# 8. Environmental Impacts & Mitigation Measures

## 8.1 Introduction

The aim of Section 8 is to identify the environmental impacts and mitigation measures for the proposed Sunrise Gas Project. The chapter is structured so that both impacts and mitigation measures are discussed within the following phases:

- Drilling and Associated Activities;
- Installation and Construction;
- Commissioning and Operation; and
- Decommissioning.

Tables summarising the source of impact, potential environmental impacts, their effect and duration are included at the beginning of each phase.

### 8.1.1 Impacts

The impacts on the environment have been classified under the headings listed below and in accordance with the order of occurrence of the activity; drilling program, installation/construction, commissioning/operation and decommissioning. However, not all of the impacts listed will be relevant to every phase of the project.

- Atmospheric Emissions;
- Discharges to Sea;
- Noise, Vibration, Light and Heat;
- Waste to Shore; and
- Other Impacts

Where possible, environmental impacts are placed into context so that their significance and magnitude are considered. The classification of impacts has been standardised throughout the report in accordance with classification definitions as stated in **Table 8-1**.

**Table 8-1 Classification of Impacts**

| Category | Type | Description |
|---|---|---|
| Change | Negative<br>Positive<br>Neutral | A change which reduces the quality of the environment<br>A change which improves the quality of the environment<br>A change which does not affect the quality of the environment |
| Duration | Temporary<br>Short-term<br>Medium-term<br>Long-term<br>Permanent | Impact lasting for one year or less<br>Impact lasting one to seven years<br>Impact lasting seven to twenty years<br>Impact lasting twenty to fifty years<br>Impact lasting over fifty years |
| Effect | Negligible<br>Minor<br>Moderate<br>Significant<br>Serious | No likely environmental damage<br>Temporary impact with no impact on sensitive resources<br>Recoverable environmental loss with localised impact on sensitive resources<br>Severe recoverable environmental loss with regional impact on environmental resources<br>Widespread chronic environmental loss with widespread impact on environmental resources |

Source: EPA Classification

### 8.1.2 Mitigation Measures

Whilst mitigation measures implemented during the course of the construction, operation and decommissioning phases of the Sunrise Gas Project are vital for the protection of the environment, mitigation measures also form an inherent part of the pre-construction planning process.

This has taken the form of extensive and in depth consultation with all relevant government and non-government organisations (NGOs), as well as the public, to ensure consideration of all relevant impacts and concerns, and the implementation of appropriate mitigation measures. This process has already commenced for the Sunrise Project, with all relevant regulatory authorities and organisations consulted with, and the onset of the public consultation phase of the project (Chapter 10).

Consultation with adjacent marine users including fishermen, port authorities, traditional marine resource users, shipping companies, conservation groups and other affected parties will form an integral part of the ongoing consultation process facilitating good working relationships and the exchange of information between interested parties.

In-depth planning has also gone into the physical location of the development with careful environmental considerations given to the final location. Selection of the pipeline routes have been optimised to take into account potential environmentally sensitive areas. Baseline surveys have been undertaken identifying benthic communities to minimise placement on sensitive marine habitats.

An Emergency Response Plan and Oil Spill Contingency Plan which has already been prepared for the Timor Sea region will be implemented for the Sunrise Gas project which will address emergency and contingency arrangements and oil spill incidents. These plans will include:

- Oil spill trajectory modelling capability based on site specific metocean conditions and knowledge of oil weathering rates;
- Identification of oil-sensitive marine and coastal resources and priority protection areas;
- Identification of internal and external emergency organisations, responsibilities and resources (human and equipment and materials) for oil spill response, and call out details; and
- Spill response and clean up strategies for offshore and shoreline.

Mitigation measures have been based on APPEA’s ‘Code of Environmental Practice’ (APPEA, 1996). The Draft EMP contained in the following Chapter 9 provides further detail on the environmental safeguards required to prevent or limit damage to the environment.

### 8.1.3 Commitments

Commitments will be carried across the life of the project by Woodside and other future operators. During the planning and design phases, prior to drilling and construction, the following commitments will be adhered to, as detailed in **Chapter 9**. During the design phase equipment and machinery will be selected to minimise environmental impacts.

- Prepare a Drilling Environment Plan to ensure efficient power generation and planning of vehicle and vessel movements;
- Prepare a Facility Environment Plan to ensure efficient power generation, planning of vehicle and vessel movements and overall optimal operation;
- Obtain approval for non-water based drilling fluids. An Environment Plan will be drawn up and approved for the drilling programme prior to commencement;
- Implement an Emergency Response Plan (ERP);
- Implement WEL existing Timor Sea Oil Spill Contingency Plan. Amend this plan if required;
- Issue Notice to Mariners alerting them of development and associated activities;
- Minimise flaring where possible;
- Install breakaway self-sealing couplings on floating hoses that contain condensate;
- Design an adequate stormwater drainage system to allow oily waste and potential contaminated liquid waste to be collected and contained separately from clean stormwater;
- Install appropriate noise attenuation controls including silencers cladding where practicable;
- Prepare and implement a Waste Management Plan;
- Issue Notice to Mariners alerting them of development and associated activities;

- Prepare and implement greenhouse gas strategy to minimise emissions of greenhouse gas;
- Design and implement operational measures to minimise flaring and venting;
- The reduction of methane emissions to negligible levels through the combustion of regeneration offgas; and
- Maximise the use of waste heat from gas turbines.

## 8.2 Impacts during Drilling and Associated Activities

**Table 8-2** overleaf summarises the source of impact, potential environmental impacts, their effect and duration for the Drilling and Associated Activities phase which includes:

- Wellhead platform installation; and
- Drilling of platform and subsea wells.

## Table 8-2 Summary of Potential Environmental Impacts for Drilling and Associated Activities

| Project Component | Source of Impact | Potential Environmental Impact | Effect | Duration |
|---|---|---|---|---|
| Wellhead Platform Installation | a) Physical presence of production and wellhead platforms.<br>b) Power generation during installation<br>c) Lighting.<br>d) Disposal of construction wastes.<br>e) Presence of construction and support vessels.<br>f) Discharge of sewage and greywater.<br>g) Discharge of domestic waste including food scraps. | **Atmospheric Emissions**<br>▪ Greenhouse gases produced by drilling unit power generation (primarily $CO_2$)<br>▪ Atmospheric pollutants (primarily $NO_x$, $SO_x$, VOCs and smoke/particulates);<br>**Discharges to the Sea**<br>▪ Potential localised reduction in water quality.<br>**Noise, Vibration, Light and Heat**<br>▪ Potential disturbance to marine biota and birds.<br>▪ Potential attraction of marine organisms to the lights such as turtles<br>**Waste to Shore**<br>▪ Improper disposal. | <br>Negligible<br>Negligible<br><br>Negligible<br><br>Negligible<br>Negligible<br><br>Negligible | <br>Short-term<br>Short-term<br><br>Short-term<br><br>Short-term<br>Short-term<br><br>Temporary |
| Drilling of Platform and Subsea Wells | a) Anchoring/spudding of drilling unit.<br>b) Cuttings discharge and adherent drilling fluid.<br>c) Use of water based drilling fluids for the initial section of each well or for vertical wells.<br>d) Use of non-water based drilling fluids for deviated sections of wells.<br>e) Activity of support/supply vessels<br>f) Discharge of drilling chemicals and hydrocarbons attached to cuttings only.<br>g) Discharge of sewage and greywater.<br>h) Discharge of domestic waste including food scraps.<br>i) Oily water discharged to the environment during installation and operation of drilling facilities.<br>j) Disposal of domestic waste including paper and plastics etc.<br>k) Power generation.<br>l) Lighting.<br>m) Refuelling at sea. | **Atmospheric Emissions**<br>▪ Greenhouse gases produced by drilling unit power generation (primarily $CO_2$)<br>▪ Atmospheric pollutants (primarily $NO_x$, $SO_x$, VOCs and smoke/particulates);<br>**Discharges to the Sea**<br>▪ Smothering effects of accumulated drill cuttings on marine biota.<br>▪ Increased turbidity in the area from cuttings discharge<br>▪ Potential accumulation of metal and hydrocarbon concentrations in seabed sediments leading to toxicity.<br>▪ Potential bioaccumulation/ bioconcentration by marine biota of contaminants in non-water based fluids.<br>▪ Potential anoxia of sediment due to natural degradation.<br>▪ Potential reduction in water quality in the area.<br>▪ Potential of a significant fuel spill.<br>**Noise, Vibration, Light and Heat**<br>▪ Potential disturbance to marine organisms and birds due to noise and vibration.<br>**Waste to Shore**<br>▪ Improper disposal.<br>**Other Impacts**<br>▪ Disturbance to seabed and potential changes to seabed characteristics from drilling unit spud cans. | <br>Negligible<br>Negligible<br><br>Negligible<br>Negligible<br>Negligible<br>Negligible<br>Negligible<br>Negligible<br>Moderate<br><br>Negligible<br><br>Negligible<br><br>Negligible | <br>Short-term<br>Short-term<br><br>Short-term<br>Short-term<br>Short-term<br>Short-term<br>Short-term<br>Short-term<br>Short-term<br><br>Temporary<br><br>Temporary<br><br>Temporary |

### 8.2.1 Wellhead Platform Installation

Before the commencement of the platform-based drilling program, a wellhead platform must be installed from where a number wells will be drilled. A wellhead platform is not required for drilling any of the subsea wells.

The platform will not be constructed on site but rather it will be towed to the offshore lease area, offloaded and assembled in two main parts; topsides and substructures. Sources of impacts associated with the installation of the wellhead platform are as follows:

- Physical presence of production and wellhead platforms;
- Power generation during installation;
- Lighting;
- Disposal of construction wastes;
- Presence of construction and support vessels;
- Discharge of sewage and greywater; and
- Discharge of domestic waste including food scraps.

In relation to these sources, the following potential impacts are discussed in **Sections 8.2.1.1** to **8.2.1.4**:

***Atmospheric Emissions***

- Greenhouse gases produced during power generation (primarily $CO_2$); and
- Atmospheric pollutants (primarily $NO_x$, $SO_x$, VOCs and smoke/particulates).

***Discharges to the Sea:***

- Potential localised reduction in water quality.

***Noise, Vibration, Light and Heat:***

- Potential disturbance to marine biota and birds.

***Waste to Shore:***

- Improper disposal.

#### 8.2.1.1 Atmospheric Emissions

Power will be required to install and construct the platform. Diesel power generators will result in the following emissions to atmosphere:

- Carbon dioxide ($CO_2$);
- Nitrogen oxides ($NO_x$);
- Sulphur dioxide ($SO_2$);
- Carbon monoxide (CO);
- Volatile organic compounds (VOC); and
- Smoke and particulates.

The diesel consumption rate during drilling has been estimated at 10-20 tonnes/day. The resulting combustion emissions will not result in a significant reduction in air quality as the quantities will be relatively small, and the project area is isolated and far from sensitive receptors.

#### 8.2.1.2 Discharges to Sea

Discharges to sea are derived from a number of potential sources including the discharge of sewage, greywater, domestic waste and foodscraps. The workforce on board vessels will generate sewage and putrescible wastes which will need to be discharged to sea.

The normal procedure (prescribed under the *P(SL)A*) is for food scraps and sanitary effluents to be passed through a grinder or comminuter so that the final product can pass through a screen of <25 mm diameter, which is conducive to the rapid biodegradation of the waste on discharge to sea. These discharges will occur on a regular basis and may lead to an extremely localised and temporary reduction in water quality, including a slight increase in nutrient availability. This routine discharge is therefore considered to have a short-term and negligible impact on the marine environment.

#### 8.2.1.3 Noise, Vibration and Light

Potential exists for marine fauna to be disturbed by noise and vibration as a result of motors or heavy construction work on site during installation of bucket foundations, etc. Transportation of the platform and other components of the facility to the Sunrise Gas Project area will also produce noise and vibrations.

The frequency of whale and turtle visitations to the Sunrise Gas Project area is perceived to be low (Woodside, 2000); although whales, turtles and dolphins are known to occur within the wider region.

The response of Australian marine fauna to acoustical emissions from oil and gas activities will range from no effect to various behavioural changes (McCauley, 1994). Cetaceans (whales, dolphins, porpoises, etc.) are sensitive to sounds below the water surface. For some offshore developments there is the potential that severe sound waves created from drilling activities could induce stress, and any pulsating or modulating effects may cause abandonment of important habitats, such as calving and nursery sites (McCauley, 1994). Smaller toothed cetaceans, such as dolphins and porpoises are known to have poor hearing in the low frequency range and may be able to approach operating vessels closely without adverse behavioural or pathological effects (Woodside, 2000).

Electro-physical studies have indicated that the best hearing range for marine turtles is in the range 100–700 Hz; however, no definitive thresholds are known for the sensitivity to underwater sounds or the levels required to cause pathological damage (McCauley, 1994). Turtles would avoid areas where sound was at such levels long before it caused them any physical harm.

Disturbance to fish is expected to be minimal as fish will be expected to avoid acoustical emissions which reach levels that may cause pathological effects. Fish have been found to be exposed to elevated acoustical levels (>205 dB re 1µPa) without lethal effects (APPEA, 1998). This is comparable to background non-biological sea noise of 85–95 dB or $1\mu Pa^2/Hz$ under extreme windy conditions and 80 dB re $1\mu Pa^2/Hz$ for rainfall (McCauley, 1994).

As disturbances associated with the drilling programme will be localised, and the effect on marine mammals, turtles and fish is expected to be moderate. Further to this, it is important to note that whales, turtles and fish are highly mobile and will temporarily avoid the Sunrise Gas Project area, if disturbed as a result of drilling operations.

Artificial lighting and well testing flares have the potential to disorientate and confuse hatchelling turtles, pregnant females turtles and seabirds. The project location is several hundred kilometres away from the nearest turtle hatching grounds, so lights from the drilling rig are not expected to impact on turtle hatchlings. Lights on the rig may result in marine life and seabirds concentrating in the immediate vicinity of the rig; however, the operation is short-term and therefore the impact is not expected to be significant.

#### 8.2.1.4 Waste to Shore

A variety of construction waste will be generated during installation of the wellhead platform. Typical wastes may include piping, sheet metal, empty drums, concrete and plastics. All waste generated will be collected during construction and shipped back to shore for disposal or alternatively reused, recycled or recovered at approved sites. If inappropriately managed, landfill facilities can result in adverse impacts on the receiving environment such as groundwater or surface water; however, the potential environmental impact from inappropriate disposal will be negligible as Woodside will ensure that all waste is disposed of properly, and in accordance with regulatory waste management requirements.

### 8.2.2 Drilling of Platform and Subsea Wells

The sources of impacts resulting from installation of both platform and subsea wells are as follows:

- Anchoring/spudding of drilling unit;
- Cuttings discharge and adherent drilling fluid;
- Use of water based drilling fluids for the initial section of each well or for vertical wells;
- Use of non-water based drilling fluids for deviated sections of wells;
- Activity of support/supply vessels;
- Discharge of drilling chemicals and hydrocarbons attached to cuttings only;
- Discharge of sewage and greywater;
- Discharge of domestic waste including food scraps;
- Oily water discharged to the environment during installation of drilling facilities and operation through inappropriate deck drainage system;
- Disposal of domestic waste including paper and plastics etc;
- Power generation;
- Lighting; and
- Refuelling at sea.

In relation to these sources, the following potential impacts are discussed in **Section 8.2.2.1** to **8.2.2.5**:

***Atmospheric Emissions:***

- Greenhouse gases produced by drilling unit power generation (primarily $CO_2$); and
- Atmospheric pollutants (primarily $NO_x$, $SO_x$, VOCs and smoke/particulates).

***Discharges to the Sea:***

- Smothering effects of accumulated drilling cuttings on marine biota;
- Increased turbidity in the area if cuttings discharged at the surface;
- Potential accumulation of metal and hydrocarbon concentrations in seabed sediments leading to toxicity;
- Potential bioaccumulation/bioconcentration by marine biota of contaminants in non-water based drilling fluids;
- Potential anoxia of sediment due to natural degradation;
- Potential reduction in water quality in the area; and
- Potential of a significant fuel spill.

***Noise, Vibration, Light and Heat:***

- Potential disturbance to marine organisms and birds.

***Waste to Shore:***

- Improper disposal.

***Other Impacts:***

- Disturbance to seabed and potential changes to seabed characteristics from drilling unit spud cans.

#### 8.2.2.1 Atmospheric Emissions

Power will be required to install and construct the platform and to drill the wells. Diesel power generators will result in the following emissions to atmosphere:

- Carbon dioxide ($CO_2$);
- Nitrogen oxides ($NO_x$);
- Sulphur dioxide ($SO_2$);
- Carbon monoxide (CO);
- Volatile organic compounds (VOC); and
- Smoke and particulates.

The emission of the gases listed above will not result in a significant reduction in air quality as the quantities will be small, and the project area is isolated and far from sensitive receptors. Woodside will minimise emissions by installing new and efficient diesel generators.

#### 8.2.2.2 Discharges to Sea

***Drilling Fluids***

Drilling muds can enter the marine environment by three methods:

- As a whole mud discharged overboard;
- From spillage; and
- Through adherence to discharged drill cuttings.

The former is highly unlikely to occur as drilling mud is continually recycled. The principal method is through the latter when drill cuttings are brought to the surface for intentional discharge.

During well construction the drilling muds are reused several times and all attempts are made to separate as much of the muds from the cuttings using different methods such as shakers and centrifuges. However, not all of the mud can be separated from the cuttings and inevitably drill cuttings are discharged with adherent mud. This is one of the most significant chemical impacts on the marine environment, depending upon the type of drilling muds used.

The target for total surface losses of drilling muds will be about 10% of the cuttings volume, ie approximately 80 $m^3$ mud loss based on a single 7 km directional well (Asia Pacific ASA, 2001). Once the muds have surpassed their usability they are usually either discharged to sea (water-based muds) or shipped back to shore (all other muds) where they are either returned to the manufacturer for recycling or disposed of in an approved method such as land farm or incineration.

As discussed in Section 3.2.7 an alternative to discharging the cuttings/adherent mud over board is to re-inject all of the drill cuttings and adherent muds, into a dedicated shallow well drilled from the wellhead platform. The feasibility of using a dedicated re-injection well is still in the preliminary stages of design. Discharge of the cuttings from the platform to the seabed is considered the most likely disposal method.

***Water Based Drilling Fluids***

Water-based muds (WBM) are comprised of clay (bentonite-sodium montmorillinite) hence the term drilling "mud". The clay has improved viscosity ie hole cleaning capability, reducing mud loss to the formation, and improving the quality filter cake on the wall of the hole. Ground barite ($BaSO_4$) is added for mud density (Craddock, 1999).

A water-based mud will be used in the construction of both the subsea wells and platform wells. It will be used for drilling the top-hole section of the platform wells, typically down to approximately 3 200 m. This is normal practice in Australia where water-based muds are used for 36, 26 and 17.5 inch sections. WBMs would not be reinjected rather all WBMs, left after the drilling campaign, will be discharged to the sea after the completion of the wells.

The impact of drilling muds and cuttings on benthic and demersal species is dependent on local environmental variables e.g. depth, current, wave regimes, substrate type etc. Impacts fall into two categories (Thatcher, 2000):

- Short-term effects due to either toxicity or burial by drilling mud and/or cuttings; and
- Longer term effects due to chemical contamination or physical alteration of sediments.

***Water Based Drilling Muds***

Water-based muds (WBMs) are low toxicity and comprise a low bioaccumulation potential and are, therefore, unlikely to cause significant impact on marine organisms. These water-based muds are routinely accepted for discharge in open waters by the DBIRD and other regulatory authorities.

WBMs use fresh or seawater as the continuous phase and the most common systems include bentonite, potassium chloride, polymers and partially hydrolysed polyacrylamide. WBM may also contain a range of additives such as biocides, weighting agents, alkaline chemicals, various salts, defoamers, corrosion inhibitors, scale inhibitors, drilling lubricants, lost circulation materials and pipe release agents. WBM do not deliver optimal performance in highly deviated, horizontal and /or long reach stepout wells. However, WBMs provide the least environmental impact due to their non-toxic nature an ability to disperse and biodegrade rapidly (Terrens et al., 1998).

Recovery of the benthos following the discharge of WBM occurs rapidly. Evidence for this is provided by a field experiment conducted by Bakke, et al. (1985). In this study, trays of seabed sediment devoid of flora and fauna were covered with a 10 mm layer of water base mud slurry, returned to the sea and periodically sampled to assess recolonisation. Sampling of trays found colonisation by algae (principally diatoms), meiofauna and macrofauna components commenced immediately. Peak meiofauna densities were reached within 2 weeks and macrofauna diversity was found to be comparable to mature sediment communities within one year.

A post WBM drilling survey on the North West Shelf (NWS) undertaken by Woodside (Hanley, 1993) demonstrated that little environmental effect remained after three years. Levels of barium, lead and chromium were slightly elevated at stations within 200 m of the Wanaea 3 wellhead and cluster analysis of dominant taxa demonstrated that a different community persisted at Station 1, only 10 m from the wellhead. This difference was believed to be due to the variation in sediment composition (increased $SiO_2$ and grain size) rather than to any chemical effect.

***Oil Based Drilling Muds***

The first oil based muds used were diesel-based, containing a high proportion of toxic aromatic hydrocarbons (>25%). In the early 1980s, there was considerable concern in the North Sea regarding the discharge of drill cuttings coated with diesel based OBMs, and the use of diesel based drilling muds was banned in the North Sea in 1984. Subsequently, base oils with lower aromatic hydrocarbons were used, as toxicity was traced to aromatic content. These muds are referred to as Low Toxicity Mineral Oils (LTO) and have a lower concentration of aromatic compounds. However, more efficient solids control equipment and cuttings treatments were developed to reduce the amount of oil-on-cuttings. Limitations on the amount of oil that could be discharged to the marine environment were then introduced. In 1996, the maximum oil-on-cuttings allowed in the North Sea was 1% (by dry weight).

The main chemicals used in oil-based drilling muds include:
- Base oil – with reduced aromatic and polynuclear aromatic components. New systems use vegetable oil, polyglycols or esters amongst others;
- Brine Phase $CaCl_2$, NaCl, KCl;
- Gelling products Modified clays reacted with organic amines;
- Alkaline Chemicals e.g. $Ca(OH)_2$;
- Fluid Loss Control: Chemicals derived from lignites reacted with long chain or quaternary amines; and
- Emulsifiers: Fatty acids and derivatives, rosin acids and derivatives, dicarboxylic acids, polyamines.

Of a total of 694 wells drilled offshore in Western Australia since 1971 only 73 wells have used LTOBM or SBM. Of these wells none used diesel-based muds and only 22 used LTOBM. Of the 184 wells drilled offshore in Northern Territory, LTOBM was used for 2 wells in the 1980's with cuttings recovered and not dumped at sea.

The environmental issues with OBMs are related to toxicity, uptake and bioaccummulation of hydrocarbons from the cuttings piles on the seabed.

For the Sunrise Gas Project oil-based muds may be best suited to the drilling of a dedicated re-injection well, approximately 900 m in depth, should that option proceed. However, the OBM would only be used in the drilling of the middle or lower sections of the well and would therefore not be discharged but reinjected into the dedicated well, thereby eliminating or limiting the environmental effects. In this case the cuttings would be disposed to the well annulus between the casing and the well bore in the form of a slurry.

***Synthetic Based Muds (SBMs) including Ester-Based Drilling Muds (EBMs)***
A synthetic based drilling fluid, such as 'Biogreen' or 'Nexus', is a necessity for drilling extended reach platform wells. SBM's are normally used in the 12.25 inch and/or 8.5 inch hole sections.

Due to rapid settling SBMs do not disperse in the water column and do not increase water column turbidity. The percentage of oil on cuttings is dependent on the following factors:
- Formation characteristics;
- Rate of drilling; and
- Solids removal equipment efficiency.

The SBMs displaying less viscosity and greater hydrophobicity, for example esters, will have the greatest dispersibility. Several studies have been conducted globally into the environmental effects of SBMs. Impacts on the marine environment are normally gauged by four environmental processes discussed below:

- Fate, Persistence and Biodegradability;
- Ecotoxicity; and
- Bioaccumulation/bioconcentration.

