Chelonia-1 and -2 Exploration Wells, boundary of Ningaloo Marine Park, North West Shelf

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Apache Northwest Pty Ltd

Report and recommendations
of the Environmental Protection Authority

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Summary and recommendations

Apache Northwest Pty Ltd proposes to drill two exploration wells, Chelonia-1 and -2, in Permit Area EP342 which is located at the head of Exmouth Gulf. Both wells will have the same surface location, situated outside the Ningaloo Marine Park, approximately 100 m from the boundary, and 4 km to the SSW of South Muiron Island. Drilling of both wells will be completed within a period of approximately 44 days. This report provides the Environmental Protection Authority's (EPA's) advice and recommendations to the Minister for the Environment on the environmental factors, conditions and procedures relevant to the proposal.

Section 44 of the *Environmental Protection Act 1986* requires the EPA to report to the Minister for the Environment on the environmental factors relevant to the proposal and on the conditions and procedures to which the proposal should be subject, if implemented. In addition, the EPA may make recommendations as it sees fit.

Relevant environmental factors

Although a number of environmental factors were considered by the EPA in the assessment, it is the EPA's opinion that the following are the environmental factors relevant to the proposal, which require detailed evaluation in the report:

(a) Hydrocarbons (from spills) - the risk and consequences of an oil spill;

(b) Drilling fluids - contamination from accidental spills, use and disposal;

(c) Drill cuttings - physical impacts of disposal;

(d) Other operational discharges - risk of contaminating the marine environment;

(e) Coral reefs - impacts through direct disturbance and contamination;

(f) Seabirds - impacts through direct disturbance and contamination;

(g) Marine fauna, threatened fauna and endangered species - impacts through direct disturbance and contamination;

(h) Shorelines, intertidal and shallow subtidal zone - impacts through direct disturbance and contamination; and

(i) Ningaloo Marine Park/Muiron Islands - impacts on the values of these conservation reserves as a result of the proposal.

The EPA has also provided advice in relation to hydrocarbon production, the sensitivity of the marine environment in the vicinity of the proposed wells and the potential impacts of artificial lights on turtles.

Conclusion

The EPA has considered the proposal by Apache Northwest Pty Ltd to drill the Chelonia-1 and -2 exploration wells near the boundary of the Ningaloo Marine Park, North West Shelf.

The EPA notes the proximity of the proposed wells to environmentally sensitive areas, namely the Ningaloo Reef and Muiron Islands.

In view of the short duration and seasonal timing (summer) of drilling and the management and oil spill contingency measures to be applied, the risk of oil or fuel spills from the proposed short-term exploration drilling project is considered to be extremely low. Furthermore, the risk of a spill occurring and contacting sensitive marine environments is comparable with the risks calculated for other exploration well drilling on the North West Shelf which have been assessed by the EPA.

The EPA has concluded that, given the results of the risk assessment, the proposal can be managed in an environmentally acceptable manner such that it is highly unlikely that the EPA's environmental objectives would be compromised, provided that the conditions recommended in Section 4, and set out in formal detail in Appendix 3, are imposed.

Recommendations

The EPA submits the following recommendations to the Minister for the Environment:

1. That the Minister notes that the project being assessed is for the drilling of two oil exploration wells in a sensitive marine environment adjacent to the border of the Ningaloo Marine Park and near the Muiron Islands.
2. That the Minister considers the report on the relevant environmental factors of Hydrocarbons (from spills); Drilling fluids; Drill cuttings; Other operational discharges; and Ningaloo Marine Park/Muiron Islands as set out in Section 3.
3. That the Minister notes that the EPA has concluded that the risk of oil or fuel spills from the proposed short-term exploration drilling project is considered to be extremely low, and it is most unlikely that the EPA's objectives would be compromised, provided there is satisfactory implementation by the proponent of the recommended conditions set out in Section 4, including the proponent's commitments.
4. That the Minister imposes the conditions and procedures recommended in Appendix 3 of this report.

Conditions

Having considered the proponent's commitments and information provided in this report, the EPA has developed a set of conditions which the EPA recommends be imposed if the proposal by Apache Northwest to drill the Chelonia-1 and -2 exploration wells on the North West Shelf is approved for implementation. These conditions are presented in Appendix 3. Matters addressed in the conditions include the following:

(a) the proponent shall fulfil the commitments in the Consolidated Commitments statement set out as an attachment to the recommended conditions in Appendix 3;

(b) prior to commencement of drilling, the proponent shall prepare a written prescription for contractor work practices covering drilling operations and support vessel operation to ensure that work practices are carried out at the level of international best practice;

(c) to avoid the potential for hydrocarbon fall-out and smoke plumes, the proponent shall not carry out burning or flaring of hydrocarbons when production testing; and

(d) prior to the commencement of drilling, the proponent shall develop contingency plans for alternative disposal of drill cuttings in the event that disposal of drill cuttings to the lost circulation zone is not possible.

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1. Introduction and background

Apache Northwest Pty Ltd, the proponent, proposes to drill two exploration wells, Chelonia-1 and -2, in Permit Area EP342 which is located at the head of Exmouth Gulf. Both wells will have the same surface location, situated outside the Ningaloo Marine Park, approximately 100 m from the boundary, and 4 km to the SSW of South Muiron Island (Figure 1). Drilling of both wells will be completed within a period of approximately 44 days.

The proposed wells are close to environmentally sensitive areas, namely the Ningaloo Reef (12 km SW) and the Muiron Islands (4 km NNE). Given the high conservation significance of these areas, the Environmental Protection Authority (EPA) determined that the proposal should be formally assessed at the level of Consultative Environmental Review (CER). The EPA notes that the proposed Chelonia site is approximately 50 metres from the Loggerhead well which was drilled by Lasmo Oil (Apache's predecessor) in 1992 without incident.

The CER prepared by the proponent, hereafter called 'the CER' (Apache Energy Ltd, 1998), contains detailed ecological risk assessments using a similar methodology to that used in the Apache Energy Wonnich assessments near the Montebello Islands. This involves a consideration of the probability of a spill occurring at source (primary risk), the probability of the spill reaching sensitive areas (secondary risk) and the potential short and long-term environmental consequences (also referred to as tertiary and quaternary risks respectively).

Further details of the proposal are presented in Section 2 of this Report. Section 3 discusses environmental factors relevant to the proposal. Conditions and procedures to which the proposal should be subject if the Minister determines that it may be implemented are set out in Section 4. The EPA provides other advice in Section 5, Section 6 presents the EPA's conclusion and Section 7 the EPA's recommendations.

A list of people and organisations that made submissions is included in Appendix 1. References are listed in Appendix 2, and recommended conditions and procedures and proponent's commitments are provided in Appendix 3.

The DEP's summary of submissions and the proponent's response to those submissions has been published separately and is available in conjunction with this report.

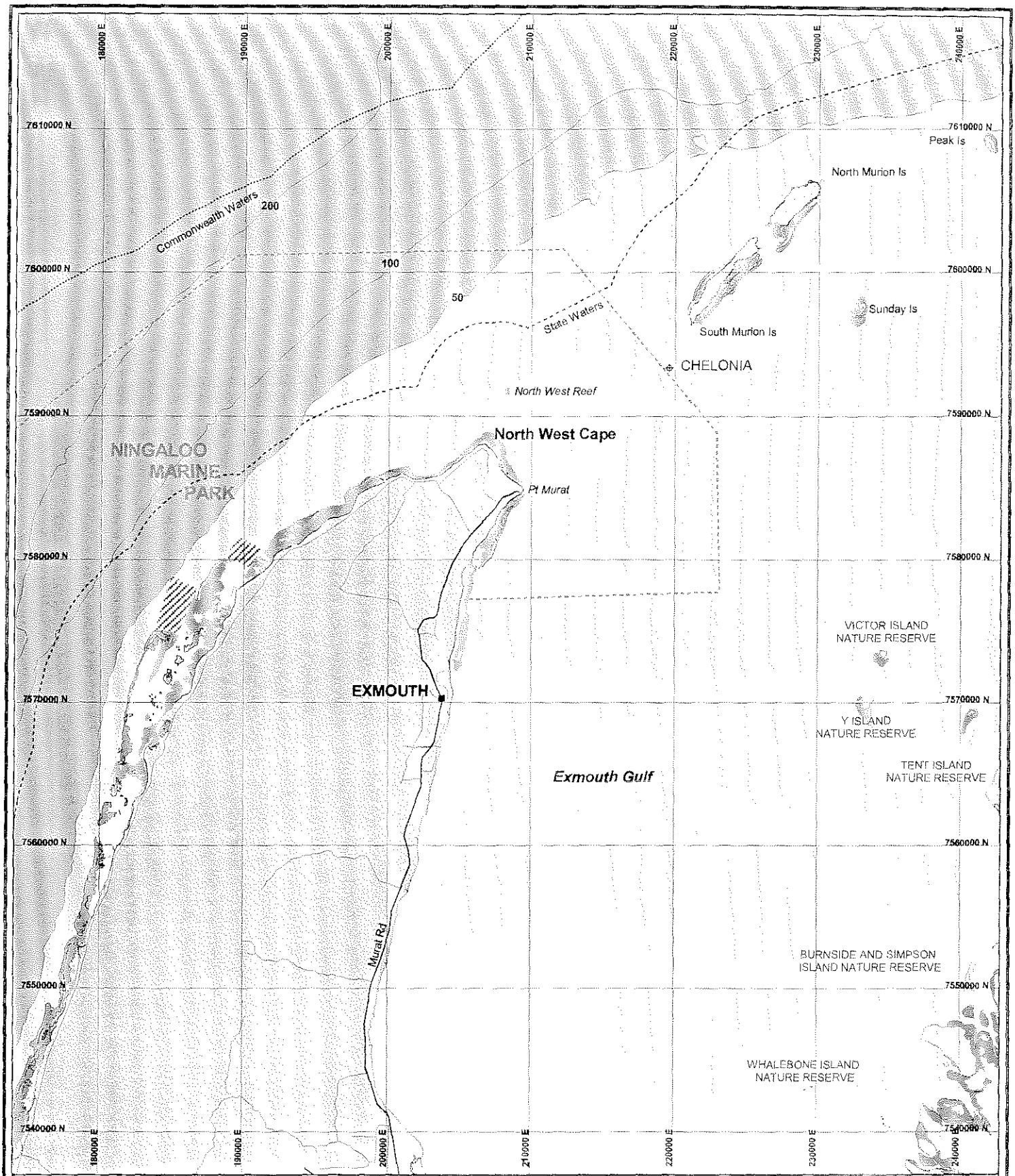
2. The proposal

Drilling program

Apache Northwest Pty Ltd proposes to drill two exploration wells, Chelonia-1 and -2, near the border of the Ningaloo Marine Park on the North West Shelf. The Chelonia-1 well will be drilled initially and, if hydrocarbons are encountered, the drill string will be pulled back and sidetracked to drill the second well, Chelonia-2.

Both wells will have the same surface location, situated just outside the Ningaloo Marine Park, approximately 100 m from the boundary, and 4 km to the SSW of South Muiron Island (Figure 1). The Chelonia-1 and -2 wells will be directionally drilled to an estimated vertical depth of approximately 2 850 metres to reach a drilling target located below the Ningaloo Marine Park (Figure 2). The proposed Chelonia site is located approximately 50 metres from the Loggerhead well which was drilled without incident by Lasmo Oil in 1992.

The proposal is for exploration drilling only. The drilling program is expected to last for a maximum of 25 days for one well and 44 days for two wells. Production testing will be carried out on one well and, should a resource (oil or gas) be discovered in commercial quantities, the wells will be sealed and suspended. The wells will require additional environmental assessment prior to any further development.



Legend

- Coral communities with high species diversity; patchy coral reefs, predominantly massives interspersed with large rubble
- Intertidal Limestone pavements; reef flats; intertidal rubble deposits
- Intertidal sand
- Mangrove
- Sandy Beaches
- Macroalgal communities; pavement/rubble with macroalgae and seagrass; isolated coral bommies
- Subtidal sand
- Saline coastal flat
- Supratidal area
- Unknown - Lack of Data

N

Scale 1:350 000

3 0 3 6 9 12 Kilometres

Universal Transverse Mercator Projection
Zone 50

SOURCES
Marine habitats mapped from aerial photography by BBG. Terrestrial habitats derived from AUSLIG 1:250000 Geodata.

