from well blowouts, the MODU incident scenarios in which the greatest impact might be expected would include vessel grounding, collisions or explosions that lead to a total loss of hydrocarbon inventory (most likely to be marine diesel fuel) although this is unlikely as diesel/hydrocarbon stock is stored in multiple locations in separate tanks and containers. Table 5.15 highlights the number of explosions, collisions and vessel contacts for MODUs in the UKCS and the frequency of incidents per operational year. These data also indicate a general reduction in the frequency of incidents between the period 2000 to 2007 compared to the period 1990 to 1999. Whilst it is not indicated whether accidental releases occurred from each incident recorded, the data suggests that the frequency of incidents which could lead to an accidental release has decreased.

Table 5.15 Number of explosions, collisions and vessel contacts from MODUs in the UKCS from 1990 to 2007 and frequency of incidents per operational year (OGUK, 2009)

Type of incident	Period					
	1990 to 1999		2000 to 2007		1990 to 2007 (total)	
	Number	Frequency per operational year	Number	Frequency per operational year	Number	Frequency per operational year
Vessel contact	108	0.166	25	0.055	133	0.120
Collision	14	0.021	1	0.0022	15	0.014
Explosion	10	0.015	-	-	10	0.009

5.5.3 Sources and likelihood of occurrence of chemical spills

Chemical spills may occur during chemical transfer, chemical/mud handling or through mechanical failure. The most frequently reported accidental releases from vessel traffic are associated with upsets in bilge treatment systems and are usually small (<1 tonne). The most recent Advisory Committee on Protection of the Sea report on discharges to sea (Dixon, 2015) states that approximately 73% of accidental chemical releases were considered under the OSPAR list of substances used and discharged offshore as Posing Little or No Risk to the Environment, that none of the chemicals were included in the OSPAR list of chemicals for priority action (which are considered to pose the greatest potential impact) and that none of the releases resulted in a significant environmental impact.

5.5.4 Potential impacts of hydrocarbon spills

5.5.4.1 Behaviour of hydrocarbons at sea

The potential environmental impact of a spill depends on a wide variety of factors, which in the offshore environment include:

> Accidental release volume;

> Type of hydrocarbon released;

> Direction of travel of the slick;

> Weathering properties of the hydrocarbon;

> Exposure of environmental receptors to the released material (presence of receptors may vary seasonally); and

> Sensitivity of exposed environmental receptors (may also vary seasonally).

Using the ITOPF classification key for oil types, Iolar crude is expected to be consistent with a Group III oil. The specific gravity of oil is its density in relation to pure water, which has a specific gravity of 1. Iolar crude is expected to have a specific gravity of 0.85, indicating that the oil from a subsea blowout is likely to rise to the sea surface and remain there during calmer conditions, although there is the potential for this oil to suspend below the sea surface during rougher weather conditions.

The Oil Spill Contingency and Response model (OSCAR) has been developed by Sintef to model the fate of spilled oil at sea. It has a built-in oil database, containing over 110 oils, along with various gridded wind and current files, originally produced by the Norwegian Met Office.

OSCAR is a 3D model, designed to predict the fate of oil particles at the surface, sub-surface and once dissolved. OSCAR calculates and records the distribution in three physical dimensions, plus time, of a contaminant on the water surface, along shorelines, in the water column, and in the sediments.

OSCAR Stochastic modelling uses a minimum of 110 runs, spanning a period of 5 years between 2008 and 2013. Stochastic scenarios modelled for the proposed exploration well include a blowout resulting in an unconstrained flow from the well for 146 days, a blowout resulting in an unconstrained flow from the well for 35 days and loss of the drill ship diesel fuel inventory. These scenarios were modelled across four seasons – spring (March to May), summer (June to August), autumn (September to November) and winter (December to February).

The release scenarios modelled for the Project are listed in Table 5.16. In line with current regulatory and industry commentary and experience with credible worst-case scenario identification, the following assumptions have been made while undertaking the modelling in this report:

> Interactions: all scenarios are run with the assumption that there is no response from any party; operator, local or national government. This approach is taken in order to view the worst-case predictions of a spill and should be used as guidance only; and

> Timeframes: diesel model runs were given a full 14 days following cessation of release, crude releases were given a full 30 days following cessation of release. The extra run time was in order to fully examine the fate of released hydrocarbons.

A minimum threshold of 0.3 µm was applied to sea surface oiling results and figures in line with BEIS guidance (BEIS, 2017).

Table 5.16 Summary of accidental hydrocarbon release model scenarios carried out for the Project

Scenario	Hydrocarbon Type	Spill Volume (m^3)	Modelled Depth of Release	Model Type
Instantaneous drill ship diesel inventory spill	Marine diesel	16,565	Surface	Stochastic
Well blowout using the predicted unconstrained well flow rate for 146 days	Iolar crude (OSCAR Gulfaks crude used as surrogate)	2,856,856	Seabed	Stochastic
Well blowout using the predicted unconstrained well flow rate for 15 days	Iolar crude (OSCAR Gulfaks crude used as surrogate)	737,213	Seabed	Stochastic

The following subsections present the results of the modelling for the three spill scenarios discussed above.

5.5.4.1.1 Scenario 1 – Drill ship diesel inventory

Stochastic modelling indicated a low probability of sea surface contamination across most of the affected area, with probability >10% restricted to an area of approximately 150 km diameter concentrated to the southeast of the release point (Figure 5.8). The maximum time-averaged thickness figure (Figure 5.9) indicates that the thickness of any surface slick would remain <5 μm across most of the affected area, with each of the purple or brown streaks of thicker oil showing one of the possible directions that a surface slick might travel in under a specific set of environmental conditions.

The minimum arrival time of surface oil is presented in Figure 5.10. Maximum probability of diesel crossing transboundary lines, and minimum arrival time of diesel at transboundary lines, is summarised by season in Table 5.17. Diesel may reach international waters most rapidly in Spring (3 d 10 h), although the highest probability (4.8%) occurs in Autumn. Diesel is not predicted to enter other national jurisdictions. The minimum potential beaching time and the maximum beaching probability for each season is summarised in Table 5.18. The highest probability of diesel beaching occurs in Summer (2.9%) as does the minimum predicted beaching time (7 d 13 h). The (low) possibility of diesel beaching is predicted to be restricted to the southwest coast of Ireland (Figure 5.11) and arrival time is predicted to be similar across all beaching locations (Figure 5.12).

Table 5.17 Scenario 1 - Probability and time taken to cross transboundary lines by season

Median line(s) crossed	Location	Minimum crossing time	Probability of Contamination (% range)
Winter	n/a	Does not cross	0%
Spring	International Waters	3 d 10 h - 14 d 0 h	1 % - 3.8 %
Summer	International Waters	6 d 18 h - 14 d 0 h	1 % - 1.9 %
Autumn	International Waters	5 d 13 h - 14 d 0 h	1 % - 4.8 %

Table 5.18 Scenario 1- Probability and time taken to beach

		Winter	Spring	Summer	Autumn
Ireland	Probability of contamination (%)	0 %	0 %	1 % - 2.9 %	1 %
	Arrival time	Does not beach	Does not beach	7 d 13 h - 14 d 0 h	8 d 8 h - 13 d 7 h
Protected areas with beaching oil probability >40%		None			
Maximum mass of beached oil in any single run (te)		None	None	429	23.3
Maximum mass of beached emulsion in any single run (te)		None	None	435	23.6
Maximum volume of beached emulsion in any single run (m^3)		None	None	514	27.9

Figure 5.8 Scenario 1 – Probability of sea surface oiling (above 0.3 µm threshold)

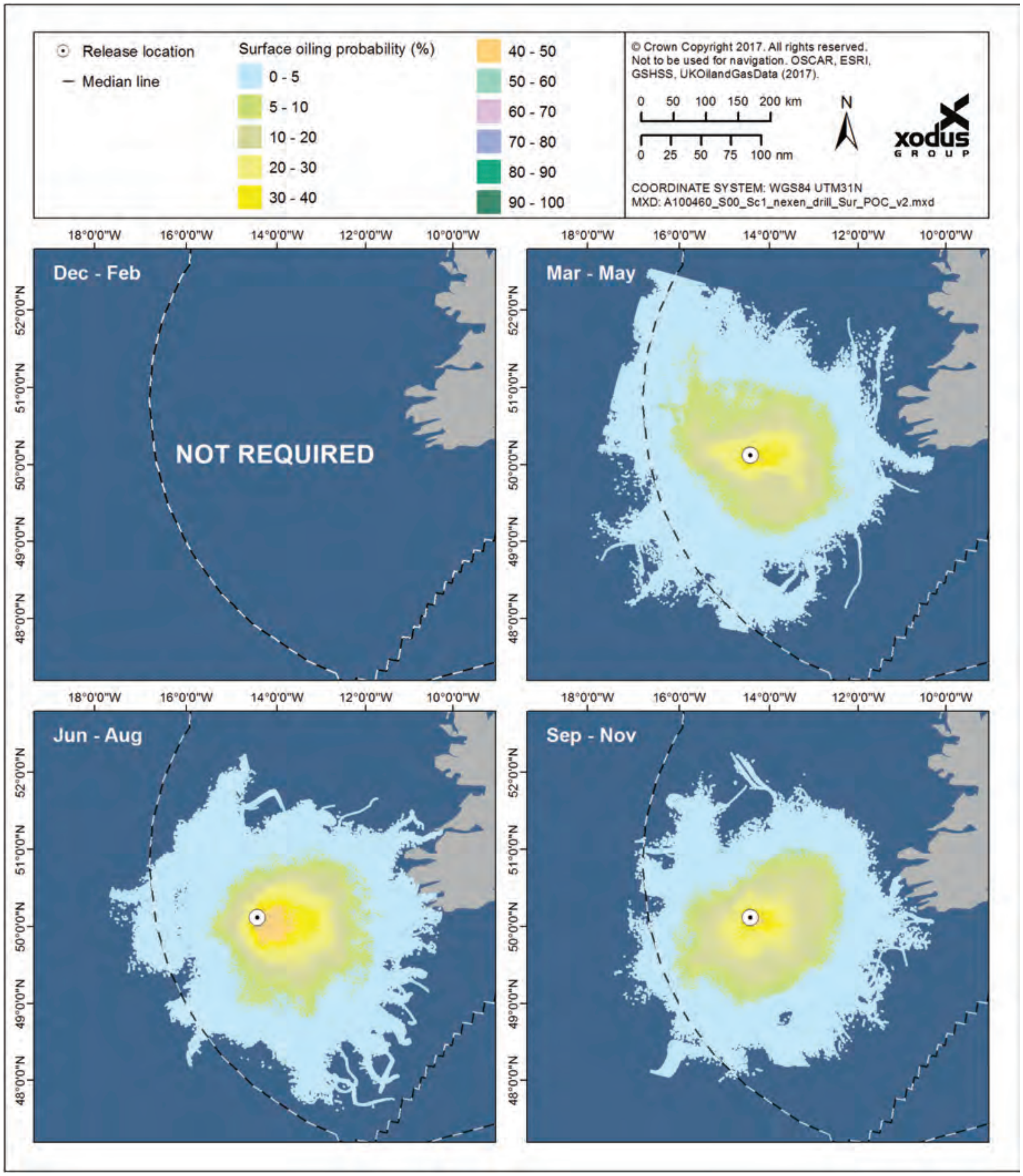


Figure 5.9 Scenario 1 – Maximum time averaged thickness surface oil thickness (above 0.3 µm threshold)

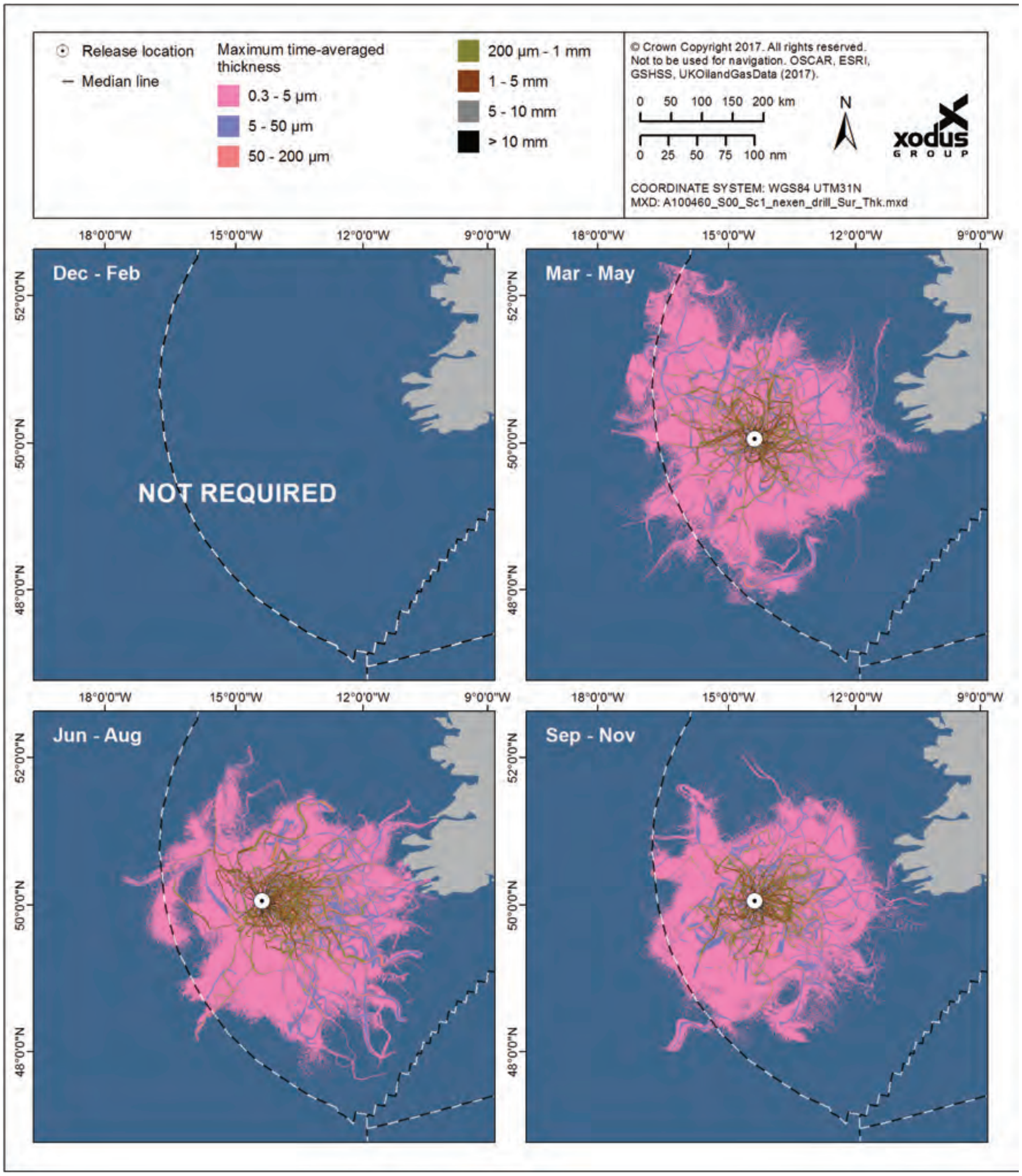


Figure 5.10 Scenario 1 – Minimum arrival time of surface oil (above 0.3 µm threshold)

