NOPSEMA
Australia's offshore energy regulator

INFORMATION PAPER

Application of oil spill modelling in Environment Plans

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Table of Contents

Abbreviations/acronyms

AEP	Australian Energy Producers
ALARP	As low as reasonably practicable
AIMS	Australian Institute of Marine Science
AMSA	Australian Maritime Safety Authority
ANZECC	Australian and New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
DCCEEW	Department of Climate Change, Energy, the Environment and Water
EMBA	Environment that may be affected
Environment Regulations	Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2023
EP	Environment Plan
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
NOPSEMA	National Offshore Petroleum Safety and Environmental Management Authority
OPEP	Oil Pollution Emergency Plan
OPGGS Act	*Offshore Petroleum and Greenhouse Gas Storage Act 2006*
OPP	Offshore Project Proposal
OSMP	Operational and Scientific Monitoring Program
PAH	Polycyclic Aromatic Hydrocarbons
THC	Total Hydrocarbons

Units/metrics

ppb	Parts per billion
g/m^2	Grams per square metre
$litres/km^2$	Litres per square kilometre
µg/L	Micrograms per litre

1. Introduction

1.1. Information paper series

This Information Paper forms part of a series of documents published by the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA) that provide information relevant to the environmental management of offshore petroleum and greenhouse gas storage activities in Australian Commonwealth waters, which are subject to the provisions of the Commonwealth *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (OPGGS Act) and the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2023 (the Environment Regulations), including the NOPSEMA Program endorsed under Part 10 of the *Environment Protection and Biodiversity Conservation Act 1999*. The Information Paper series outlines aspects of good environmental management practice relevant to Australia's offshore petroleum industry.

This Information Paper provides general information and advice to assist titleholders in the application, interpretation and presentation of oil spill modelling results in Environment Plans (EP) and Oil Pollution Emergency Plans (OPEP). It should be read in conjunction with other relevant information available on the NOPSEMA website, particularly guidance for the preparation of EPs and OPEPs.

NOPSEMA encourages titleholders to apply the information presented in this paper when preparing EPs, as it provides for a consistent foundation for titleholders to identify, evaluate and manage oil pollution risks from their activities; however, it is not a regulatory requirement, or otherwise mandatory. It is expected that titleholders provide sound justification for any approaches adopted in the EP.

1.2. Purpose and scope

NOPSEMA recognises that oil spill modelling (see **Box 1**) is a valuable tool for informing risk evaluation and management, including response planning; however, it is technically complex and can be easily misinterpreted and misunderstood in the absence of appropriate context. Further, as with all models, oil spill model outcomes have inherent limitations, which may be due to the type and quality of input data, and/or assumptions within the model itself. A well-informed, consistent and robust approach to oil spill modelling and a clearly explained presentation of modelling outputs are needed to provide rigorous evaluations of oil spill risk and to effectively communicate outcomes.

Box 1 – What is oil spill modelling?

Oil spill modelling is a tool used in risk evaluation and emergency response planning. It essentially involves using a computer program to simulate hypothetical oil spills and predict how oil may behave and spread in the marine environment under varying oceanographic and meteorological conditions. It can be used to identify the environment that may be affected by oil, inform the assessment of potential consequences of oil on the environment, inform the evaluation and adoption of oil spill preparedness and response control measures and inform operational and scientific monitoring arrangements.

The purpose of this Information Paper is to provide information and advice to assist titleholders in the application, interpretation and presentation of oil spill modelling in EPs and OPEPs. In addition, the Information Paper provides advice on communicating modelling outcomes with stakeholders. Aspects of

this Information Paper may be broadly relevant to Offshore Project Proposals (OPP) and proponents should consider this in the context of the regulatory requirements that apply to OPPs.

There are a number of different approaches to oil spill modelling. The two commonly applied approaches are stochastic and deterministic modelling (see **Box 2**). These approaches may be used in combination to inform oil spill risk assessments, and response and preparedness planning. This Information Paper primarily focuses on the application of stochastic modelling but also has application to the use of deterministic modelling in oil spill response planning.

Box 2 – Stochastic modelling vs deterministic modelling

Stochastic modelling is created by overlaying the results of multiple (often 10's to 100's) individual computer-based spill simulations. The simulated oil spills typically start from the same location (e.g. a drilling location or production platform), applying common hydrocarbon type and release scenario inputs with different start times/dates and subject to wind and weather conditions drawn from historical records or other models. Stochastic modelling identifies all the areas that could be affected by multiple overlaid spill simulations rather than just presenting one spill simulation.

Deterministic modelling creates a computer-based simulation of a single hypothetical spill subject to a single set of wind and weather conditions. It forecasts the fate and behaviour of oil from a single model run. When used in a planning context to inform preparation of an EP, deterministic modelling provides a representation of what a single oil spill could look like and the area it may affect.

Deterministic modelling is also often conducted following an actual oil pollution event to predict where oil may go and how it may behave in the marine environment at the time of the event. When used this way, its results help inform how a response may be mounted in near real time.

For more information about stochastic and deterministic modelling, see NOPSEMA's oil spill modelling fact sheets available on its website.