Drawn by: NGIS (Australia) Pty Ltd
Map ID: apache_gis/projects/habmaps/chelonia
DATE: November 17 1998

apache ENERGY

MARINE HABITATS NEAR THE CHELONIA LOCATION

Figure 1

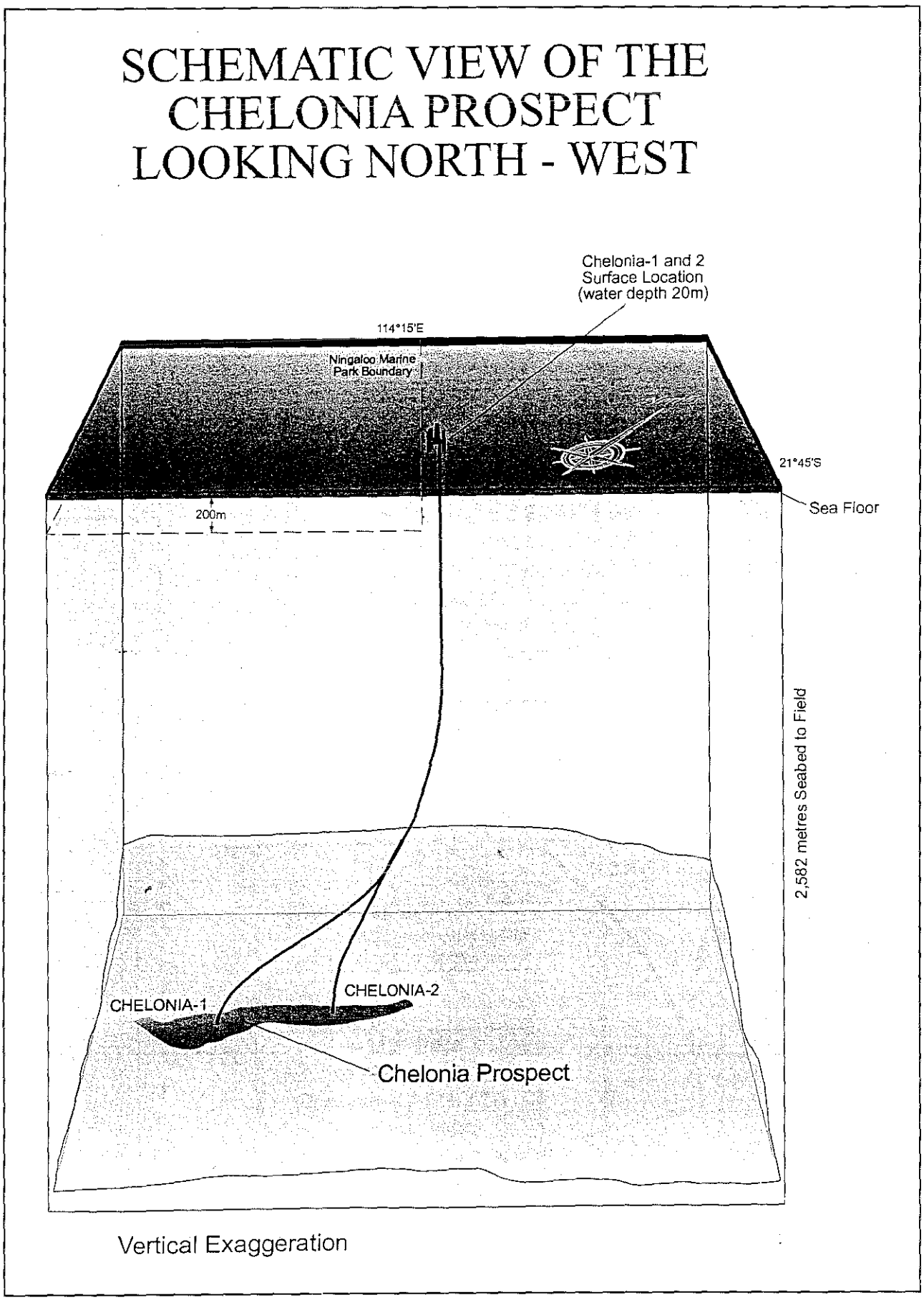


Figure 2. Schematic view of the Chelonia drilling prospect.

Oil characteristics

If oil is encountered at Chelonia, the proponent expects it to be similar to the oil encountered at Leatherback-1 which was drilled by Apache in 1991. Leatherback-1 is located approximately 10 km from the proposed Chelonia site and has a similar reservoir depth to that expected at Chelonia.

Leatherback-1 oil is a slightly weathered light crude (API gravity of approximately 30°) with a high wax content (~12%) and relatively high pour point (~27 °C). Weather testing of Leatherback crude at summer temperatures (32 °C) showed rapid evaporation in the first eight hours with the loss of approximately 35% of the total mass of oil (Apache Energy, 1998). Leatherback oil contains few light end compounds (~3%) and can be regarded as slightly toxic to marine organisms (Apache Energy, 1998).

Leatherback crude showed a propensity to form an oil-in-water emulsion (mousse) in the presence of wind and wave turbulence, however the emulsion was unstable and proved to be amenable to some dispersants in the early stages of weathering (Apache Energy, 1998). Tar ball formation commenced as early as 2 hours after contact with the water, which reduces the potential for the oil to disperse into the water column although this also reduces the evaporation rate of the oil and its amenability to chemical dispersion (Apache Energy, 1998).

Rig

A jack-up drilling rig will be used for the drilling program. The rig will be towed to the site and jacked up into position, supported by three legs bearing on the seafloor. The CER outlines that the seafloor in the vicinity of the proposed well site is limestone pavement overlain in places by a veneer of mainly gravel size sediments, supporting a sparse fauna of filter and particulate feeding macroinvertebrates such as seawhips, sponges and bryozoans. Impacts associated with rig positioning will be limited to the physical effect of the rig legs on the seafloor, and it is considered that any impacts will be localised and temporary.

Oil (from spills)

One of the major issues associated with this proposal (and other petroleum exploration and production proposals) is the potential for spillage of hydrocarbons (fuel or crude oil) from equipment and operations. The proponent has undertaken risk assessment and trajectory modelling for a number of hydrocarbon spill scenarios, and this is discussed in detail in Section 3.2.

Drilling fluids

It is proposed to use water-based drilling fluids, with the exception of the 12¼" section (the deviated section) of the wells where Petrofree (a low toxicity and biodegradable ester-based fluid) will be used. Drilling fluids are discussed further in Section 3.3

Drill cuttings

Initial drill cuttings (the rock chips from the drilling operation), expected to be a maximum of 16 m^3, will be deposited on the seabed adjacent to the well. The proponent intends to dispose of remaining cuttings (450 m^3 and 350 m^3 for Chelonia-1 and -2 respectively) down the annulus to the lost circulation zone. The proponent has outlined that, should no lost circulation zone be encountered, the entire volume of cuttings will be deposited to the seafloor. Drill cuttings are discussed in further detail in Section 3.4.

Other operational discharges

Operational discharges associated with off-shore drilling include deck drainage, waste oil, pipe dope and domestic wastes (sewage and grey water). Further details are given in Section 3.5.

Oil spill contingency measures

A dedicated Oil Spill Response Vessel fitted with an ocean-rated oil containment boom, oil recovery unit and oil dispersant spray application booms will remain at the drilling location throughout the entire drilling program. The proponent will develop an Oil Spill Contingency Plan prior to drilling which contains specific management measures regarding containment and clean-up in the unlikely event of an oil spill.

Production testing

Production testing will be carried out on one well to measure a number of factors, including the presence, characteristics and flow of hydrocarbons. Should the wells prove to be commercial, they will be plugged in accordance with a Department of Minerals and Energy (DME) approved program pending a decision regarding approval for production. Any proposal for oil or gas production will require further environmental impact assessment. If hydrocarbons are not encountered in commercial quantities, the well will be plugged and abandoned according to DME procedures.

Lighting

Due to safety regulations, the drilling rig must be brightly lit for 24 hours a day. This lighting may attract birds, fish, turtles and other marine life. The rig is approximately 4 km from the nearest turtle nesting beach (South Muiron Island). A previous Commonwealth Scientific and Industrial Research Organisation (CSIRO) survey has shown that the lights of a rig are not visible to turtle hatchlings from this distance, and it is therefore considered that the lights on the rig are unlikely to attract hatchlings (Apache Energy, 1998).

The main characteristics of the proposal are summarised in Table 1 below. A detailed description of the proposal is provided in Section 2 of the CER (Apache Energy, 1998).

Table 1. Summary of key proposal characteristics

Element	Description	
	Chelonia-1	Chelonia-2
Surface location	21°44'38.87" S 114°17'3.88" E	same
Type of well	Directional	Directional
Proposed drilling period	Summer period (1 Nov - 1 March)	Summer period (1 Nov - 1 March)
Water depth	20 metres	20 metres
Drilling days	26	18
Drilling rig	Jack-up rig	Jack-up rig
Drilling fluid	Water-based and Petrofree	Water-based and Petrofree
Vertical depth	~2 850 metres	~2 850 metres
Measured depth	~4 100 metres	~3 500 metres
Volume of cuttings	~450 cubic metres	~350 cubic metres
Volume of cuttings on seabed (assuming annulus disposal)	~16 cubic metres	None
Production testing	one well only	one well only
Reservoir access	6 days	3 days
Habitat type	Limestone pavement with sand veneer	Limestone pavement with sand veneer
Nearest landfall	Muiron Islands	Muiron Islands
Nearest sensitive resource	Intertidal sand and subtidal fringing reef South Muiron Island (4 - 6 km)	Intertidal sand and subtidal fringing reef South Muiron Island (4 - 6 km)

3. Environmental factors

3.1 Relevant environmental factors

Section 44 of the *Environmental Protection Act 1986* requires the EPA to report to the Minister for the Environment on the environmental factors relevant to the proposal and on the conditions and procedures to which the proposal should be subject, if implemented. In addition, the EPA may make recommendations as it sees fit.

It is the EPA's opinion that the following are the environmental factors relevant to the proposal, which require detailed evaluation in this report:

(a) Hydrocarbons (from spills) - the risk and consequences of an oil spill;

(b) Drilling fluids - contamination from accidental spills, use and disposal;

(c) Drill cuttings - physical impacts of disposal;

(d) Other operational discharges - risk of contaminating the marine environment;

(e) Coral reefs - impacts through direct disturbance and contamination;

(f) Seabirds - impacts through direct disturbance and contamination;

(g) Marine fauna, threatened fauna and endangered species - impacts through direct disturbance and contamination;

(h) Shorelines, intertidal and shallow subtidal zone - impacts through direct disturbance and contamination; and

(i) Ningaloo Marine Park/Muiron Islands - impacts on the values of these conservation reserves as a result of the proposal.

Note that the factors 'Seabirds', 'Marine fauna, threatened fauna and endangered species', 'Coral reefs' and 'Shorelines, intertidal and shallow subtidal zone' will be discussed in this report under the factor 'Ningaloo Marine Park/Muiron Islands'.

The above relevant factors were identified from the EPA's consideration and review of all environmental factors (preliminary factors) generated from the CER document and the submissions received, in conjunction with the proposal characteristics (including significance of the potential impacts), the adequacy of the proponent's response and commitments. On this basis, the EPA considers that the preliminary factors: Seafloor and Mangroves and other issues raised in the submissions do not require further evaluation by the EPA. The identification process is summarised in Table 2.

The relevant environmental factors are discussed in Sections 3.2 to 3.6 of this report and are summarised in Table 3.

3.2 Hydrocarbons (from spills)

Description

The potential for hydrocarbon spillage (from well drilling, production testing or fuel spillage) is considered to be a key issue, especially given the proximity of the Chelonia wells to the Ningaloo Marine Park and the Muiron Islands.

The proponent has undertaken risk assessment to predict the risk of spills occurring, which is discussed below. The proponent also carried out oil spill trajectory modelling and field validation to determine the probability of such spills contacting sensitive areas. This is discussed in Section 3.6: Ningaloo Marine Park/Muiron Islands.