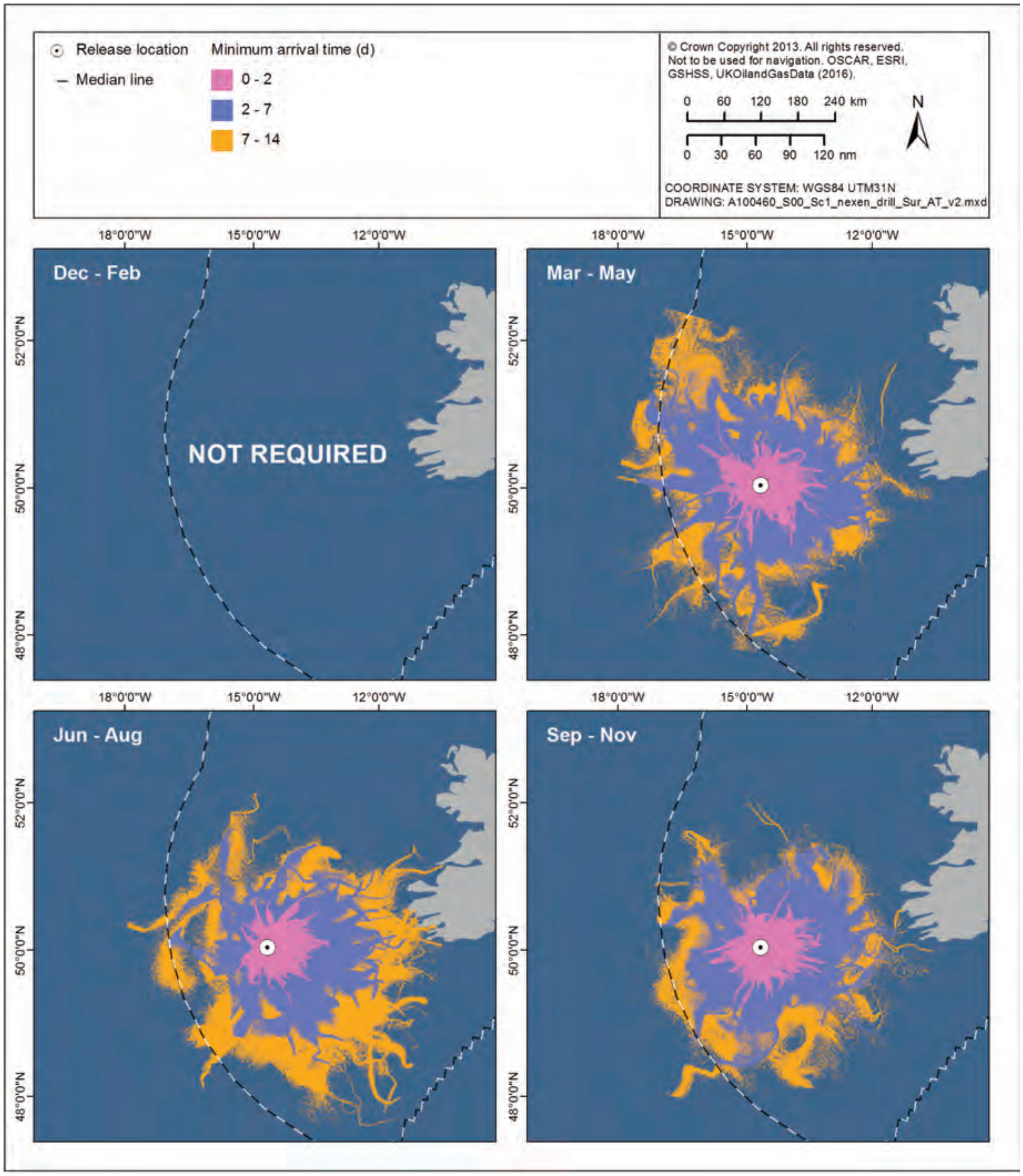


Figure 5.11 Scenario 1 – Probability of shoreline oiling

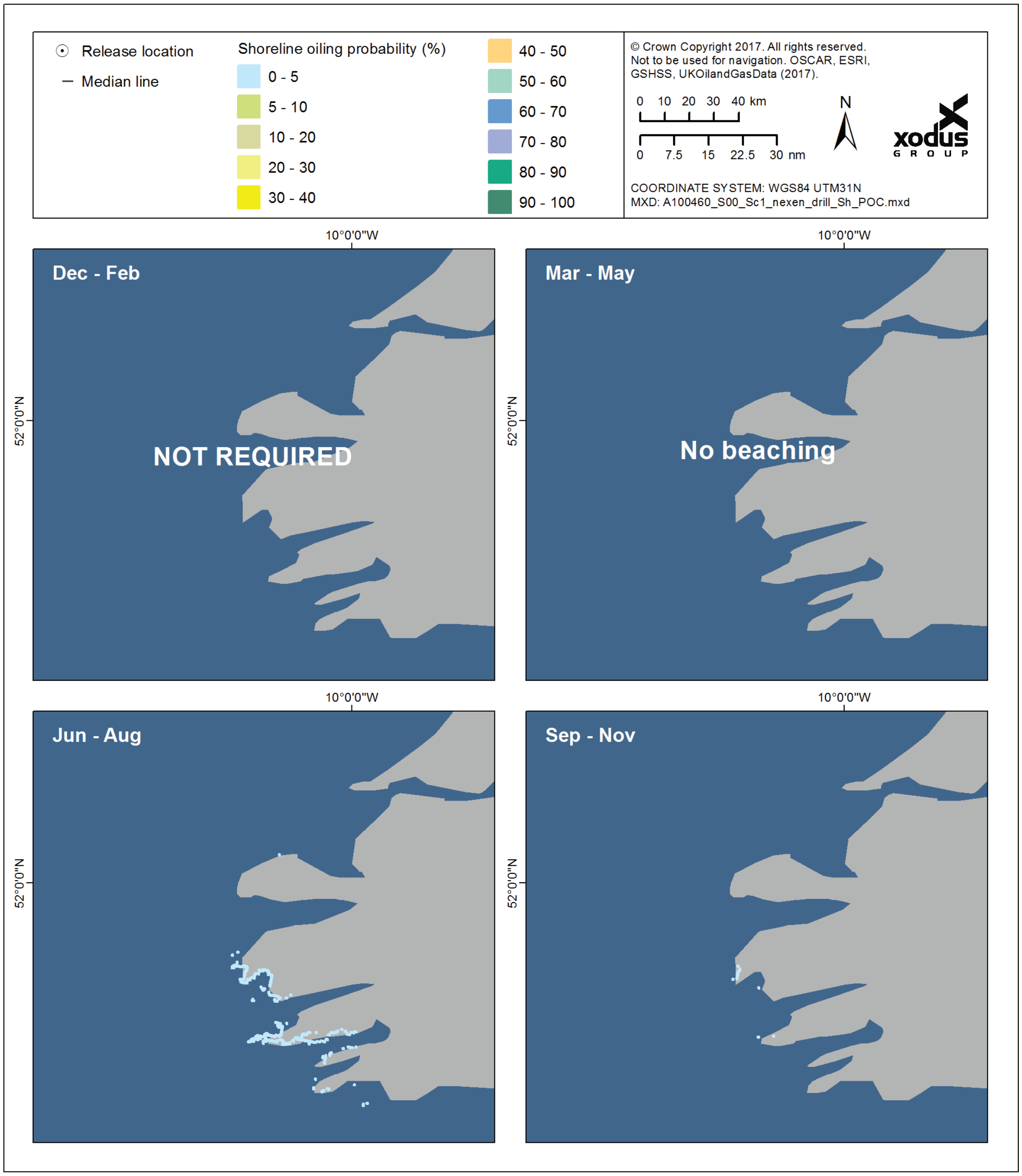
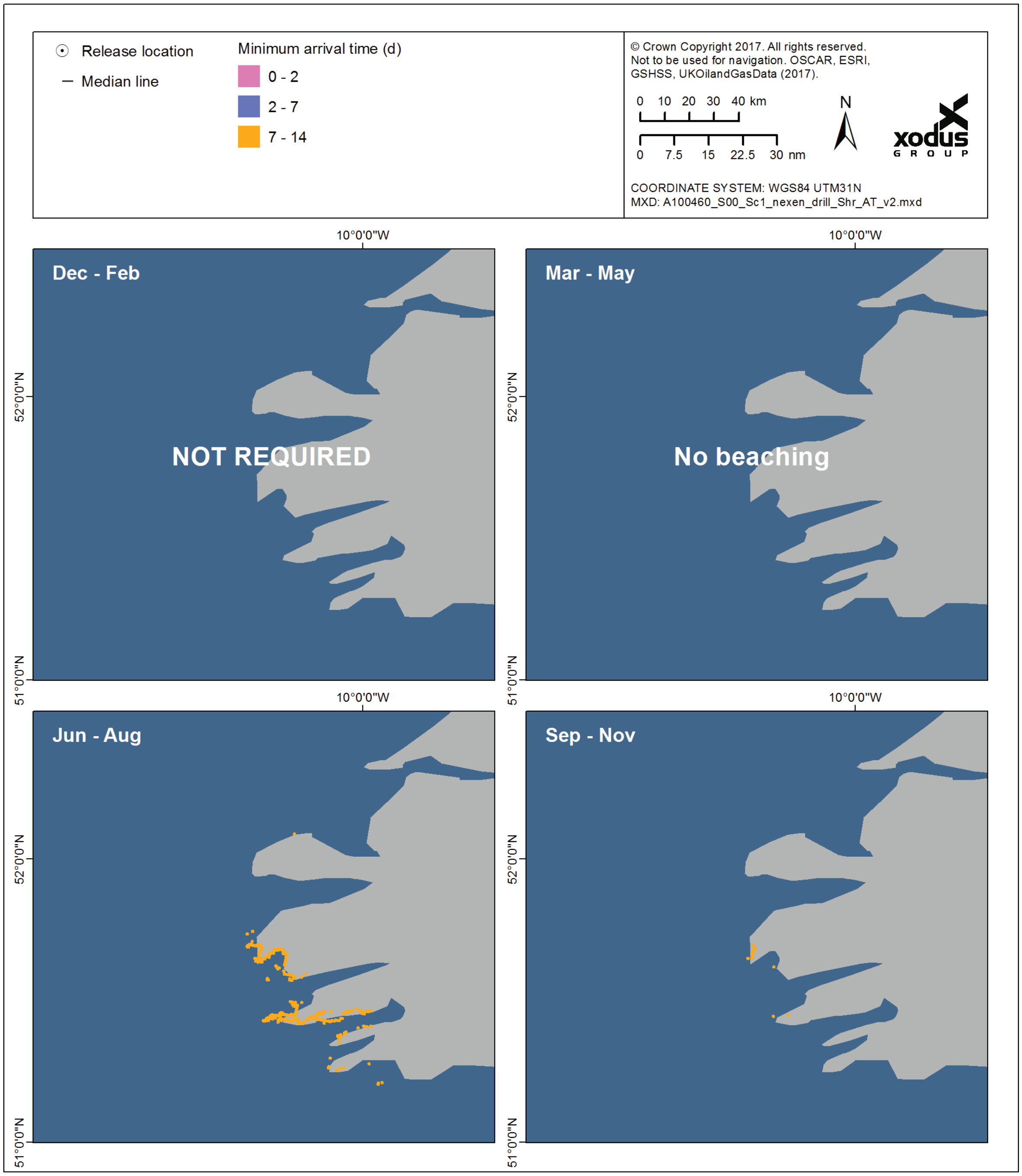


Figure 5.12 Scenario 1 – Minimum beaching time



5.5.4.1.2 Scenario 2 – Well blowout ceasing after 146 days

Modelling indicated that there is a high probability of sea surface oiling across a large proportion of Irish territorial waters to the West of Ireland, with the location of the highest probability areas varying by season (Figure 5.13). A surface oil sheen exceeding 5 µm thick could travel hundreds of kilometres from the release point, although it should be noted that the area of thick oil shown in Figure 5.14 represents over 100 individual spill simulations, and the area of thick oil produced by any single spill would be much smaller.

The minimum arrival time of surface oil presented in Figure 5.15 shows that oil could reach international waters after approximately six days, and UK waters after approximately 30 days, although reference to Figure 5.13 shows that the probability of oil reaching UK waters is <40%. Probability and time taken to cross transboundary lines is summarised by season in Table 5.19 where probability is ≥1%.

The probability of shoreline oiling is shown in Figure 5.16, and minimum arrival time to shore is shown in Figure 5.17. For locations where beaching probability is ≥1%, the maximum probability and minimum oil arrival time for each season is summarised in Table 5.20. The area with the highest probability of beaching and the fastest minimum beaching time is predicted to be the southwest coast of Ireland. Probability of oil beaching in all other national jurisdictions is generally <5%, with the exception of the autumn season where there is a maximum 7.1% probability of oil beaching in Argyll and Bute.

Table 5.19 Scenario 2 - Probability and time taken to cross transboundary lines by season

Median line(s) crossed	Location	Minimum crossing time	Maximum probability of crossing (%)
Winter	International Waters	7 d 3 h	100 %
	UK	41 d 22 h	37.5 %
	Faroe Islands	126 d 5 h	1.9 %
Spring	International Waters	6 d 16 h	100 %
	UK	56 d 12 h	39.4 %
	Faroe Islands	161 d 16 h	1 %
Summer	International Waters	8 d 9 h	100 %
	UK	30 d 12 h	24.8 %
	Faroe Islands	171 d 19 h	1 %
	France	40 d 6 h	1 %
Autumn	International Waters	6 d 22 h	100 %
	UK	73 d 9 h	38.5 %
	Faroe Islands	122 d 17 h	3.8 %
	Iceland	175 d 18 h	1 %

Table 5.20 Scenario 2 - Probability and time taken to beach

Location		Winter	Spring	Summer	Autumn
Ireland (numerous locations with highest probabilities in the southwest)	Maximum probability of contamination (%)	64.4 %	98.1 %	87.1 %	72.1 %
	Minimum arrival time	23 d 10 h	31 d 12 h	18 d 3 h	23 d
UK (Northern Ireland)	Maximum probability of contamination (%)	1.9 %	1 %	1 %	1.9 %
	Minimum arrival time	124 d 9 h	139 d 4 h	143 d 22 h	135 d
UK (southwest England)	Maximum probability of contamination (%)	1 %	1 %	2 %	1 %
	Minimum arrival time	144 d 7 h	122 d 8 h	87 d 21 h	173 d 10 h
UK (northwest, southwest and south Wales)	Maximum probability of contamination (%)	0 %	1 %	2 %	0 %
	Minimum arrival time	Does not beach	141 d 19 h	18 d 3 h	Does not beach
UK (northwest to southwest Scotland)	Maximum probability of contamination (%)	3.8%	1%	1%	7.1%
	Minimum arrival time	97 d 23 h	134 d 20 h	139 d 23 h	98 d 10 h

Location	Winter	Spring	Summer	Autumn
Protected areas with beaching oil probability >40%	Blasket Island SAC & SPA, Three Castle Head to Mizen Head SAC, Sheep's Head SAC & SPA, Kenmare River SAC, Valencia Harbour/Portmagee Channel SAC, Roaringwater Bay and Island SAC, Iveragh Peninsula SPA, Beara Peninsula SPA, Dingle Peninsula SPA, Puffin Island SPA	Blasket Island SAC, Lower River Shannon SAC, Mount Brandon SAC, Three Castle Head to Mizen Head SAC, Sheep's Head SAC & SPA, Roaringwater Bay and Island SAC, Barley Cove to Ballyrisode Point SAC, Kenmare River SAC, Valencia Harbour/Portmagee Channel SAC, Iveragh Peninsula SPA, Beara Peninsula SPA, Dingle Peninsula SPA, Puffin Island SPA, Deenish Island and Scariff Island SPA, Loop Head SPA	Blasket Island SAC, Ballinskelligs Bay and Inny Estuary SAC, Killarney National Park, Macgllycuddy's Reeks and Caragh River Catchment SAC, Lower River Shannon SAC, Mount Brandon SAC, Barley Cove to Ballyrisode Point SAC, Kenmare River SAC, Valencia Harbour/Portmagee Channel SAC, Iveragh Peninsula SPA, Beara Peninsula SPA, Dingle Peninsula SPA, Puffin Island SPA, Deenish Island and Scariff Island SPA, Loop Head SPA, Kerry Head Shoal SAC	Blasket Island SAC, Three Castle Head to Mizen Head SAC, Sheep's Head SAC & SPA, Roaringwater Bay and Island SAC, Kenmare River SAC, Valencia Harbour/Portmagee Channel SAC, Iveragh Peninsula SPA, Beara Peninsula SPA, Dingle Peninsula SPA, Puffin Island SPA, Deenish Island and Scariff Island SPA
Maximum mass of beached oil in any single run (te)	23,400	4,230	3,380	21,200
Maximum mass of beached emulsion in any single run (te)	92,300	16,300	13,600	82,200
Maximum volume of beached emulsion in any single run (m^3)	94,300	16,700	13,800	84,100

Figure 5.13 Scenario 2 – Probability of sea surface oiling (above 0.3 µm threshold)

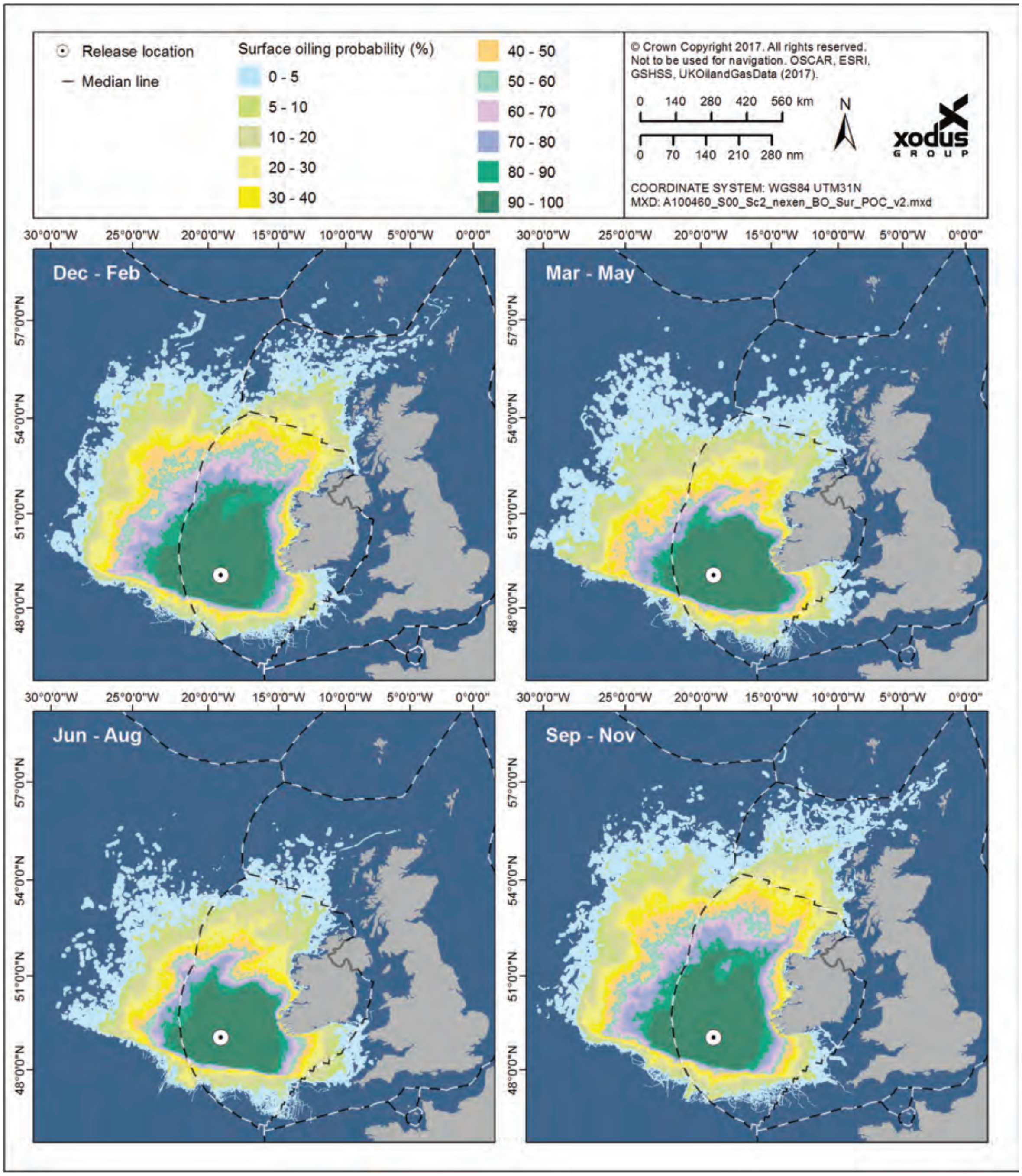


Figure 5.14 Scenario 2 – Maximum time averaged thickness surface oil thickness (above 0.3 µm threshold)

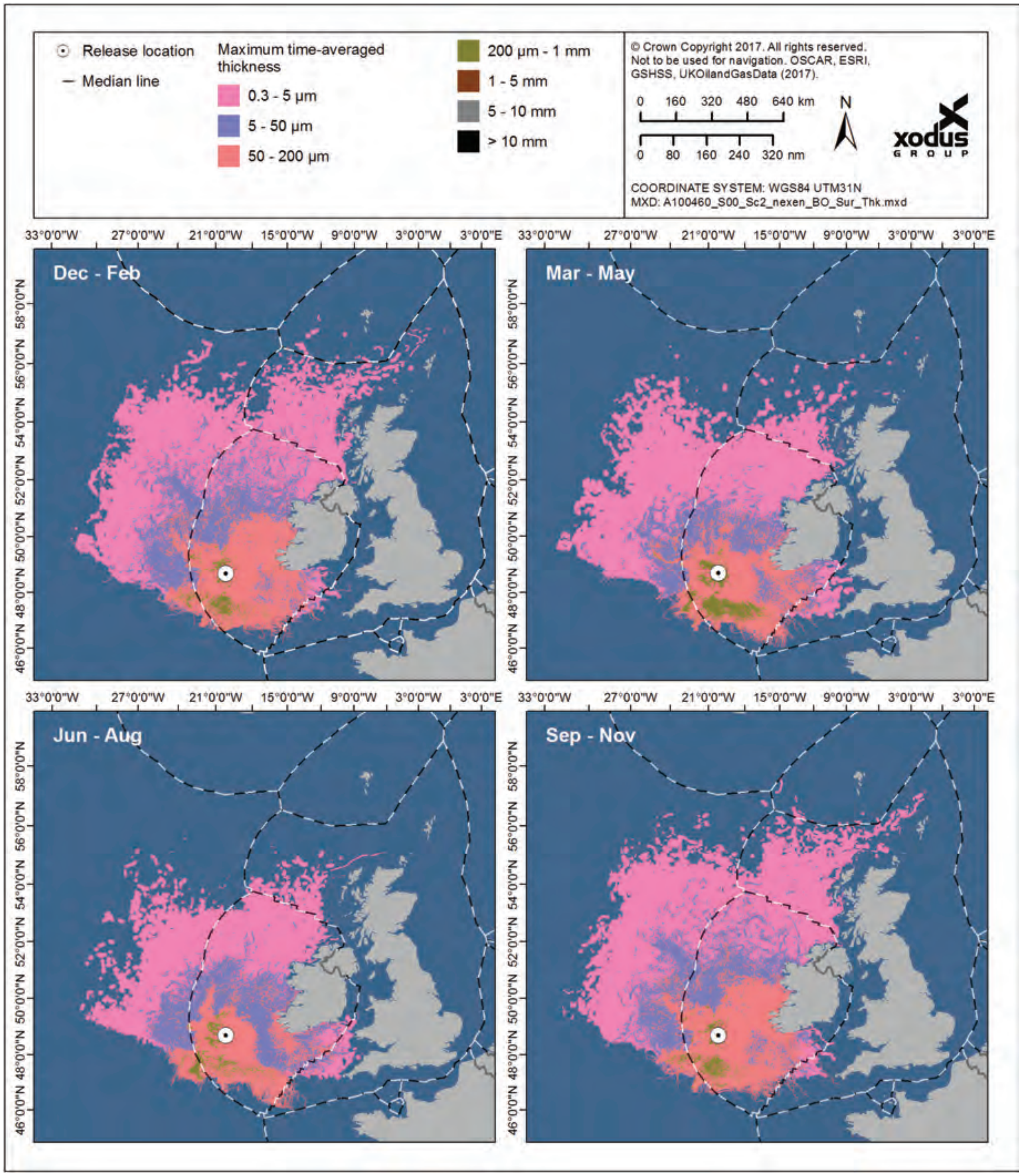


Figure 5.15 Scenario 2 – Minimum arrival time of surface oil (above 0.3 µm threshold)