This information paper should be read in conjunction with NOPSEMA's Oil Pollution Risk Management Guidance Note (GN1488), which provides information on the application of the Environment Regulations to oil pollution risk management.

Guidance Note GN1488 – Oil Pollution Risk Management

This Information Paper is not written with the intent of providing information or advice on the design or operation of oil spill models or the use of oil spill modelling in the event of an actual oil pollution incident.

In addition, the Information Paper does not provide information or advice on the application of modelling in the evaluation and management of routine emissions and discharges from offshore petroleum activities (e.g. produced water).

Further, this Information Paper does not provide specific information or advice on identifying relevant persons for the purpose of consultation under regulation 25 of the Environment Regulations. Refer to NOPSEMA's Consultation in the Course of Preparing an Environment Plan Guideline (GL2086) for further information on that topic.

Guideline GL2086 – Consultation in the Course of Preparing an Environment Plan

2. Oil spill model inputs

Oil spill modelling relies on a range of inputs to accurately simulate the behaviour and trajectory of oil in the marine environment. Using high quality, site-specific inputs provides confidence that the model realistically represents how oil is likely to behave in the actual environmental setting for the release.

Key model inputs include:

- the source and characteristics of the oil spill release event (e.g. well blowout, pipeline leak, loss of containment from a vessel)
- the location of the oil spill release and historical or modelled information on the physical environment of that location (and the broader area that might be exposed to oil), such as physicochemical conditions of the water column and sea surface layers (e.g. water temperature, salinity, including stratification), wind data, ocean current data, tidal conditions and bathymetry data
- the type and characteristics of the oil (i.e. physical properties), including density, specific gravity, viscosity and hydrocarbon classification
- the volume and rate of discharge of the oil, including the total volume of oil that could credibly be released and the timeframe over which it could be released
- the scenario(s) to be modelled, including unmitigated vs mitigated scenarios, surface or subsurface discharge, instantaneous release or continuous release, number of simulations and different release days and seasons.

It is important that titleholders detail the model inputs, parameters and assumptions in the EP to demonstrate that the results generated by the modelling are appropriate for the oil pollution risks of the proposed activity. The EP should demonstrate that the modelling is directly applicable to the proposed activity and matches the sources, oil types, release durations, volumes and release locations relevant to the spill risk scenarios identified.

3. Selecting oil spill exposure values

Oil spill exposure values applied to modelling outputs are vital for identifying features of the environment that may be affected by oil, assessing the potential consequences of oil on the environment and informing the evaluation and adoption of preventative, preparedness and response control measures (including monitoring arrangements) to manage the risk to as low as reasonably practicable (ALARP) and an acceptable level. These values, which apply to floating oil, shoreline oil, dissolved oil and entrained oil, help determine the potential extent and degree of exposure to different phases of oil (see **Box 3**).

Box 3 – Forms of hydrocarbons

Floating oil refers to oil that is predicted to be floating on the surface of the water.

Shoreline oil refers to oil that is predicted to reach the coastline, including beaches, rocky shores and mangroves.

Dissolved oil is the portion of oil that is predicted to have dissolved into seawater. Dissolved oil contains soluble and semi-soluble compounds.

Entrained oil consists of oil droplets that are predicted to suspend in the water column. Entrained oil contains mostly insoluble compounds but can include soluble and semi-soluble compounds that have not yet dissolved or degraded.

The exposure values selected may vary depending on the purpose and the specific circumstances relevant to the oil spill risk.

Given the importance of applying appropriate oil spill exposure values to meet the requirements of the Environment Regulations, NOPSEMA provides the following general advice:

- a range of exposure values should be applied when analysing the results of oil spill modelling, depending on the purpose for which the modelling outputs are to be used (see **Table 1** and **Section 4** below), including:
    i. identification of the environment that may be affected by hydrocarbons, including the pathways and degree of exposure (in accordance with regs 21(2) and (3));
    ii. evaluation of consequences of hydrocarbon exposure on all relevant values, sensitivities and features of the environment (in accordance with regs 21(5) and (6));
    iii. informing the evaluation and adoption of oil spill response preparedness and response control measures (and protection priorities) that provide the best net environmental benefit (in accordance with regs 21(5), (6) and (9)); and
    iv. informing operational and scientific monitoring arrangements, including monitoring priorities (regs 22(9) and (10)).
- the exposure values selected should enable the titleholder to meet the requirement for an EP to evaluate all environmental impacts and risks. To achieve this, it is necessary to identify and evaluate the potential consequences of different levels of contact exposure. A comprehensive evaluation of oil spill consequences is considered foundational for the titleholder to detail evidence and reasoning in the EP to justify its decision-making about appropriate oil spill response options and capability
- the exposure values selected should be appropriate to inform the evaluation of consequences to all relevant features, values and sensitivities of the environment (noting the scope of 'environment' as defined in regulation 5) that may be affected by oil on/in the water surface, water column and shorelines
- the exposure values selected should be suitably justified and supported by scientific evidence where possible. In the absence of robust scientific evidence, conservative exposure values should be selected to account for the uncertainty in consequences on ecological, social, economic and cultural features of

the environment, but also for the broader uncertainties associated with oil spill modelling inputs, environmental conditions and predictions of receptor exposure

- zones representing different exposure intensities and probabilities of exposure may be used to account for uncertainty in consequences.