***Fate, Persistence and Biodegradability***

SBMs biodegrade in the environment. In general, for a given concentration, the degradation for esters (EBMs) is greater than for other SBMs (Neff *et al*. in Macro-Environmental, 2001). Biodegradation results for Biogreen, also suggest that persistence time in the sediments will be short, although this will be affected by depth of burial and oceanographic conditions. Biodegradation of Biogreen has been calculated at around 50% in anaerobic conditions after 60 days and between 61% and 98% in aerobic conditions after 28 days indicating that Biogreen is highly biodegradable.

A closed-bottle biodegradation test was used (Papp and West in Craddock, 1999) to select a drilling mud, based on a fish oil ester, for Woodside's Goodwyn Alpha wells, drilled in 1998 and 1999. The two ester-based muds tested were based on the fish oil based ester (Biogreen), and a palm oil ester (Petrofree), of the other two muds tested one was a Paraffin-Based Mud (PBM) and the other a SBM. It was concluded that the two ester based drilling muds biodegrade faster and more completely than the other muds tested. Results from Woodside's closed bottle anaerobic biodegradation test were 85% and 58% ultimate biodegradation for the ester-based muds, compared to 11% and 18% respectively for the SBM and PBM. After 20 days no ester-based muds remained within the solvent extracted aqueous phase.

Thatcher (2000) compiled data required for regulatory approval in the North Sea, Gulf of Mexico and Australia; the relevant biodegradation results are detailed in **Table 8-3** below.

**Table 8-3 Available Biodegradation data for Ester Based Muds**

| Protocol | Fish oil Based Ester | Palm Oil Based Ester |
|---|---|---|
| 28 day aerobic degradation % | 61 | - |
| 28 day aerobic biodegradation % | 86 | 93 |
| 28 day aerobic biodegradation % | 98 | - |
| 28 day anaerobic biodegradation % | 45-55 | 82.8 |

Source: Thatcher 2000

***Ecotoxicity***

A guide to toxic grades used to classify drilling fluids and other substances is provided below. The $LC_{50}$ concentration is the concentration of the test substance that results in the mortality of 50 per cent of the test population over a given time period and $EC_{50}$ is the concentration that gives a defined affect on 50 per cent of the test organisms (URS, 2001).

| ***Toxicity Rating*** | | ***LC50 Value (mg/L)*** |
|---|---|---|
| Very Toxic | - | <1 |
| Toxic | - | 1–100 |
| Moderately Toxic | - | 100–1000 |
| Slightly Toxic | - | 1000–10000 |
| Almost Non-Toxic | - | 10000–100000 |
| Non-Toxic | - | >100000 |

Various toxicity tests and protocols can be used depending on location. Suspended Particulate Phase (SPP) toxicity bioassay tests were conducted on Biogreen drilling mud and base oil using three Australian marine species (Tsvetnenko & Evans in Macro-Environmental, 2001). Whole fluid toxicity tests on Biogreen are presented in **Table 8-4**.

**Table 8-4 Toxicity Tests on Biogreen**

| Species | Unit | Results | Comments | Base/Whole Fluid Tested |
|---|---|---|---|---|
| *Isochrysis sp.* | 96hr $IL_{50}$ | >100 000 | Non-toxic | Whole Fluid |
| *Isochrysis sp.* | 96hr $IL_{50}$ | >100 000 | Non-toxic | Base Fluid |
| *Gladioferens imparipes* | 48hr $LL_{50}$ | >100 000 | Non-toxic | Whole Fluid |
| *Gladioferens imparipes* | 48hr $LL_{50}$ | 67 100 | Almost non-toxic | Base Fluid |
| *Penaeus monodon* | 96hr $LL_{50}$ | >100 000 | Non-toxic | Whole Fluid |
| *Penaeus monodon* | 96hr $LL_{50}$ | >100 000 | Non-toxic | Base Fluid |
| *Corophium volutator* | 10 day $LC_{50}$ | >11 633 | Almost non-toxic | Whole Fluid |
| *Corophium volutator* | 10 day $LC_{50}$ | 3 000 | Slightly toxic | Base Fluid |
| *Abra alba* | 96hr $EC_{50}$ | 300–1 200 | Moderately to slightly toxic | Base Fluid |
| *Arcatia tonsa*), | 48hr $LC_{50}$ | >5 000 | Slightly toxic | |
| *Skeletonema tonsa* | $EC_{50}$ | >2 000 | Slightly toxic | |
| *Skeletonema costatum* | 72hr $EC_{50}$ | 2 333 | Slightly toxic | |

Source: Tsvetnenko & Evans in Macro-Environmental, 2001

*$LC_{50}$-The concentration that results in fatality of 50 % of the test organisms*

*$EC_{50}$-The concentration that gives a defined (sub-lethal) effect on 50 % of the test organisms.*

*$IL_{50}$ – Inhibition Load for 50 % of the test organisms.*

*$LL_{50}$ – Lethal Load for 50 % of the test organisms.*

The results presented in **Table 8-4** are comparable to the results for the Biogreen base oil which were as follows:

- 96h IL50 for growth of *Isochrysis sp*., >100,000 mg/L.
- 48h LL50 for *Gladioferens imparipes* >67,100 mg/L almost non-toxic.
- 96h LL50 for *Penaeus monodon* >100,000 mg/L.

In ecotoxicity tests (**Table 8-4**) on commercially important Western Australian species, the Biogreen has been rated as “almost non-toxic” to “non-toxic”. Toxic or sub-lethal effects are only likely to occur within hundreds of metres from the discharge point, beyond which the muds will be adequately dispersed and diluted. Rapid biodegradation of Biogreen suggests that the impact on benthic organisms will be short lived (half life of 110 – 133 days for esters).

The use of an ester-based mud, such as Biogreen, is likely to only have a short-term, negligible impact on the surrounding environment.

***Bioaccummulation/Bioconcentration***

Bioaccumulation typically refers to the uptake and retention of a contaminant by an organism while bioconcentration refers to the net accumulation of a contaminant resulting from simultaneous uptake and release.

When testing the potential for bioaccumulation the rate of uptake and release of test organisms should also be considered. Rapid depuration may reduce the potential for bioaccumulation. Where there is potential for the bioaccumulation of heavy metals that may be contained in drilling muds the bioavailability of heavy metals in these compounds should be considered. In most cases, the heavy metals are bound up in the muds or are in a form that is not released and thus not available for biota to bioaccumulate. The bioaccumulation potential of a drilling mud can be expressed as the ratio of the equilibrium concentrations of dissolved substances in n-octanol and water (also known as $Log_{10}$ Pow). The $Log_{10}$ Pow value should be below 7 *(*Tsvetnenko & Evans 1998).

Bioaccumulation can be expressed as a Log Bioaccumulation Factor (BCF), which is the ratio of the concentration in the organism’s tissues to the ambient concentration in the environment (expressed as dry weight or lipid weight). The lower the BCF value the better as this would indicate that whilst the organism has taken up some contaminant, the rate of uptake and release has stabilised such that the body burden of the organism is no longer increasing.

Whilst drilling fluids have very low concentrations of heavy metals, cadmium and mercury show high bioaccumulation potential in most biota. Cadium and mercury are used to estimate potential bioaccumulation as they provide a worst case scenario. The $Log_{10}$ Pow and Log Bioaccumulation Factor for potential ester based drilling muds is given in **Table 8-5**.

**Table 8-5 Available Bioaccumulation Data for Potential Ester Based Muds**

| Protocol | Biogreen | Petrofree |
|---|---|---|
| Octanol/Water Partition co-efficient (log Pow) | 1.69 | 4.99 |
| Log Bioconcentration Factor (*Mytilus edulis*) | 3–7.6 | 3.51 (lipid wt.) |

*Source:* Tsvetnenko & Evans 1998

Based on the data provided, both Biogreen and Petrofree would have a low potential for bioaccumulation. The low Log Pow indicates that the metals are unlikely to be readily bioavailable and the low Log BCF indicates that biota are unlikely to accumulate sufficient quantities of heavy metal to cause them harm.

***Effects of SBM Cuttings on Benthic Communities***

Biological effects on benthic communities due to the deposition of SBM/EBM cuttings may result from one or any combination of the following:

- Toxicity of the drilling muds ingredients;
- Effects of sediment anoxia, caused either by the depletion of oxygen during the microbial biodegradation of organic materials in the SBM cuttings, or by the burial/smothering of organic material following the deposition of SBM cuttings (Craddock, 1999);
- Direct burial by drill cuttings solids; and
- Changes in texture and physical/chemical properties in the sediments.

Several studies have been conducted on the effects of EBMs on the marine environment. A seabed monitoring program around the Fortescue platform in the Bass Strait was undertaken focusing on the initial drilling of 21 wells using only WBM, and a further 18 wells, seven of which were drilled with an ester-based mud for some of the lower-hole sections.

The following summarises the findings of the studies (Terrens *et al.* in Craddock, 1999):

- The highest concentration of ester in the sediment was observed at completion of drilling within 100 m of the platform;
- The ester concentration had reduced from 6,900 ppm to an average of 230 ppm after four months and was not found after 11 months;
- The impact on sediment in fauna was limited to 100 m from the discharge point, with recovery evident within 4 months of the completion of drilling;
- Infauna showed a rapid recovery after drilling had concluded; and
- Over the past 20 years of drilling operations a huge amount of field data has been gathered through environmental surveillance projects. The findings of these projects are summarised in **Table 8-6**.

**Table 8-6 Summary of Field Studies of the Fate and Effects of SBM Cuttings Discharges[1]**

| Water Depth (m) | Cuttings Discharge | Field Surveys | SBM Fates | SBM Effects |
|---|---|---|---|---|
| North Sea | | | | |
| 30 | 477 t | 4 (pre 1,4 & 11 months) | <200 m, ester concentrations to 4,700 mg/kg at 4 months, still detected after 11 months. > 200 m, esters near background. Est. ½ ~133 d. | At 4 months, sediments to 75 m anaerobic. Benthic fauna diminished < 200 m. Evidence of some recovery <200 m after 11 months. |
| 67 | 96.5 t | 3 (at end of drilling, 1 & 2 y) | < 200 m accumulation of high concentration of ester. Decrease after 1 & 2 years | Impoverished fauna < 100 m, no impacts >200 m, recovery 1 year. |
| 30 | Not reported | 1,4 &b 11 months after drilling. | Maximum recovered concentration of ester 410 mg/kg after 4 months, decreasing to 251 mg/kg after 11 months. | Effects were extensive at the 4 month. Survey showed reduced abundance and diversity. Effects still remained after 11 months but localised to within 200 m of well site. |
| 150 | 304 t | 2 (post drilling 1 year) | Highest ester concentration 8,400 mg/kg at 25 m after drilling dropped to 1,800 mg/kg after 1 year. Some contamination to 200 m. | Number of individuals increased, species numbers and diversity decreased at stations with highest ester concentration. |
| Australia | | | | |
| 70 | 2,000 $m^3$ | 5 (pre-drilling to 11 months after drilling) | Ester concentration declined rapidly from maximum of 12,000 mg/kg after drilling to 200 mg/kg 6 months later. | Change in benthic community structure with 100m of platform shortly after drilling with recovery within 4 months. |

*Source; Macro-Environmental, 2001.*
*Note: [1]This complete table from Macro-Environmental (2001) refers to all SBMs not only ester-based muds.*

The key conclusions are briefly summarised below (Macro-Environmental, 2001; Thatcher, 2000):

- Ester-based muds degrade relatively rapidly compared with other mud types;
- Benthic community responses are often associated with a decrease in oxygen concentration in surface sediment layers;
- Organic enrichment appears to be the main mechanism of adverse impact from SBM cuttings on benthic communities;
- Recovery of the contaminated area begins one year after discharges of ester-based muds cease;
- Effects on benthic fauna from SBM discharges are rarely seen outside a radius of 500 m; and
- When effects are observed changes in benthic communities usually include a decrease in the number of taxa and biological diversity, however, the total number of individuals and biomass of benthic fauna present may increase in some cases.

Environmental conditions differ between the Timor Sea and the North Sea but conditions in the former may favour a faster recovery of the discharge area. This is dependent on the type of drilling mud used, water depths, sea temperatures, cyclonic/current activity etc. An increase in the latter two factors is known to increase the rate of biodegradation and recolonisation of the discharge area in ester based muds (Thatcher, 2000).

***Drill Cuttings***

The impact of drill cuttings on the marine environment has been somewhat discussed in the preceding discussion on drilling muds, as muds are usually only discharged as an adherent to cuttings. Impacts specifically relating to cuttings are expanded upon below.

In the Sunrise Gas Field, drill cuttings will primarily comprise carbonates, marl, shale/siltstone and sandstone. The major volume of cuttings deposited on the seabed will be from the hole sections drilled with WBM. However, there will be the possibility that cuttings and drilling fluids will be lost down hole to the formation as a result of lost circulation (Craddock, 1999). The cuttings (and adherent WB &S/EB muds) will be discharged to the seabed as the base case.

The potential environmental impacts that will be associated with the discharge of drill cuttings will include:

- Smothering effects of accumulated drill cuttings on marine biota;
- Increased turbidly within the vicinity of the discharge point;
- Potential occurrence of Naturally Occurring Radioactive Material (NORMS); and
- Potential accumulation of metal concentration from formation materials leading to toxicity.

***Risk of Cuttings Reaching Sensitive Environments***

Asia-Pacific ASA was commissioned by Woodside to undertake discharge modelling of drill cuttings to determine dispersion and deposition of cuttings, which would facilitate the determination of potential environmental impacts.

***Determination of release trajectories and fates***

Modelling was undertaken by Asia-Pacific ASA using MUDMAP and OILMAP based on the parameters provided in **Table 8-7,** which is currently representative of the conditions produced by the directional drilling programme. The modelling has been based on the discharge of all cuttings from the wellhead platform and not the subsea wells, and excludes the potential for resuspension and transport of cuttings by seabed currents, thus predicted cumulative loads can be considered as conservative estimates of sedimentation loads.

The model was prepared to simulate a release under representative wind and tidal conditions for three defined sets of conditions:

- NW Monsoon (generally occurring April–September);
- SE Trade Winds (generally occurring October–March); and
- A period when calm (< 5 knots) and variable wind conditions coincided with neap tides. Weak tides are most common during the transitional seasons (September/October and March/April).

**Table 8-7 Summary of Model Parameters for Fate of Drill Cuttings With EBM[1]**

| Parameter | Value |
|---|---|
| Total volume of drill cuttings | 800 $m^3$ |
| Total volume of ester based fluid | 80 $m^3$ |
| Discharge orientation | 12 inch vertical pipe |
| Pipe release depth | Approx. 28 m above MSL [2] |
| Mean density of drill cuttings | 2,550 $kg/m^3$ |
| Density of combined discharge | 2,600 $kg/m^3$ |
| Period of discharge | 240 hours (10 days) |
| Duration of simulation | 480 hours (20 days) |
| Water temperature | 28 °C |
| Salinity | 32 ‰ [2] |

*Note 1: As the design phase of the Sunrise Project proceeds the parameters used in the modelling exercise will be firmed up and increasingly accurate values generated.*
*Note 2: MSL- Mean Sea Level, ‰-parts per thousand*

The drilling program is expected to generate a total of about 800 $m^3$ of cuttings for a single seven km directional well, with which it is assumed that approximately 80 $m^3$ of ester based drilling fluids (10% of cuttings volume) would be lost from the recirculation systems. Cuttings are expected to range in size from fine material of about 20 µm up to chips of material at about 700 µm (**Table 8-8**). Ester based drilling fluids are also expected to adhere to cuttings and settle out with them (Terrens *et al.*, 1998) which would result in a predicted mean density of cuttings of about 2,600 kg/$m^3$.

**Table 8-8 Assumed Particle-size Distribution for Drill Cuttings**

| Mean size (µm) | Proportion of volume ($m^3$) | Settling Velocity (cm/s) |
|---|---|---|
| 707.1 | 0.56 | 9 |
| 353.6 | 7.45 | 4 |
| 176.8 | 17.08 | 1.6 |
| 88.4 | 18.3 | 0.45 |
| 44.2 | 12.18 | 0.1 |
| 22.1 | 44.43 | 0.04 |

***Results of modelling***

The results of modelling are given in **Figure 8-1** to **Figure 8-6** and are summarised in **Table 8-9**. Modelling indicates that the area over which cuttings would settle, hence the seabed locations that could be affected, will vary with prevailing environmental conditions. Cuttings released under SE Trade Wind conditions (winter) are predicted to principally settle out in a south-westerly direction, up to approximately 155 km from the point of discharge (**Table 8-9**, and **Figure 8-1 to Figure 8-2**). The footprint predicted under these conditions extended to Echo Shoals and covered an area of approximately 5,245 $km^2$. With this area of coverage, the load at any one location is expected to be low. The peak cumulative cuttings load and thickness at any location within the footprint is estimated to be approximately 7.5 g/$m^2$ and 2.9 µm, respectively, as an average over a grid cell (**Table 8-9**, and **Figure 8-3** to **Figure 8-4).**

Cuttings discharged at the Surise Gas Field will not impact on the island of Timor nor the Indonesian Archipelago. The Timor Trench will effectively limit the distribution of cuttings as the material will not be capable of resurfacing once it has settled onto deeper waters.

Cuttings released under NW Monsoon (summer) conditions are predicted to principally settle out along a north-south axis. A proportion of the lighter material (33% of total cuttings volume) that is transported northward is predicted to remain in the water column for a protracted period of time (beyond the 20 day period of simulation) as the water depth increases at a greater rate than the predicted rate of sinking under the influence of local currents. Heavier material is predicted to settle out up to 85 km from the well site (**Table 8-9**, and **Figure 8-3** and **Figure 8-4**) over a predicted footprint an area of approximately 3,750 $km^2$. The highest cumulative cuttings load and thickness at any location within the footprint are slightly higher than for the winter case at approximately 13.4 g/$m^2$ and 5.2 µm respectively (**Table 8-9**, and **Figure 8-3** and **Figure 8-4**).

**Table 8-9 Predicted Spread of Cuttings under Different Environmental Conditions**

| Parameter | Discharge Conditions | | |
|---|---|---|---|
| | Winter (high energy) | Summer (high energy) | Calm (low energy) |
| Maximum total sedimentation (g/$m^2$) | 7.48 | 13.37 | 54.61 |
| Maximum cumulative thickness (µm) | 2.93 | 5.24 | 24.41 |
| Maximum distance (km) | 155 | 85 | 24 |
| Area of coverage ($km^2$) | 5245 | 3750 | 693 |

Modelling during the calm environmental conditions, which typically occur during the short transitional seasons between summer and winter, indicates that the drill cuttings will settle out over a much reduced footprint area (693 $km^2$) contained within 24 km of the discharge point. Consequently, predictions for the highest cumulative cuttings load and total thickness at any location are significantly higher at approximately 56.6 $g/m^2$ and 21.4 µm respectively (**Table 8-8** and **Figures 8-5 to 8-6**).

The discharge of cuttings during the transitional seasons is therefore likely to have a greater potential to smother seabed benthos. During winter and summer, any potential smothering is likely to occur within 100 m of the discharge point. Modelling indicates that cumulative loads and predicted total thickness of the settling of cuttings are very low and it is likely that such cutting and sediment loads would have negligible impact of the existing condition of benthic communities. Some habitat disturbance will occur due to the difference in particle characteristics (such as size and abrasiveness) to the existing sediment. However, this change may be temporary as sediment redistributes and disperses over time.

Turbidity generated from the discharge of cuttings and general drilling activities can affect photosynthetic activity; however, no significant impact is anticipated as existing benthic communities have adapted to low photosynthetic activity as a result of the large water depths surrounding the Sunrise Gas Project area. Modelling indicates that the nearest shallow waters to the southwest of the Sunrise Gas Project will receive an estimated maximum cumulative load of only 4$g/m^2$ during winter (**Figure 8-1**). These shallow areas will receive little or no load during summer or transitional seasons (**Figure 8-3** and **Figure 8-6**). Turbidity is unlikely to affect benthic communities in the vicinity of the drilling operations.

Formation materials retrieved from the well may also include heavy metals. The deposition of heavy metals on the seabed will create the potential for metal bioaccumulation which may possibly lead to toxicity. Marine organisms will be able to uptake metals; however, it is considered unlikely that this would result in toxic effects as the metals would be present in low concentrations and in a form not biologically available (Chandler *et al.*, 1990).

***Summary of Drilling Impacts***

The modelling of cuttings discharge has been presented to show the maximum extent of distribution of material. The modelling assumed a discharge at 28 m above mean sea level. Discharge above the sea surface leads to greater spatial distribution of material and a much larger footprint size. The modelled scenarios thus grossly over estimate the spread of cuttings. Cuttings generated during drilling for this project, if not discharged down well, would be released between 54 and 68 m below sea level. This would markedly reduce the spread of material.

The modelling also assumed over 50% of the material discharged was of a size fraction less than 60 µm (clay). This is also a over estimate which leads to significantly greater spreading of the cuttings by currents.

Figures showing the predicted spatial extend of cuttings discharge must take into account the significant over estimation built into the modelling by the very conservative assumptions of particle size and the point of cuttings discharge.

Modelling has shown that in most cases the material is of a concentration less than 10 $g/m^2$ and of a thickness of less than 10 µm (0.01 mm). In reality, this material would be practically undetectable during field investigations at distances of more than 2 km from the site of discharge. The drilling activities are therefore predicted to have a limited short-term impact on the ecology of the area.

Smothering of benthos is likely to be limited to within 100 m of the site of cuttings discharge and the effects of turbidity in the area is predicted to be minimal.

It is predicted that rapid biodegradability of the drilling fluids and their low toxicity would not impact on the biota present in the vicinity of the drilling operation. While some benthos would be smothered close to the discharge of the cuttings, recolonisation would take place. Studies undertaken in Australia and elsewhere in the world in similar habitats indicate that recolonisation would take place over a time scale of 6 months to 2 years (**Table 8-4**).

***Other Discharges***

A variety of waste products will be produced during the drilling programme and will have the potential to be discharged to sea. The discharge of waste may include:

- Discharge of drilling chemicals and hydrocarbons only attached to cuttings;
- Discharge of sewage and greywater;
- Oily water discharged to the environment during installation of drilling facilities; and
- Possible loss of fuel during refuelling at sea.

The potential environmental impacts that may result from the above discharges include:

- Potential accumulation of contaminants in seabed sediments leading to toxicity;
- Potential reduction in water quality in the area; and
- A potentially significant fuel spill.

The above discharges will be small in comparison to the discharges of cuttings. These discharges are common also to the construction and operation phases of the project (see **Sections 8.4** and **8.6**).

#### 8.2.2.3 Noise, Vibration and Light

Potential exists for marine fauna to be disturbed by noise, vibration and light; a result of heavy construction work on site during installation of bucket foundations and mandatory industrial lighting. These activities and the potential impacts on marine fauna have been previously discussed in **Section 8.2.1.3**.

#### 8.2.2.4 Waste to Shore

Wastes that will be generated during the drilling programme will be appropriately disposed of on shore. The potential environmental impacts associated with the disposal of waste onshore have been previously discussed in **Section 8.2.1.4**.

#### 8.2.2.5 Other Impacts

Seabed disturbance, other than that caused by the routine discharge of drilling fluids and cuttings, will result from the establishment of up to eleven subsea production wells (spudding of the drilling unit) and the deployment and retrieval of the drilling rig's anchor. Each well will disturb an area of about 100 $m^2$ and an anchor is expected to occupy an area less that 10 $m^2$. Further information on mooring systems and anchoring is provided in Section 3.2.10.

The increase in turbidity and potential smothering of benthos from anchoring may result from the localised suspension of sediment from anchoring. Resuspended sediment is expected to settle following disturbance. Impacts to benthic communities are not considered to be significant due to the low diversity and low abundance of significant benthic communities and the absence of any hard substrate communities such as corals within the immediate vicinity of the Sunrise area.