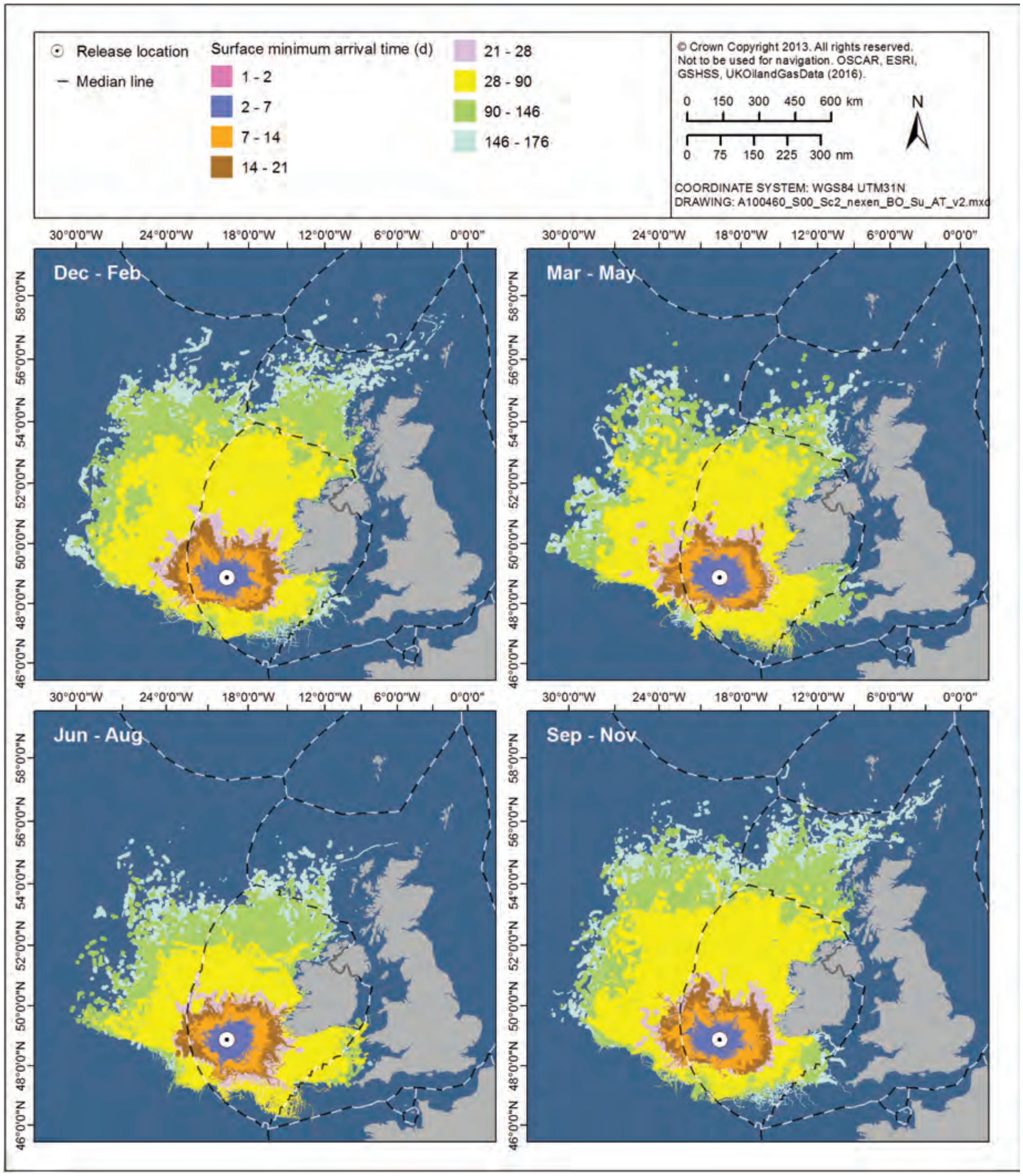


Figure 5.16 Scenario 2 – Probability of shoreline oiling

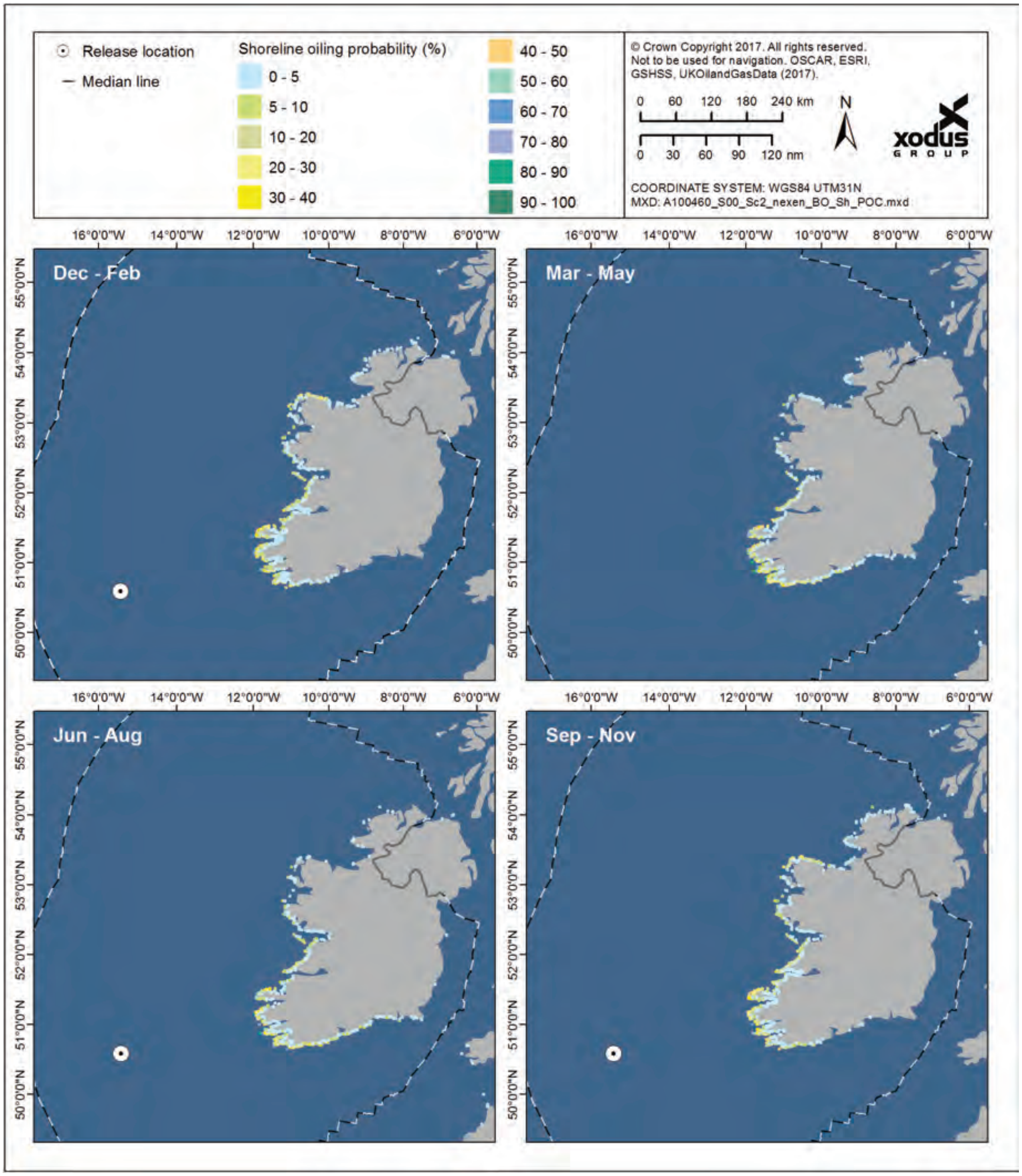
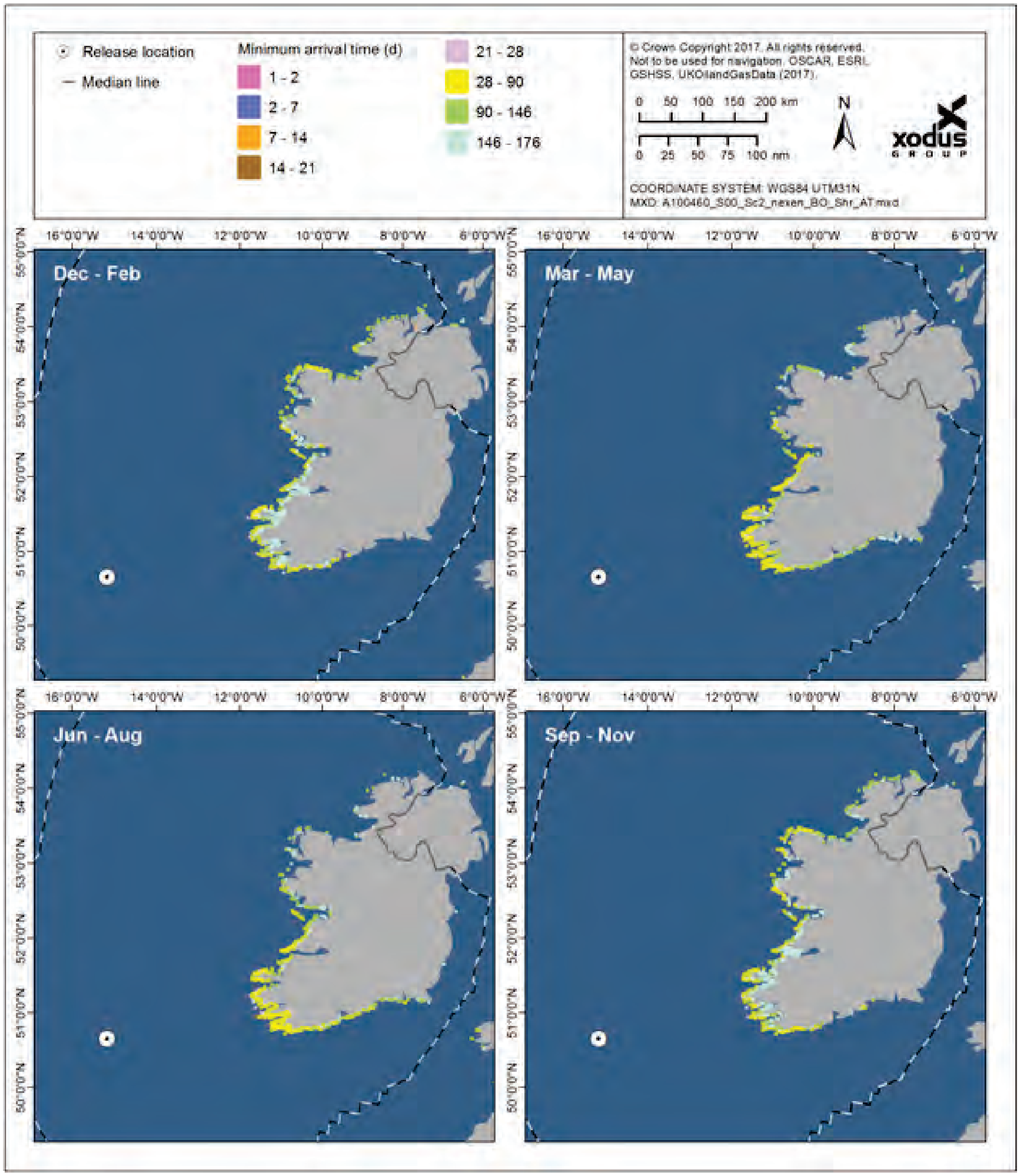


Figure 5.17 Scenario 2 – Minimum beaching time



5.5.4.1.3 Scenario 3 – Well blowout ceasing after 35 days

Modelling indicated that there is a high probability of sea surface oiling across a large area of sea to the west of southern Ireland, with the location of the highest probability areas varying by season (Figure 5.18). A surface oil sheen exceeding 5 μm thick could travel hundreds of kilometres from the release point, although it should be noted that the area of thick oil shown in Figure 5.19 represents over 100 individual spill simulations, and the area of thick oil produced by any single spill would be much smaller.

The minimum arrival time of surface oil presented in Figure 5.20 shows that oil could reach international waters after approximately six days, and UK waters after approximately 30 days (in the summer simulations), although reference to Figure 5.18 shows that the probability of oil reaching UK waters is <5%. Probability and time taken to cross transboundary lines is summarised by season in Table 5.21.

The probability of shoreline oiling is shown in Figure 5.21, and minimum arrival time to shore is shown in Figure 5.22. For locations where beaching probability is ≥1%, the maximum probability and minimum oil arrival time for each season is summarised in Table 5.22. Beaching was only predicted to occur in Ireland, with the highest probabilities and fastest minimum arrival times occurring on the southwest coast. Probability of beaching only exceeded 25% in the summer simulations.

Table 5.21 Scenario 3 - Probability and time taken to cross transboundary lines by season

Season	Location	Minimum crossing time	Maximum probability of crossing (%)
Winter	UK	Does not cross	0 %
	International waters	6 d 4 h	78.8 %
Spring	UK	49 d 19 h	1.9 %
	International waters	7 d 0 h	83.7 %
Summer	UK	29 d 0 h	4.8 %
	International waters	7 d 18 h	48.1 %
Autumn	UK	Does not cross	0 %
	International waters	7 d 7 h	78.8 %

Table 5.22 Scenario 3 - Probability and time taken to beach

Location		Winter	Spring	Summer	Autumn
Ireland (predominantly the southwest)	Maximum probability of contamination (%)	21.2 %	20.2 %	51.9 %	25 %
	Minimum arrival time	21 d 0 h	23 d 2 h	16 d 15 h	20 d 12 h
Protected areas with beaching oil probability >40%		None	None	Three Castle Head to Mizen Head SAC, Sheep's Head SAC & SPA, Kenmare River SAC, Valencia Harbour/Portmagee Channgel SAC, Iveragh Peninsula SPA, Beara Peninsula SPA, Deenish Island and Scariff Island SPA	None
Maximum mass of beached oil in any single run (te)		1,062	2,850	2,760	1,270
Maximum mass of beached emulsion in any single run (te)		3,850	11,500	10,400	4,710
Maximum volume of beached emulsion in any single run (m^3)		3,950	11,700	10,700	4,830

Figure 5.18 Scenario 3 – Probability of sea surface oiling (above 0.3 µm threshold)

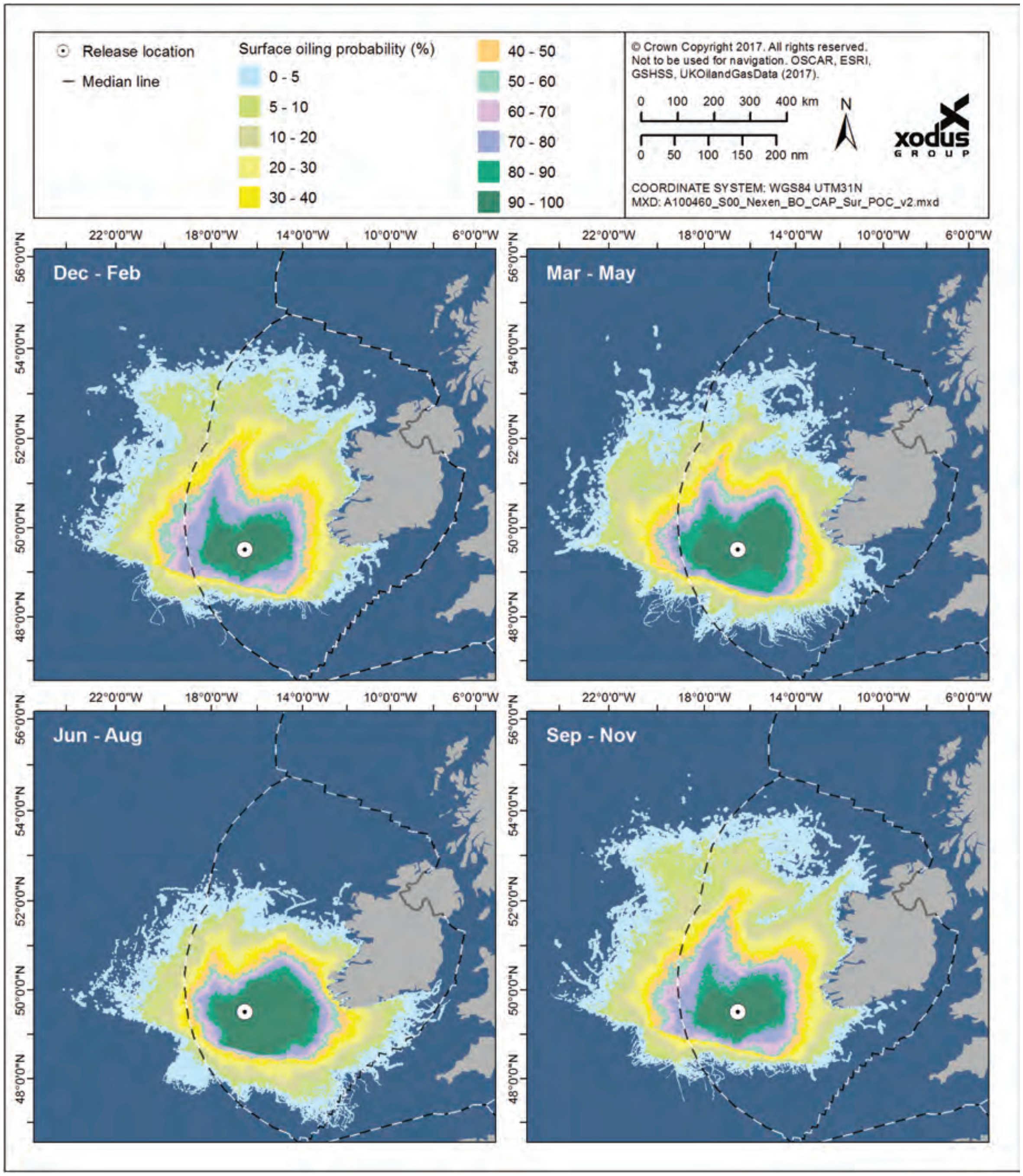


Figure 5.19 Scenario 3 – Maximum time averaged thickness surface oil thickness (above 0.3 µm threshold)

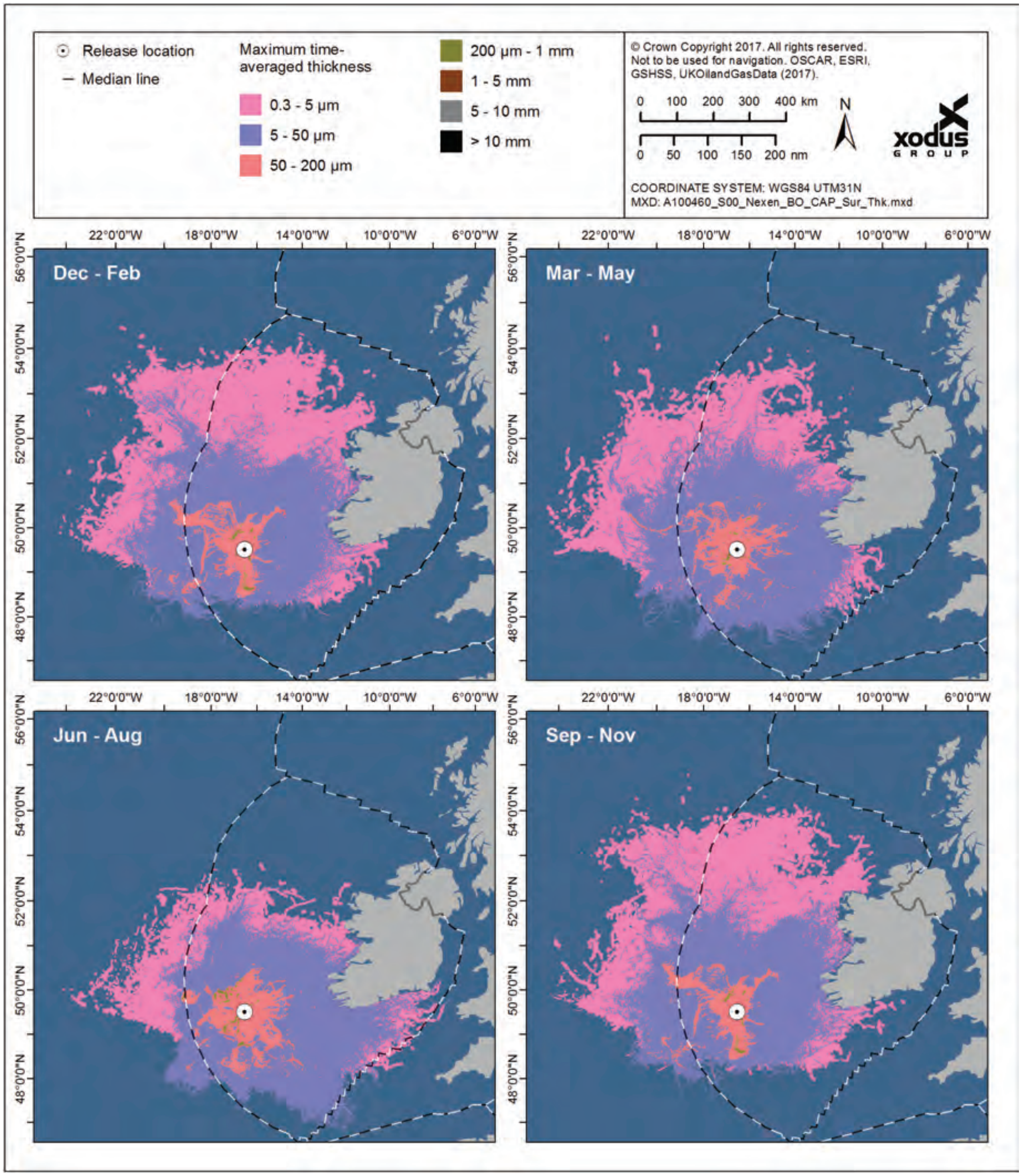


Figure 5.20 Scenario 3 – Minimum arrival time of surface oil (above 0.3 µm threshold)