3.1. Recommended exposure values

To assist with the consistent application of oil spill modelling and risk evaluation, NOPSEMA has identified a range of generic exposure values that are based on peer-reviewed literature, relevant policy and management context, or relevant national and international guidance regarding the known limitations of oil spill response techniques and impacts/consequences of oil in the environment.

The recommended exposure values presented in **Table 1** are not a regulatory requirement, or otherwise mandatory. NOPSEMA encourages titleholders to adopt these values, where appropriate, to provide for consistent application, interpretation and presentation of oil spill modelling results in EPs and OPEPs. Notwithstanding, it is expected that titleholders provide sound justification for any approaches adopted in the EP.

There may be circumstances where alternative exposure values may be relevant and are selected, taking into consideration the characteristics of the oil and the values and sensitivities of the receiving environment. Where titleholders use alternative exposure values, the EP will need to provide justification of the suitability of the selected alternative exposure values.

Table 1 Recommended exposure values

Type	Exposure values[1][2]	Purpose		
		Identifying the existing environment that may be affected (EMBA) by oil [regs 21(2) and (3)] and assessing the consequences of oil on the environment [regs 21(5) and (6)]	**Informing the evaluation and adoption of oil spill preparedness and response control measures [regs 21(5), (6) and 22(9)]**	**Informing operational and scientific monitoring arrangements [regs 22(9) and (10)]**
Floating oil	**High** 50 g/m^2 (~50,000 litres/km^2)	✓ It represents the concentration of floating oil at or above which there is an increased likelihood of consequences on ecological, social, economic and cultural features of the environment.	✓ At this concentration or above, containment and recovery (e.g. booms and skimmers), and chemical treatment (e.g. dispersant application) control measures are expected to be most effective.	✓ It represents the concentration of floating oil at or above that is of high priority for operational and scientific monitoring. At this concentration, hydrocarbons transition from appearing as metallic sheen to continuous or discontinuous 'true oil' on the surface of the ocean (Bonn Agreement, 2004; see **Box 4**).
	Moderate 10 g/m^2	✓ It represents a lower concentration for identifying ecological features of the environment that may be affected by	✓ At this concentration or above, containment and recovery (e.g., booms and skimmers), and chemical treatment	✓ It represents the concentration of floating oil that is of priority for operational and scientific monitoring.

[1] The exposure values are instantaneous oil concentrations, where instantaneous would generally be determined by the model time step. For example, the concentrations may be time averaged over one to several hours.
[2] The use of the terms "low", "moderate" and "high" exposure values relates to oil concentration and does not necessarily correlate to the degree of consequences/impacts on the environment.

Type	Exposure values[12]	Purpose		
		Identifying the existing environment that may be affected (EMBA) by oil [regs 21(2) and (3)] and assessing the consequences of oil on the environment [regs 21(5) and (6)]	**Informing the evaluation and adoption of oil spill preparedness and response control measures [regs 21(5), (6) and 22(9)]**	**Informing operational and scientific monitoring arrangements [regs 22(9) and (10)]**
	(~10,000 litres/km^2)	floating oil, and for assessing the potential consequences on these features. For example, exposure to concentrations of floating oil at or above this level may be harmful to birds and marine mammals (French et al., 1996; French-McCay, 2009).	(e.g. dispersant application) control measures may become effective (AMSA, 2015a), depending on the environment and hydrocarbon characteristics.	At this concentration, hydrocarbons may appear as a metallic sheen (Bonn Agreement, 2004).
	Low 1 g/m^2 (~1,000 litres/km^2)	✓ It represents a lower concentration for identifying social, economic and cultural features of the environment that may be affected by floating oil, and for assessing the potential consequences on these features. At this concentration, consequences on ecological features of the environment are generally not expected; however, consequences may occur depending on factors such as the sensitivity of specific features or management/conservation/protection	At this concentration, available response control measures may have limited effectiveness, depending on the environment and hydrocarbon characteristics. Natural degradation may be the response option with the highest net environmental benefit.	✓ It represents a lower concentration for defining the planning area for operational and scientific monitoring, within which further analysis can be done to inform monitoring priorities. At this concentration, hydrocarbons may appear as a silver to rainbow sheen under calm conditions (Bonn Agreement, 2004).