Table 2. Identification of Relevant Environmental Factors

FACTOR	PROPOSAL COMPONENT WITH POSSIBLE IMPACT	GOVERNMENT AGENCY AND PUBLIC COMMENTS	IDENTIFICATION OF RELEVANT ENVIRONMENTAL FACTORS
BIOPHYSICAL			
Coral reefs	Coral communities in the vicinity of the proposed Chelonia wells include reefs around the Muiron Islands (NNE 4 km) and Ningaloo Reef (including Bundegi Reef; SW 12 km). Less developed coral communities occur at Sunday Island. Impacts of increased sedimentation and turbidity (as a result of introduction of drilling fluids and drill cuttings to the marine environment) include the smothering of coral reefs and associated benthic fauna. Mortality is expected to increase with the thickness of the solids. The risk of a large oil or diesel spill occurring and contacting coral reefs in the vicinity of the proposed well site is discussed below under Ningaloo Marine Park/Muiron Islands.	A number of submissions asserted that the potential risks to coral reefs from spills are unacceptable, particularly to the coral reefs of the Muiron Islands. The Muiron Islands are recommended for marine conservation (Wilson Report) and are believed to be an important source of coral recruitment for the Ningaloo Reef, especially Bundegi Reef.	The proposed drilling rig location is in an area of bare substrate, devoid of coral reefs. Therefore placement and stabilisation of the rig is unlikely to impact on coral reefs. The proponent intends to dispose of all but the initial drill cuttings down the annulus. In the event that there is no lost circulation zone, all drill cuttings and drilling fluids will be deposited onto the seabed. Potential impacts of such disposal include generation of turbidity plumes and smothering of benthic communities. Such impacts may extend within the boundaries of the Ningaloo Marine Park The proponent has made a commitment to ensure that there will be no access to the Muiron Islands, and that support vessel anchorage will be away from coral reefs. Hydrocarbon spills are discussed below under the factor Hydrocarbons (from spills) and the factor Ningaloo Marine Park/Muiron Islands **Considered a relevant environmental factor - discussed under the factor Ningaloo Marine Park/Muiron Islands.**
Seafloor	The seafloor in the Chelonia area comprises an extensive low profile pavement with coarse veneers and with scattered filter feeding organisms (eg sponges, sea pens) Disposal of drilling fluids and cuttings to the seafloor may result in mounds on the seafloor and consequent increases in turbidity and sedimentation. This issue is discussed below under the factors 'Drilling fluids' and 'Drilling cuttings'.		The seafloor in the vicinity of the Chelonia wells is primarily bare pavement, which is well represented in the Exmouth region. The seafloor in this area is therefore not considered to be of high conservation value. **Not considered to be a relevant environmental factor.**

FACTOR	PROPOSAL COMPONENT WITH POSSIBLE IMPACT	GOVERNMENT AGENCY AND PUBLIC COMMENTS	IDENTIFICATION OF RELEVANT ENVIRONMENTAL FACTORS
Shoreline, intertidal & shallow subtidal zone	The main intertidal habitats near Chelonia are narrow sandy beaches, sand bars and small patches and platforms of intertidal beach rock around South Muiron Island. Intertidal sand beaches and beach rock communities also occur along the North West Cape. Sandy beaches of the Muiron Islands are important turtle nesting sites. Turtles nest in summer when Apache proposed to drill the Chelonia wells. Potential impacts on intertidal and subtidal habitats and associated biota may also occur. The risk of oil and diesel spills and impacts on shorelines, intertidal and subtidal zones is discussed further under the factor Ningaloo Marine Park/Muiron Islands.	It was considered that the potential impacts upon the shorelines, intertidal and subtidal zones of the Muiron Islands and Sunday Islands in the event of a spill may be significant and have not been adequately addressed.	Additional assessment is required to assess the extent to which the EPA's objective is met. Potential impacts on shorelines, intertidal and shallow subtidal zones are discussed further under the factor Ningaloo Marine Park/Muiron Islands. **Considered a relevant environmental factor - discussed under the factor Ningaloo Marine Park/Muiron Islands.**
Mangroves	There are well developed mangals along the south and eastern coasts of the Exmouth Gulf and limited mangrove systems (sparse trees) on the coast near Bundegi. Mangroves are particularly susceptible to the harmful impacts of hydrocarbons. However, the mangals are predicted to be beyond the range of predicted impact in the event of a hydrocarbon spill.	Concerns were raised by CALM about the use of chemical dispersants near mangals. Resource Classification and Sensitivity Codes note that chemical dispersants should be avoided for mangroves (in the event of an oil spill). Authorisation would be required from the DME and DEP for use of dispersant close to shore and near sensitive habitats.	Trajectory modelling indicates that the mangroves are beyond the predicted range of effects from an oil spill. **Not considered to be a relevant environmental factor.**
Marine fauna, threatened fauna and endangered species	Whales, sea birds, whale sharks, turtles, dolphins and pelagic fish species are found in the area. Chelonia lies within Area A of the Exmouth Gulf Prawn Fishery. Limited disturbance of dugongs, whales, dolphins, turtles, and migratory birds (which are most abundant in summer and autumn) during normal operations. Potential impact on marine fauna in the event of a hydrocarbon spill. Potential for light from the rig to deter/disorientate nesting adult turtles and hatchlings.	The issue of potential disturbance to turtle nesting was raised in a number of submissions. CALM noted that although the nearest turtle nesting beach is 4 km away, adult turtles and hatchlings at sea may be disoriented by rig lights.	Results of a light survey/audit undertaken by the CSIRO on a similar jack-up rig located on the Leatherback-2 site, some 2 km south of the Muiron Islands found that illumination from the lights on the rig generally dissipated beyond 100 m. Drilling during the summer months to avoid impacts on humpback whales, whale sharks and coral spawning. However, beaches of the Muiron Islands are an internationally breeding areas for turtles which nest in summer. **Considered a relevant environmental factor - discussed under the factor Ningaloo Marine Park/Muiron Islands.**

FACTOR	PROPOSAL COMPONENT WITH POSSIBLE IMPACT	GOVERNMENT AGENCY AND PUBLIC COMMENTS	IDENTIFICATION OF RELEVANT ENVIRONMENTAL FACTORS
Seabirds	The area (particularly the Muiron Islands) includes important seabird nesting and feeding areas as well as areas utilised by protected wading birds and diving birds. Artificial lights on jack-up drilling rig may result in a concentration of seabirds on the infrastructure Potential impacts on seabirds may result from spills of hydrocarbons and drilling fluids.		Disturbance to seabirds associated with drilling activities will be temporary and minimal. The Muiron Islands are a significant feeding and nesting area for many species of birds (including migratory species during summer and autumn. Effects of hydrocarbon contamination on seabirds can include both lethal and sub-lethal effects **Considered a relevant environmental factor - discussed under the factor Ningaloo Marine Park/Muiron Islands.**
POLLUTION			
Hydrocarbons (from spills)	Potential for spillage of hydrocarbons from drilling activities, production testing or fuel spillage. Size of spillage, season, prevailing conditions and oil spill recovery effectiveness will determine the extent of impact upon marine flora and fauna, marine water quality and reefs, shorelines and tidal habitats. Four spill scenarios considered: • Blowout - resulting in the spill of 600 000 L of crude oil; • Support vessel fuel tank rupture - resulting in the spill of 80 000 L of diesel; • Production test spillage - resulting in the spill of 8 000 L of crude oil; and • Rig refuelling accident - resulting in the spill of 2 500 L diesel. The primary probability for each of the above spill scenarios (over summer for the 44 day drilling program) have been calculated from international data as: Blowout - 7.5×10^{-5} Support vessel fuel tank rupture - 7.0×10^{-5} Production test spillage - 7.0×10^{-7} Rig refuelling accident - 2.7×10^{-3} The probability of these spills contacting sensitive marine resources and the consequences of these spills are discussed under the factor Ningaloo Marine Park/Muiron Islands.	A number of submissions raised concerns regarding the potential for hydrocarbon spills and the affect such spills may have on the sensitive environments in the vicinity of the well. Impacts on the Ningaloo Marine Park and the Muiron Islands were of particular concern. It was considered that the use of closed chamber production testing should be examined. The DME considered that the spill risks may be overestimated, and questioned the validity of the environmental risk assessment methodology.	Apache states that the best available international data base was used for the risk assessment. There is insufficient Australian data to statistically determine risk of oil spill from the local industry. Apache is committed to undertaking drilling during summer when the risk to the west side of the NW Cape is determined to be very low. While Apache recognises that the area may be subject to cyclonic winds during these months, the company considers the risk of a spill occurring is negligible. In particular, a cyclone watch and preparation procedure will be in place and there will be complete shutdown of the drilling operation and isolation of the well in the event of a cyclone. The drilling rig is tested to ensure its integrity to resist severe weather conditions and impact loads. The risk assessment and results of trajectory modelling, and the consequences of a spill are a major component of this assessment and need to be discussed more fully. **Considered to be a relevant environmental factor.**

FACTOR	PROPOSAL COMPONENT WITH POSSIBLE IMPACT	GOVERNMENT AGENCY AND PUBLIC COMMENTS	IDENTIFICATION OF RELEVANT ENVIRONMENTAL FACTORS
Drilling fluids	Water based drilling fluids will be used with the exception of the $12^{1}/_{4}$" section of the wells where Petrofree (a low toxicity ester based fluid) will be used. Water based fluid will be discharged down the annulus. Petrofree fluid will be recycled for reuse. Some residual fluid will be retained on the cuttings, a small proportion of which will be deposited onto the seabed. If a lost circulation zone is not established, residual drilling fluids will be discharged to the seabed with the total volume of drill cuttings. The Petrofree spill modelling (for 90 m^3 and 5 000 m^3) predicts that the bulk of the material would settle out fairly rapidly, while the lighter particles may remain in the water column for up to 24 hours and travel up to 12 km from the well. The heaviest concentrations are predicted to accumulate on the seafloor up to 5 km from the well. During summer the Petrofree trajectory is predicted to move north-east and away from Ningaloo Marine Park. Shallow areas surrounding South Muiron Island may be impacted under some model trajectories.	Concerns were raised that the Proponent has not adequately dealt with drilling fluids and cuttings, in particular if there is no lost circulation zone. Concerns were raised about the possibility of a drilling fluid spill affecting the Ningaloo Reef and the coral and rocky shore communities of the Muiron Islands. It was considered that the methodology used in the simulations of a Petrofree spill is not statistically robust and is likely to miss the worst case scenario.	Apache consider that the approach taken to estimate the fate of drilling fluids is the most rigorous currently available. The results may not provide a definitive distribution, but in general indicate that relatively light sedimentation loads would reach sensitive habitats surrounding the Muiron Islands and North West Cape. Proponent has made a commitment to make all endeavours to dispose drill cuttings and excess drilling fluid down the annulus (commitment 9). Management measures to mitigate potential impacts of the disposal of drilling wastes and drilling fluids to the seafloor should lost circulation not be encountered are considered necessary. **Considered to be a relevant environmental factor.**
Drill cuttings	Drill cuttings from drilling operations will initially be deposited on the seabed until emplacement of the first casing. The volume of cuttings which will require disposal to seabed is estimated to be ~16 m^3. However, should no lost circulation zone be encountered, total drill cuttings will be deposited on the seabed. Total volumes of cuttings are estimate to be ~450 m^3 and ~350 m^3 for Chelonia-1 and -2 respectively. Deposition to the marine environment may result in increased localised turbidity and smothering of seafloor fauna with mortality increasing with mound thickness. Drill cutting mounds are expected to dissipate within a relatively short period.	Concerns were raised about the potential to create a plume from the cuttings that adversely impacts the marine environment, particularly the Ningaloo Marine Park (100 m away). Concerns were also raised that the proponent has not adequately dealt with drilling cuttings, particularly if there is no lost circulation zone. It is noted that a robust assessment of the probability of annular disposal being possible is not provided.	Initial drill cuttings will be deposited to seafloor. Apache has made a commitment to make all endeavours to dispose drill cuttings and excess drilling fluid down the annulus (commitment 9). Should disposal of drill cuttings down the annulus not be possible, the proponent expects the plume to be temporary and localised. Information gained from the disposal of 443 m^3 of cuttings to the seafloor from the adjacent Loggerhead-1 well indicates that cuttings will rapidly disperse due to the fast water currents in the area. **Considered to be a relevant environmental factor.**