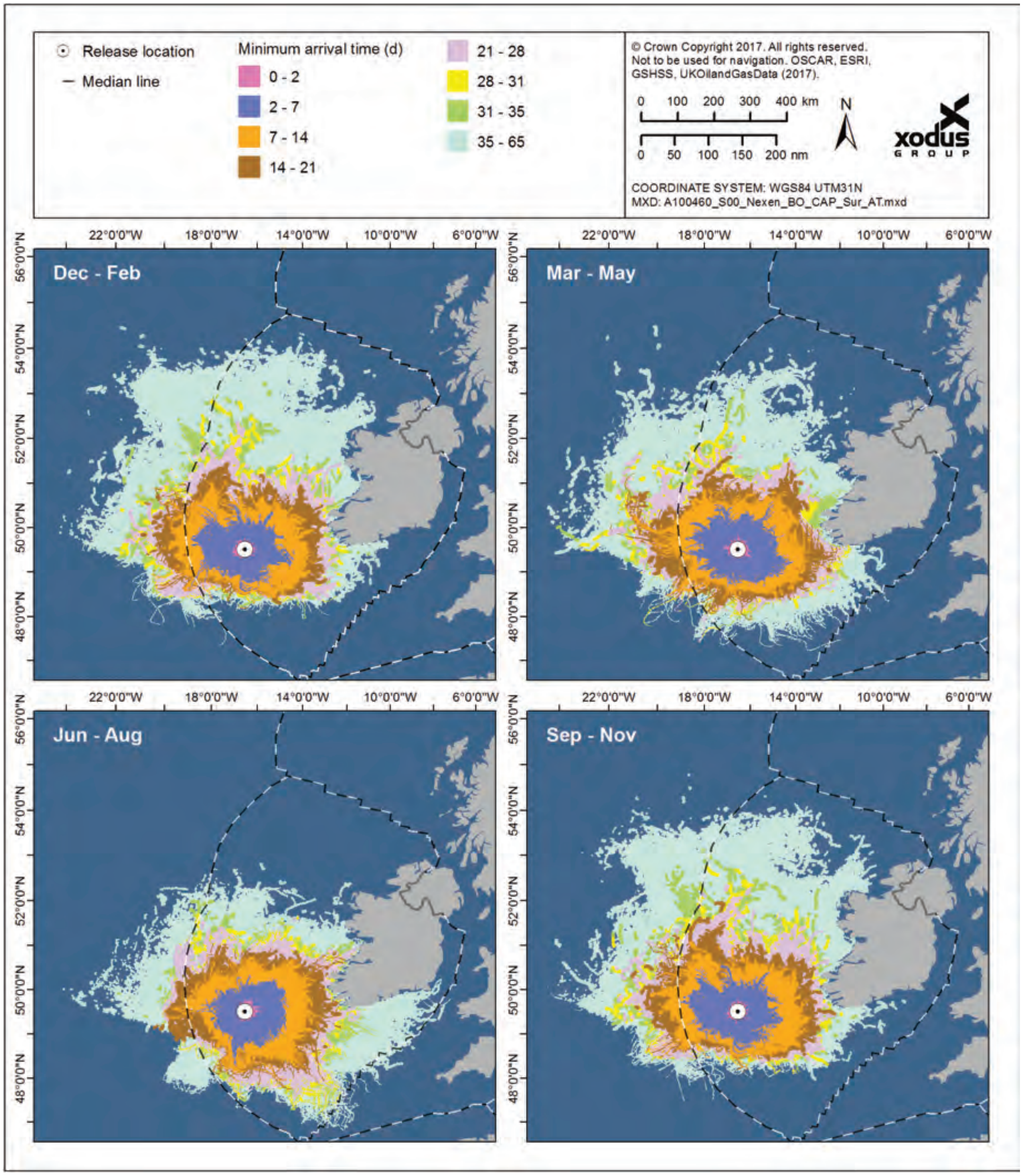


Figure 5.21 Scenario 3 – Probability of shoreline oiling

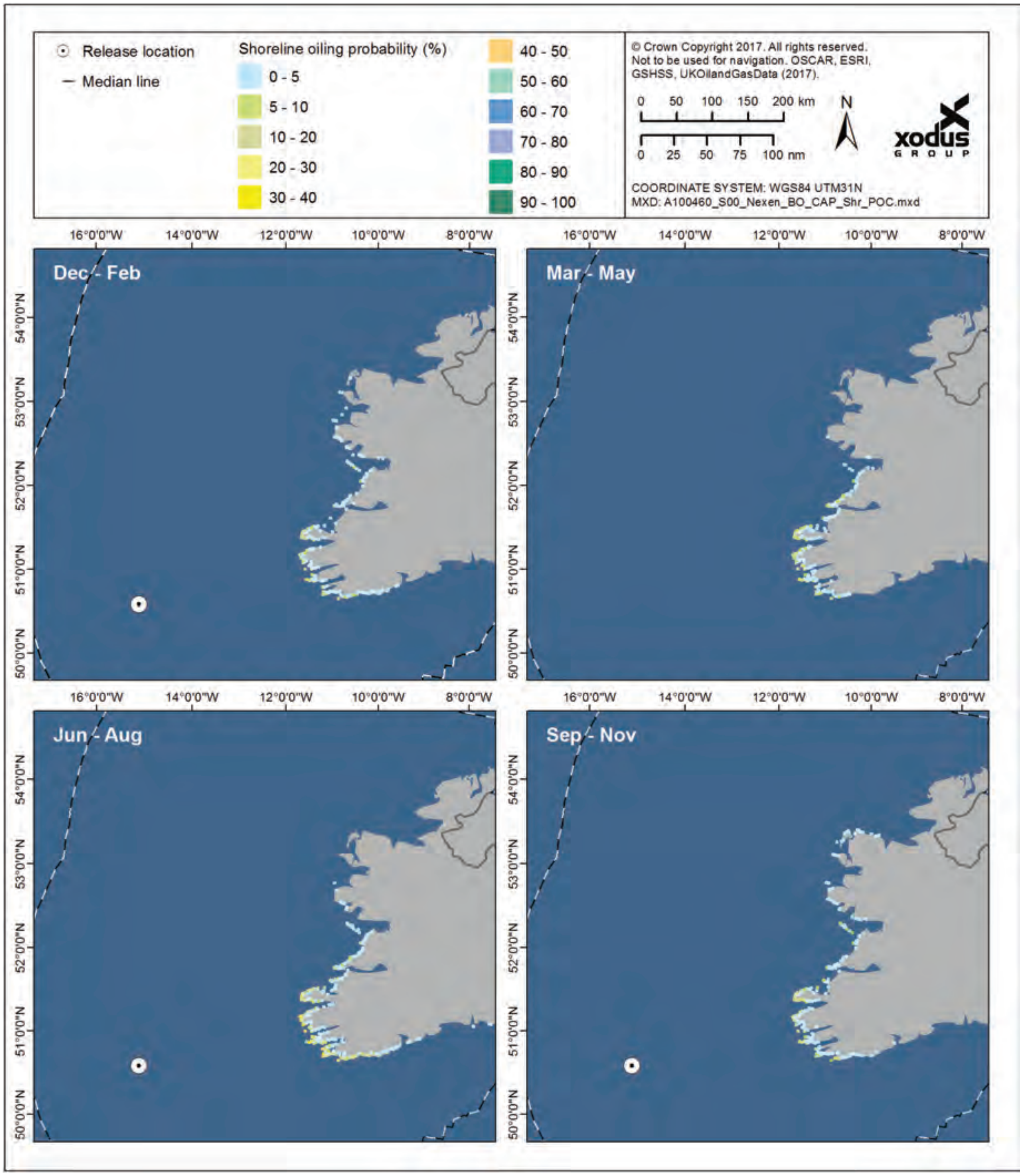
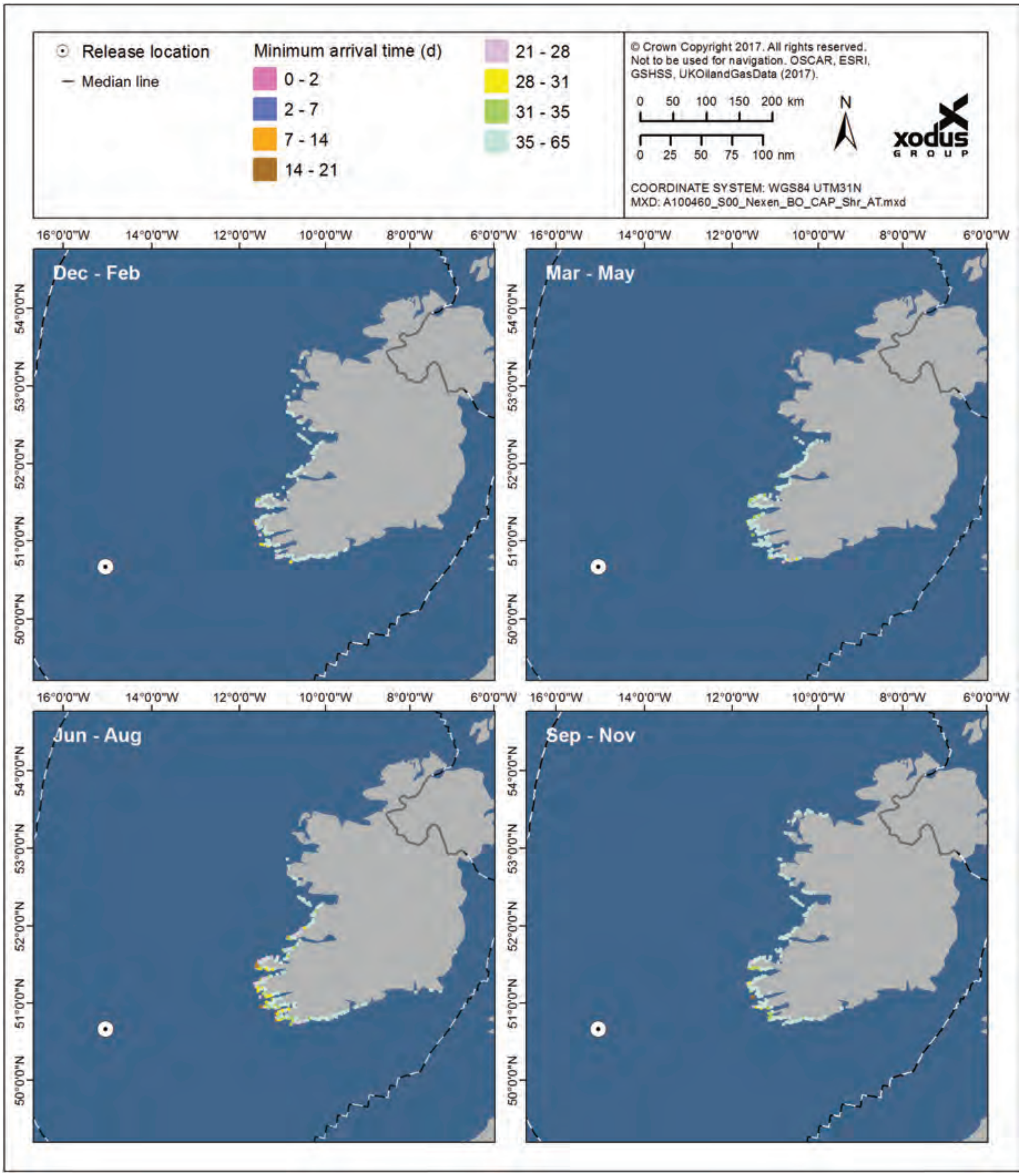


Figure 5.22 Scenario 3 – Minimum beaching time



5.5.4.2 Environmental sensitivity to spills

Environmental sensitivity to spills is a function of both the likelihood of impact from a spill (as considered in previous sections) and the sensitivity of the environment. Offshore and coastal sensitivities need to be considered separately as different parameters will apply.

There may be impacts on plankton in the immediate area of the release for the duration of the release due to the dissolution of aromatic fractions into the water column. Such effects will be greater during a period of plankton bloom and during fish spawning periods. However, acute toxic effects are not likely to be measurable in the medium to long-term following cessation of the hydrocarbon release. Once a release has cleared, plankton are usually quickly replaced by advection from adjacent areas. The plankton community is generally less vulnerable to one-off incidents, such as crude oil or marine gas releases, than to continuous releases. This is due to the high reproductive and growth rates of planktonic species and those with planktonic larval stages which counter the high mortality prevalent during normal conditions. This is complemented by inward advection of individuals from surrounding waters (North Sea Task Force, 1993). Contamination of plankton may lead to aromatic hydrocarbons accumulating in the food chain. These could have long-term chronic effects such as reduced fecundity and breeding failure on fish, bird and cetacean populations.

Following an accidental release event, hydrocarbons can come into contact with benthic organisms via several pathways, including sedimentation of dispersed oil, dissolution in the water column and bio-deposition, where pelagic organisms that are contaminated with hydrocarbons die and fall to the seabed as marine snow. Application of dispersant may cause hydrocarbons to disperse into bottom-water currents, which can then bring the hydrocarbons into contact with the benthos where seabed topography rises into the path of the currents. Following the *Deepwater Horizon* spill, elevated sediment toxicity was identified up to approximately 25 km from the release site. Impacts on benthic faunal diversity were detectable above natural variation up to 15 km from the release site. Impacts were identified across soft- and hard-bottom communities including cold-water coral assemblages. Partial recovery of some receptors was recorded four years after the release, with populations of affected species beginning to increase, and tissue contamination beginning to reduce, however recovery of long-lived species assemblage such as cold-water corals is expected to take much longer (DHNRDAT, 2016).

Adult fish are not generally affected by hydrocarbon slicks on the sea surface, and mature fish of most species can tolerate water-soluble oil fraction concentrations of about 10 mg/l. Some species can survive much higher concentrations unless whole hydrocarbons or dispersed hydrocarbon droplets coat the gills and cause asphyxiation. Adult teleost (bony) fish are generally more resistant than other marine organisms to hydrocarbons, because their surfaces are coated with hydrocarbon-repellent mucus. Adult fish can be affected through the gills, by ingestion, or by eating contaminated prey (JNCC, 1999). Although various development disorders as well as mortalities may occur to some degree under hydrocarbon slicks, and studies have repeatedly showed negative effects on adult individuals, research to date has generally failed to detect consequential effects on adult populations (Fodrie, *et al*., 2014). Potential sub-lethal effects of hydrocarbons on fish include impairment of reproductive processes and increased susceptibility to disease and predators. Egg and juvenile stages are the most vulnerable to hydrocarbons. Consequently, it is the spawning and nursery grounds that are most sensitive. Section 3.3.3 describes the numerous and diverse fish species present in the potential impact area, and the species expected to spawn on the continental shelf and slope.

As described in Section 3.3.4, there are numerous seabird species that utilise FEL 3/18 during the year. Seabirds are not normally affected by routine offshore oil and gas operations. However, in the unlikely event of an oil spill, birds are vulnerable to oiling from surface pollution, which could cause direct toxicity through ingestion, and hypothermia as a result of the bird's inability to waterproof their feathers. The magnitude of any impact will depend on the number of birds present, the percentage of the population present, their vulnerability to spilled hydrocarbons and their recovery rates from oil pollution. Birds are most vulnerable in the moulting season when they become flightless and spend a large amount of time on the water surface.

Some species are more vulnerable than others due to differences in seasonal distribution and behaviour, e.g., birds which spend more time on the water surface are more vulnerable than those that spend more time airborne. The potential vulnerability of each group encountered in the area is discussed below. All data in this discussion is taken from DCENR (2015).

Fulmars are considered very vulnerable to oil pollution because they spend more time on the water surface than any of the other species listed here. Gannets are similarly vulnerable for the same reasons, with the additional concern that approximately 70% of the world population breeds in Britain and Ireland at relatively few colonies, meaning a spill close to a colony could have global population level impacts. Manx shearwaters are also very vulnerable; whilst predominantly aerial and highly mobile, they have a tendency to aggregate in large groups on the sea surface at feeding and breeding areas, and they are also subsurface feeders. This means they will have a high probability of coming into contact with polluted water, and if a large group is contaminated it could have population level impacts, especially as 94% of the world's population breeds in British and Irish waters. Conversely, great, Cory's and sooty shearwaters are considered not to be vulnerable to oil pollution in FEL 3/18 because they are highly aerial species that only occur at low densities in the area.

Great skuas are considered vulnerable because they occur in high densities on the Porcupine Bank and spend more time on the water surface than Arctic, Pomarine and long-tailed skuas, which have more aerial habits and do not occur in high densities and are therefore considered not very vulnerable.

Of the gull species expected in the area, Sabine's gulls are highly dispersed, and lesser black-backed and herring gulls are widely dispersed with high global populations, therefore none of the species are considered vulnerable. Great black-backed gulls are not considered to be directly vulnerable due to their aerial habit and wide distribution; however, as prolific scavengers they may be affected by changes in fishing vessel activity following a spill. Kittiwakes are the most vulnerable gull species in the area because they spend more time on the water surface.

Common and Arctic terns are highly aerial and not found in high densities in offshore waters, therefore foraging birds are not considered vulnerable. They would, however, be highly vulnerable to an oil spill reaching the coast and contaminating breeding and feeding grounds.

Auks are some of the most numerous marine birds, living mostly at sea and going to land to breed. They are relatively poor fliers and spend most of their time on the sea surface, often in large groups. They are therefore extremely vulnerable to oil pollution. Atlantic puffins have the most oceanic habit, with common guillemot and razorbill mostly remaining in shelf and coastal waters. When oil pollution events occur, guillemots and razorbills are the most common species to wash ashore dead.

Cetaceans are also present in the vicinity of the Project (see Section 3.3.5.1). In the event of a spill, the amount of hydrocarbon ingested or aspirated which is likely to cause harm will depend on the species and their feeding strategy, the overall health of individuals before ingestion or exposure, and the characteristics of the hydrocarbons. It is thought unlikely that a population of cetaceans in the open sea would be affected by a spill in the long-term (St Aubin, 1990). Baleen whales are particularly vulnerable whilst feeding, as oil may stick to the baleen if the whales "filter feed" near surface slicks. Cetaceans are pelagic (move freely in the oceans) and migrate. Their strong attraction to specific areas for breeding or feeding may override any tendency for cetaceans to avoid the noxious presence of hydrocarbons. However, data on the effects of spills on cetaceans are limited and determining a causal relationship between exposure and detrimental effects on cetaceans is difficult.

Marine reptiles may be directly impacted by oil pollution through similar mechanisms to cetaceans. Individuals could be contaminated while surfacing to breath, resulting in skin and eye irritation and possible damage to the respiratory system through inflammation and infection. Ingestion of contaminated prey may result in poisoning. Marine turtles may also be indirectly impacted through disruption of their food supply.

A major release could also have an impact on the fishing industry, should certain areas be closed to fishing or fish catches require to be destroyed due to taint. Section 3.5.1 demonstrates that the Project location is in an area of very low fishing activity, although a large spill could impact adjacent and coastal fisheries.

The likelihood of a hydrocarbon spill impacting the coastal environment is a function of the likelihood of a hydrocarbon spill occurring and the probability of the spilled hydrocarbons beaching. The degree of impact will depend on the volume of hydrocarbon beaching, the composition of the beached hydrocarbons, the type of beach (as detailed below) and the receptors present. Coastal receptors would include nearshore and breeding seabird populations, shore birds, marine mammals including cetaceans, pinnipeds and otters, and sublittoral and coastal habitats including SACs and SPAs (see Section 3.4).

Intertidal areas of the coast show varying degrees of sensitivity to spills, the function of both actual effects on specific organisms and the physical fate of the release substances within the habitat concerned. For example, high energy rock, boulder or cliff coastlines are of low vulnerability to hydrocarbon pollution, while in contrast, sheltered, low energy shorelines are of moderate to high vulnerability. In general, the west coast of Ireland has cliff coastlines, although there are many low-energy environments (for example bays, loughs and saline lagoons) that occur in more sheltered areas.

5.5.5 Risk reduction

5.5.5.1 Prevention

Nexen is aware of the risk of a spill event occurring during the Project and the crew of the drill ship will therefore undergo environmental awareness and safety training. Incident response training will form part of the induction for any crew joining the drill ship or Project vessels. The drill ship will have a safety case and will be class certified by a recognised certifying authority.

