10th December 2003

Department of Industry and Resources
Petroleum Division
Safety and Environment
11th Floor, Mineral House
100 Plain Street
East Perth   WA   6004

Attention: Zoe Jones

Dear Zoe

RE: GUDRUN-2 – STATE WATERS

Apache proposes to drill the Gudrun-2 exploration / development well in permit TL1 in State waters, in early January 2004. The well will be drilled from the Harriet A platform as shown in the attached Figure 1.

The Environmental Assessment and Management Plan for Endymion-1(EA-60-RI-129) will be used to drill the well, as it covers the expected environmental risk and control measures to be undertaken during the drilling program. Oil spill modelling for summer conditions is included in the EAMP.

The Gudrun-2 well details are provided in Table 1. The well will be drilled with water based mud and synthetic based mud using the ENSCO-56 drill rig. Synthetic based mud is required for the bottom hole section due to the deviation of the well. The drilling programme will generate an estimated 245 m^3 of cuttings (132 m^3 WBM and 113 m^3 SBM). Approximately $70m^3$ WBM cuttings will be discharged to the seabed. All SBM cuttings are intended to be reinjected down the annulus. Water depth at the proposed Gudrun-2 drill site is approximately 25 m deep.

Drilling Program

The drilling procedure for the well will be to drill a 660 mm hole to a depth of ±22 m below the seabed with seawater (90%) and gel sweeps (10%). A 508 mm conductor casing is then installed into the hole and cemented into position. A diverter will then be installed. The next section of drilling is with water based mud and involves a 406 mm hole with 340 mm casing to a depth of 1050 m (982 m TVD). BOP's will then be installed. The next section of drilling is with synthetic based mud and will involve a 216 mm hole to give a total well depth of 4140 m (1957m TVD). Upon completion of the well evaluation program, the well will be plugged and abandoned or completed. If the well is to be completed, a tapered production casing string will then be run in the 216mm hole and cemented prior to running the completion.

All work on the well will be undertaken in accordance with the regulations and guidelines set out in the *Petroleum (Submerged Lands) Acts, Schedule: Specific Requirements as to*

Offshore Petroleum Exploration and Production – 1995. On the completion of the drilling program the rig will be jacked down and towed away.

Synthetic Based Mud

Apache propose to use an MI Australia Pty Ltd synthetic based mud product with a base fluid consisting of LAO C14/16/18. The base fluid will have no greater than 65% of the C14 component with the remainder either C16 or C18. The composition of the base fluid will be verified by GCMS prior to Apache using it on Gudrun-2. The following ecotoxicity data on OECD test species and biodegradation rates are provided on a product known as Novatec LAO C14/16/18 which has up to 70% of the C14 component. This is 8representative of the mud to be used on Gudrun-2.

Skeletonema costatum	72 h EC50	>1,000 mg/kg
Acartia tonsa	58 h LC50	>2,000 mg/kg
Corophium volutator	10 d LC50	3,030 mg/kg

Aerobic degradation over 28 days >99%
Anaerobic degradation over 77 days 50%

MI Australia Pty Ltd have committed to Apache to commission acute toxicity testing of local WA species for this synthetic based mud product.

Previous Drilling at Harriet Platform

Harriet-1 was drilled as an exploration well in October 1983 with the well suspended as a potential oil producer. Harriet Alpha platform was subsequently built on the site in 1985 and production started in 1986. Since then 10 wells have been drilled from Harriet Alpha platform, all using water based mud.

A summary of the environmental guidelines and commitments for the Gudrun-2 well as they will appear in the drilling programme is included in Table 2.

Should you require any further information, please contact me on 9422 7481.

Yours faithfully

Libby Howitt
Environmental Scientist

Figure 1: Location of the proposed Gudrun-2 well site also showing the proximity to Endymion-1.

Table 1: Gudrun-2 well details

Gudrun-2	TL/1
Surface hole location *GDA94 lats and longs*	20° 36' 8.112" S 115° 36' 51.379" E GDA '94
Type of well *Exploration vs Development; Vertical vs Deviated*	Exploration / Development
Approximate water depth *(m)*	25
Approximate length of drilling period: *Dry Hole and Development case*	12 dry hole 19 days completed
Proposed total depth of well *(measured)*	4140m
Drilling rig	Ensco 56
Drilling fluid *if SBM, name product*	WBM & SBM
Annular disposal?	yes
Estimate volume of cuttings for WBM &/or SBM (m^3): *Total for well* *Disposed to seabed* *Disposed down annulus*	245 m^3 total (132 m^3 WBM, 113 m^3 SBM) 70 WBM to seabed 113 m^3 SBM down annulus
Scheduled commencement date	January 2004
Nearest land or reef system	Lowendal Islands
Distance to nearest land or reef system (km)	6.3km to Varanus Island 5.3 km to closest island in Lowendal group.
Oil Spill Modelling	Oil spill modelling from Endymion-1 location.

Table 2: Apache Environmental Guidelines and Drilling Rig Environmental Commitments

The following Apache guidelines will be followed and commitments adhered to on the Gudrun-2 well. These have been extracted from the Apache EMP for Endymion-1 (Doc Ref EA-60-RI-129) and modified to include injection of SBM cuttings.

Activity	Requirement
Disposal of drilling fluid and drilling cuttings	• Use of **WBM and SBM approved. SBM cuttings to be reinjected. WBM cuttings may be disposed of to seabed.** • Solids control equipment to be optimised to ensure maximum separation of fluid from cuttings. • Follow Apache refuelling procedures and SBM transfer procedure when used (AE-91-IQ-098) • Record volume of drilling fluid disposed into the ocean on environmental spreadsheet. Results to be reported to the Environmental Manager at the end of the well.
Pipe Dope	• Use pipe dope that has lowest concentration of heavy metals and hydrocarbons but still meets safety and performance criteria. • Record volume of pipe dope used on location on environmental spreadsheet. Results to be reported to the Environmental Manager at the end of the well.
Cooling water	• Cooling water to be discharged at barge level to facilitate cooling and oxygenation
Deck drainage, chemical storage and management	• Maintain good housekeeping practices • Chemicals are to be stored in bunded areas away from open drains and chemical containers intact • Drip trays are to be used under all machinery and fuel points and valves. • In the event of a spill, take all actions to control the spill and divert deck drainage to on board containment tanks for treatment through oil in water separator. • Ensure absorbent material is on board to use in soaking up chemical or oil spills. • Maintain oil water separators regularly to ensure 15 ppm oil concentration alarm is functional • All releases of oil in water of greater than 50mg/l (over a 24 hour period) are to be reported to Apache Perth office • **All spills >80L must be reported to DoIR within 2 hours either directly by contacting the DoIR Duty Inspector on 08 9480 9096 or via Perth office.** • Report all spills <80L through Apache incident reporting system
Spillage of diesel fuel or oil	•Follow Apache refuelling procedures (AE-91-IQ-098) •In event of a spill take all actions to control the spill. •No dispersant use without DoIR approval • **All spills >80L must be reported to DoIR within 2 hours either directly by contacting the DoIR Duty Inspector on 08 9480 9096 or via Perth office**. •Report all spills <80L through Apache incident reporting system
Discharge of combustion products from engines	• Inspections and tuning of engines and equipment are included on a regular maintenance schedule.
Waste Oil Management	• Waste oil and grease to be drummed and returned to mainland for recycling • Records of volume of waste oil taken off rig forwarded to the Environmental manager at the end of the well.

Solid waste management • Food scraps • Garbage • Litter • Scrap metal and wood etc	•All solid waste (**including food scraps**) to be **sent onshore for disposal** •No disposal of debris, garbage or litter into the sea. (skips need covers to prevent wind blown rubbish – especially plastics and styrofoam cups) •Segregate industrial waste (scrap metals / drums etc), wherever possible, for appropriate disposal onshore. •Reduce, reuse and recycle waste wherever practicable. •Record the volume and type of waste taken off rig and forward to the Environmental Manager at the end of the well. •ROV survey to check no rubbish left on seabed. Any debris will be removed.
Sewage discharge	•Sewage is to be treated to tertiary level prior to discharge. •Sewage treatment plant is to be maintained to ensure effective treatment
Anchoring	•No workboats are to anchor in areas where coral reefs occur (none known in immediate vicinity of Gudrun-2).
Operational Environmental Awareness	• Personnel are familiar with the environmental requirements of the EMP and all guidelines and procedures outlined are being followed. • All personnel have signed off the rig register book confirming their induction.
Megafauna Observations	•Fill in whale and turtle observation data sheets and forward to the Environmental Manager at the end of the well.

Perth Office Commitments

Activity	Requirement
Prior to drilling	• Make EMP for Endymion-1 available to personnel involved in drilling program
Discharge of combustion products from engines	• Report greenhouse gas emissions data to Federal Government annually.
Environmental Audit	• Audit drilling rig every six months whilst under contract to Apache Energy •Review electronic waste and chemical log received from rig.

ENERGY LIMITED

Endymion-1

Permit Area TL/1

Exploration Drilling Program

Environmental Assessment & Management Plan

July 2002

EA-60-RI-129

REV 1

Distribution list:
Department of Mineral and Petroleum Resources
Department of Environmental Protection - Karratha
Department of Conservation and Land Management – Karratha
WAFIC
Apache Senior Drilling Engineer
Apache Drilling Supervisor
MODU Person in Charge
Marine Manager – Workboats x 2
Environment Library
Main Library

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1.0 INTRODUCTION

1.1 Background

Apache Energy Pty Ltd (Apache) is the operator Permit Area TL/1, located in state waters on the North West Shelf.

Apache has drilled over 90 wells in this and other permit areas on the North West Shelf since 1983. Apache is active in exploration and development drilling in the North West Shelf, having drilled 24 wells in 2001, 24 wells in 2000 and 18 wells in 1999.

The proponent's address is:

Apache Energy Ltd
Level 3, 256 St Georges Terrace
Perth, Western Australia 6000

Contact Person for this well is:

Kaye Dixon
Environmental Scientist
Ph: 9422 7205

1.2 Project Description

The proposed well, Endymion-1 is located on the North West Shelf of Western Australia at Apache's Sinbad platform (Figure 1).

The Sinbad platform is a five slot platform located about 18km NNE of Varanus Island. Two wells have been drilled from the platform into the Sinbad field. They have reached the end of their useful life.

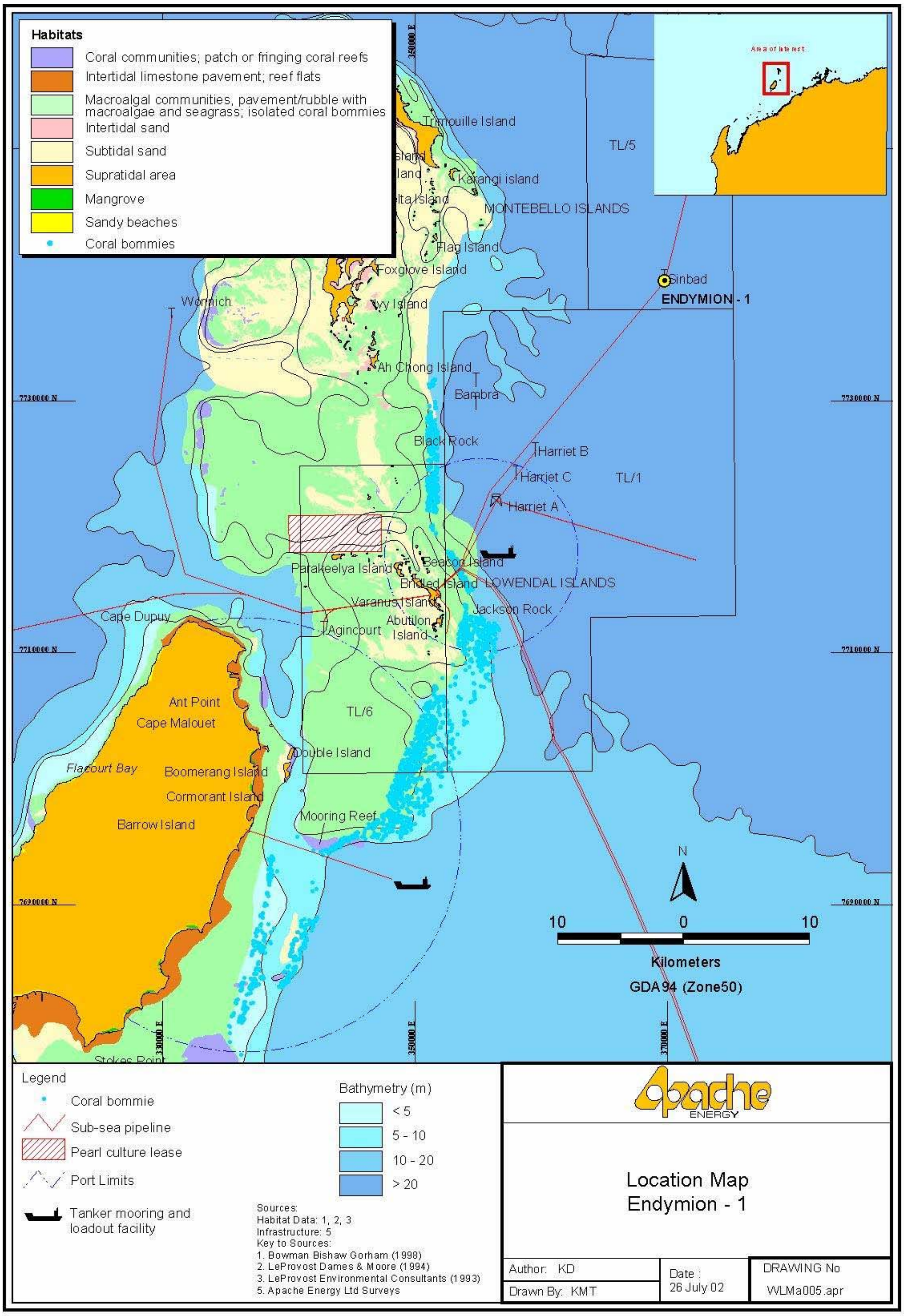
Endymion-1 is a new well intended to drill a target about 3,600m from the Sinbad platform. The proposed Endymion-1 drilling program is scheduled to commence early September 2002. The drilling program is expected to take 11 days. The actual start date will be determined by the availability of the jack up drill rig which is drilling a number of wells in the region for Apache, hence the drilling may occur within a period a few weeks either side of this date (i.e. mid-late August through to late September).

The details for Endymion-1 are given in Table 1.

Table 1 Well Details

Endymion-1	
Surface hole location	20° 29' 0.20" S 115° 42' 43.87" E GDA '94
Type of well	Exploration
Approximate water depth (m) AHD	40
Approximate length of drilling period (days)	11 dry hole
Proposed total depth of well	3600m (2126m TVD).
Drilling rig	Ensco 56
Drilling fluid	WBM + SBM
Volume of cuttings (estimate only) m^3	Dry Hole – 148 m^3 Completed – 177 m^3
Annular disposal?	Not Possible
Volume of cuttings disposed to sea floor	Dry Hole – 49 / 99 Completed 49 / 128 WBM / SBM m^3
Scheduled commencement date	August / September 2002
Nearest land or reef system	Montebello Islands
Distance to nearest land or reef system (km)	11km closest island (Whale Rock), 17 km to Hermite Island, 15 km to Trimouille Island
Oil Spill Modelling	Endymion-1 modelling winter, transition and summer.

Figure 1 Location of Endymion-1



The well will be drilled using the jack-up drilling rig Ensco 56. This drilling rig is a self-elevating, cantilever jack up platform. The rig will be towed into position by one or two support vessels. When in position, the legs are jacked down to the seafloor and the rig raises itself above the platform approximately 27m above the sea surface.

The one or two support vessels which will tow and position the rig will also supply the rig with fresh water, food, fuel, bulk drilling fluid materials and drilling hardware. These vessels will operate between the rig and the Port of Dampier.

The drilling rig and support vessel crews will be accommodated aboard their respective vessels. Crew changes will involve transfer by helicopter to and from Barrow Island.

1.3 Operational Details

Specific drilling procedures and well details for Endymion-1 follow.

Drilling Procedure Endymion-1
The drilling procedure for the well will be to drill a 610 mm hole to a depth of 26 m below the seabed with seawater (90%) and gel sweeps (10%). A 508 mm conductor casing is then installed into the hole and cemented into position. The next section of drilling involves a 406 mm hole and 340 mm casing to a depth of 895 m (870 m TVD). The casing strings are cemented to control formation pressure and well bore instability. After cementing each casing string, it and the BOP is pressure tested before drilling continues. Formation pressures within the well bore and the volume of returned drilling fluid are continuously monitored. If flowing formation is detected, the drilling fluid density is increased proportionately to provide primary well control. The BOP is used to seal the well in the event of a fluid flow from the well that cannot be controlled by the existing mud density.

The next sections of drilling involve a 216 mm hole to give a total well depth of 3600 m (2126m TVD). Upon completion of the well evaluation program, the well will either be plugged and abandoned or completed. If the well is to be completed, part of the 216mm hole will be opened up to 311mm and a 244mm casing string run to about 2100m (1466m TVD). A production liner will then be run in the original 216mm hole and the well completed as a gas producer.

All work on the well will be undertaken in accordance with the regulations and guidelines set out in the *Petroleum (Submerged Lands) Acts, Schedule: Specific Requirements as to Offshore Petroleum Exploration and Production – 199*5. On the completion of the drilling program the rig will be jacked down and towed away. A remotely operated vehicle will then be used to survey the seabed to ensure that no debris remains from the operations.

The well will be drilled with both water based drilling fluid and synthetic based mud. The SBM proposed for this well is Synteq, an olefin based mud. Product information sheets and MSD sheet indicates that the mud has very low toxicity e.g. EC50 for *Corophium volutator* was greater than 1000 mg/L.

Water based drilling fluid will be used in the 610 and 406mm hole. The well will be drilled with synthetic based drilling fluid in the 216mm hole and contingent 311mm hole sections. Whilst not an extended reach drilling well, the required drilling profile will result in a well with a 68° tangent section. It is considered necessary to drill this hole section with synthetic based mud in order to manage the drilling risk. All the cuttings will be discharged to the seabed. Water depth is 40m.

Cuttings injection is not possible in this instance. The well will be drilled from an older platform where the conductor size is limited to 508mm by internal guides. This results in very small annular clearances between the conductor and the mud line support of the 340mm casing. The small annular clearance means that despite there being a suitable lost circulation zone below the conductor, reliable injection will not be possible.

If hydrocarbons are encountered, it will not be necessary to carry out any production testing.

1.4 Safety Precautions

Before drilling operations commence at Endymion-1, routine precautions will be undertaken by the drilling contractor to ensure the stability of the drilling rig and to minimise the risk of movement during storm conditions. Previous drilling in the region has provided information on the nature and stability of the seabed and the underlying strata, particularly with respect to the expected depth of penetration by the rig legs. The positioning and jack-up operation will be closely supervised by the drilling supervisor, rig supervisor and vessel skippers.

During drilling, a temporary 500 m radius exclusion zone around the rig will be declared. Any vessels that operate in the surrounding waters will be informed by radio about the exclusion zone around the rig as they approach.

The well will be designed and engineered to standards approved by DMPR to ensure that well pressures remain under control. Annular, ram and drill string BOPs will be used. A typical BOP stack design system would incorporate the following:

- double ‘U’ ram, 10,000 psi working pressure;
- single ‘U’ ram, 10,000 psi working pressure; and
- an annular preventer, 5,000 psi working pressure.

The BOP system will be able to contain pressure far in excess of pressures (3,308 psia) encountered in reservoirs generally found in the Carnarvon Basin.

Casing sizes and lengths and the intervals where the hole is cement sealed around the casing will be selected to maximise well control. Experience gained from the numerous wells drilled in State waters will facilitate well design. Well design is conservative to ensure a margin of safety to control any higher than expected pressures.

An Emergency Response Manual (AE-00-ZF-025) and Oil Spill Contingency Plan (AE-00-EF-008), detailing safety procedures in the event of an accident or emergency situation, will be available on the drilling rig as required by legislation as part of the approval to drill the well. Copies of these documents are introduced in the Environmental and Safety Induction and are available to all personnel on the drilling rig and support vessels.

2.0 REGIONAL DESCRIPTION OF THE ENVIRONMENT

2.1 Bathymetry and Seabed Features

The water depth in the offshore region range from intertidal along island shorelines and in shoal areas to more than 50 m in the deeper waters offshore to the northwest and east of the region. The seafloor to the west of the Barrow Island and the Montebello complex drops away steeply into deep water off the edge of the North West Shelf. Much of the water surrounding the Montebello Islands and extending south to Barrow Island and the Lowendals is very shallow, ranging in depth from intertidal to approximately 5m.

At the Sinbad platform (location of Endymion-1), the depth of water is approximately 40m AHD. Water depths increase to the north to greater than 50m, but become shallower approaching the Montebellos to the west and the Lowendals to the south.

Regional surveys on the North West Shelf indicate the seafloor composition is uniform throughout the area, but with spatial variation in the grain size and origin of the surface sediments (McLoughlin & Young 1985; Woodside 1990; Sainsbury *et al* 1992). Surface sediments in the area are predominantly composed of skeletal remains of marine fauna, with lenses of weathered sands (McLoughlin & Young 1985).

A seabed survey has been undertaken for Endymion-1. The seabed consists of carbonate sand with some areas of well defined megaripples with amplitudes less than 0.5m and lengths up to 80m. These bedforms suggest that locally the current is fairly strong tending north-northwest and south-southeast (Thales, 2002).

2.2 Geomorphology

Barrow Island and the Lowendals and the Montebello Islands are part of a shallow submarine ridge, which extends north from the mainland near Onslow (IUCN 1988). The ridge contains extensive areas of intertidal and shallow subtidal limestone pavement surrounding the numerous, mostly small islands which are found in the region.

The Western Australian Museum (WAM 1993) describes the Montebello Islands as low lying and includes 95 islands larger than 50 metres in length and 170 smaller islets and reefs. They are composed of Pleistocene limestone and cross bedded sandstones, capped in places with consolidated or active sand dunes with elevations up to 40m. Most islands are bare rocky terrain without any beaches.

The total shoreline of intertidal land within the Montebello group is approximately 210km in length and significantly longer if the margins of intertidal areas, particularly the western barrier reef, are included. An extensive shallow intertidal zone is therefore contained within a relatively small total area.

The Lowendal Islands group contains over 40 islands, islets and rocky stacks comprised of eroded Pleistocene limestone. Shoreline profiles are typically steep, and contain relatively narrow low intertidal zones, which dip onto the extensive shallow subtidal platform that characterises the area. Both the lower intertidal and shallow subtidal zones comprise semi-planar limestone pavement.

The limestone base of some of the larger islands (including Abutilon, Varanus, Bridled and Parakeelya Islands) are overlain with dunes of white aeolian sands and depression deposits of orange sand. The smaller islands comprise low, steep-sided and mostly bare rocky islets and stacks, many exhibiting relict wave cut platforms some 3m above the present sea level. The shallow subtidal pavement is partly covered by dynamic sheets and ribbons of sands that are generated by continuing erosion of the islands and by in situ biota. The sand sheets and veneers are mobilised and dispersed by wind waves and tidal currents and by episodic storms, including cyclones (Marine Parks and Reserves Selection Working Group 1994).

A shallow subtidal ridge extends between Barrow Island in the south to the northern end of the Montebello complex and encompasses the Lowendal complex. The seabed is primarily less than 5m deep and consists of sand veneered limestone pavement with patches of fringing coral reef.

The most extensive marine substrate in the region bounded by Barrow Island and the Lowendal Islands is the wide tracts of shallow subtidal limestone pavement, which occur at depths between 0m and 8m LAT. This semi-planar pavement is bare or covered by sheets, ribbons and intertidal wedges of sand.

2.2 Metocean Conditions

Climate

The climate of the region is subtropical with moderate winters and very hot summer temperatures, occasional cyclones and mostly summer rainfalls.

The average maximum temperature in summer is 36°C at Onslow (closest mainland recording station). On average, 217 days each year at Onslow have a maximum temperature above 30°C and 25 of these are above 40°C (Western Mining Corporation 1990). The winters are generally moderate with average maximum temperatures ranging between 24°C and 28°C, and average minimum temperatures ranging between 11°C and 18°C (Bowman Bishaw Gorham, 1995).

Annual rainfall (average 265mm) is significantly influenced by the passages of cyclones, which mainly occur from January to March. Three to four cyclones per year are typical, primarily between December and March (WNI 1995). The mean annual evaporation is relatively high, for example 3,166mm recorded at Onslow.

Salinity and temperature

Salinity is relatively uniform at 34-35 parts per thousand throughout the water column and across the shelf. Due to the low rainfall there is little freshwater run-off from the adjacent mainland (Blaber *et al*. 1985). Shelf waters are usually thermally stratified with a marked change in water density at approximately 20m (SSE 1993). Surface temperatures vary annually, being warmest in March (32°C) and coolest in August (19°C). Vertical gradients are correlated to sea surface temperatures, and are greatest during the warm-water season (SSE 1991). Near bottom water temperature is approximately 23°C, with no discernible seasonal variation.

Wind

Wind patterns are monsoonal with a marked seasonal pattern. During winter (June - August), moderate to strong south-easterlies and easterlies prevail, while during summer moderately southerly, south-westerly and westerly winds dominate. Transitional wind periods, during which either pattern may predominate, can be experienced in April-May and September of each year.

Oceanography

Surface water temperatures in the region typically range from 26 to 31°C in summer and 19 to 24°C in winter (Bowman Bishaw Gorham 1994). Stratification of the water column in summer results in seabed temperatures 6 to 8°C lower than the surface temperatures.

Tides in the region are semi-diurnal with variations between neap and spring tides ranging from 1m at neap tides to 2m at spring tides.

Surface currents will average 0.25 to 0.3m/s and usually travel at 10° to the left of the wind direction (Bowman Bishaw Gorham, 1995). Due to local bathymetric and topographic influences, variations in speed and direction may be apparent throughout the water column. Residual currents generated by the Leeuwin Current appear to contribute less than 0.1m/s (0.2 knots) to the ambient current speed (NSR Environmental Consultants, 1995).

The oceanic swell in the region is predominantly south-westerly. Winter swells are typically in the range 1 to 2m but occasionally reach 3m in the presence of severe cold fronts. In summer the swell is more variable and tends westerly (Bowman Bishaw Gorham, 1995). Swell generated by tropical cyclones in summer may have a significant wave height between 8 to 10m. Sea waves, generated by local synoptic winds are in general less than 2m high with a relatively short period (1-10 seconds). These waves reflect the prevailing wind direction.

2.3 Biological Environment

The regional subtidal environment consists of a shallow limestone pavement at depths ranging from intertidal to greater than 20m. Sheets and ribbons of calcareous sands varying in thickness from less than 5cm to greater than 1m frequently veneer the pavements. The sands are mobilised and dispersed as sand waves by water currents and more dramatically, storm events such as cyclones. Pavement in exposed areas is often continuously swept clean of sand.

The shallow waters and intertidal areas of the region support a range of habitats and wildlife (refer to Figure 2). These include coral reefs, seagrass and algal beds, and mangroves. The nearest shallow water subtidal and intertidal habitats surround Barrow Island, Lowendal Islands, Montebello Islands, the Dampier Archipelago and the mainland coast. Endymion-1 is located 11km away from the closest of the Montebello Islands (Whale Rock), 23km from Varanus Island and 80km from the closest of the Dampier Archipelago islands (Enderby Island). The Montebellos, Lowendals and Barrow Island have similar habitats to the Dampier Archipelago, consequently the biota is similarly diverse (WAM 1993; APPEA 1997). Comparative surveys of the predominant faunal groups indicate that the area supports species characteristic of both the Pilbara coast and islands further offshore (e.g. Ashmore Reef), together with tropical Indo-west Pacific species with a widespread distribution (WAM 1993).

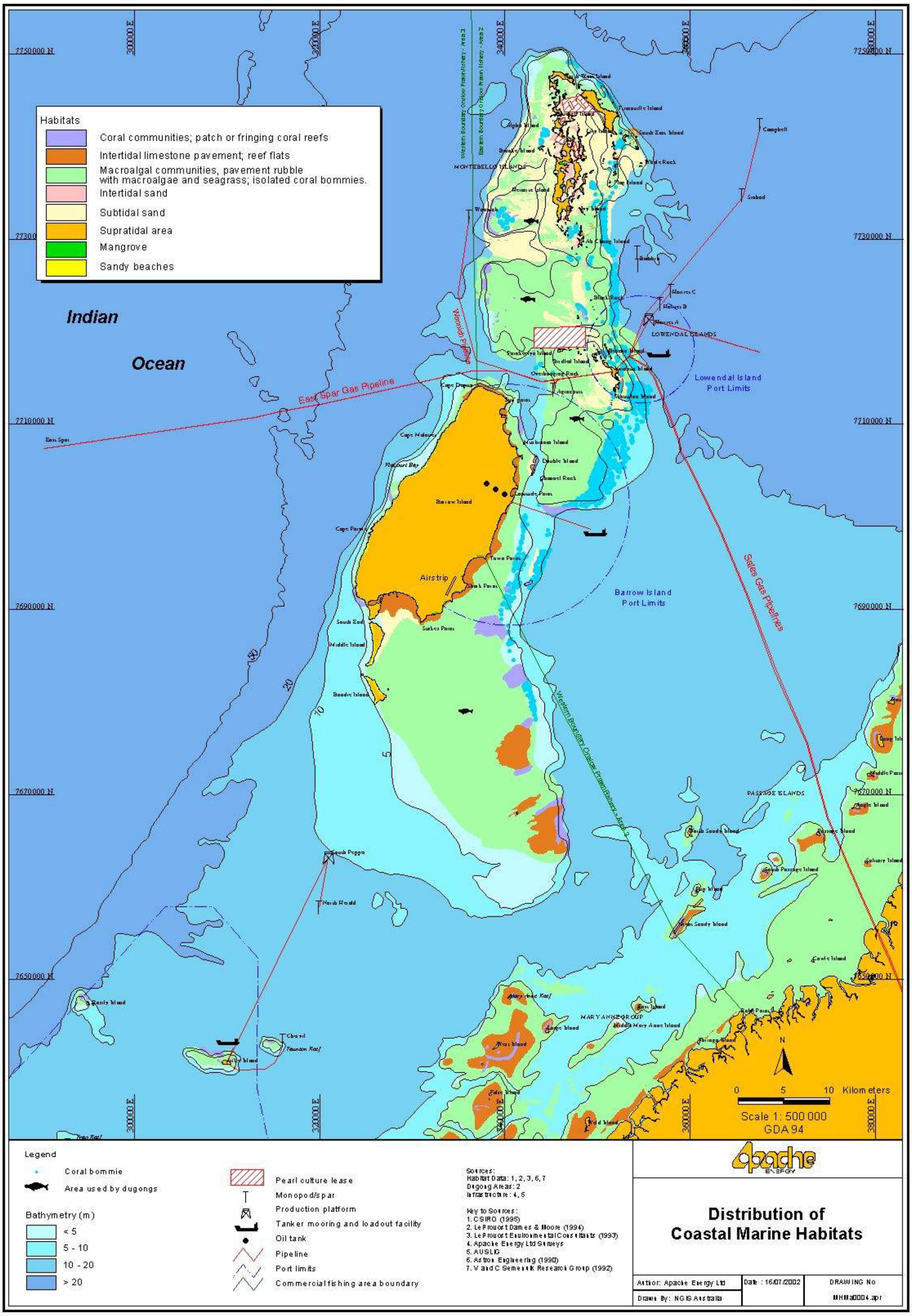
The water column supports a range of marine mammals, reptiles, pelagic and benthic fish, drift species and plankton. The sea surface also supports some species of seabirds that feed at sea. The main marine communities are described below.