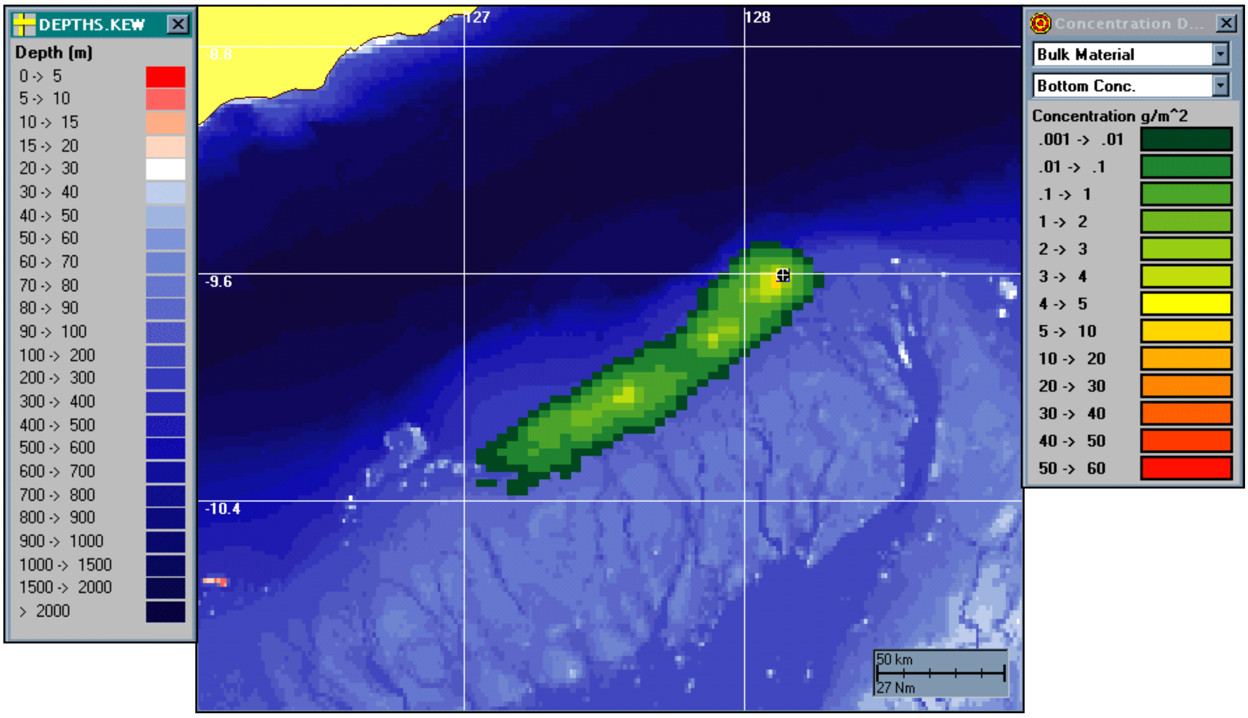


**Figure 8-1 Predicted Cumulative Loads of Cuttings During a High-energy Winter Period.**

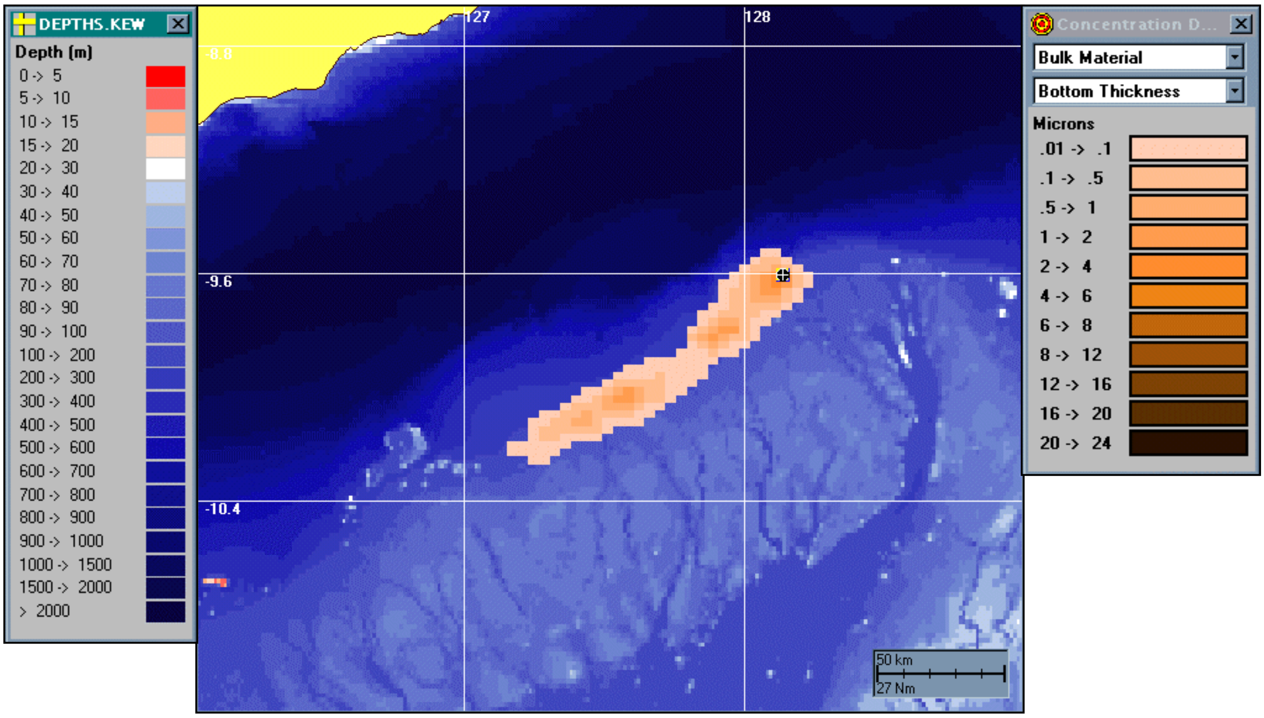


**Figure 8-2 Predicted Thickness of Cuttings During a High-energy Winter Period**

*Results are showing the predicted distribution of bulk material displayed over the bathymetry of the area (Source AGSO)

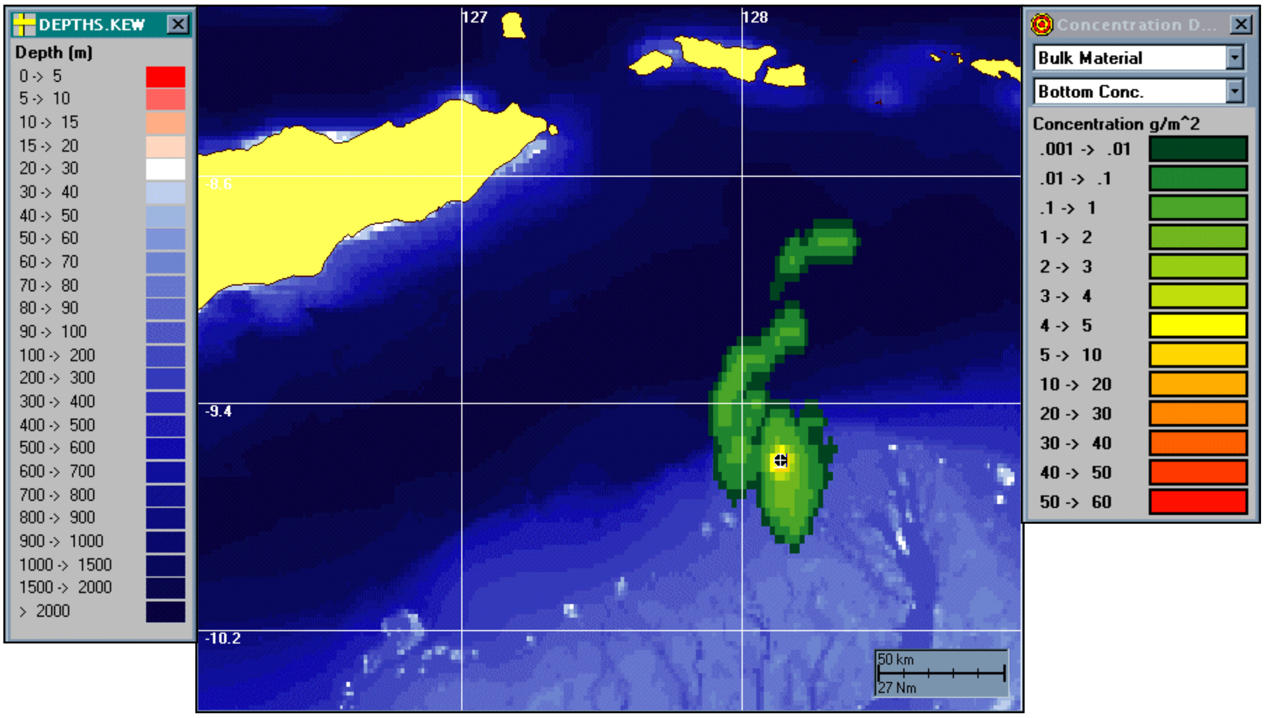


**Figure 8-3 Predicted Cumulative Loads of Cuttings During a High-energy Summer Period**

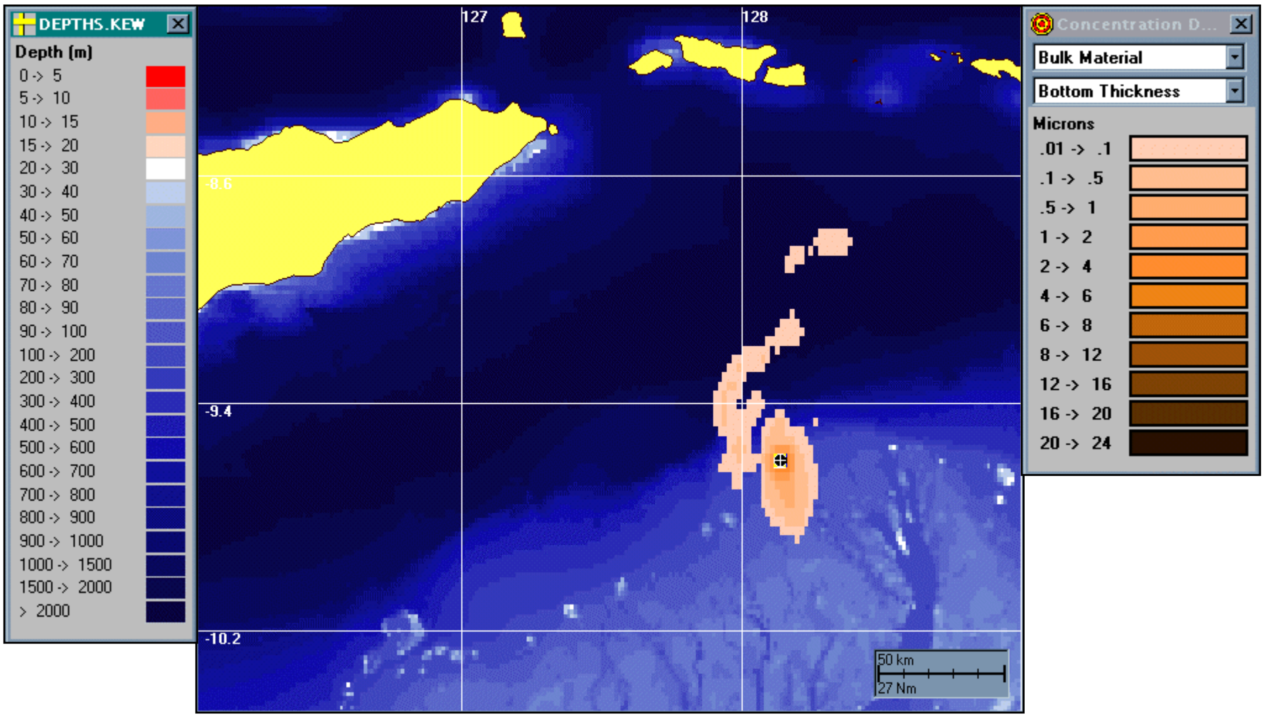


**Figure 8-4 Predicted Thickness of Cuttings During a High-energy Summer Period**

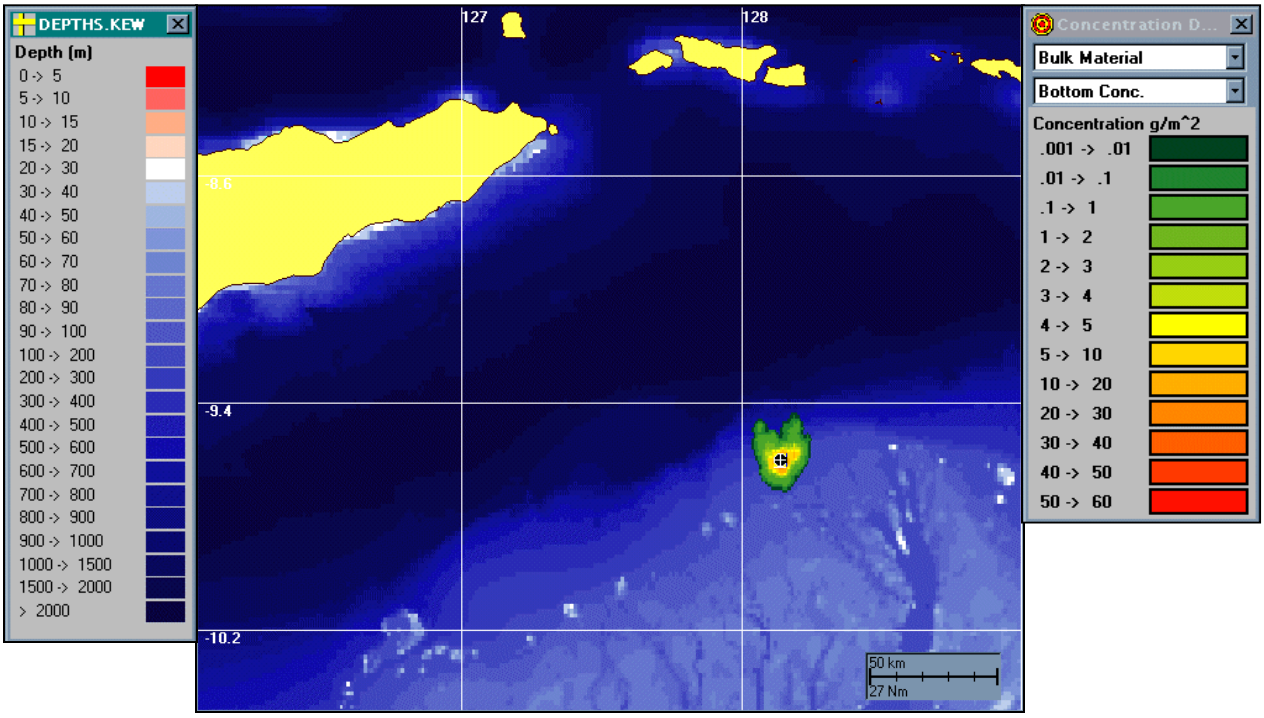


**Figure 8-5 Predicted Cumulative Loads During a Low-energy Calm Period**

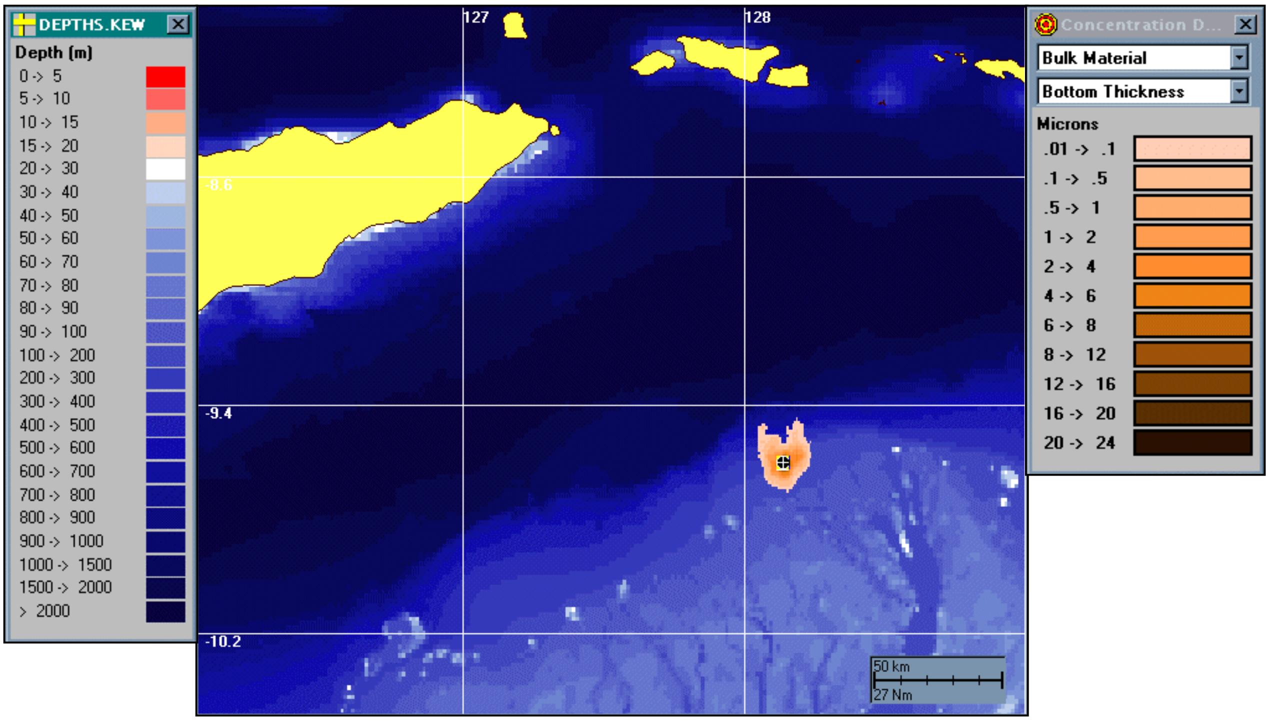


**Figure 8-6 Predicted Bottom Thickness During a Low-energy Calm Period**

*Results are showing the predicted distribution of bulk material displayed over the bathymetry of the area (Source AGSO).

## 8.3 Mitigation Measures for Drilling and Associated Activities

During drilling operations Woodside will minimise or avoid wherever possible impacts on the surrounding environment and on marine/resource users as outlined below.

### 8.3.1 Drilling Rig

Drilling rig selection will ensure the operator's capacity for sound environmental management of drilling operations. Factors that will be taken account of will include:

- Ensure the drilling rig has adequate safety systems such as blow out preventers, alarms and automated shutdown devices which meet regulatory and industry standards and for which adequate maintenance and testing programs are in place;
- Ensure the drilling rig has safe operating procedures in place which meet regulatory and industry standards including chemicals and waste management aspects, etc;
- Ensure the drilling rig has efficient solids control and mud circulation systems which maximise recycling of drilling fluids; and
- Ensure the drilling rig has adequate comminution, containment, drainage and monitoring systems to prevent overboard discharges of unpermitted effluents (e.g. oil, or chemical contaminated effluents, whole food scraps and sewage, etc.

### 8.3.2 Drilling Muds

In selecting drilling fluids Woodside will take the following into consideration:

- Where practicable and possible low toxicity water-based drilling fluid formulations will be used;
- Oil-based formulations will only be used where absolutely necessary; and
- Where required lubricity or other fluid properties cannot be achieved using a water-based drilling fluid, a synthetic fluid which is of proven low toxicity will be used.

### 8.3.3 Crew Induction

An environmental and safety induction will be undertaken with crew members prior to commencement of any drilling-related operations. Items that will be covered include:

- Regulatory requirements for drilling operations;
- Environmental considerations and special procedures to be used for environment protection in the permit area; and
- Safety procedures with particular regard for appropriate conduct on vessels and safe use of equipment.

### 8.3.4 Wildlife Protection

Although no protected species are known to exist in the vicinity of the Sunrise Gas field, should such a situation arise in the future Woodside, will take all reasonable measures to ensure no adverse impacts on significant wildlife resources. These will include:

- Specifying routes and/or operating procedures for supply vessels and helicopters, which minimise impact on wildlife.

### 8.3.5 Spills Prevention

Procedures and systems to prevent accidental spills will be implemented throughout the drilling operations and these will include:

- Safety systems including blowout preventers;
- Contained oil and chemical, packaging and storage areas;

- Containment around oil and chemical use areas and equipment such as the pipe deck, mud tanks, pumps etc;
- Efficient oil/water separators in bilges (and ballast tanks where not segregated from containment sources); and
- Safe fuel transfer procedures from supply vessel to drilling rig eg checking product transfer hoses for leaks, monitoring tank levels etc.

### 8.3.6 Chemicals and Hazardous Materials

A chemicals and hazardous material management plan will be adopted taking into account relevant regulatory requirements and environmental considerations such as:

- Provision of Material Safety Data Sheets and handling procedures for hazardous chemicals and materials;
- Provision of appropriate absorbent material and spill clean-up equipment;
- Provision of segregated and contained storage areas; and
- Use of low impact chemicals and materials as far as practicable.

### 8.3.7 Emergency Response

The emergency response plan will be implemented to deal with all environmental incidents including:

- Oil and Chemical Spills;
- Fire prevention; and
- Diesel or bunker fuel spill.

### 8.3.8 Waste Management

A project-specific waste management plan will be adopted which will take in to account the regulatory requirements of the P(SL)A, maritime laws and legislation of the Northern Territory Government.

The waste management plan will address the following two areas:

- Discharges to Sea; and
- Solid and Hazardous Waste.

The release of contaminants to the sea from deck wash will be minimised by ensuring the following:

- Absorbents and containers are available in the rig to clean up small accumulations of oil and grease around work areas and decks;
- Accumulations of oil, grease and other contaminants are collected and removed from the deck prior to every washdown;
- Oil-contaminated deck drainage is diverted to a settling tank to allow separation of oil from water (URS, 2001).

### 8.3.9 Discharges to Sea

- No waste will be disposed overboard except for the following:
  - Comminuted sewage and food wastes;
  - Drilling cuttings and adherent water-based drilling muds;
  - Excess water-based drilling muds at the completion of a well or if different properties apply; and
  - Uncontaminated deck washdown wastes.
- The total volume of discharges will be minimised and recirculation of drilling fluids optimised;
- Drill cuttings and fluid discharges will be analysed to avoid oil contamination;
- Discharges from essential operations such as grouting of the conductor and surface casing strings for eg cement mixture circulation to seabed, surplus cement fluid and powder etc.;

- To achieve optimal dispersal stage discharges will be implemented eg disposal of excess fluid at the end of well; and
- Where small amounts of oil additives are added to drilling fluid on a one-off basis, consultation will take place with the Designated Authority on the disposal method – disposal to sea may be considered if concentrations are low, the site environment is suitable and or additional treatment (oil separation) is undertaken.

### 8.3.10 Air Emissions and Energy Use

- Minimise emissions from fired machinery and optimise fuel use efficiency;
- Minimise flaring and emissions from production tests; and
- Optimise flare burner characteristics to ensure maximum burning of all hydrocarbons produced during production test.

### 8.3.11 Solid and Hazardous Waste

Non-hazardous wastes may include paper, rope, cardboard, sacking, timbers, metal scrap, domestic packaging and plastic. Hazardous wastes generated during the drilling phases may include chemicals, paints, batteries, oil filters, drilling fluid additives/chemicals, fuel and lubricating oils. The following mitigation measures will be implemented to ensure no adverse impacts on the environment occur:

- Segregate waste as much as possible and ensure safe storage and labelling of maintenance, chemical packaging, batteries, waste lube oils and other industrial waste for return to shore, recycling and or treatment and disposal in an approved manner;
- Collection of all solid domestic waste for return to shore and approved disposal; and
- Retention of oil based drilling fluids and returned to shore for reuse and recycling if possible or alternatively treatment and approved disposal.

No adverse impacts on the environment are expected with the implementation of these mitigation measures.

### 8.3.12 Physical Presence of Rig

Measures to be implemented to ensure the least possible impact on mariners or other marine users will include:

- Advance notification of the presence of the rig to local fishermen and other relevant parties;
- Ensure radio watch on shipping traffic and fishing vessels; and
- Notification of the Australian Maritime Safety Authority of the rig location and anchor distances.
- Adequate lighting of the rig.

### 8.3.13 Commitments

- Prepare a Drilling Environment Plan;
- Minimise flaring where possible;
- Obtain approval for non-water based drilling fluids. An Environment Plan will be drawn up and approved for the drilling programme prior to commencement;
- Implement an Emergency Response Plan (ERP);
- Implement WEL existing Timor Sea Oil Spill Contingency Plan. Amend this plan if required;
- Induct all personnel with particular attention given to correct handling of chemicals and pollution prevention requirements; and
- Issue Notice to Mariners alerting them of development and associated activities.