Type	Exposure values[12]	Purpose		
		Identifying the existing environment that may be affected (EMBA) by oil [regs 21(2) and (3)] and assessing the consequences of oil on the environment [regs 21(5) and (6)]	**Informing the evaluation and adoption of oil spill preparedness and response control measures [regs 21(5), (6) and 22(9)]**	**Informing operational and scientific monitoring arrangements [regs 22(9) and (10)]**
		objectives of the environment (e.g. marine protected areas and First Nations cultural heritage).		
Shoreline oil	**High** 1,000 g/m^2	✓ It represents the concentration of shoreline oil at or above which there is an increased likelihood of consequences on ecological, social, economic and cultural features of the environment. For example, impacts may occur to salt marsh plants and mangroves exposed to shoreline oil at or above this concentration (Lin and Mendelssohn, 1996; Grant et al., 1993; Suprayogi and Murray, 1999).	✓ It represents the concentration of shoreline oil that is likely to require intensive clean-up effort. Natural degradation alone is unlikely to result in a net environmental benefit when compared with active clean-up options (AMSA, 2015b).	✓ It represents the concentration of shoreline oil that is of high priority for operational and scientific monitoring.
	Moderate 100 g/m^2	✓ It represents a lower concentration for identifying ecological features of the environment that may be affected by shoreline oil, and for assessing the	✓ It represents the concentration of shoreline oil that is likely to require clean-up effort on man-made structures, sandy or rocky beaches/ shorelines, as	✓ It represents the concentration of shoreline oil that is of priority for operational and scientific monitoring.

Type	Exposure values[12]	Purpose		
		Identifying the existing environment that may be affected (EMBA) by oil [regs 21(2) and (3)] and assessing the consequences of oil on the environment [regs 21(5) and (6)]	**Informing the evaluation and adoption of oil spill preparedness and response control measures [regs 21(5), (6) and 22(9)]**	**Informing operational and scientific monitoring arrangements [regs 22(9) and (10)]**
		potential consequences on these features. For example, sublethal and lethal impacts may occur to shorebirds and marine fauna (e.g. fur-bearing aquatic mammals, such as sea lions, and marine reptiles) exposed to shoreline oil at or above this concentration (French et al., 1996; French-McCay, 2009).	well as more sensitive marine habitats (AMSA, 2015b).	
	Low 10 g/m^2	✓ It represents a lower concentration for identifying social, economic and cultural features of the environment that may be affected by shoreline oil, and for assessing the potential consequences on these features. At this concentration, consequences on ecological features of the environment are generally not expected; however, consequence may occur depending on factors such as the sensitivity of specific features or	At this concentration, available response control measures may have limited effectiveness, depending on the environment and hydrocarbon characteristics. Natural degradation may be the response option with the highest net environmental benefit.	✓ It represents a lower concentration for defining the planning area for operational and scientific monitoring, within which further analysis can be done to inform monitoring priorities.

Type	Exposure values[12]	Purpose		
		Identifying the existing environment that may be affected (EMBA) by oil [regs 21(2) and (3)] and assessing the consequences of oil on the environment [regs 21(5) and (6)]	**Informing the evaluation and adoption of oil spill preparedness and response control measures [regs 21(5), (6) and 22(9)]**	**Informing operational and scientific monitoring arrangements [regs 22(9) and (10)]**
		management/conservation/protection objectives for the environment (e.g. marine protected areas and First Nations cultural heritage).		
Dissolved oil	**High** 300 µg/L (ppb) PAH[3]	✓ It represents a concentration of dissolved oil at or above which there is an increased likelihood of consequences on ecological, social, economic and cultural features of the environment. For example, toxic effects, including acute toxicity and lethal effects to species or life stages may occur at or above this concentration (e.g. fish and invertebrates) (French-McCay, 2002).	✓ A relevant consideration in informing the identification of protection priorities and selection of response control measures that provide the best net environmental benefit.	✓ It represents the concentration of dissolved oil that is of high priority for operational and scientific monitoring.

[3] Dissolved oil exposure values are expressed as micrograms per litre (µg/L or parts per billion (ppb) polycyclic aromatic hydrocarbons (PAHs).

Type	Exposure values[12]	Purpose		
		Identifying the existing environment that may be affected (EMBA) by oil [regs 21(2) and (3)] and assessing the consequences of oil on the environment [regs 21(5) and (6)]	**Informing the evaluation and adoption of oil spill preparedness and response control measures [regs 21(5), (6) and 22(9)]**	**Informing operational and scientific monitoring arrangements [regs 22(9) and (10)]**
	Moderate 50 µg/L (ppb) PAH	✓ It represents a concentration of dissolved oil at or above which there is an increased likelihood of consequences on ecological, social, economic and cultural features of the environment. For example, toxic effects, including lethal and sublethal effects to sensitive species or life stages may occur at or above this concentration (e.g. fish and invertebrates) (French-McCay, 2002).	✓ A relevant consideration in informing the identification of protection priorities and selection of response control measures that provide the best net environmental benefit.	✓ It represents the concentration of dissolved oil that is of priority for operational and scientific monitoring.
	Low 10 µg/L (ppb) PAH	✓ It represents a lower concentration for identifying ecological, social, economic and cultural features of the environment that may be affected by dissolved oil, and for assessing the potential consequences on these features. For example, sublethal effects to sensitive species or life stages may occur	✓ A relevant consideration in informing the identification of protection priorities and selection of response control measures that provide the best net environmental benefit.	✓ It represents a lower concentration for defining the planning area for operational and scientific monitoring, within which further analysis can be done to inform monitoring priorities.