Macroalgae and seagrass

Macroalgae and seagrasses are most prolific over the shallow pavement limestone reefs adjacent to the offshore islands. Seagrasses also form extensive meadows over some of the shallow sand flats (e.g. at Conzinc Island).

Macroalgae and seagrasses are important primary producers in tropical inshore waters. Seagrasses are directly grazed by dugongs (Prince 1986), and both seagrasses and macroalgae are grazed by green turtles (Prince, pers. comm. 1997). Few tropical fish species graze directly on seagrass or macroalgae. However, both vegetation types support a diverse and abundant fauna of small invertebrates that are the principal food source for many inshore fish species (Blaber & Blaber 1980). Small crustaceans, such as amphipods, copepods and isopods that emerge from this vegetation at night are fed upon by planktivorous fish, such as herring, sardine and anchovy (Robertson & Watson 1978). Dense schools of these fish are, in turn, fed upon by both predatory fish, such as tuna and mackerel, and diving birds, such as shearwater and terns. Beds of both seagrasses and macroalgae support the juvenile stages of prawn species that are commercially important in the region (Loneragan *et al*. 1994).

Figure 2 Habitats in the vicinity of Endymion-1



Mangroves

Mangals occur in the Montebello and Lowendal Islands, along the south eastern and southern shores of Barrow Island, in sheltered pockets on the offshore islands of the Dampier Archipelago, and a number of creeks on the mainland coast.

The mangals of the Montebello Islands range in density from isolated mangrove trees to areas of more than 15 hectares. These are particularly prevalent on the east side of Hermite Island. At least four species are present with *Avicennia marina* occurring alone or in mixed assemblages in association with *Bruguiera exaristata*, *Ceriops tagal* and/*or Rhizophora stylosa* (Marine Parks and Reserves Working Group 1994). The Crocus Island stand is reported to include the river mangrove *Aegiceras corniculatum* (Western Australian Museum 1993).

Isolated mangrove stands also occur on Varanus and Bridled Islands in the Lowendal Group and along the south eastern and southern shores of Barrow Island.

Invertebrate Filter-Feeding Communities

Invertebrate filter-feeding communities are commonly found on hard substrates in greater than 10 m water depth or in soft sediments throughout the region. Communities that may be present on hard substrates include gorgonids, colonial and solitary ascidians, bryozoans and scleractianian corals, while soft bottom infauna includes polychaete worms, bivalves and crustacean species.

Sandy Shores

Sandy beaches occur between the rocky headlands on most of the larger islands in the region. They support a limited range of resident fauna, principally small burrowing fauna such as polychaete worms, bivalve molluscs and amphipod crustaceans (LeProvost Semeniuk Chalmer 1986).

The sandy beaches and adjoining limestone pavements provide feeding grounds for wading birds and nesting sites for species of birds such as the pied oystercatcher and beach thick-knee as well as seabirds like the caspian, bridled and fairy terns. During summer, three species of turtles typically use these beaches for nesting.

Rocky Shores

Rocky shores are the dominant shoreline type on the western side of the offshore islands. In the Lowendal, Barrow and Montebello Islands, the rocky shore profile and the characteristic zonation of its fauna can be classified into five zones. The height of each zone is consistent with the tidal range data for the two closest hydrographic stations (Trimouille Island and Chevron Landing at Barrow Island). The spring and neap tidal ranges at these stations are 2.4m and 0.8m (Trimouille Island) and 2.5m and 0.6m (Barrow Island) respectively. The five zones are as follows:

Supratidal Zone

Located above the mean high water spring tides (MHWS) mark, the supratidal or 'wave-splash' zone is colonised by cyanobacterial films and littorinid snails, predominantly *Nodilittorina millegrana* (LEC 1992, 1993).

Upper Intertidal Zone

This is a relatively narrow zone located between MHWS and the top of the oyster bioherms, just above mean high water neap tides (MHWN). The upper intertidal zone is typically 50-60cm high (vertical range 30 - 100cm) and dominated by star barnacles (*Chthamalus malayensis*). Chitons (*Acanthopleura gemmata*) and limpets (acmaeids, patellids and *Siphonaria* spp) are also commonly numerous in this zone, but at frequencies that are one or two orders of magnitude less than the star barnacles.

Mid-tidal Zone

This zone is relatively broad (up to 150cm high), extends from 20-30cm above MHWN to 20-30cm below mean low water neap (MLWN), and is dominated by rock oysters (*Saccostrea cuccullata*) and their biohermic development. The rock oyster bioherms frequently produce a bulge in the rocky shoreline profile, typically along the floor of the wave-cut notch when present. Apart from the oysters, the mid-tidal zone is also characterised by the presence of black mussels (cf. *Musculista glaberrima*) and drupes such as *Thais aculeata* and *Morula granulata*. False limpets (*Siphonaria* spp.) and barnacles (*C. malayensis* and *T. squamosa*) are common, but usually at lower abundances than in the upper intertidal zone.

Lower Intertidal Zone

This zone is approximately 50-60cm in height and occupies the narrow strip beneath the rock oysters and mean low water springs (MLWS) mark. It is colonised by a variety of fauna, which is typically dominated by boring mussels (*Lithophaga* sp.) and boring barnacles (*Lithotrya valentiana*).

Lowest Intertidal Zone

The lowest intertidal zone extends from MLWS to LAT. It is approximately 40cm high and usually remains submerged except during extreme low tides. This zone can have a steep or even vertical profile at headlands, but within small bays and notches it frequently comprises a narrow sloping platform (1-7m wide) that extends from the cliff face.

Hermit crabs are typically the most numerous components of a macrofauna otherwise dominated by molluscs, including a range of gastropods (cowries, drupes, trochids, turbans and top shells), and bivalves such as tridacnid clams and rock borers (*Lithophaga* (cf. *L. teres*)), and *Hiatella* (cf. *H. australis*). Algae and sponges are occasionally present, as are isolated coral colonies, although the latter occur less frequently.

Corals

Corals tend to occur in relatively shallow areas of strong currents where water movements constantly transport nutrients and food supplies. The closest corals to the proposed drilling location are surrounding the Barrow/Lowendal/Montebello Island complex and also the Dampier Archipelago.

Corals occur on submerged limestone reefs and submarine slopes as fringing reefs and patch reefs in the shallow waters (5-10m) to the south, east and north of the Lowendal Islands. Corals are also present on exposed limestone pavement in slightly deeper waters (up to 20m) running north towards the Montebello Islands (LeProvost Semeniuk Chalmers 1986, LeProvost Dames Moore 1994). This habitat extends south along the eastern edge of the Barrow Island Shoals. Fringing coral reef habitat is also associated with many islands such as Airlie Island, Passage Islands Group, Mary Anne Group and Twin Islands. These reefs create a habitat that supports a diverse assemblage of reef fish and invertebrates.

Corals form fringing and patch reefs running parallel to the coast on the oceanic boundary of the Dampier Archipelago. Reefs inshore of the archipelago generally have a low diversity and low abundance, probably due to high sediment loads. Mermaid Sound, with lower sediment loads and wave energy has the highest coral diversities. Deeper subtidal reefs support a luxuriant and diverse assemblage of filter feeding animals, comprising mostly of sponges, gorgonians, whip corals, bryozoans, ascidians and hydroids.

Coral spawning usually occurs in March and April (Table 2). The major spawning typically occurs ten days after the full moon in March and a smaller one occurs again in April. Recent studies by AIMS suggest that a small coral spawning may also occur in October. The species that spawn at this time appear to be different to the March/April spawning.

Fish

The demersal habitat of the North West Shelf hosts a diverse assemblage of fish, many of which are commercially exploited by trawl and trap fisheries, for example the genera *Lethrinus* (emperor) and *Lutjanus* (snapper) (Sainsbury *et al* 1985). Pelagic fish in this area include tuna, mackerel, herring, pilchard and sardine. Game fish such as marlin and sailfish also occur (BBG 1994).

Sheltered inshore areas and mangrove-lined creeks of the Dampier Archipelago support a characteristic and rich fish fauna of greater than 100 species (Blaber *et al*. 1985). This fauna has little overlap with that of deeper waters (>20m) of the North West Shelf. Consequently, the inshore habitats in this region are not considered to be significant nursery grounds for commercially important deeper-water fish species (Blaber *et al*. 1985).

Turtles

There are four species of marine turtles known to occur on the North West Shelf; the green (*Chelonia mydas*), flatback (*Natator depressus*), loggerhead (*Caretta caretta*) and hawksbill (*Eretmochelys imbricata*). All four species are endemic to the tropical regions. All four species are on the National List of Threatened Species (Appendix 1). The leatherback turtle (*Dermochelys coriacia*) may also visit the open waters.

Barrow Island, the Lowendal Islands, the Montebello Islands, Thevenard Island, Mary Anne Group and Airlie Island are common nesting and feeding grounds for the hawksbill, flatback and green turtle. The loggerhead turtle tends to inhabit deeper waters and does not typically nest on these beaches. The across shelf distribution of these species is not well known, but is thought to vary among the species. For example, green turtles are herbivores and therefore concentrate over depths that support benthic plant life (<20m). Hawksbill turtles also forage in shallow waters, but in areas of coral reef. In contrast, loggerhead, flatback and leatherback turtles are known to feed on midwater plankton and benthic animals, and can forage in mid-shelf water depths (about 50m).

Most of the turtle species peak nesting season is from November to March (Table 2). Sea turtle nests are generally located above the high tide line. Hatchlings emerge approximately 60 days after nesting has occurred and can be found on the beaches between October and May with numbers peaking between December and February.

CALM (RIT Prince) and K Pendoley (PhD student, Murdoch University) have carried out limited surveys of nesting effort in the region. The results to date suggest that beach use in the area by species is as follows (predominant species listed first):

Trimouille, North West, Hermite Islands (Montebello group)
greens > flatback > hawksbill

Varanus, Beacon, Bridled Islands (Lowendals)
hawksbill > flatback > greens

Barrow Island (east coast)
flatback >> green >hawksbill

Barrow Island (west coast)
greens >> flatback > hawksbill

Marine mammals

Several species of marine mammals occur in the waters of the region, some being seasonal visitors while others occur at low densities all year round. Marine mammals that may occur in the region include whales, dugongs and dolphins.

Dugong (*Dugong dugong*) occur across the tropical coastal waters of Australia from Shark Bay to Queensland and are afforded protection under national legislation and international agreements (Appendix 1). Dugongs are herbivorous and are generally associated with seagrass beds, upon which they feed. They are commonly found in shallow (less than 5m deep) sheltered areas, often near island or large bays. Dugong are known to occur in the shallow, warm waters around the islands, although not in the large concentrations seen further south in the Exmouth Gulf or Shark Bay (Prince 1989). Current knowledge on the size and distribution of dugong populations and their migratory habits in the region between North West Cape and the Dampier Archipelago is limited. Recent aerial surveys of dugong distribution have found that the animals occur around Barrow Island, Airlie Island, Lowendal Islands and the Montebello Islands further offshore (Prince 2001).

Dolphins are relatively common in the region. Species known to occur in the region are the bottlenose dolphin (*Tursiops truncatus*), common dolphin (*Delphinus delphis*), Indo-pacific humpback dolphins (*Sousa chinensis*) and the striped dolphin (*Stenella coeruleoalba*) (listed status in Appendix 1).

A number of whale species, including the short-finned pilot whale (*Globicephala macrorhynchus*), false killer whale (*Pseudorca crassidens*), tropical byrdes whale (*Balaenoptera edeni*), southern minke whale (*Balaenoptera acutorostrata*) and humpback whale (*Megaptera novaeangliae*), also occur in the region (listed status in Appendix 1).

The migratory whale route, where most whales are observed, occurs in deeper waters (>20 metres), passing westward of Barrow Island and north of the Montebello Islands.

The most common whale that is observed off the North West Shelf is the humpback whale, *Megaptera novaeangliae*. These whales migrate between Antarctica and Kimberley regions annually between June and mid November (Table 2) and generally travel in the deeper continental shelf waters during both their northern and southern migrations. Present estimates of the population of humpbacks migrating through this area are between 3,000 and 4,000 (BBG, 1995).

The migration paths and timing of humpback whales in Western Australian waters is described in Jenner et.al (2001). The peak northerly migration is likely to be towards the end of July, with the southerly migration at the north of the Montebello Islands peaking late August to early September. The peak migratory period can vary by three weeks from year to year. Cow/calf pods follow the peak migration period by 2 to 3 weeks.

The southern migratory path runs from Dampier towards the northern end of the Montebello Islands and then turns south passing to the west of Barrow Island. From here the migration splits with some whales entering Exmouth Gulf to socialise or rest, whilst others continue south in deeper water (>50m). Very few whales pass inshore of Barrow Island across the Barrow Shoals.

Blue whales (endangered), Fin whales (vulnerable) and Sei whales (vulnerable) are generally not seen close to shore. All three are deep water species (Tucker 1989, Bryden et al 1998).

Seabirds

Various species of migratory and resident seabirds feed and nest on the surrounding islands within the region.

Seabirds feed in the waters surrounding the Lowendal/Montebello/Barrow Island groups and use the islands for roosting and nesting sites. The wedge-tailed shearwater, *Puffinus pacificus*, has significant rookeries on Varanus Island and some of the satellite islands. Rookeries also occur on islands of the Montebello Group (CALM seabird database). Wedge-tailed shearwaters are protected under international agreements with Japan (Japan Australia Migratory Birds Agreement) and China (China Australia Migratory Birds Agreement).

The bridled tern, *Sterna anaethetus*, nests throughout the Lowendal and Montebello Island groups. Other abundant, widespread species include crested and lesser crested terns, *S. bergii* and *S. bengalensis*, the osprey, *Pandion haliaetus*, and the white-bellied sea eagle, *Haliaetus leucogaster*. The beach stone curlew, *Esacus neglectus*, is on the CALM priority fauna list and occurs within the Lowendal/Montebello/Barrow Island groups. Other seabirds known to inhabit the region include the silver gull, white-breasted sea eagle, eastern reef egret, pied oyster catcher and four species of terns.

Species of birds that may be found on the North West Shelf and are on threatened species lists are given in Appendix 1.

Table 2 NW Shelf biological resources breeding cycles and human activity seasons

SPECIES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Dugong breeding	breeding								breeding			
Turtle nesting												
Turtle hatching												
Coral spawning			X *	X						X		
Whale migration						north			south			
Algae	growing				Shedding fronds				growing			
Seabird nesting (terns and shearwaters												
Prawn trawling												
Tourism												
Drilling Period												

** split spawning occurs every three years.*

Key

- Peak activity, presence reliable and predictable
- Low level of abundance/activity/presence
- Activity not occurring within the area
- Timing of drilling activity

2.4 Socio-Economic Environment

Population centers

The population centers adjacent to the region in which the drilling program is located are the Port of Dampier and Port Hedland, the smaller coastal and fishing towns of Onslow and Point Samson.

Dampier, Karratha and Port Hedland are the main service and population centers for the region. Although developed initially for the iron ore industry, these towns have expanded to service the oil and gas industry located on the North West Shelf. Onslow is also a service port for currently producing offshore oilfields including Barrow, Saladin, Airlie and Harriet fields.

Recreation

Local people seeking aquatic recreation such as boating, diving and fishing, use the coast and islands of the Pilbara. These activities are concentrated in the vicinity of the population centres such as Dampier, Onslow, Point Samson and Port Hedland. The open waters of the Commonwealth permit areas do not support significant recreational or tourism activity.

Commercial Fisheries

The region supports three important commercial fisheries:

- Pilbara Trap Fishery (demersal);
- Pilbara Trawl Fishery (demersal); and
- North Coast Shark Fishery (pelagic and demersal gill netting, pelagic long lining and drop lining).

Commercial trawling activity is largely confined to between the 50m and 100m bathymetric contours. The area inshore of the 50m isobath is excluded from the trawl fishery to protect juvenile commercial fish. Nine boats operate the fishery, with the highest fishing effort occurring between September and May.

Pearling is a key industry in the coastal region. Live pearl shell is harvested off the Pilbara coast for use in pearl culture leases located at the Montebello Islands and the Dampier Archipelago.

Prawn trawling activities occur near Onslow and Nickol Bay with the major target species being the tiger, western king and banana prawns.

Aboriginal History

An extensive search of the Montebello Islands for Aboriginal artefacts has located evidence of occupation in small caves on Campbell Island, located in the central part of the island chain. The occupation appears to date from time prior to the most recent sea level rises (+/- 7,000 years before present). There is no evidence of aboriginal occupation more recently than this (Veth 1993). Similar evidence has been found on Barrow Island.

Shipwrecks

The English ship ‘Tryal’ was wrecked on what are now known as the Tryal Rocks just north of the Montebello Islands in 1622. This ship wreck is protected by the Marine Archaeological Act 1973 and has `National Estate' status.

A further uncharted wreck, the 19th century ship ‘Wild Wave’, is understood to be located on the seaward side of the south-west section of the Montebellos barrier reef.

Two other wrecks, one believed to be of a lugger wrecked about 1915 and one of a more recent vessel, are reported in or near the vicinity of Willy Nilly Lagoon in the central part of the Montebellos.

There are no shipwrecks or heritage sites in the vicinity of the proposed well.

Conservation Status

The Montebello/Barrow/Lowendal Island complex is located to the west and south of the proposed well site. The Montebello Islands are gazetted to high water as A-class Conservation Park 42196. The Lowendal Island group is a C Class Nature Reserve (reserve # 33902, declared 5 March 1976) for the conservation of flora and fauna.

Barrow Island is an A Class Nature Reserve (#11648) for the conservation of flora and fauna.

The conservation values of the area have been recognised in the document “A Representative Marine Reserve System for Western Australia” (1994). The marine waters surrounding the Montebello/Lowendal/Barrow Island groups are listed on the Register of the National Estate. This area is currently under review by CALM as a Marine Conservation Reserve.

3.0 MODELLING OF OIL SPILLS

3.1 Background

In order to conduct a thorough environmental impact assessment it is necessary to model the behaviour of potential oil spill scenarios associated with the drilling program. Oil spill modelling is done as a standard component of Apache's environmental risk assessment process prior to the drilling of all wells. The results of the oil spill modelling process are used in conjunction with the project description (section 1) and the environmental description (section 2) to identify the risks associated with an accidental discharge of hydrocarbons. The risk matrix for these accidental discharges is discussed further in section 4. The methods and criteria used in modelling a spill from the well location are discussed below.

3.2 The Characteristics of Oil

If oil is encountered at Endymion-1, it may be similar to one of the five oils that are found within the area, Campbell condensate, Wonnich crude oil, Harriet crude oil, Agincourt crude, or Stag crude oil. Battelle Laboratories conducted a detailed study of the weathering, chemical composition and toxicity of Stag, Wonnich, Harriet, Campbell, Agincourt and diesel oils (Battelle 1998; Neff *et al.* 2000a). These data are summarised in Appendix 2 and below.

Diesel fuel

Diesel fuel is a middle distillate fuel with an ^{o}API gravity of 33.2. About 23% of the mass of Australian diesel fuel spilt on water in tropical conditions will weather within five days on the sea surface (Neff *et al.* 2000a). During evaporative weathering, low molecular weight aliphatic and aromatic hydrocarbons and phenols are lost from the oil, leaving higher concentrations of less volatile, higher molecular weight hydrocarbons. Diesel does not form a stable oil in water emulsion and is amenable to dispersants.

Toxicity testing has identified diesel as being toxic to the marine species tested, with some species of sea urchin larvae and crustaceans being the most sensitive. Diesel fuel appears to retain its toxicity during weathering due to the slow loss of light ends. In addition, the additives used to improve certain properties of diesel (e.g. ignition quality, flow improvers) contribute to the toxicity of the diesel oil.

Stag oil

Stag field oil is a heavy crude with a low pour point and virtually no paraffin wax. The relatively high viscosity of this oil allows the oil to spread, but limits its capacity to evaporate. Evaporation does occur, albeit slowly and over a long period of time. Stag oil has also a tendency to form a stable emulsion as the oil weathers. Dispersants have been found to be highly effective on Stag oil up to 12 hours after spillage (MFRI 1996). Neither fresh nor weathered Stag crude is toxic to marine test organisms.

Wonnich oil and Campbell condensate

Wonnich oil and Campbell condensate oils are very light paraffinic oils with low pour points, and low viscosities. Laboratory weathering of these oils has found that they will evaporate readily with approximately 65% lost in the first hour, 80-90% lost in the first day and 100% loss after one week of weathering. These oils will not sink and are therefore amenable to dispersion the entire time they are on the open ocean. They are comprised of 15% monocyclic aromatic hydrocarbons (MAH) of which approximately 9% are BTEX compounds (those thought to be responsible for the toxicity of crude oils). The oils have relatively low levels of the toxic low molecular weight 2- ring polycyclic aromatic hydrocarbons (PAHs).

Toxicity testing found these oils ranged from slight to high toxicity depending on the age of the crude (degree of weathering) and the species tested.

Harriet oil

Harriet is a middle weight crude oil that will lose up to 55% of its mass after one week on the ocean and is amenable to dispersion after weathering. Five percent of the fresh crude is comprised of MAH of which approximately half are BTEX compounds. Total PAH concentrations are low (2%) while wax concentrations are high.

Toxicity results for marine test animals were low to moderate and were related to the degree of weathering of the crude and the test species.

Agincourt oil

Agincourt is a middle weight crude, similar to Harriet, with a high wax content. Agincourt loses about 70% of its mass after one week on the ocean and will form a stable water-in-oil emulsion that may contain up to 70 – 80 % water. Fresh Agincourt crude contains about one percent MAH and low concentration of total PAHs.

Toxicity results for marine test animals were low to moderate and were related to the degree of weathering of the crude and the test species.

It should be noted that the laboratory evaporative weathering results do not take into account loss of hydrocarbons through dissolution, photooxidation or biodegradation. A further 5-10% loss through dissolution alone is anticipated for Wonnich, Campbell and Harriet (Battelle 1998). It is predicted that Wonnich, Campbell and Harriet oils would remain in an optimal physical state for either skimming or chemical dispersion for at least one week after which Campbell and Wonnich would be completely gone and Harriet would be highly weathered but not emulsified. Stag could form emulsions, however these can be easily broken and the oil skimmed or dispersed (Battelle 1998).

3.3 Modelling Criteria

The interaction of the prevailing tide and wind at the time of a spill is fundamental in determining the oil spill trajectory. Factors controlling hydrodynamic flow in the region are used to model trajectories. Apache uses a 3-dimensional ocean current model (GCOM3D) to predict currents within the vicinity of proposed wells. An oil spill behaviour model (SIMAP) is then used to predict the fate of hydrocarbon spills as they are transported by the modelled currents and prevailing winds. A geographic information system within SIMAP maintains information on the location of the resources in the region.

Apache have detailed data for modelling hydrodynamic flows for the North West Shelf including:

- high-resolution measurements of bathymetry to define the 3 dimensional structure of the seabed (spatial resolution of 100m or less);
- measured tidal constituents (phase and direction) to define speed and direction of tidal currents; and
- a database of historic wind records covering several years.

Predictions of the oceanographic model have been verified against tidal current measurements and drogue trajectories for some areas within this region (Hubbert 1997; AIMS 1998).

The modelling system forms part of Apache's oil spill contingency plan and response system. Should a spill occur, the model would be run in conjunction with field surveillance to provide forewarning of the habitats that may be affected.

Oil spill trajectories have been modelled from the Endymion-1 location to predict the behaviour of potential oil spill scenarios associated with the drilling program and assess the environmental risk. An oil spill trajectory was modelled for the four scenarios listed below during wind conditions comparable to those likely to be experienced.

- 2,500 L diesel spill from refuelling incident, instantaneous release;
- 80,000 L diesel spill from rupture of rig or support vessel fuel tank, 6 hour release;
- 8,000 L crude spill from drill stem testing, 1 hour release; and
- 600,000 L crude spill from blowout, 12 hour release.

Harriet crude has been used as the representative oil for the crude oil spill. The modelling takes into account the specific characteristics of diesel and Harriet crude, as derived from laboratory studies and discussed in Section 3.2. Seawater surface temperatures are set at the average temperatures reported at particular times of year (WNI 1996). Wind data from Varanus Island are used to determine the range of winds over a two month period covering the proposed time of drilling for the well.

The SIMAP model generates 100 hypothetical spills for each scenario. Each individual spill ran under randomly selected conditions of wind and sea-surface current conditions taken from the appropriate 2 month GCOM3D run. The trajectory and fate of each spill was used to generate statistical probabilities that locations on the water surface or shoreline would be contacted by oil (based on the proportion of spills arriving) and the minimum time before this may occur (the shortest time for any of the spills).

3.4 Consequences of an Oil Spill

Summer, winter and transitional conditions have been modelled.

Summer season

The chances of an oil spill from Endymion-1 reaching the adjacent islands or mainland within the first four days of a spill under summer wind conditions are extremely low. Oil did not reach any shoreline under any of the modelled scenarios.

Under summer conditions, when winds are predominantly from the west to south west, the majority of spills were predicted to drift to the north or northeast of the Montebello Islands. Modelling indicated less than 10% probability of surface oil coming within 7km of any shoreline during this season (Figures 2-5, Table 3).

Winter season

Based on the results for the Endymion-1 spill scenarios, the shorelines of islands within the Montebellos / Lowendals and Barrow Island are at most risk from a spill under winter conditions (Figures 6-9, Table 4).

Most spills generated at Endymion-1 were predicted to drift west, northwest or southwest of the spill site and contact to shorelines of the Montebello and the Lowendal Island groups was indicated at a rate up to 42% and 25% of the time, respectively. Strong currents operating in the channel between the Montebello and Lowendal groups, and between the Varanus Island and Barrow Island, carried surface oil to the northern, eastern and north-western shores of Barrow Island in up to 20% of the simulations modelled. Some spills were also predicted to travel to the south-southwest from the spill site for a distance of up to 185km, potentially exposing the shorelines of Rosily, Bessieres, Black Ledge, Serrurier and Flat Islands within 4 days of release.

Modelling indicated that contact of shorelines in the Montebello Islands could potentially occur within 5 hours from the time of release, the Lowendals within 12 hours, and Barrow Island within 27 hours. Surface oil was not expected to reach Rosily Island within 62 hours. The shortest time before contact of the more southern islands (Bessieres, Black Ledge, Serrurier and Flat Islands) was 85 hours (approx. 3.5 days).

Transitional Season

Under wind conditions from the transitional months, the predominant drift direction was to the north-northeast and thus away from land. However, modelling indicated a probability of shoreline contact exceeding 1% for all spill scenarios tested (Figures 10-13, Table 5). The probability of contact was predicted to be relatively small (< 6%) but to increase with the size of the spill. Highest probability of contact was indicated for the Montebello Island group, followed by the Lowendal Island group and Barrow Island.

The large diesel spill was predicted to potentially expose shorelines of both the Montebello and Lowendal Island groups within 55 hours and 57 hours respectively.

A large spill of crude was predicted to have up to 7% chance of exposing the Montebello shorelines, and up to 6% chance of exposing the Lowendal Islands during the transitional periods. Modelling indicated contact with shorelines in the Montebello Island group within 46 hours, and the Lowendal Island group within 60 hours of the spill.

In all scenarios, there was a 2-3% chance of the spill travelling south-southeast of the Lowendal Islands. During the large diesel and small crude scenarios, the spill was forced through the shallow waters between the Lowendals and Barrow Island in 2% of simulations. Although Barrow Island shorelines were not exposed, surface spills were predicted to come within 1km of Barrow shores at Surf Point and within 2km of Double and Cormorant Islands.