## 8.4 Impacts During Installation and Construction

**Table 8-10** overleaf summarises the source of impact, potential environmental impacts, their effect and duration for the Installation and Construction phase which includes:

- Subsea Facilties;
- PCUQ platform and FSO; and
- Subsea pipeline construction.

### 8.4.1 Subsea Facilities

The installation and construction of subsea facilities linking the wells to the Wellhead and PCUQ Platforms entails the construction of wellheads, manifolds, flow lines and risers. The subsea gas export pipeline from the Sunrise field to the Wye piece is discussed separately in **Section 8.4.3.** The activities associated with the installation and construction of subsea facilities and potential environmental impacts are discussed in the following sections. The sources of impacts identified during the impact assessment were as follows:

- Installation of subsea facilities;
- Anchoring of construction vessel(s);
- Discharge of sewage and greywater;
- Discharge of domestic waste including food scraps;
- Disposal of domestic waste including paper, packaging, plastics etc;
- Power generation; and
- Refuelling at sea.

In relation to these sources, the following potential impacts are discussed in **Sections 8.4.1.1** to **8.4.1.4**:

***Atmospheric Emissions:***

- Greenhouse gases produced by vessel power generation (primarily $CO_2$);
- Atmospheric pollutants (primarily $NO_x$, $SO_x$, VOCs and smoke/particulates);

***Discharges to the Sea:***

- Potential significant fuel spill.

***Noise, Vibration, Light and Heat:***

- Potential disturbance to marine organisms and birds.

***Waste to Shore:***

- Improper disposal.

#### 8.4.1.1 Atmospheric Emissions

Power will be required to install and construct subsea facilities. Power will be produced from diesel generators that will result in the emissions of $CO_2$, $NO_x$ and other gases, smoke and particulates to the atmosphere. The diesel consumption rates have been estimated at between 10 and 30 tonnes per day. The emissions will not result in a significant reduction in air quality as the project area is isolated and far from sensitive receptors.

## Table 8-10 Summary of Potential Environmental Impacts for Installation and Construction

| Project Component | Source of Impact | Potential Environmental Impact | Effect | Duration |
|---|---|---|---|---|
| Subsea Facilities (well heads, manifolds, flowlines, risers, etc.) | a) Installation of subsea facilities.<br>b) Anchoring of construction vessel(s)<br>c) Discharge of sewage and greywater.<br>d) Discharge of domestic waste including food scraps.<br>e) Disposal of domestic waste including paper and plastics etc.<br>f) Power generation.<br>g) Refuelling at sea. | **Atmospheric Emissions** | | |
| | | ▪ Greenhouse gases produced by vessel power generation (primarily $CO_2$). | Negligible | Short-term |
| | | ▪ Atmospheric pollutants (primarily $NO_x$, $SO_x$, VOCs and smoke/particulates); | Negligible | Short-term |
| | | **Discharges to the Sea** | | |
| | | ▪ Potential significant fuel spill. | Minor | Temporary |
| | | **Noise, Vibration, Light and Heat** | | |
| | | ▪ Potential disturbance to marine organisms and birds. | Negligible | Temporary |
| | | **Waste to Shore** | | |
| | | ▪ Improper disposal. | Negligible | Temporary |
| PCUQ Platform and FSO | a) Transportation of the PCUQ Platform and FSO to site.<br>b) Power generation.<br>c) Installation of the PCUQ Platform and the FSO on site.<br>d) Physical presence of PCUQ Platform and FSO.<br>e) Installation of foundations of the PCUQ platform.<br>f) Lighting.<br>g) Presence of construction and support vessels.<br>h) Installation of mooring for the FSO. | **Atmospheric Emissions** | | |
| | | ▪ Greenhouse gases produced by vessel power generation (primarily $CO_2$) | Negligible | Short-term |
| | | ▪ Atmospheric pollutants (primarily $NO_x$, $SO_x$, VOCs and smoke/particulates). | Negligible | Short-term |
| | | **Discharges to the Sea** | | |
| | | ▪ Potential reduction in water quality in the area. | Negligible | Short-term |
| | | **Noise, Vibration, Light and Heat** | | |
| | | ▪ Potential disturbance to marine organisms and birds. | Negligible | Short-term |
| | | ▪ Potential attraction of marine organisms to the lights. | Negligible | Short-term |
| | | **Waste to Shore** | | |
| | | ▪ Improper disposal. | Negligible | Temporary |
| Subsea Pipeline | a) Potential pre-sweep along pipeline route<br>b) Prelay with rock dump.<br>c) Laying of pipeline on seabed.<br>d) Hydrotesting | **Atmospheric Emissions** | | |
| | | ▪ Greenhouse gases produced by vessel power generation (primarily $CO_2$) and vehicles | Negligible | Short-Term |
| | | ▪ Atmospheric pollutants (primarily $NO_x$, $SO_x$, VOCs & smoke/particulates). | Negligible | Short-Term |
| | | **Discharges to the Sea** | | |
| | | ▪ Smothering of benthos. | Negligible | Temporary |
| | | **Noise, Vibration, Light and Heat** | | |
| | | ▪ Potential disturbance to marine organisms and birds. | Negligible | Temporary |
| | | **Waste to Shore** | | |
| | | ▪ Improper disposal. | Negligible | Temporary |
| | | **Other Impacts** | | |
| | | ▪ Disturbance due to repositioning of anchors. | Negligible | Temporary |
| | | ▪ Temporary disruption of commercial, recreational fisheries and recreational areas. | Negligible | Temporary |

#### 8.4.1.2 Discharges to Sea

The discharge of wastewater, chemicals and domestic waste has the potential to reduce the quality of water surrounding the Sunrise area. A variety of waste products will be generated and a number of chemicals will be used during construction. These may include:

- Potential discharge of domestic waste including food scraps;
- Discharge of sewage and greywater; and
- Refuelling at sea.

The potential environmental impacts that may result from the above discharges include the potential occurrence of a significant fuel spill.

***Sewage and Putrescible Waste***
The workforce upon vessels required for the installation and construction of subsea facilities will generate sewage and putrescible wastes (refer to **Section 8.2.1.1**). The discharge of domestic waste may lead to the localised reduction in water quality, including increased nutrient availability. As a result, this routine discharge of waste to the sea is considered to have a negligible impact.

***Fuel Spills***
A fuel spill could occur during the transfer of fuel during the process of refuelling. Spills are likely to be small and result from handling losses rather than significant ruptures of hoses and tanks. The spills will be localised and expected to disperse and volatilise rapidly. It is very unlikely that small spills of lighter than water oils will reach the seabed or any of the shallow shoals located about 30 km to the south-west of the Sunrise Gas Project area. Fuel spills will result in a negative impact to the quality of surrounding waters; however, as a result of rapid dispersion and mixing the impact will be temporary. A description of the impacts associated with larger diesel spills is provided in **Section 8.6.1.2**.

#### 8.4.1.3 Noise, Vibration and Light

***Noise and Vibration***
Noise and vibration associated with the installation and construction of subsea facilities will be minimal and of a much reduced level than emissions expected during the installation of the wellhead platform (**Section 8.2.1.3).** The effects of noise and vibration on marine fauna are discussed in **Section 8.2.1.3.** It is possible that marine fauna will be disturbed by the activities and emissions of noise and vibration from construction. Such disturbance is very unlikely to be harmful to marine fauna as they are highly mobile and will be expected to avoid the area. This impact is temporary and of a short duration.

***Light***
Industrial lighting will be required during the installation and construction of subsea facilities to comply with regulatory safety requirements. There is a potential that turtles may be attracted to the area by light falling on the sea surface; however, such an attraction is not considered to be adverse as turtles are able to move away from the area if they are disturbed (refer to **Section 8.2.1.3)**. Light is more of a concern for turtle hatchlings near shore (refer to **Section 8.2.1.3)**.

#### 8.4.1.4 Waste to Shore

A variety of construction wastes will be generated during the installation and construction of subsea facilities. The disposal and resultant environmental impacts from construction wastes have been previously discussed in **Section 8.2.1.4**.

### 8.4.2 PCUQ Platform and FSO

The installation of the PCUQ Platform and FSO involves their transportation to site and fixing them into position. Both facilities are to be fabricated elsewhere. The activities associated with the installation of these facilities and potential environmental impacts are discussed in the following sections. The sources of impacts identified during the impact assessment were as follows:

- Transportation of the PCUQ Platform and FSO to site;
- Power generation;
- Installation of the PCUQ Platform and FSO on site;
- Physical presence of PCUQ Platform and FSO;
- Installation of foundations of the PCUQ Platform;
- Lighting;
- Presence of construction and support vessels; and
- Installation of mooring for the FSO.

In relation to these sources, the following potential impacts are discussed in **Sections 8.4.1.1** to **8.4.1.4**:

***Atmospheric Emissions:***

- Greenhouse gases produced by vessel power generation (primarily $CO_2$); and
- Atmospheric pollutants (primarily $NO_x$, $SO_x$, VOCs and smoke/particulates);

***Discharges to the Sea:***

- Potential reduction in water quality in the area

***Noise, Vibration, Light and Heat:***

- Potential disturbance to marine organisms and birds; and
- Potential attraction of marine organisms such as turtles to the lights.

***Waste to Shore:***

- Improper disposal.

#### 8.4.2.1 Atmospheric Emissions

Power will be required to install and construct the PCUQ Platform and to connect the FSO. Power during installation will be produced from diesel generators that will result in the emissions of combustion gases, smoke and particulates. Atmospheric emissions associated with the operation of diesel generators and resultant environmental impacts will have a negligible impact on the environment.

#### 8.4.2.2 Discharges to Sea

The discharge of wastewater and domestic waste has the potential to reduce the quality of water surrounding the Sunrise Gas Project area during the establishment of the PCUQ platform and the FSO on site. These are also generated during the installation and construction of other project facilities and may include:

- Potential discharge of domestic waste including food scraps; and
- Discharge of sewage and greywater.

These potential environmental impacts and discharges to sea have been previously discussed in **Section 8.4.1.2** and will have a negligible impact on the environment.

#### 8.4.2.3 Noise, Vibration and Light

***Noise and Vibration***
Noise and vibration associated with the installation of the PCUQ Platform and the FSO will be generated from the establishment of foundations and vessel engines. Acoustical emissions are expected to be similar in magnitude as those generated during the installation of the wellhead platform (**Section 8.2.1.3)**. The effects of noise and vibration on marine fauna are discussed in **Section 8.2.1.3**.

It is likely that marine fauna will be disturbed by the activities and emissions of noise and vibration from construction. Such disturbance is very unlikely to be harmful to marine fauna as they are highly mobile and will be expected to avoid the area. Noise and vibration is, therefore, expected to have a negligible impact on the environment.

***Light***
There is a potential that turtles may be attracted to the area by the lights, however such an attraction is not considered to be adverse as turtles are able to move away from the area if they are disturbed. The impacts of lighting on marine fauna have been previously discussed in **Section 8.2.1.3**.

#### 8.4.2.4 Waste to Shore

Only a small quantity of waste will be generated during the installation of the PCUQ Platform and the FSO. The disposal and resultant environmental impacts have been previously discussed in **Section 8.2.1.4**.

### 8.4.3 Subsea Pipeline Construction

The proposed subsea pipeline will extend along a 218 km route to the proposed location of the Bayu-Undan 'Wye' piece. Sections of the route may require preparation prior to the pipeline being laid on the sea bed which may include a pre-sweep and pre-lay with rock armour to provide stability and protection for the pipeline. The sources of impacts related to pipeline construction as identified during the impact assessment are as follows:

- Potential pre-sweep along pipeline route;
- Potential pre-lay with rock armour;
- Laying of pipeline on seabed; and
- Hydrotesting.

In relation to these sources, the following potential impacts are discussed in **Sections 8.4.1.1** to **8.4.1.4**:

***Atmospheric Emissions:***
- Greenhouse gases produced by vessel power generation (primarily $CO_2$) and vehicles; and
- Atmospheric pollutants (primarily $NO_x$, $SO_x$, VOCs and smoke/particulates);

***Discharges to the Sea:***
- Smothering of benthos.

***Noise, Vibration, Light and Heat:***
- Potential disturbance to marine organisms and birds.

***Waste to Shore:***
- Improper disposal.

***Other Impacts:***
- Temporary disruption of fisheries and recreational areas; and
- Disturbance due to repositioning of lay barge anchors.

#### 8.4.3.1 Atmospheric Emissions

Atmospheric emissions, primarily $CO_2$ associated with the operation of the subsea pipelaying barge will result in negligible short term environmental impacts. The barge may also emit vapours containing VOCs and small quantities of other pollutants to the atmosphere during pipelaying. The potential environmental impact associated with these atmospheric emissions is a reduction of air quality. Release and venting of gases during operations will be minimal and negligible. Any impact that may occur to air quality will be localised. As a result, atmospheric emissions from the FSO are considered to have a negligible short term impact.

#### 8.4.3.2 Discharges to Sea

Installation of the subsea pipeline will result in routine discharges to sea including sewage and putrescible waste. There is the potential for fuel spills to occur and water containing biocides, corrosion inhibitors and oxygen scavenger will be discharged following hydrotesting. The potential environmental impacts associated with each of these potential discharges have been previously discussed in **Sections 8.2.2.2** and **8.4.1.2**.

Disturbance to the seabed is unlikely to affect water quality and the associated increase in turbidity is likely to be minimal. The preparation of the seabed and the laying of the pipeline will have a direct impact on the seabed and the benthic communities it supports. Direct disturbance and loss of organisms will occur in areas that are directly impacted. These impacts are considered to be localised and of a short duration. The benthos present along the pipeline route is common and widespread and would quickly recolonise the impacted area.

#### 8.4.3.3 Noise, Vibration and Light

Noise and vibration associated with the installation of the subsea pipeline will be minimal. The effects of noise and vibration on marine fauna are discussed in **Section 8.2.1.3.** Such disturbance is very unlikely to be harmful to marine fauna as they are highly mobile and will be expected to leave and avoid the area.

There is a potential that turtles may be attracted to the area by the lights, however such an attraction is not considered to be adverse as turtles are able to move away from the area if they are disturbed. The impacts of lighting on marine fauna have been previously discussed in **Section 8.2.1.3**.

#### 8.4.3.4 Waste to Shore

A variety of construction wastes will be generated during the installation of the subsea pipeline. The disposal and resultant environmental impact from construction wastes has been previously discussed in **Section 8.2.1.4**.

#### 8.4.3.5 Other Impacts

- Potential for Localised Scouring:

Evidence of sediment transport processes is seen in Beagle Gulf, where seabed currents are relatively high. In the waters of the subsea export pipeline route, currents are lower and scour and other transport phenomena are not expected nor have they been noted during the course of the surveys undertaken to date. Consequently, the stability of the pipeline is unlikely to be impacted from scouring by tidal movements within the vicinity of the pipeline. This aspect is presently being considered in the design of the pipeline and appropriate measures will be undertaken to ensure that the integrity of the pipeline is maintained at all times.

- Disruption to Commercial Fisheries:

During the installation of the subsea pipeline, commercial fishing along the route of the pipeline may be impacted by an anchoring exclusion zone. This zone will ensure that damage to the pipeline from vessels will be minimised. Consultation with all relevant fishery organisations and the Seafood Council will take place at an early stage to ensure a satisfactory agreement is reached.

## 8.5 Mitigation Measures During Installation and Construction

### 8.5.1 General Measures

Due to the fact that the wellhead and PCUQ platforms will not be constructed offshore but towed to site and assembled in place, there will be very little in the way of construction on site thereby ensuring minimal waste generation. Installation of the platforms will occur over a very short period of time thereby minimising any impacts on the surrounding environment. Mitigation measures will focus on issues such as waste management, air and noise emissions and restriction of the development to the defined project area.

During construction and installation Woodside will include the following mitigation measures to avoid any adverse impacts on the environment:

- Charts of the route and notification will be given to marine users prior to construction/installation;
- Navigation and safety lighting will be provided to ensure that any shipping or recreational activities are able to clearly identify the presence of activity;
- Woodside will confine activities to the minimum development area required to minimise the area impacted;
- Work areas will be kept to a minimum with pipeline laying restricted to at most a 10 km width corridor. Within this corridor pipe laying operations will occur with a 1 km corridor in as much as is possible. Any pre-lay rock armour that may be required, will be confined to a much smaller area usually 10 m in width;
- Woodside will endeavour to minimise all disturbance to marine life and fisheries. However, as no breeding areas are affected by the development impacts will be kept to a minimum;
- Minimise all air emissions and discharges. Efficient planning of vehicle and vessel movements will minimise fuel usage;
- All waste will be managed in accordance with a project–specific waste management plan and in accordance with current waste legislation;
- All chemicals will be managed in accordance with a project–specific chemicals management plan; and
- Any rock dumping along the pipeline route will be kept to a minimum.

### 8.5.2 Marine Support Vessels

All marine support activities must comply with maritime laws and implement good environmental working standards. These will include the following:

- All support services are conducted in accordance with relevant legislation and the operating companies requirements;
- Goods and materials are properly package, labelled for transportation and transfer;
- Refuelling and similar operations will be conducted in accordance with port authority requirements and all hoses, fittings and fail-safe devices will be fully operational;
- Efficient oil/water separation in bilges and disposal of clean bilge water in offshore areas, where permitted;
- No disposal of wastes en route from offshore facilities to shore base;
- Comminution of sewage and food waste and disposal in offshore areas only where permitted and containment of sewage and food wastes for onshore disposal when in nearshore waters; and

- The collection of own wastes for return to shore and correct disposal.

### 8.5.3 Commitments

Woodside, or any future operator, will adhere to the following commitments during the Installation and Construction Phase of the Project:

- Minimise flaring where possible; and
- Install breakaway self-sealing couplings on floating hoses that contain condensate.

## 8.6 Impacts During Commissioning and Operation

**Table 8-11** summarises the source of impact, potential environmental impacts, their effect and duration for the Commissioning and Operation phase which includes:

- Wellhead and PCUQ Platforms including Subsea Facilities;
- FSO and Shuttle Vessels; and
- Subsea Pipeline.

### 8.6.1 Wellhead and PCUQ Platforms including Subsea Facilities

Once installed, the Wellhead, PCUQ Platforms and associated subsea facilities would be commissioned and then function for the lifetime of the Sunrise Gas Project which is expected to be in the order of 30 years. The sources of impacts resulting from the operation of the Wellhead and PCUQ platforms and the subsea facilities are as follows:

- Potential blowout of wellhead;
- Hydrotesting of facilities;
- Potential rupture of flowline or riser;
- Potential diesel spill;
- Potential condensate spill;
- Emergency shutdown of facility;
- Discharge of Produced Formation Water (PFW);
- Discharge of cooling water;
- Disposal of waste associated with maintenance of the platforms;
- Discharge of potentially contaminated stormwater from machinery, workshop, deck wash-down areas, oily water, waste oil and lubricants;
- Discharge of sewage and greywater;
- Disposal of domestic waste including food scraps;
- Potential collision of shuttle tanker or supply vessels with platforms;
- Operational noise;
- Power generation and compression turbines producing greenhouse gas emissions; and
- Hazardous materials.

In relation to these sources, the following potential impacts are discussed in **Sections 8.6.1.1** to **8.6.1.5**:

***Atmospheric Emissions:***

- Significant emission of greenhouse gases due to export compression;
- Significant emission of greenhouse gases due to power generation;
- Significant emission of greenhouse gases due to flaring; and
- Significant emission of smoke and particulates.

***Discharges to the Sea:***

- Potential significant hydrocarbon contamination from condensate spill;
- Potential significant hydrocarbon contamination from diesel spill;
- Potential significant impact from PFW discharge;

- Potential reduction in local water quality; and
- Potential reduction in water quality due to hydrotesting (biocides, scale and corrosion inhibitors and oxygen scavengers).

***Noise, Vibration, Light and Heat:***

- Potential disturbance to marine organisms and birds.

***Waste to Shore:***

- Improper disposal.

## Table 8-11 Summary of Potential Environmental Impacts for Commissioning and Operation

| Project Component | Source of Impact | Potential Environmental Impact | Effect | Duration |
|---|---|---|---|---|
| Wellhead Platform, Processing, Compression, Utilities and Quarters (PCUQ) and Subsea Facilities | a) Potential blowout of wellhead.<br>b) Hydrotesting of facilities.<br>c) Potential rupture of flowline or riser.<br>d) Potential diesel spill.<br>e) Potential condensate spill.<br>f) Emergency shutdown of facility.<br>g) Discharge of Produced Formation Water (PFW).<br>h) Discharge of cooling water.<br>i) Disposal of waste associated with maintenance of the platforms.<br>j) Disposal of oily water, waste oil, etc.<br>k) Discharge of sewage and greywater.<br>l) Disposal of domestic waste including food scraps.<br>m) Potential collision of shuttle tanker or supply vessels with platforms.<br>n) Operational noise.<br>o) Power generation and compression turbines producing greenhouse gases emission to air.<br>p) Hazardous materials | **Atmospheric Emissions** | | |
| | | ▪ Significant emission of greenhouse gases due to export compression. | Minor | Long-term |
| | | ▪ Significant emission of greenhouse gases due to power generation. | Minor | Long-term |
| | | ▪ Significant emission of greenhouse gases due to flaring. | Minor | Short-term |
| | | ▪ Significant emission of smoke and particulates. | Negligible | Long-term |
| | | **Discharges to the Sea** | | |
| | | ▪ Potential significant hydrocarbon contamination from condensate spill. | Moderate | Temporary |
| | | ▪ Potential significant hydrocarbon contamination from diesel spill. | Minor | Temporary |
| | | ▪ Potential significant hydrocarbon from PFW discharge. | Negligible | Long-term |
| | | ▪ Potential reduction in local water quality. | Negligible | Short-term |
| | | ▪ Potential reduction in water quality due to hydrotesting | Negligible | Short-term |
| | | **Noise, Vibration, Light and Heat** | | |
| | | ▪ Potential disturbance to marine organisms and birds. | Negligible | Long-term |
| | | **Waste to Shore** | | |
| | | ▪ Improper disposal. | Negligible | Long-term |
| | | **Other Impacts** | | |
| | | ▪ Creation of hard substrate that could be colonised by marine pest species. | Negligible | Long-term |
| | | ▪ Recolonisation of a different community to that originally found in the area. | Minor | Long-term |
| FSO and Shuttle Vessels | a) Potential spill during condensate transfer to shuttle tankers.<br>b) Ballast water discharge from offtake tankers once on site.<br>c) TBT and other antifoulant paints on tankers.<br>d) Vessel hulls fouled with exotic marine organisms.<br>e) Cargo tank venting to atmosphere.<br>f) Potential collision with shuttle tankers or supply vessels.<br>g) Power generation emissions.<br>h) Discharge of sewage and greywater.<br>i) Disposal of domestic waste including food scraps. | **Atmospheric Emissions** | | |
| | | ▪ Cargo tank emissions from loading of FSO and shuttle tankers. | Negligible | Long-term |
| | | **Discharges to the Sea** | | |
| | | ▪ Contamination of marine environment by anti-fouling agents. | Negligible | Long-term |
| | | ▪ Introduction of marine pest species from offtake tanker de-ballasting and hullfouling. | Moderate | Long-term |
| | | ▪ Potential significant hydrocarbon contamination from condensate spill. | Moderate | Temporary |
| | | ▪ Potential significant hydrocarbon contamination from diesel spill. | Minor | Temporary |
| | | **Othe Impacts** | | |
| | | ▪ Interference with shipping. | Negligible | Long-term |
| Subsea Pipeline | a) Potential rupture of pipeline.<br>b) Hydrotesting of pipeline.<br>c) Physical Presence of the pipeline. | **Atmospheric Emissions** | | |
| | | ▪ Potential emissions of natural gas in the event of a leak. | Significant | Long-term |
| | | **Discharges to the Sea** | | |
| | | ▪ Potential reduction in local water quality due to release of hydrotest water (biocides, corrosion inhibitors and oxygen scavengers).. | Negligible | Temporary |
| | | **Othe Impacts** | | |
| | | ▪ Physical presence of pipeline. | Negligible | Long-term |

***Other Impacts:***

- Creation of hard substrate that could be colonised by marine pest species;
- Recolonisation of a different community to that originally found in the area; and
- Attraction of seabirds and turtles to the production facility.