Type	Exposure values[12]	Purpose		
		Identifying the existing environment that may be affected (EMBA) by oil [regs 21(2) and (3)] and assessing the consequences of oil on the environment [regs 21(5) and (6)]	**Informing the evaluation and adoption of oil spill preparedness and response control measures [regs 21(5), (6) and 22(9)]**	**Informing operational and scientific monitoring arrangements [regs 22(9) and (10)]**
		at or above this concentration (e.g. coral larvae) (French-McCay et al, 2018). Below this concentration, consequences may occur depending on factors such as the sensitivity of specific features or management/conservation/protection objectives for the environment (e.g. marine protected areas and First Nations cultural heritage). A lower concentration may be appropriate in some circumstances, such as shallow clear waters (<20 m), to account for the effect of phototoxicity (French-McCay et al, 2018).		
Entrained	**High**	✓ It represents a concentration of entrained oil at or above which there is an increased likelihood of consequences on ecological, social, economic and cultural features of the environment.	✓ A relevant consideration in informing the identification of protection priorities and selection of response control measures (e.g. dispersant application) that provide the best net environmental benefit.	✓ It represents the concentration of entrained oil that is of high priority for operational and scientific monitoring.

Type	Exposure values[12]	Purpose		
		Identifying the existing environment that may be affected (EMBA) by oil [regs 21(2) and (3)] and assessing the consequences of oil on the environment [regs 21(5) and (6)]	**Informing the evaluation and adoption of oil spill preparedness and response control measures [regs 21(5), (6) and 22(9)]**	**Informing operational and scientific monitoring arrangements [regs 22(9) and (10)]**
	1,000 µg/L (ppb) THC[4]	For example, sublethal effects to sensitive species or life stages may o occur at or above this concentration (e.g. Fish and invertebrates) (French-McCay, 2025; Negri et al, 2025).		
	Moderate 100 µg/L (ppb) THC	✓ It represents a lower concentration for identifying ecological, social, economic and cultural features of the environment that may be affected by entrained oil, and for assessing the potential consequences on these features. It is a conservative exposure value to account for the uncertainty in consequences on ecological, social, economic and cultural features of the environment.	✓ A relevant consideration in informing the identification of protection priorities and selection of response control measures (e.g. dispersant application) that provide the best net environmental benefit.	✓ It represents the concentration of entrained oil that is of priority for operational and scientific monitoring.

[4] Entrained oil spill exposure values are expressed as micrograms per litre (µg/L) or parts per billion (ppb) total hydrocarbons (THC).

Type	Exposure values[12]	Purpose		
		Identifying the existing environment that may be affected (EMBA) by oil [regs 21(2) and (3)] and assessing the consequences of oil on the environment [regs 21(5) and (6)]	**Informing the evaluation and adoption of oil spill preparedness and response control measures [regs 21(5), (6) and 22(9)]**	**Informing operational and scientific monitoring arrangements [regs 22(9) and (10)]**
	Low 10 µg/L (ppb) THC	At this concentration, consequences on ecological, social, economic and cultural features of the environment are generally not expected; however, consequences may occur depending on factors such as the sensitivity of specific features or management/conservation/protection objectives for the environment (e.g. marine protected areas and First Nations cultural heritage).	Available response control measures are limited. Natural degradation may be the response option with the highest net environmental benefit.	✓ It represents a lower concentration for defining the planning area for operational and scientific monitoring, within which further analysis can be done to inform monitoring priorities. It is based on exceedance of water quality guidelines (ANZECC/ARMCANZ, 2000).

Note: ✓indicates that the exposure value should be applied for that specific purpose.

Box 4 – The Bonn Agreement Oil Appearance Code

The Bonn Agreement Oil Appearance Code is a series of five categories or 'codes' that describe the relationship between the appearances of oil on the sea surface to the thickness of the oil layer, as presented in **Table 2**.

Table 2 The Bonn Agreement Oil Appearance Code

Code	Description – Appearance	Layer Thickness Interval (µm)	Litres per km^2
1	Sheen (silvery/grey)	0.04 to 0.30	40 – 300
2	Rainbow	0.30 to 5.0	300 – 5000
3	Metallic	5.0 to 50	5000 – 50,000
4	Discontinuous True Oil Colour	50 to 200	50,000 – 200,000
5	Continuous True Oil Colour	More than 200	More than 200,000