Table 3: Predicted risks to shorelines from oil spills at Endymion-1 under summer conditions

Season	Spill Scenario	Shoreline	Probability of contact	Minimum time before exposure	Worst case volume on any shorelines (T)	Percentage of initial spill (%)
Summer	2500L Diesel	Montebello Island Group	< 1	-	-	-
	2500L Diesel	Lowendal Island Group	< 1	-	-	-
	2500L Diesel	Barrow Island Group	< 1	-	-	-
Summer	80,000L Diesel	Montebello Island Group	< 1	-	-	-
	80,000L Diesel	Lowendal Island Group	< 1	-	-	-
	80,000L Diesel	Barrow Island Group	< 1	-	-	-
Summer	8000L Crude	Montebello Island Group	< 1	-	-	-
	8000L Crude	Lowendal Island Group	< 1	-	-	-
	8000L Crude	Barrow Island Group	< 1	-	-	-
Summer	600,000L Crude	Montebello Island Group	< 1	-	-	-
	600,000L Crude	Lowendal Island Group	< 1	-	-	-
	600,000L Crude	Barrow Island Group	< 1	-	-	-

Table 4: Predicted risks to shorelines from oil spills at Endymion-1 under winter conditions

Season	Spill Scenario	Shoreline	Probability of contact	Minimum time before exposure	Worst case volume on any shorelines (T)	Percentage of initial spill (%)
Winter	2500L Diesel	Montebello Island Group	10%	5 hrs	0.1 T	5%
	2500L Diesel	Lowendal Island Group	11%	14 hrs	0.4 T	18%
	2500L Diesel	Barrow Island Group	8%	30 hrs	0.2 T	7%
	2500L Diesel	Rosily Island	5%	74 hrs	<0.0001 T	<0.001%
	2500L Diesel	Bessieres Island	1%	90 hrs	<0.0001 T	<0.001%
	2500L Diesel	Black Ledge	1%	91 hrs	<0.0001 T	<0.001%
	2500L Diesel	Serrurier Island	2%	86 hrs	<0.0001 T	<0.001%
	2500L Diesel	Flat Island	2%	86 hrs	<0.0001 T	<0.001%
Winter	80,000L Diesel	Montebello Island Group	32%	9 hrs	12.8 T	19%
	80,000L Diesel	Lowendal Island Group	20%	15 hrs	4.8 T	7%
	80,000L Diesel	Barrow Island Group	9%	29 hrs	15.1 T	22%
	80,000L Diesel	Rosily Island	8%	62 hrs	<0.0001 T	<0.001%
	80,000L Diesel	Bessieres Island	4%	85 hrs	<0.0001 T	<0.001%
	80,000L Diesel	Black Ledge	2%	85 hrs	<0.0001 T	<0.001%
	80,000L Diesel	Serrurier Island	2%	85 hrs	<0.0001 T	<0.001%
	80,000L Diesel	Flat Island	2%	86 hrs	<0.0001 T	<0.001%
Winter	8000L Crude	Montebello Island Group	20%	14 hrs	1.2 T	18%
	8000L Crude	Lowendal Island Group	18%	14 hrs	0.8 T	12%
	8000L Crude	Barrow Island Group	18%	27 hrs	1.2 T	18%
	8000L Crude	Rosily Island	8%	64 hrs	0.2 T	3%

	8000L Crude	Bessieres Island	1%	95 hrs	0.15 T	2%
	8000L Crude	Black Ledge	3%	88 hrs	0.1 T	2%
	8000L Crude	Serrurier Island	3%	89 hrs	0.4 T	6%
	8000L Crude	Flat Island	4%	88 hrs	0.4 T	6%
Winter	600,000L Crude	Montebello Island Group	42%	14 hrs	85.7 T	17%
	600,000L Crude	Lowendal Island Group	25%	12 hrs	30.1 T	6%
	600,000L Crude	Barrow Island Group	20%	27 hrs	78.5 T	16%
	600,000L Crude	Rosily Island	7%	69 hrs	4.4 T	1%
	600,000L Crude	Bessieres Island	2%	95 hrs	0.1 T	0.03%
	600,000L Crude	Black Ledge	2%	96 hrs	0.1 T	0.01%
	600,000L Crude	Serrurier Island	1%	96 hrs	< 0.0001 T	<0.001%
	600,000L Crude	Flat Island	1%	91 hrs	3.1 T	0.6%

Table 5: Predicted risks to shorelines from oil spills at Endymion-1 under transitional conditions

Season	Spill Scenario	Shoreline	Probability of contact	Minimum time before exposure	Worst case volume on any shorelines (T)	Percentage of initial spill (%)
Transitional	2500L Diesel	Montebello Island Group	1%	76 hrs	0.24 T	12%
	2500L Diesel	Lowendal Island Group	<1%	-	-	-
	2500L Diesel	Barrow Island Group	<1%	-	-	-
Transitional	80,000L Diesel	Montebello Island Group	3%	55 hrs	12.5 T	19%
	80,000L Diesel	Lowendal Island Group	2%	57 hrs	0.22 T	0.3%
	80,000L Diesel	Barrow Island Group	<1%	-	-	-
Transitional	8000L Crude	Montebello Island Group	7%	56 hrs	1.11 T	17%
	8000L Crude	Lowendal Island Group	6%	60 hrs	0.1 T	1%
	8000L Crude	Barrow Island Group	<1%	-	-	-
Transitional	600,000L Crude	Montebello Island Group	6%	46 hrs	73.3 T	15%
	600,000L Crude	Lowendal Island Group	3%	72 hrs	0.79 T	0.2%
	600,000L Crude	Barrow Island Group	<1%	-	-	-

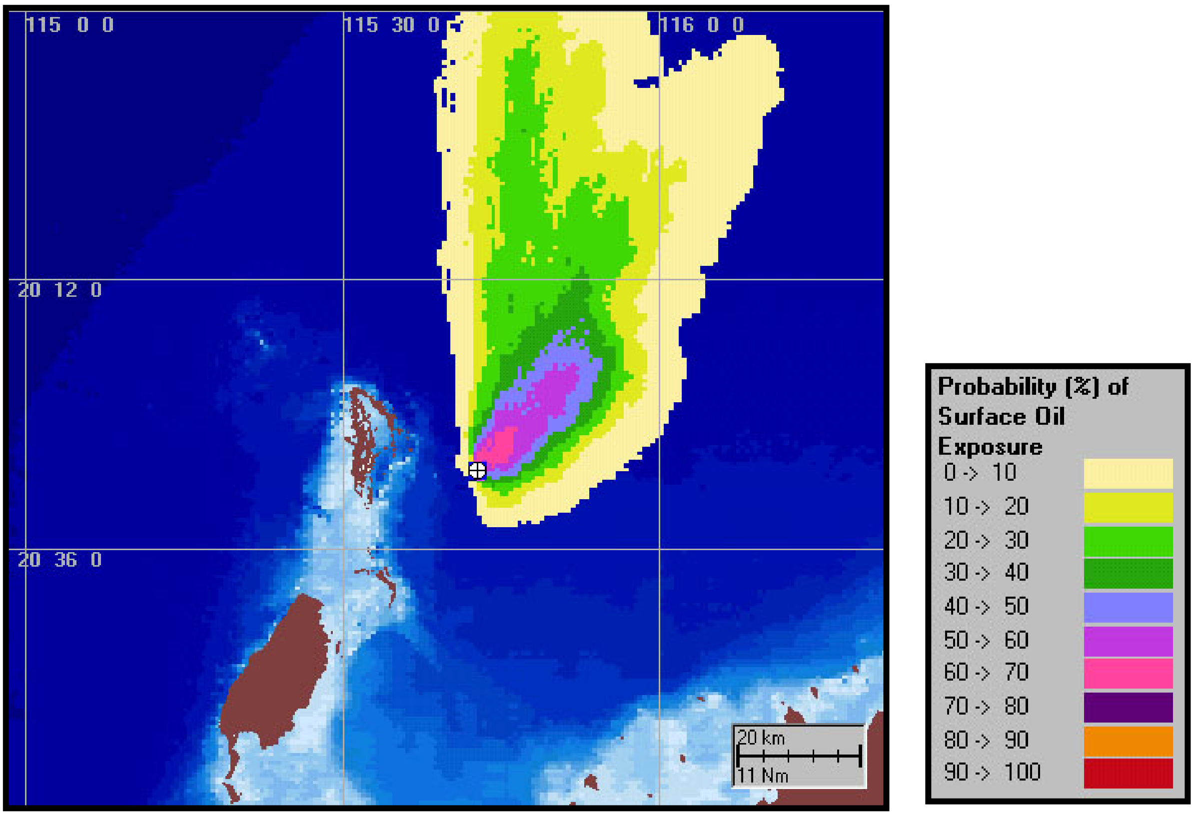


Figure 3a: Probability of diesel contacting surface waters from a 2,500 L spill from Endymion-1 using summer wind conditions.

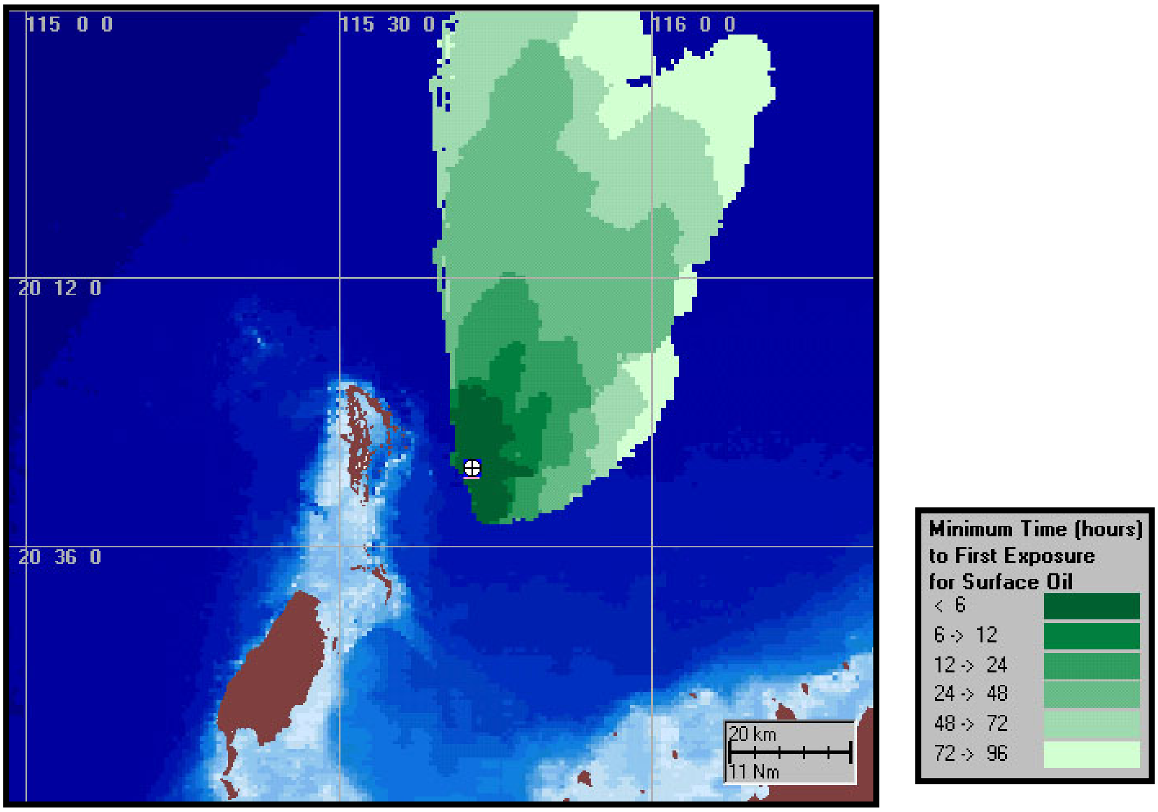


Figure 3b: Minimum time taken for diesel to contact surface waters from a 2,500 L spill from Endymion-1 using summer wind conditions

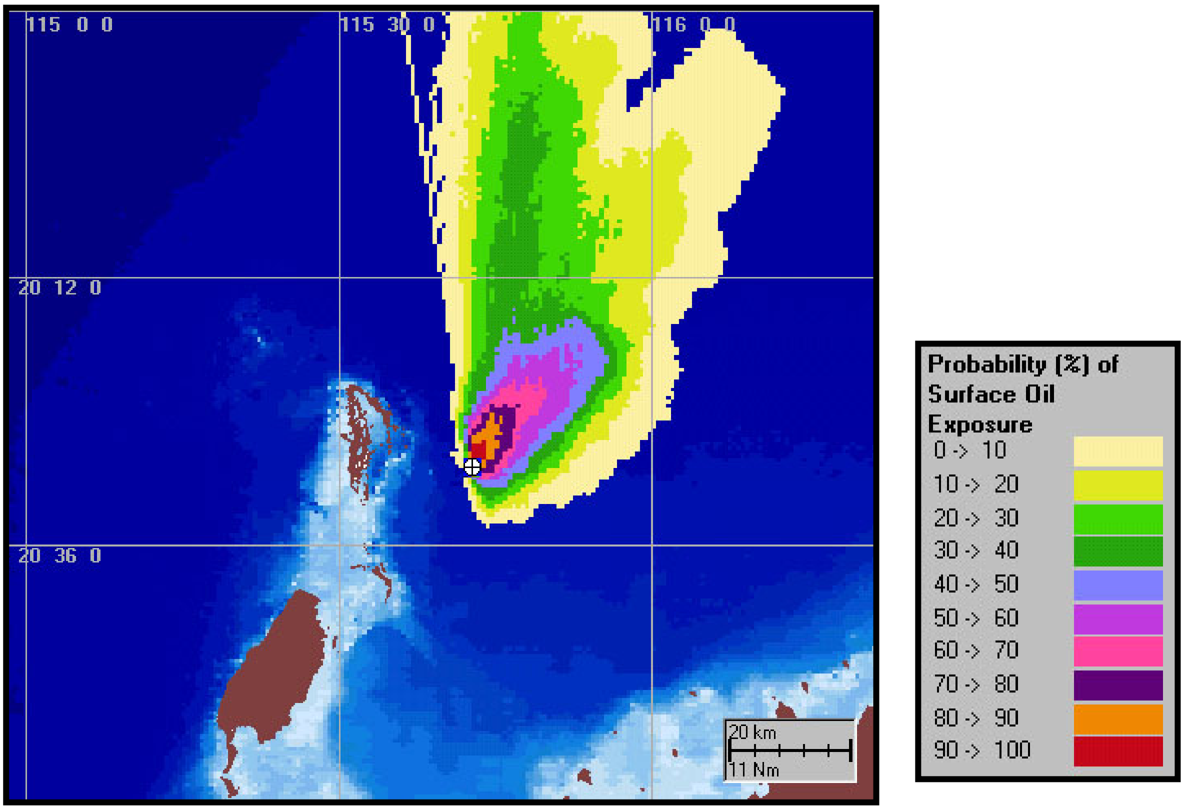


Figure 4a: Probability of diesel contacting surface waters from an 80,000 L spill from Endymion-1 using summer wind conditions.

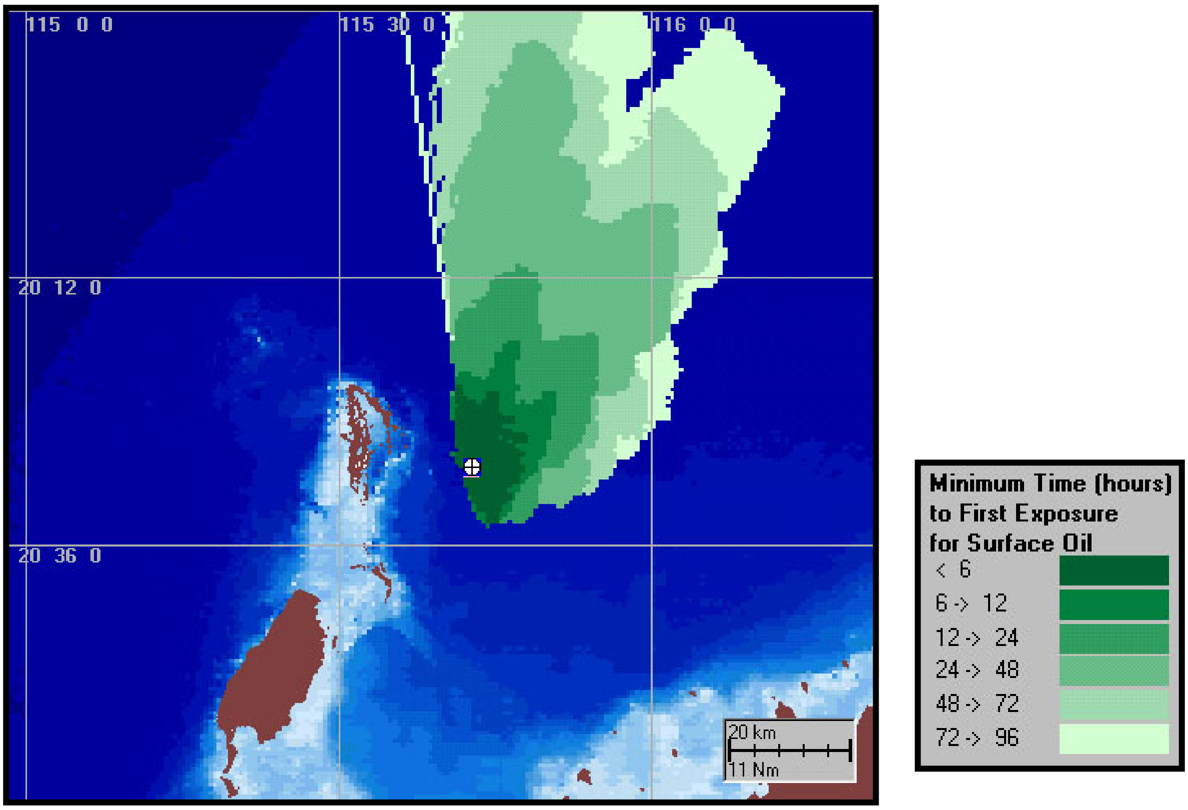


Figure 4b: Minimum time taken for diesel to contact surface waters from an 80,000 L spill from Endymion-1 using summer wind conditions

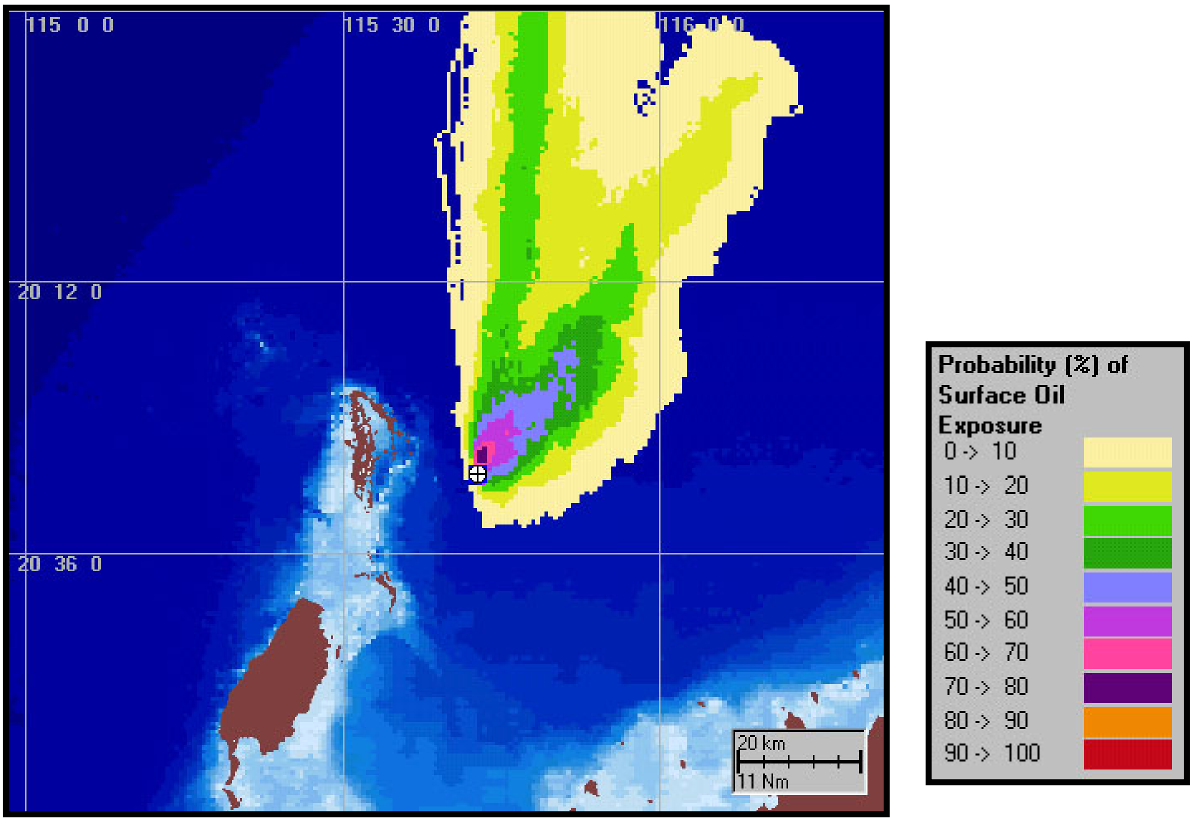


Figure 5a: Probability of crude contacting surface waters from an 8,000 L spill from Endymion-1 using summer wind conditions

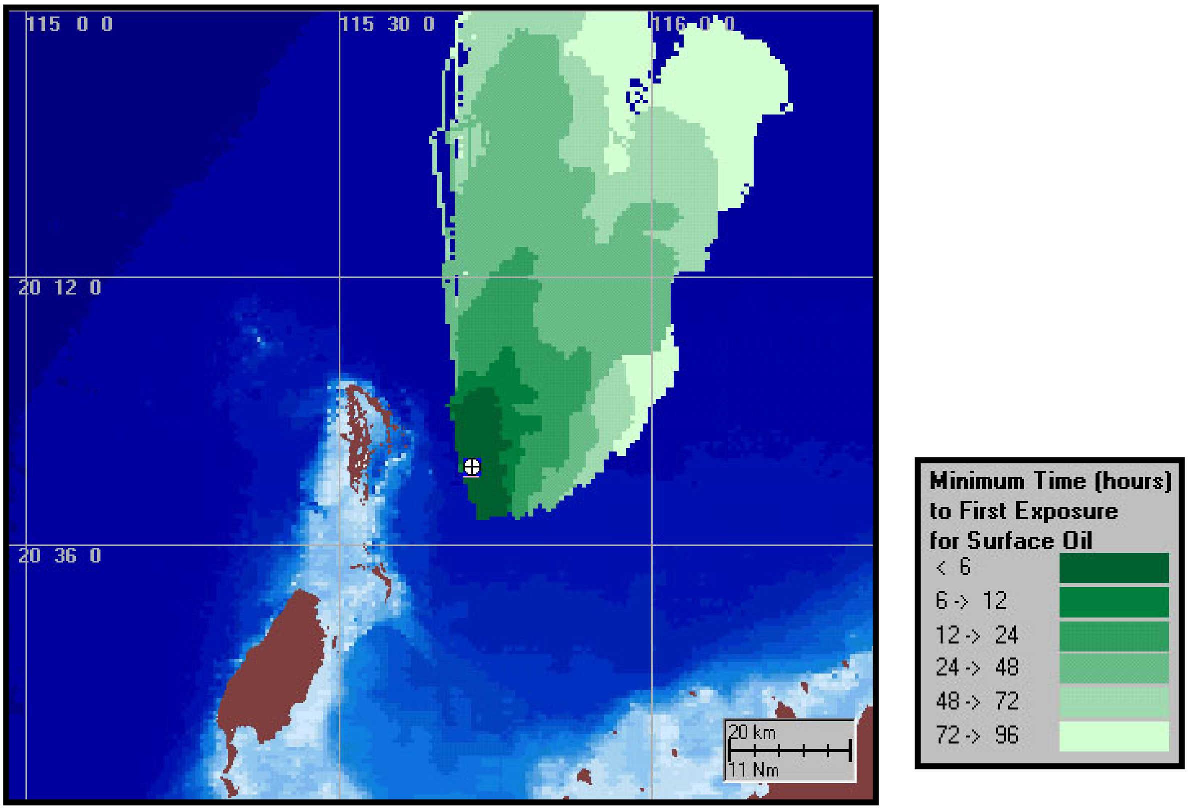


Figure 5b: Minimum time taken for crude to contact surface waters from an 8,000 L spill from Endymion-1 using summer wind conditions

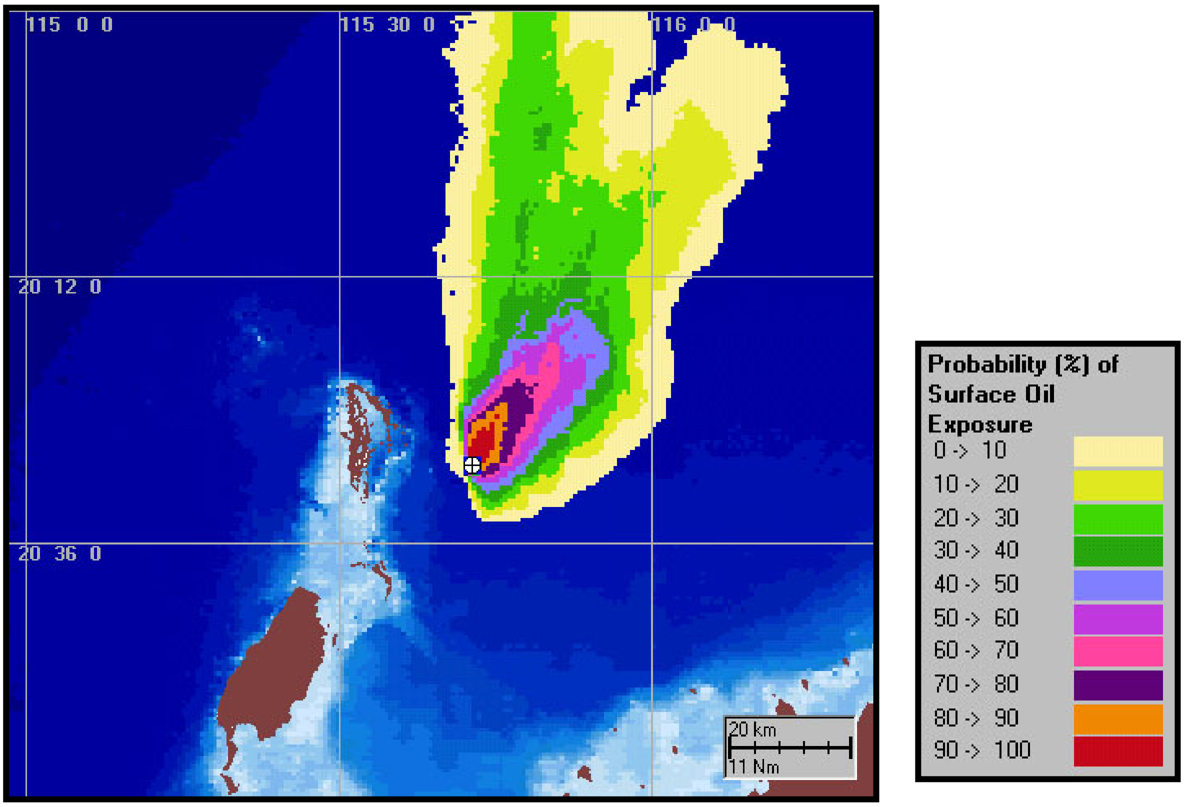


Figure 6a: Probability of crude contacting surface waters from a 600,000 L spill from Endymion-1 using summer wind conditions

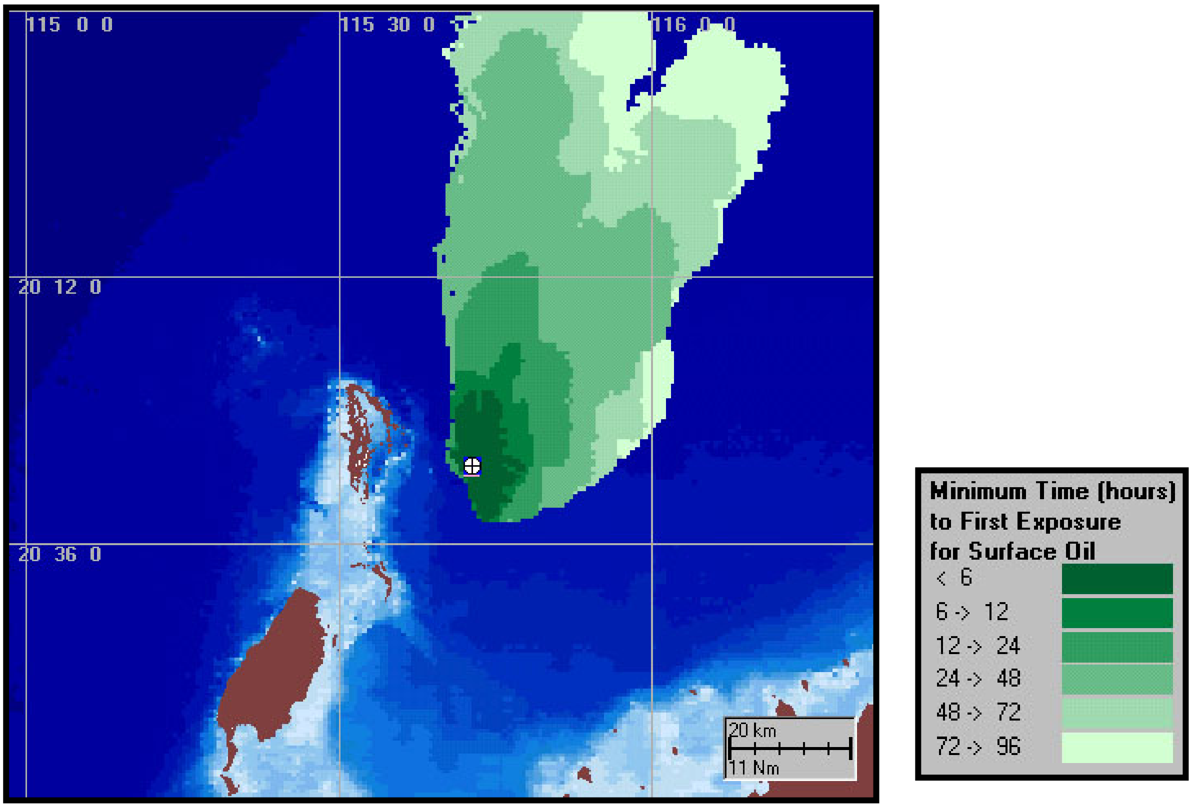


Figure 6b: Minimum time taken for crude to contact surface waters from a 600,000 L spill from Endymion-1 using summer wind conditions

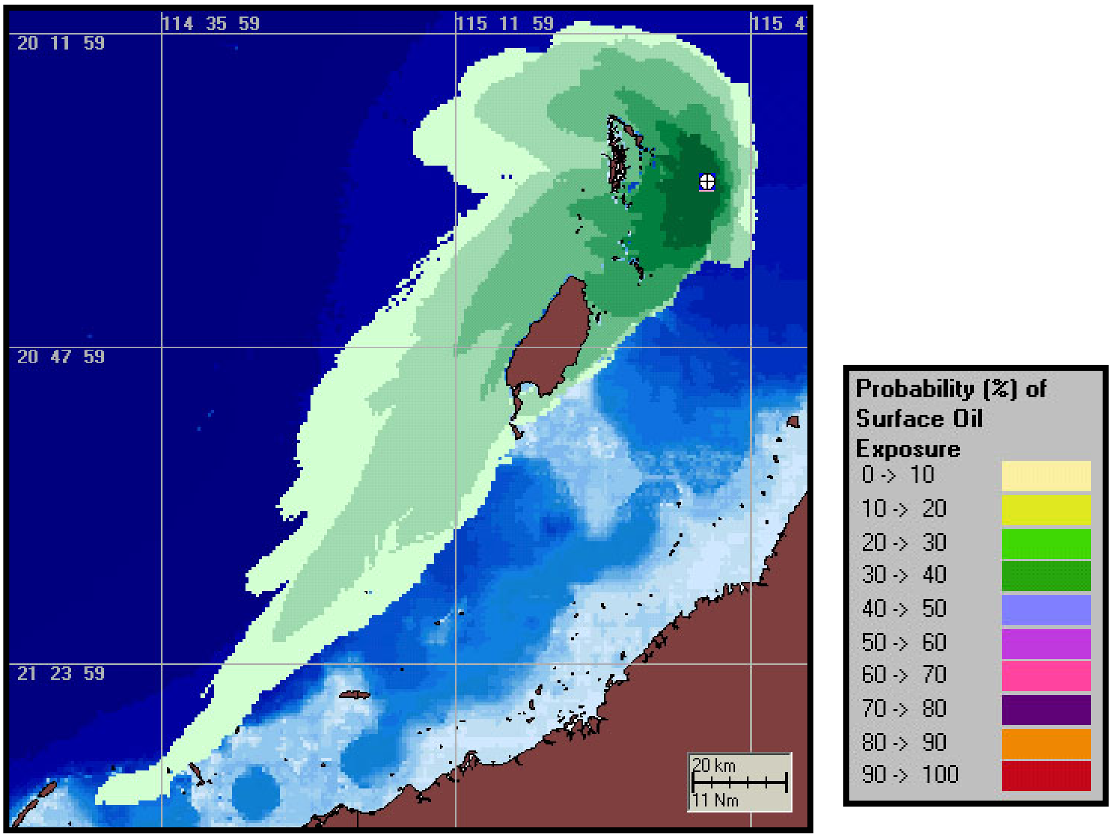


Figure 7a: Probability of diesel contacting surface waters from a 2,500 L spill from Endymion-1 using winter wind conditions.