#### 8.6.1.1 Atmospheric Emissions

During commissioning and operation, greenhouse gases and air pollutants will be emitted to the atmosphere as a result of the following activities:

- Export compression;
- Power generation for equipment, utilities and support;
- Routine flaring (eg flare line purging for safety purposes); and
- Flaring during emergency shutdown.

The former three activities will occur continuously. After a 3-month commissioning period, emergency flaring is only expected to occur on an infrequent basis. Minor atmospheric emissions will also be expected from venting.

The following environmental impacts will occur:

- Emissions of greenhouse gases due to compression (primarily $CO_2$);
- Emissions of greenhouse gases due to power generation (primarily $CO_2$);
- Emissions of greenhouse gases due to flaring (primarily $CO_2$); and
- Emissions of smoke and particulates.

***Power Generation and Compression***

Power generation will require ~12 MW of power on an ongoing basis. Compression (of export gas from Sunrise to Darwin) will require ~90 MW of power, also on an ongoing basis. The power generation and gas export compression turbines, combined, are expected to emit between 600,000 and 700,000 tonnes $CO_2$ per annum, and ~5000 tonnes $NO_x$ per annum. The $CO_2$ emissions will contribute to the greenhouse inventory. Greenhouse emissions are expected to be one of the largest emissions associated with the facility. Woodside will minimise greenhouse emissions, through selection of energy efficient turbines and other equipment, and by making efforts to integrate waste heat recovery into facility designs.

The combustion processes will also emit $NO_x$, $SO_x$ and CO, which are considered air pollutants. These emissions will not impact any nearby sensitive receptors, as the project area is isolated and far from sensitive receptors. The expectation is that no air quality standards, eg National Air Quality Protection Measures (NEPMs) will be exceeded for exposure to people outside the immediate area.

***Flaring***

Flaring will be minimised as the Wellhead and PCUQ Platforms can be started up once the pipeline to the Wye piece has been hydrotested. This will allow power generation (~12 MW) mostly using Bayu-Undan gas rather than imported diesel. Export gas compression (~90 MW) will only be applicable once Sunrise gas is being generated for export (in excess of Sunrise power generation requirements).

Baseload, sustained flaring is expected to be roughly 25 tonnes/day for line purging, etc. This rate is relatively low compared to other offshore facilities, as design efforts have been undertaken to minimise flaring which will reduce the loss of saleable export gas. Occasionally, upset flaring will occur for short periods (hours) during the project's 3-month commissioning period. Philosophically, Sunrise is a gas project rather than a liquids (oil/condensate) project. Therefore, the economics of the project are predicated on the successful export of essentially all the gas not needed for power generation and compression. The project's Joint Venture Partners (JVPs) will not allow sustained flaring of saleable gas product at significant rates (or inefficient power generation/compression turbines) as this would make the project uneconomic.

#### 8.6.1.2 Discharges to Sea

The discharge or accidental spillage of condensate, diesel, solid wastes or chemicals has the potential to degrade the quality of water surrounding the facility. A variety of waste products will be generated and a number of chemicals will be used during operation.

The environmental impacts from discharges and spills to the ocean will be varied depending upon the nature of the waste, chemical or substance entering the marine environment and the quantity that is released. The potential environmental impacts associated with the discharge of produced formation water, deck drainage, sewage and putrescible wastes, chemicals and hydrocarbon spills and cooling water, and are discussed in detail below.

***Produced Formation Water (PFW)***
Treated Produced Formation Water (PFW) will most likely be discharged to the ocean. However, the potential exists for PFW to be reinjected into a dedicated shallow well. This option will be considered during the detailed design phase. PFW will be discharged at a rate of approximately 4,000 barrels/day over the life of the project and is likely to contain 20–30 mg/L oil-in-water following treatment. At these rates a maximum volume of entrained oil of 13–20 kg/day will be discharged. Produced formation water will disperse rapidly. The rate of dispersion will depend on the characteristics of the produced water (ie salinity and temperature), and the mixing energy of the receiving waters. It should be noted that the volume of PFW increases greatly for a few years after year 10 as the Troubadour wells come onstream. The volume decreases soon after, as some wells die or are shut in due to too much water production. Predicted PFW volumes are shown in **Table 8-12.**

**Table 8-12 Predicted Produced Formation Water Volumes**

| Start Up | Year | PFW Volume (bpd) | No. of Wells |
|---|---|---|---|
| 2005 | 0 | | 4 |
| 2006 | 1 | 348 | 6 |
| 2007 | 2 | 376 | 7 |
| 2008 | 3 | 440 | 9 |
| 2009 | 4 | 443 | 10 |
| 2010 | 5 | 609 | 12 |
| 2011 | 6 | 695 | 12 |
| 2012 | 7 | 1029 | 13 |
| 2013 | 8 | 1287 | 14 |
| 2014 | 9 | 1816 | 16 |
| 2015 | 10 | 1696 | 18 |
| 2016 | 11 | 2220 | 19 |
| 2017 | 12 | 3011 | 20 |
| 2018 | 13 | 2923 | 20 |
| 2019 | 14 | 3629 | 21 |
| 2020 | 15 | 707 | 22 |
| 2021 | 16 | 763 | 22 |
| 2022 | 17 | 1060 | 22 |
| 2023 | 18 | 1706 | 22 |
| 2024 | 19 | 2833 | 22 |

| Start Up | Year | PFW Volume (bpd) | No. of Wells |
|---|---|---|---|
| 2025 | 20 | 5314 | 22 |
| 2026 | 21 | 11411 | 22 |
| 2027 | 22 | 16702 | 22 |
| 2028 | 23 | 18040 | 22 |
| 2029 | 24 | 9240 | 22 |
| 2030 | 25 | 9690 | 22 |
| 2031 | 26 | 6492 | 22 |
| 2032 | 27 | 4074 | 22 |
| 2033 | 28 | 5789 | 22 |
| 2034 | 29 | 9165 | 22 |
| 2035 | 30 | 8831 | 22 |
| 2036 | 31 | 3286 | 22 |
| 2037 | 32 | 3337 | 22 |
| 2038 | 33 | 3084 | 22 |
| 2039 | 34 | 2036 | 22 |
| 2040 | 35 | 2227 | 22 |
| 2041 | 36 | 2187 | 22 |
| 2042 | 37 | 2170 | 22 |
| 2043 | 38 | 2165 | 22 |
| 2044 | 39 | 2171 | 22 |
| 2045 | 40 | 2201 | 22 |

The potential environmental impacts associated with the discharge of PFW include:

- Potential oil-in-water exceedance;
- Potential change to water temperature, salinity and turbidity; and
- Chronic toxic effects on sensitive organisms and ecosystems.

Considering the discharge of PFW to the ocean as the 'base case', a high level of dilution and dispersion is expected to minimise the impacts on sensitive organisms and ecosystems. It has been estimated that sensitive species are unlikely to be affected by discharge of PFW at dilutions greater than 1:1,000 (Swan *et al.*, 1994) which is estimated to be within approximately 100 m of the discharge point.

Produced formation water is known to contain a combination of hydrocarbons, heavy metals, nutrients and naturally occurring radioactive materials. Whole effluent ecotoxicological investigations at the Buffalo Field have shown that a dilution of 1:33 was sufficient to reduce the toxicity of PFW to a level where the test organisms (marine algae, rock oyster and urchins) were unaffected (No Observed Effects Concentration). This dilution was achieved within 50 m of the production facility in worst-case conditions of no wind and neap tides (SKM, 2001).

Marine organisms likely to be impacted are those in the vicinity of the discharge outlet. Pelagic fish have the ability to avoid the produced water plume or only be exposed to it temporarily, however, documented evidence is not presently available. Planktonic species are known to be abundant and have rapid turnover rates (LeProvost Dames & Moore, 1997). The impact of produced formation water on planktonic organisms is considered to be potentially adverse locally but of no regional significance.

***Deck Drainage***

No wastes will be routinely discharged via deck washdown. Detergent washdown of the decks may result in minor quantities of chemical residues such as oil and grease and pipe dope entering the direct overboard drain. Drainage water with significant oil contamination is sent to the oil/water separator and oil is decanted. No significant impacts are anticipated because of the minor quantities of overboard discharges involved and the localised area of impact.

***Sewage and Putrescible Wastes***

Sewage and putrescible wastes will be disposed of in accordance with Clauses 222 and 616 of the schedule of the *Petroleum (Submerged Land) Act – Schedule 1995*, which requires that food scraps and sanitary effluents be passed through a grinder or comminuter so that final product will pass through a screen <25 mm diameter prior to disposal to the sea. Discharges will occur on a more or less continual basis. There will be a temporary increase in nutrient availability; however, it is expected that considerable dilution and dispersion will occur ensuring that any increase will be negligible.

Increased nutrient availability may result in the attraction of marine organisms. This is not considered to lead to any adverse impacts. Marine organisms will be able to move away and avoid the area if the proposed activities disturb them.

***Diesel Spill***

Facilities will be designed to minimise the risk of any diesel spill. An Oil Spill Contingency Plan (OSCP) already exists for the area which will be updated if necessary to include the Sunrise Gas Project.

Modelling undertaken by Asia-Pacific ASA for a diesel spill scenario at the production facility indicates that it is unlikely that diesel fuel will make contact with any shorelines or exposed reefs prior to evaporation or decay. Diesel spills may result from the potential rupture of storage tanks, leakage or damage to hoses and overfilling of storage tanks. A simulation was carried out for a diesel spill of 50 $m^3$ at the surface over a period of 6 hours using the three dimensional oil spill trajectory and fates model, SIMAP. Diesel spills are expected to be moderately volatile and have a high proportion of residual oil, which will resist evaporation after loss of approximately 80% of the initial volume. This residual oil will have a relatively high density and will thus be easily entrained where it may not be detectable to an observer. The residue would continue to disperse and decay over time.

The probability of surface exposure and the highest predicted concentration of diesel at surface locations surrounding the production facility during summer conditions is provided in **Figure 8-7** and **Figure 8-8.** The spill disperses to the north-east over the Timor Trench with highest worst case maximum surface oil masses of 13 $g/m^2$ at the production facility that rapidly disperses to surface masses between 0.1 and 1.0 $g/m^2$. Corresponding winter conditions are provided in **Figure 8-9** and **Figure 8-10** which illustrates spill dispersion in a southwest direction and corresponding transitional season conditions are provided in **Figure 8-11** and **Figure 8-12**. The spill disperses to the south-west along the continental shelf with highest worst case maximum surface oil masses of 14 $g/m^2$ at the production facility that rapidly disperses to surface masses between 0.1 and 1.0 $g/m^2$. Diesel spills occurring in the transition season are subject to less dispersion across the surface and are contained closer the production facility. These differences between the seasons largely reflect the seasonal differences in the wind patterns.

Maximum mean concentrations of dissolved aromatic hydrocarbons resulting from a diesel spill do not exceed 6.0 ppb at any location within the water column during summer conditions. These concentrations are comparable to the interim guideline (ANZECC/ARMCANZ 2000) which stipulates acceptable criteria of 7 µg/L (ppb). Spills will not impact on the island of Timor nor the Indonesian Archipelago. Entrainment of oil from a spill is not predicted to reach shallow water environments or to deeper water banks in the area.

***Condensate Spills and Blowouts***

A well or other subsea blowout such as a complete flowline rupture is a major emergency scenario that could result in uncontrolled discharges to sea. A blowout occurrence is highly unlikely and requires a systems failure to result in loss of well control, usually beginning with loss of formation pressure control with the fluid system. In Australia, there have been six well blowouts since offshore drilling operations commenced in the 1960's. Oil was spilled to the sea in only one case and the volume spilt was small. As a result of technological and procedural improvements, there has not been a blowout since 1984 (Woodside, 1998). The likelihood of a blow-out is therefore deemed a low risk.

Product spill from a potential blow-out was modelled by Asia Pacific ASA for a release scenario of 1,113 $m^3$ of condensate at the seabed (162 m below mean sea level) over a period of about 12 hours. This scenario represents the expected loss of condensate from the full-flow release potential of one of the production flow lines leading to the platform. The full-blown release potential for a typical well case is 350 mmcf/day, of which the condensate to gas ratio would be 40 bbl/mmcf. Thus, an estimated 14,000 bbl (2,226 $m^3$) of condensate will be lost per day. Spill modelling was undertaken for an inventory of 1,113 $m^3$ over 12 hours on the basis that the well would be isolated over this period. Entrainment of oil from a spill is not predicted to reach shallow water environments or to deeper water banks in the area.

***Hydrotesting***

The potential environmental impacts that may result from the discharge of chemicals & water during and after hydrotesting of flowlines and risers include the reduction in water quality and the use of biocides, scale and corrosion inhibitors and oxygen scavengers.

Hydrotesting of flowlines and risers involves the injection of filtered seawater comprising small quantities of additives including biocide, corrosion inhibitors and oxygen scavenger. Hydrotesting will be undertaken immediately following the construction and connection of the lines to ensure that no leakages occur, the lines are clean and capable of carrying the product at high pressure.

To ensure that the entire lengths of all flow lines and risers are treated with hydrotest water, a slightly greater volume of hydrotest water to the capacity of all lines will be injected. A small volume will be allowed to escape from the downstream end (at the wells and manifolds). At the conclusion of hydrotesting, during the commissioning phase when hydrocarbons are first flowed from the wells to the platforms, the hydrotest water will be discharged to the sea, from the PCUQ platform.

The concentrations of the chemical additives in hydrotest water will be carefully determined. For example, with oxygen scavenger, the plan is to add just enough to remove the oxygen normally present in the volume of seawater needed, adjusting for the seawater's temperature (which determines oxygen content, in mg/L). For biocide, the plan is to add just enough to kill the bacteria in the filtered seawater without overdosing. Normally, the biocides selected also degrade quickly with time, so as to to make any residual biocide in the hydrotested line as environmentally non-impacting as possible upon discharge. The additives will be in a diluted form in hydrotest water and when discharged to the sea will be further diluted to extremely low concentrations that are expected to be harmless to sensitive communities and marine organisms in the area. The discharge of hydrotest water is considered to result in a negligible impact.