The worst case credible accidental release scenario arises from loss of primary and secondary well control. The following provides a high level overview of design and operational measures that reduce the likelihood of a well control incident:

- A full risk assessment will be performed as part of well planning;
- Nexen Engineering Standards will be implemented;
- The well will be designed to NPUK well control standard ECN-DR-STD-00067;
- The well will be designed to be killable with the penetration test wellbore being abandoned as per industry practices with the hole filled with a kill weight mud at the seabed surface. Once confirmed that the well is static, the bottom hole assembly[19] shall be removed from the well hole.
- While drilling, the primary well control barrier in the main conduit (i.e. the annulus immediately around the drill pipe) will be the hydrostatic pressure imparted by correctly weighted drilling fluid and secondary well control measures will include the BOP and cut-off valves on all machinery, pipelines and hoses;
- Outside the main conduit, previous casings in the next annulus out also have barriers, i.e. seal assemblies in casing hangers, and cement isolation between reservoir and surface - there may be one or more cement seals set in each annulus;
- Well design, materials and drilling procedures will combine to ensure that the surface environment can be isolated from the wellbore by at least two independent barriers during all stages of well construction and abandonment;
- The BOP rated design pressure will comfortably exceed the anticipated reservoir pressures and the BOP will undergo maintenance and inspection prior to use;
- Barriers will be tested prior to use, during installation and post-installation;
- Shallow hazards (from shallow gas or over-pressured shallow formation water) have been assessed by seismic survey prior to drilling, and the results have been incorporated into the well design;
- The plug and abandonment plan will be reviewed and approved by Nexen;
- The crew of the drill ship will undergo environmental awareness and safety training;
- Incident response training will form part of the induction for any crew joining the drill ship or Project vessels; and
- The drill ship will have a safety case and will be class certified by a recognised certifying authority. The safety case documents the design criteria which are based on recent metocean data (see Section 2.4).

[19] The bottom hole assembly it is the lowest part of the drill string, extending from the bit to the drill pipe.

Two barriers shall be in place at all times during the entire well life cycle in order to prevent any unintentional flow from the well. However, for top hole operations prior to the BOP installation, only one barrier shall be in place. In the event that only one barrier is available following BOP installation, a full risk assessment shall be performed and a dispensation against the standard put in place

The highest likelihood of hydrocarbon spillage will occur during diesel bunkering operations from supply vessels to the drill ship. Bunkering operations will only take place during hours of good visibility, in appropriate weather conditions. Bunkering equipment will be undergo scheduled maintenance to prevent failures and will be visually inspected immediately prior to each operation. Transfer hoses will have flotation collars and dry-break couplings and will be over-rated for the expected pumping pressure. During operations, radio contact will be maintained between the supply vessel and the drill ship and dedicated lookouts will perform constant visual monitoring of gauges, hoses, fittings and the sea surface. The drill ship and supply vessels will be fitted with automatic cargo level monitoring systems. Spill response kits will be located close to hydrocarbon storage/bunkering areas and appropriately stocked.

The possibility of vessel collisions will be reduced by maintaining a 500 m safety exclusion zone around the drill ship while it is on location. Access inside the zone, for example for supply vessels, will be managed by the Offshore Installation Manager in adherence with standard maritime safety and navigation procedures. A guard vessel will be on station 24 hours a day. Nexen will ensure relevant stakeholders are consulted prior to the commencement of operations. Notice to mariners and notification of relevant authorities will be issued as required in the Rules and Procedures Manual for Offshore Petroleum Exploration and Appraisal Operations.

The risk from a chemical spillage will be reduced by:

> Selecting drilling fluid additives which achieve the lowest possible environmental impact;

> Selecting chemicals approved by both Nexen and the Irish regulations;

> Risk assessing each chemical during the preparation of the PUDAC; and

> Managing all chemicals in line with Nexen engineering and operating standards and procedures.

The likelihood of dropped object incidents will be reduced by:

> Preparation and implementation of procedures for supply transfer, manual handling, deployment and retrieval over marine equipment and over-side lifting.

5.5.5.2 Response measures

> An Oil Spill Contingency Plan (OSCP) for the Project has been prepared, in accordance with the Sea Pollution (Amendment) Act 1999The OSCP will be approved by the Irish Coast Guard prior to the commencement of the activity. The OSCP will contain effective response strategies to minimise the impact from any hydrocarbon spill.

> Shipboard Oil Pollution Emergency Plans (SOPEPs) will be in place for any vessels of greater that 400 gross tonnage used during the proposed operations in line with MARPOL 73/78 Annex I. This will include the IceMAX drill ship when it is sailing and not on location. Vessels will also hold International Oil Pollution Prevention Certificates and maintain Oil Record Books.

> Small level 1 spills, which disperse quickly, and pose little threat to environmental sensitivities will generally be controlled by onsite resources. Level 2 or 3 spills with the potential to impact the surrounding environment will be managed by an onshore Nexen Incident Management Team (IMT). Detailed response arrangements for all levels of spill will be included in the OSCP.

5.5.6 Residual impacts

5.5.6.1 Hydrocarbon release

The most likely spill risk is associated with hose failure during a bunkering operation. These spills are expected to be small in volume and procedures will be in place to reduce the risk of spillage, in particular written procedures, regular inspection of equipment and provision of spill kits. Given the potential impact being limited from a release of hydrocarbons from a bunkering operation due to the small volumes involved, the consequence is ranked as '**moderate**' due to the possible breach of regulatory consent limits from the discharge of hydrobcarbons. Small spills from decks and bunkering operations are more common in the industry when compared to the likelihood of a blowout event; for this reason the likelihood of a spill during bunkering is ranked as '**unlikely**'. Combining the consequence and likelihood scoring results in an impact significance level of '**minor**' and is therefore considered '**not significant**'.

Another potential scenario that would lead to diesel release is the total loss of the drill ship diesel fuel inventory following a vessel collision. The potential impact of such an event would likely be '**moderate**' due to the potential impact on local seabird populations. The main causes of in-field vessel collision are human error and mechanical failure e.g., engine control and electrical failure of vessel control systems, with a small proportion of events attributed to bad weather. Collisions with sufficient energy to cause a hull breach are expected to be '**remote**'. Combining the consequence and likelihood scoring results in an impact significance level of '**minor**' and is therefore considered '**not significant**'.

A 145 day blowout event would result in a wide area of sea surface oiling and could potentially reach the coastline as shown by the oil spill modelling results. The consequences of a prolonged blowout will vary depending on factors such as wind speed and direction and sea state, however, regardless of these factors there are likely to be population-level impacts on several bird species, and there is a high likelihood that other sensitive coastal receptors will also be impacted on a regional scale, with recovery being long-term or even non-existent for some receptors, for example seabird populations that are already stressed due to loss of habitat or prey availability.

Given the potential for widespread impact from a worst-case release of hydrocarbons, the residual consequence is ranked as '**severe'**. However, as discussed in Section 5.5.2.2, blowout events of such magnitude are extremely uncommon and the likelihood of a blowout is considered '**remote**'. Combining the consequence and likelihood scoring results in an impact significance level of '**moderate**' and is therefore considered '**not significant**'. Regardless of this ranking, prevention of well control incidents is a primary concern for Nexen, and rigorous prevention and mitigation measures will be planned and implemented as summarised in Section 5.5.5.

5.5.6.2 Chemical release

In addition to the hydrocarbon spill risk, there is also the risk of a chemical release during drilling activities. Chemical releases may occur during chemical transfer, chemical/mud handling, or through mechanical failure.

The fate of any chemical entering the water column is dependent upon how the physicochemical properties of the chemical influence its partitioning between environmental media and its susceptibility to degradation (DTI, 2001). Given the high energy marine environment of the wider area, chemical spills are expected to disperse rapidly in the offshore marine environment, and it is not expected that there will be any measurable negative effects on any of the receptors in the area.

Given the lack of measurable impacts from a worst-case release of chemicals, the residual consequence is ranked as '**negligible**'. Chemical spills do occur in the industry and the likelihood of a chemical release is ranked as '**possible**'. Combining the consequence and likelihood scoring results in a resultant impact significance level of '**negligible**' and is therefore considered '**not significant**'. Nexen will endeavour to reduce the likelihood of chemical releases by implementing the prevention and mitigation measures summarised in Section 5.5.5.

5.6 Cumulative Impacts

In accordance with the EIA Directive (2011/92/EU) as amended by Directive (2014/52/EU) and Habitats Directive (92/43/EEC), companies must consider the impact that proposed plans and projects could have on the receiving environment in combination with other plans and projects in the area.

There are currently no existing projects in the Porcupine Basin nor are there any approved projects in the Porcupine Basin area for 2019.

During 2016 the DCCAE awarded several Licensing Options in the Porcupine Basin in the Phase 1 and 2 Awards from the 2015 Atlantic Margin Licensing Round. There are also a number of active Frontier Exploration

Licences (FELs) from the 2011 licensing round which have entered Phase Two, with a commitment to drill an exploration well. It can be assumed that exploration activities, including seismic acquisition and/or exploration drilling, may take place in some or all of these areas in 2019. However, no details are available to Nexen at the time of submission of this document.

5.7 Transboundary Impacts

Of the potential environmental impacts identified and assessed in Sections 5.1 to 5.5 above, an accidental release of hydrocarbons is the only potential impact which could potentially result in transboundary impacts.

Accidental release modelling undertaken for the project – which assumed no response measures were implemented – indicated a limited probability that in the event of a worst case well blowout event a transboundary impact could result. Modelling showed a worst-case oil release could cross into UK, Faroese, French or Icelandic waters depending on the meteorological conditions at the time, and there was a small (maximum 7.1%) chance of oil beaching on UK beaches. The historical blowout frequency data presented in Section 5.5.1 indicates that the likelihood of a well blowout large enough to lead to such a transboundary impact is highly unlikely.

The risk of an accidental hydrocarbon release having a transboundary impact is recognised by the Irish and the UK Government and other governments around the North Sea. Agreements are in existence for dealing with international releases with states bordering Ireland, these include:

- Planning and exercises conducted under the Bonn Agreement; and
- Arrangements under the International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC Convention).

5.8 Summary of residual impact significance

Table 5.23 below summarises the residual impacts as assessed and presented in Sections 5.1 to 5.5 above. The assessment criteria used are presented in Section 4.3.

Table 5.23 Residual impacts summary table

Source of impact	Potential Impact	Residual Consequence	Residual Frequency	Residual Impact Ranking	Residual Significant
Physical Presence	Seabed impacts to benthic species and seabed habitats.	Minor	2	Negligible	Not significant
	Interactions with other sea users: • Increased vessel traffic and collision risk.	Minor	2	Negligible	Not significant
	Interactions with other sea users: • Temporary exclusion.	Minor	2	Negligible	Not significant
	Interactions with other sea users: • Dropped objects.	Minor	3	Minor	Not significant
Underwater Noise	Injury to marine mammals.	Negligible	1	Negligible	Not significant
	Disturbance to marine mammals.	Minor	3	Minor	Not significant
Atmospheric Emissions	Atmospheric Emissions.	Minor	2	Negligible	Not significant
Discharges to Sea	Seabed impacts.	Negligible	1	Negligible	Not significant
	Water column impacts.	Minor	2	Negligible	Not significant

Source of impact	Potential Impact	Residual Consequence	Residual Frequency	Residual Impact Ranking	Residual Significant
Accidental releases	Hydrocarbon release: • Bunkering.	Moderate	Unlikely	Minor	Not significant
	Hydrocarbon release: • Loss of drill shop fuel inventory.	Moderate	Remote	Minor	Not significant
	Hydrocarbon release: • Well blowout.	Severe	Remote	Moderate	Not significant
	Chemical release.	Negligible	Possible	Negligible	Not significant

6 ENVIRONMENTAL MANAGEMENT

6.1 Introduction

This section outlines the environmental management philosophy and procedures that will be in place to ensure that the mitigation and management measures described in this document will be implemented effectively.

6.2 Environmental Management and Commitments

Nexen is committed to protecting the environment and consequently manages environmental matters as a critical business activity. Nexen has an Environmental Management System (EMS) that applies to all exploration, drilling, development, production and associated activities. The Project described in this submission will be carried out in accordance with this management system and with Nexen policy and procedures. The EMS was verified on the 4th May 2017.

Nexen has a corporate combined Health, Safety Environment and Social Responsibility Policy (HSE&SR)), which provides a public statement of its commitment to protecting the environment associated with all exploration and production activities. A copy of this policy is provided in Figure 6.1.

ERA for the Project, including consultation with stakeholders, is an ongoing process which will continue through all stages of operations.

The mitigation and management measures identified during the ERA process will be incorporated into a commitments register. These commitments will be incorporated into the Environmental Management Plan (EMP) for the Project.

Figure 6.1 Nexen HSE and SR Policy

Nexen UK's Commitment to

Health, Safety, Environment & Social Responsibility

This Policy Commitment underpins the requirements outlined in the Corporate Policy Framework and applies to all activities carried out by and under the control of Nexen Petroleum (U.K.) Limited, its branches and subsidiaries (NPUL).

Within NPUL, the Board of Directors own and takes responsibility for our overall HSE&SR performance working with our executive leadership and functional teams. We believe that management and staff commitment to HSE&SR is essential to ensuring a healthy, safe and environmentally acceptable operating environment.

We see our people are our most important asset and we will not compromise our HSE&SR standards to achieve other corporate goals, in so far as it is reasonably practicable. As such, we value the experience, professionalism and integrity of our workforce, and the commitment, leadership and accountability of all personnel for our HSE&SR performance.

We integrate HSE&SR planning and management into our day-to-day activities, defining individual responsibilities, authority and accountability. By providing adequate control of HS&E risks arising from our work activities, we strive to prevent accidents, injuries and cases of work related ill health, damage to equipment and the environment.

We meet all applicable regulatory requirements, as well as other compliance requirements to which we subscribe, and strive to deliver continuous improvement in our HSE&SR performance.

Occupational Health and Personal Safety

NPUL consult with our people on matters affecting their health and safety working conditions, plant and equipment, and provide appropriate HSE&SR information, instruction, training and supervision to employees and contractors.

We strive to optimise the safety of all our worksites by contracting those contractors who can demonstrate that they have suitable HS&E performance and management systems in place. In addition, we ensure that emergency response capability is in place and periodically test for all our operations and facilities.

We ensure all workers are competent to carry out their tasks, in so far as they can impact on the health and safety of themselves and those around them, or the environment.

NPUL maintains safe and healthy working conditions, by providing and maintaining safe plant and equipment, and ensuring that the use and handling of substances is carried out safely.

Process Safety

NPUL applies the principles of Process Safety Management to maintain the integrity of our operations.

We ensure that risks associated with major accident hazards, arising out of our offshore operations, are identified and controlled.

Environmental Management

NPUL is committed to integrating responsible environmental management into all aspects of its operations.

Our EMS provides the framework for setting and reviewing environmental targets and objectives, and the process by which the EMS is documented, implemented and maintained. Our actions will support the prevention of pollution and the reduction of waste generation.

Social Responsibility

We are committed to behaving ethically and to contribute to economic development while improving the quality of life of the workforce and their families as well as the local community within the sphere of our activities.

At regular intervals the Board of Directors reviews and revises this policy, as necessary. The Directors of the company each individually and collectively share the commitment and will seek to act as Directors in accordance with the above principles.

Ray Riddoch
Nexen Petroleum (U.K.) Ltd MD

nexen
A CNOOC LIMITED COMPANY

ECN-HS-POL-00065 Revision 7.0, August 2018

7 ENVIRONMENTAL RISK ASSESSMENT CONCLUSIONS

This environmental risk assessment has been prepared and submitted to PAD to support an application for approval under Section 2 of the Rules and Procedures for Offshore Petroleum Exploration and Appraisal Operations (part 2 of PAD, 2014) for drilling a single exploration well in the Iolar prospect in Frontier Exploration Licence (FEL) 3/18 in the Porcupine Basin offshore west of Ireland . The report presents the assessment of the potential impacts of the Project on the marine environment, to demonstrate if the Project would be likely to have significant effect on the environment by virtue, inter alia, of its nature, size and location.

Through descriptions of the Project and the baseline environment, potential interactions between aspects of the Project and receptors (or factors) have been identified. For each interaction; this has been assessed and significance of the interaction given. Where required, mitigation measures have been proposed to lower the significance of planned and unplanned operations and reduce the potential impact on the marine environment.

The Project has been assessed in combination with other projects and plans in the region, to identify any potential for cumulative impacts. Although there is expected be some temporary minor environmental impact during the Project, through the implementation of industry best practise, legal requirements and guidance, and Nexen project-specific commitments, residual impacts of the Project have been assessed as not significant.

8 ENVIRONMENTAL IMPACT ASSESSMENT SCREENING

The requirement for EIA is based upon the overall significance of all resulting impacts from the project considered together. The EC Guidance on EIA Screening (2017) provides a checklist consisting of 27 questions relating to the potential impacts of a project and the significance of such impacts. The checklist forms the basis for overall communication of significance evaluation for this EIA screening report and provides an overview of the anticipated impacts of the project upon the human and natural environment. The checklist has been used as an aid, alongside the full assessment provided in the above document, to screen the Project to determine if there are likely to be significant impacts and if an EIA is required.

Screening checklist question	Yes / No? Briefly describe	Is this likely to result in a significant effect? Yes/No? – Why?
Brief Project Description:	To drill a single exploration well, Iolar, within Frontier Exploration Licence 3/18 in the Porcupine Basin offshore west of Ireland	
1. Will construction, operation or decommissioning of the Project involve actions which will cause physical changes in the locality (topography, land use, changes in water bodies, etc)?	**Yes** The discharge of cuttings, muds and cement onto the seabed during drilling would result in a cuttings pile around the drilling location.	**No** The cuttings pile will be small and only occur in the vicinity of the well with recovery expected in a relatively short timescale. **Section 5.4**
2. Will construction or operation of the Project use natural resources such as land, water, materials or energy, especially any resources which are non-renewable or in short supply?	**Yes** The use of natural resources will predominantly entail use of fossil fuels. No other natural resources are expected to be used.	**No** The usage of the natural resources required (fossil fuels and other products/materials required to operate the drill ship and associated support vessels) will be comparable to other shipping operations. The quantification of the fossil fuels that will be required are presented in **Section 2.4**, Table 2.2, alongside **Section 5.3**, Table 5.9. The purpose of the project is to identify the potential for further natural resources.
3. Will the Project involve use, storage, transport, handling or production of substances or materials which could be harmful to human health or the environment or raise concerns about actual or perceived risks to human health?	**Yes** The operation of vessels and drilling will require the usage and extraction of fossil fuels and the use of board chemicals at sea.	**No** Nexen will have an approved oil spill contingency plan (OSCP) in place prior to drilling. It will be designed to assist the decision-making process during a spill, indicate what resources are required to combat the spill (taking into account the explosion risks associated with hydrocarbons), minimise any further discharges, and mitigate its effects.