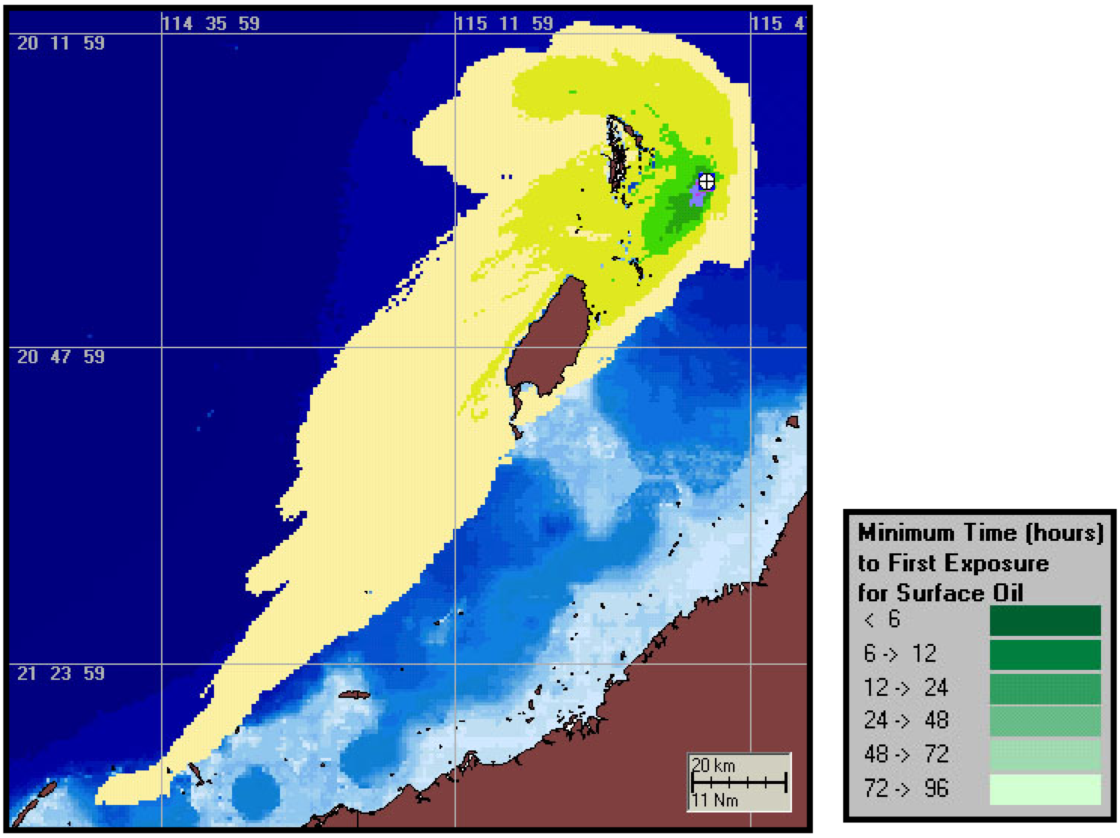


Figure 7b: Minimum time taken for diesel to contact surface waters from a 2,500 L spill from Endymion-1 using winter wind conditions

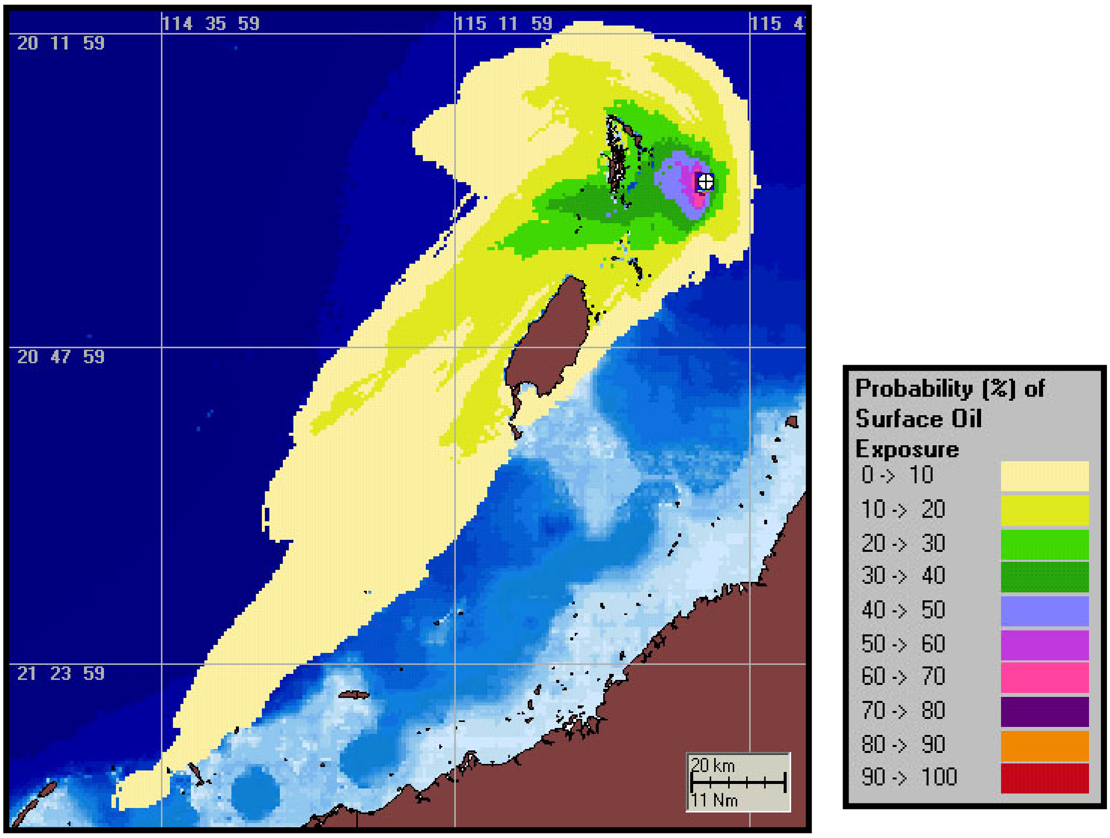


Figure 8a: Probability of diesel contacting surface waters from an 80,000 L spill from Endymion-1 using winter wind conditions.

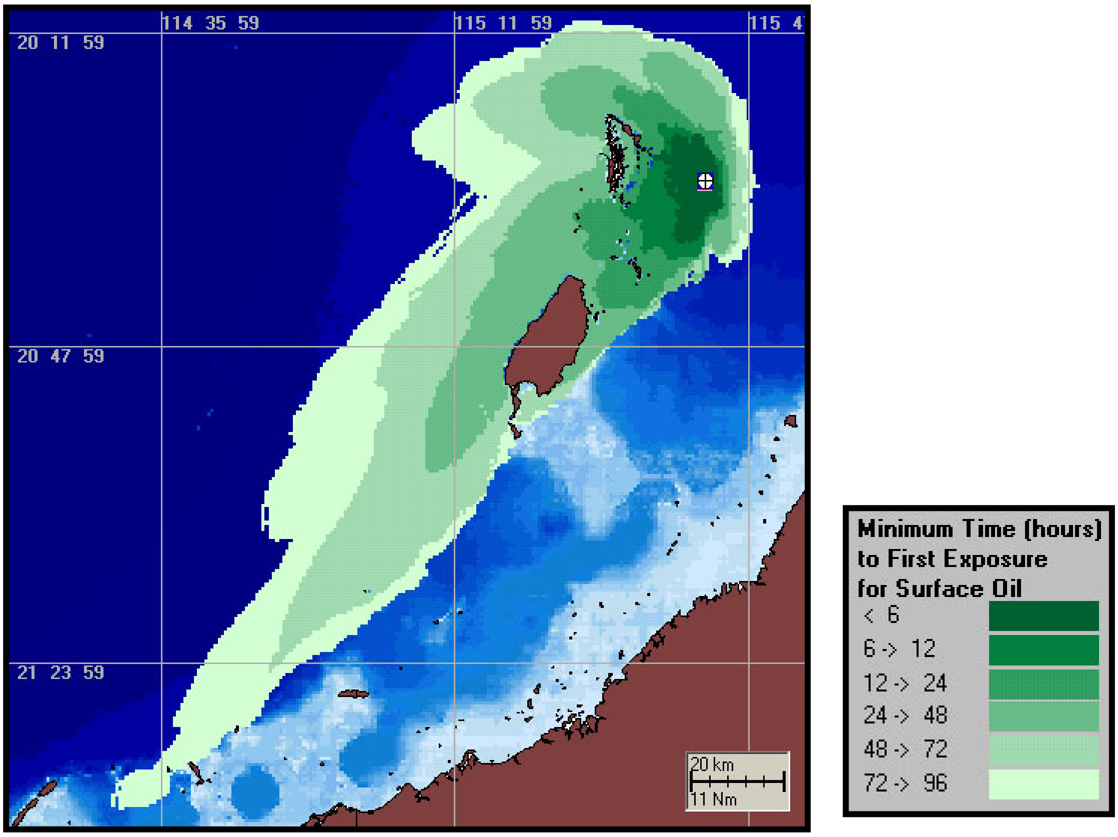


Figure 8b: Minimum time taken for diesel to contact surface waters from an 80,000 L spill from Endymion-1 using winter wind conditions

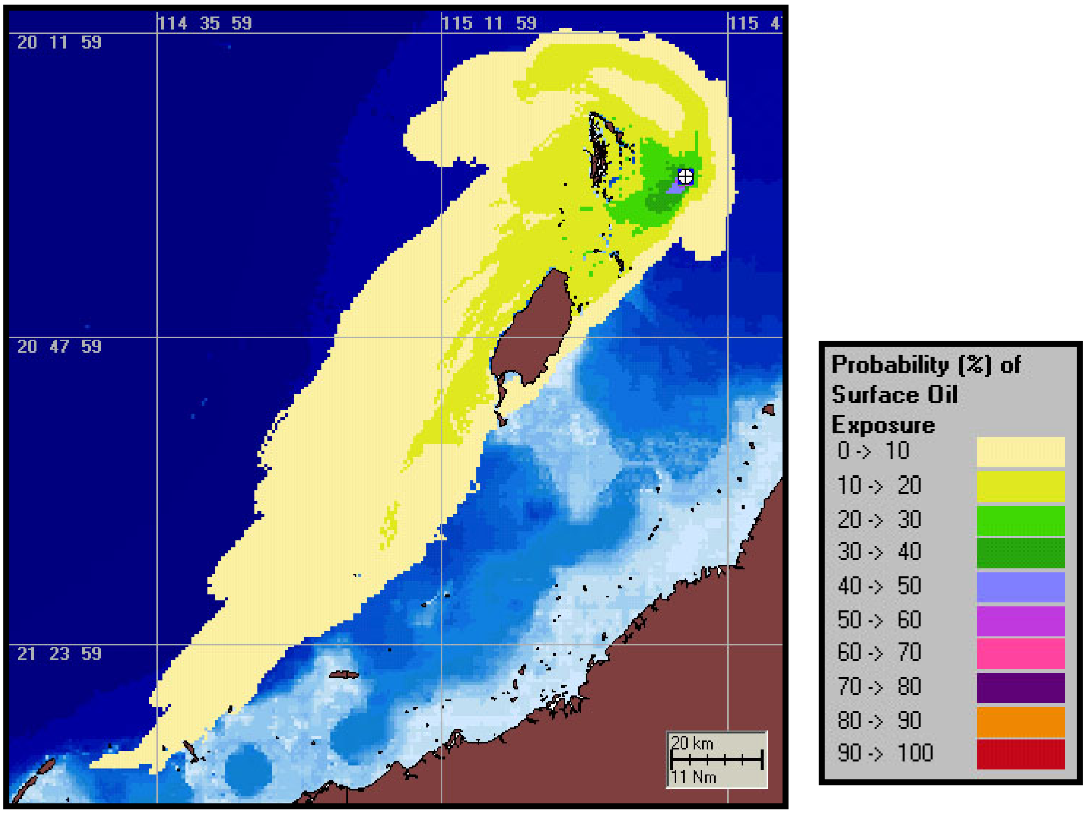


Figure 9a: Probability of crude contacting surface waters from an 8,000 L spill from Endymion-1 using winter wind conditions

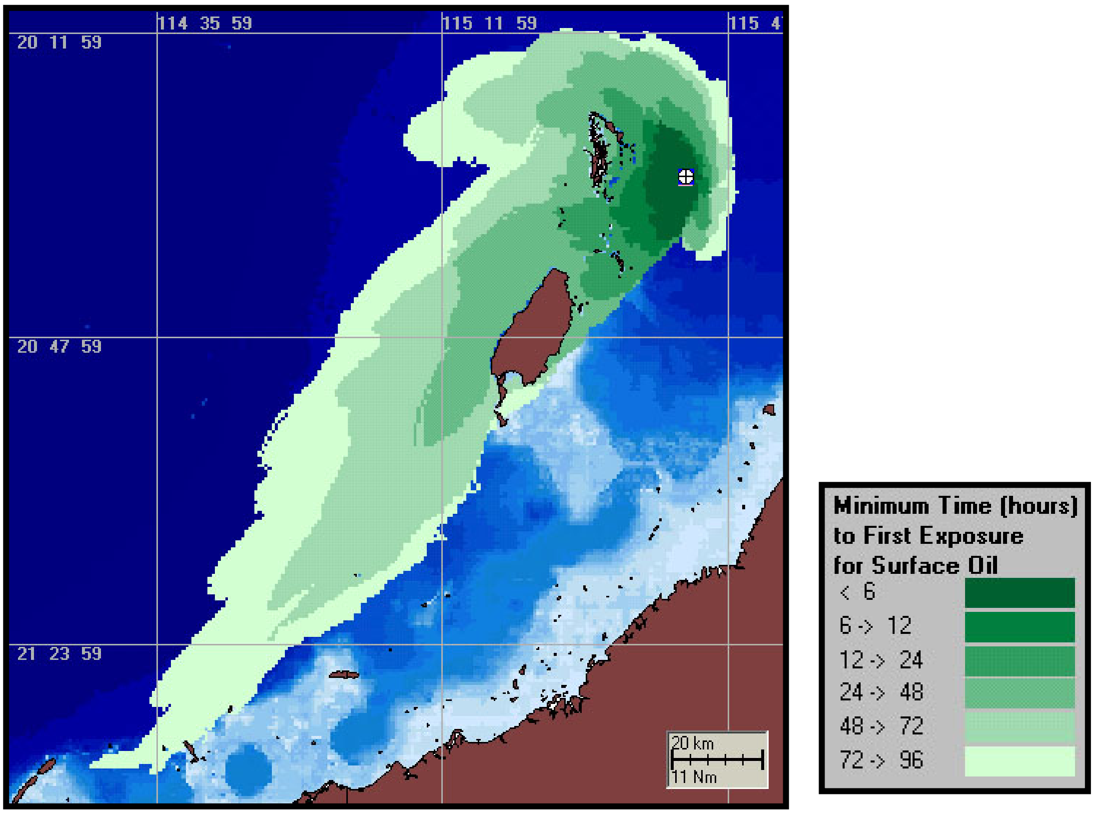


Figure 9b: Minimum time taken for crude to contact surface waters from an 8,000 L spill from Endymion-1 using winter wind conditions

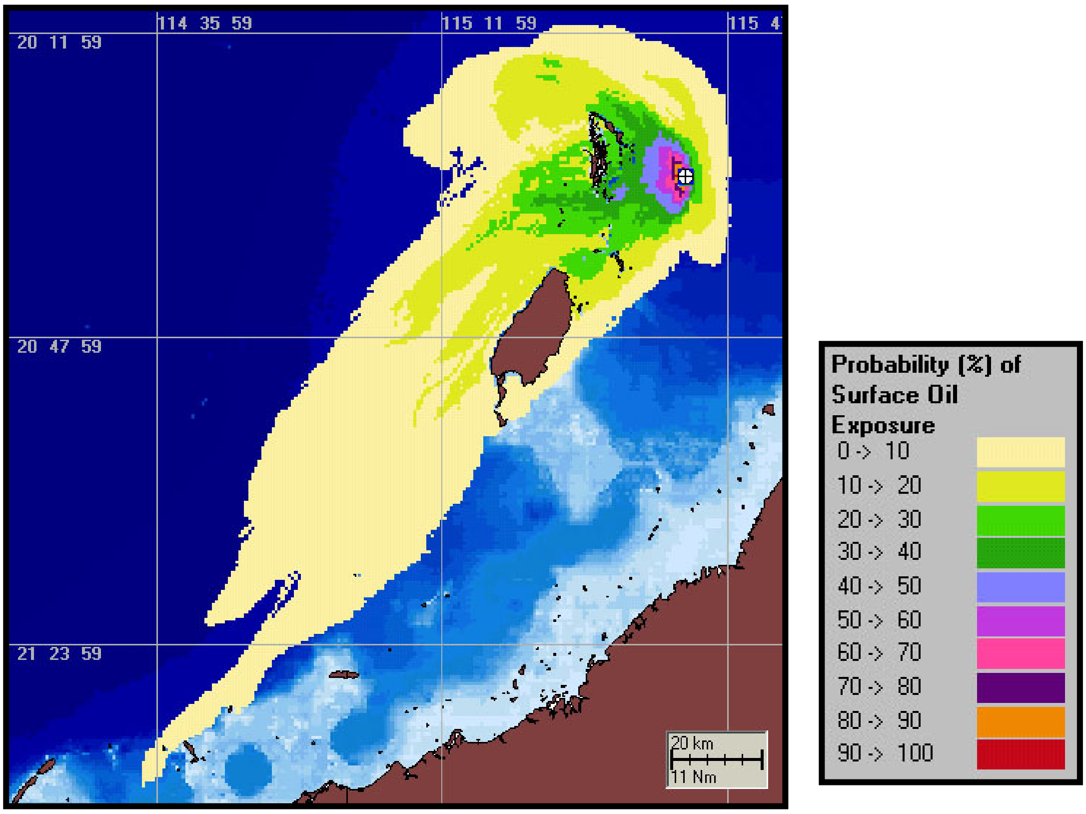


Figure 10a: Probability of crude contacting surface waters from a 600,000 L spill from Endymion-1 using winter summer wind conditions

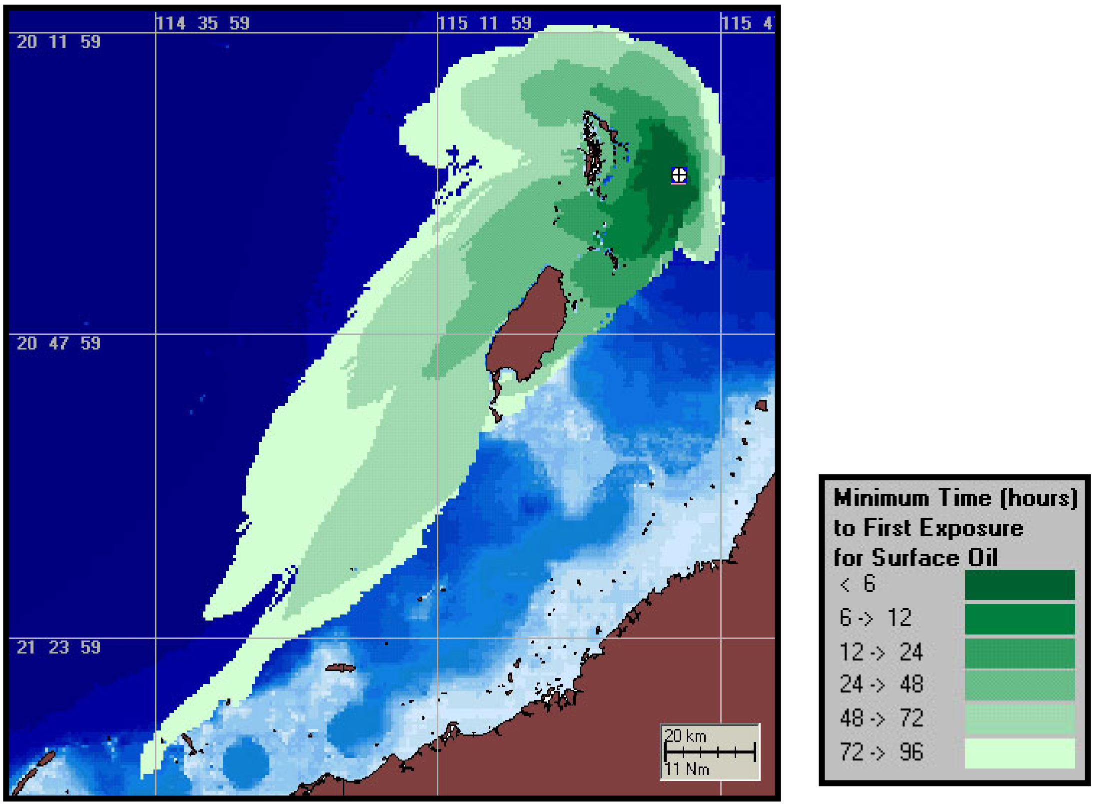


Figure 10b: Minimum time taken for crude to contact surface waters from a 600,000 L spill from Endymion-1 using winter wind conditions

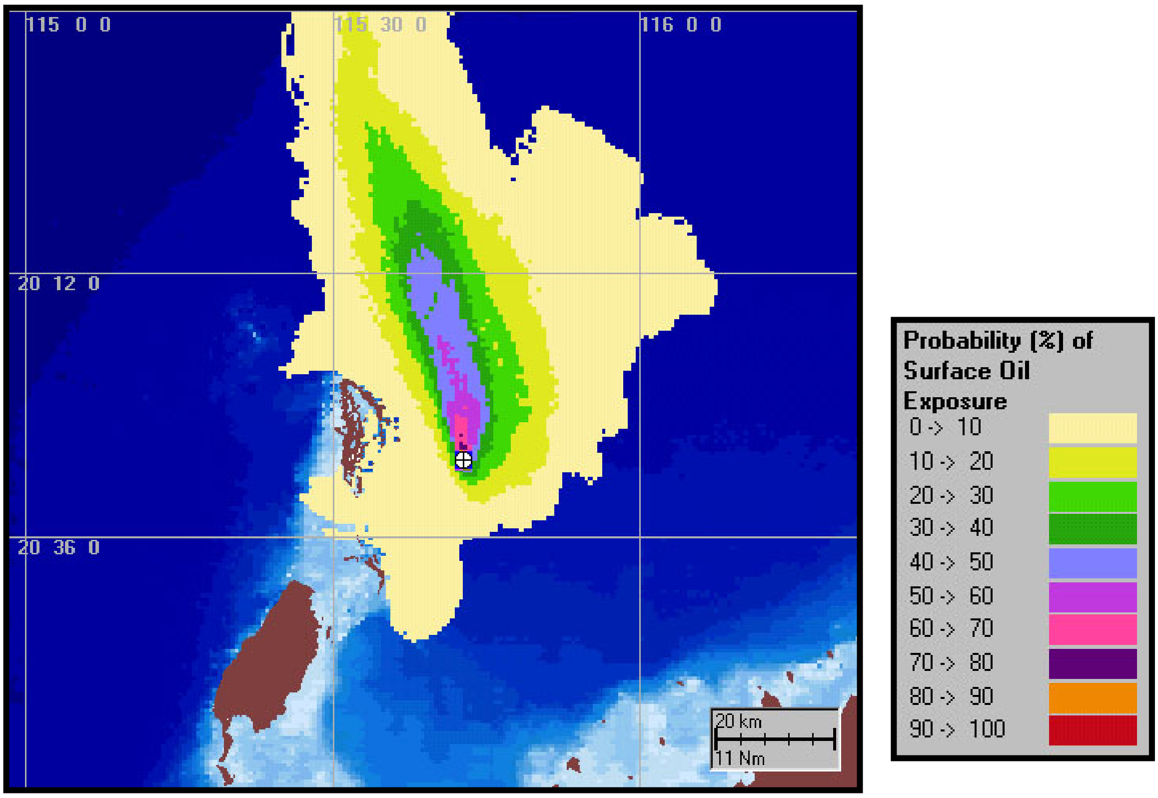


Figure 11a: Probability of diesel contacting surface waters from a 2,500 L spill from Endymion-1 using transitional (September) wind conditions.

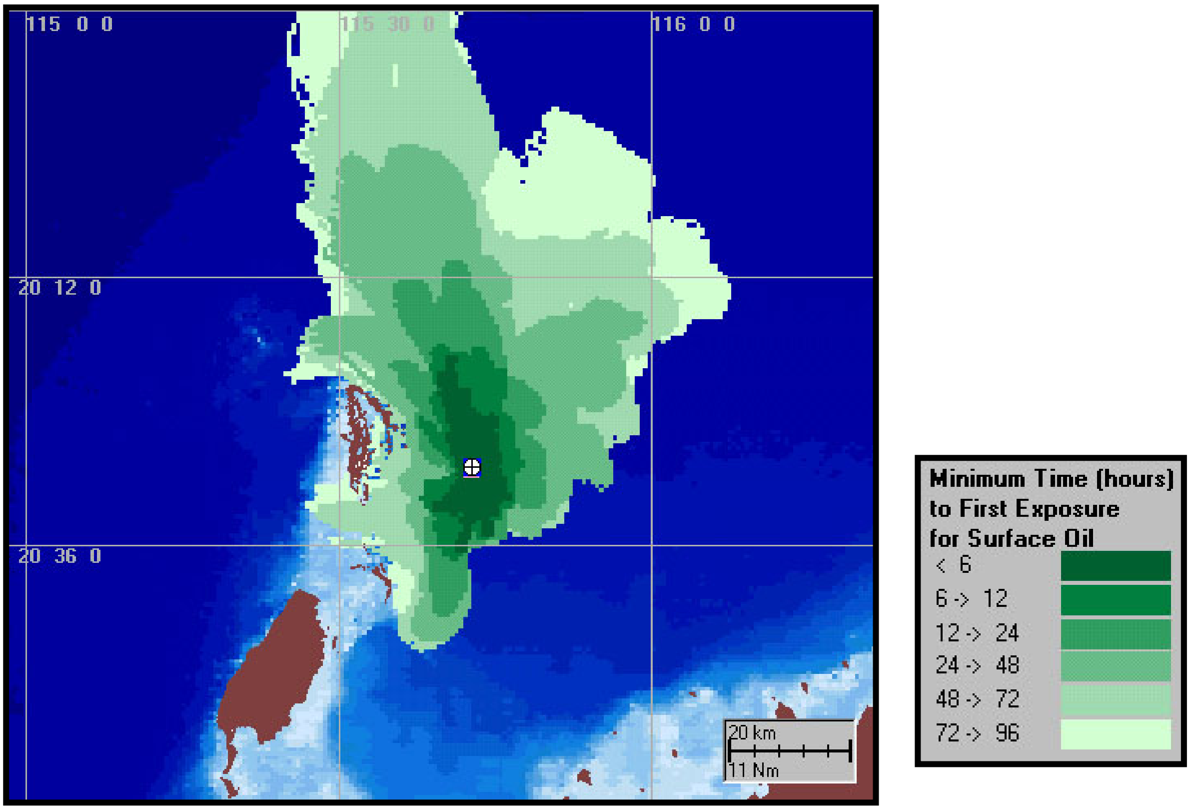


Figure 11b: Minimum time taken for diesel to contact surface waters from a 2,500 L spill from Endymion-1 using transitional (September) wind conditions

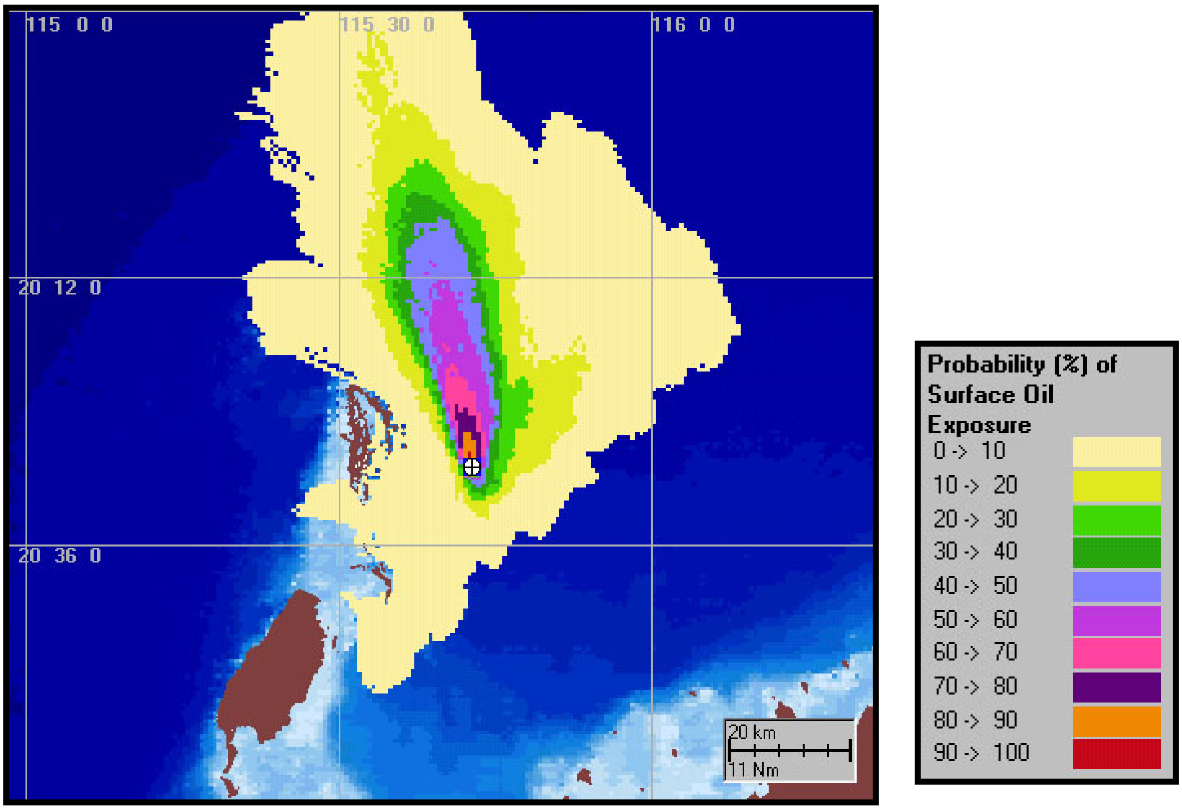


Figure 12a: Probability of diesel contacting surface waters from an 80,000 L spill from Endymion-1 using transitional (September) wind conditions.