FACTOR	PROPOSAL COMPONENT WITH POSSIBLE IMPACT	GOVERNMENT AGENCY AND PUBLIC COMMENTS	IDENTIFICATION OF RELEVANT ENVIRONMENTAL FACTORS
Other operational discharges	Other operational discharges include deck drainage, waste oily water and waste oil, domestic wastes, sewage, paper, scrap steel and metal, and packaging and atmospheric emissions. Oily discharges will be collected via a closed drainage system and treated to statutory limits. Treated water will be discharged to sea. Waste oil will be recycled. Putrescibles and burnable materials will be disposed of onshore. Solid wastes will go to a landfill or be recycled. Sewage and grey water will be treated and discharged above sea level. Cooling water will be discharged above sea level.	Concerns were raised in public submissions as to the likelihood of produced formation water impacting on the marine environment. It was considered that the option for "closed chamber' production should be examined.	Drilling fluid will create a pressure greater than the reservoir pressure, therefore no formation water will be discharged into the marine environment. The Chelonia wells fall within the 12 nautical mile limit imposed by the Petroleum (Submerged Land) Act for disallowing the disposal of food scraps and sanitary effluent. Specific approval for discharge of tertiary treated sewage and <25 mm organic wastes may be given by DME. The option for closed chamber production testing should be considered in an effort to limit associated atmospheric, visual impacts and fallout. **Considered to be a relevant environmental factor.**
SOCIAL SURROUNDINGS			
Ningaloo Marine Park/Muiron Islands	The proposed Chelonia site is ~ 100 m outside the Ningaloo Marine Park boundary and approximately 4 km SSW of the Muiron Islands (C Class Nature Reserve). The Islands are also important seabird nesting rookeries and green turtles nest on the beaches. There is potential for contamination of these sensitive marine environments through hydrocarbon and Petrofree spills and the deposition of drilling cuttings and residual drilling fluids. Such contamination may impact on marine water and sediment quality, shorelines, coral reefs and subtidal areas in the vicinity of the Chelonia wells. Primary risk assessment is outlined under 'Hydrocarbons (from spills)', Secondary risk has been calculated from trajectory modelling, and short and long term consequences (tertiary and quaternary risk respectively) have been estimated using available information. Drilling is planned for the summer period. Results of risk assessment has identified that large spills of oil or diesel are likely to result in hydrocarbons contacting the Muiron Islands. Contact with Point Murat (Ningaloo Marine Park) was not recorded in summer trajectories.	A number of submissions raised concerns regarding potential impacts on the Ningaloo Marine Park. Concerns were centred around the potential for spillages of hydrocarbons and drilling fluids. Concerns have also been raised that the CER does not adequately highlight the values of the Muiron Islands. It was considered that the consequences of a hydrocarbon spill have not been adequately dealt with, and that the categorisation of the consequences of a spill are based on arbitrary timelines.	Modelling indicates that, in the unlikely event of a large oil or diesel spill, there would be contact with the Muiron Islands. Given the proximity of the proposed Chelonia well location, the risk of hydrocarbon spills and the impacts these spills may have on sensitive environmental resources needs further assessment. Under some conditions, modelling indicates that there would be contact with the shallow areas surrounding the Muiron Islands in the event of a Petrofree spill. This requires further assessment. Potential impacts on the Ningaloo Marine Park and the Muiron Islands resulting from disposal of total drill cuttings onto the seabed requires further assessment. **Considered to be a relevant environmental factor.**

Table 3. Summary of Assessment of Relevant Environmental Factors

RELEVANT FACTOR	RELEVANT AREA	EPA OBJECTIVE	EPA ASSESSMENT	EPA ADVICE
Hydrocarbons (from spills)	Area encompassing Exmouth Gulf region, Ningaloo Marine Park, Muiron Islands and Sunday Island	Ensure that the risk of spillage is extremely low, that actions are taken to reduce identified risks, and that drilling operations and equipment are at the level of international best practice for drilling in environmentally sensitive areas.	The primary probability for the four spill scenarios identified for this proposal (over summer for the 44 day drilling program) have been calculated from international data as: • Blowout - 7.5×10^{-5} • Support vessel fuel tank rupture - 7.0×10^{-5} • Production test spillage - 7.0×10^{-7} • Rig refuelling accident - 2.7×10^{-3} The probability of these spills contacting sensitive marine resources and the consequences of these spills are discussed under the factor Ningaloo Marine Park/Muiron Islands.	Having particular regard to: • the fact that the probability of a hydrocarbon spill is considered extremely unlikely; • the fact that, should a hydrocarbon spill occur, it is likely to be of small volume only; • the fact that operational measures to minimise the potential for spills will be utilised during drilling; • that fact that DME will set safety and environmental conditions which must be met by the proponent; and • the proponent's commitments to minimise the likelihood of a spill (commitment 7 and 8), it is the EPA's opinion that the proposal can be managed such that it is highly unlikely that the EPA's environmental objective for hydrocarbons (from spills) would be compromised, provided that that additional management measures recommended by the EPA are implemented.
Drilling fluids	Area encompassing Exmouth Gulf region, Ningaloo Marine Park, Muiron Islands and Sunday Island	Ensure that the probability of spillage is extremely low, that actions are taken to reduce identified risks, and that drilling operations and equipment are at the level of international best practice for drilling the environmentally sensitive areas.	• Water based fluid will be used with the exception of the $12^{1}/_{4}$" section of the wells, where Petrofree (an ester based fluid) will be used. Petrofree is readily degradable under aerobic and anaerobic conditions and exhibits low toxicity to marine organisms. • Water based fluid will be discharged down the annulus and Petrofree will be recycled. • Should no lost circulation zone be encountered, the proponent proposed to dispose of all drilling wastes to the seabed. • Modelling of a Petrofree spillage predicts that heaviest concentrations would accumulate on the seafloor up to 5km from the well. Particles that remain in the water column for up to four tidal oscillations could travel up to 12km from the well.	Having particular regard to: • the fact that water based fluid will be used with the exception of the $12^{1}/_{4}$" section of the wells, where Petrofree (an ester based fluid) will be used; • the fact that Petrofree is biodegradable with low toxicity; • the fact that results of trajectory modelling indicate that relatively light sedimentation loads would reach the Ningaloo Marine Park; • the fact that the proponent has developed transfer and handling procedures to reduce the risk of a Petrofree spill; and • the proponent's commitment that all endeavours will be made to dispose of excess drilling fluid down the annulus (commitment 9), it is the EPA's opinion that the proposal can be managed to meet the EPA's objective for drilling fluids, provided that the proponent develops contingency plans for alternative disposal of drilling wastes off-site in the event that disposal of drilling wastes to the lost circulation zone is not possible.

RELEVANT FACTOR	RELEVANT AREA	EPA OBJECTIVE	EPA ASSESSMENT	EPA ADVICE
Drill cuttings	Area encompassing Exmouth Gulf region, Ningaloo Marine Park, Muiron Islands and Sunday Island	Ensure that drill cuttings created by drilling do not adversely affect the surrounding environment.	• It is proposed to dispose of initial drill cuttings (~16 m^3) to the seabed and remaining drill cuttings down the annulus. Total volumes of cuttings are estimated to be ~450 m^3 and ~350 m^3 for Chelonia-1 and -2 respectively. • Should no lost circulation zone be encountered, the proponent proposes to dispose of drill cuttings to the seabed. • The seabed in the vicinity of the project area is predominantly bare substrate. • Previous disposal of cuttings to the seafloor in the area resulted in localised and temporary changes in the sediment biota. It is anticipated that cuttings will rapidly disperse.	Having particular regard to: • the proponent's commitment that all endeavours will be made to dispose drill cuttings and excess drilling fluid down the annulus (commitment 9); • the fact that the seabed in the vicinity of the wells is largely bare substrate; and • the fact that disposal of cuttings to the seabed during previous drilling in the Exmouth Gulf has resulted in only localised and temporary changes in sediment biota. Furthermore, cuttings were found to rapidly disperse, it is the EPA's opinion that the proposal can be managed to meet the EPA's objective for drill cuttings provided that, prior to the commencement of drilling, the proponent develops contingency plans for alternative disposal of drill cuttings in the event that disposal of drill cuttings to the lost circulation zone is not possible
Other operational discharges	Area encompassing Exmouth Gulf region, Ningaloo Marine Park, Muiron Islands and Sunday Island	Ensure that operational discharges associated with the project do not adversely affect the surrounding environment.	• The proponent has outlined that no formation water will be discharged into the marine environment. • Oily discharges will be collected via a closed drainage system and treated prior to discharge. • Sewage will undergo tertiary treatment prior to discharge to the sea. • Putrescibles will be disposed of onshore. Solid wastes will go to a landfill or be recycled. • The Chelonia wells fall within the 12 nautical mile limit imposed by the Petroleum (Submerged Land) Act for disallowing the disposal of food scraps and sanitary effluent.	Having particular regard to: • the fact that oily water will be collected, separated and treated. Oil will then be removed for recycling and waste water will be discharged to the sea; • the fact that sewage will undergo tertiary treatment prior to discharge to the sea; • the proponent's commitment to conduct a debris survey at the completion of the drilling to confirm that no debris has been left on the seafloor (commitment 10); and • the fact that no formation water will be discharged it is the EPA's opinion that the proposal can be managed to meet the EPA's objective for other operational discharges, provided that the proponent gains approval from the DME for the offshore disposal of treated sewage and organic kitchen wastes.

RELEVANT FACTOR	RELEVANT AREA	EPA OBJECTIVE	EPA ASSESSMENT	EPA ADVICE
Ningaloo Marine Park/Muiron Islands	The Ningaloo Marine Park on the eastern side of the North West Cape and North and South Muiron Islands and their surrounding waters.	Protect the conservation values, biodiversity and ecosystem functions of Ningaloo Marine Park and the Muiron Islands.	• The proposed drilling rig location is ~100 m from the Ningaloo Marine Park boundary and 4 km from the Muiron Islands. • Potential for contamination of these sensitive marine environments through hydrocarbon and Petrofree spills and the deposition of drilling cuttings. • Drilling is planned for the summer period. Overall probability of contact during 25 day drilling program (1 well) from worst case scenario (blow-out - 600 000 L crude oil) in summer is 6.5 x 10^{-6} that a max of 16 565 L will contact Sth Muiron Is within a min of 20 hrs and 3.0 x 10^{-6} that a max of 11 700 L will contact Nth Muiron Is within a min time of 21 hours. Potential for contact with Point Murat is less than 5.0 x 10^{-7}, with no contact recorded. Over the 44 day drilling program (2 wells) the probabilities of a blowout increase slightly to 9.8 x 10^{-6}, 4.5 x 10^{-6} and no contact for South Muiron Island, North Muiron Island and Point Murat respectively. • Probabilities for spills are comparable to, or better than, those predicted for the Wonnich Gas Development situated south-west of the Montebello Islands. • In the unlikely event that a spill occurs, such hydrocarbon contact may have significant impacts on shorelines (including nesting turtles and seabirds) and the nearshore environment of the Muiron Islands. Consequences of a crude oil spill are likely to be as a result of smothering rather than from the toxic components in the oil, given the likely oil characteristics. • Recovery rates are difficult to determine and vary from one year to several decades for various environmental components.	Having particular regard to: • the fact that risk assessment has indicated that it is unlikely that hydrocarbon or Petrofree spills will impact upon the Ningaloo Reef or the Muiron Island reefs; • the fact that drilling will be carried out in summer when the probability of a spill contacting the Muiron Islands or the Ningaloo Marine Park, and the potential for impacts on whales, whale sharks and coral spawning is reduced (commitment 3); • the fact that the proponent will upgrade the existing Oil Spill Contingency Plan for the tenement to include the Chelonia drilling program (commitment 4) and that an oil spill response exercise will be carried out to ensure an efficient response in the case of an oil spill (commitment 6); • the fact that an ocean-rated oil spill boom and a dedicated oil spill vessel will be on standby at the drilling location at all times (commitment 5); • that fact that DME will set safety and environmental conditions which must be met by the proponent; • the fact that operational measures to minimise the potential for spills will be utilised during drilling; • the fact that the proponent holds insurance for liability, control and clean-up and that the Certification of Currency of Insurance will be drawn up in accordance with directions from the DME; and • proponent's commitments to minimise the likelihood of a spill of diesel and crude oil during refuelling and production testing (commitment 7, 8), it is the EPA's opinion that the proposal can be managed such that it is highly unlikely that the EPA's environmental objective for Ningaloo Marine Park/Muiron Islands would be compromised, provided that: • prior to commencement of drilling, the proponent shall prepare a written prescription for contractor work practices covering drilling and support vessel operation to ensure that work practices are carried out at the level of international best practice; and • to avoid the potential for hydrocarbon fall-out and smoke plumes, the proponent shall not carry out burning or flaring of hydrocarbons when production testing.