Screening checklist question	Yes / No? Briefly describe	Is this likely to result in a significant effect? Yes/No? – Why?
	There is potential that an accident could occur which could result in a loss of fossil fuels and /or chemicals to the environment which could be harmful to the environment and raise concerns about the actual and perceived risks to human health.	There is a very low probability that an accidental event would occur which could result in potential impacts to the environment or human health. The assessment presented in this document concluded that overall the potential significance of an accidental release of fossil fuels or chemicals is considered to be moderate and not significant. Overall the Project is not expected to result in potential risks to human health. **Section 5.5**
4. Will the Project produce solid wastes during construction or operation or decommissioning?	**Yes** Wastes are generated from the drilling rig and vessels as a result of normal operational such as bulk wastes (including domestic refuse, scrap metals and packaging) In addition wastes, cuttings, muds and cement wastes will be generated during the Project which have the potential to impact the seabed fauna and flora and the water column.	**No** Wastes generated as a result of the drilling operations are not expected to differ from typical routine shipping or survey activities. All solid wastes will be managed under a robust Waste Management Plan (WMP). This plan will detail the requirements for the segregation and appropriate storage, transfer and transport of wastes (to reduce risk of loss of containment). Waste will be segregated, appropriately stored and returned to shore for treatment/disposal by an approved waste contractor. Drill derived wastes will be either discharged at the seabed or returned to the drilling ship for shipping to shore for onshore management and disposal. The cuttings pile generated from the discharge of cuttings, muds and wastes onto the seabed will be small and only occur in the vicinity of the well with recovery expected be quick. Potential water column impacts are also likely to be very short term and localised. **Section 5.4**
5. Will the Project release pollutants or any hazardous, toxic or noxious substances to air or lead to exceeding Ambient Air Quality standards in Directives 2008/50/EC and 2004/107/EC?	**Yes** Power generation will be required for the operation of the drill ship, support vessels and helicopters. Thus, emissions to air will occur as a result of the generation of power as a result of fossil fuel consumption for delivery of the activities	**No** Practical steps to limit the release of atmospheric emissions during the Project will include advanced planning to enable efficient operations and fuel utilisation and well maintained and operated power generation equipment The contractor will comply with the MARPOL Convention 73/78 Appendix VI on atmospheric emissions: no emissions of ozone depleting substances, content of

Screening checklist question	Yes / No? Briefly describe	Is this likely to result in a significant effect? Yes/No? – Why?
	In an unplanned event a small quantity of gas would be released to the atmosphere during the well control operations. This could also potentially result in the emissions of greenhouse gases	sulphur in fuel oil not exceeding 3.5% m/m, and no incineration of garbage containing more than traces of heavy metals. All vessels and the drill ship will comply with the Merchant Shipping (Prevention of Air Pollution from Ships) (Amendment) Regulations 2014 The quantification of the atmospheric emissions that will be generated as a result of the Project are presented in **Section 5.3** in **Table 5.9.**
6. Will the Project cause noise and vibration or release of light, heat energy or electromagnetic radiation?	**Yes** Noise will be generated within the marine environment during the Project. Noise would be generated predominantly as a result of DP thrusters on the drill ship, vessels, drilling and seismic airguns during vertical seismic profiling (VSP)	**No** The assessment presented in this document concluded that through the implementation of the NPWS (2014) guidance that no significant impacts to marine mammals are anticipated. **See Section 5.2**
7. Will the Project lead to risks of contamination of land or water from releases of pollutants onto the ground or into surface waters, groundwater, coastal wasters or the sea?	**Yes** The operation of vessels and drilling will require the usage and extraction of fossil fuels and the use of board chemicals at sea. There is potential that an accident could occur which could result in a loss of fossil fuels and /or chemicals to the environment which could be harmful to the environment and raise concerns about the actual and perceived risks to human health.	**No** Nexen will have an approved oil spill contingency plan (OSCP) in place prior to drilling. It will be designed to assist the decision making process during a spill, indicate what resources are required to combat the spill (taking into account the explosion risks associated with hydrocarbons), minimise any further discharges, and mitigate its effects. There is a very low probability that an accidental event would occur which could result in potential impacts to the environment or human health. The assessment presented in this document concluded that overall the potential significance of an accidental release of fossil fuels or chemicals is considered to be moderate and not significant. **Section 5.5**
8. Will there be any risk of accidents during construction or operation of the Project	**Yes** The operation of vessels and drilling will require the usage and extraction of fossil	**No** Nexen will have an approved oil spill contingency plan (OSCP) in place prior to drilling. It will be designed to assist the decision-making process during a spill, indicate what

Screening checklist question	Yes / No? Briefly describe	Is this likely to result in a significant effect? Yes/No? – Why?
which could affect human health or the environment?	fuels and the use of board chemicals at sea. There is potential that an accident could occur which could result in a loss of fossil fuels and /or chemicals to the environment which could be harmful to the environment and raise concerns about the actual and perceived risks to human health.	resources are required to combat the spill (taking into account the explosion risks associated with hydrocarbons), minimise any further discharges, and mitigate its effects. There is a very low probability that an accidental event would occur which could result in potential impacts to the environment or human health. The assessment presented in this document concluded that overall the potential significance of an accidental release of fossil fuels or chemicals is considered to be moderate and not significant. **Section 5.5**
9. Will the Project result in environmentally related social changes, for example, in demography, traditional lifestyles, employment?	**No**	**No**
10. Are there any other factors which should be considered such as consequential development which could lead to environmental effects or the potential for cumulative impacts with other existing or planned activities in the locality?	**Yes** The exploration drilling will provide greater detail to Oil & Gas Operators on the hydrocarbon prospectively of the field. This increases the probability of the discovery of recoverable hydrocarbon resources. A future oil or gas production phase resulting from the exploration drilling is not feasible for consideration as a consequential development During 2016 (February and June) the DCCAE awarded several Licensing Options in the Porcupine Basin in the Phase 1 and 2 Awards from the 2015 Atlantic Margin Licensing Round. It can	**No** There are no existing developments in the Porcupine Bsain nor are they any known plans for future exploration or seismic activities during 2019 within the region. All future planned activities will be the subject of separate applications for approval submitted to DCCAE-PAD.

Screening checklist question	Yes / No? Briefly describe	Is this likely to result in a significant effect? Yes/No? – Why?
	be assumed that all of the relevant licence applications included some sort of seismic acquisition programme, and therefore it is suspected that most or all of these areas may be planned to be acquired in 2019, although no details are known.	
11. Is the project located within or close to any areas which are protected under international, EU, or national or local legislation for their ecological, landscape, cultural or other value, which could be affected by the Project?	**Yes** There are four offshore SACS in waters to the west of Ireland, the nearest of which is located 119 km to the north-west of the proposed well location - the Belgica Mound Province SAC. There are numerous SACs, SPAs, NHAs, pNHA and Ramsar sites along the south and west coast of Ireland. The nearest coastal protected site is approximately 220 km from the proposed well location. An Appropriate Assessment Screening Report has been prepared.	**No** The only source events identified to have pathways with connectivity to the protected sites were underwater noise and a blowout scenario as part of an accidental event. Harbour porpoise was identified as a relevant feature (receptor) of three SACs (Blasket Islands, Roaring Bay and Islands and West Connacht Coast SAC) that could potentially be impacted by underwater noise caused by the Project. When assessing the potential impacts from underwater noise, given the best practice measures that will be in place (e.g. soft start), it was determined that noise emissions did not cause a LSE and therefore these three sites do not require a Stage 2 Appropriate Assessment. Modelling of the worst-case accidental release in the form of a prolonged well blowout resulted in oil reaching the west coast of Ireland, leading to connectivity to SPAs designated for marine seabirds and SACs designated for fish, marine mammals, otters, marine habitats and freshwater pearl mussels. Screening the modelled scenario based on surface probability and quantity of contamination identified 45 SACs and 27 SPAs that required further assessment. In the event of a worst-case well blowout occurring, there would likely be significant effects on at least some of the sites assessed, due particularly to the high sensitivity of birds to oiling. The occurrence likelihood of a sufficiently severe accidental event that would cause an effect on these protected sites is however considered remote, based on historical event frequencies and the risk management and best practice measures that will be in place. As such, it is concluded that accidental events associated with the Project are not expected to have a LSE on any protected sites. A Stage 2 Appropriate Assessment is therefore not required.

Screening checklist question	Yes / No? Briefly describe	Is this likely to result in a significant effect? Yes/No? – Why?
		See Nexen (2018)
12. Are there any other areas on or around the location which are important or sensitive for reasons of their ecology e.g. wetlands, watercourses or other waterbodies, the coastal zone, mountains, forests or woodlands, which could be affected by the project?	**Yes** The wider area in the Porcupine Seabight where the Project is located is at times an important pelagic tuna fishery and is also host to an array of marine mammals. The coastline of south and west Ireland contain sensitive habitats including wetlands, coastal water bodies and estuaries. The operation of vessels and drilling will require the usage and extraction of fossil fuels and the use of board chemicals at sea. There is potential that an accident could occur which could result in a loss of fossil fuels and /or chemicals into the marine environment which could affect these sensitive areas.	**No** Nexen will have an approved oil spill contingency plan (OSCP) in place prior to drilling. It will be designed to assist the decision making process during a spill, indicate what resources are required to combat the spill (taking into account the explosion risks associated with hydrocarbons), minimise any further discharges, and mitigate its effects. There is a very low probability that an accidental event would occur which could result in potential impacts to the environment or human health. The assessment presented in this document concluded that overall the potential significance of an accidental release of fossil fuels or chemicals is considered to be moderate and not significant. **Section 5.5**
13. Are there any areas on or around the location which are used by protected, important or sensitive species of fauna or flora e.g. for breeding, nesting, foraging, resting, overwintering, migration, which	**Yes** There are numerous SACs, SPAs, NHAs, pNHA and Ramsar sites along the south and west coast of Ireland. The nearest coastal protected site is approximately 220 km from the Project. A number of	**No** Under Article 12 of the Habitats Directive, assessment of LSE was conducted on protected species. Marine mammals and terrestrial mammals (otters) were deemed to require further assessment as part of this Stage 1 Appropriate Assessment Screening process. However, on assessing the likelihood of impact from underwater noise and accidental releases on the Annex IV species compared to either their

Screening checklist question	Yes / No? Briefly describe	Is this likely to result in a significant effect? Yes/No? – Why?
could be affected by the project?	these sites are important for breeding, nesting, foraging and overwintering birds An Appropriate Assessment Screening Report has been prepared.	estimated Irish populations it was determined neither require further assessment as part a Stage 2 Appropriate Assessment. **See Nexen (2018)**
14. Are there any inland, coastal, marine or underground waters (or features of the marine environment) on or around the location that could be affected by the Project?	**Yes** The Project is located within the marine environment, potential features that could be affected include seabed habitats and species, marine mammals and other marine biota. Potential affects could result from a number of activities associated with the project including: - Interaction with seabed during drilling, including deposition and settlement of drill cuttings - Underwater noise from drilling rig, vessels and VSP - Accidental releases. The coastline of south and west Ireland contain sensitive habitats including wetlands, coastal water bodies and estuaries. The operation of vessels and drilling will require the usage and extraction of fossil fuels and the use of board chemicals at sea. There is potential that an accident could occur which could result in a loss of fossil fuels and /or chemicals into the marine environment which could affect these cotasl sensitive areas.	**No** Nexen will have an approved oil spill contingency plan (OSCP) in place prior to drilling. It will be designed to assist the decision-making process during a spill, indicate what resources are required to combat the spill (taking into account the explosion risks associated with hydrocarbons), minimise any further discharges, and mitigate its effects. There is a very low probability that an accidental event would occur which could result in potential impacts to the environment or human health. The assessment presented in this document concluded that overall the potential significance of an accidental release of fossil fuels or chemicals is considered to be moderate and not significant. **Section 5.5**

Screening checklist question	Yes / No? Briefly describe	Is this likely to result in a significant effect? Yes/No? – Why?
15. Are there any areas or features of high landscape or scenic value on or around the location which could be affected by the project?	**Yes** The coastline of south and west Ireland are in places of high landscape value. The operation of vessels and drilling will require the usage and extraction of fossil fuels and the use of board chemicals at sea. There is potential that an accident could occur which could result in a loss of fossil fuels and /or chemicals into the marine environment which could affect these sensitive areas.	**No** Nexen will have an approved oil spill contingency plan (OSCP) in place prior to drilling. It will be designed to assist the decision-making process during a spill, indicate what resources are required to combat the spill (taking into account the explosion risks associated with hydrocarbons), minimise any further discharges, and mitigate its effects. There is a very low probability that an accidental event would occur which could result in potential impacts to the environment or human health. The assessment presented in this document concluded that overall the potential significance of an accidental release of fossil fuels or chemicals is considered to be moderate and not significant. **Section 5.5**
16. Are there any routes or facilities on or around the location which are used by the public for access to recreation or other facilities, which could be affected by the project?	**Yes** The coastline of south and west Ireland is a valued resource for recreational activities such as surfing, angling, bathing, wildlife watching and tourism. The operation of vessels and drilling will require the usage and extraction of fossil fuels and the use of board chemicals at sea. There is potential that an accident could occur which could result in a loss of fossil fuels and /or chemicals into the marine environment which could affect these recreational areas.	**No** Nexen will have an approved oil spill contingency plan (OSCP) in place prior to drilling. It will be designed to assist the decision-making process during a spill, indicate what resources are required to combat the spill (taking into account the explosion risks associated with hydrocarbons), minimise any further discharges, and mitigate its effects. There is a very low probability that an accidental event would occur which could result in potential impacts to the environment or human health. The assessment presented in this document concluded that overall the potential significance of an accidental release of fossil fuels or chemicals is considered to be moderate and not significant. **Section 5.5**

Screening checklist question	Yes / No? Briefly describe	Is this likely to result in a significant effect? Yes/No? – Why?
17. Are there any transport routes on or around the location which are susceptible to congestion or which cause environmental problems, which could be affected by the project?	**Yes** The densest area of shipping lies to the south of Ireland in the Celtic Sea. Shipping levels are moderate to low around the Project location.	**No** Nexen will implement measures to minimise interference which include consultation and notification with relevant authorities and organisations use of a standby vessel and maintain a 500 m safety zone around the drill ship. **See Section 5.1.2**
18. Is the project in a location where it is likely to be highly visible to many people?	**No** The project is located 232.4 km offshore, it is not visible from the shoreline.	**No**
19. Are there any areas or features of historic or cultural importance on or around the location which could be affected by the project?	**Yes** The drilling of the well has the potential to interact with features of archaeological significance that might be present within the footprint.	**No** There are no known wrecks within archaeological features around the Project location. In line with the PAD requirements Nexen will undertake an Underwater Archaeological Assessment prior to the drilling activities.
20. Is the project located in a previously undeveloped area where there will be loss of greenfield land?	**No** The site constitutes a previously explored and undeveloped but licenced marine space. The Project is temporary in nature and does not constitute a development.	**No**
21. Are there existing land uses on or around the location e.g. homes, gardens, other private property, industry, commerce, recreation, public open space, community facilities, agriculture, forestry, tourism, mining or quarrying which could be affected by the project?	**Yes** Fishing activity in this offshore area may be somewhat affected by the Project, but the impact will be minor and restricted to the vicinity of the drill ship which is stationary.	**No** Impacts upon fishing activity, shipping, or any other activities at sea within the area, are not expected to be significant and will occur over the temporary duration of the Project. Nexen will consult with relevant authorities and organisations. Nexen will also communicate with other sea users through standard communication channels, including A Notice to Mariners which will be developed and disseminated to other marine users through the Marine Safety Directorate and Kingfisher bulletins. In,

Screening checklist question	Yes / No? Briefly describe	Is this likely to result in a significant effect? Yes/No? – Why?
		addition a standby guard vessel will operate on site for the duration of drilling operations and Nexen will consider the requirement for a fisheries liaison officer (FLO). **See Section 5.2**
22. Are there any plans for future land uses on or around the location which could be affected by the project?	**No**	**No**
23. Are there any areas on or around the location which are densely populated or built-up, which could be affected by the project?	**Yes** The project is an entirely offshore project located 232.4 km offshore. The operation of vessels and drilling will require the usage and extraction of fossil fuels and the use of board chemicals at sea. There is potential that an accident could occur which could result in a loss of fossil fuels and /or chemicals into the marine environment which could affect rural communities living on the west coast of Ireland.	**No** Nexen will have an approved oil spill contingency plan (OSCP) in place prior to drilling. It will be designed to assist the decision-making process during a spill, indicate what resources are required to combat the spill (taking into account the explosion risks associated with hydrocarbons), minimise any further discharges, and mitigate its effects. There is a very low probability that an accidental event would occur which could result in potential impacts to the environment or human health. The assessment presented in this document concluded that overall the potential significance of an accidental release of fossil fuels or chemicals is considered to be moderate and not significant. **Section 5.5**
24. Are there any areas on or around the location which are occupied by sensitive land uses e.g. hospitals, schools, places of worship, community facilities, which could be affected by the project?	**No** The project is located 232.4 km offshore	**No**

Screening checklist question	Yes / No? Briefly describe	Is this likely to result in a significant effect? Yes/No? – Why?
25. Are there any areas on or around the location which contain important, high quality or scarce resources e.g. groundwater, surface waters, forestry, agriculture, fisheries, tourism, minerals, which could be affected by the project?	**Yes** The Porcupine Seabight within which the Project is located contain commercial fishing resources. The coastal waters of west Ireland are important for mariculture and tourism. The operation of vessels and drilling will require the usage and extraction of fossil fuels and the use of board chemicals at sea. There is potential that an accident could occur which could result in a loss of fossil fuels and /or chemicals into the marine environment which could affect these areas and resources.	**No** Nexen will have an approved oil spill contingency plan (OSCP) in place prior to drilling. It will be designed to assist the decision-making process during a spill, indicate what resources are required to combat the spill (taking into account the explosion risks associated with hydrocarbons), minimise any further discharges, and mitigate its effects. There is a very low probability that an accidental event would occur which could result in potential impacts to the environment or human health. The assessment presented in this document concluded that overall the potential significance of an accidental release of fossil fuels or chemicals is considered to be moderate and not significant. **Section 5.5**
26. Are there any areas on or around the location which are already subject to pollution or environmental damage e.g. where existing legal environmental standards are exceeded, which could be affected by the project?	**No** No readily identifiable areas exist within the proposed well location where environmental standards are exceeded.	**No** It is not likely that the project will have any significant impacts upon areas which already suffer from environmental damage.
27. Is the project location susceptible to earthquakes, subsidence, landslides, erosion, flooding or extreme or adverse climatic conditions e.g. temperature inversions, fogs, severe winds, which could	**Yes** The Atlantic waters within which the project is located can be subject to severe winds, fogs, wave heights etc.	**No** Such environmental conditions are expected within the Atlantic waters. Nexen intends to undertake the drilling activities in the months of the year less prone to extreme environmental conditions and therefore they are not expected to result in environmental problems for the drilling activities.

Screening checklist question	Yes / No? Briefly describe	Is this likely to result in a significant effect? Yes/No? – Why?
cause the project to present environmental problems?		

9 EIA SCREENING CONCLUSIONS

Under the European Union (Environmental Impact Assessment) Regulations implemented into Irish legislation the Project can be screened out for further EIA under the following grounds:

> The exploration activities do not fall under the description of activities projects included within Annex I of the Directive;

> The exploration activities could be considered to fall under Annex II of the Directive. As such, the nature, scale and location of the Project has been considered and the Project has been subjected to this screening assessment. The results of the screening assessment presented in Section 8 of this report conclude that the project will not cause significant individual environmental impacts; and

> The operation is not likely to have significant impacts upon Natura 2000 sites as determined by the Appropriate Assessment Screening Report (Nexen, 2018).

Using EC screening methodology (EC 2017), no individual project impacts (as set out within individual questions in the screening checklist in Section 8) have been assessed as significant, and therefore this report screens out the requirement to carry out an EIA under the European Union (Environmental Impact Assessment) (Petroleum Exploration) Regulations 2013 and EU EIA Directive 2014/52/EU.

10 HABITATS DIRECTIVE ASSESSMENT SCREENING CONCLUSIONS

The Appropriate Assessment (Natura Impact Statement) Screening Report has been prepared alongside this EIA Screening Report to fulfil the approval requirements as set out by PAD (Nexen, 2018). The purpose of the Appropriate Assessment (Natura Impact Statement) Screening Report was to identify whether there was a potential for the Project, either individually or in combination with other plans and projects, to have an LSE on a Natura site or a European Protected Species.

The Project required a Stage 1 Appropriate Assessment Screening to identify whether there is potential for the proposed activities to have a LSE on a Natura 2000 site (SAC or SPA including draft, candidate and proposed sites).

The only source events from the Project that had pathways with connectivity to the protected sites were underwater noise and a blowout scenario as part of an accidental event.

Harbour porpoise was identified as a relevant feature (receptor) of three SACs (Blasket Islands, Roaring Bay and Islands and West Connacht Coast SAC) that could potentially be impacted by underwater noise caused by the Project. When assessing the potential impacts from underwater noise, given the best practice measures that will be in place (e.g. soft start), it was determined that noise emissions did not cause a LSE and therefore these three sites do not require a Stage 2 Appropriate Assessment.

Modelling of the worst-case accidental release in the form of a prolonged well blowout resulted in oil reaching the west coast of Ireland, lead to connectivity between the Project and SPAs designated for marine seabirds and SACs designated for fish, marine mammals, otters, marine habitats and freshwater pearl mussels. Screening the modelled scenario based on surface probability and quantity of contamination identified 45 SACs and 27 SPAs that required further assessment. In the event of a worst-case well blowout occurring, there would likely be significant effects on at least some of the sites assessed, due particularly to the high sensitivity of birds to oiling. The occurrence likelihood of a sufficiently severe accidental event that would cause an effect on these protected sites is however considered remote, based on historical event frequencies and the prevention measures that will be in place. As such, it is concluded that accidental events associated with the Project are not expected to have a LSE on any protected sites. A Stage 2 Appropriate Assessment is therefore not required.