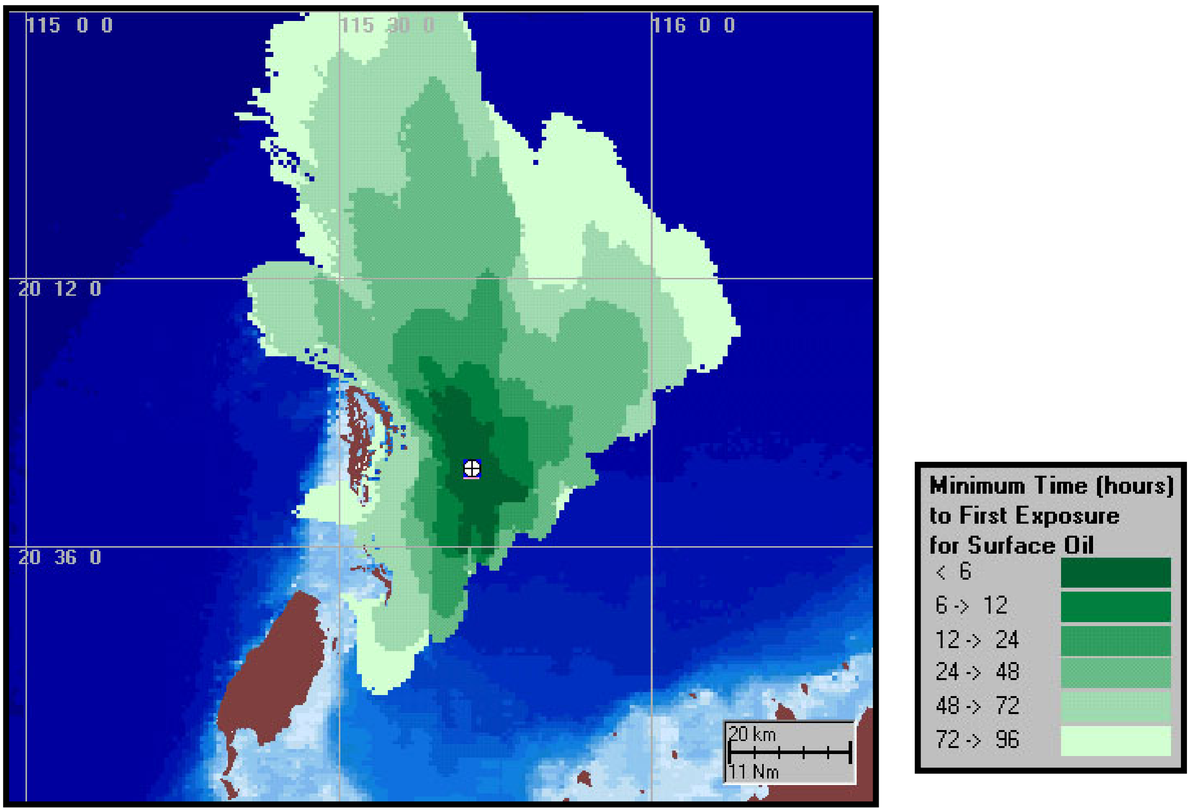


Figure 12b: Minimum time taken for diesel to contact surface waters from an 80,000 L spill from Endymion-1 using transitional (September) wind conditions

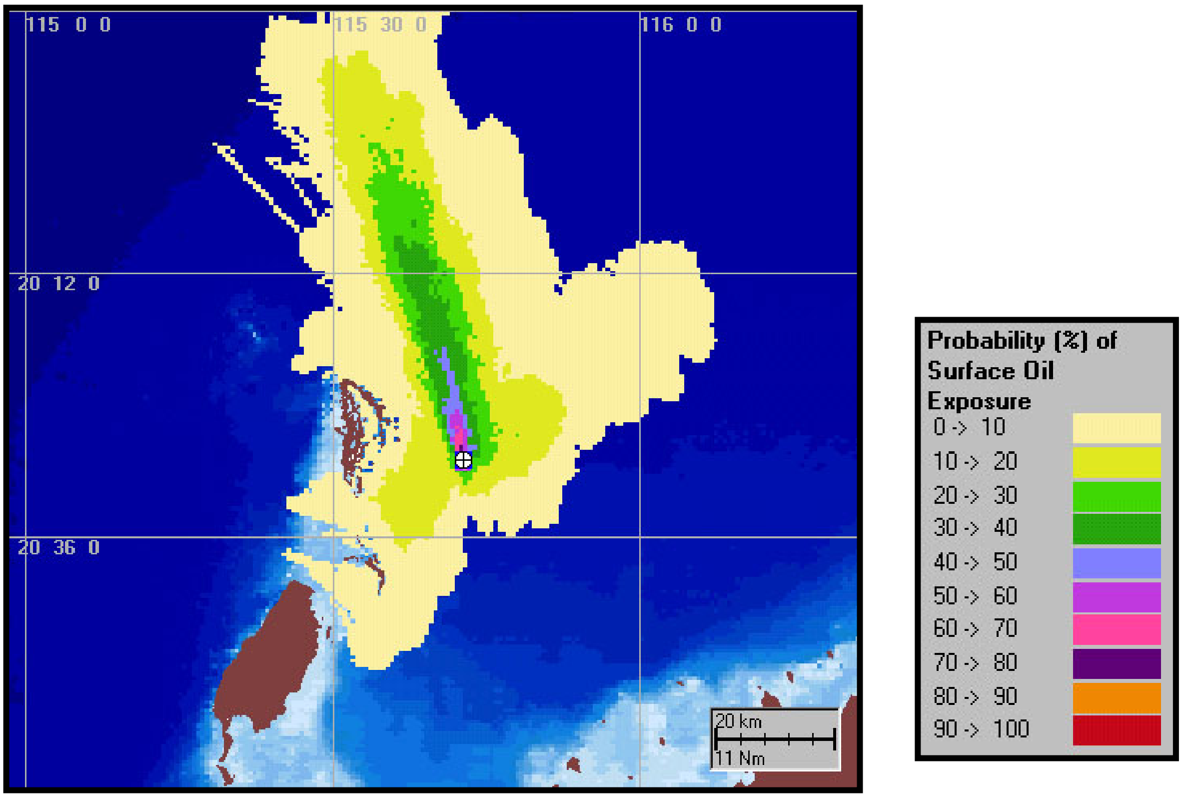


Figure 13a: Probability of crude contacting surface waters from an 8,000 L spill from Endymion-1 using transitional (September) wind conditions

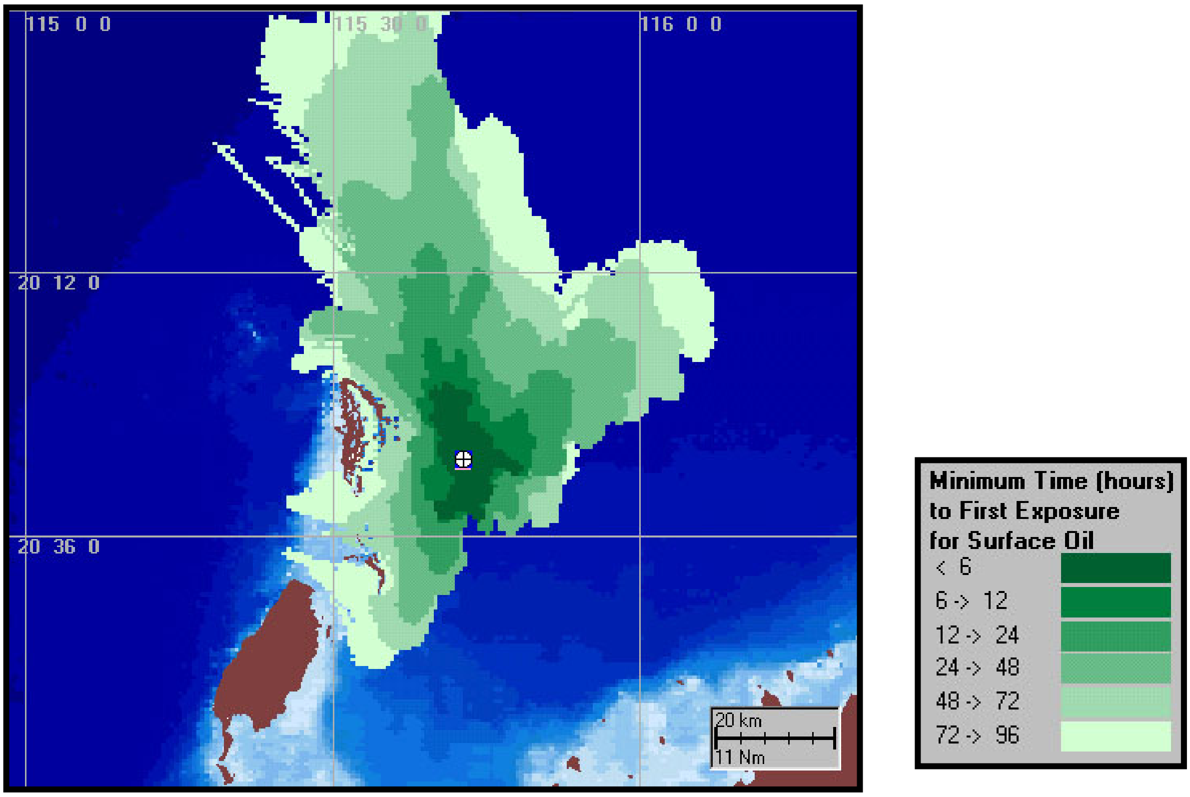


Figure 13b: Minimum time taken for crude to contact surface waters from an 8,000 L spill from Endymion-1 using transitional (September) wind conditions

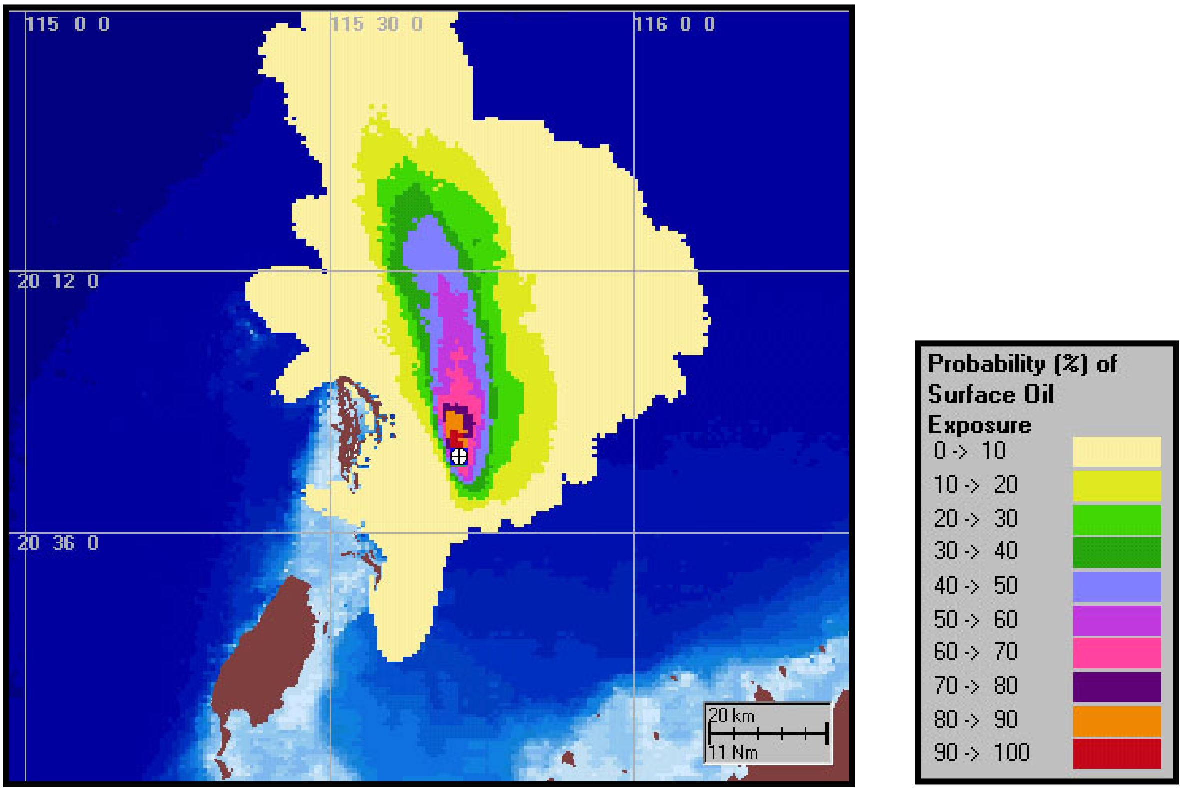


Figure 14a: Probability of crude contacting surface waters from a 600,000 L spill from Endymion-1 using transitional (September) wind conditions

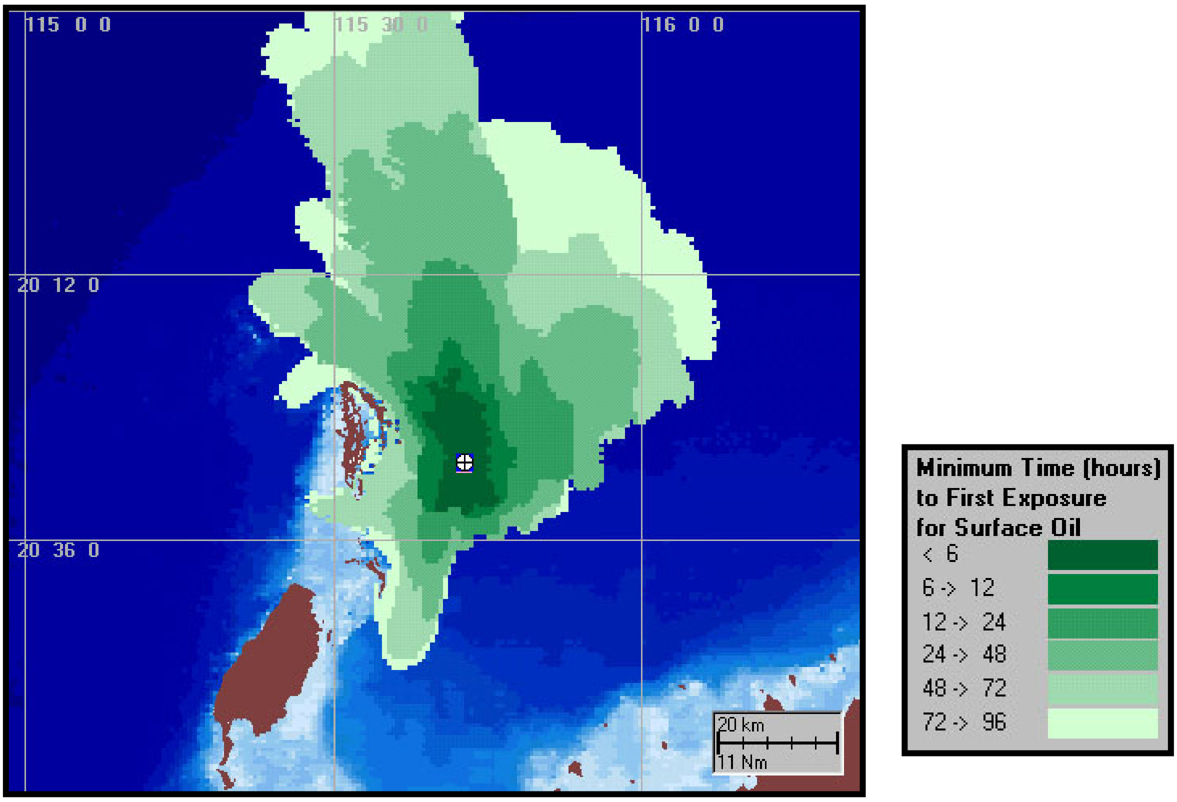


Figure 14b: Minimum time taken for crude to contact surface waters from a 600,000 L spill from Endymion-1 using transitional (September) wind conditions

4.0 ENVIRONMENTAL RISK ASSESSMENT METHODOLOGY

This section describes the risk assessment methods used for analysing the environmental impact during drilling activities. The purpose of this analysis is to identify risks and develop risk-reducing measures for preventing and mitigating impacts from the project.

The risk assessment has been carried out on both routine and non-routine sources of impact. In determining the risk, consideration was made of the distance between the well location and nearshore sensitive resources, the depth of water at the well location, the toxicity of the oil and the results of oil spill trajectory analysis.

Environmental risk assessment consists of four broad steps (Standards Australia 1999):

- Identify the risk;
- Analyse the risk;
- Evaluate and prioritise the risks; and
- Treat the risks.

These steps are described briefly below.

Risk identification

Risk identification involves identifying the sources of risk i.e. those activities or incidents that could result in an environmental impact. Risks are categorised into those arising from routine operations and those arising from incidents that are not part of routine operations.

Risk analysis

Risk analysis determines the likelihood of an activity or event occurring, and the consequences of that activity or event on the environment. The risks associated with potential oil spills as they apply to the proposed well were analysed quantitatively using hydrodynamic modelling.

The criteria used to determine likelihood is given in Table 6. Likelihood is based on the existing controls that are in place to prevent the impact, the nature of materials or substances that contribute to the impact, and the frequency with which the activity may occur.

The consequence of the identified hazard is rated according to definitions given in Table 6. The consequence is dependent on the potential impact of the event in the first instance. Quantities and concentration released, time scale of release, and regulatory requirements are considered.

Risk evaluation

Risk evaluation helps to prioritise the risks i.e. determining if the risk of an activity or incident is acceptably low, or if management actions are required to reduce the risk to as low as reasonably practicable (ALARP).

The risk matrix (Tables 7 and 8) has been created for the analysis of impact arising from drilling activities associated with Endymion -1. The environmental risk ranking is determined by a combination of the expected frequency of the hazard occurring (likelihood) and the consequence of its occurrence to arrive at a risk level from the risk matrix given in Table 7.

The descriptions for the categories of risk and the associated management requirements are listed in Table 8.

The results of the risk evaluation are summarised in Table 9 for risks associated with routine operations and in Table 10 for risks associated with incidents resulting from accidental discharges.

Risk treatment

Management actions to treat the risks are incorporated into Table 9 and Table 10. Apache's management actions aim to reduce the environmental risks of the drilling program to as low as reasonably practical.

Table 6: Guidance for determining likelihood and consequence.

LIKELIHOOD OF RISK OCCURRING	
Expected to occur	Is expected to occur in most circumstances during the life cycle of an individual item or system.
Probably will occur	Will probably occur in most circumstances during the life cycle of an individual item or system.
May occur	Likely to occur at sometimes during the life cycle of an individual item or system.
Unlikely to occur	Unlikely, but possible to occur in sometime in the life of an individual item or system.
Rare	May occur, but in exceptional circumstances.
CONSEQUENCE	
Serious	Large scale detrimental effect that is likely to cause a highly significant effect on local ecosystem factors such as water quality, nutrient flow, community structure and food webs, biodiversity, habitat availability and population structure (e.g. abundance, fecundity, age structure). Long-term recovery period measured in decades.
Significant	Detrimental effect that will cause a significant effect on local ecosystem factors. Recovery period measured in years to decades.
Moderate	Impact that will cause a detectable effect in local ecosystem factors. Recovery period measured in months to years.
Minor	Incidental changes to abundance/biomass of biota in the affected area, insignificant changes overall ecological function. Recovery measured in months.
Negligible	Short-term, localized and insignificant impacts to habitat or populations. Rapid recovery measured in days to months.

Table 7: Risk matrix

		CONSEQUENCES				
		Serious	Significant	Moderate	Minor	Negligible
LIKELIHOOD	Expected to Occur	Unacceptable	Unacceptable	Unacceptable	B	Negligible
	Probably will Occur	Unacceptable	Unacceptable	A	B	Negligible
	May occur	Unacceptable	A	B	B	Negligible
	Unlikely to occur	A	A	B	Negligible	Negligible
	Rare	A	B	Negligible	Negligible	Negligible

Table 8: Definitions of risk category and management response

CATEGORY	DESCRIPTION and RESPONSE
Unacceptable	Immediate changes to design or procedures are required (e.g. hazardous discharge, large volumes of contaminant).
A	Risk reduction measures are required.
B	Acceptable risk, risk reduction measures should be considered depending on proximity to sensitive resources.
Negligible	Risks are sufficiently low to be acceptable.

5.0 RISK ASSESSMENT OF ROUTINE DRILLIGN OPERATIONS

The routine activities of the drilling program and an overview of the management actions to be taken are given in Table 9. The environmental risk associated with the routine discharges and activities identified are negligible except for drill cuttings and fluids and pipe dope which are considered an acceptable risk with reduction measures in place to minimise the impacts from the discharge of these materials to the seabed. Detail on the various discharges and activities and the reasons for the low degree of risk assigned are given below.

5.1 Physical Impacts

Rig positioning and anchoring

Imprints on the seabed by the drilling rig legs is the main source of physical impact associated with drilling operations. The weight of a jack-up drilling rig results in the formation of a depression in the seafloor at each of the sites where the legs are positioned. The area of disturbance to the seafloor will be dependent on the substrate type. From past experience, the area of each of the depressions will be approximately $105m^2$. Once the drilling rig is moved from site, the leg depressions will act as traps for marine detritus and sand. These depressions will eventually fill and therefore the effect is temporary as recolonisation by benthic organisms is likely to be rapid (BBG 2000).

Noise and artificial lights

Due to safety regulations, lights on the drilling rig must be kept on 24 hours per day. The Sinbad platform is also kept alight 24 hours per day. These lights attract some marine life and seabirds. Observations from other platforms located in open waters on the North West Shelf indicates that the interaction with seabirds will be limited.

Turtles are known to use a variety of cues for navigation when in the water, however light is not thought to be an important cue for adults, which may use the offshore area around the drilling rig (Apache 1997, CSIRO 1998). A study in the Gulf of Mexico found that turtles observed near production platforms were feeding on animals attracted to the platform lights, rather than being miss-oriented by the lights themselves (Minerals Management Service 1992). Hatchling turtles are known to use light to orient towards the ocean when leaving nesting beaches. However since the drilling of the well is planned for August / September, which is out of the turtle breeding season, hatchlings are not likely to be present at the time.

Drilling activities, machinery, helicopters and boat engines will cause noise during the drilling operation. The primary concern arising from the noise generation is the potential effects upon seabirds and marine mammals. Due to the transient nature of the rig location and its isolation from nearby land, there is a very low potential for significant disturbance to seabirds by operation of the facility. The noise generated by helicopters will be mitigated by following a regular flight path that avoids low-level flight over islands and potential seabird colonies.

The effect of noise from drilling operations on marine animals is not well understood. Some studies have demonstrated that whales can hear platforms and may avoid them (Geraci & St Aubin 1987, quoted in Swan *et al*. 1994). In contrast, anecdotal reports indicate that whales and turtles will approach and investigate operating rigs (Swan *et al*. 1994). This behaviour was observed for humpback whales around the rig used for development drilling at the Stag location and at Apache's production facilities off Varanus Island. There is no evidence to suggest that the localised noise or discharges associated with drilling operations impact negatively on whales.

During the time of drilling (August / September) the southern migration of Humpback whales is known to occur (Jenner *et al.* 2001). However the known migration path is to the outer edge of the continental shelf (Western Side of Barrow Island) in deeper water and not in the waters on the eastern side of the island chain where the drilling is proposed.

5.2 Liquid and Solid Wastes

Drilling cuttings and fluids

Drill cuttings will be continuously discharged overboard after separation from the drilling fluid. The cuttings are inert rock particles and are not expected to exceed 1 - 1.5cm in size. The volume of cuttings from Endymion-1 is expected to be approximately 148m^3 (dry hole) or 177m^3 (completed well). The cuttings will be discharged overboard throughout the drilling program. Drill cuttings are heavy and will drop out of the water column and settle to the seabed rapidly, resulting in the formation of a small mound. Due to strong currents in the area, the cuttings mound will erode away and be dispersed through time. While present, the mound may be colonised by fish and other fauna.

A combination of water-based drilling fluids and synthetic drilling fluids will be used during the drilling program. For water based fluids, water is used as the base fluid and additives such as barite, bentonite, vegetable fibres, calcium chloride, lime and starch can be used to aid in lubrication, cooling and density. For synthetic based drilling fluids a synthetic olefin isomer (Synteq) and brine emulsion will be used.

Although the drilling fluid will be recirculated, some drilling fluid adheres to the discharged cuttings and is disposed overboard. When using synthetic based muds, Apache reinjects cuttings to the loss circulation zone wherever possible, however as outlined in section 1.2, this option is not feasible at this location, hence cuttings will be directed to the sea bed for disposal.

The approximate volume of cuttings containing water based muds that are planned to be discharged to the seabed is 49m^3. The volume of cuttings containing synthetic based muds will be 99m^3 (dry hole) or 128m^3 (completed well).

Only water based drilling fluid remaining at the end of the well will be discharged overboard just below sea level to aid in dilution and dispersion. Due to the high-energy state of the ocean in this region, the turbidity plume is likely to disperse quickly. Synthetic based drilling fluid remaining at the end of the well will not be discharged overboard but will be transferred to the support vessels for recycling on the mainland.

The potential impacts arising from routine discharge of drilling fluids and cuttings are listed below. These impacts are expected to be localised and transient.

- burial of benthos,
- alteration of the benthic substrate, and
- increased turbidity in the water column.

The physical impacts associated with drilling fluid discharge can include increased water column turbidity and physical smothering of the seabed and biota. This is typically manifested in a change in infaunal species and or abundance in close proximity to the drilling location (10's of meters). Corals adapted to clear water environments may be particularly susceptible to high sediment loading in the water column. On the North West Shelf, however, the marine waters are regularly subjected to high sediment loads during spring tidal cycles (twice a month), high winds and storms. Consequently corals in the Montebello, Lowendal and Barrow Island area are well adapted to high suspended sediment loads and are unlikely to be adversely affected by drilling fluid in the water column especially given the distance of the well locations from these habitats.

Previous studies of drilling operations indicate that the disposal of cuttings may result in the localised smothering of infauna living in the area receiving the discharge. For the East Spar development in Commonwealth Waters, the area of impact was not more than 100 m and short lived (recovery in less than 18 months) (Sinclair Knight Merz 1996, 1997; Kinhill 1997). An infauna survey at Stag platform undertaken two years after commissioning of the installation indicated that the distribution of drilling cuttings were mostly restricted to within 50m of the platform, with minor impact up to 1000m (IRC 2001). Stag is a production platform with 12 producing wells.

A summary of literature examining the biological impacts of water based drilling fluids has been published by the US Minerals Management Service (Boehm *et al.*, 2001). In an effort to identify the worst case impacts, the studies summarised in the literature review generally focussed on long term drilling programs from fixed locations (i.e. production drilling of numerous wells from a single platform). The conclusions pertinent to drilling fluid discharges are paraphrased below.

"Drilling fluid chemicals dilute rapidly in the water column and, in all but very deep or high energy environments, much of the drilling fluid and cuttings solids settle rapidly to the bottom near the rig site (Neff 1987). Concentrations of barium, as a tracer for drilling effluent's, may be 10-20 times above background in surficial sediment near the discharge and decrease to background within 2,000 m down current. Most of the ingredients of drilling fluid chemicals have a low toxicity to marine organisms (Neff 1987), but the fluids and cuttings that settle on the seabed can significantly alter the benthic sedimentary regime."

"The GOOMEX studies (Kennicutt *et al.* 1996) were intended to test and evaluate a range of biological, biochemical and chemical methodologies to detect and assess chronic sublethal biological impacts in the vicinity of long duration activities associated with oil and gas E&P. Contaminant concentrations at most locations were below levels thought to induce biological responses."

Information regarding barite toxicity was also summarised by Boehm *et al.* (2001) and it was concluded that barite has a "very low toxicity". A discharge of barite was modelled and the results indicated that the highest predicted exposure concentration in the modelled plume would be at least two orders of magnitude lower than the toxic concentrations reported in the literature for marine species.

Information on the effects of synthetic based muds in Australian conditions is limited with most literature primarily related to deeper and colder waters (eg North Sea). To help address the lack of field data, Apache has committed to undertaking a study to compare the effects of SBM versus WBM from drilling operations in shallow water environments.

Studies of SBM in Bass Straight (in 70 m water) indicate that esters from SBM were not persistent in sediments, with concentrations decreasing significantly within 6 months of drilling. Within 4 months of drilling, benthic biological parameters had returned to pre drilling conditions (Terrens et.al. 1998 in Neff *et al.* 2000b).

Sewage and putrescible domestic wastes

Discharge of sewage and food scraps will comply with Clause 222 (Housekeeping) of the Schedule to the *Petroleum (Submerged Lands) Act*. Putrescible galley wastes will be bagged and placed in skips for onshore disposal. Ensco 56 is equipped with a Red Fox Unit, which processes sewage using maceration, aeration and chlorination prior to discharge thereby complying with clause 222. The grey water from showers and the laundry are discharged directly overboard.