Risk assessment

Risk assessment undertaken for this proposal (and other off-shore drilling proposals) involves calculating the probability of an oil spill occurring (referred to as primary risk) and determining the risk of such a spill contacting a sensitive part of the environment (secondary risk). The short term consequences (or tertiary risk) and long term consequences (quaternary risk) of contact with the sensitive part of the environment can then be estimated qualitatively. Primary risk is discussed in this section and secondary, short and long term consequences (tertiary and quaternary risk) are discussed below in Section 3.6: Ningaloo Marine Park/Muiron Islands.

Primary risk is estimated using international oil spill data for operations of this type. Data gained from trajectory modelling is then used in conjunction with primary risk data to calculate the risk of a spill occurring and contacting a sensitive resource (secondary risk).

The proponent consulted Det Norske Veritas (DNV) Consulting Services, an internationally recognised risk consultant, regarding risk assessment for the Chelonia proposal. DNV utilised international data collected over many years from the oil and gas industry to calculate the spill-size frequency curves for various scenarios. The primary probabilities for different spill scenarios were then determined from these data. The figures provided by DNV to Apache Northwest are therefore considered to provide an indication of the likely probability of each spill scenario occurring. The EPA recognises that the risk database is based on international data, and acknowledges that drilling conditions are likely to differ widely between countries. The EPA also notes the fact that the probabilities calculated by DNV do not take into account management measures which will be implemented by the proponent to reduce the potential for spills to occur. These measures are discussed further below.

The proponent undertook risk assessment and trajectory modelling for four possible spill scenarios:

- Blowout - resulting in the spill of 600 000 L (3 774 barrels) of crude oil;
- Support vessel fuel tank rupture - resulting in the spill of 80 000 L (503 barrels) of diesel;
- Production test spillage - resulting in the spill of 8 000 L (50 barrels) of crude oil; and
- Rig refuelling accident - resulting in the spill of 2 500 L (16 barrels) of diesel.

The four potential hydrocarbon spill scenarios are discussed further below.

Blowout

A blowout is the term used for loss of well control, potentially resulting in a large oil spill. A blowout represents the worse case oil spill scenario and could only occur if all blowout preventers and other safety mechanisms failed.

In the history of the Australian oil and gas industry, there have been six blowouts, the last in 1984 (Volkman et al, 1994). All were gas/condensate blowouts and none resulted in any significant oil spill (Volkman et al, 1994). A recent independent review of the environmental implications of the offshore oil and gas industry noted that, due to improved technology (including monitoring equipment, blowout preventers, automatic shut-in valves, new drilling muds and improved seismic surveys and site analyses), the risk of a blowout occurring in Australia during the 1990's is very low (Swan et al, 1994).

As is standard practice in the offshore oil and gas industry, the rig to be used for the drilling of the Chelonia -1 and -2 wells will use monitoring equipment, blowout preventers and automatic shut-in valves. Additionally, petroleum legislation administered by the DME requires a detailed safety risk analysis to be carried out for all drilling rigs. This involves a detailed independent assessment of the rig's equipment (including blowout preventers) and operations to 'as low as reasonably practicable' standard.

The proponent has estimated that a spill of 600 000 L of crude oil may occur as a result of a blowout. This is considered to be a conservative scenario, as a blowout of 600 000 L is considered to be a large spill.

DNV's spill size-frequency curve for spills associated with a blowout during drilling is shown in Figure 3. This data indicates that the probability of a blowout of 600 000 L of crude oil occurring is estimated to be 5.0×10^{-5} per well drilled. Therefore, for drilling of one well (25 day drilling program) the probability of a blowout is estimated to be 5.0×10^{-5}. Rather than doubling this figure for the drilling of two wells (44 day drilling program), it is considered that a more realistic figure is obtained by multiplying this probability by 1.5, due to the fact that the drilling of the second Chelonia well involves drilling of the lower sections of the well only rather than the entire length of the well. The probability of a blowout of 600 000 L of crude during the 44 day drilling program is therefore estimated to be 7.5×10^{-5}.

Note that this risk estimate is considered conservative because it is based on international data (wells in other fields may be overpressured and more likely to blowout; other countries have less strict conditions on drilling) and includes blowouts resulting in small spills.

Support vessel fuel tank rupture

There is the potential for a large diesel spill to occur due to a rupture of a fuel tank on a support vessel or on the rig itself as a result of collision, vessel sinking or vessel grounding. The proponent has estimated that the largest diesel spill which could occur is 80 000 L. It is considered that this is a conservative scenario, as no spill larger than this has been recorded on the international database for diesel spills associated with handling (Apache Energy, 1998).

DNV's spill size-frequency curve for spills associated with diesel handling is shown in Figure 4. This data indicates that the probability of a spill of 80 000 L of diesel occurring is 7.0×10^{-5} per well drilled. The proponent has advised that this probability is based on drilling programs of 40 - 60 days for each well drilled (Scott Langtree, Apache Energy, *pers comm*). As both Chelonia-1 and -2 will be drilled in a maximum of 44 days, the proponent considers that the probability of a diesel spill from support vessel or rig fuel tank rupture should remain the same for drilling of both wells. As this probability is likely to be influenced by the time the support vessel remains on site rather than the number of wells drilled, the EPA agrees with this rationale. Therefore, the risk of a spill of 80 000 L of diesel from support vessel or rig fuel tank rupture has been taken to be 7.0×10^{-5} for both the 25 and 44 day drilling programs.

Production test spillage

One of the main sources of small oil spills (of the order of 1 000 L) from offshore exploration is spillage from burning-off during production testing (EPA, 1997). The proponent has estimated that a maximum of 8 000 L of crude oil may be spilt as result of production testing.

DNV's spill size-frequency curve for crude oil spills associated with production testing, is shown in Figure 5. This figure illustrates that the probability of a spill of 8 000 L of crude oil occurring during production testing is 7.0×10^{-7} per well tested. Production testing will be carried out on one well only, therefore this figure remains the same for the 25 and 44 day drilling programs.

Rig refuelling accident

Small diesel spills may result from leakage or spillage of diesel during refuelling. The proponent has estimated that a maximum of 2 500 L of diesel may be spilt as a result of refuelling. The EPA notes that this is a conservative estimate, as the proponent has outlined that shut off valves will be used on all hoses, which will limit the maximum volume of diesel which could be spilt to the contents of the refuelling hose (around 200 L).

DNV's spill size-frequency curve for spills associated with diesel handling is shown in Figure 4. This figure indicates that the probability of a spill of 2 500 L of diesel during handling is 9.0×10^{-4}. The proponent has advised that this is the probability value for the 25 day program, which takes into account two refuellings. During the 44 day program Apache has estimated that 6 refuellings will be required, and that the probability value can therefore be multiplied by three.

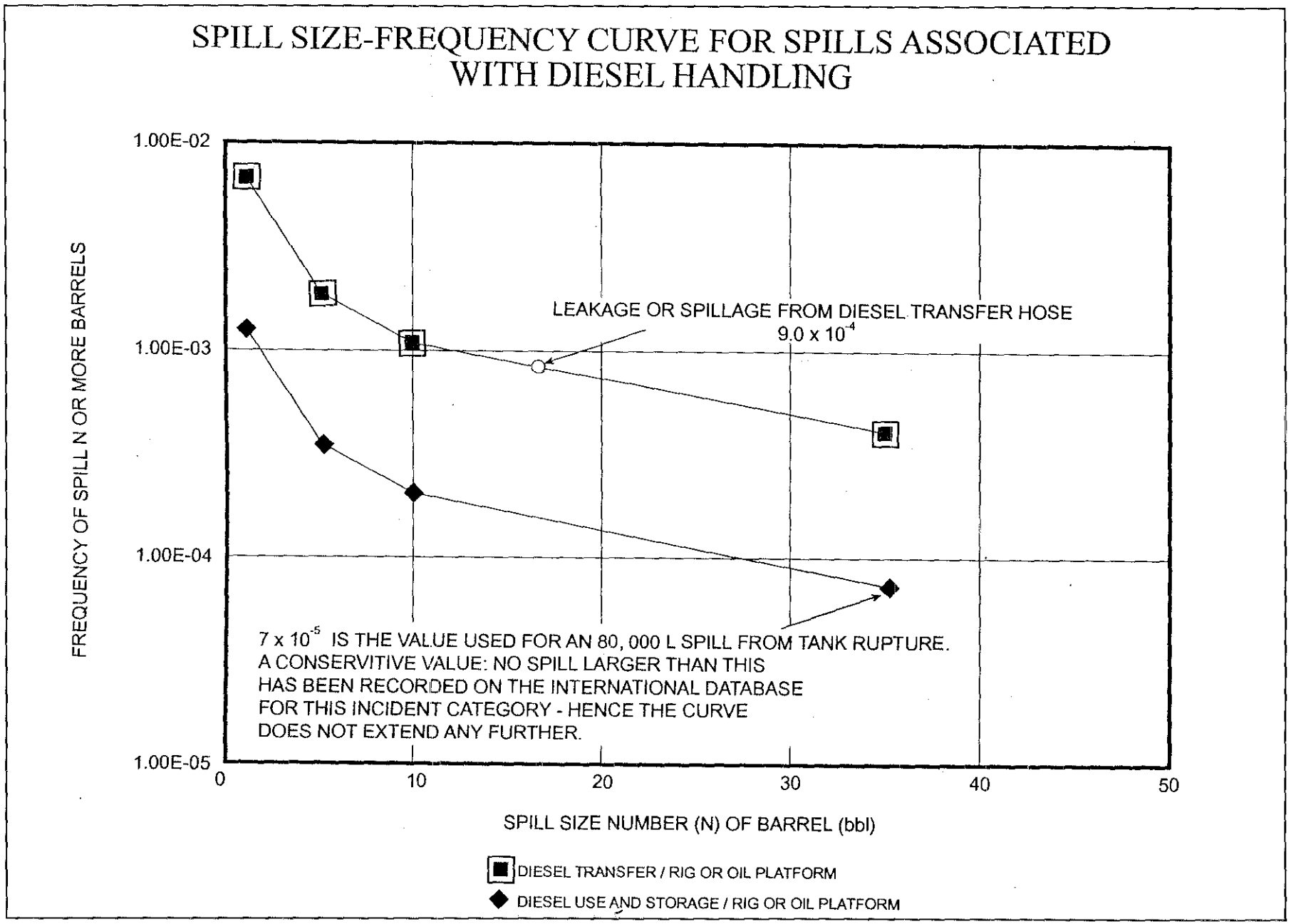


Figure 4. Spill size-frequency curve for spills associated with diesel handling.