Under Article 12 of the Habitats Directive, assessment of LSE was also conducted on protected species. Marine mammals and terrestrial mammals (otters) were deemed to require further assessment as part of this Stage 1 Appropriate Assessment Screening process. However, on assessing the likelihood of impact from underwater noise and accidental releases on these Annex IV species compared to their estimated Irish populations it was determined neither require further assessment as part a Stage 2 Appropriate Assessment.

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APPENDIX A ENVID MATRIX

No.	Activity	Aspect and Impact	Planned or Unplanned Activity	Known Safeguards and Controls in Place	Potential Consequence: Regulatory	Potential Consequence: Environmental	Potential Consequence: Stakeholder	Potential Consequence: Final Consequence	Frequency /Probability	Significance	Potential to act cumulatively?	Potential for transboundary impact?	Comment / Additional Mitigation	Action	Action Owner	Action Deadline
1.01	Physical presence of drillship / semisub drilling rig and support vessels (DP)	Generation of underwater noise - Acoustic disturbance to marine mammal species (behavioural) - protected species	P	Consideration to be given to timing of drilling activities.	1	3	3	2	4	3	N	N	Underwater noise modelling will be conducted			
1.02	Drilling (VSP)	Generation of underwater noise - Acoustic disturbance to marine mammal species (behavioural) - protected species	P	VSP activities over very short duration (8-12 hr duration) MMO assumed to be present during VSP operations as part of normal industry standards including NPWS guidance. Levels are unlikely to cause injury to marine mammals (below PTS thresholds). Nexen will follow the mitigations as per Section 4.3.4. of NPWS Guidance to Manage the Risk to Marine Mammals from Man-made Sound Sources in Irish Waters.	2	3	3	3	1	1	N	N	PAM for night time VSP operations			
1.03	Physical Presence of drill rig and support vessels (DP rig) Plus 8 transponders left at location (bucket sized) Plug and abandon - cutting wellhead approx. 2m below the mudline	Seabed disturbance - Damage to benthic habitat and species	P	DP eliminates impacts to seabed from anchors and chains. Habitat Assessment and Environmental Baseline Survey undertaken. Pre-spud ROV survey of well site to be undertaken to increase the likelihood that areas of high sensitivity will be avoided at the well site. ROV survey post drilling. Support vessel station keeping will be through use of DP.	1	2	1	1	4	2	N	N				
1.04	Physical presence of drillship and support vessel (DP)	Seabed disturbance - Damage/ disturbance to features of archaeological significance	P	Archaeological mitigation plan; presence of a marine archaeologist on the rig looking at the ROV feed prior to spud? To be clarified by the regulator. Site survey carried out - no findings. Pre-spud ROV survey.	2	N/A	1	2	4	2	N	N				

No.	Activity	Aspect and Impact	Planned or Unplanned Activity	Known Safeguards and Controls in Place	Potential Consequence				Frequency /Probability	Significance	Potential to act cumulatively?	Potential for transboundary impact?	Comment / Additional Mitigation	Action	Action Owner	Action Deadline
					Regulatory	Environmental	Stakeholder	Final Consequence								
1.05	Physical presence of drillship and support vessels	Interference with and exclusion of other sea users - Social/ cultural impact - displacement of fishing activities in the area, interference with other sea users (e.g. fishing and shipping) leading to isolated and short-term concern.	P	Relatively short duration of drilling activities (up to 150 days); single drilling location. Adherence to navigation light display requirements, including visibility, light position/shape appropriate to activity. Adherence to navigation noise signals as required. Pre-drill fisheries study and consultation with Fish Producer Organisations; FLO onboard drill ship (only if Sinbad state that one is required). 500m zone around rig. ERRV and PSV. Notice to Mariners/Kingfisher notifications.	2	N/A	2	2	4	2	Y	N	If the drillship is in the path of commercial ships they will need to make a slight deviation to their path, which is likely to be a negligible distance considering the overall distances these vessels travel. Level of fishing activity dependant on tuna fishing activity and location.			
1.06	Physical presence of drillship and support vessels	Light emissions - Disturbance to seabirds and other fauna from light emissions	P	No flaring Short duration of activities. Drilling during summer. Lights on derrick face down. Lights are there for safety reasons/navigation.	1	1	1	1	4	1	N	N	Bird migratory pathways are large compared to area of influence of lights from the drillship and support vessels; existing shipping and fishing in the area emitting light			
1.07	Use of drillship and support vessels (4/6 engines controlling 6 thrusters on drillship (TBC), 3 PSVs on location plus 1 ERRV)	Atmospheric emissions - Emissions of greenhouse gases; reduced local air quality from atmospheric emissions	P	Emissions not significant in Irish or global terms; short duration of activities; rapid dispersion of air pollutants in offshore environment. Comply with MARPOL 73/78 Annex VI requirement for atmospheric emissions. No well test flaring.	2	2	1	2	4	2	Y	N				
1.08	Use of drillship and support vessels	Routine discharges to the marine environment - Temporary nutrient enrichment of the water column and localised and temporary adverse effect to marine biota.	P	Compliance with MARPOL 73/78 Annex I, IV and V requirements; short duration of activities; deep water open sea environment with high potential for dispersion. Vessel sewerage system capacity suitable for full crew. Nexen specific standards - TBC. Marine Standard (internal).	2	2	1	2	4	2	N	N		Check whether there are any additional requirements for Ireland.	Nexen - Brian Beattie	June

No.	Activity	Aspect and Impact	Planned or Unplanned Activity	Known Safeguards and Controls in Place	Potential Consequence: Regulatory	Potential Consequence: Environmental	Potential Consequence: Stakeholder	Final Consequence	Frequency /Probability	Significance	Potential to act cumulatively?	Potential for transboundary impact?	Comment / Additional Mitigation	Action	Action Owner	Action Deadline
1.09	Drilling	Chemical use and discharge - Increase in turbidity and toxic effects to marine biota and reduction in water quality (water column) [Considering major sources of drilling - WBM discharge - duration is assumed to be for WBM discharge period].	P	Drilling fluid (WBM) additives selected to achieve lowest possible environmental impact. Chemical selection complying with Nexen requirements and Irish regulations (avoid use of SUB chemicals where possible); chemical risk assessment during preparation of PUDAC; deep water open sea environment with high potential for dispersion; single well only. Skip and ship all OBM cuttings. The management of drilling fluids, drill cuttings, cementing fluids and subsea control fluids (BOP - small quantities) will be consistent with all appropriate Nexen Engineering Standards, Operating Standards, Procedures. Use of solids control equipment (SCE): Shale shakers and centrifuges. Emergency discharge of cement - planning, PUDAC.	2	2	1	2	2	1	N	N	Additional chemical monitoring throughout the drilling campaign.			
1.10	Drilling	Discharge to sea - Disposal of drill cuttings, cement and WBM (routine) - Smothering/burial of benthic habitats/communities due to deposition of drill cuttings, muds and cement on the seabed. There will be jetting of cement around wellhead to clear it.	P	Habitat Assessment and Environmental Baseline Survey Pre-spud ROV survey of well site to be undertaken to increase the likelihood that areas of high sensitivity will be avoided at the well site. Drill cuttings modelling to identify likely depositional areas. Drilling fluid (WBM) additives selected to achieve lowest possible environmental impact. Chemical selection complying with Nexen and Irish regulations; chemical risk assessment during preparation of PUDAC. Majority of cuttings deposition anticipated to occur within a restricted area around the well site. Wider dispersion of lower hole cuttings will result in an only very thin layer of cuttings (mm's) on the seabed The management of drilling fluids, drill cuttings, cementing fluids and subsea control fluids will be consistent with all appropriate Nexen Engineering Standards, Operating Standards, Procedures	2	2	1	2	2	1	N	N				

No.	Activity	Aspect and Impact	Planned or Unplanned Activity	Known Safeguards and Controls in Place	Potential Consequence: Regulatory	Potential Consequence: Environmental	Potential Consequence: Stakeholder	Final Consequence	Frequency /Probability	Significance	Potential to act cumulatively?	Potential for transboundary impact?	Comment / Additional Mitigation	Action	Action Owner	Action Deadline
1.11	Drilling	Waste management - Disposal of drill cuttings (OBM) by skip and ship for onshore treatment and disposal.	P	Sent to Peterhead - Transboundary requirements. Waste Standard (reference TBC). Peterhead Waste facilities adheres to onshore regulatory requirements.	2	2	2	2	3	2	Y	Y		Confirm number of skips required for skip and ship, and number of vessel trips required.	Nexen	June
1.12	Use of drilling rig and support vessels	Drillship drainage - Toxic effects to marine biota and reduction in water quality	P	Deep water open sea environment with high potential for dispersion; bunded areas for chemical and fuel storage. Compliance with MARPOL 73/78 Annex I, IV and V requirements. NPI Safety Case.	2	2	1	2	4	2	N	N		Information from rig on drains system	Nexen - Mark Jamieson	June
1.13	Use of helicopters	Helicopter travel to and from the rig - Disturbance to marine fauna	P	Short duration of activities; helicopter noise is highly localised in the water column. Kerry or Cork airport - TBC. Flight path TBC.	1	1	1	1	4	1	N	N		Confirm airport, flight path Confirm whether there are sensitive sites in the area.	Nexen Xodus	June
1.14	Chemical use and discharge	Accidental loss of drilling fluid from the riser. - Emergency PLANNED disconnect (i.e. weather) - Toxic effects to marine biota and reduction in water quality Approx. 1500 barrels	P	Brine displaces the OBM - loss of brine to sea in this scenario. The management of drilling fluids, drill cuttings, cementing fluids and subsea control fluids will be consistent with all appropriate Nexen Engineering Standards, Operating Standards, Procedures.	2	1	1	1	3	2	N	N	Emergency response and oil spill contingency plan. Approved SOPEP on drillship			

No.	Activity	Aspect and Impact	Planned or Unplanned Activity	Known Safeguards and Controls in Place	Potential Consequence				Frequency /Probability	Significance	Potential to act cumulatively?	Potential for transboundary impact?	Comment / Additional Mitigation	Action	Action Owner	Action Deadline
					Regulatory	Environmental	Stakeholder	Final Consequence								
1.15	Drilling	Chemical use and discharge (contingency) - Toxic effects to marine biota and reduction in water quality	P	Drilling fluid (WBM / OBM) additives selected to achieve lowest possible environmental impact. Chemical selection complying with Nexen and Irish regulations; chemical risk assessment during preparation of PUDAC; deep water open sea environment with high potential for dispersion; single well only The management of drilling fluids, drill cuttings, cementing fluids and subsea control fluids will be consistent with all appropriate Nexen Engineering Standards, Operating Standards, Procedures. Generally a risk in the lower (OBM) sections - no discharge to sea.	3	2	2	2	4	2	N	N				
1.16	Unplanned atmospheric emissions	During exploration drilling, a kick may occur in the reservoir. A small quantity of gas would be released to the atmosphere during well control operations - Emissions of greenhouse gases; reduced local air quality	UP	Nexen will verify that drillship contractor procedures align with the relevant Nexen Engineering requirements which cover all aspects of primary and secondary well control for floating drilling operations, specifically: Well design • assessment of formation pressure and fracture gradient along the length of the well • shallow gas analysis and assessment • planned mud weight overbalance • leak off or limit testing • assessment of well control equipment requirements • well bore monitoring equipment – two independent systems for monitoring the well bore shall be provided (typically, the drilling contractor and the mud logging contractor) • well choke and kill systems. Venting shall have no measurable impact on local/regional air quality and human health	1	1	3	2	3	3	Y	N	Potential volume of released gas to be quantified. Regulatory is ranked low as there is no environmental legislation that applies to these kinds of atmospheric releases. This would be related to the Safety Case.			

No.	Activity	Aspect and Impact	Planned or Unplanned Activity	Known Safeguards and Controls in Place	Potential Consequence: Regulatory	Potential Consequence: Environmental	Potential Consequence: Stakeholder	Potential Consequence: Final Consequence	Frequency /Probability	Significance	Potential to act cumulatively?	Potential for transboundary impact?	Comment / Additional Mitigation	Action	Action Owner	Action Deadline
1.17	Use of drilling rig	Accidental discharge of hydrocarbon and chemicals - from decks and during bunkering - Toxic effects to marine biota and reduction in water quality	UP	Bunkering will be undertaken in accordance with Nexen operational bunkering standard/procedure, whereby under normal operations bulk transfers are started only in daylight hours and when sea conditions are appropriate; • constant visual monitoring of gauges, hoses, fittings and, sea surface; • radio communication between rig and support vessel; • preventative maintenance of refuelling equipment / connections • look-out man on watch for leaks at all times Bulk transfer hoses for diesel will have flotation collars and dry-break couplings, and hoses are inspected prior to use and over-rated for pumping pressure used; Rig and vessel level monitoring systems with alarms (TBC) A 500 m radius safety zone will be maintained around the drill rig as required; the OIM will manage vessel access and activities within this zone. Adherence to standard maritime safety/ navigation procedures. Incident response is highlighted in the induction Compliance with MARPOL 73/78 Annex I: • Regulation 7: Vessels will hold a valid International Oil Pollution Prevention (IOPP) certificate. • Regulation 17: Vessels will maintain an oil record book. • Regulation 37: Shipboard Oil Pollution Emergency Plans (SOPEPs) will be developed, approved and kept onboard vessels. Nexen SOPs, Standards, etc. Chemicals and/or hydrocarbons will be handled and stored in compliance with the Safety Data Sheets (SDSs). • Chemicals will be stored safely and handled to prevent the release to the marine environment.	3	2	2	2	4	3	N	N	Discuss need for modelling of a small diesel spill			

No.	Activity	Aspect and Impact	Planned or Unplanned Activity	Known Safeguards and Controls in Place	Potential Consequence				Frequency /Probability	Significance	Potential to act cumulatively?	Potential for transboundary impact?	Comment / Additional Mitigation	Action	Action Owner	Action Deadline
					Regulatory	Environmental	Stakeholder	Final Consequence								
				Spill response kits located in proximity to hydrocarbon storage/bunkering areas and appropriately stocked/replenished as required. Nexen Oil Spill Response procedures ISO14001 - rig												
1.18	Chemical use and discharge	Accidental loss of drilling fluid in the riser - Failure of joint packer (above water line - loss of approx. -2.8m) Toxic effects to marine biota and reduction in water quality	UP	Drilling fluid (OBM only) additives selected to achieve lowest possible environmental impact. Maintenance program	3	1	3	2	3	2	N	N	Emergency response and oil spill contingency plan. Approved SOPEP on drillship			

No.	Activity	Aspect and Impact	Planned or Unplanned Activity	Known Safeguards and Controls in Place	Potential Consequence				Frequency /Probability	Significance	Potential to act cumulatively?	Potential for transboundary impact?	Comment / Additional Mitigation	Action	Action Owner	Action Deadline
					Regulatory	Environmental	Stakeholder	Final Consequence								
1.19	Chemical use and discharge	Accidental loss of drilling fluid from the riser. - Emergency disconnect. - Toxic effects to marine biota and reduction in water quality Approx. 1500 barrels	UP	Drilling fluid (OBM) additives selected to achieve lowest possible environmental impact. The management of drilling fluids, drill cuttings, cementing fluids and subsea control fluids will be consistent with all appropriate Nexen Engineering Standards, Operating Standards, Procedures.	3	1	3	2	3	2	N	N	Emergency response and oil spill contingency plan. Approved SOPEP on drillship			
1.20	Drilling of well	Loss of well integrity (well blowout) resulting in loss of oil and gas - Environmental - Fatal and toxic effects to marine biota and reduction in water quality; oiling of seabirds on sea surface; oiling of coastal habitats and species, including protected sites Social/cultural - impacts on fishing industry and impacts to local tourism activities	UP	Implementation of Nexen Engineering Standards Well design designed to well design standard. Well designed to be killable. Trained and competent personnel Regular BOP preventative maintenance and testing; BOP rated for predicted well / reservoir pressures A range of industry standard well barrier equipment, materials and procedures to ensure all permeable zones penetrated by a well bore, with the potential to contain hydrocarbons or over-pressured water, are isolated from the surface environment by a minimum of two barriers at all times during all phases of the well construction and abandonment A range of procedures/ assurance processes in place to monitor/ test the integrity of barriers, prior to use/ installation, during use/ installation and post installation, as required Shallow hazards assessment completed; information gained from shallow seismic surveys is considered in the well design Proven and verified barriers in place and in-flow tested. Nexen technical review / approval of P&A plan Completion design will manage blow-out risk including any technology advancements	5	5	5	5	1	2	N	N	Implement Nexen oil spill response plan. Capping stack. Preparation of a Well Relief Plan prior to well being drilled. Response dependent on modelling of plume trajectory in relation to the identified zones of potential impact/ sensitive receptors and a net environmental benefit analysis specific to the spill event undertaken prior to implementing responses Response strategy may include dispersant use (seems to have little benefit) and offshore containment / recovery to minimise risk of hydrocarbons reaching sensitive shallow water and shoreline environments Where the plume is transported offshore away from the coast, the most likely response will be to monitor and evaluate the spill. Where a spill plume is predicted to contact the coast then a more proactive response such as use of dispersants will be used as outlined in the ERP BOP can be closed to stop flow; possible ROV override of BOP controls (contingency if required) Re-plug and abandon to ensure barrier integrity Well blow-out and relief modelling Standards: The Nexen Well control standard 'ECN-DR-STD-00067' Nexen Well Integrity Policy, ECN-DR-POL-50021 - The integrity of the well shall be maintained by this policy Casing Design and Assessments Standard, ECN-DR-STD-00068, Rev 8.0. Well Policy, GBL-GBL-WD-POL-00043 Well Standards, ENC-DR-STD-00018, Rev 4.0 Directional Drilling Standard, ECN-DR-STD-50015 Well statement of requirements, Rev 4.0, 10th July 2018 Wellbore stability Report, CC328-68 Porcupine WBS Report			

No.	Activity	Aspect and Impact	Planned or Unplanned Activity	Known Safeguards and Controls in Place	Potential Consequence				Frequency /Probability	Significance	Potential to act cumulatively?	Potential for transboundary impact?	Comment / Additional Mitigation	Action	Action Owner	Action Deadline
					Regulatory	Environmental	Stakeholder	Final Consequence								
1.21	Physical presence of drill rig and support vessels	Loss of containment from drillship / support vessel of fuel storage tanks (marine diesel) due to vessel Collision - Environmental impacts from hydrocarbon release	UP	Implementation of 500 m safety zone around the drillship. Stakeholder consultation including preparation and circulation of factsheet; notifications to mariners and notification of relevant authorities as defined in the Rules and Procedures Manual for offshore petroleum exploration and appraisal operations The drillship diesel tanks are situated on the inside of the drillship which decreases the likelihood of loss of diesel from the actual drillship? Normal operational procedures followed. Vessel helmsman maintains visual watch for obvious hazards. Nexen marine standards Timing of activities during suitable weather window Use of guard vessel; consideration of FLO onboard	5	4	5	5	1	2	N	N	Implement oil spill response plan. The presence of radar, AIS system, and other collision avoidance system together with the presence on location at all times of two vessels (the drillship and the support vessel) minimises the likelihood of the event? Discuss need for modelling loss of MODU diesel inventory			
1.22	Use of drilling rig	Dropped objects overboard - Social/cultural risk - creation of snagging risk resulting in loss of or damage to fishing gear and catch; Environmental risk - creation of marine pollution and damage to benthic habitat. Marine pollution leading to breach of MARPOL if large object	UP	Good housekeeping practices, with all wastes correctly stored. Storage of hazardous chemicals as per MSDS Drillship Safe Work Procedures to prevent dropped objects Waste Management Plan Drillship operating standards will be followed (e.g. Safe Work Procedures: Bulk Transfer from Supply Vessel, Manual Handling Safe Work Procedure and Dropped Object Prevention). Operational procedures will be in-place on board the drillship and support vessels for: • deployment and retrieval of marine equipment; and • over-the-side lifting (including appropriate crane rigging and load ratings, crane operator and rigger training and competency requirements) Nexen procedures and waste management plan. Ongoing personnel awareness and training,	2	2	2	2	3	2	N	N	ROV and boat recovery where practicable Low levels of fishing in the area.			