The crew numbers about 60 persons at any one time. Approximately 12,000L of domestic discharges will be generated per day. The discharge of these wastes will temporarily add to the nutrient load of the surrounding waters, however this is expected to be rapidly dispersed and diluted as a result of the daily diurnal tides.

Deck drainage

Under routine conditions, deck drainage from the Ensco 56 discharges to the sea. Discharge is via the flume lines which also contain return seawater. Housekeeping practices on the Ensco 56 ensure that decks are kept clean during drilling operations.

The drainage system on the Ensco is configured such that in the event of a spill, drainage can be diverted to on board containment tanks for treatment. The main deck and cantilever drains can be routed to a contaminated water tank (280 bbls capacity), which is connected to an oily water separator (designed to treat to 15mg/L). Treated water discharges to the flume lines and oil is directed to a waste oil tank (56 bbls). Fluid collected in the waste oil tank would be pumped into drums for disposal onshore.

Drains from the rig floor can be routed to the mud spill tank, which can be pumped to the mud return line. The cement unit engine compartment drains are routed to the hazardous drains tank which is also connected to an oily water separator.

Chemicals and waste materials

Chemicals used or stored on board the drilling rig will be managed so as to prevent damage to the containers and thus reduce the likelihood of any leaks or spills either onto the deck or into the ocean.

Chemicals that may be found on-board include:

- drilling fluid additives such as biocides, corrosion inhibitors, viscosity, weighting and fluid loss control chemicals;
- cementing and drilling fluid chemicals such as cement, inorganic salts, bentonite

and barite; and

- miscellaneous chemicals – pipe dope, lubricating oils, cleaning and cooling agents.

Chemicals will be stored such that spills and leaks are contained. Any spills or leaks will be cleaned up immediately using absorbent material. Waste oils are collected for disposal or recycling onshore. The minimum volume of chemicals will be used.

All solid wastes will be returned to the mainland for disposal. Drums and scrap metal are re-used or recycled, and non-reusable solids are disposed of onshore via Dampier at an appropriate industrial disposal site.

All other wastes will be segregated and stored on the rig, and transported to Dampier for disposal at the Karratha industrial tip unless special disposal methods are required.

5.3 Atmospheric emissions

Sources of atmospheric emissions will be from power generation, process drivers and transport vessels associated with the drilling operation. Fuel burning equipment on the rig, as well as helicopters and support vessels will contribute to emissions of gases including carbon dioxide and oxides of nitrogen. These emissions are not expected to have any local environmental consequences but will add a very small amount to the global inventory of greenhouse gases. These emissions will be minimised by using efficient equipment. All engines, compressors etc. will be maintained on a regular basis and tuned to optimal efficiency. An inventory of equipment and fuel consumption rates will be kept for emissions reporting.

5.4 Socio-economic Environment

The standard $500m^2$ exclusion zone will be established around the platform. This will cause a temporary restriction to marine vessel movement in the vicinity of the platform. The rig is well lit at night and during times of poor visibility.

5.5 Summary of Effects of Routine Operations

The environmental impact arising from drilling Endymion-1 is expected to be minimal and confined to the immediate vicinity of the drilling rig.

There will be a minor disturbance to benthic organisms due to the placement of the drilling rig. The sediment plumes and increased turbidity during the drilling period will be localized and transitory. The discharge of drill cuttings associated with any water based or synthetic based drilling fluids will cause short-term, localised turbidity. The high energy of the open ocean will disperse these materials quickly and the impact is expected to be minimal. The disposal of drill cuttings at the well site will result in the deposit of a small mound. Detailed studies of the impact of drill cuttings disposal on benthic fauna indicate that only highly localised and short-lived changes in the physical, chemical and biological characteristics of the seabed will occur. Due to strong currents in the area, the cuttings mound will degrade and erode away being dispersed. While present, the mound will be colonised by fish and other fauna.

The adjacent marine resources should not be affected by the routine discharges (grey water, cooling water, sewage) due to the dilution that will occur after the discharges enter the sea and the use of biodegradable detergents.

Marine fauna such as dolphins, dugongs and turtles may avoid or be temporarily attracted to the rig during the drilling operations. This should not pose a threat to their well being due to the short period of time the drilling rig is on location.

Routine activities from the proposed well will not adversely affect the conservation values of the area, as they are not expected to cause any significant, permanent degradation of the water column or damage to the ecosystem factors of the region.

TABLE 9: Environmental Analysis of Impact - Routine Activities - Drilling

Risk ID	Hazard	Causes	Potential Environmental Impact	Existing controls	Likelihood	Consequence	Risk Ranking	Comments
R1	Positioning of drilling rig & platform unit	Legs of rig & production unit forming depressions into seabed. Approximately 105 m^2 per leg.	No impact until rig and unit has been removed from site. Remaining depressions will act as traps for detritus and sand. Will eventually fill with sand and become unrecognisable. Limited damage expected to seabed.		Expected to occur	Negligible	Negligible	
R2	Artificial lights	Lights on rig & platform must be left on at all times due to safety regulations. Lights are an attractant to marine life and some birds.	May result in a concentration of some animals. Any animal aggregating will be short-term.	Fluorescent lights meeting safety standards.	Expected to occur	Negligible	Negligible	Drilling will occur outside turtle breeding season and during southern whale migration season. Well is not located within main migration path.
R3	Drilling fluids (WMB and SMB)	Drilling fluids are a by-product of drilling operations. Reinjection of drill cuttings is not feasible at this location. Residual water based mud will be discharged directly to ocean on completion of drilling program.	Dispersion of fluid will be rapid in open ocean. Drilling is of short duration and turbidity plume will dissipate rapidly. Limited and short term damage expected to water column and seabed.	• Solids control equipment will be optimised to ensure maximum separation of fluid from cuttings and minimum loss of fluid during drilling.	Expected to occur	Minor	B	

Risk ID	Hazard	Causes	Potential Environmental Impact	Existing controls	Likelihood	Consequence	Risk Ranking	Comments

R4	Drill cuttings	Generation of coarse to fine rock and sand chips cut out of formation by drill bit. Estimate $148m^3$ (dry hole) – $177m^3$ (completed hole).	Potential for smothering biota, change in the particle size, minor heavy metal contamination. Dispersion of cuttings will be rapid in open ocean conditions. Rapid recovery of benthos.	Cuttings to be treated in solids control equipment prior to discharge.	Expected to occur	Minor	B	Discharge to seabed via a pipe to minimise dispersion and turbidity during drilling.
R5	Cooling water	Diesel fuelled power generators discharge water at a temperature slightly above ambient seawater (~3 ^{o}C).	Localised small increase in water temperature.	Water will be discharged at barge level (~15m above sea level) to facilitate cooling and oxygenation.	Expected to occur	Negligible	Negligible	
R6	Oil contaminated drainage water	Deck drainage water directed overboard under routine conditions.	Potential for localised impact on water quality. Discharge will have very low concentration of hydrocarbons, which will evaporate and dissipate very rapidly.	Good housekeeping practices keep decks clean.	Expected to occur	Negligible	Negligible	

Risk ID	Hazard	Causes	Potential Environmental Impact	Existing controls	Likelihood	Consequence	Risk Ranking	Comments
R7	Galley wastes - rig and support vessels	Generation of kitchen wastes (putrescible and burnable wastes) Putrescibles on rig are bagged and returned to shore for disposal	Contribution to landfill	Separation of putrescible wastes from solids (i.e. tins cans) by using clearly marked bins in the galley.	Expected to occur	Negligible	Negligible	Support vessels abide by MARPOL regulations
R8	Sewage, grey water - rig and support vessels	By-product of human habitation. Wastes (approx. 12,000 L per day on rig) will contain biodegradable dishwashing detergent, and soap.	Potential for localised impact on water quality. Detergents will break down rapidly and dilution will ensure eutrophication will not occur.	• Biodegradable soaps to be used on the rig. • Sewage will be treated via the sewage treatment plant and discharged above sea level. • Sewage treatment plant to be maintained to ensure effective treatment.	Expected to occur	Negligible	Negligible	Support vessels abide by MARPOL regulations
R9	Waste oil	Hydraulic and lubricating oils are required for machinery. Used oil will be contained in drums and returned to mainland for recycling.	Potential for localised impact on water quality. Small volumes would disperse and weather rapidly.	Drums containing oil will be stored within a bunded area on the rig until transported to the mainland for recycling as per Apache guidelines.	Unlikely to occur	Negligible	Negligible	

Risk ID	Hazard	Causes	Potential Environmental Impact	Existing controls	Likelihood	Consequence	Risk Ranking	Comments
R10	Solid wastes	By-products of drilling activities such as paper, wood, steel, and drums. Disposal via landfill or recycling.	Contribution to landfill if not recycled.	Waste will be segregated on the rig into clearly marked skips for appropriate waste disposal method.	Expected to occur	Negligible	Negligible	
R11	Pipe dope	Pipe dope is used as a sealant, lubricant, and for cleaning of pipestring. Contains heavy metals and grease. Approx. 75 L per well. Pipe dope is amalgamated with the drill fluid and retained on drill cuttings and dispersed in open ocean conditions.	Localised impact on water quality. Will disperse in open ocean conditions.	Use pipe dope that has lowest concentration of heavy metals and hydrocarbons, is biodegradable, but still meets safety and performance criteria.	Expected to occur	Minor	B	
R12	Fishing	Workforce fishing from rig or supply vessels.	Removal of marine fauna.	No fishing is allowed from the drilling rig production unit or supply vessels.	Rare	Negligible	Negligible	

Risk ID	Hazard	Causes	Potential Environmental Impact	Existing controls	Likelihood	Consequence	Risk Ranking	Comments
R13	Atmospheric emissions	Combustion of fuel in fuel burning equipment.	Combustion products to atmosphere. Generation of black smoke during operational upsets. Contribute small amount to total greenhouse loading in atmosphere.	• Engines will be tuned to run at the most efficient capacity to minimise volume of emissions.	Expected to occur	Negligible	Negligible	
R14	Anchoring of support vessels	Lowering of anchor onto seabed floor	Damage to seabed structures and disturbance to seabed	Use site survey data to identify sea bed features to be avoided by anchors.	Expected to occur	Negligible	Negligible	
R15	Noise	Noise from drilling activities, machinery, helicopters and boat engines	Potential disturbance animals such as birds.	Drilling duration at each location short, great distance to land.	Expected to occur	Negligible	Negligible	

6.0 ENVIRONMENTAL ANALYSIS OF POTENTIAL IMPACT FROM ACCIDENTAL DISCHARGES

6.1 Sources of Spills

The sources of potential spillage from exploration and appraisal drilling are summarized in Table 10. The main potential spill sources are:

- leakage or spillage of diesel or lubricating oil from engines;
- leakage or spillage from the diesel transfer hose;
- leakage of chemicals from drums stored on the drilling rig;
- accidental discharge of drilling fluid from the shakers or transfer hoses;
- rupture of a fuel tank; and
- uncontrolled discharge at surface due to loss of control of a well.

The discharge of main concern is accidental spillage of oil and the potential sources that may give rise to the largest spills are listed in Table10 and are discussed below.

Refuelling

Spills of diesel fuel during refuelling can be caused by hose breaks, coupling failures or tank overfilling, and generally involve volumes less than 2,500L. Quantities are minimised by prompt shutdown of pumps by automatic safety valves.

In order to minimise the risk of spillage, a refuelling procedure has been developed (Appendix 3) which includes the following measures:

- the transfer hoses will be fitted with ‘dry’ couplings;
- a vacuum breaking system will be in place to drain the fuel left in the hose after completing the transfer, back to the supply vessel tanks;
- drip trays will be provided beneath the refuelling hose connections on the supply vessel and the rig;
- refuelling will occur only at times when sea conditions are sufficiently calm for there to be minimal risk to the transfer lines;
- crew of both the rig and the workboat will stay in continuous contact during the whole of the operation via handheld radios and will actively monitor the operation for its entire duration; and
- suitable absorbent material will be held on the supply vessel and the rig to mop up any small spills.

Well control

Extensive training, procedures and equipment are in place to maintain well control and prevent blowouts. Blowouts would not only impact the environment, but could also result in loss of life and property.

During drilling, kicks can occur. A kick is defined as a flow of formation fluids or gas into the well bore. If the pressure within the formation being drilled is greater than the hydrostatic pressure of the drilling fluid acting on the well bore, an influx of formation fluids (oil, gas, water) into the well bore can occur. The severity of the kick will depend on the porosity and permeability of the formation (i.e. how it allows fluid to flow through it), and the difference between the formation pressure and drilling fluid pressure.

A blowout is an uncontrolled kick and can take place at the surface or underground between two separate permeable bodies of rocks (formations). Kicks are prevented by maintaining the correct density of the drilling fluid down the well bore. This is achieved by adjusting the concentration of various components of the drilling fluid so that the fluid hydrostatic pressure is greater than the formation pressure.

There are a number of warning signs which indicate that a kick is taking place. These include an increase in drilling fluid flow rate, an increase in the drilling bit penetration rate (indicating a change in the type of rock being drilled) and the presence of gas bubbles in the returned drilling fluid. If one or more warning signs of a kick are observed, steps are taken to check for flow from the well and the well is immediately shut-in. The well can then be easily brought under control by adjusting the density and weight of the drilling fluid.

Any wells drilled to intersect a reservoir can be controlled utilizing properly weighted drilling fluids. Drilling fluids, along with use of up-to-date drilling equipment, and regulated “best practice” drilling practices, ensures that the risk of a blowout is very small.

The requirements associated with any drilling program include detailed procedures for all drilling activities, blowout prevention equipment maintenance, regular (minimum weekly) blowout prevention drills and table-top oil spill exercises.

6.2 Real Time Modelling of Oil Spills

The modelling system forms part of Apache’s oil spill response system. Should a spill occur, the model would be run in conjunction with field surveillance to predict the trajectory and fate of spilled hydrocarbons thereby providing forewarning of the habitats that may be affected.

6.3 Oil Spill Response Actions and Strategies

An accidental spillage of hydrocarbons may occur during operations. Emergency response manuals have been prepared and the relevant documents are shown in Table 12.

Should an oil spill occur, Apache would immediately take the following actions:

- Follow procedures to protect human life and equipment. Implement procedures to reduce the risk of fire or explosion.
- Cut of the supply to the spillage.
- Identify the extent of spillage and the weather/current conditions in the area.
- Implement offshore and onshore actions for oil spill tracking, dispersion, containment, collection, treatment and clean-up as appropriate.
- Response actions will be coordinated in accordance with the three tiers of Oil Spill Control depending on the size of the spill, the proximity to environmentally sensitive areas and the resources available to control the spill. Response team members and responsibilities are set out in the Oil Spill Contingency Plan.
- If an oil slick is likely to reach a shoreline, advise fisheries and pearling companies, and wildlife agencies. Advise appropriate agencies to assume responsibility for wildlife rehabilitation activities.
- Monitor affected shoreline and intertidal zones to determine environmental effects of spill impact and clean up operations.

Response strategies to spillage include the following principal options:

- Take no action other than surveillance.
- Combat the slick at sea.
- Shoreline deflection and/or clean-up.

The implementation of a strategy or combination of strategies is dependent upon physical conditions prevalent at the time. The speed and direction of winds and currents, general sea conditions and the type of oil spilt will determine which option or combination of options is suitable.

Containment and recovery, and shoreline deflection and/or clean-up will be used in the event that the oil approaches or reaches sensitive resources.

Table 10: Environmental effects, risk and prevention of accidental fluid discharge into the sea.

Risk ID	Hazard	Causes	Potential Environmental Impact	Existing controls	Likelihood	Consequence	Risk Ranking	Comments
NR1	Leakage from engines or machinery	Engine oil, hydraulic fluid and diesel, 20 – 50L	Localised impact on water quality. Containment on rig, therefore unlikely to reach ocean. Should small amounts of hydrocarbon reach the environment, it would dissipate and evaporate very quickly.	• Drip trays and sumps placed under all engines. • Oil collected in deck sump, emptied on regular basis and stored in containment tank prior to shipping to shore. • Deck drainage system can be routed to containment tanks in event of spill. • daily inspections.	Probably will occur	Negligible	Negligible	
NR2	Spillage or leakage of drilling fluid from transfer hose.	Drilling fluid, 2,000L (13 bbls)	Fluid would cause short term turbidity but would disperse rapidly. Smothering unlikely due to dispersion.	• continuous fluid volume monitoring using computer systems which can detect change of less than 800 L fluid change. • visual monitoring and continual maintenance of system. • mud tanks area bunded. • master valve of mud pits padlocked at all times. • rig floor sealed, not open to marine environment. •Only dry materials for water based fluid passed from support vessel to the rig. Fluid is mixed in bulk tanks located within the hull of the drilling rig.	May occur	Negligible	Negligible	

Risk ID	Hazard	Causes	Potential Environmental Impact	Existing controls	Likelihood	Consequence	Risk Ranking	Comments
NR3	Spillage of chemicals from drums.	Light oils, treatment chemicals, 1,500 L	Localised impact on water quality. Spills should be contained within bunded areas, or if on decks, then deck drain system can be directed to containment tanks.	• Quantity on rig small. • Drums are stored on pallets and in bunded areas away from open grates wherever possible. Injection chemicals placed on skids.	May occur	Negligible	Negligible	
NR4	Leakage or spillage of diesel from transfer hose. (refuelling accident)	Diesel, 2,500 L,(15 bbls)	Impact on water quality. Sensitive habitats distant, chance of reaching shorelines is very low.	• Detailed refuelling procedures developed and followed. • Refuelling only during suitable weather and sea-state conditions. • refuelling only to occur at the discretion of the skipper of the vessel and master of the rig. • hose and couplings checked for integrity prior to refuelling. • oil spill contingency plan (OSCP) approved by the DMPR. • OSCP has strategies for managing a spill. • oil spill model used for spill predictions.	May occur	Negligible	Negligible	Modelling of a 2,500L diesel spill indicated a very low chance of the spill coming into contact with a shoreline during summer conditions. In winter conditions, the spill drifted northwest to southwest with the possibility of shoreline contact. Under transitional conditions the majority of the spill trajectories headed north-northeast away from land.

Risk ID	Hazard	Causes	Potential Environmental Impact	Existing controls	Likelihood	Consequence	Risk Ranking	Comments
NR5	Rupture of drilling rig fuel tank or support vessel fuel tank due to impact.	Diesel, 80,000 L (503 bbls)	Sensitive habitats distant, chance of reaching shorelines is very low. Some risk of fire.	• Fuel tanks are located above the surface of the water and are contained within the hull of the rig. • hull of drilling rig is double skinned. • fuel tanks also protected by ballast tanks. • radio contact between rig and supply vessel at all times. • support vessel stands away crane arm distance from rig during offloading and onloading. • work near drilling unit only in suitable seastate - to the discretion of the skipper of the vessel and master of the rig. • weather forecasts sent directly to the rig by the met bureau twice a day. Can be increased to hourly basis in emergencies. • oil spill contingency plan (OSCP) approved by the DMPR.	Rare	Moderate	Negligible	Modelling of an 80,000L diesel spill indicated a very low chance of the spill coming into contact with a shoreline during summer conditions. In winter conditions, the spill drifted northwest to southwest with the possibility of shoreline contact, particularly Montebello's, Lowendal's and Barrow Island. Under transitional conditions the majority of the spill headed north-northeast away from land, with low probability of land contact.

Risk ID	Hazard	Causes	Potential Environmental Impact	Existing controls	Likelihood	Consequence	Risk Ranking	Comments
NR6	Blow-out during drilling	Moderately heavy to light weight crude oil, 600,000 L (36,000 bbls)	Sensitive habitats distant, chance of reaching shorelines is very low. Could impact the marine resources if winds and currents carry the oil towards the shallow marine areas adjacent to the mainland. Oil will be weathered.	• Automatic shut-down system. • International, National and State applications to be complied with. • all management procedures specified in Vessel Safety Case which must be approved by DMPR. • only trained, certified personnel used on rig floor. • four blow-out preventors (BOPs) used. • routine pressure testing of BOPs and casing to legislative standards. • utilize drilling fluid weight designed to known reservoir pressure. • oil spill contingency plan (OSCP) approved by the DMPR.	Rare	Significant	B	Modelling of an 600,000L crude spill indicated a very low chance of the spill coming into contact with a shoreline during summer conditions. In winter conditions, the spill drifted northwest to southwest with the possibility of shoreline contact, particularly Montebello's, Lowendal's and Barrow Island. Modelling indicated that up to 17% of the initial spill could contact a shoreline. Under transitional conditions the majority of the spill headed north-northeast away from land, with less than 6% probability of land contact

7.0 ENVIRONMENTAL IMPLEMENTATION STRATEGY

The objectives of this Environmental Plan are:

- to achieve and demonstrate sound environmental practice at the level of international best practice by managing all activities of the drilling program which may have an impact on the natural environment; or

- where an impact is unavoidable, minimise, ameliorate and manage the damage.

In accordance with these objectives, the following components will be used for the management of the drilling programs for Endymion-1. These components comprise the implementation strategy.

- Key roles, responsibility and environmental policy

Addresses the top down commitment and responsibilities, and that the policy is in place to ensure the protection of the environment.

- Legislation, conditions and commitments

Identifies relevant legislation, conditions and commitments applicable to the environmental aspects of the program.

- Environmental risk assessment

Identifies the potential environmental risks and hazards for the program (refer to sections 5 and 6).

- Routine operations and emergency response procedures

Generates risk reduction measures including asset integrity inspections, work instructions, procedures and emergency response plans.

- Performance objectives, standards and criteria

Defines the environmental performance objectives, standards and criteria that need to be met to ensure environmental protection.

- Communication and education

Ensures the knowledge, acknowledgment and advice of the environmental conditions and surrounding resources to the workforce and the community.

- Incident reporting, recording and reporting, and audits

Ensures the reporting and investigation of environmental incidents and reporting requirements, and is used as a basis for continual improvement. Addresses the assessment of performance and compliance.

At a broad scale, the program will be managed to comply with the Apache Environmental Policy, which is given in Appendix 4.

7.1 Key Roles, Responsibilities and Environmental Policy

It is important that the responsibilities of Apache personnel and relevant contractors are understood and followed during all operations. The key roles for ensuring the protection of the environment and associated responsibilities for each role are listed below.

Managing Director

- Ensure compliance with the environmental policy.
- Assume responsibility for providing adequate resources for environmental management.
- Implement an emergency response strategy in the case of an incident.
- Maintain communication with company personnel, government agencies and the media.

Operations Manager

- Ensure compliance with the Apache's Environmental Policy.
- Ensure overall compliance with the Environmental Plan with advice and guidance from the Drilling Manager, the MODU Person in Charge and the Environmental Manager.
- Report environmental incidents to the Environmental Manager.
- Assist the Managing Director in the development of a response strategy in the event of a spill incident.

Drilling Manager

- Ensure overall compliance with the Environment Plan with advice and guidance from the Senior Drilling Engineer and Environmental Manager.
- Report environmental incidents to the Environmental Manager.
- Assist the Operations Manager in the development of a response strategy in the event of a spill incident.

Senior Drilling Engineer

- Ensure compliance to all relevant environmental legislative requirements, commitments, conditions and procedures as given in this Environment Plan.
- Maintain clear communication with the Drilling Supervisor.
- Report environmental incidents to the Drilling Manager and ensure follow-up actions are carried out.
- Assist the Drilling Manager and Drilling Supervisor in the event of an oil spill incident.
- Ensure follow-up actions from environmental audits have been carried out.

MODU Person in Charge

- Implement and ensure compliance to all relevant environmental legislative requirements, commitments, conditions and procedures as given is this Environment Plan.
- Communicate hazards and risks to the workforce and their implications, and the importance or following good work practices.
- Apply appropriate enforcement mechanisms to prevent breaches of the Environment Plan.
- Develop a response plan in the event of an incident in close liaison with the Apache Drilling Supervisor.

- Carry out follow-up actions from environmental audits.

Apache Drilling Supervisor

- Monitor that the relevant environmental legislative requirements, commitments, conditions and procedures are being followed on the drilling rig and support vessels.
- Maintain clear communication between the company and the drilling contractor on environmental issues.
- Report environmental incidents and ensures follow-up actions.

Environmental Manager

- Liase with the Drilling Manager and Senior Drilling Engineer to ensure compliance to legislation, procedures, standards and commitments.
- Carry out environmental education and inductions.
- Participate in the oil spill response strategy.
- Develop and implement a relevant environmental monitoring program.
- Conduct environmental audits of the drilling rig to ensure compliance.

Masters of Support Vessels

- Implement and ensure adherence to all relevant environmental legislative requirements, commitments, conditions and procedures on-board the vessel.
- Maintain clear communication with the crew.
- Communicate hazards and risks to the workforce and their implications, and the importance or following good work practices.
- Maintain the vessels in a state of preparedness for emergency response.
- Report environmental incidents to the MODU Person in Charge and ensure follow-up actions are carried out.
- Apply appropriate enforcement mechanisms to prevent breaches of the Environment Plan.

Apache personnel and contractors / Crew of support vessels

- Apply this management plan in letter and in spirit.
- Follow good housekeeping procedures and work practices.
- Encourage improvement wherever possible.
- Report incidents to the MODU Person in Charge or the Drilling Supervisor.

7.2 Legislation, Condition and Commitments

The Endymion-1 well site is located in State waters and is controlled by the *Petroleum (Submerged Lands) Act 1982*. The Act is administered by the Western Australian (WA) Minister for Mines, advised by the WA Department of Minerals and Petroleum Resources.

The principal State legislative requirements that are relevant to the well are summarised below:

State Environmental Legislation

- *Petroleum (Submerged Lands) Act 1982*; also known as P(SL)A 1982
- *P(SL) Act Schedule Specific Requirements as to Offshore Petroleum Exploration and Production 1995* (regulates both State and Commonwealth activities)
- *Environmental Protection Act 1986*
- *Conservation and Land Management Act 1984*
- *Fish Resources Management Act 1994*
- *Wildlife Conservation Act 1950-1980*
- *Pollution of Waters by Oil and Noxious Substances Act 1987*
- *Prevention of Pollution of Water by Oil Act 1960*

Petroleum (Submerged Lands) Act 1982

The *P(SL)A Schedule Specific Requirements as to Offshore Petroleum Exploration and Production 1995* clauses applicable to Endymion-1 are listed below:

Emergency Response Manuals, Clause 202:
Operations shall not be carried out without an Emergency Response Manual, approved by MPR which sets out procedures for emergencies including the escape or ignition of petroleum.

Oil spills, Clause 220:
Take action as necessary to minimize the loss of petroleum and the pollution of the area… shall be taken.

No chemical dispersants shall be used on oil spills without approval.

Housekeeping, Clause 222:
(1) Decks and floors of a platform shall be kept clean and free of oil and grease.
(2) Adequate storage space for tools and equipment shall be provided on a platform.
(3) No waste materials other than other than food scraps, sanitary effluents, drilling fluid or formation water conforming tot he requirements of sub clause 616(6) shall be released into the sea.
(4) Food scraps, and from 1 January 1992, sanitary effluents may only be released into the sea where a platform is located more than 12nm from land and after the material has passed through a comminuter or grinder such that the material to be released is capable of passing through a screen with openings no greater than 25mm.
(5) Waste materials other than the waste materials which by sub-clause (3) may be released into the sea shall be stored on the platform in suitable metal containers or in some other approved way and returned to shore for disposal.
(6) Adequate space shall be provided around equipment on a platform to ensure safe

working conditions.
(7) Drum stocks of fuel or lubricating oil on a platform shall be stored as far as reasonably practicably possible from areas where drilling operations are being carried out.
(8) Gas cylinders on a platform shall be properly secured.
(9) Liquefied gas cylinders on a platform shall be in an upright position.
(10) No flammable liquids with a flashpoint below 38degC shall be kept on a platform without approval.
(11) The stairways and walkways of a platform shall be kept free from obstruction.

Reporting escape or ignition of petroleum or other material, Clause 285:
(1)Report forthwith to an inspector of:
- (a) oil in water >50mg/l
- (b) 80L or greater of oil
- (c) uncontrolled escape of petroleum or other flammable or combustible material.

(2) A report in writing of any occurrence referred to in subclause (1) shall be submitted to the Director as soon as practicable after the occurrence specifying –
- (a) the date, time and place of the occurrence
- (b) the quantity or approximate quantity of liquid that escaped or burned
- (c) particulars of damage caused by the escape or ignition
- (d) the events so far as they are known or suspected that caused or contributed to the escape or ignition
- (e) particulars of methods used to control the escape or ignition
- (f) particulars of methods used or proposed to be used to repair property damaged by the escape or ignition; and
- (g) measures taken or to be taken to prevent a possible recurrence of the escape or ignition.

Approval to Flare, Clause 615:
Except in an emergency, the flaring or venting of petroleum shall not be carried out without approval.

Pollution, Clause 616:
(1) Every reasonably precaution shall be taken to avoid pollution of the environment.
(2) Waste gas from vents and pressure vessels shall be disposed of using safe methods.
(3) Subject to sub-clause (6) the flow into the sea of crude oil, oil sludge or an emulsion of petroleum and water, shall be prevented.

Commonwealth Environmental Legislation

Environment Protection and Biodiversity Conservation Act 1999

Under this legislation all activities that will, or have the potential to, affect matters of "National Environmental Significance" are prohibited except; when undertaken in accordance with approval by the Minister for Environment, or when approved through a Bilateral Agreement with a State or Territory, or when approved through a process accredited by the Minister. Matters of "National Environmental Significance" are;

- World Heritage Areas;
- Wetlands Of International Importance;
- Listed Threatened Species And Communities;
- Listed Migratory Species;
- Nuclear Actions; and
- Commonwealth Marine Areas.

Endymion-1 was not referred to Environment Australia as there were no impacts that may affect matters of National Environmental Significance.

Other commonwealth legislation includes:

- *Australian Heritage Commission Act 1975*
- *Historic Shipwrecks Act 1976*
- *Wildlife Protection (Regulation of Exports and Imports) Act 1982*
- *Hazardous Waste (Regulation of Exports and Imports) Act 1989*
- *Ozone Protection Act 1989*
- *Navigation Act 1912*
- *Protection of the Sea (Civil Liability) Act 1981*
- *Protection of the Sea (Oil Pollution Compensation Fund) Act 1993*
- *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*
- *Protection of the Sea (Powers of Intervention) Act 1981*

International Environmental Legislation

In addition to relevant legislation and regulations, Australia is signatory to a number of international conventions and agreements which oblige the Commonwealth government to take various actions to prevent pollution and to protect specified habitats, flora and fauna. Those which are relevant to the drilling of Endymion-1 are listed below.