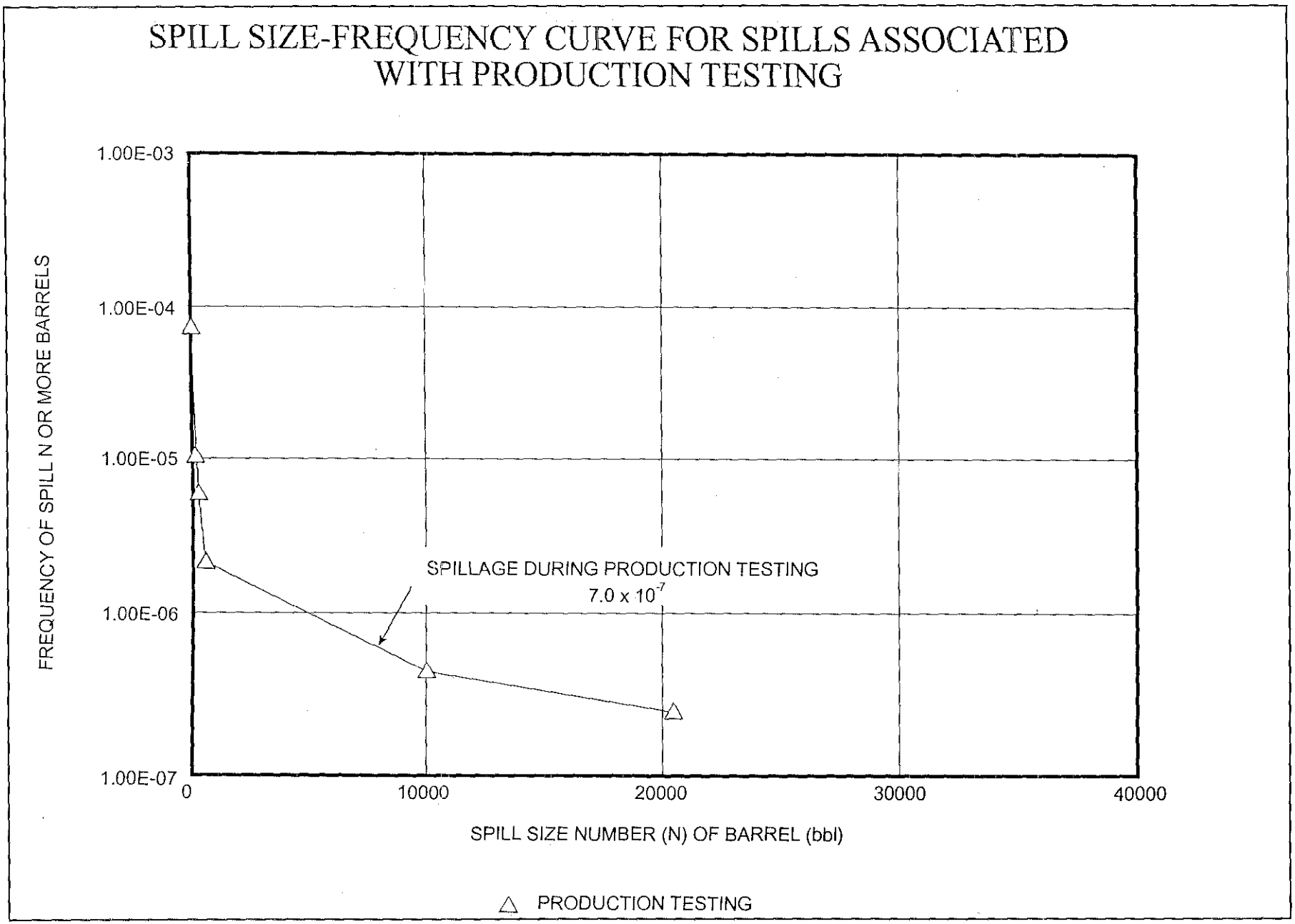


Figure 5. Spill size-frequency curve for spills associated with production testing.

The probability for a spill of 2 500 L of diesel during handling for the 44 day program is therefore 2.7 x 10^{-3}. The proponent has stated that the actual number of refuellings will range between 3 - 6 and will be dependent on the rig used.

A summary of the four spill scenarios, and the primary risk estimates for each scenario, are summarised in Table 4 below.

Table 4. Possible spill scenarios for primary risk from drilling operations.

Spill type	Spill volume	Primary probability (25 day program: one well)	Primary probability (44 day program: two wells)
Blowout	600 000 L crude oil	5.0 x 10^{-5}	7.5 x 10^{-5}
Support vessel fuel tank rupture	80 000 L diesel	7.0 x 10^{-5}	7.0 x 10^{-5}
Production test spillage	8 000 L crude oil	7.0 x 10^{-7}	7.0 x 10^{-7}
Rig refuelling accident	2 500 L diesel	9.0 x 10^{-4}	2.7 x 10^{-3}

Submissions

A number of submissions received by the EPA raised concerns regarding the potential for hydrocarbon spills and the affect such spills may have on the sensitive environments in the vicinity of the well. Impacts on the Ningaloo Marine Park and the Muiron Islands were of particular concern. Concerns were also raised regarding any future plans to develop a production well at this location should hydrocarbons be found in commercially viable quantities.

The adequacy of spill trajectory modelling, and field validation, was also raised in submissions. Specifically, it was considered that the length of time that validation tests were carried out was not adequate, and that modelling undertaken by the proponent was not carried out for all weather conditions (the possibility of cyclones during drilling was raised).

It was also considered that the use of closed chamber production testing should be examined to attempt to reduce hydrocarbon spills associated with fallout and to limit atmospheric emissions.

Assessment

The area considered for assessment of this factor is the area encompassing the Exmouth Gulf region, Ningaloo Marine Park, Muiron Islands and Sunday Island (Figure 1).

The EPA's objective in regard to this environmental factor is to ensure that the risk of spillage is extremely low, that actions are taken to reduce identified risks, and that drilling operations and equipment are at the level of international best practice for drilling in environmentally sensitive areas.

Primary risk

The primary risk probabilities calculated by DNV for four spill scenarios are given in Table 4 above. The data in this table indicates that the risk of small diesel spills occurring during refuelling is relatively low (2.7×10^{-3} for a spill of 2 500 L over 44 days), and the risk of larger spills is extremely low (7.5×10^{-5} for a blowout resulting in 600 000 L of crude oil and 7.0×10^{-5} for a fuel tank rupture resulting in 80 000 L of diesel over 44 days). Secondary probabilities, short and long term consequences for the four spill scenarios are discussed below in Section 3.6: Ningaloo Marine Park/Muiron Islands.

Management measures

These primary probability calculations do not take into account the management measures which the proponent will implement to minimise the potential for each of the above spill scenarios to occur. These management measures would therefore be expected to reduce the probability of spills occurring. The proponent must comply with safety and environmental conditions relating to the drilling of Chelonia-1 and -2 set by DME. The proponent has also outlined a number of additional risk reduction measures which will be implemented during the drilling of Chelonia-1 and -2. DME conditions and proponent's commitments include:

- engineering of well design in excess of conditions encountered in the region;
- four Blow Out Preventers (BOPs) will be used;
- drilling fluids will be the correct weight for reservoir pressures;
- there will be routine pressure testing of BOPs and casing;
- trained personnel will be used on the oil rig;
- design of an Oil Spill Contingency Plan approved by the DME and DEP (commitment 4);
- oil spill equipment will be on standby at the rig at all times (commitment 5);
- an oil spill response exercise will be carried out (commitment 6); and
- methods used for production testing will reduce the risk of crude oil fallout during testing (commitment 8).

In line with procedures adopted during the Wonnich drilling programs, the EPA considers that the proponent should also implement the following additional management measures:

- prior to commencement of drilling, the proponent shall prepare a written prescription for contractor work practices covering drilling and support vessel operation to ensure that work practices are carried out at the level of international best practice; and
- to avoid the potential for hydrocarbon fall-out and smoke plumes, the proponent shall not carry out burning or flaring of hydrocarbons when production testing.

Summary

The EPA notes that the proposed drilling location is in close proximity to sensitive environments, including the Ningaloo Marine Park and the Muiron Islands. The EPA recognises that there is public concern regarding the potential impacts that an operation of this type may have on these environments, and is aware of the public perception that such a proposal is likely to result in an oil spill.

Having particular regard to:

- the fact that a large hydrocarbon spill is considered extremely low;
- the fact that, should a hydrocarbon spill occur, it is likely to be of small volume only;
- the fact that operational measures to minimise the potential for spills will be utilised during drilling;
- that fact that DME will set safety and environmental conditions which must be met by the proponent; and
- the proponent's commitments to minimise the likelihood of a spill (commitment 7 and 8),

it is the EPA's opinion that the proposal can be managed such that it is highly unlikely that the EPA's environmental objective for hydrocarbons (from spills) would be compromised, provided that the additional management measures recommended by the EPA, as outlined above, are implemented, provided that:

- prior to commencement of drilling, the proponent shall prepare a written prescription for contractor work practices covering drilling and support vessel operation to ensure that work practices are carried out at the level of international best practice; and
- to avoid the potential for hydrocarbon fall-out and smoke plumes, the proponent shall not carry out burning or flaring of hydrocarbons when production testing.

The EPA acknowledges that, even with the management measures outlined above, the risk of a large oil or diesel spill, however small that risk might be, always remains. The impact that such a spill may have on the sensitive environments in the vicinity of the well is discussed in Section 3.6: Ningaloo Marine Park/Muiron Islands.

3.3 Drilling fluids

Description

Drilling fluids are used during the drilling of wells in order to maintain appropriate viscosity in the well and to ensure drill cuttings are brought to the surface. The proponent has outlined that water based drilling fluids are proposed to be used with the exception of the 12¼" section of the wells where Petrofree (a low toxicity ester-based fluid) will be used. Petrofree is readily degradable under aerobic and anaerobic conditions and exhibits low toxicity to marine organisms (Apache Energy, 1998). No chemically based drilling fluids will be used for the drilling of the initial hole: only seawater (90%) and clay (10%) will be used in this section.

It is proposed to discharge water-based fluid down the annulus. Petrofree fluid will be recycled for reuse. Should no lost circulation zone be encountered, it is proposed to discharge residual drilling fluids into the sea rather than down the annulus.

The potential for spills of drilling fluids has also been given consideration, and the proponent has undertaken modelling to determine the trajectory of Petrofree spills.

Risk assessment

Two drilling fluid spill scenarios were considered for trajectory modelling: spills of 90 m^3 and 5 000 m^3. The risk of a spill occurring has not been determined due to insufficient data (Apache Energy, 1998).

The Petrofree spill modelling for both spill scenarios predicts that the bulk of the material would settle out fairly rapidly, while the lighter particles may remain in the water column for up to 24 hours and travel up to 12 km from the well. The heaviest concentrations are predicted to accumulate on the seafloor up to 5 km from the well.

During summer, the Petrofree trajectory is predicted to move north-east and away from Ningaloo Marine Park. Results of modelling has indicated that shallow areas surrounding South Muiron Island may be contacted under some model trajectories.

Submissions

Concerns were raised about the possibility of a drilling fluid spill affecting the Ningaloo Reef and the coral and rocky shore communities of the Muiron Islands. It was considered that the methodology used in the simulations of a Petrofree spill is not statistically robust and is likely to miss the worst case scenario.

It was also considered that the proponent had not adequately dealt with disposal of drilling fluids and cuttings, in particular if no lost circulation zone is encountered.

Assessment

The area considered for assessment of this factor is the area encompassing the Exmouth Gulf region, Ningaloo Marine Park, Muiron Islands and Sunday Island (Figure 1).

The EPA's objective in regard to this environmental factor is to ensure that the probability of spillage is extremely low, that actions are taken to reduce identified risks, and that drilling operations and equipment are at the level of international best practice for drilling in environmentally sensitive areas.

Drilling fluids have the potential to contaminate the environment in the vicinity of the proposed well through routine drilling operations and through spills.

The proponent has outlined that water-based drilling fluids and Petrofree, a low toxicity ester-based fluid, will be used to facilitate drilling. Apache Northwest proposes to discharge water based drilling fluids down the annulus and recycle Petrofree for reuse. In the event that no lost circulation zone is encountered, it is proposed to discharge water based drilling fluids to the sea.

Risk assessment

Secondary risk

The trajectory of spills of Petrofree have been estimated by the proponent using computer modelling. This modelling indicates that, for both small and large (90 m^3 and 5 000 m^3) spills of Petrofree, while heaviest concentrations are predicted to accumulate on the seafloor within 5 km of the well, lighter particles may remain in the water column for up to 24 hours and travel up to 12 km from the well. During summer, the Petrofree trajectory is predicted to move towards the Muiron Islands, and during winter, into the Ningaloo Marine Park. It is proposed to drill the Chelonia well during summer to reduce the potential risks to the Ningaloo Marine Park.

Given that the South Muiron Island coral reefs, intertidal platforms and shoreline are approximately 4 km from the drilling site (Figure 1), either a small or large Petrofree spill is likely to result in heavy concentrations of Petrofree on the seafloor. Lighter particles of Petrofree may reach coral reefs, intertidal platforms and shorelines of the Ningaloo Marine Park.