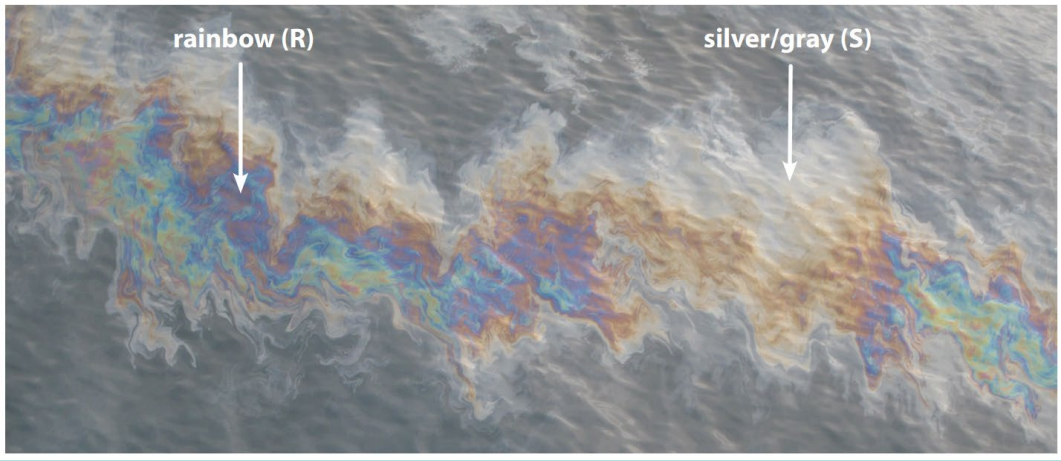

Figure 1 Photograph showing the difference in oil colour and thickness of the sea surface (Image credit: NOAA Office of Response and Restoration)

4. Using oil spill modelling outcomes

4.1. Defining the environment that may be affected by an oil spill

Regulation 21(2) *- The environment plan must:*

(a) describe the existing environment that may be affected by the activity; and

(b) include details of the particular relevant values and sensitivities (if any) of that environment.

Regulation 21(3) *– Without limiting paragraph (2)(b), relevant values and sensitivities may include any of the following:*

(a) the world heritage values of a declared World Heritage property;

(b) the National Heritage values of a National Heritage place;

(c) the ecological character of a declared Ramsar wetland;

(d) the presence of a listed threatened species or listed threatened ecological community;

(e) the presence of a listed migratory species;

(f) any values and sensitivities that exist in, or in relation to, part or all of:

(i) a Commonwealth marine area; or

(ii) Commonwealth land.

Regulation 5 *- Environment means:*

(a) ecosystems and their constituent parts, including people and communities; and

(b) natural and physical resources; and

(c) the qualities and characteristics of locations, places and areas; and

(d) the heritage value of places;

and includes the social, economic and cultural features of the matters mentioned in paragraphs (a), (b), (c) and (d).

The EP must describe the existing environment that may be affected (EMBA) by the activity (in accordance with regs 21(2) and (3)).

NOPSEMA expects the EP to describe the area that may be exposed to hydrocarbons in the event of an oil pollution incident from the activity and the extent of oil spill response and monitoring activities. The EP should describe the environment in a level of detail that is commensurate to the degree and likelihood of oil exposure.

A common approach to defining the EMBA for an oil pollution incident is to use the outputs of stochastic modelling (see **Box 2**). It is important to understand that the area affected by an actual oil pollution event will be much smaller than the outer boundary produced by a stochastic model. This is because this area does not represent the trajectory of a single computer-based spill simulation. Rather, it represents the compilation of possible outcomes and encompasses the area predicted to be affected from a number of computer-based spill simulations (often hundreds of simulations).

Titleholders should consider the following information and general advice when using oil spill modelling to inform the EMBA by an oil pollution incident:

- using the outputs of the modelling, titleholders may wish to define a number of geographical boundaries (zones) representing different exposure intensities and/or probabilities of exposure within the broader EMBA
- oil spill exposure values, and/or probabilities of exposure, should not be used to constrain the extent of predicted oil contact derived from oil spill modelling, as this has the effect of excluding potentially affected receptors, sensitivities and values. For example, where coastlines are identified as being exposed to oil, titleholders should consider the inclusion of any semi-enclosed coastal embayments and inlets where these features have not been identified by the model as being exposed to oil
- Titleholders should identify and describe the environment that may be contacted by surface and subsurface hydrocarbons from a worst-case oil pollution incident in a level of detail commensurate to the degree and likelihood of exposure. This includes:
  - the key values and sensitivities of the social, economic and cultural features of ecosystems and their constituent parts, the natural and physical resources, qualities and characteristics of locations, places and areas, and the heritage values of places; and
  - matters protected under Part 3 of the of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).
- the level of detail provided on the existing environment should be commensurate with the environmental value and sensitivity of receptors including their vulnerability, abundance, distribution, resilience and the predicted extent, severity, and duration of potential oil pollution consequences.

4.2. Evaluating potential environmental consequences of an oil spill

Regulation 21(5) *- The environment plan must include:*

(a) details of the environmental impacts and risks of the activity; and

(b) an evaluation of all the impacts and risks, appropriate to the nature and scale of each impact or risk; and

(c) details of the control measures that will be used to reduce the impacts and risks of the activity to as low as reasonably practicable and an acceptable level.

Regulation 21(6) *- To avoid doubt, the evaluation mentioned in paragraph (5)(b) must evaluate all the environmental impacts and risks arising directly or indirectly from:*

(a) all operations of the activity; and

(b) potential emergency conditions, whether resulting from accident or any other reason.

GN1344 provides general guidance on NOPSEMA's expectations of titleholder risk evaluation processes to address the regulatory requirements.

Guidance Note GN1344 – Environment Plan Content Requirements

GN1488 provides information on the application of the Environment Regulations to oil pollution risk management.