- Climate Change Convention (1992)
- Vienna Convention on the Protection of the Ozone Layer and the Montreal Protocol; on Substances that Deplete the Ozone Layer (1987)
- Convention On Biological Diversity (1992)
- Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention) (1979)
- Bilateral Agreements on the Protection of Migratory Birds
- UN Convention on the Law of the Sea (1982)
- London (Dumping) Convention (1972)
- International Convention for the Protection of Pollution from Ships (1973) and Protocol (1978)
- International Convention on Oil Pollution Preparedness, Response and Co-operation (1990)
- International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties (1969)

- International Convention on Civil Liability for Oil Pollution Damage (1969)

Industry and Corporate Codes of Practice
The petroleum exploration and production industry operates within an industry code of practice (APPEA Code of Environmental Practice). Apache also has its own corporate performance standards and criteria that must be met internally. These industry and corporate standards provide guidelines for activities that are not formally regulated and have evolved from the collective knowledge and experience of the oil and gas industry both nationally and internationally.

Apaches Environmental Policy (Appendix 4) provides broad guidelines for the environmental responsibilities of all company personnel and the conduct of company activities.

7.3 Routine Operations and Emergency Response Procedures

The major environmental risks associated with the drilling program have been identified in the detailed risk assessment given in sections 5 and 6.

Routine Operations

The Drilling Supervisor, MODU Person in Charge, and Masters of the support vessels are responsible for ensuring that all procedures are available to personnel and that the procedures are carried out properly. The relevant procedures, commitments and guidelines are given in Table 11.

Table 11 Standard Operating Guidelines and Procedures pertinent to environmental management.

Procedure or Guideline	Document Number	Location
Refuelling Management Plan	DR-91-IG-001 (see Appendix 3)	Drilling rig and support vessels
Apache Environmental Guidelines: Oil spills Waste management Conservation	Appendix 5	Drilling rig
Whale Watching Procedure	Appendix 6	Drilling rig
Turtle Observation Sheet	Appendix 7	Drilling rig
Incident reporting procedure	AE-91-IF-002	Drilling rig
Summary of Environmental Commitments	Appendix 5	Drilling rig

In addition to the above, the rig may also develop its own job specific work procedures that address environmental management issues.

Emergency Response

An accidental spillage of hydrocarbons may occur during the drilling program. Emergency response manuals have been prepared. The relevant guidelines and documents are shown in Table 12.

Table 12 Emergency response guidelines and manuals

Document Title	Document Number
NWS Oil Spill Contingency Plans	AE-00-EF-008/1Vol 1Operations AE-00-EF-008/1 Vol 2 Environment
Emergency Response Management Manual	AE-00-ZF-025
Emergency Response Plan (MODU Operations North West Shelf Area)	AE-00-ZF-024
NWS Operations consolidated Cyclone Response Plan	AE-91-IF-010
Oil spill guidelines	Appendix 5
Incident Reporting Procedure	AE-91-IF-002

These documents will be held on the drilling rig and will be accessible to all personnel.

7.4 Performance Objectives, Standards and Criteria

The environmental performance of the drilling program can be measured, benchmarked and reported by the development of Environmental Performance standards. These standards are objective and verifiable data that are measured, calculated or estimated providing Apache with the means of:

- demonstrating compliance with regulatory requirements and standards;
- performing against assessment criteria; and
- achieving and demonstrating best practice and continual improvement to the regulators and public.

The environmental performance, objectives, standards and criteria for Endymion-1 are listed in Table 13. They are compiled from the environmental risk assessment and include environmental discharges or actions that:

- have a risk ranking of B or greater;
- result in the discharge of a volume of 100 L (or cubic meters) or more into the ocean; or
- have a documented regulatory, industry or company guideline or standard.

Table 13 Objective, Standards and Criteria

Environmental hazard or aspect (Risk Assessment matrix number, Tables 9 and 10)	Performance Objective	Standards and Procedures	Criteria
Disposal of drilling fluid and drilling cuttings (R3, R4, NR 2)	Minimise the volume of drilling fluid being discharged into the ocean.	Record drilling fluid usage	Rig PIC to record volume of drilling fluid disposed into the ocean, as m^3 per well. Results to be reported to the Environmental Manager at the end of the well.
Cooling water (R5)	Minimise elevation of water temperature above ambient levels.	ANZECC water quality guidelines for protection of aquatic ecosystems, <2°C above ambient.	Audit shows water being discharged at barge level (allows for cooling and oxygenation as it falls to sea level)
Oil in water levels (R6, NR1)	Avoid and minimise impact on water quality.	• MARPOL limit of 15ppm on all water discharged from oily water slops tanks or bilges • P(SL)A Clause 222 (1) decks and floors of a platform shall be kept clean and free from oil and grease • P(SL)A Clause 285 (1) (a) any release of oily water with >50mg/L oil in water is to be reported to DMPR. • P(SL)A Subreg (26) Report incidents within 2 hours • P(SL)A Clause 616 (1) & (3) Pollution	Audit shows: • if oily water separator is used, the 15 ppm limits are being met. • good housekeeping being maintained • all releases of oil in water of greater than 50mg/l has been reported. • Spills are reported through Apache incident reporting system

Environmental hazard or aspect (Risk Assessment matrix number, Tables 9 and 10)	Performance Objective	Standards and Procedures	Criteria
Pipe Dope (R11)	Avoid and minimise impact on water quality.	• Apache environmental guidelines is to use pipe dope that has lowest concentration of heavy metals and hydrocarbons, is biodegradable, but still meets safety and performance criteria. • Record Pipe dope usage	Rig PIC to record volume of pipe dope used on location. Results to be reported to the Environmental Manager at the end of the well.
Spillage of diesel fuel (during refuelling from transfer hoses or on board tanks, or rupture of rig or support vessel fuel tank) (NR5, NR4, NR5)	Prevent spills of diesel during transfers	• P(SL)A Subreg (26) Report incidents within 2 hours • P(SL)A Clause 220 Oil Spills • P(SL)A Clause 285 (1) (b) all spills >80L to be reported to the DMPR • P(SL)A Clause 616 (1) & (3) Pollution • Apache Refuelling Management Procedures • Apache OSP Volumes 1 & 2 • Apache incident reporting system	Audit shows: • compliance with company refuelling procedures • OSCP in place and approved by DMPR • all actions taken to control an oil spill were taken and dispersant use was not initiated without DMPR approval • spills >80L reported to DMPR and Apache within 2 hours of occurrence. • Spills <80L reported through Apache incident reporting system

Environmental hazard or aspect (Risk Assessment matrix number, Tables 9 and 10)	Performance Objective	Standards and Procedures	Criteria
Oil spill (crude) from blowout. (NR6)	Prevent crude oil spills into the ocean from a blowout. Minimise negative effects on water quality.	• Drilling program to meet DMPR drilling standards. • Apache OSCP Vol 1 & 2. • P(SL)A Clause 220 Oil Spills • Apache to hold a valid Certificate of Currency of Insurance • P(SL)A Clause 285 (1) (b) all spills >80L to be reported to the DMPR • P(SL)A Subreg (26) Report incident within 2 hours • P(SL)A Clause 616 (1) & (3) Pollution • Apache incident reporting system	Audit shows: • DMPR Application to Drill approved • Approval of OSCP by DMPR • Annual exercise of the OSCP • Compliance with P(SL)A Clauses 220, 285 & 616. • a Certificate of Currency of Insurance for the well • spills >80L reported within 2 hours of occurrence. • Spills <80L reported through Apache incident reporting system
Chemical spill (NR3)	Prevent chemical spills from entering the ocean, minimise negative effects on water quality	• P(SL)A Clause 222 (1) Housekeeping, clean decks • Apache environmental guidelines on good housekeeping • Apache contractor guidelines • Appropriate bunding around chemical storage area • No breaches in chemical container integrity	Audit shows: • chemicals stored in bunded area and chemical containers intact • all chemical spills >20L reported to Apache Perth Office • chemical spills cleaned up according to Apache environmental guidelines • absorbent material is on board to use in soaking up chemical or oil spills.

Environmental hazard or aspect (Risk Assessment matrix number, Tables 9 and 10)	Performance Objective	Standards and Procedures	Criteria
Discharge of combustion products from engines (R13)	Minimise GHG emissions	Federal GHG Challenge Reporting requirements	Audit shows: • greenhouse gas emissions data reported to Federal Govt by the Environmental Manager annually. • inspections and tuning of engines and equipment are included on a regular maintenance schedule.
Solid waste management (R10)	Minimise waste volumes. Avoid and minimise negative effects on water quality. Ensure responsible containment and disposal of wastes.	• P(SL)A Clause 222(4) storage of rubbish. • Apache environmental policy to reduce, reuse and recycle. • Apache environmental guidelines • Industrial waste disposed at appropriate disposal sites	Audit shows: • compliance with PSLA Clause 222 and Apache environmental guidelines • records of the volume and type of waste taken off rig are collated by the rig PIC and forwarded to the Environmental Manager at the end of each well. • ROV survey to check no rubbish left on seabed. Any debris will be removed.

Environmental hazard or aspect (Risk Assessment matrix number, Tables 9 and 10)	Performance Objective	Standards and Procedures	Criteria
Waste Oil Management (R9)	Manage waste oils to prevent discharge to the sea	Apache environmental guidelines	• Audit shows compliance with guidelines for waste oil handling and management. • Records of volume of waste oil taken off rig forwarded to the Environmental Manager at the end of each well.
Handling and disposal of kitchen wastes (R7)	Avoid and minimise negative effects on water quality.	P(SL)A Clause 222 (4), Food scraps are not to be disposed overboard at all within 12nm of land.	Audit shows food wastes are disposed in compliance with P(SL)A clause 224 (4)
Sewage / organic waste discharge (R8)	Avoid / minimise impact on water quality	PSLA Clause 222 (4) treated sewage	Audit shows sewage is treated to tertiary level prior to discharge.

Environmental hazard or aspect (Risk Assessment matrix number, Tables 9 and 10)	Performance Objective	Standards and Procedures	Criteria
Environmental Audit	Ensure compliance with audit schedule requirements	Apache commitment drilling rig to be audited every six months whilst under contract to Apache Energy	Audit shows two audit reports per year.
Operational Environmental Awareness	All personnel involved in the drilling program to be aware of the environmental sensitivities and requirements of the well	Endymion-1 EP On site EH&S induction required for all visitors, biannual induction for all crew members.	Audit shows: • personnel are familiar with the environmental requirements of the EP and all guidelines and procedures outlined are being followed. • all personnel have signed off the rig register book confirming their induction.
Incident Reporting	Report any incidents which may potentially impact the environment	Apache incident reporting system P(SL)A Subreg (26) Report incident within 2 hours	Audit shows Environmental Manager is receiving incident reports.
Megafauna Observations	Collate data on the presence and behaviour of whales and sea turtles in the vicinity of the rig.	Whale watching procedures Sea turtle observation sheet.	Audit shows observation data sheets are compiled and forwarded to the Environmental Manager for each well.

7.5 Communication and Education

Communication

A consultation program is not planned for this specific well. However, Apache consults regularly with the community in relation to its activities.

Copies of this Environmental Plan will be distributed to the following organisations:

Department of Minerals and Petroleum Resources
Department of Environmental Protection
Department of Conservation and Land Management
Western Australian Fisheries Industry Council (WAFIC)

The covering letter for the EP will provide contact details in the event that any of the organisations have questions about the drilling program.

Education

Qualified members of staff (e.g. rig PIC / medic / safety officer) will give personnel and contractors involved in the drilling program an environmental induction. The topics covered will include:

- an overview of this Plan;
- regulatory and procedural requirements;
- environmental policy principles;
- environmental resources at risk; and
- environmental procedures to be used.

Issues Covered at an Induction

Resource Sensitivity

- Resource maps to be put up on the drilling rig.
- Sensitive resources located nearby. These resources include islands, corals and shallow water shoals.
- Islands important for turtle breeding - four species breed on the beaches, the Hawksbill is listed as an endangered species.
- Numerous animals are found in the open water environment - dolphins, whales, seabirds, and turtles.
- Oil can be devastating to marine life. Must avoid any sort of spillage.

Pertinent Legislation

- Everyone must be aware of the legislation that pertains to the development program and where these acts can be found.
- State P(SL)A is the main legislation.
- We are working under commitments that are legally binding.
- Environmental Management Plan is legally binding.
- Any spillage of oil or other chemicals is reportable to Apache. Spills >80 L to DMPR within 2 hours under the P(SL)A.
- Apache Environmental Policy and Environmental Plan.
- Policy should be displayed.
- Show copy of EMP and where it can be found.
- Specific guidelines to be mentioned.
- General housekeeping to be kept to a high standard: keep decks clean of litter, rags etc.
- Nothing is to be thrown or dumped overboard.

- All precautions must be made to avoid spillage of anything into the marine environment. If oil or chemicals are spilt, they must be cleaned up immediately and the soiled clean-up materials disposed of in skips. Don't hose spillage overboard.
- All spillage >80 L must be reported to the drilling supervisor. If smaller spills reach the marine environment, these must also be reported - not to reprimand, but to ensure that procedures are checked to make sure they don't happen again.
- When using pipe doping, use the minimum amount and avoid spillage to the deck floor. Use doping with lowest concentration of heavy metals.
- Emphasise the importance of proper storage of chemicals and drums. The integrity of the drums should be checked to make sure they are not leaking. Drums of liquid must be within bunded areas.
- Put drip trays under anything that may drip oil or chemicals and clean these up on a regular basis.
- Segregate wastes into clearly marked bins/skips and recycle wherever possible. Use minimal volume of chemicals.

7.6 Incident Reporting, Recording and Reporting, and Audits

The people responsible for recording and reporting the various environmental performance standards are listed below.

Incident reporting

All environmental incidents will be reported in the first instance to the MODU Person in Charge. The Environmental Manager will record all incidents into Apache's Environmental Incidents database as per Apache's Incident Reporting Procedure (Document AE-91-IF-002). Onshore and offshore management will participate in any incident investigations.

All spills over 80L will be reported to the DMPR.

Recording and Reporting

Internal and government reporting on performance standards will be carried out by the Environmental Manager or their delegate, and distributed to the company and government on an annual basis.

Audits

The Environmental Manager (or designate) and MODU Person in Charge will carry out environmental compliance to Environmental Plans every six months. An audit of Ensco 56 was undertaken in August 2001 and February 2002.

The pro forma used for environmental audits of a drilling rig is given in Appendix 8. The Senior Drilling Engineer will be responsible for any remedial action that needs to be carried out.

8.0 GLOSSARY OF ACRONYMS

AQIS	Australian Quarantine and Inspection Service
CALM buoy	Canternary Anchor Leg Mooring buoy
DMPR	Department of Minerals & Petroleum Resources WA
DPIE	Department of Primary Industries
EP	Environment Plan
Mcf	Million cubic feet
mg/L	Milligrams per litre
OIW	Oil in water
OSCP	Oil Spill Contingency Plan
PIC	Person in Charge
PFW	Produced formation water
ppm	parts per million
PSLA	Petroleum (Submerged Lands) Act
TPH	Total petroleum hydrocarbons
WA	Western Australia
WAF	Water accommodated fraction

9.0 REFERENCES

Apache Energy (1997) Impact of Artificial Lighting on Sea Turtles. Unpublished report.

APPEA (1997). Potential arrangements for multiple use management in the Montebello Islands – Barrow Island region. A Petroleum Industry Perspective. November 1997. 80 pp.

Australian Institute of Marine Science (1998). Montebello Island Region – Biodiversity values. A report for Environment Australia.

Battelle (1998) Weathering, chemical composition and toxicity of four Western Australian crude oils. A report to Apache Energy. Project N002239. August 21 1998.

Blaber, S.J.M. & Blaber, T.G. (1980). Factors affecting the distribution of juvenile and inshore fish. *Journal of Fish Biology* 17:143-162.

Blaber S.J.M., Young J.W. and Dunning M.C. (1985). Community structure and zoogeographic affinities of the coastal fishes of the Dampier region of north-western Australia. Australian Journal of Marine and Freshwater Research, 36(2): 247-266.

Boehm P.D., A. Turton, D. Raval, D. Caudle, D. French, N. Rabalaise, R Spies and J. Johnson. 2001. Deepwater Program: Literature Review, Environmental Risks of Chemical Products used in Gulf of Mexico Oil and Gas Operations; Vol 1: Technical Report. OCS Study MMS 2001-011. US Department of the Interior, Minerals Management Service Gulf of Mexico OCS Region, New Orleans, LA 326pp.

Bowman Bishaw Gorham (1994). Dampier Port Authority, Environmental Management Plan. Report to Dampier Port Authority. June 1994.

Bowman Bishaw Gorham (1995) North West Shelf Environmental Resource Atlas Report. Prepared for BHP Petroleum Pty Ltd. February 1995.

Bowman Bishaw Gorham (2000). Survey of Environmental Impacts of Simpson-1 drilling. Report to Apache Energy Ltd, September 2000

Bryden, M., Marsh, H. and P. Shaughnessy. (1998) Dugongs, Whales, Dolphins and Seals. A guide to the sea mammals of Australasia. Allen and Unwin, Sydney. 176 pp.

CSIRO Minesite Rehabilitation Research Program (1998). An assessment of the facility lights on the drilling rig Ron Tappmeyer and the potential for mis-orientation of turtles. A report for Apache Energy. Report number H192. February 1998.

Hubbert, G.D. (1997) Ocean circulation in the region of Barrow Island, Varanus Island and the Montebello Islands on the Australian North West Shelf. Validation of the GEMS 3D Coastal Ocean Model (GCOM3D) A report for Apache Energy. July 1997.

IRC (2001). Stag Oilfield Environmental Monitoring 2000 Survey. A report for Apache Energy Limited. 17 September 2001.

IUCN (World Conservation Union) (1988) Lowendal Islands Nature Reserve,
Jenner, K.C.S, Jenner, M.N.M and McCabe, K.A (2001) Geographical and Temporal Movements of Humpback Whales in Western Australian Waters. APPEA Journal 2001 p749 – 765.

Montebello Islands and Adjacent Reefs. In Wells, S.M. (ed.) Coral Reefs of the World. Vol. 2: Indian Ocean, Red Sea and Gulf. IUCN Conservation Monitoring Centre, Cambridge , in collaboration with the United Nations Environment Programme.

Kennicutt II M.C., P.N. Boothe, T.L. Wade, S.T. Sweet, R. Rezak, F.J. Kelly, J.M. Brooks, B.J. Presely & D.A. Wiesenburg, 1996. Geochemical Patterns in Sediments Near Offshore Production Platforms. Canadian Journal of Fisheries and Aquatic Sciences 53:pp 2254-2566.

Kinhill Pty Ltd (1997). East Spar First Post-commissioning Survey Report. A report to Apache Energy. October 1997. Report EA-00-RI-9981/B

Kinhill Pty Ltd (1998). East Spar Benthic Survey. Biological Monitoring Program. A report to Apache Energy. October 1998. Report EA-66-RI-006/B

LeProvost Dames & Moore (1994) Harriet Oil and Gas Fields Development Marine Management and Monitoring Programme. Unpublished report.

LeProvost Environmental Consultants (1992) Varanus Island – Environmental Appraisal Bay Cable 2D Seismic Survey. Unpublished report.

LeProvost Environmental Consultants (1993) Harriet- Marine Management and Monitoring Programme – 7th Annual Report. Unpublished Report.

LeProvost Semeniuk & Chalmer (1986). Harriet Oilfield Marine Biological Monitoring Programme. Environmental Description, Establishment of Baseline and Collection of First Data Set. Unpublished Report to Bond Corporation Pty Ltd.

Loneragan, N.R., Kenyon, R.S., Haywood, R.S., Haywood, M.D.E. & Staples, D.A. (1994). Population dynamics of juvenile tiger prawns (*Penaus esculentus* and *P. semisulcatus*) in seagrass habitats of the Western Gulf of Carpentaria, Australia. *Marine Biology* 119:133-143.

Marine Parks and Reserves Selection Working Group (1994). A Representative Marine Reserve System for Western Australia: A report of the Marine Parks and Reserves Selection Working Group. Published by the Department of Conservation and Land Management, Perth Western Australia.

McLoughlin R. J. & Young P. C. (1985). Sedimentary provinces of the fishing grounds of the North-West Shelf of Australia: Grain-Size frequency analysis of surficial sediments. *Australian Journal of Marine and Freshwater Research* 36: 671-81.

Minerals Management Service (1992) Gulf of Mexico Sales 142 and 143: Central and Western Planning Areas Final Environmental Impact Statement. Prepared by U.S. Department of the Interior.

Neff J.M., 1987. Biological Effects of Drilling Fluids, Drill Cuttings and Produced Waters. 469-538. In D.F. Boesch & N.N. Rabalaise (eds) Long Term Environmental

Effects of Offshore Oil and Gas Developments. Elsevier Applied Science Publishers, London, 696pp.

Neff, J.M. Ostazeski, S. Gardiner, W. & Stejskal, I. (2000a). Effects of weathering on the toxicity of three offshore Australian crude oil and a diesel fuel to marine animals. *Environmental Toxicology and Chemistry* 19:1809-1821.

Neff, J.M., McKelvie, S., and Ayres, Jr R.C. (2000b) Environmental Impacts of Synthetic Based Drilling Fluids. US Department of the Interior Minerals Management Service, Gulf of Mexico OCS Region

NSR (1995). Wandoo full field development. Public Environmental Report for Ampolex Ltd, NSR Environmental Consultants Pty Ltd. November 1995.

Prince, R.I.T. (1986). Dugongs in Northern Waters of Western Australia. Department of Conservation and Land Management. Technical Series 7.

Prince, R.I.T. (1989). Dugongs: Conservation and Management. Australian Veterinary Association National Conference. Perth, 27 March – 1 April 1989.

Prince, R.I.T. (2001) Aerial survey of the distribution and abundance of dugongs and associated macroinvertebrate fauna- Pilbara Coastal and Offshore Region, W.A. Report to Environment Australia.

Robertson A.I. & Watson, G.F. (1978). Trophic relationships of the macrofauna associated with intertidal seagrass flats in Western Port Bay, Victoria. *Marine Biology* 48:207-213.

Sainsbury, K.J., Kailola, R.J. & Leyland, G.G. (1985). *Continental Shelf Fishes of Northern and Northwestern Australia.* An Illustrated Guide. John Wiley and Sons, London.

Sainsbury K.J., Campbell, R.A. and Whitlaw, A.W (1992). Effects of trawling on the marine habitat on the North West Shelf of Australia and implications for sustainable fisheries management. In: Hancock D. A. (Editor). *Sustainable Fisherie tthrough Sustaining Fish Habitat*. Canberra Australia. Australian Government Publishing Service, 1993, 137-145. Aust Soc. for Fish. Biol. Workshop, Victor Harbour, SA, 12-13 August 1992.

Sinclair Knight Merz (1996). East Spar Gas Field Long Term Environmental Monitoring Program. Pre-production survey. A report for WMC Resources, October 1996.

Sinclair Knight Merz (1997). East Spar biological monitoring program; first post-commissioning survey. A report to Apache Energy. Report H175. October 1997.

SSE (1991). Normal and extreme environmental design criteria. Campbell and Sinbad locations, and Varanus Island to Mainland Pipeline. Volume 1. Prepared for Hadson Energy Limited by Steedman Science and Engineering. Report E486. March 1991.

SSE (1993). Review of oceanography of North West Shelf and Timor Sea regions pertaining to the environmental impact of the offshore oil and gas industry. Vol I prepared for Woodside Offshore Petroleum and the APPEA Review Project of

Environmental Consequences of Development Related to the Petroleum Production in the Marine Environment: Review of Scientific Research, Report E1379, October 1993.

Standards Australia (1999) Environmental Risk Management Guide – Draft.

Swan, J.M., Neff, J.M. & Young, P.C. (1994). Environmental Implications of Offshore Oil and Gas Development in Australia - the findings of an Independent Scientific Review. Australian Petroleum Exploration Association, Canberra.

Thales Geosolutions (Australasia) Limited (2002) Endymion -1 Debris C;earance Report 31 July 2002. A report for Apache Energy Limited.

Tucker, M. (1989) Whales and Whale Watching in Australia. Australian national Parks and Wildlife Service.

Veth, P. (1993) The aboriginal occupation of the Montebello Islands, North west Australia. *Australian Aboriginal Studies* 2: 39-50.

Ward T. J. & Rainer S. F. (1988). Decapod crustaceans of the North West Shelf, a tropical continental shelf of North-western Australia. *Australian Journal of Marine and Freshwater Research* 39: 751-765.

Western Australian Museum (1993). A Survey of the Marine Fauna and Habitats or the Montebellos Islands. Berry, P. F. (ed). A Report to the Department of Conservation and Land Management.

Western Mining Corporation (1990) Five Year Offshore Drilling Programme- Consultative Environmental Review. Unpublished report.

Woodside (1990). Preliminary environmental impact assessment Report. Cossack Field Development. Woodside Offshore Petroleum Pty Ltd. September 1990.

WNI (1995). Preliminary report on ambient and non-cyclonic design criteria for the Stag location. WNI Science & Engineering. December 1995.

WNI (1996). Metocean Conditions on the North West Shelf of Australia, Cape Lambert to the North West Cape Relating to Jack-up Drilling Operation (DR-50-ED-001). July 1996.

APPENDIX

APPENDIX 1

List of species classified as threatened that occur within the region

Common name	Scientific name	THREATENED SPECIES LIST					
		National List of Threatened Species (EPBC Act)[1]	CALM Declared Threatened Fauna	ANZECC Threatened Fauna List	Bonn Convention[2]	JAMBA[3]	CAMBA[4]
FISH							
Three-keel pipefish	*Campichthys tricarinatus*	Listed marine species					
Short-bodied pipefish	*Choeroichthys brachysoma*	Listed marine species					
Cleaner pipefish	*Doryrhamphus janssi*	Listed marine species					
Ladder pipefish	*Festucalex scalaris*	Listed marine species					
Brock's pipefish	*Halicampus brocki*	Listed marine species					
Glittering pipefish	*Halicampus nitidus*	Listed marine species					
Grey nurse shark	*Carcharian taurus*	Vulnerable	Vulnerable	Vulnerable			
SEASNAKES							
	Acalyptophis peronii	Listed marine species					
	Aipysurus apraefrontalis	Listed marine species					
Duboi's seasnake	*Aipysurus duboisii*	Listed marine species					
Spine-tailed sea snake	*Aipysurus eydouxii*	Listed marine species					
	Aipysurus foliosquama	Listed marine species					
	Aipysurus fuscus	Listed marine species					
Olive sea snake	*Aipysurus laevis*	Listed marine species					
	Aipysurus tenuis	Listed marine species					
	Astrotia stokesii	Listed marine species					
	Disteira kingii	Listed marine species					
	Disteira major	Listed marine species					
	Ephalophis greyi	Listed marine species					
	Hydrophis coggeri	Listed marine species					
	Hydrophis czeblukovi	Listed marine species					
	Hydrophis elegans	Listed marine species					
	Hydrophis ornatus	Listed marine species					
Yellow-bellied sea snake	*Pelamis platurus*	Listed marine species					
TURTLES							
Loggerhead	*Caretta caretta*	Endangered	Vulnerable	Endangered	Endangered		

Common name	Scientific name	THREATENED SPECIES LIST					
		National List of Threatened Species (EPBC Act)[1]	CALM Declared Threatened Fauna	ANZECC Threatened Fauna List	Bonn Convention[2]	JAMBA[3]	CAMBA[4]
turtle					migratory species		
Green turtle	*Chelonia mydas*	Vulnerable	Taxa in need of monitoring	Vulnerable	Endangered migratory species		
Hawksbill turtle	*Eretmochelys imbricata*	Vulnerable	Taxa in need of monitoring	Vulnerable	Endangered migratory species		
Flatback turtle	*Natator depressus*	Vulnerable					
SIRENI							
Dugong	*Dugong dugon*	Listed marine species	Specially protected fauna		Migratory species subject to Agreements		
Fin whale	*Balaenoptera physalus*	Vulnerable	Vulnerable	Vulnerable			
Sei whale	*Balaenoptera borealis*	Vulnerable	Vulnerable	Vulnerable			
MAMMALS							
Humpback whale	*Magaptera novaeangliae*	Vulnerable	Vulnerable	Vulnerable	Endangered migratory species		
Indo-pacific humpback dolphin	*Sousa chinensis*		Taxa in need of monitoring				
Spinner dolphin	*Stenella longirostris*		Taxa in need of monitoring				
BIRDS							
Wedge-tailed shearwater	*Puffinus pacificus*	Listed marine species				X	
Brown booby	*Sula leucogaster*	Listed marine species				X	X
Australian pelican	*Pelecanus conspicillatus*	Listed marine species					
Lesser frigatebird	*Fregata ariel*	Listed marine species				X	
Cattle egret	*Ardea ibis*	Listed marine species					
Eastern Reef Egret	*Egretta sacra*	Listed marine species					X
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	Listed marine species					X
Brahminy kite	*Haliastur indus*	Listed marine species					
Osprey	*Pandion haliaetus*	Listed marine species			Migratory species subject to Agreements		
Peregrine falcon					Migratory species subject to Agreements		
Brown falcon					Migratory		

Common name	Scientific name	THREATENED SPECIES LIST					
		National List of Threatened Species (EPBC Act)[1]	CALM Declared Threatened Fauna	ANZECC Threatened Fauna List	Bonn Convention[2]	JAMBA[3]	CAMBA[4]
					species subject to Agreements		
Nankeen kestral	*Falco cenchroides*	Listed marine species			Migratory species subject to Agreements		
Beach Stone-curlew	*Esacus neglectus*	Listed marine species	Taxa in need of monitoring				
Grey plover	*Pluvialis squatarola*	Listed marine species			Migratory species subject to Agreements	X	X
Eastern golden plover	*Pluvialis dominica*	Listed marine species			Migratory species subject to Agreements	X	
Mongolian sand plover	*Charadrius mongolus*	Listed marine species			Migratory species subject to Agreements	X	X
Large sand plover	*Charadrius leschenaultii*	Listed marine species			Migratory species subject to Agreements	X	X
Red-capped plover	*Charadrius ruficapillus*	Listed marine species					
Ruddy turnstone	*Arenaria interpres*	Listed marine species			Migratory species subject to Agreements		X
Whimbrel	*Numenius phaeopus*	Listed marine species			Migratory species subject to Agreements	X	X
Grey tailed tattler	*Heteroscelis (Tringa) brevipes*	Listed marine species			Migratory species subject to Agreements	X	X
Common sandpiper	*Actitis hypoleucos*	Listed marine species			Migratory species subject to Agreements	X	X
Greenshank	*Tringa nebularia*	Listed marine species			Migratory species subject to Agreements	X	X
Terek sandpiper	*Xenus cinereus*	Listed marine species				X	X
Black-tailed godwit	*Limosa limosa*	Listed marine species			Migratory species subject to Agreements	X	X
Bar-tailed godwit	*Limosa lapponica*	Listed marine species			Migratory species	X	X

Common name	Scientific name	THREATENED SPECIES LIST					
		National List of Threatened Species (EPBC Act)[1]	CALM Declared Threatened Fauna	ANZECC Threatened Fauna List	Bonn Convention[2]	JAMBA[3]	CAMBA[4]
					subject to Agreements		
Great knot	*Calidris tenuirostris*	Listed marine species			Migratory species subject to Agreements	X	X
Sharp-tailed sandpiper	*Calidris acuminata*	Listed marine species			Migratory species subject to Agreements	X	X
Red-necked stint	*Calidris ruficollis*	Listed marine species			Migratory species subject to Agreements	X	X
Sanderling	*Calidrid alba*	Listed marine species			Migratory species subject to Agreements	X	X
Silver gull	*Larus novaehollandiae*	Listed marine species					
Caspian tern	*Sterna caspia*	Listed marine species					X
Common tern	*Sterna hirundo*	Listed marine species					
Roseate tern	*Sterna dougallii*	Listed marine species					
Bridled tern	*Sterna anaethetus*	Listed marine species				X	X
Little tern	*Sterna albifrons*	Listed marine species	Taxa in need of monitoring			X	X
Fairy tern	*Sterna nereis*	Listed marine species					
Crested tern	*Sterna bergii*	Listed marine species					
Lesser crested tern	*Sterna bengalensis*	Listed marine species					X
Australian magpie lark	*Grallina cyanoleuca*	Listed marine species					
Richard's pipit	*Anthus novaeseelandiae*	Listed marine species					
Tree martin	*Hirundo nigricans*	Listed marine species					
Welcome swallow	*Hirundo neoxena*	Listed marine species					

1 EPBC Act — Environment Protection and Biodiversity Act 1999 Cth

2. Bonn Convention — Convention on the Conservation of Migratory Species of Wild Animals, Bonn, 23 June 1979. Australian Treaty Series 1991 No 32.