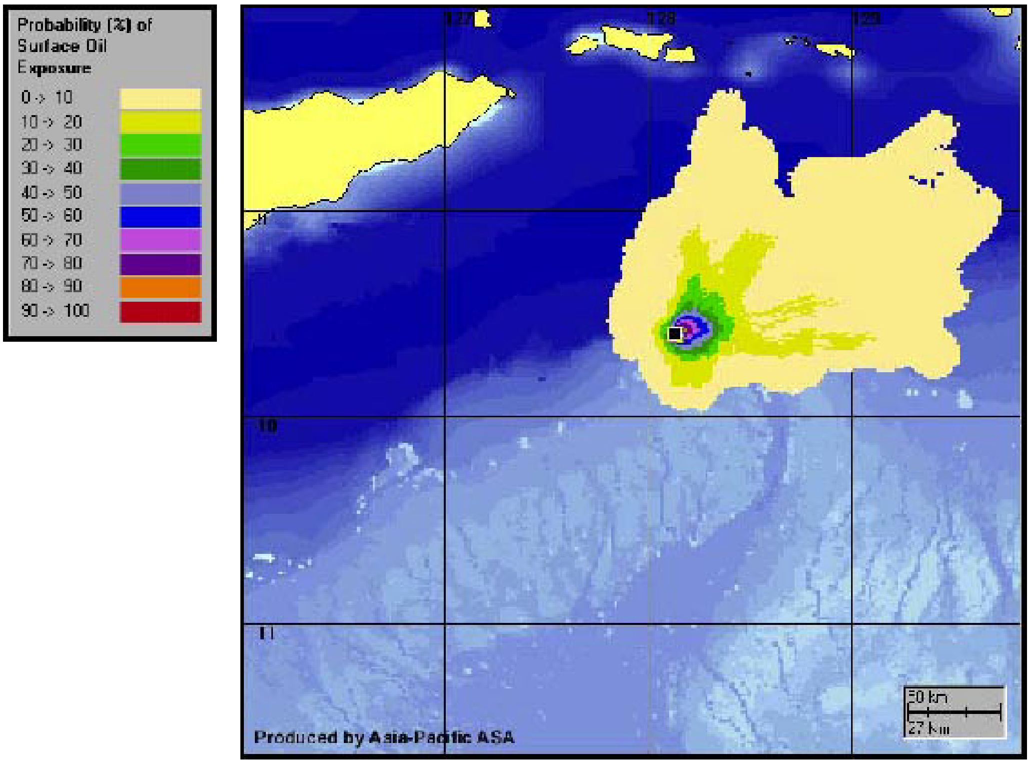


**Figure 8-7 Probability of Surface Exposure to Diesel During Summer Conditions**

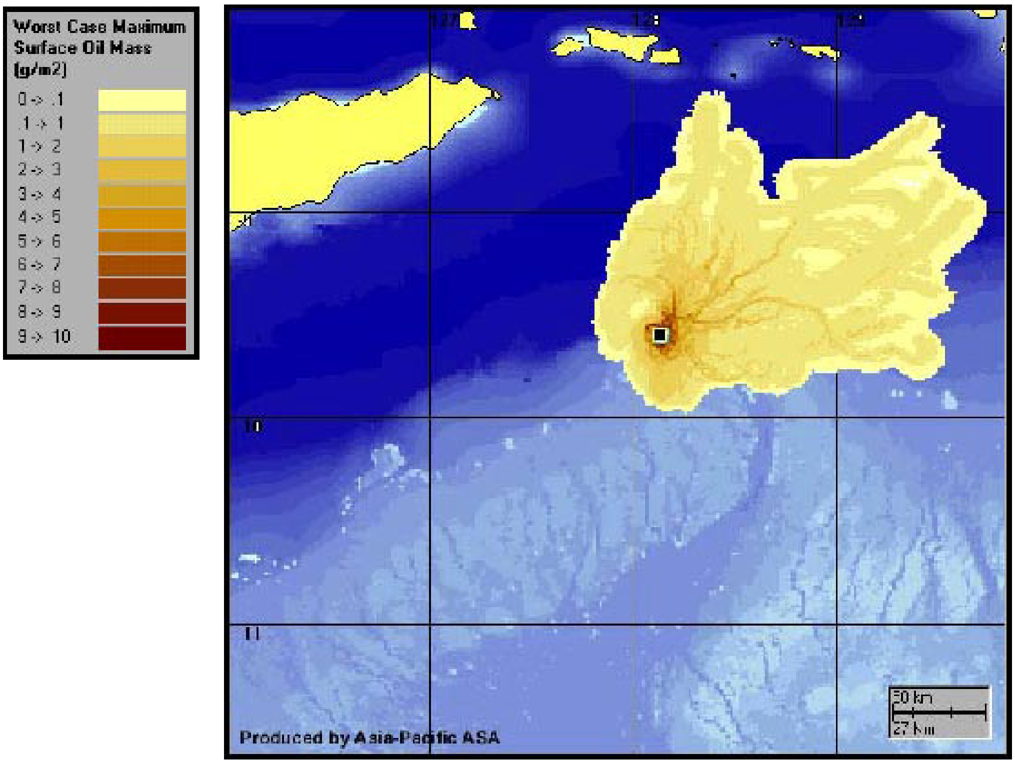


**Figure 8-8 Predicted Surface Diesel Concentration During Summer Conditions**

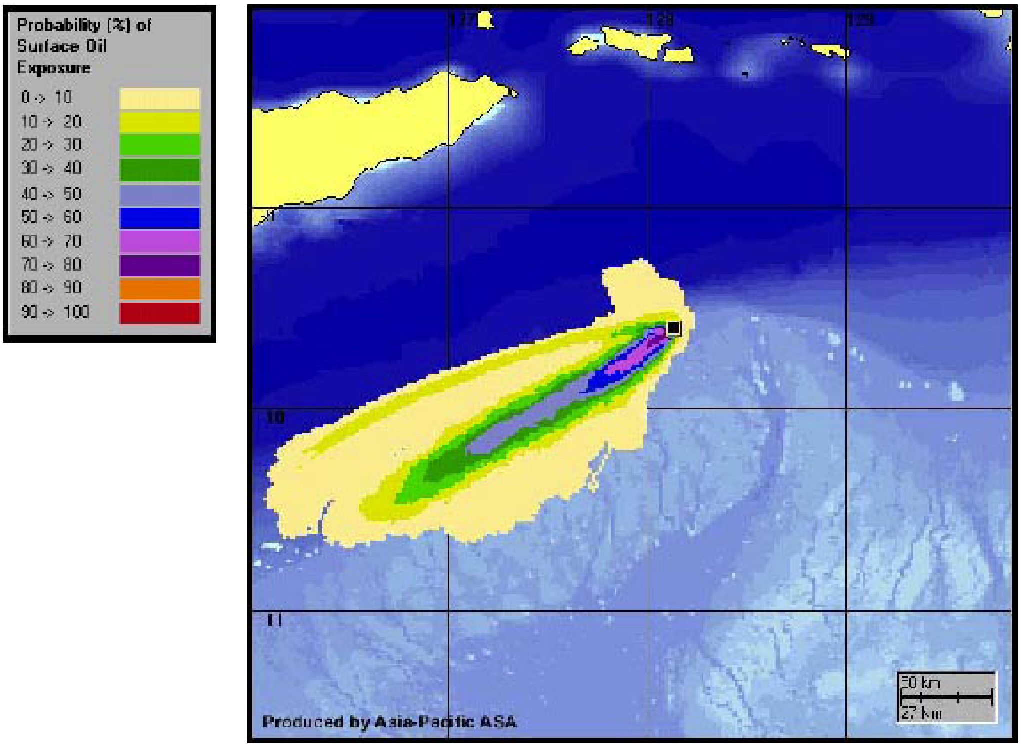


**Figure 8-9 Probability of Surface Diesel Exposure During Winter Conditions**

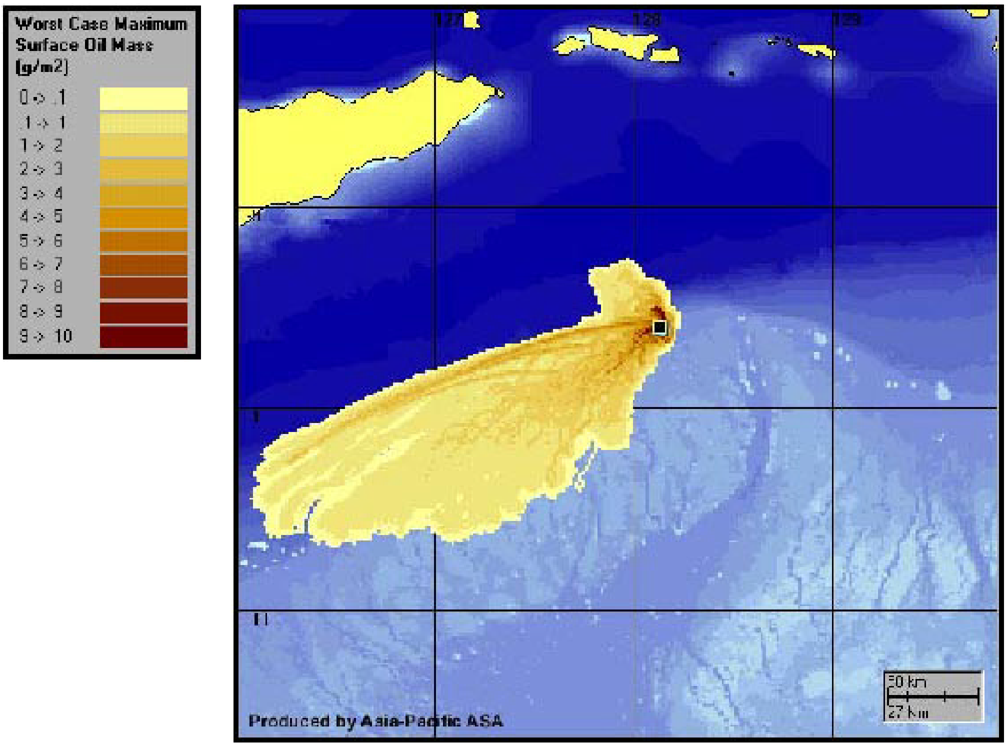


**Figure 8-10 Predicted Surface Diesel Concentration During Winter Conditions**

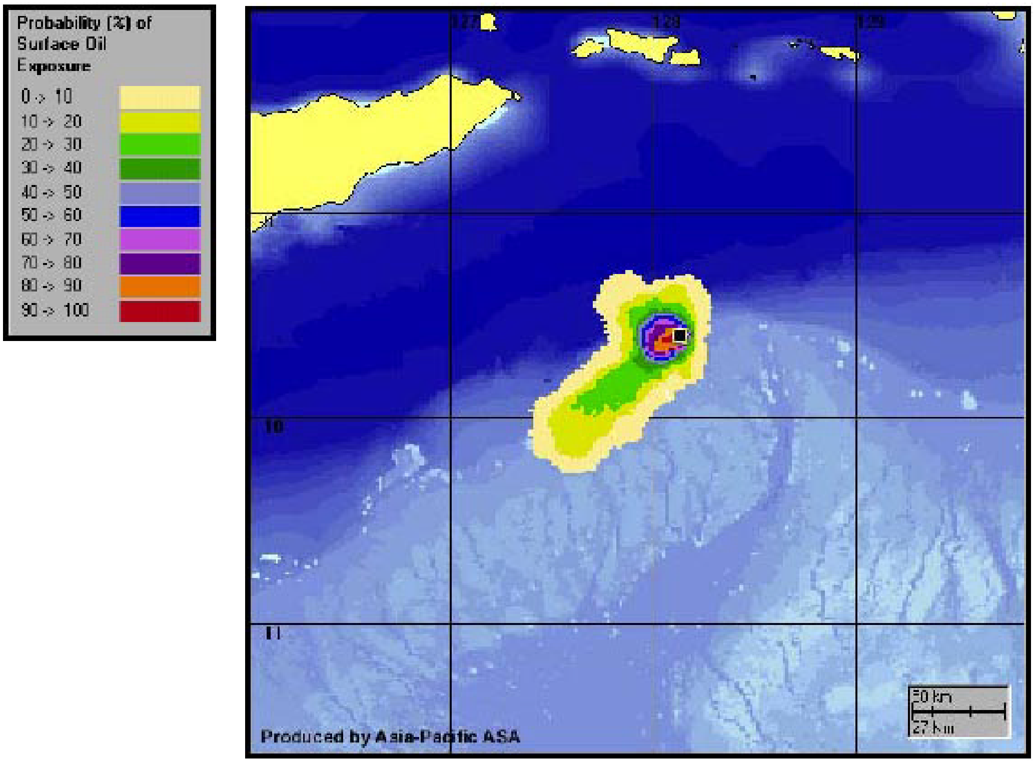


**Figure 8-11 Probability of Surface Diesel Exposure During Transitional Season Conditions**

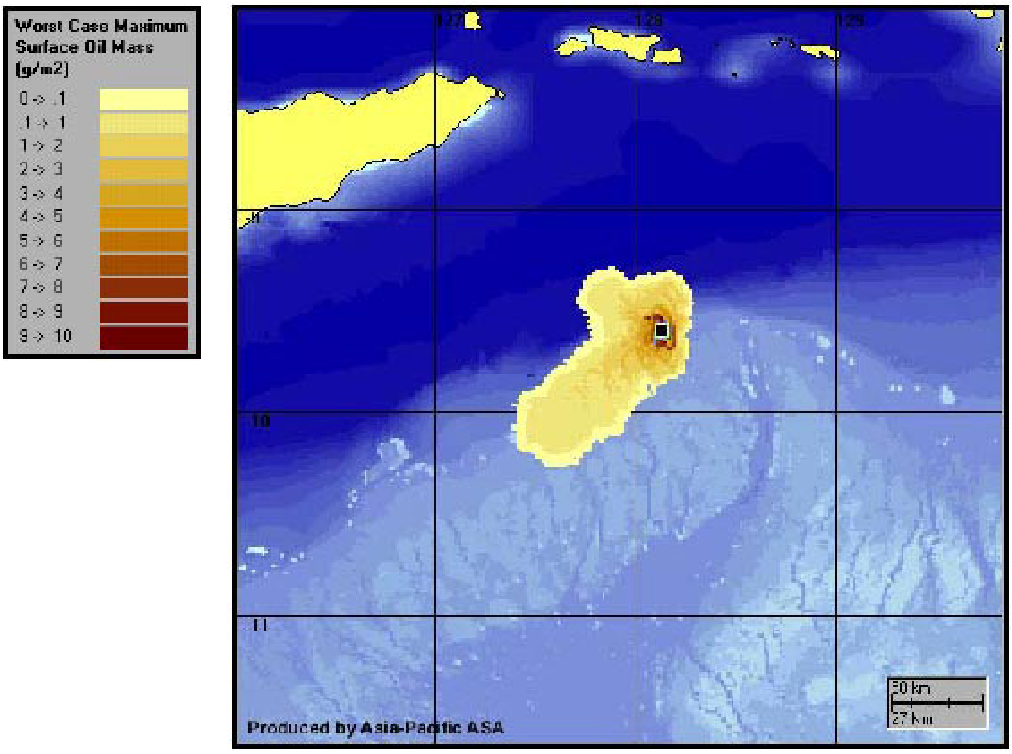


**Figure 8-12 Predicted Surface Diesel Concentration During Transitional Conditions**

Similar to diesel spills, condensate is unlikely to make contact with any shorelines or exposed reefs prior to evaporation and decay. Simulations carried out for a dispersion period of 10 days indicates no exposure to coastlines under conditions representative of any season. Condensate discharge would be largely evaporated within 48 hours at sea-surface temperatures experienced in the Timor Sea. The condensate is expected to contain only a small proportion of residual components (~3%) that would resist evaporation.

Modelled simulations of rising and expanding plume of condensate indicates that relatively low loads (mass per unit area) would be generated at any location on the surface (below 8 x $10^{-4}$ g/$m^2$). However the area affected by the plume could experience concentrations of entrained oil up to 2,000 ppb (equivalent to 2 ppm) and dissolved aromatic concentrations up to 300 ppb (**Table 8-13**). Maximum sediment loads are predicted to be relatively low (<0.05 g/$m^2$).

**Table 8-13 Summary of Highest Predicted Loads for Any Condensate Spill Scenario**

| Scenario | Surface | | Aromatic | | Entrained | | HC_Sediment | |
|---|---|---|---|---|---|---|---|---|
| | Mean (g/m) | Max (g/m) | Mean (ppb) | Max (ppb) | Mean (ppb) | Max (ppb) | Mean (g/m) | Max (g/m) |
| Summer | $1.6 \times 10^{-5}$ | $7.1 \times 10^{-4}$ | 257.9 | 988.6 | 2,008.3 | 11,725.1 | $1.4 \times 10^{-5}$ | $1.2 \times 10^{-3}$ |
| Winter | $8.4 \times 10^{-6}$ | $5.1 \times 10^{-4}$ | 200.12 | 838.7 | 1,951.6 | 7,582.4 | $9.3 \times 10^{-3}$ | $5.2 \times 10^{-2}$ |
| Transitional | $2.0 \times 10^{-5}$ | $7.3 \times 10^{-4}$ | 294.9 | 810.9 | 2,004.7 | 8,418.9 | $1.7 \times 10^{-2}$ | $4.7 \times 10^{-2}$ |

The probability of surface exposure and highest predicted concentration of condensate at surface locations during summer conditions is illustrated in **Figure 8-13** and **Figure 8-14**. The spill disperses to the north-east over the Timor Trench with highest worst case oil masses of 7.1 x $10^{-4}$ g/$m^2$ (**Table 8-13**). Maximum concentrations of dissolved aromatic hydrocarbons are predicted to reach 989 ppb at any location within the water column during summer conditions (**Table 8-13**). Predicted maximum concentrations of total hydrocarbons at sea bed locations during summer conditions will also be very low, typically <0.0001 g/$m^2$ (**Table 8-13**). The deposition of hydrocarbons on the seabed sediment will be confined within a 20 km radius of the platform and will avoid the shallow shoals located approximately 30 km to the southwest of the platform.

Corresponding winter conditions are provided in **Figure 8-15** and **Figure 8-16** which illustrate condensate dispersion and hydrocarbon deposition and corresponding transitional season conditions are provided in **Figure 8-17** and **Figure 8-18**. **Table 8-9** provides a summary of the highest predicted loads for any location in each of the seasonal scenarios.

The potential environmental impacts associated with diesel and condensate spills may include (Apache Energy, 2001):

- Lethal toxic effects – where death of an organism results from direct interference of a component of the diesel or condensate;
- Sub-lethal effects – chronic, biological effects of hydrocarbons through disruption of physiological and/or behavioural responses, but not resulting an immediate death;
- Bioaccumulation – where hydrocarbons may be transferred through the food web;
- Tainting – uptake of oil or certain fractions of hydrocarbons;
- Direct smothering and suffocation;
- Physical or chemical alteration to a habitat resulting in a change in population; or
- Changes to local community structure.

Numerous studies have been undertaken to determine the effects and toxicity of hydrocarbon spills on marine organisms. A summary of the likely impacts on marine organisms from diesel and condensate spills is provided below (Apache Energy, 2001):

- *Plankton*
  Plankton occurring in the immediate vicinity of the discharge point is likely to suffer high mortality. The repopulation of plankton is known to be rapid due to high reproductive rates and immigration from areas outside of the impacted areas (Davenport, 1982). In open waters such as that of the Sunrise Gas Project area plankton populations are very low; however, it is expected that they would return to normal within a number of days of a spill.
- *Benthic Communities*
  Numerical modelling has indicated that the deposition of hydrocarbons on the seabed will be restricted within a 20 km radius of the platform. A spill would result in local damage to communities and organisms inhabiting the seabed. Heavier oils have the potential to reside in sediment for several years however the characteristics of the condensate of the Sunrise Gas Project indicates that a high proportion will evaporate and the remainder will rapidly decay and disperse over time. Sediment resuspension from tide, current, storm activities and bioturbation from organisms will assist in the recovery of the benthic communities that would be impacted.
- *Fish*
  Fish stocks would be less affected due to their mobility and ability to avoid contaminated water and thus impacts would be short-term. However, in severe cases there may be effects of toxicity as a result of entrained hydrocarbons in the water column. Previous studies have indicated that deaths of adult fish have been attributed to toxic effects of water or tainted food, ingestion and to suffocation by clogging of the gills (Clark, 1982; Jones, 1989).
- *Seabirds*
  Although seabirds are highly mobile and capable of avoiding polluted areas they may dive into oil slicks. The covering of the birds plumage with oil may result in drowning or hypothermia as birds rely on the air trapped between their feathers to provide insulation and buoyancy. Oiled feathers lose their water repellency and become matted down. Lightly oiled birds are able to clean themselves but will ingest oil in the process. This may in turn lead to liver, kidney and other tissue damage. Some bird populations will be able to recovery rapidly from the impacts of diesel and hydrocarbon spills, however, the rate of recovery will be largely dependent on:
  - the existence of a reservoir of young breeding adults from which breeding colonies can be replenished; or
  - a high reproductive rate.
- *Turtles*
  Similar to fish, turtles will be expected to avoid areas of contaminated water. In the event that they come into contact with diesel or condensate they may experience eye infections. Little else is known about the direct impacts of hydrocarbons on turtles.
- *Marine Mammals*
  Marine mammals will be expected to avoid areas of contaminated water; however, like turtles, they may experience eye infections if contact is made with hydrocarbons. Whales and dolphins have been observed to avoid surface oil slicks (Baker *et al*., 1989).

***Cooling Water***

Approximately 10,000 cubic metres per hour of cooling water from the production facility will be discharged to the ocean surface under the PCUQ Platform on a continual basis at an approximate temperature of 45°C, approximately 18°C above ambient. Seawater will be used for cooling water and is unlikely to require the addition of chemicals. The cooling water discharged will not contain any hydrocarbon. The discharge of cooling water will have a localised effect on water temperature restricted to the vicinity of the discharge point.