Guidance Note GN1488 – Oil Pollution Risk Management

Titleholders should consider the following information and general advice in using oil spill modelling to inform the evaluation of oil pollution risks:

- the exposure values selected should be relevant to informing risk evaluations of potential socio-economic consequences (e.g. fish tainting effects, impacts on recreational and cultural values) and environmental consequences (e.g. toxic effects)
- various exposure values should be applied to interpret modelling to inform an evaluation of potential consequence to receptors/features that might be contacted by oil at these exposure values (see **Table 1**). This should include suitable discussion of contemporary scientific literature and/or oil-specific scientific investigations into the effects of hydrocarbon exposure on relevant receptors/features. This discussion should consider the pathway and duration of exposure. The risk evaluation should also take into account the composition and range of contaminants that may be present in the hydrocarbon (e.g. heavy metals)
- in the preparation of an EP, the level of content and effort to evaluate effects should be scaled according to the predicted oil exposure levels and contact probabilities. For example, receptors of low sensitivity, exposed to low levels or with very low probability of oil contact will require a less detailed description and evaluation
- the description of potential consequences should present the likely range and scale of consequences of hydrocarbon exposure based on the scientific evidence, while also acknowledging any uncertainty or diversity of opinions in the scientific literature. The potential consequences on features should not be downplayed or ignored, based on a limited set or dated research. Where reliable research is not available, any assumptions made in the consequence evaluation should be appropriately acknowledged and justified in the EP
- duration of exposure is a relevant consideration in evaluating the potential consequences associated with oil contact at various concentrations. Application of duration of exposure should consider the different exposure pathways in context of the range of receptors/features that are present in the receiving environment
- where duration is incorporated into modelling exposure values for the purpose of evaluating consequences of a spill, this should be presented in conjunction with instantaneous exposure values that set the context in relation to identification of environmental values and sensitivities that may be contacted by oil

- scientific uncertainties regarding the consequences of hydrocarbon exposure should be acknowledged in risk evaluations. For example, the toxic effects of dissolved hydrocarbons on selected marine species are relatively-well understood, in comparison to the level of understanding about how entrained oil droplets affect the environment. Further, emerging research continues to identify a range of influences on oil toxicity (e.g. effects of ultraviolet radiation in shallow waters (French-McCay et al. 2018)) and sublethal effects of dissolved hydrocarbons at lower concentrations. A precautionary approach should be applied in the absence of certainty consistent with the principles of ecologically sustainable development
- when using modelling to inform risk assessments, titleholders should consider the limitations, precision and spatial resolution of the modelling and the level of uncertainty in the modelling inputs and outputs. An appropriate level of conservatism should be applied to the modelling outputs and consideration of whether receptors/features located outside but near the boundary of the predicted distribution of oil in the environment should be included in the evaluation of risks. For example, it would be reasonable to expect that a sensitive receptor/feature, such as protected marine areas located adjacent to the boundary of the area predicted to be affected by the modelling, may also need to be monitored for exposure (or as a control site) at the time of an actual oil pollution incident, to account for uncertainties in the modelling and to ground truth predictions in an oil pollution incident.

4.3. Informing oil spill response planning and preparedness

Regulation 22(9) *– The oil pollution emergency plan must include adequate arrangements for responding to and monitoring oil pollution, including the following:*

(a) the control measures necessary *for timely response to an emergency that results or may result in oil pollution;*

(b) the arrangements and capability that will be in place, for the duration of the activity, to ensure timely implementation of the control measures, including arrangements for ongoing maintenance of response capability;

(c) the arrangements and capability that will be in place for monitoring the effectiveness of the control measures and ensuring that the environmental performance standards for the control measures are met;

(d) the arrangements and capability in place for monitoring oil pollution to inform response activities.

Regulation 22(10) *- The implementation strategy must provide for monitoring of impacts to the environment from oil pollution and response activities that:*

(a) is appropriate to the nature and scale of the risk of environmental impacts for the activity; and

(b) is sufficient to inform any remediation activities.

4.3.1. Response arrangements

GN1488 provides information on the application of the Environment Regulations to oil pollution risk management.

Guidance Note GN1488 – Oil Pollution Risk Management

Titleholders should consider the following general advice in using oil spill modelling to inform the selection of oil spill response arrangements:

- the outputs of oil spill modelling should be used by titleholders to identify areas at greatest risk, including protection priorities, sensitive marine habitats, shorelines and social, cultural and economic features of the environment
- the resource requirements for responding to worst-case oil pollution scenarios should be identified and defined based on reasonable planning assumptions and realistic response considerations. Relevant modelling outputs such as predicted shortest time to contact, highest volumes ashore, and consequences to protection priorities, should be relied upon to inform the response requirements.

4.3.2. Monitoring arrangements

IP1349 provides information and general advice to assist titleholders in planning and implementing Operational and Scientific Monitoring Programs (OSMPs) for oil spills from offshore activities.

Information Paper IP1349 – Operational and Scientific Monitoring Programs

In defining a planning area for scientific monitoring purposes, NOPSEMA is of the view that the 'low' exposure values (see **Table 1**) should be used, within which further analysis can be done to inform monitoring priorities. This does not mean that titleholders are required to develop and maintain an equal level of monitoring capability for the entire planning area.