No.	Activity	Aspect and Impact	Planned or Unplanned Activity	Known Safeguards and Controls in Place	Potential Consequence				Frequency /Probability	Significance	Potential to act cumulatively?	Potential for transboundary impact?	Comment / Additional Mitigation	Action	Action Owner	Action Deadline
					Regulatory	Environmental	Stakeholder	Final Consequence								
				and dropped object prevention programs (e.g. lanyards on hardhats, hand tools)												
1.23	Physical presence of wellhead/BOP and surface riser	Snagging risk - Social/ cultural risk- creation of potential snagging risk to demersal and pelagic fishing gear resulting in loss or damage of equipment, catch or potentially the vessel. Consequence assessed considering loss of or damage to equipment only.	UP	Standard communication channels e.g. notice to mariners Stakeholder consultation Guard vessel Consideration of need for FLO on guard vessel	2	N/A	3	3	3	2	N	N				
1.23	Physical presence of wellhead/BOP and surface riser	Interaction with vessels in 500m zone.	UP	Standard communication channels e.g. notice to mariners Stakeholder consultation Guard vessel Consideration of need for FLO on guard vessel	2	N/A	3	3	3	2	N	N				

APPENDIX B SOURCE NOISE DATA UNDERWATER NOISE SOUND PROPAGATION CALCULATION

Appendix B.1 Summary of Noise Sources

The potential sources of underwater noise associated with the drilling phases of this project are as follows:

> Drilling a single exploration well in deep water using a drill ship;
> Vessel activity – e.g. drilling support vessel, supply vessels; and
> Vertical seismic profiling (VSP).

Noise source data has been taken from a combination of publicly available noise data for similar equipment and activities, empirical calculations and theoretical predictions. It should be noted that even where specific noise measurement data is available, these data are often not in a suitable form for assessing the impacts of noise on wildlife. Consequently, it is often necessary to apply empirical corrections to convert from, for example, rms sound pressure levels to SEL or peak pressure levels.

For vertical seismic profiling (VSP), these operations can be characterised as impulsive i.e. series of repetitive sounds whereas noise from vessels and drilling operations tend to be continuous in nature. It is therefore necessary to model these two types separately and compare the results against their respective threshold limits for continuous noise (non-impulsive) and multi-pulse (impulsive) noise.

Appendix B.2 Drilling Operations

The deep-water drilling will be carried out using either a semi-submersible drilling unit or a purpose-built drill ship. Both types use thrusters to maintain its position via dynamic positioning; along with noise from drilling operations it is the dynamic positioning systems that contribute significantly to the overall underwater noise signature.

As information relating underwater noise from drilling operations is extremely limited it has been necessary to utilise proxy data based on the Stena Forth drill ship (Kyhn *et al*., 2011). This drill ship is a double hulled, 228 m long, 42 m wide ship with a displacement of 96,000 Mt, equipped with six 5500 kW fixed pitch azimuth thrusters (Rolls Royce Aquamaster AQM UUC 455 L-Drive) and six 7430 kW diesel generators (Wartsilla 16V32). This is considered representative of the type of mobile offshore drilling unit likely to be deployed off the west coast of Ireland in the South Porcupine Basin.

Based on measured data an equivalent source level of 184 dB re 1 μPa (rms) at 1m was determine during drilling operations. Under drilling operations noise levels were comparable in all directions except in the aft direction (180°) where levels were consistently ~5 dB lower than the other directions in the range up to 10 kHz. As a result of this, a worst-case scenario has been assumed i.e. no directionality has been included in the calculations. Noise data for the drill ship includes the use of dynamic positioning systems required to keep the vessel stationary during drilling operations to maintain stability.

The third-octave band spectrum shape for drilling activities for the Stena Forth is shown in Figure B.1.

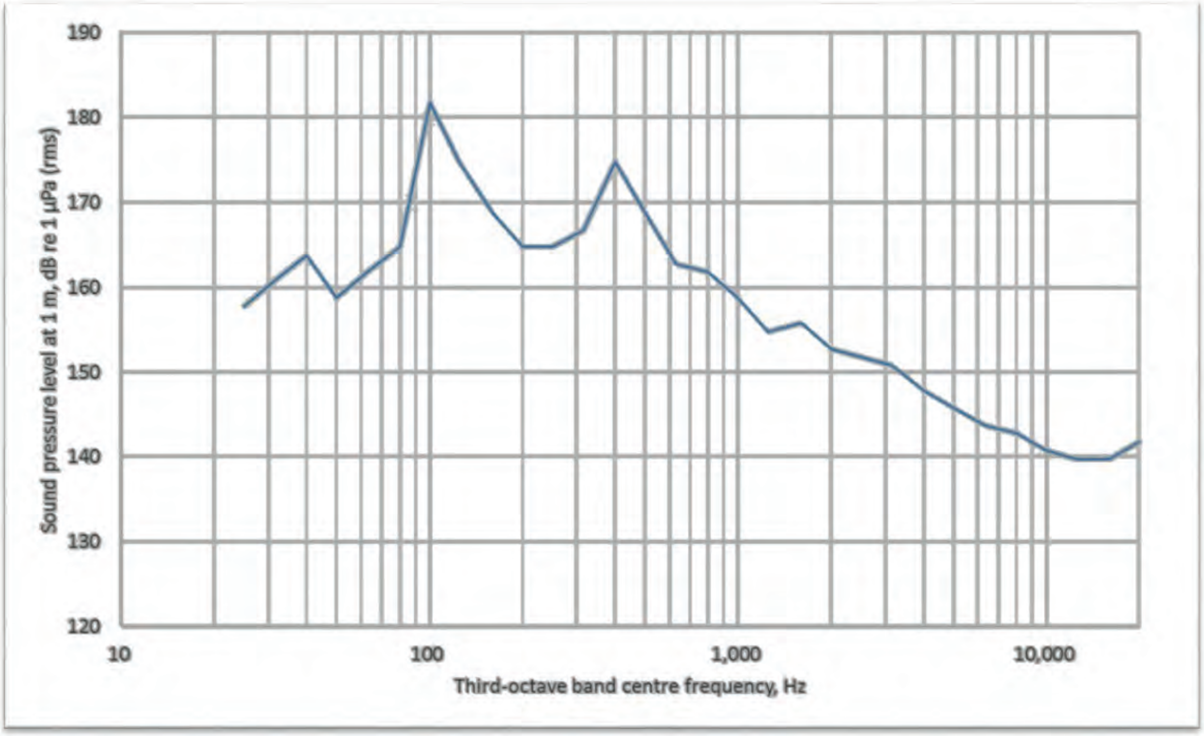

Figure B.1 Third-octave band sound pressure level spectrum of drill ship under drilling operations (Kyhn *et al.,* 2011)

For the source levels a correction of 3 dB has been applied to the rms sound pressure level to derive the peak sound pressure level. The SEL is based on the rms sound pressure level integrated over the exposure time.

The report (Kyhn *et al*., 2011) also stated that during maintenance operations a level of 190 dB re 1 µPa (rms) was obtained although full details of this particular operation were not provided i.e. what equipment was operating and whether other vessels were working in the vicinity. As such this data has not been disregarded.

Drilling is generally acknowledged (NPWS, 2014) to produce moderate levels of continuous omnidirectional sound at low frequency (several tens of Hz up to c.10 kHz). Source sound pressure levels have been reported to lie within the 145-190 dB re 1 µPa range. While sound exposure levels from such operations are thought to be below that expected to cause injury to a marine mammal, they have the potential to cause lower level disturbance, masking or behavioural impacts. However, it is noted that the use of dynamically-positioned platforms and associated vessel activity can combine to make drilling operations a potentially significant source of anthropogenic sound.

Appendix B.3 Support Vessels

A drilling support vessel is likely to be in attendance during drilling operations and a marine survey vessel will also be required during VSP operations.

In the absence of specific underwater data, source noise levels for the standby / support vessel has been based on those presented in Austin & McGillivray (2005). The vessel on which the measurements were carried out is the Maersk Rover which is a Type: R (L) class vessel of 67 m length. This gives a source level of 188 dB re 1 µPa (rms). A correction of 3 dB has been applied to the rms sound pressure level to derive the peak sound pressure level, and the SEL is based on the rms sound pressure level integrated over the exposure time.

Note that noise from shipping movements is not covered by NPWS (2014).

Appendix B.4 Vertical Seismic Profiling

VSP refers to measurements made in a vertical wellbore using geophones inside the wellbore and a source at the surface near the well. Operations vary in terms of 'well configuration', the number and location of sources and geophones, and how they are deployed. In a marine environment, the source used is an air gun which can produce noise levels that are harmful to marine mammals.

There is considerable literature relating to airgun noise underwater (e.g. Breitzke *et al.,* 2008; Tolstoy *et al*., 2009; Richardson *et al.,* 1995). For this study, the source noise levels were based on a combination of manufacturer's data for VSP airguns supplemented by measured noise data for other projects and extrapolations to derive the frequency spectra for higher frequencies than those typically supplied by the manufacturers.

Based on information supplied by the project, namely: an air gun volume of 250 cu inch, 2000 psi, and with a maximum shot rate of 10 secs, a surrogate airgun has been identified. The information used in this study is summarised in Table B.1 and is based on manufacturer's data for the Sercel G-Gun II 250 airgun.

Description	Source Data
Type of array	Dual cluster
Pressure psi	2000
Total volume, cu inch	250
Airgun equipment depth, m	2.5
Maximum shot rate, secs	10
Zero to peak pressure, bar-m	3.5
Peak to peak, bar	5.4

Table B.2: Source data for vertical seismic profiling

As the actual type of air-gun is yet to be selected, the above represents one possible option. Zero-to-peak pressure levels have been converted to dB re 1 μPa, resulting in a peak-to-peak sound pressure level for this option of 235 dB re 1 μPa.

For this study, the source levels have supplemented by measured sound data from Breitzke *et al*. (2008), Tolstoy *et al*. (2009) and Richardson and Thomson (1995), in order to produce low and mid-frequency data. The low and mid-frequency data has been extrapolated to derive the third-octave frequency spectra at higher frequencies based on the gradient of the power spectral density[20] and third-octave band plots.

The SEL represents the total energy of an event or number of events normalised to a standardised one second interval. This allows a comparison of the total energy of different sounds lasting for different time periods. As a pressure pulse from a source array propagates towards the receiver, the duration of the pulse increases. Thus, the relationship between the peak sound pressure level and the SEL changes with distance. The SEL level was calculated based on the rms sound pressure level normalised to a one second time interval. The single pulse SEL values have been combined for each pulse as part of the cumulative SEL modelling scenarios.

It is important to note that the rms sound pressure level will depend upon the integration window used or, in other words, the measurement time for the rms. Using a longer duration measurement would result in a lower rms sound pressure level than using a shorter one. For the purposes of this assessment, the measurement time has been set as the interval over which 90% of the sound energy arrives at the receiver (T90). As sound propagates through the ocean, effects such as reverberation and dispersion will increase the delay time of the impulsive sound, meaning that the difference between the peak and rms levels will increase with distance.

[20] The power spectral density (PSD) is the power carried by the wave, per unit frequency of the signal.

This has been estimated based on measurements of seismic noise at various distances to derive estimated T90 times.

An additional phenomenon occurs where the seismic waveform elongates with distance from the source due to a combination of dispersion and multiple reflections. Measurements presented by Breitzke *et al*. (2008) indicate elongation of the T90 window up to approximately 800 ms at 1 km. This temporal “smearing” reduces the rms amplitude with distance (because the rms window is longer) and has been included within the disturbance modelling scenarios. Since the ear of most marine mammals integrates low frequency sound over a window of approximately 200 ms (Madsen *et al*., 2006), this duration was used as the maximum integration time for the received rms sound pressure level.

The source levels stated above are likely to be overestimated in the near-field as the modelled back projection to 1 m does not consider the interaction between the source elements. This in turn overestimates near-field received levels, which are then compared to animal thresholds. In reality, near-field source sound levels will be lower than that predicted by this vertical far-field calculation. The spatial extent of the near-field effect can be derived from acoustic first principles (e.g. Urick, 1983) and is proportional to the square of the largest array dimension and frequency. The near-field extent will vary with salinity, pressure and source timing. Over-prediction due to near-field errors can be expected at receiver distances closer than this.

Another important factor affecting the received sound pressure level from seismic source arrays is the source directivity characteristics. Source arrays are designed so that the majority of acoustic energy is directed downwards towards the ocean bottom. Therefore, the amount of energy emitted horizontally will be significantly less than directed downwards. This is a frequency dependent effect and is more pronounced at higher frequencies than at lower frequencies. Directivity corrections have been applied to the source sound level data based on the software model output, which provides broadband normalised amplitudes at varying angles of azimuth (angle around the boat parallel to the surface of the water, progressing around the boat from port to starboard) and dip angle (angle under the boat, progressing from prow to stern). Directivity corrections have been applied assuming that the animal is directly in-line with the vessel (0º azimuth).

Appendix B.5 Effect of Background Noise

Background or “ambient” underwater noise is generated by a number of natural sources, such as rain, breaking waves, wind acting on the water’s surface, seismic noise, biological noise and thermal noise. Biological sources include marine mammals (which use sound to communicate, build up an image of their environment and detect prey and predators) as well as certain fish and shrimp. Anthropogenic sources also add to the background noise, such as fishing boats, ships, industrial noise, seismic surveys and leisure activities. Generalised ambient noise spectra attributable to various noise sources (Wenz, 1962) are shown in Figure B.2.

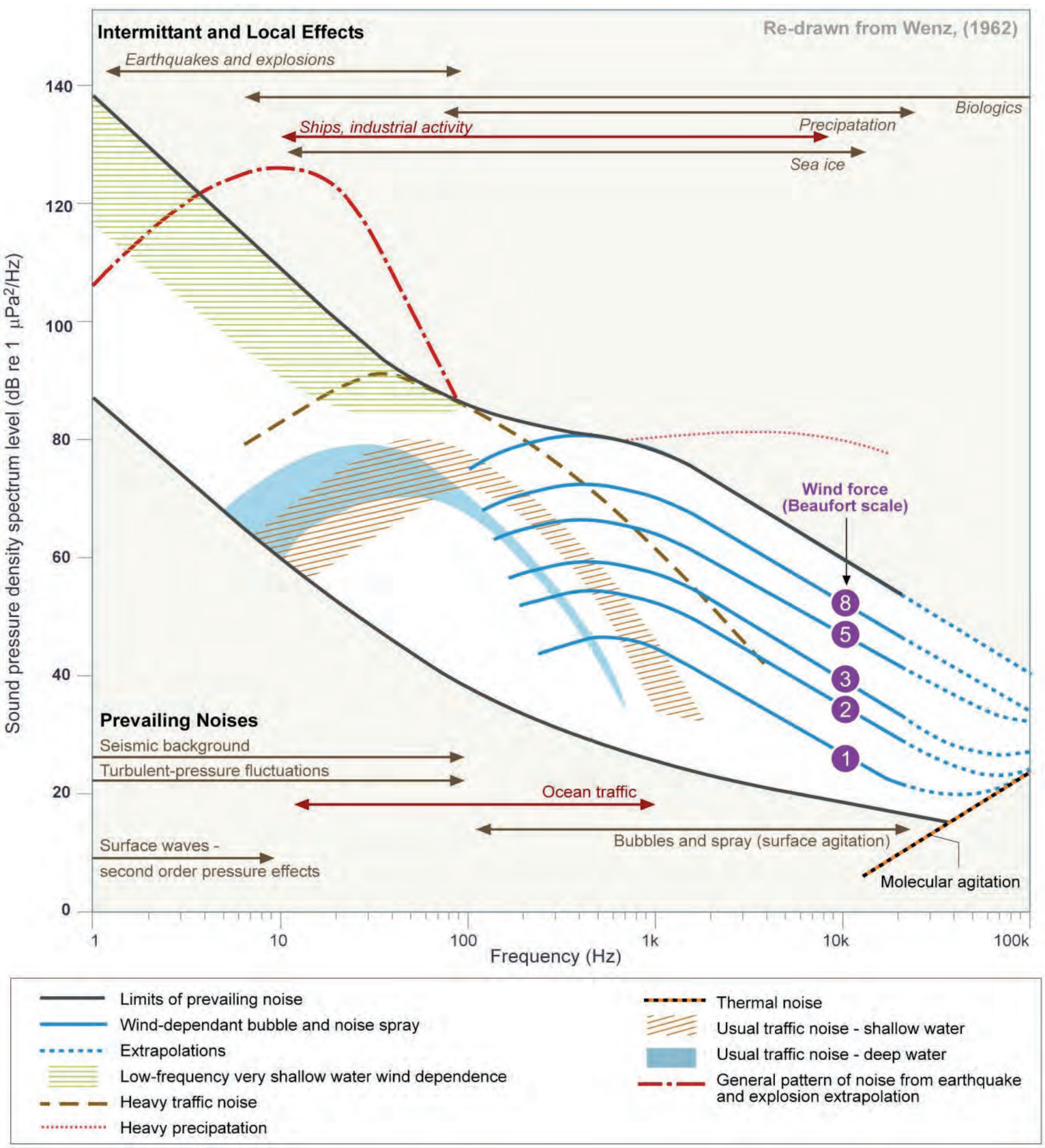

Figure B.2: Generalised ambient noise spectra attributable to various noise sources

Much of the research relating to both physiological effects and behavioural disturbance due to noise on marine species is based on determining the absolute noise level for the onset of that effect. As a result, criteria for assessing the effects of noise on marine mammals and fish tend to be based on the absolute noise criteria, as opposed to the difference between the baseline noise level and the specific noise being assessed (Southall *et al.* 2007; NPWS, 2014). Given the lack of evidence based studies investigating the effects of noise relative to background on marine species, the value of establishing the precise baseline noise level is somewhat diminished. It is important to understand that baseline noise levels will vary significantly depending on, amongst other factors, seasonal variations and different sea states, meaning that the usefulness of establishing such a value would be limited. Nevertheless, it can be useful (though not essential) when undertaking an assessment of underwater noise to understand the range of noise levels likely to be prevailing in the area so that any noise predictions can be placed in the context of the baseline. It is important to note however, that even if an accurate baseline noise level could be determined, there is a paucity of scientific understanding regarding how various species distinguish anthropogenic sound relative to masking noise. An animal's perception of sound is likely to depend on numerous factors including the hearing integration time, the character of the sound and hearing sensitivity. It is not known, for example, to what extent marine mammals and fish can detect tones of lower magnitude than the background masking noise. Therefore, it is necessary to exercise considerable caution if attempting any comparison between noise from the development and the baseline noise level. For example, it does not follow that because the broadband sound pressure level due to the source being considered is below the numeric value of the baseline level that this means that marine mammals or fish cannot detect that sound. This is particularly true where the background noise is dominated by low frequency sound which is outside the animal's range of best hearing acuity. Until such a time as further research is conducted to determine a dose response relationship between the "signal-to-noise" level and behavioural response, a precautionary approach should be adopted.

Ambient noise levels have been recorded in the Porcupine basin by the Centre for Marine Science and Technology (2015) in the absence of noise from seismic / vessel operations. The time-averaged broadband noise levels (between 8 and 2500 Hz, 1/3 octave band limits centre frequencies) ranged from between 74-141 dB re 1μPa with mean and median levels of 107 and 109 dB re 1μPa.

It should therefore be noted that the 120 dB re 1 μPa rms sound pressure level criterion for disturbance from continuous noise lies within the range of likely background noise levels. It is therefore important to understand that exceeding the criteria for potential onset of disturbance effects does not in itself mean that disturbance will occur. Southall *et al*. (2007) notes that:

"…*the available data on behavioural responses do not converge on specific exposure conditions resulting in particular reactions, nor do they point to a common behavioural mechanism. Even data obtained with substantial controls, precision, and standardized metrics indicate high variance both in behavioural responses and in exposure conditions required to elicit a given response. It is clear that behavioural responses are strongly affected by the context of exposure and by the animal's experience, motivation, and conditioning. This reality, which is generally consistent with patterns of behaviour in other mammals (including humans), hampered our efforts to formulate broadly applicable behavioural response criteria for marine mammals based on exposure level alone*."

Consequently, the behavioural disturbance zones should be viewed as the maximum likely extent within which behavioural change could occur. The fact that an animal is within this area does not necessarily mean that disturbance will occur.

Appendix B.6 Summary of Noise Levels Used in Modelling

Source levels used in the underwater noise assessment and the origin of the data used are summarised in Table B.2.

Activity	Data source	Peak sound pressure level, dB re 1 µPa	SEL, dB re 1 $\mu Pa^2 s$	RMS sound pressure level, dB re 1 µPa
Drill ship (including thrusters)	Kyhn *et al.* (2011)	187	184 (1 s)	184
Drilling support vessel	Austin & McGillivray (2005)	191	188 (1 s)	188
VSP	Sercel G-Gun II 250	226	220	-

Table B.2: Noise generating activity source data

Throughout the drilling programme a standby vessel will be on station with the drill ship. It should be noted that the model treats all combined sources to be located at the same position this will therefore have the effect of over estimating the near field impacts, although is a valid assumption away from the source in the acoustic region known as the far field.

Appendix B.7 References used in Appendix B

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