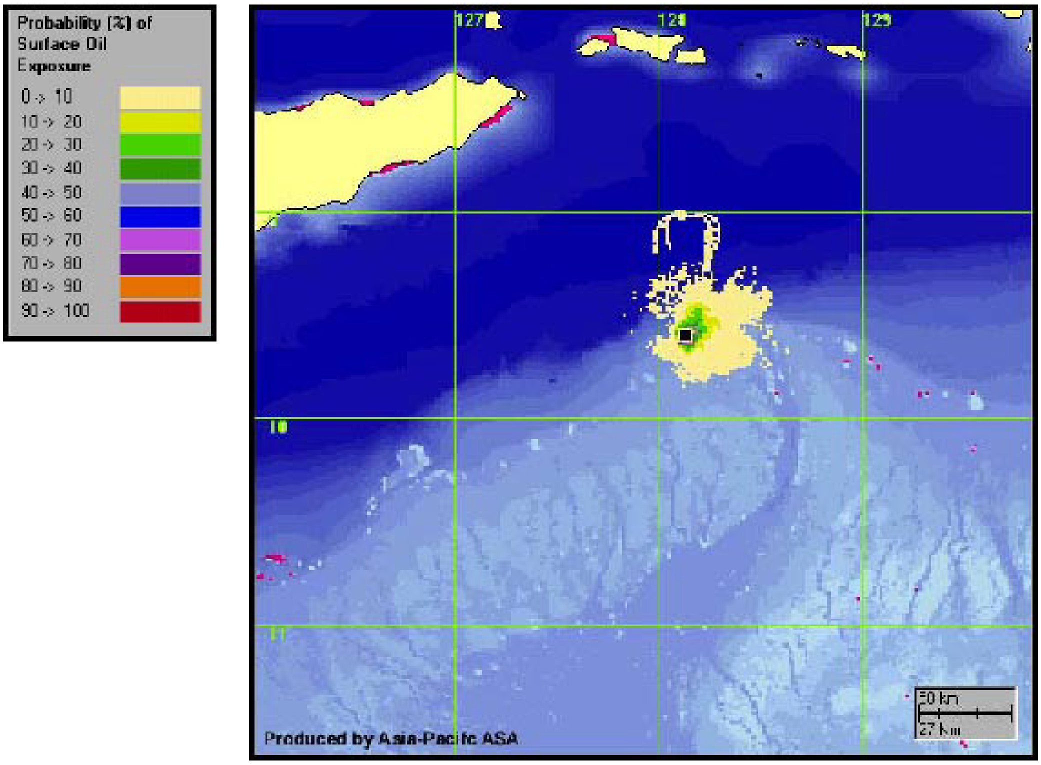


**Figure 8-13 Probability of Surface Condensate Exposure During Summer Conditions**

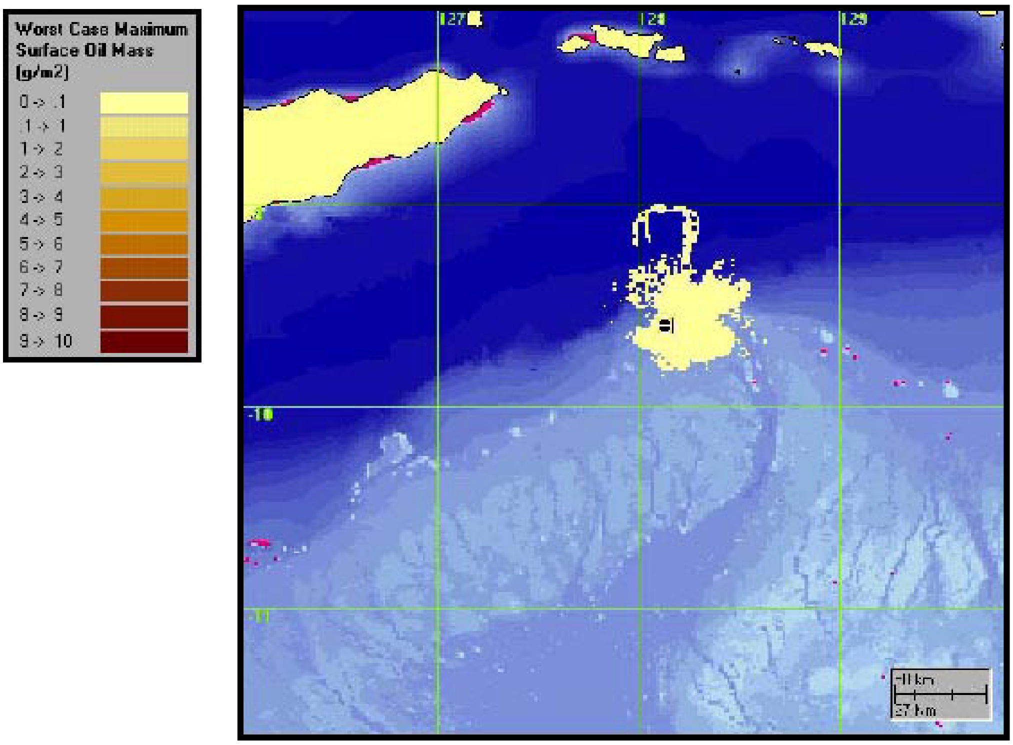


**Figure 8-14 Predicted Surface Condensate Concentration During Summer Conditions**

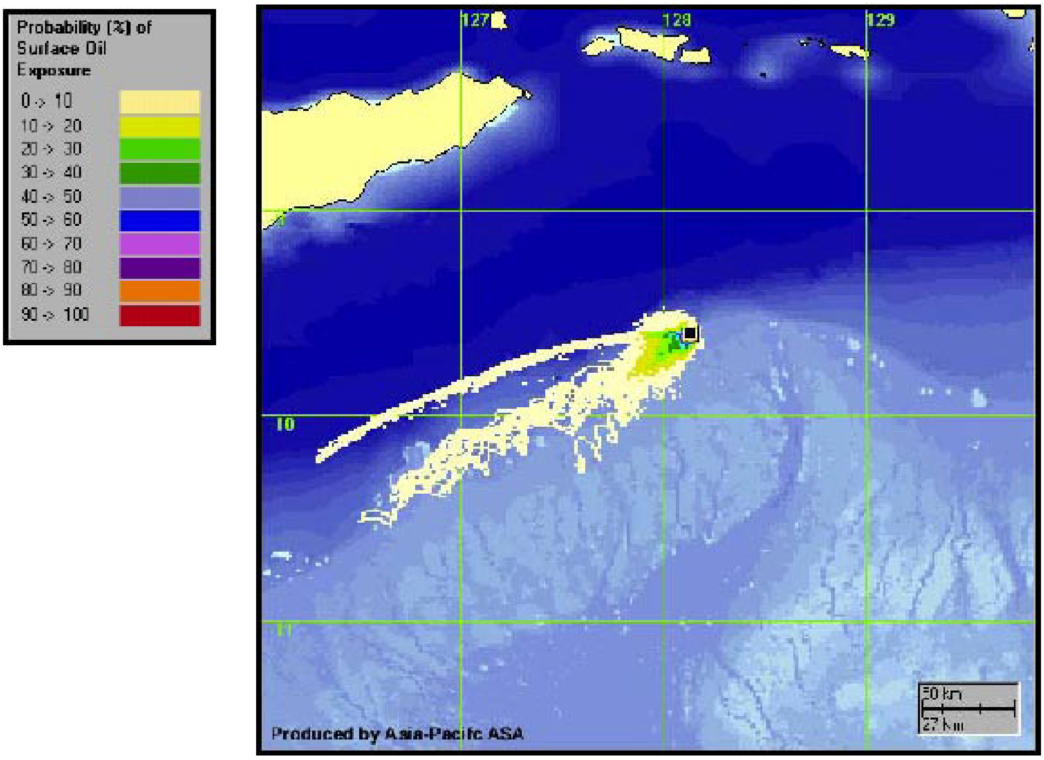


**Figure 8-15 Probability of Surface Condensate Exposure During Winter Conditions**

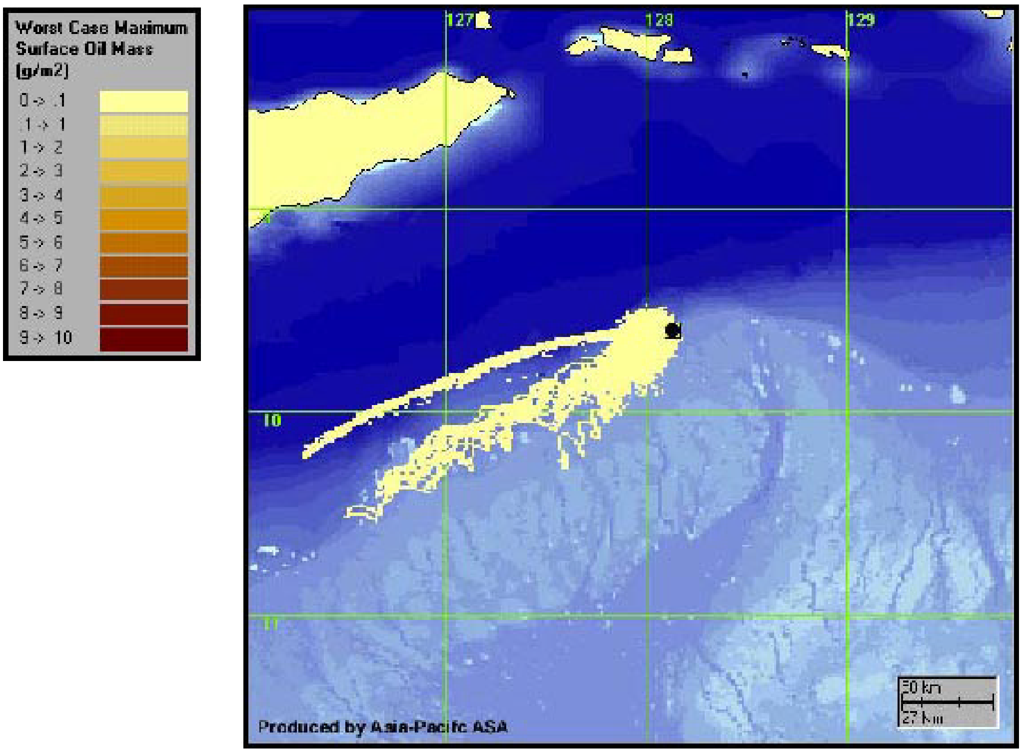


**Figure 8-16 Predicted Surface Condensate Concentration During Winter Conditions**

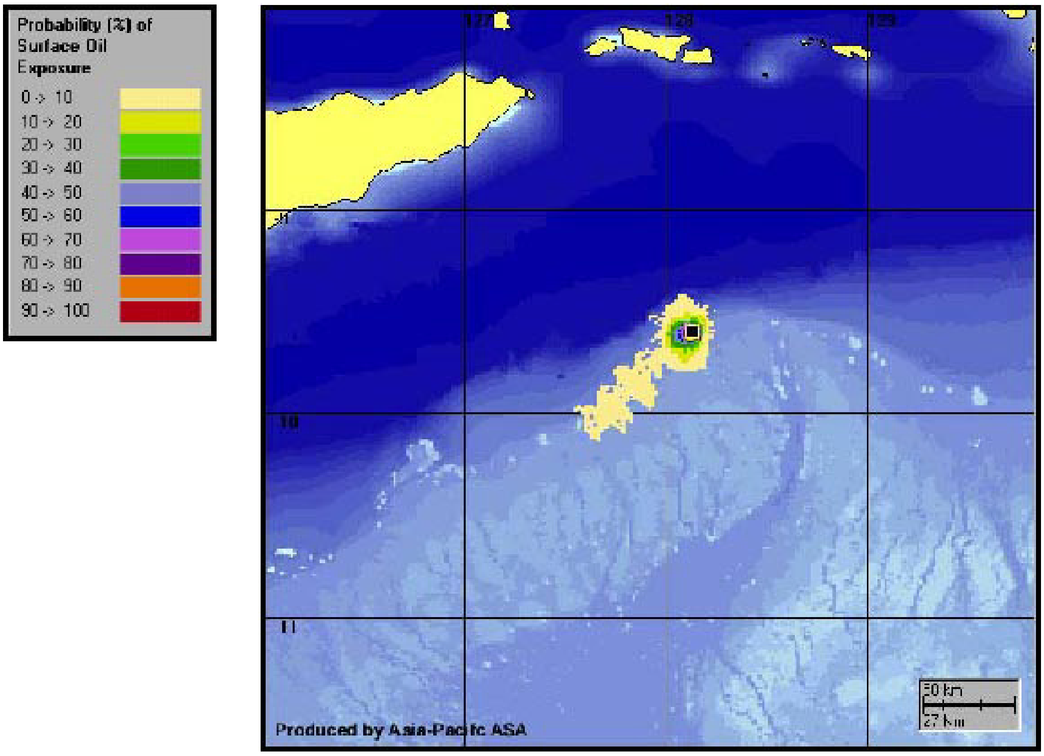


**Figure 8-17 Probability of Exposure to Condensate Spill during Transitional Season Conditions**

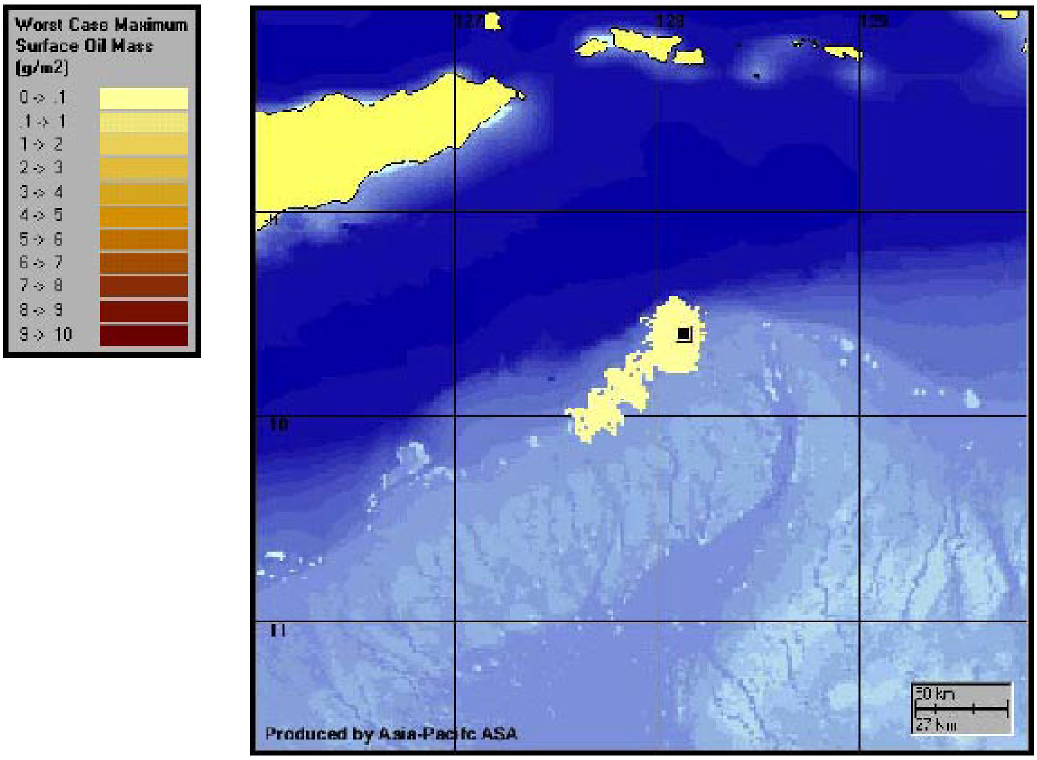


**Figure 8-18 Predicted Surface Condensate Concentration During Transitional Conditions**

#### 8.6.1.3 Noise, Vibration, Light and Heat

Noise and vibration during the commissioning and operation of the subsea facilities, wellhead and PCUQ platforms will be generated from flaring and operation of equipment. Light will be generated from lighting and flaring with the latter also emitting heat. The potential impacts associated with the generation of noise, vibration, light and heat include:

- Potential disturbance to marine organisms and birds; and
- Potential attraction of marine organisms, in particular turtles as a result of flaring and industrial lighting.

***Noise and Vibration***

Marine fauna may be disturbed from the operation of the production facility and vessel movements. The impact of acoustical emissions on fauna has been previously discussed in **Section 8.2.1.3**. Operational noise is not considered to have either a negative or positive impact on fauna. There will be some disturbance, however, this will not result in any beneficial or adverse impact. It is concluded that noise and vibration generated during operation will have a neutral and negligible effect on marine fauna.

***Light***

Lighting will be required on the production facility to comply with regulatory safety requirements. Routine flaring and in particular emergency flaring will also generate light that may attract turtles to the production facility. This attraction is not considered to result in an adverse impact.

***Heat***

Heat generated from flaring has the potential to be harmful to birds that may fly over the production facility. It is likely that the heat generated from the flare will deter birds away from the flare stack, thus preventing direct harm that may occur from direct contact with the flare.

#### 8.6.1.4 Waste to Shore

The disposal of waste to shore has the potential to reduce the quality of the environment if the waste is not disposed of in an approved manner. There is the potential to reduce the quality of surface, ground and marine waters through leachate contaminants.

During operation it is likely that the following wastes will be disposed to shore:

- Waste oil;
- Waste lubricants;
- Chemical drums and other storage containers;
- Scrap metal, piping and other solid waste materials generated from periodic maintenance; and
- Packaging materials (plastic, cardboard, paper and pellets).

These wastes will be disposed of in an approved manner. A project-specific waste management policy will be followed consistent with Woodside's corporate waste minimisation policy. Where possible waste will be reused, recycled, recovered or returned to the supplier for treatment, as an alternative to being disposal at landfill. However, in the event that improper disposal does occur, the potential environmental impacts are considered to be negligible due to the relatively small quantities of waste being disposed, and the likelihood is that the impact will be localised.

#### 8.6.1.5 Other Impacts

***Presence of Facilities***

The presence of large areas of hard substrate will provide a substrate for the colonisation of encrusting organisms present in the plankton. There is a potential that a different community, to that originally found in the area may become established and may include exotic marine species. The colonised communities are likely to attract a variety of fish that may utilise the newly formed habitat as a source of food and refuge. The reef-like nature of the submerged structures will cause a localised increase in the diversity and abundance of marine life, although this cannot be assigned either a positive or negative overall effect. If the option to remove the submerged structures during decommissioning is exercised, thereby removing the artificial habitat and associated communities, then the overall environmental impact will be negligible. This issue will be further addressed in the Decommissioning Plan that will be submitted in accordance with DBIRD guidelines.

The reef effect of submerged structures is believed by some to promote or increase the dominance of predatory species. However, this has not been adequately demonstrated. Perhaps the best case study for Australia is the biological monitoring of the HMAS Swan (Morrison 2001). A very large fish and encrusting invertebrate community has established over a four year period on a scuttled vessel in 30 m of water. The initial colonisation was dominated by prey species during the first year and subsequently the presence of predatory species has stabilised the community structure approximating that of local natural reefs. Predatory species have not been promoted above that of natural reefs and prey species appear not to be any more vulnerable. The effect of the artificial reef was localised and surrounding habitat was not effected.

The presence of the submerged structures should not be considered beneficial nor should they be considered harmful. Hard structures in deep water provide a habitat which may otherwise not be present. The colonisation of new habitat would stabilise over time and any ecological effects would be localised.

***Commercial and Recreational Fishing***

The presence of the platforms and associated facilities will represent a potential navigational hazard to commercial vessels. Species of importance to the fishing industry are unlikely to be impacted by the operations of the Sunrise Gas Project. A 500 m exclusion zone will apply around the facility although little fishing effort is focussed in water depths greater than 100 m. The Sunrise Gas Project area is located in water depth of about 140–400 m. Minor effects on commercial fishing activities could result from restriction of access to fishing grounds and loss or damage to fishing gear. This impact is highly unlikely to occur as no trawling is undertaken in the area and it is believed that only one licensed fishing boat uses the area on a very occasional basis. Taking into consideration the current usage of the area for fishing, the proposed activities associated with the Sunrise Gas Project are considered to have a neutral long-term impact on fishing activities.

### 8.6.2 FSO and Shuttle Vessels

The FSO, once installed and commissioned, would serve as a storage and offloading facility for condensate. Periodically, shuttle vessels from either Australia or overseas will arrive to take on condensate and transport it to its intended market. The sources of impacts identified during the impact assessment were as follows:

- Potential spill during condensate transfer to shuttle tankers;
- Ballast water discharge from offtake tankers once on site;
- TBT and other antifoulant paints on tankers;
- Vessel hulls fouled with marine organisms;
- Cargo tank venting to atmosphere;
- Potential collision with shuttle tankers or supply vessels;
- Power generation emissions;
- Discharge of sewage and greywater; and

- Disposal of domestic waste including food scraps.

In relation to these sources, the following potential impacts are discussed in **Sections 8.6.2.1** to **8.6.2.4**:

***Atmospheric Emissions:***
- Cargo tank emissions from loading of FSO and shuttle tankers.

***Discharges to the Sea:***
- Contamination of marine environment by anti-fouling agents;
- Introduction of marine pest species from offtake tanker de-ballasting and hull fouling;
- Potential significant hydrocarbon contamination from a condensate spill; and
- Potential significant hydrocarbon contamination from a diesel spill.

***Other Impacts:***
- Interference with shipping.

#### 8.6.2.1 Atmospheric Emissions

The FSO and offtake tankers will emit cargo tank vapours containing VOCs and small quantities of other pollutants to the atmosphere when loading. The VOC release rate is estimated at ~10 tonnes/day for the FSO and ~8 tonnes/day (on average) for the offtake tankers. The FSO will release cargo tank vapours at a steady rate as condensate is filled into it from the PCUQ Platform. In contrast, the offtake tankers will release much larger quantities when loading, but loading will only take a fraction of a day every ~3 weeks.

The potential environmental impact is the reduction of air quality. Any impact that may occur to air quality will be localised. As a result, atmospheric emissions from the FSO are considered to have a local negative impact. Under current Kyoto Protocol definitions, cargo tank venting of VOCs is not a significant issue since VOCs currently have a global warming potential of zero. The cargo tank vapours are expected to contain very low levels of methane.

#### 8.6.2.2 Discharges to Sea

The discharge of wastewater, chemicals, domestic waste and ballast water from the FSO and offtake tankers has the potential to degrade the quality of water surrounding the FSO. A variety of waste products will be generated during the operation of the FSO. The activities that may lead to this include:
- Ballast water exchange;
- The use of antifouling paints on tankers;
- Discharge of sewage and greywater;
- Tank washing;
- Potential condensate spills during transfer to shuttle tankers; and
- Potential collision between vessels.

The potential environmental impacts associated with the above discharges are discussed below.

***Ballast Water***
Ballast water from coastal waters elsewhere in Australia or overseas has the potential to impact upon marine communities through the introduction of exotic organisms. Shuttle vessels arriving to offtake condensate from the FSO will need to de-ballast and supply vessels may arrive with hull biofouling.

A range of marine organisms may be transported in large numbers within ballast water and some of these organisms may be capable of invading new ecosystems and upsetting the ecological balance.

Vessels that have biofouling on their hulls as a result of poor maintenance or ageing antifouling paint may introduce exotic marine organisms to the area.

The potential impact is related to the origin of the vessels that could potentially introduce marine pest species. Ballast water or hull fouling organisms from habitats with similar environmental conditions to that of the Sunrise Gas Project area have a much higher success rate for colonisation. Those organisms that are isolated by great distances or geographical barriers are even more prone to be a problem of introduction.

AQIS mandatory procedures would normally allow vessels passing through the Sunrise Gas Development Area to undertake ballast water exchange as it is classified as open ocean. However, vessels arriving at the Sunrise Gas Project area will be required to carry out deballasting in open ocean waters away from the nearby banks, platforms and FSO, preferably over the Timor trench where possible. In addition, there will be a requirement for the shipping company to demonstrate to Woodside that the vessel hulls have been adequately maintained and free of biofouling organisms. This will minimise the risk for such organisms being introduced into an area where they may become colonised on new hard substrates and potentially being transported to Australian ports via vessels travelling between the Australian mainland and the Sunrise Gas Project area.

***Antifoulant Contamination***

The leaching of antifouling paints containing tributyltin (TBT) from vessels has the potential to adversely impact upon marine organisms. TBT is highly toxic at very low concentrations and causes imposex in marine gastropod molluscs at sublethal levels. TBT is relatively quickly broken down in the presence of oxygen while in the water column; however, in sediments it can persist for periods of years, particularly in anoxic conditions.

In November 1999, the International Maritime Organisation (IMO) directed the Marine Environment Protection Committee to develop an instrument, legally binding throughout the world, to address the harmful effects of antifouling systems used on ships. The objective was to institute a global ban on the application of TBT paints on ships by 1 January 2003 and a complete prohibition on the presence of TBT paints on ships by 1 January 2008. The 5-year gap allows for ships legally coated with TBT before 1 January 2003 to operate until their next dry-docking for maintenance. These conditions will apply to all vessels, including the FSO and offtake tankers, related to the Sunrise Gas Project.

Given that marine organisms and benthic communities in the Sunrise Gas Project area are common and widespread the potential impact of TBT on the marine ecology of the area is considered to be localised and negligible. With reference to the EPA classification criteria, the potential impact of TBT contamination is considered to be a negative, long term impact; however, this is generally only the case in areas of high accumulation such as ports.

***Drainage Systems***

The FSO will be equipped with a suitable drainage system to collect stormwater and where possible to separate clean stormwater from potentially contaminated stormwater. Potentially contaminated stormwater and other oily waste streams produced during the operation of the FSO will be contained in suitable storage ‘slops’ tanks. Clean stormwater will be discharged to the sea without the need for treatment. There is the potential for contained oily wastewater to be discharged to sea in the event of an overflow or leakage of the storage basin.

The potential reduction of water quality is considered to be a negligible impact as the potential discharge will be small, localised and diluted as a result of dispersion and mixing and is unlikely to reach the seabed in sufficient quantities or concentrations to impact on the benthos.

***Sewage and Putrescible Wastes***
Sewage and putrescible wastes will be produced by the workforce on the FSO. The environmental impacts associated with the discharge of such waste to the sea has been previously discussed in **Section 8.2.1.1**. The FSO will comply with P(SL)A – Schedule 1995 requirements.

***Oil Spills and Collisions***
Any spills and leaks of diesel and condensate would result in the localised reduction of water quality. Dispersion and mixing of any hydrocarbons spilled would reduce the concentrations of the contaminants in the water column hence reducing the significance of the impact. Modelling of larger diesel and condensate spills has been undertaken and these have been previously discussed in **Section 8.6.1.2**.

#### 8.6.2.3 Waste to Shore

The FSO will generate wastes including paper, plastic, bottles, cans that will be required to be disposed onshore. The disposal of waste onshore has the potential to reduce the quality of the surrounding environment if the waste is not disposed of properly. The potential impacts associated with this have been previously discussed in **Section 8.2.1.4**.

#### 8.6.2.4 Other Impacts

The presence of the FSO and the movement of associated vessels have the potential to disrupt other ships travelling along designated shipping routes. However, the proposed facilities are unlikely to impact on any shipping activities as they are not located near to any designated shipping lanes.

### 8.6.3 Subsea Pipeline

The subsea pipeline, once installed and commissioned, would conduct compressed gas for the lifetime of the Sunrise Gas Project which is expected to be in the order of 30 years. The sources of impacts identified during the impact assessment were as follows:

- Hydrotesting of pipeline;
- Potential rupture of pipeline; and
- Physical presence of the pipeline.

In relation to the above listed sources of impacts, the following potential impacts are discussed in following subsections.

***Atmospheric Emissions:***
- Potential emissions of natural gas in the event of a leak.

***Discharges to the Sea:***
- Potential reduction in local water quality due to release of hydrotest water (biocides, corrosion inhibitors and oxygen scavengers)

***Other Impacts:***
- Physical presence of pipeline.

#### 8.6.3.1 Atmospheric Emissions

Atmospheric emissions would only occur in the unlikely event of a pipeline rupture.

#### 8.6.3.2 Discharges to Sea

- Hydrotesting:

During the operation of the pipeline there will be no routine discharges to sea.

During the commissioning phase, hydrotest water, comprising filtered seawater and additives including biocide, corrosion inhibitors and oxygen scavenger, will need to be displaced from the pipeline. As discussed in **Section 8.4.3.1,** hydrotest water is injected into the pipeline following the completion of construction to ensure that the pipeline is constructed intact and that no leakages occur. During commissioning, hydrotest water will be displaced from the pipeline and discharged to the sea. The discharge will most likely occur to the sea surface at the PCUQ Platform if Bayu Undan gas can be used to start up the Sunrise facility by back-flowing from the WYE piece. However, if Bayu Undan gas is not available, the hydrotest water will most likely be displaced to the sea floor at the WYE piece.

The hydrotest water discharges will have negligible impact on the marine environment because hydrotest water will contain very low concentrations of additives and when discharged will be substantially diluted. Furthermore, as discharges will not occur in the nearshore area.

#### 8.6.3.3 Other Impacts

- Physical Presence of Pipeline:

The presence of the hard substrate of the pipeline is likely to provide a suitable substrate for the colonisation of encrusting organisms. There is a potential that a different community, including exotic species, to that originally found in the are may become established. The colonised communities are likely to attract a variety of fish that may utilise the newly formed habitat as a source of food and refuge. The reef-like nature of the subsea pipeline will cause a localised increase in the diversity and abundance of marine life. For this reason the environmental impact is considered to be beneficial on a local scale.

## 8.7 Mitigation Measures for Commissioning and Operation

### 8.7.1 Commissioning

During commissioning of the facility and pipelines, care will be taken to ensure that no adverse impacts on the environment occur.

Consideration will be given to controlling and minimising where possible the use of biocides and toxic chemicals contained within the hydrotest water. The chemicals used in the pressure testing will be carefully selected with regard to toxicity.

Woodside will ensure that appropriate collection, treatment and discharge options are identified and approved by regulatory authorities to avoid adverse environmental impacts at the point of discharge. In this regard pipeline hydrotest water will be discharged in offshore waters, where an adequate hydrographic regime will ensure rapid and sufficient dilution, so that there is no impact on nearshore areas.

### 8.7.2 Operation

#### 8.7.2.1 General Operation and Maintenance procedures

Woodside will ensure that the facility will implement sound operating procedures for operation and maintenance procedures. In this regard Woodside will implement the following measures:

- Good house-keeping measures will be implemented and maintained.
- All fittings and equipment will be routinely checked and maintained.

- Any areas of spillage and leakage will be promptly reported and necessary maintenance works and control measures undertaken immediately.
- All monitoring devices and alarms will be operative.
- Adequate process surveillance will be undertaken.
- Personnel will be adequately informed of procedures.
- Oil Spill Prevention.
- Navigation and safety lighting will be provided to ensure that any shipping or recreational activities are able to clearly identify the presence of activity.

#### 8.7.2.2 Spills

The following measures are recommended to minimise spill of oil, diesel or chemicals and minimise impact if a spill were to occur.

- Hoses for diesel/ oil/ chemical transfer to be fitted with high reliability breakaway self-sealing couplings;
- Mooring hawser to be fitted with quick release hook and load monitoring cell;
- Consider designing all flowlines for 1 in 10,000 year storms - provided with shutdown valves and HP/LP sensors;
- Spill kits available for clean-up of minor spills;
- Process spill and leak detection, alarm, shutdown and isolation devices will be maintained in good operating conditions;
- Efficient containment and separation of contaminated run-off decks, machinery areas and oil/chemical storage areas; and
- An Oil Spill Contingency Plan (OSCP) has been prepared by Woodside for the Timor Sea. If necessary this OSCP will be amended to meet the specific requirements of the field development.

#### 8.7.2.3 Emergency Response

Woodside will ensure that the ERP are tested and reviewed at regular intervals and the operational personnel are appropriately informed of emergency procedures and trained to effectively implement them.

#### 8.7.2.4 Hydrocarbon Loading

Transportation of condensate, as well as diesel for fuelling etc, to and from the offshore facilities will require vessel transfers. In this regard consideration will be given to the following procedures:

- All regulatory requirements will be observed including standards for design and application of hardware eg flanges, valves, couplings, fittings etc;
- Marine operating procedures define acceptable ocean conditions for the tanker to be connected to the transfer hose and for the export of condensate to take place;
- The transfer hose will be flushed with seawater prior to disconnecting in the event of rough weather;
- Pressure sensors will be installed to detect and trigger alarms for stopping the transfer of condensate to the tanker in the event of a high or low pressure trip;
- Flowlines and hoses are certified and tested prior to use;
- Dry break couplings will be fitted to hoses;
- All fittings and hoses will be routinely inspected and maintained;
- All spillages, leaks or points of excessive wear will be properly reported and the necessary maintenance work and control measures undertaken without delay;
- All monitoring devices and alarm systems will be fully operative; and
- Development and adoption of hydrocarbon loading procedures to minimise the possibility of spillage.

#### 8.7.2.5 Chemicals and Hazardous Materials Management

In summary all chemicals that will need to be discharged into the marine environment will be tested for toxicology and bio-accumulation/ biodegradation. The following approaches will be adopted to minimise chemical usage:

- *Hydrate Inhibitor Chemical Use*

An evaluation of flowline insulation vs. hydrate inhibition will be conducted. In certain flowline configurations, avoidance of hydrate formation may not be effectively guaranteed with flowline insulation alone due to low seabed temperatures and low water production. It may be necessary to inject hydrate inhibitors continuously under such circumstances. If continuous mono ethylene glycol (MEG) injection is used for hydrate inhibition, the MEG will be recovered on the topsides and recirculated. Hydrate inhibition requirements will consider start-up, shutdown scenarios.

- *Self-Equalising Subsea Shutdown Valve (SSSVs)*

All wellheads will be provided with methanol or MEG injection for pressure equalisation and hydrate prevention on start-up. Self-equalising SSSVs will be considered such that methanol injection will not be required. Quantities of chemicals used for such operations are relatively small. These chemicals are highly soluble in water and will be partitioned into produced water phase and a relatively small fraction will get mixed with the product gas and condensate with no significant impact on product quality.

- *Scale Inhibitor Injection*

Available data do not show scale formation tendency but with onset of water production, scale forming potential may occur and scale inhibition may be required. Selection of scale inhibitor will take into account its environmental suitability and compatibility with other chemicals used.

- *Minimise need to dose demulsifier/anti-foam agent in separator*

All separator internals will be selected to achieve minimum breakdown of droplet size and minimising foaming. Proper selection of separator inlet device and internals have shown to greatly improve separation efficiency and minimise consumption and cost of defoaming agent / demulsifier chemicals. A review of the existing state of the art separator internals will be conducted to determine best separator internals for each case to achieve this objective. These chemicals will be mainly discharged with produced water.

- *Minimise need to dose anti-foaming agent in dehydration and stabiliser*

Selection of high-efficiency separator internals will also result in minimisation of condensate carryover with gas and thereby reduce potential for foaming in the Tri Ethylene Glycol (TEG) contactor thereby reducing likelihood of anti-foam agent use in the TEG contactor. A filter coalescer will be provided at the inlet to the stabiliser to minimise foaming in the stabiliser.

- *Minimise continuous corrosion inhibitor injection*

The gas export pipeline may be designed for wet operation for a certain number of days over the design life for start-up and upset conditions. Small quantities of corrosion inhibitor injection may be required during such periods, which will pass on with the product gas stream with no significant impact on product specification.

- *Minimise environmental impact of biocide, corrosion inhibitor, chemical scavenger and dye use in hydrotest water*

It is a common practice to use sea water treated with chemicals such as biocide, corrosion inhibitor, chemical scavenger and dye for flooding and hydrotesting of subsea flowlines and pipelines. This water is ultimately discharged to sea during pre-commissioning. This is a one-off operation and does not constitute continuous discharge. Chemicals with low toxicity, low bio-accumulation potential and high biodegradability will be selected for this purpose. Type of chemicals used will need to be approved by relevant authorities and DBIRD prior to use.

- *Minimise environmental impact of release of hydraulic fluid from subsea control systems.*

Hydraulic fluid which is a proprietary mixture, typically consisting of a 25:75 mixture of glycol and water and certain inhibitor chemicals, are released subsea in small quantities during subsea valve actuation. This system will be similar to that used in recent subsea developments including Wannea Cossack and Laminaria subsea production systems.