Consequences

Petrofree is composed of approximately 35% by weight of various solid, inert materials (Apache Energy, 1998). The main impacts associated with Petrofree spillage are therefore likely to be as a result of increased turbidity and sedimentation. Additionally, the CER outlines that Petrofree will biodegrade rapidly, which may result in localised increases in biological oxygen demand (BOD).

As outlined above, the coral reefs, intertidal platforms and shorelines of the South Muiron Island are likely to receive heavy concentrations of Petrofree in the event of a spill. Potential impacts of such heavy concentrations of Petrofree include smothering of benthic marine organisms (bottom dwelling marine life) such as corals and sponges, which is likely to result in increased mucous formation and potentially death.

Where high concentrations of Petrofree occur, biodegradation may result in increased BOD. Any significant increase in BOD over an area of water is likely to result in fatality of marine organisms, particularly more immobile fauna such as molluscs.

Lighter concentrations of Petrofree may reach the coral reefs, intertidal platforms and shorelines of the Ningaloo Marine Park, which are approximately 12 km from the proposed drilling site. Impacts of Petrofree in low concentrations are likely to be limited to localised increase in turbidity. The low concentrations of Petrofree which may reach these sensitive habitats is considered unlikely to result in significant impacts.

Management measures

Management measures and operational procedures that the proponent has outlined will be implemented to reduce the potential for spills of drilling fluids include:

- workboats and rig properly prepared for Petrofree;
- all hoses pressure rated and tested;
- non-return valves fitted;
- mud tank area bunded;
- continuous fluid volume monitoring; and
- rig and vessel audits to ensure proper equipment and practices.

Given the proximity of the wells to the Ningaloo Marine Park, the EPA considers that, in addition to the management measures outlined above, the proponent should develop contingency plans for alternative disposal of drilling wastes off-site in the event that disposal of drilling wastes to the lost circulation zone is not possible.

Summary

The EPA notes that Apache Northwest considers that the approach taken to estimate the trajectories of drilling fluids is the most rigorous currently available.

Having particular regard to:

- the fact that water-based fluid will be used with the exception of the $12^{1}/_{4}$" section of the wells, where Petrofree (an ester-based fluid) will be used;
- the fact that Petrofree is biodegradable with low toxicity;
- the fact that results of trajectory modelling indicate that relatively light sedimentation loads would reach the Ningaloo Marine Park;
- the fact that the proponent has developed transfer and handling procedures to reduce the risk of a Petrofree spill; and

- the proponent's commitment that all endeavours will be made to dispose of excess drilling fluid down the annulus (commitment 9),

it is the EPA's opinion that the proposal can be managed to meet the EPA's objective for drilling fluids, provided that the additional management measure recommended by the EPA, as outlined above, is implemented.

3.4 Drill cuttings

Description

The proponent has outlined that, during drilling of the initial hole, drill cuttings (rock chips produced during drilling) are unconstrained by casing and will be deposited on the seabed adjacent to the well. The maximum volume of cuttings which will require discharge to the seabed is estimated to be approximately 16 m^3, which will consist of tertiary sediments of mostly gravel size. The proponent intends to dispose of remaining drill cuttings down the annulus to the lost circulation zone. Should no lost circulation zone be encountered, total drill cuttings will be deposited on the seabed. Total volumes of cuttings are estimated to be approximately 450 m^3 and 350 m^3 for Chelonia-1 and -2 respectively.

Deposition of cuttings onto the seabed may result in increased turbidity and localised smothering of nearby benthic communities. Such impacts are likely to increase as the volume of drill cuttings increases. The proponent has advised that the seabed in the vicinity of the Chelonia wells is predominantly bare substrate with scattered marine fauna such as sponges as seapens, and is therefore unlikely to be significantly impacted by disposal of cuttings.

Submissions

Concerns were raised that the proponent has not adequately dealt with disposal of drill cuttings, particularly if no lost circulation zone is encountered. It is considered that the potential for creation of a mound or plume from the cuttings may adversely affect the marine environment, particularly the Ningaloo Marine Park, which is approximately 100 m from the drilling location. It is considered that further evaluation of the area to be affected by the disposal of cuttings to the seabed should be undertaken should this method of disposal be considered.

Furthermore, it is noted that a robust assessment of the probability of annular disposal being possible is not provided.

Assessment

The area considered for assessment of this factor is the area encompassing the Exmouth Gulf region, Ningaloo Marine Park, Muiron Islands and Sunday Island (Figure 1).

The EPA's objective in regard to this environmental factor is to ensure that drill cuttings created by drilling do not adversely affect the surrounding environment.

As outlined above, the disposal of drill cuttings to the seafloor will be restricted to the drilling of the initial hole. Remaining drill cuttings are then proposed to be discharged down the annulus to the lost circulation zone. Should no lost circulation zone be encountered, the total volume of drill cuttings will be deposited onto the seabed.

The proponent has outlined that studies of previous drilling operations in Exmouth Gulf, when cuttings were deposited on the seafloor, identified only very localised and short-lived changes in the sediment biota. Additionally, information gained from the disposal of 443 m^3 of cuttings to the seabed from the adjacent Loggerhead-1 well indicates that cuttings are expected to rapidly disperse due to the fast water currents that flow over the area.

The EPA notes that disposal of total cuttings from the adjacent Loggerhead-1 well appeared to rapidly disperse. However, it is acknowledged that deposition of cuttings to the marine environment may result in increased localised turbidity and smothering of seafloor fauna, with mortality increasing with mound thickness.

Although the proponent has made a commitment (commitment 9) that every endeavour will be made to dispose of drill cuttings down the annulus into the lost circulation zone, it is recognised that a lost circulation zone may not be encountered and that cuttings may be deposited onto the seafloor. Given the proximity of the drilling location to the Ningaloo Marine Park and the Muiron Islands, the EPA considers that disposal of cuttings in this manner is not acceptable. The EPA considers that, prior to commencement of drilling operations, the proponent should develop contingency plans for alternative disposal of cuttings in the event that disposal to the annulus is not possible.

Summary

Having particular regard to:

- the proponent's commitment that all endeavours will be made to dispose drill cuttings and excess drilling fluid down the annulus (commitment 9);
- the fact that the seabed in the vicinity of the wells is largely bare substrate; and
- the fact that disposal of cuttings to the seabed during previous drilling in the Exmouth Gulf has resulted in only localised and temporary changes in sediment biota. Furthermore, cuttings were found to rapidly disperse,

it is the EPA's opinion that the proposal can be managed to meet the EPA's objective for drill cuttings provided that, prior to the commencement of drilling, the proponent develops contingency plans for alternative disposal of drill cuttings in the event that disposal of drill cuttings to the lost circulation zone is not possible

3.5 Other operational discharges

Description

Other operational discharges associated with the drilling of the Chelonia wells include deck drainage, waste oily water and waste oil, domestic wastes, sewage, paper, scrap steel and metal, and packaging and atmospheric emissions.

The proponent has outlined that oily discharges will be collected via a closed drainage system and treated to statutory limits. Treated water will then be discharged to sea. Waste oil will be collected and removed for recycling.

Sewage will undergo tertiary treatment using an activated-sludge sewage treatment plant which macerates, partially digests and sterilises the sewage before discharge to the ocean. It is estimated that 35 m^3 will be discharged per day. Kitchen, shower and laundry waste water (grey water) will be discharged directly overboard. Organic kitchen wastes will be macerated and disposed offshore. It is estimated that approximately nine litres of wastes will be produced per day (Apache Energy, 1998).

The CER outlines that putrescibles and burnable materials will be disposed of onshore and solid wastes will go to a landfill or be recycled.

Submissions

Concerns were raised in public submissions as to the likelihood of produced formation water impacting on the marine environment.

Assessment

The area considered for assessment of this factor is the area encompassing the Exmouth Gulf region, Ningaloo Marine Park, Muiron Islands and Sunday Island (Figure 1).

The EPA's objective in regard to this environmental factor is to ensure that operational discharges associated with the project do not adversely affect the surrounding environment.

Inappropriate disposal of wastes associated with drilling proposals may result in the contamination of the marine environment. Given that sewage will undergo tertiary treatment and that oily waste water will be collected and treated to below statutory limits prior to discharge, the EPA considers that it is unlikely that disposal of these operational discharges will affect the surrounding environment. Given the small volume of macerated organic kitchen wastes that will be generated during the drilling proposal, and the fact that these discharges will be intermittent, the EPA considers that disposal of these wastes is also unlikely to significantly impact the marine environment.

The proponent has outlined that the drilling program is likely to extend through the layer of formation water that may be present in the reservoir, however, no formation water will come to the surface as drilling fluid will create a pressure greater than the reservoir pressure. This will keep all hydrocarbons and formation water within the reservoir and therefore no formation water will be discharged into the marine environment.

The EPA notes that the Chelonia wells fall within the 12 nautical mile limit imposed by the Petroleum (Submerged Land) Act for disallowing the disposal of food scraps and sanitary effluent. The EPA understands that the proponent may gain specific approval for discharge of tertiary treated sewage and <25 mm organic wastes from DME.

Having particular regard to:

- the fact that oily water will be collected, separated and treated, and oil will then be removed for recycling and waste water will be discharged to the sea;
- the fact that sewage will undergo tertiary treatment prior to discharge to the sea;
- the proponent's commitment to conduct a debris survey at the completion of the drilling to confirm that no debris has been left on the seafloor (commitment 10); and
- the fact that no formation water will be discharged

it is the EPA's opinion that the proposal can be managed to meet the EPA's objective for other operational discharges, provided that the proponent gains approval from the DME for the offshore disposal of treated sewage and organic kitchen wastes.

3.6 Ningaloo Marine Park / Muiron Islands

Description

The Ningaloo Marine Park was gazetted in 1987. Values of the Ningaloo Reef include high biodiversity, unique biophysical attributes and scientific, tourism and educational values (Marine Park Working Group, 1983). The principle aim of the Park is to provide for conservation of the marine environment with recreational use to the extent that it is compatible with conservation of its natural environment (Department of Conservation and Land Management (CALM), 1989).

Similar values exist in the area surrounding the Muiron Islands, which are C class nature reserves. The Report of the Marine Parks and Reserves Selection Working Group (the 'Wilson Report') recommends that an area of waters encompassing the Muiron and Sunday Island group be considered for reservation (Marine Parks and Reserves Selection Working Group, 1994).

In the event of a spill, the type of material spilled (crude oil, condensate or diesel), size of spillage, season, prevailing weather and sea conditions and effectiveness of oil spill contingency measures will determine the extent of impact upon marine flora and fauna, marine water quality, coral reefs, shorelines and tidal habitats.

Sensitive habitats

Significant habitats which exist in the Ningaloo Marine Park (including the North West Cape) and the Muiron Islands include coral reef communities, shorelines and intertidal and shallow subtidal zones (Figure 1.). In addition to these sensitive habitats, the area of the Ningaloo Marine Park and Muiron Islands also supports a number of significant wildlife species, such as many turtle species, dugongs, dolphins and the seasonally present humpback whale, whale sharks and seabirds.

Coral reef communities

The proposed drilling rig location is in an area of bare substrate with scattered seafloor fauna, devoid of coral reefs. The nearest coral communities in the vicinity of the proposed Chelonia wells include reefs around the Muiron Islands (NNE 4 km) and Ningaloo Reef (including Bundegi Reef; SW 12 km). Less developed coral communities occur at Sunday Island.

Coral spawning occurs synchronously on the Ningaloo Reef and other reefs of the northwest shelf, and takes place 7 - 10 nights after the full-moon in March and April. The EPA is advised that coral spawning in 1999 will occur over 9 - 11 March and 7 - 10 April (Andrew Heywood, Australian Institute of Marine Science, *pers comm*).

Shorelines

The sandy beaches of the Muiron Islands and in the vicinity of Cape Vlaming on the North West Cape are important breeding areas for loggerhead, green and hawksbill turtles. The Muiron Islands are considered to be an internationally important breeding area for the loggerhead turtle (Dr R Prince, CALM, *pers comm*). The loggerhead turtle is listed under Schedule 1 (fauna rare or likely to become extinct) of the Wildlife Protection Act 1950, and as endangered under the Commonwealth Endangered Species Act 1992. The green and hawksbill turtles are not listed under the Wildlife Protection Act but are listed nationally as vulnerable and internationally (by the World Conservation Union) as endangered. The green, hawksbill and loggerhead turtles are also protected under the Convention on the Conservation of Migratory Species of Wild Animals (the Bonn Convention), to which Australia is a signatory (EPA, 1997).