AEP has published a Joint Industry Operational and Scientific Monitoring Plan Framework for oil pollution monitoring arrangements that titleholders can use for monitoring planning purposes. The framework includes an Operational and Scientific Monitoring Bridging Implementation Plan template to allow titleholders to tailor the arrangements to their specific circumstances. NOPSEMA has prepared a Regulatory Advice Statement - Joint Industry Operational and Scientific Monitoring Framework to assist titleholders in applying the framework and template to produce fit-for-purpose oil pollution monitoring arrangements in an EP and to meet the requirements of the Environment Regulations.

4.4. Presenting modelling outputs in EPs and OPEPs

NOPSEMA provides the following general advice in relation to presenting the outputs of oil spill modelling in EPs and OPEPs:

- a mix of geographic representations (mapped) and tabular formats should be used to present the outputs of oil spill modelling in EPs and OPEPs. Consideration should be given to the conclusion or outcomes that the map or table is aiming to support. For example, if the EP is describing a particular impact or set of related impacts from an oil spill, then a map showing the boundary of possible exposure at a relevant limit, and the probabilities of exposure at that limit, should be used. Similarly, if the EP is seeking to justify appropriate response capability, then time to exposure tables could be one

way to demonstrate that appropriate spill response arrangements, available within appropriate timeframes, are in place

- geographic representations should be at a suitable scale(s), use consistent terminology/symbology and be adequately labelled to allow for ease of interpretation of the modelling presented
- the scales and symbology adopted to classify hydrocarbons presented in geographic representations should reflect relevant scientific literature and standards
- geographic representation should clearly identify the exposure value and number of individual scenarios
- geographic representations may be used to depict the probability of and time to contact for different exposure values
- geophysical representations may be used to depict point-in-time predictions at intervals relevant to the spill duration (e.g. Day 1, Day 5, Day 10 … etc.)
- geographic representations may be used to depict zones representing different exposure intensities and/or probabilities of exposure
- tabular representation of modelling outputs may be used to describe predicted contact with spatially defined receptors (e.g. shorelines, faunal congregations, protected areas, etc.). Modelling output tables should include predictions of minimum time to contact at relevant exposure values, peak exposure values, worst case loadings and periods of exposure
- three-dimensional graphical representations of water column exposure may be used when hydrocarbons are predicted to contact shallow receptors (e.g. coral reefs, seagrass systems)
- geographical representations of deterministic or individual hypothetical spills may be used to depict minimum time to shoreline, minimum time to jurisdictional boundaries, largest exposure area, maximum volume ashore and longest length of shoreline contacted by hydrocarbons
- geographical representations of mitigated and non-mitigated scenarios can be helpful to demonstrate the predicted effectiveness and potential impacts of oil spill response control measures. For example, comparing the modelled extent of surface and water column oil concentrations and shoreline accumulations, with and without dispersant application.

4.5. Communicating modelling outcomes with stakeholders

Communicating oil spill modelling results effectively with stakeholders requires simplifying technically complex information and data while maintaining accuracy and transparency. This allows stakeholders to be able to meaningfully engage with the modelling results and better understand the risk and inform environmental management. As such, NOPSEMA provides the following general advice:

- a range of visual aids and maps should be used to support communications with stakeholders, such as geographic representations (maps), videos, presentations, animations, conceptual models, infographics or other graphics. By way of example, the use of animation or time-lapse visualisations in communications can help stakeholders understand how a spill might evolve over time
- information sheets, fact sheets and non-technical summaries should be used to explain the outcome of the oil spill modelling

- communications should be tailored to the audience and where appropriate use plain language (clear, simple and expressed terms) and avoid technical jargon. Where necessary, define technical terms clearly
- present oil spill modelling results through realistic, scenario-based narratives to make the information easier to comprehend
- exposure values should be communicated in terms of the appearance and significance of oil spill risk in real terms. For example, describing concentrations of floating oil in terms of predicted appearance as per the Bonn Agreement Oil Appearance Code (see **Box 4**)
- avoid showing a single boundary, outer limit of hydrocarbon exposure in communications with stakeholders as it can be easily misinterpreted without appropriate context and explanation of what that boundary represents
- clearly communicate the likelihood and consequences of an oil pollution incident, and how the risk is being managed
- be upfront about the assumptions, limitations and uncertainties of the model and explain how these are addressed or accounted for in risk evaluation and response planning.

5. Relevant legislation

Offshore Petroleum and Greenhouse Gas Storage Act 2006

Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2023

6. Related documents

Please refer to NOPSEMA's webpage for latest revisions of the following relevant documents:

N-04750-GN1344 – Guidance Note - Environment Plan Content Requirements

N-04750-GL1721 – Guideline - Environment Plan Decision-making

N-0475-0GN1488 – Guidance Note - Oil Pollution Risk Management

N-04750-IP1349 – Information Paper - Operational and Scientific Monitoring Programs

N-04750-GL2086 – Guideline – Consultation in the Course of Preparing an Environment Plan

NOPSEMA has also produced a range of fact sheets and a short video to help explain oil spill modelling in a more accessible and simplified format. These are available at Oil pollution risk management | NOPSEMA.

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