More information is contained in **Section 8.3.6.**

#### 8.7.2.6 Waste Management

A project-specific waste management plan will be adopted which will take into account the regulatory requirements of the P(SL)A, maritime laws and legislation of the Northern Territory Government.

The waste management plan will address:
- Discharges to Sea; and
- Solid and Hazardous Waste.

All solid wastes will be stored appropriately and will not be released to sea. The use of licensed disposal sites at Darwin further reduces the risks of environmental impacts. The following mitigation measures will ensure that solid and hazardous waste will not adversely impact on the environment.

- As much as possible waste will be segregated into distinct waste streams eg packaging, chemicals, industrial waste, batteries etc and stored in appropriate locations;
- Waste will be labelled appropriately for return to shore where disposal at landfill, or if possible reuse, recycling or recovery will take place;
- Solid domestic waste will be returned to shore and disposed at an approved landfill; and
- Woodside will ensure, as much as possible, that care is taken to avoid accidental release of synthetic materials to the sea, for eg plastic bags, to avoid adverse impacts on the environment especially marine life.

#### 8.7.2.7 Discharges to Sea

During operation of the facility the following measures will be applied:
- No waste will be disposed overboard except for the following:
  - Comminuted sewage and food wastes;
  - PFW;
  - Ballast water;
  - Cooling water; and
  - Uncontaminated wastewaters eg separated deck drainage, bilge water etc
- Discharges will meet oil –in-water standards;
- Treatment facilities will be of sufficient design capacity to handle PFW, and other oily waters from dirty work areas (deck area drainage, machinery space drainage etc;
- The effluent discharges from treatment facilities will be monitored by appropriate techniques prior to discharge, and monitoring equipment will undergo periodic checking in accordance with statutory requirements;
- All treatment methods will be suitable for the physical and chemical characteristics of the water discharge eg emulsified wastewater may require demulsification facilities;
- Cooling water releases will be controlled to minimise thermal effects; and

- As a minimum sewage and food scraps will be comminuted prior to discharge in offshore waters and in accordance with P(SL)A requirements.

Produced formation water will be separated from the oil using an approved oil separation system and will be discharged overboard during routine operations. The overboard stream will be monitored for oil content and will be discharged under the rules laid down in the P(SL)A. An approved oil in water monitoring system will be used to record oil levels and to ensure that the concentration does not exceed permitted levels. The 'Oil In Water' meter will be regularly tested and calibrated to maintain its accuracy.

Good house-keeping and spills procedures are critical to prevent contamination of the storm run-off water. Deck areas will be kept clean and free of contaminated material. Any spills of chemicals or oil are cleaned up using absorbent material. Contaminated absorbent material will be stored in approved covered containers and transported to shore for disposal. It is also important that all spills are cleaned up prior to the next rainfall event.

Bunds around equipment and process areas will ensure that any runoff potentially carrying contamination is directed to the slops tank. Chemicals or oils in drums will preferably be stored inside the bund areas. If any storage is required outside the bunds then trays will be placed under the drums so that runoff is diverted to the bund or slops tank.

#### 8.7.2.8 Air Emissions/Energy Use

- Flaring will be minimised;
- Emissions from fired machinery will be minimised and fuel use optimised.

The following five options are considered for mitigating environmental impact of venting hydrocarbon vapour from the FSO cargo tanks:

- Base case - the hydrocarbon containing inert gas is directly vented;
- Vent recovery option –the gas is compressed and cooled/ dehydrated and condensate recovered is returned to FSO;
- Vent absorption – in this option the vent gas is compressed and scrubbed with cold condensate to recover non-methane VOCs and the offgas is vented;
- Flare - this option requires flaring of vent gas; and
- Hydrocarbon inert gas – in this case fuel gas is used as blanketing gas instead of inert gas. Displaced gas from FSO is compressed and returned to process. A pipeline to supply and return fuel gas will be required between production platform and the FSO.

For the shuttle tanker, any process to either return the inert gas to the FSO or any process such as recovery or flaring will primarily depend on facilities available on the tanker. The gas is primarily inert gas with a certain percentage of LPG. The venting occurs primarily while loading condensate from the PCUQ, as cargo tank gases are displaced by the liquids.

#### 8.7.2.9 Noise, Vibration, Light and Heat

Woodside will attain occupational health standards for noise emissions by installing silencers, cladding and other appropriate noise attenuation controls where practicable. Due to the distance of the facility offshore noise will not be a major issue.

Methods for minimising noise, vibration, light and heat impacts are included in the following table.

**Table 8-14 Alternatives for Minimising Impacts of Noise, Vibration, Light and Heat**

| Aspect | Alternatives |
|---|---|
| Noise | Acoustic Enclosures<br>Low Noise Electric Drives/Generators<br>Elimination of Gear Boxes<br>Low Noise Valves |
| Vibration | Use Centrifugal Compressors<br>Vibration Dampeners<br>Vibration Monitoring |
| Light | Low Intensity Flare Tips<br>Enclosed Flare |
| Heat | Waste Heat Recovery Units (WHRU) |

#### 8.7.2.10 Marine Support Vessels

**Refer to Section 8.5.2.**

#### 8.7.2.11 Physical Presence

A 500 m safety exclusion zone will be maintained around the facility and no vessels are allowed to enter or anchor within the zone without the permission.

To reduce the risk of collision with vessels using the area, fisheries and shipping will be made aware of the presence of facility, flowlines and 500 m exclusion zone. The facility will be marked on the Australian navigational charts. Notices will be issued to shipping and appropriate navigation marker lights will be displayed.

### 8.7.3 Commitments

Woodside will implement the following commitments throughout the operation and commissioning phase of the Project:

- Prepare a Facility Environment Plan to ensure efficient power generation, planning of vehicle and vessel movements and overall optimal operation;
- Minimise flaring where possible;
- Prohibit the use of ozone depleting substances-CFCs and halons;
- Undertake regular inspections/maintenance of the subsea pipeline in accordance with DNV OS F101 (2000);
- Induct all personnel with particular attention given to correct handling of chemicals and pollution prevention requirements;
- Continuously monitor the quantity and hydrocarbon content of Produced Formation Water;
- Monitor cooling water for temperature and hydrocarbon content;
- Restrict ballast water exchange to deep, ocean waters; and
- Continuously monitor and supervise the transfer of product and diesel between vessels.

## 8.8 Impacts During Decommissioning

**Table 8-15** summarises the source of impact, potential environmental impacts, their effect and duration for the Commissioning and Operation phase which includes:

- Wellhead Platform, Wells and Associated Subsea Facilities;
- PCUQ Platform and FSO; and
- Subsea Pipeline.

### 8.8.1 Wellhead Platform, Wells and Associated Subsea Facilities

The sources of impacts associated with the decommissioning of the wellhead platform, subsea wells and associated subsea facilities are as follows:

- Plugging and abandonment of wells;
- Removal of well heads;
- Removal of flowlines, manifolds and risers; and
- Vessel and rig movements.

In relation to these sources, the following potential impacts are discussed in **Sections 8.8.1.1** to **8.8.1.4**:

***Discharges to the Sea:***
- Potential discharge of residual hydrocarbons.

***Noise, Vibration, Light and Heat:***
- Disturbance to noise sensitive marine life.

***Waste to Shore:***
- Improper disposal.

***Other Impacts:***
- Disruption of benthic communities that have established on and adjacent to the facilities.

#### 8.8.1.1 Discharges to Sea

It is likely that residual hydrocarbons, and potentially other oily wastes, will remain within storage basins and containers, flowlines and risers. The inventory of residual hydrocarbons may be discharged to the sea resulting in a reduction of water quality and the bioaccumulation and toxicity to marine ecology. Appropriate mitigation measures (as discussed in the following Section) will be outlined in a Decommissioning Plan. However in the event that such a discharge occurs the magnitude of the environmental impact will be a negative short term but negligible impact for the following reasons:

- Relatively small potential release volumes for residual hydrocarbons;
- Mixing and dispersion will dilute any leaks to concentrations that are not harmful; and
- Marine organisms and benthic communities that could be impacted by the plume are common and widespread in the region.

#### 8.8.1.2 Noise and Vibration

Noise from decommissioning will be generated from cutting activities and the movement of vessels. These disturbances will be temporary, of short duration and localised. Marine mammals, turtles and fish are highly mobile and if within the vicinity of the Sunrise Gas development during decommissioning they are likely to move away. It is unlikely that there will be any direct impact on marine organisms thus the generation of noise and vibration is considered to be a potential negative, short term but negligible impact.

#### 8.8.1.3 Waste to Shore

Wastes will most likely be disposed of onshore. This may include large quantities of subsea piping, storage drums, metal sheets, concrete and steel. The disposal of waste to shore has the potential to reduce the quality of the environment and create hazardous conditions for fauna if the waste is not disposed of properly.

The potential environmental impact from inappropriate disposal will be negligible, as Woodside will ensure that all waste be disposed in accordance to regulatory requirements. With reference to EPA classification criteria the potential environmental impact of improper disposal will be a negative but short-term impact.

#### 8.8.1.4 Other Impacts

The removal of the wellhead platform and subsea facilities will result in the removal of benthic communities that have encrusted on the hard stand surfaces of the platform and subsea facilities. These communities are likely to have developed over the duration of the operation and the removal of such communities will also impact the fish and other organisms that rely on such communities as a food source. The removal of the platforms will result in the direct loss of these communities and the reduction of fish populations in the area. The environmental impact will be permanent one and is considered to be a minor impact. It is accepted industry practice that all facilities and associated infrastructure be removed to at least 55 m below the sea surface, such that an appropriate level of safeguard is provided for potential future activities in the area.

### Table 8-15 Summary of Potential Environmental Impacts for Decommissioning

| Project Component | Source of Impact | Potential Environmental Impact | Effect | Duration |
|---|---|---|---|---|
| Wellhead Platform, Wells and Associated Subsea Facilities | a) Plugging and abandonment of wells.<br>b) Removal of well head.<br>c) Removal of flowlines, manifolds and risers.<br>d) Vessel and rig movements. | **Discharges to the Sea**<br>▪ Potential discharge of residual hydrocarbons. | Negligible | Short-term |
| | | **Noise, Vibration, Light and Heat**<br>▪ Disturbance to noise sensitive marine life. | Negligible | Short-term |
| | | **Waste to Shore**<br>▪ Improper disposal. | Negligible | Short-term |
| | | **Other Impacts**<br>▪ Disruption of benthic communities that have established on and adjacent to the facilities. | Negligible | Permanent |
| PCUQ Platform and FSO | a) Removal of Wellhead Platform components and equipment.<br>b) Jackup and removal of the PCUQ.<br>c) Disconnection of FSO from flowlines.<br>d) Movement of FSO offsite. | **Discharges to the Sea**<br>▪ Potential hydrocarbon contamination by oil spillage. | Negligible | Short-term |
| | | **Noise, Vibration, Light and Heat**<br>▪ Disturbance to noise sensitive marine life. | Negligible | Short-term |
| | | **Waste to Shore**<br>▪ Improper disposal. | Negligible | Short-term |
| | | **Other Impacts**<br>▪ Disruption of benthic communities that have established on and adjacent to the facility. | Negligible | Permanent |
| Subsea Pipeline | a) Abandonment of subsea pipeline.<br>b) Removal of subsea pipeline.<br>c) Potential discharge of residual hydrocarbons | **Discharges to the Sea**<br>▪ Potential hydrocarbon contamination by oil spillage. | Negligible | Short-term |
| | | **Noise, Vibration, Light and Heat**<br>▪ Disturbance to noise sensitive marine life and terrestrial fauna. | Negligible | Short-term |
| | | **Waste to Shore**<br>▪ Disposal (abandonment of subsea pipeline)<br>▪ Disposal (removal of subsea pipeline) | Negligible<br>Moderate | Short-term<br>Permanent |
| | | **Other Impacts**<br>▪ Disruption of benthic communities and habitats that have been established on and adjacent to the pipeline. | Negligible | Medium Term |

### 8.8.2 PCUQ Platform and FSO

The PCUQ Platform will be removed from the site at decommissioning for possible reuse elsewhere. The facility will be removed by a reverse floatover technique. Essentially the structures will be placed on vessels and shipped off site for reuse/recycling.

The FSO and all mooring systems above the seabed will be completely removed with only anchor piles remaining. The sources of impacts identified from the above activities associated with the decommissioning of the PCUQ Platform and FSO are as follows:
- Removal of Wellhead Platform components and equipment;
- Jackup and removal of the PCUQ;
- Disconnection of FSO from flowlines; and
- Movement of FSO offsite.

In relation to these sources the following impacts are expected, as discussed in **Sections 8.8.2.1** to **8.8.2.4**:

***Discharges to the Sea:***
- Potential hydrocarbon contamination by oil spillage;

***Noise, Vibration, Light and Heat:***
- Disturbance to noise sensitive marine life.

***Waste to Shore:***
- Improper disposal.

***Other Impacts:***
- Disruption of benthic communities that have established on and adjacent to the facilities.

#### 8.8.2.1 Discharges to Sea

Minor spills of oil and the release of residual hydrocarbons from the uncoupling of connections, used storage containers and general handling may lead to the potential reduction of water quality. The environmental impacts associated with minor spills have been previously discussed in **Section 8.8.1.1**. It is concluded that this potential environmental impact will be a negative short-term but negligible impact.

#### 8.8.2.2 Noise and Vibration

Noise from decommissioning will be generated from cutting activities and the movement of vessels. The environmental impacts associated with the generation of noise and vibration has been previously discussed in **Section 8.8.1.2**. It is unlikely that there will be any direct impact on marine organisms thus the generation of noise and vibration is considered to be a potential negative, short-term but negligible impact.

#### 8.8.2.3 Waste to Shore

All wastes will be disposed onshore. This may include storage drums, metal sheets, concrete and steel. The disposal of waste to shore has been previously discussed in **Section 8.8.1.3**. The potential environmental impact of improper disposal will be a negative but short-term impact.

#### 8.8.2.4 Other Impacts

It is accepted industry practice that all facilities and associated infrastructure be removed to at least 55 metres below the sea surface, such that an appropriate level of safeguard is provided for potential future activities in the area.

### 8.3.3 Subsea Pipeline

A number of options for the decommissioning of the subsea pipeline will be considered by Woodside including full removal, deep burial, leave in-place (after flushing and cleaning) or a combination of these. At this stage no decision has been made on the abandonment policy, however, a Decommissioning Plan will be prepared by Woodside and approved, prior to decommissioning commencing. The ultimate decommissioning undertaken at the conclusion of the Sunrise Gas Project will be subject to the legislative requirements of the day. The sources of impacts identified from the above activities associated with the decommissioning of the sections of the subsea pipeline:

- Abandonment of subsea pipeline;
- Removal of subsea pipeline; and
- Potential discharge of residual hydrocarbons/chemicals.

***Discharges to the Sea:***

- Potential hydrocarbon contamination by oil spillage;

***Noise, Vibration, Light and Heat:***

- Disturbance to noise sensitive marine life.

***Waste to Shore:***

- (Improper) Disposal.

***Other Impacts:***

- Disruption of benthic communities that have established on and adjacent to the pipeline.

#### 8.3.3.1 Discharges to Sea

Residual hydrocarbons are likely to be encountered during cleaning and flushing of the pipeline whilst decommissioning. Potential contaminants are likely to be similar to that contained in hydrotest water used during commissioning. Small concentrations of biocides and corrosion inhibitors will be contained in wastewater. Wastewater from cleaning and flushing will be discharged offshore such that impacts to sensitive receptors are avoided. The presence of residual hydrocarbons, biocides and corrosion inhibitors will have the potential to reduce water quality. The environmental impacts associated with the discharge of hydrocarbons and other contaminants to the sea have been previously discussed in **Section 8.8.1.1**. It is concluded that this potential environmental impact will be a negative short term but negligible impact.

#### 8.3.3.2 Noise and Vibration

In the event that the subsea pipeline will be completely removed, cutting activities will generate acoustical emissions. The subsea pipeline will need to be cut into sections to allow the transport of the pipeline onshore. The lay barge and support vessels will also generate acoustical emissions however these are expected to be much lower than those produced from cutting.

In the event that the pipeline will be buried, acoustical emissions will be generated by vessels and equipment used to transport and dump fill over the pipeline.

The potential environmental impacts on marine fauna from noise and vibration have been previously discussed in **Section 8.8.1.2**. It is unlikely that there will be any direct impact on marine organisms from noise and vibrations generated by decommissioning activities of the subsea pipeline. Therefore the generation of noise and vibration is considered to be a potential negative, short-term but negligible impact.

#### 8.8.3.3 Waste to Shore

If the pipeline is removed, disposal onshore will be necessary. This may include materials such as concrete and steel in quantities of at least 0.5 million tonnes. This impact is considered permanent in duration but minor. If feasible Woodside will investigate alternative options to disposal at landfill. The disposal of waste to shore has been previously discussed in **Section 8.8.1.3**. In the event that the pipeline will be buried, there will be no requirement to dispose of waste onshore.

#### 8.8.3.4 Other Impacts

A decommissioning plan will be prepared by Woodside and approved by the relevant regulatory authorities prior to initiation of decommissioning.

If the pipeline is to be removed it will result in a loss of benthic communities and increased turbidity within the vicinity of disturbance. The increase in turbidity and potential smothering of benthos from either removing the pipeline or dumping of fill is likely to occur as result of the localised suspension of sediment. Resuspended sediment is expected to settle following disturbance. The environmental impact on benthic communities is considered to be minor as the communities are generally resilient and are expected to recolonise the area soon after disturbance. On the other hand, if the pipeline remains in place, following cleaning and flushing, the impact would be deemed negligible and neutral.

## 8.9 Mitigation Measures for Decommissioning Phase

### 8.9.1 General

A decommissioning plan will be developed by Woodside in accordance with the guidelines currently being drawn up by the DBIRD. This plan will take into account the concerns and views of other marine users as well as the current and future values of the area. The disposal or reuse/recycling of structures and equipment and the safe decommissioning of wells will also be considered.

A number of options will be considered by Woodside for the decommissioning of the wellhead platform. The ultimate decommissioning undertaken at the conclusion of the Sunrise Gas Project will be subject to the legislative requirements of the day. The options to be considered include:

- Complete removal of jacket;
- Toppling of jacket on side and leaving as artificial reef;
- Cutting of the jacket at seabed and towing to deep water for disposal as an artificial reef; and
- Removing of the top bays of the jacket.

Equipment and facilities no longer required for production will be decommissioned safely taking the following into consideration:

- All wells developed by the project will be permanently sealed off below the seabed and abandoned in accordance with industry standard and legislation of the day;
- Intrafield pipelines and manifolds will most likely be cleared of hydrocarbons, depressurised, cleaned and left in place;
- Risers will also be cleaned but will be removed; and
- All waste materials will be managed in accordance with the project-specific Waste Management Plan.

At present it has not been decided exactly how the pipeline will be dealt with at the end of its working life. The potential options will be considered in the Decommissioning Plan, which will be drawn up in accordance with DBIRD guidelines and relevant legislation.

### 8.9.2 Commitments

- Prepare and Implement a Decommissioning Plan.

## 8.10 Preliminary Hazard Analysis

This section summarises Woodside's objectives in the management of safety, hazards and risks during the course of the Sunrise Project. The information below has been summarised from Woodside's 'Concept Health, Safety and Environment (HSE) Case' Woodside (2001) which brings together the methodologies, results and conclusions of hazard analysis conducted for the Project to date. Reference should be made to this document for such details.

The governing legislation *Petroleum (Submerged Lands) (Management of Safety on Offshore Installations) Regulations* requires a Safety Case to be in force for an offshore facility. The primary objective of the HSE Case is to demonstrate to the Regulator, stakeholders, shareholders, workers and the public that essential controls are in place such that the major HSE risks arising from the operations are both tolerable and reduced to as low as reasonably practicable (ALARP). Major HSE risks are defined as those associated with major ('high risk') hazards and are illustrated in a risk matrix.

The objectives of the concept HSE Case (Woodside 2001) at this early stage of the development are:

- To demonstrate that the design option creates an acceptable major accident and environmental risk that is as low as reasonably practicable;
- To demonstrate that the adequacy of the concepts have been considered to achieve the lowest reasonably practicable level of risk for personnel on the installation;
- To evaluate the Project's understanding of the inherent risk in the concept and operation and identify the requirement for controls through the Develop and Execute phases to ensure operational phase risks are as low as reasonably practicable (ALARP). The resulting documentation can be used to demonstrate that:
    - All major potential hazards applicable to the Sunrise Project concept design have been identified and are controlled;
    - The risks have been identified, evaluated and measures taken to reduce the risks to a level of ALARP; and
    - Recovery systems will be put in place for the unlikely event of loss of control.

The Project activities will be guided by the requirements of Woodside's 'Guideline for HSE Management During Opportunity and Project Realisation' which provides guidance for HSE hazard management activities within the four phases of the 'Opportunity and Project Realisation Process' (OPREP), ie. Assess, Select, Develop and Execute.

These requirements will ensure the identification and understanding of all known hazards and their associated risks; and mishap risk eliminated or reduced to acceptable ALARP levels. The overall objective is to achieve acceptable mishap risk through a systematic approach of hazard analysis, risk assessment and risk management.

Design of the Sunrise Gas Facilities safety systems will be based upon the requirements and guidance of the following (where applicable) main reference systems, documents and Regulations:

- Woodside HSE Management System;
- API RP 14 C Analysis, Design, installation and Testing of Basic Surface Safety Systems for Offshore Production Platforms;
- API RP 14 J, Design and Hazard Analysis for Offshore Production Facilities;
- API 521, Guide for Pressure Relief and Depressurising Systems;

- Petroleum (Submerged Lands) Act 1967, Commonwealth of Australia, and the associated schedules "*Specific Requirements as to Offshore Petroleum Exploration and Production – 1999* and "*Management of Safety on Offshore Installations – Regulations 1996*; and
- *Navigation Act 1912* and Amendments and Regulations pursuant to the Act (which includes requirements of the International Convention for the Safety of Life at Sea (SOLAS) as called up by P(SL)A).

Sunrise project philosophies have been prepared, based upon the above reference sources to guide safety systems design. These include:

- Safety Systems Design Philosophy;
- Flare Relief and Blowdown Philosophy;
- Hazardous Area Classification Philosophy;
- Fire and Explosion Protection Philosophy; and
- Philosophy for Escape, Temporary Refuge and Evacuation.

These documents provide guidance on design aspects to be considered in the control of hazards and on application of different hardware systems for recovery. The documents outlined above will be upgraded to reflect design maturity in the Design Phase of the Sunrise Project. A number of studies will be undertaken to provide additional checks on the design integrity including:

- HAZID Studies/Reviews: - to be held at various stages to identify the major hazards, which must be removed or managed.
- Base Case Review: A HAZID was performed in May 2001 on field and facility layouts. This study reviewed at a high level all known field activities for the design case.
- HAZOPs (Hazard and Operability Studies): are a safety study seen as being a valuable tool for design review. A HAZOP is a systematic review of the entire process and utility systems for a facility with the aim of identifying potential hazard or operability "deviations" from design or operational intent. For Sunrise HAZOP studies have been conducted as follows:
    - Select Phase: A coarse HAZOP of Process Flow Diagrams was conducted at the end of the Select Phase of the Project (May 2001) when concept drawings and documentation were available.
    - Coarse Quantitative Risk Assessment (QRA) studies have been initiated to determine risk levels of options and as an aid to management decisions on project development. Coarse QRA studies have been progressed for the above purpose in the Select Phase and will be preformed in the Basis of Design (BOD) /Project Specification phases. The select phase preliminary QRA results are presented in the 'Concept HSE Case' Woodside (2001).

The objectives of the hazard analysis concepts conducted to date are to demonstrate:

- That all major health, safety and environmental risks will be identified and assessed;
- That the control, mitigation and recovery measures that will be put in place to manage these hazards are adequate; and
- That identified risks will be reduced to as low as reasonably practicable (ALARP).

In the Project Select phase, health and safety-related activities are concentrated on the identification and comparison of major hazards and the selection of options to minimise total project life-time risks both in terms of potential loss of life, voluntary and when applicable involuntary, individual risk.

There has been a number of Hazard Identification exercises QRA's undertaken to evaluate different options and to demonstrate ALARP risk levels throughout the Project development. Safety has been a major driver in concept and option selection.