3. JAMBA — Agreement between the Government of Australia and the

		Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment. Australian Treaty Series 1981 No 6.
4.	CAMBA	Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds in Danger of Extinction and their Environment. Australian Treaty Series 1988 No 2

APPENDIX 2

Definitions of oil characteristics and toxicity of the various oils.

Property	Definition
Density	Mass per unit volume of a substance. Temperature-dependent. Oil will float on water if the density of the oil is less than that of the water. The density of spilled oil will increase with time, as the more volatile (and less dense) components are lost. After considerable evaporation, the density of some crude oils may increase enough for the oils to sink below the water surface. Oils with low densities, have low specific gravities and high API gravities.
Flash Point	Temperature to which the fuel must be heated to produce a vapour/air mixture that is ignitable when exposed to an open flame under specified test conditions. Flash point is an extremely important factor in relation to the safety of spill clean-up operations. Many freshly spilled crude oils also have low flash points until the lighter components have evaporated or dispersed.
Viscosity	Measure of a fluid's resistance to flow; the lower the viscosity of a fluid, the more easily it flows. Like density, viscosity is affected by temperature such that as temperature decreases, viscosity increases. Viscosity affects the rate at which spilled oil will spread, the degree to which it will penetrate shoreline substrates, and the selection of mechanical spill countermeasures equipment.
Pour Point	The lowest temperature at which the oil will just flow, under standard test conditions.
Interfacial Tension	Force of attraction between the molecules at the interface of two fluids. At the air/liquid interface, this force is often referred to as surface tension. The surface tension of an oil, together with its viscosity, affects the rate at which an oil spill spreads.
Emulsions	A water-in-oil emulsion is a stable dispersion of small droplets of water in oil. When formed from crude oils spilled at sea, these emulsions can have very different characteristics from their parent crude oils which in turn has important implications for the fate and behaviour of the oil and its subsequent clean-up.
Saturates	Hydrocarbons called alkanes with structures of C_nH_{2n+2} (aliphatics) or C_nH_{2n} in the case of cyclic saturates (alicyclics). Small saturates ($<C_{18}$) are the most dispersible components of oils. Large saturates (waxes) can produce anomalous evaporation, dispersion, emulsification, and flow behaviours.
Aromatics	Hydrocarbon compounds that have at least one benzene ring as part of their chemical structure. The small aromatics (one and two rings) are fairly soluble in water, but also evaporate rapidly from spilled crude oil. Larger aromatics show neither of these behaviours to any extent.
Resins and Asphaltenes	Hydrocarbons composed of condensed aromatic nuclei which may carry alkyl and alicyclic systems containing heteroatoms such as nitrogen, sulphur, and oxygen. Metals such as nickel, vanadium, and iron are also associated with asphaltenes. Both groups do not appreciably evaporate, disperse or degrade, and both groups stabilise water-in-oil emulsions when they are present in quantities greater than 3%.

Property	Definition
Waxes	Waxes are predominantly straight-chain saturates with melting points above 20°C.
Volatile Organic Compounds	Benzene, toluene, ethylbenzene, and xylenes (BTEX), and substituted benzenes are the most common volatile organic compounds, making up to a few percent of the total mass of some crude oils. BTEX are hazardous, carcinogenic and neurotoxic.
Toxicity	Toxicity to aquatic organisms is measured in laboratory tests and usually reported as: **LC_{50}:** Median lethal concentration is the estimated concentration of a compound that will cause death to 50 percent of the test population in a specified time after exposure. In most instances, LC_{50} is statistically derived by analysis of mortalities in various test concentrations after a fixed period of exposure. **EC_{50}:** Median effective concentration is used when an effect other than death is the observed endpoint. EC_{50} is the estimated concentration of the compound in water that will have a specific effect on 50 percent of the test population in a specified time after exposure. As with LC_{50}, the EC_{50} is generally derived statistically.
Water Accommodated Fraction (WAF)	Mix of oil in seawater used for laboratory toxicity testing.

Source: Jokuty et al. (2000) A catalogue of crude oil and product properties. Environmental Technology Centre Databases (www.etcentre.org/spills/oil_intr.htm)

(ND = no data available, mod. = moderate)

CAMPBELL CONDENSATE	Fresh	Weathering		
		1-3 hrs	1 day	1 week
Physical Characteristics:				
API gravity (classification)	54.7 (light)	-	-	-
Density (g/mL) @ 20° C	0.754	0.804	0.831	ND
Viscosity (cP) @ 20° C	0.14	0.73	1.93	ND
Interfacial Tension (mN/m)	14.7	12.9	8.7	ND
Flash Point (°C)	24	36	72	ND
Pour Point (°C)	-40	-40	-40	ND
Boiling Point (°C)	-	-	-	-
Chemical Characteristics:				
Saturates (% by weight)	62.6	65.9	65.9	ND
Aromatics (% by weight)	26.2	31.3	32	ND
Resins (% by weight)	11.3	4.5	1.8	ND
Asphaltenes (% by weight)	0	0.3	0.5	ND
Waxes (% by weight)	-	-	0.2	ND
Weathering:				
% loss after laboratory weathering	-	68	89	100
Persistent in the environment	no	-	-	-
Forms oil in water emulsions	no	no	no	no
- demulsifier effective?	-	-	-	-
Toxicity (laboratory tested):				
tropical clownfish (*Amphiprion clarkii*)	mod.-high	low	low	ND
inland silverside fish (*Menidia beryllina*)	mod.-high	low	low	ND
tropical prawn (*Penaeus vannamei*)	mod.-high	mod.-high	mod.-high	ND
mysid shrimp (*Mysidopsis bahia*)	mod.-high	mod.-high	mod.-high	ND
sea urchin larvae (*Arbacia punctulata*)	low-mod.	low	low	ND
sand dollar/sea urchin larvae (*Dendraster excentricus/Strongylocentrotus purpuratus*)	low-mod.	low	low	ND
Amenable to Dispersant:	yes	yes	no	no

(ND = no data available, mod. = moderate)

HARRIET CRUDE	Fresh	Weathering		
		1-3 hrs	1 day	1 week
Physical Characteristics:				
API gravity (classification)	36.9 (middle)			
Density (g/mL) @ 20° C	0.8352	0.860	0.870	0.879
Viscosity (cP) @ 20° C	3.54	3.65	24.51	83.07
Interfacial Tension (mN/m)	7.8	12	16.1	ND
Flash Point (°C)	38	126	142	ND
Pour Point (°C)	12	24	27	ND
Boiling Point (°C)	22.9			
Chemical Characteristics:				
Saturates (% by weight)	67.7	ND	ND	66
Aromatics (% by weight)	26.0	ND	ND	29.2
Resins (% by weight)	5.9	ND	ND	4.4
Asphaltenes (% by weight)	0.5	ND	ND	0.5
Waxes (% by weight)	5.1	7.4	8.2	13.9
Weathering:				
% loss after laboratory weathering	-	24	38	52
Persistent in the environment	mod.			
Forms oil in water emulsions	yes, unstable	yes, unstable	yes, unstable	yes, unstable
- demulsifier effective?	yes	yes	yes	yes
Toxicity (laboratory tested):				
tropical clownfish (*Amphiprion clarkii*)	low	low	low	low
inland silverside fish (*Menidia beryllina*)	mod.	low	low	low
tropical prawn (*Penaeus vannamei*)	mod.	mod.	mod.	mod.
mysid shrimp (*Mysidopsis bahia*)	mod.	mod.-high	mod.-high	mod.
sea urchin larvae (*Arbacia punctulata*)	low-mod.	mod.	mod.	mod.
sand dollar/sea urchin larvae (*Dendraster excentricus/Strongylocentrotus purpuratus)*	low	low	low	low
Amenable to Dispersant:	yes	yes	no	no

(ND = no data available, mod. = moderate)

WONNICH CRUDE	Fresh	Weathering		
		1-3 hrs	1 day	1 week
Physical Characteristics:				
API gravity (classification)	49.6 (light)			
Density (g/mL) @ 20° C	0.775	0.831	0.844	-
Viscosity (cP) @ 20° C	0.62	1.84	3.09	-
Interfacial Tension (mN/m)	24.9	18.1	14.5	-
Flash Point (°C)	<38	138	154	-
Pour Point (°C)	-15	24	27	-
Boiling Point (°C)	ND			
Chemical Characteristics:				
Saturates (% by weight)	65.5	ND	67	-
Aromatics (% by weight)	30.6	ND	29.5	-
Resins (% by weight)	2.8	ND	3.1	-
Asphaltenes (% by weight)	1.0	ND	0.7	-
Waxes (% by weight)	4.9	9.7	10.3	-
Weathering:				
% loss after laboratory weathering	-	65	76	100
Persistent in the environment	no			
Forms oil in water emulsions	no	no	no	no
Toxicity (laboratory tested):				
tropical clownfish (*Amphiprion clarkii*)	mod.-high	mod.	low	ND
inland silverside fish (*Menidia beryllina*)	mod.-high	mod.	mod.	ND
tropical prawn (*Penaeus vannamei*)	mod.-high	mod.-high	mod.-high	ND
mysid shrimp (*Mysidopsis bahia*)	mod.-high	mod.-high	mod.-high	ND
sea urchin larvae (*Arbacia punctulata*)	high	mod.-high	low-mod.	ND
sand dollar/sea urchin larvae (*Dendraster excentricus/Strongylocentrotus purpuratus)*	low-mod.	low-mod.	low-mod.	ND
Amenable to Dispersant:	yes	yes	no	no

(ND = no data available, mod. = moderate)

AGINCOURT CRUDE	Fresh	Weathering		
		1-3 hrs	1 day	1 week
Physical Characteristics:				
API gravity (classification)	44.3 (middle)			
Density (g/mL) @ 20° C	0.8	0.849	0.871	0.895
Viscosity (cP) @ 20° C	0.84	4.27	10.74	39.18
Interfacial Tension (mN/m)	23.4	24.7	25.7	28.0
Flash Point (°C)	7	44.4	83.3	146.1
Pour Point (°C)	-40	-12	12	18
Boiling Point (°C)	40			
Chemical Characteristics:				
Saturates (% by weight)	63.9	67.3	62.0	61.3
Aromatics (% by weight)	29.8	28	32.7	33.5
Resins (% by weight)	4.6	3.2	4.2	4.3
Asphaltenes (% by weight)	1.7	1.4	1.1	2.8
Waxes (% by weight)	-	-	-	5.7
Weathering:				
% loss after laboratory weathering	-	35	51	68
Persistent in the environment	moderate			
Forms oil in water emulsions	yes, stable	yes, stable	yes, stable	yes, stable
- demulsifier effective?	yes	yes	yes	yes
Toxicity (laboratory tested):				
tropical clownfish (*Amphiprion clarkii*)	low	low	low	low
inland silverside fish (*Menidia beryllina*)	low-mod.	low	low	low
tropical prawn (*Penaeus vannamei*)	low-mod.	low	low	low
mysid shrimp (*Mysidopsis bahia*)	low	low-mod.	low-mod.	low-mod.
sea urchin larvae (*Arbacia punctulata*)	low	low	low	low
sand dollar/sea urchin larvae (*Dendraster excentricus/Strongylocentrotus purpuratus)*	low	low	low	low
Amenable to Dispersant:	yes	yes	no	no

(ND = no data available, mod. = moderate)

STAG CRUDE	Fresh	Weathering		
		1-3 hrs	1 day	1 week
Physical Characteristics:				
API gravity (classification)	18.4 (heavy)	17.9	17.4	ND
Density (g/mL) @ 20° C	0.939	0.947	0.949	ND
Viscosity (cP) @ 20° C	112.9	ND	118.8	269.1
Interfacial Tension (mN/m)	10.7	ND	15.0	16.6
Flash Point (°C)	>100	128	134	ND
Pour Point (°C)	-33	-33	-30	ND
Boiling Point (°C)	169			
Chemical Characteristics:				
Saturates (% by weight)	40.5	ND	40.9	41.1
Aromatics (% by weight)	46.2	ND	50.6	47.2
Resins (% by weight)	10.7	ND	7.8	10.7
Asphaltenes (% by weight)	2.6	ND	0.7	1.1
Waxes (% by weight)	0.1	0.1	0.2	0.9
Weathering:				
% loss after laboratory weathering	-	0	2	17
Persistent in the environment	yes	yes	yes	yes
Forms oil in water emulsions	yes	yes	yes	yes
- demulsifier effective?	yes	yes	yes	yes
Toxicity (laboratory tested):				
tropical clownfish (*Amphiprion clarkii*)	low	ND	low	low
inland silverside fish (*Menidia beryllina*)	low	ND	low	low
tropical prawn (*Penaeus vannamei*)	low	ND	low	low
mysid shrimp (*Mysidopsis bahia*)	mod.	ND	low	low
sea urchin larvae (*Arbacia punctulata*)	low	ND	low	low
sand dollar/sea urchin larvae (*Dendraster excentricus/Strongylocentrotus purpuratus)*	low	ND	low	low
Amenable to Dispersant:	yes	yes	possibly	no

(ND = no data available, mod. = moderate)

DIESEL FUEL	Fresh	Weathering		
		1-3 hrs	1 day	1 week
Physical Characteristics:				
API gravity (classification)	33.2 (mid distillate)			
Density (g/mL) @ 20° C	0.855	ND	0.856	0.860
Viscosity (cP) @ 20° C	3.62	ND	4.0	5.4
Interfacial Tension (mN/m)	34.5	ND	32.6	31.4
Flash Point (°C)	78.9	ND	91.1	118.3
Pour Point (°C)	6	ND	18	12
Boiling Point (°C)				
Chemical Characteristics:				
Saturates (% by weight)	63.1	ND	64.2	63.6
Aromatics (% by weight)	34.9	ND	33.4	33.7
Resins (% by weight)	1.7	ND	1.7	1.5
Asphaltenes (% by weight)	0.2	ND	0.7	1.2
Waxes (% by weight)	ND	ND	ND	4.2
Weathering:				
% loss after laboratory weathering	-	0	3	23
Persistent in the environment	moderate			
Forms oil in water emulsions	no	no	no	no
- Effectiveness of demulsifier				
Toxicity (laboratory tested):				
tropical clownfish (*Amphiprion clarkii*)	low	ND	low	low
inland silverside fish (*Menidia beryllina*)	mod.	ND	low-mod.	low-mod.
tropical prawn (*Penaeus vannamei*)	mod.-high	ND	mod.-high	mod.-high
mysid shrimp (*Mysidopsis bahia*)	mod.-high	ND	mod.-high	mod.-high
sea urchin larvae (*Arbacia punctulata*)	low	ND	low	low
sand dollar/sea urchin larvae (*Dendraster excentricus/Strongylocentrotus purpuratus)*	mod.-high	ND	low	low
Amenable to Dispersant:	yes	yes	no	no

APPENDIX 3

Apache ENERGY

Refuelling Management Plan

1. Refuelling will be carried out under the direct supervision of the Barge Master.
2. A work permit specific to fuel transfer will be drawn up based on the detailed refuelling procedures.
3. The refuelling hose will be fitted with camlock, dry coupling links.
4. The refuelling hose will be a wire reinforced, floating hose.
5. Refuelling will be carried out in suitable sea conditions to the discretion of the Master of the Supply Vessel and the person in charge (PIC) of the rig.
6. Communications are to be maintained between the rig and the refuelling vessel at all times during refuelling using hand held radios.
7. The refuelling is to be monitored by personnel on watch at appropriate locations on the supply vessel and on the rig.
8. Sufficient oil spill clean-up material will be stored on the drilling rig and support vessel to clean-up small spillages.
9. Refuelling will be recorded in the logbook of both the supply vessel and the rig. Any difficulties experienced will be entered into the log and reported immediately to the drilling manager.

Apache ENERGY

Refuelling Procedures

- Ensure all personnel are aware of intention to refuel and emergency response procedures.
- Discuss refuelling plan and tank sequence with officers involved.
- Close and blank off all unnecessary manifold valves and connections.
- Place oil absorbent materials in key locations.
- Establish common communication link between bunkering station, duty officer, engine room and refuelling barge.
- Check all bunker tank air pipes are open and unblocked.
- Ensure all sounding pipe caps are tight, except when sounding tank.
- Reconfirm space remaining in all bunker tanks to be filled.
- Check all bunker tank high level alarms are functioning.
- Ensure all fire precautions are observed.
- Check hose is of sufficient length.
- Inspect hose and couplings for damage.
- Check weight of hose does not exceed SWL of vessel's lifting gear.
- Place drip trays under hose couplings and flanges.
- Check delivery note quantity and specification are correct.
- Discuss bunkering plan with supplier.
- Discuss vessel's emergency response procedure with supplier.
- Discuss supplier's own emergency response procedures.
- Establish communication link between vessel and supplier.
- Agree with supplier the quantity of diesel to be pumped aboard.
- Agree unit of measurement (e.g. metric tonnes, cubic metres, barrels).
- Agree maximum pumping rate and pressure.
- Appoint seaman to tend mooring lines during bunkering.
- Ensure designated overflow tank is prepared.
- Prepare filling line and open all relevant valves.
- Commence bunkering at minimum pumping rate.
- Monitor supply line pressure.

- Examine hose connections for leakage.
- Reduce pumping rate and/or open next tank before topping up.
- Close valves as each tank is completed.
- Witness, date, jointly countersign and retain sealed bunker samples.
- Ensure sufficient ullage in final tank for hose draining/line blowing.
- Notify supplier when final tank is reached.
- Give supplier’s timely warning to reduce pumping rate.
- Give supplier’s timely warning to stop pumping.
- Drain hoses into tanks on completion of bunkering and close all filling valves.
- Ensure hose is fully drained.
- Close and blank off manifold connection.
- Blank off disconnected hose couplings.
- Reconfirm all bunker line and tank filling values are secure.
- Reconfirm all bunker soundings.
- Sight, agree and record barge meter soundings.
- Verify all bunker receipt details are correct.
- Complete entry into barge vessel and rig logs.

APPENDIX 4

Apache ENERGY

ENVIRONMENTAL MANAGEMENT POLICY

Apache Energy shares the community's concern for the proper care and custody of our environment for present and future generations.

We recognise that human activity, despite being a legitimate and integral part of our global environment, has the potential to disturb the balance of nature and must be planned and managed with the utmost diligence.

We believe that by demonstrating leadership in environmental management our efforts will clearly show a concern for, and commitment to, ensuring that our activities are performed in a manner which will have the absolute minimum impact on the land, sea and air.

This leadership will be achieved by:

- Creating and maintaining an environmental awareness and responsibility in the workforce through open communication, education and training;
- Maintaining open community and government consultation regarding our work and accomplishments;
- Complying with all applicable laws and regulations and company commitments for the protection of the environment;
- Developing and implementing systems to thoroughly identify, assess and manage all activities which have the potential to affect the surrounding biological, chemical and physical environment;
- Embracing continuous improvement through setting targets, audits and reviews;
- Promoting research into and facilitating the monitoring of biological, chemical and physical processes to develop baselines, measure environmental change and to expand and broaden our scientific knowledge;
- Rehabilitating and restoring disturbed areas to a condition compatible with their prior use or status;
- Reducing the production of waste products and energy through conservation, recycling and the use of renewable resources; and
- Maintaining an emergency response capability to mitigate any potentially damaging effect of an incident.

This policy has been reviewed and endorsed by Apache Energy management who foresee benefits in, and take responsibility for, it's successful implementation. By accepting employment with Apache Energy, each employee acknowledges that he/she is responsible for the application of this policy. Success will be achieved when each project is completed with minimal impact and disturbed areas have been rehabilitated.

Jim K Bass, Managing Director

APPENDIX 5

Apache Environmental Guidelines and Drilling Rig Environmental Commitments

The following Apache guidelines will be followed for the well.

Activity	Requirement
Disposal of drilling fluid and drilling cuttings	• Use of **WBM and SBM approved with disposal of cuttings to seabed.** • Solids control equipment to be optimised to ensure maximum separation of fluid from cuttings. • Follow Apache refuelling procedures fro SBM transfers (AE-91-IQ-098) • Rig PIC to record volume of drilling fluid disposed into the ocean on environmental spreadsheet. Results to be reported to the Environmental Manager at the end of the well.
Pipe Dope	• Use pipe dope that has lowest concentration of heavy metals and hydrocarbons, is biodegradable, but still meets safety and performance criteria. • Rig PIC to record volume of pipe dope used on location on environmental spreadsheet. Results to be reported to the Environmental Manager at the end of the well.
Cooling water	• Cooling water to be discharged at barge level to facilitate cooling and oxygenation
Deck drainage, chemical storage and management	• Maintain good housekeeping practices • chemicals are to be stored in bunded areas away from open drains and chemical containers intact • Drip trays are to be used under all machinery and fuel points and valves. • in the event of a spill, take all actions to control the spill and divert deck drainage to on board containment tanks for treatment through oil in water separator. • ensure absorbent material is on board to use in soaking up chemical or oil spills. • Maintain oil water separators regularly to ensure 15 ppm oil concentration alarm is functional • all releases of oil in water of greater than 50mg/l are to be reported to Apache Perth office within 2 hours of occurrence (these are reported to DMPR). • all spills >80L reported to Apache Perth Office within 2 hours (these are reported to DMPR) • Report all spills <80L through Apache incident reporting system
Spillage of diesel fuel or oil	• Follow Apache refuelling procedures (AE-91-IQ-098) • In event of a spill take all actions to control the spill. • No dispersant use without DMPR approval • all spills >80L reported to Apache Perth Office within 2 hours (these are reported to DMPR) • Report all spills <80L through Apache incident reporting system
Discharge of combustion products from engines	• inspections and tuning of engines and equipment are included on a regular maintenance schedule.
Waste Oil	• Waste oil and grease to be drummed and returned to mainland for

Management	recycling • Records of volume of waste oil taken off rig forwarded to the Environmental manager at the end of the well.
Solid waste management • Food scraps • Garbage • Litter • Scrap metal and wood etc	• All solid waste (**including food scraps**) to be **sent onshore for disposal** • No disposal of debris, garbage or litter into the sea. (skips need covers to prevent wind blown rubbish – especially plastics and styrofoam cups) • Segregate industrial waste (scrap metals / drums etc) for appropriate disposal onshore. • reduce, reuse and recycle waste wherever practicable. • Record the volume and type of waste taken off rig and forward to the Environmental Manager at the end of the well. • ROV survey to check no rubbish left on seabed. Any debris will be removed.
Sewage discharge	• Sewage is to be treated to tertiary level prior to discharge. • Sewage treatment plant is to be maintained to ensure effective treatment
Anchoring	• No workboats are to anchor in areas where coral reefs occur (none known in immediate vicinity of Endymion-1)
Operational Environmental Awareness	• personnel are familiar with the environmental requirements of the EMP and all guidelines and procedures outlined are being followed. • all personnel have signed off the rig register book confirming their induction.
Megafauna Observations	• fill in whale and turtle observation data sheets and forward to the Environmental Manager at the end of the well.

Perth Office Commitments

Activity	Requirement
Prior to drilling	• Make EMP for Endymion-1 available to personnel involved in drilling program
Discharge of combustion products from engines	• Report greenhouse gas emissions data to Federal Govt annually.
Environmental Audit	• Audit drilling rig every six months whilst under contract to Apache Energy

APPENDIX 6

WHALE WATCHING PROCEDURE

SCOPE

This scope of this procedure is exploration drilling within Apache's permits located in Commonwealth waters on the North West Shelf of Western Australia.

OBJECTIVE

The objective of the whale watching procedure is to ensure that Apache Energy's exploration drilling operations comply with:

- Federal and State legislation.
- good industry practice.
- Apache Energy's environmental policy.

PROCEDURE

The procedure outlines the steps to be taken for the preservation, conservation and protection of whales and other cetacea.

1. The drilling rig and support vessels shall observe all provisions of the *Environment Protection and Biodiversity Conservation Act* 1999 Cth.

2. A watch of whales will be carried out during the migration season.

3. All whale sightings are to recorded on the whale sighting form. Identification of whale species and activity should be determined where possible.

4. The reports on whale sightings will be submitted to the Biodiversity Group with the Environmental Protection Group.

INFORMATION PROVIDED TO DRILLING RIG

- Whale sighting data sheet
- Australian National Parks and Wildlife Service (1989). *Whales and Whale Watching in Australia.*
- Fact sheets

APPENDIX 7

Sea Turtle Observations

Well name: ______________________________

Date	Time	Observer Name and contact number	Turtle species (if known)	Behaviour Floating at surface, diving, feeding, mating, breathing	Notes. For example, describe body shape, colour, approx. size, shell flattened or high dome shape, tail present or absent, barnacle patterns (good for identifying individuals), chunks taken out of shell (sharks), photo taken? etc

APPENDIX 8

ENVIRONMENTAL AUDIT

DRILLING RIG – ENSCO 56

DATE:
NAME OF WELL:
NAME OF RIG:
APACHE REPRESENTATIVES:
ENSCO REPRESENTATIVES:
APACHE AUDITORS:

OBJECTIVES OF THE AUDIT:
1. To ensure compliance with the Environmental Plan for the well.
2. To review operating practices.
3. To identify areas of actual or potential pollution.

OVERVIEW OF AUDIT:
1. Identification of hazardous materials, their quantities and storage areas.
2. Identification of waste disposal practices and disposal sites.
3. Observation of general housekeeping, work practices.
4. Identification of discharges from the rig.
5. Identification of training and education given to the workforce.

OUTCOME OF AUDIT: Action sheet for remedial work required.

1. INTRODUCTION

2. MANAGEMENT INFORMATION

Are the following readily available?	*Yes*	*No*	*Stored where? / Comments*
AEL Environmental Policy, Environmental Plan, Apache Environmental Guidelines			
Oil Spill Contingency Plan			
Incident reporting procedure			
Schedule to Petroleum (Submerged Lands) Act			

3. CHEMICAL STORAGE

Are liquid and solid chemicals stored on pallets?	
Are liquid chemicals stored away from open grated areas on rig?	
Where are the bulk dry and liquid chemicals stored?	

4. LIQUID WASTE MANAGEMENT

4.1 Above decks drain system	
Is there runoff into the ocean? • *Source of runoff.* • *Composition of runoff.* • *Fate of runoff.* • *Remedial action required.*	
4.2 Below decks drain system	
Is there runoff into the ocean? • *Source of runoff.* • *Composition of runoff.* • *Fate of runoff.* • *Remedial action required.*	
4.3 Waste oil	
Source(s) of oil	
Storage site(s)	
Estimated quantity	
Disposal methods / location	
Is oily water treated before discharge into the ocean?	
What is the oil in water average per day?	
Is there an automatic shut-down facility on the separator (if in use) ?	
4.4 Drilling fluid and cuttings	
Composition	
Volume discharged	
Method and location of disposal	
4.5 Liquid discharges	
Source	
Cooling water from diesel fuelled power generators	
Seawater from distillation unit (water maker).	
Toilets	
Laundry	

5. SOLIDS WASTES

Disposal of plastics, industrial burnable, drums, litter, pipe dope, scrap metal	
How is waste being segregated prior to disposal?	
Kitchen waste	

6. REFUELLING PROCEDURES

Type of fuel.	
Procedure for transfer of fuel	
Spill clean-up procedure.	

7. GENERAL HOUSEKEEPING

Pipe cleaning facilities.	
Litter bins available?	
Degree of litter on floor.	
Are there drip trays under engines, machinery and valves?	
Are oil or chemical spills cleaned up immediately?	
What oil/chemical spill facilities available on the rig?	
Equipment maintenance	

8. TRAINING, INDUCTIONS AND GUIDELINES

Has the workforce received an environmental induction?	
What degree of oil spill training have relevant personal received?	
Any other training given?	
What guidelines given to the drilling rig?	

9. REMEDIAL ACTION REQUIRED

Actions that will require remedial work	*Nominated person dedicated to the task*	*Time frame for completion*	*Corrective Action Request #*

10. CONCLUSION