The Muiron Islands are significant feeding areas for many species of seabirds and shorebirds, and are important nesting sites for the wedge-tailed shearwater (Apache Energy, 1998). Migratory species, which are most abundant in summer and autumn, include the Wedge-tailed shearwater and nine other migratory bird species which are protected under the China-Australia Migratory Bird Agreement and/or the Japan-Australia Migratory Bird Agreement (Apache Energy, 1998). Resident bird species include the eastern reef heron, the white-bellied sea eagle, the osprey and the oystercatcher (Apache Energy, 1998).

Intertidal and shallow subtidal zones

Intertidal and shallow subtidal zones are important habitats for macroalgal (seaweed) communities. Intertidal and shallow subtidal zones surround much of the Muiron Islands (NNE 4 km), and the North West Cape (SW 12 km). The macroalgal communities surrounding the Muiron Islands are likely to be important feeding areas for green turtles.

Potential impacts on sensitive habitats

The proposal has the potential to impact upon sensitive marine environments through hydrocarbon and drilling fluid spills. The potential impacts of drilling fluids and drill cuttings are discussed above in Sections 3.3 and 3.4 respectively.

The potential for hydrocarbon spills to impact on sensitive marine habitats is considered to be the key aspect to this proposal. Risk assessment methods and the probability of hydrocarbon spills occurring (primary risk) are outlined in Section 3.2 above. The potential for such spills to contact sensitive habitats, and the consequences of such contact are discussed in this section.

The size of spillage, type of oil, extent of oil weathering, season, prevailing conditions and oil spill recovery effectiveness will determine the extent of impact upon marine flora and fauna, marine water quality, reefs, shorelines and tidal habitats.

The proponent used the Apache GCOM3D/Oilmap current and oil spill computer modelling system to predict the probability that hydrocarbon spills would reach environmentally sensitive areas. The GCOM3D model was used to simulate currents based on regional wind data and tide conditions. Oilmap was then used to calculate probability contours for the transport of hydrocarbons under four different spill scenarios. The four spill scenarios and the probability that these spills could occur (primary probability) are outlined above in Section 3.2: Hydrocarbons (from spills). The modelling involved generating a number of individual simulated spill events (100 for each scenario), with each spill starting at a randomly selected date and time and running over a four day period. The proponent carried out field validation to verify the modelling results. At the request of the EPA, further field validation was undertaken by the proponent and was included in the CER document. Further details of the model used and the validation results are given in the proponent's CER document.

The probability contours for the four spill scenarios under winter conditions are illustrated in Figures 6a to 6d and for summer conditions in Figures 7a to 7d. These figures show the number of times oil contacted each location in the 100 simulated spill events (percentage), and indicate that spills are more likely to impact upon the Muiron Islands during summer and the Ningaloo Marine Park/North West Cape during winter.

The proponent has calculated the overall probability of a spill occurring and contacting a sensitive resource using the probability of contacting locations if spilled (as illustrated by the probability contours) combined with the primary probability of a spill occurring.

The overall probability of a spill occurring and contacting a sensitive resource has been calculated for the drilling of one and two wells (25 day and 44 day drilling program respectively) for both summer and winter conditions. These calculations are summarised in Table 5 below.

Submissions

A number of submissions raised concerns regarding the potential impacts of spills on the Ningaloo Marine Park and the Muiron Islands. Submissions considered that the risk of hydrocarbons reaching the Muiron Islands (and Sunday Island) in summer are unacceptable. The fact that the Muiron Islands are recommended for marine conservation (Wilson Report) was raised in a number of submissions.

One submission argues that the 'consequences' or relationship between volume of oil reaching the shorelines and associated impact has not been adequately dealt with. Furthermore, it was considered that the categorisation of the "consequences" of a spill are based on arbitrary timelines. The recovery times may not be in conformance with community views or those of authorities responsible for the Ningaloo Marine Park.

The use of closed chamber production testing (to prevent oil spillage and plumes of smoke from combustion of oil) was raised.

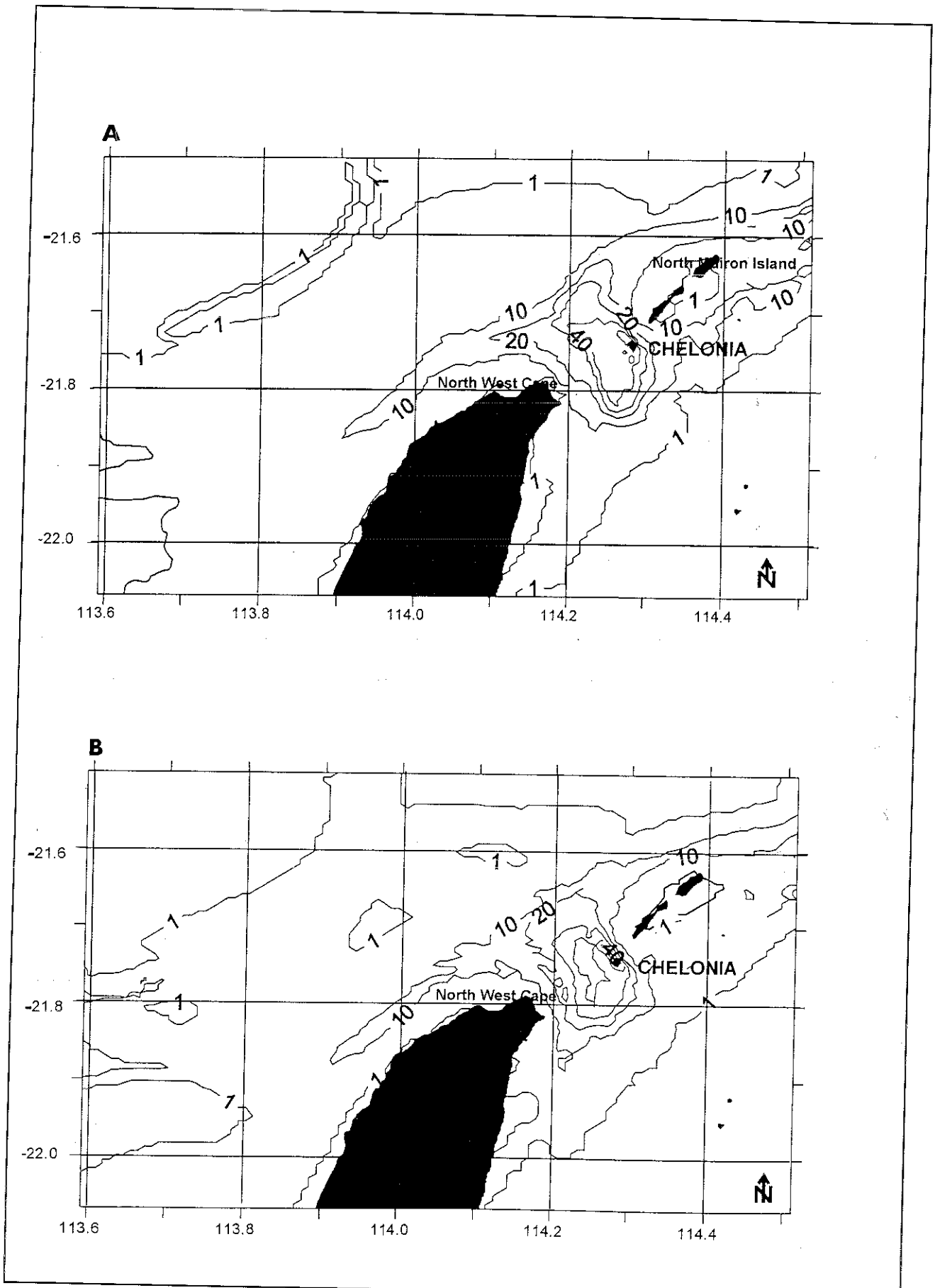


Figure 6. (a) Probability contours for a 2 500 L spill of diesel during winter, (b) Probability contours for a 8 000 L spill of crude oil during winter..

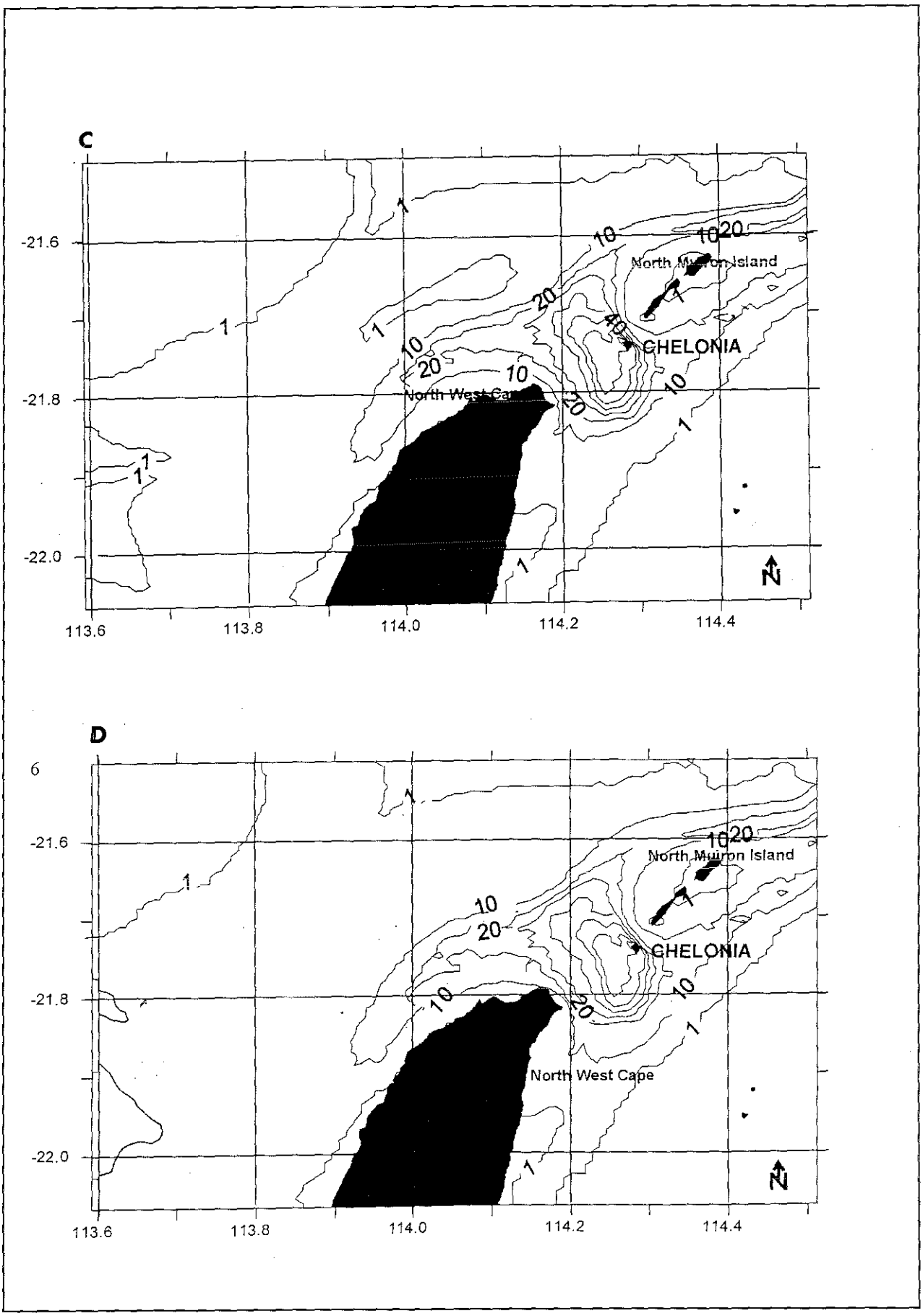


Figure 6. (c) Probability contours for a 80 000 L spill of diesel during winter, (d) Probability contours for a 600 000 L spill of crude oil during winter..

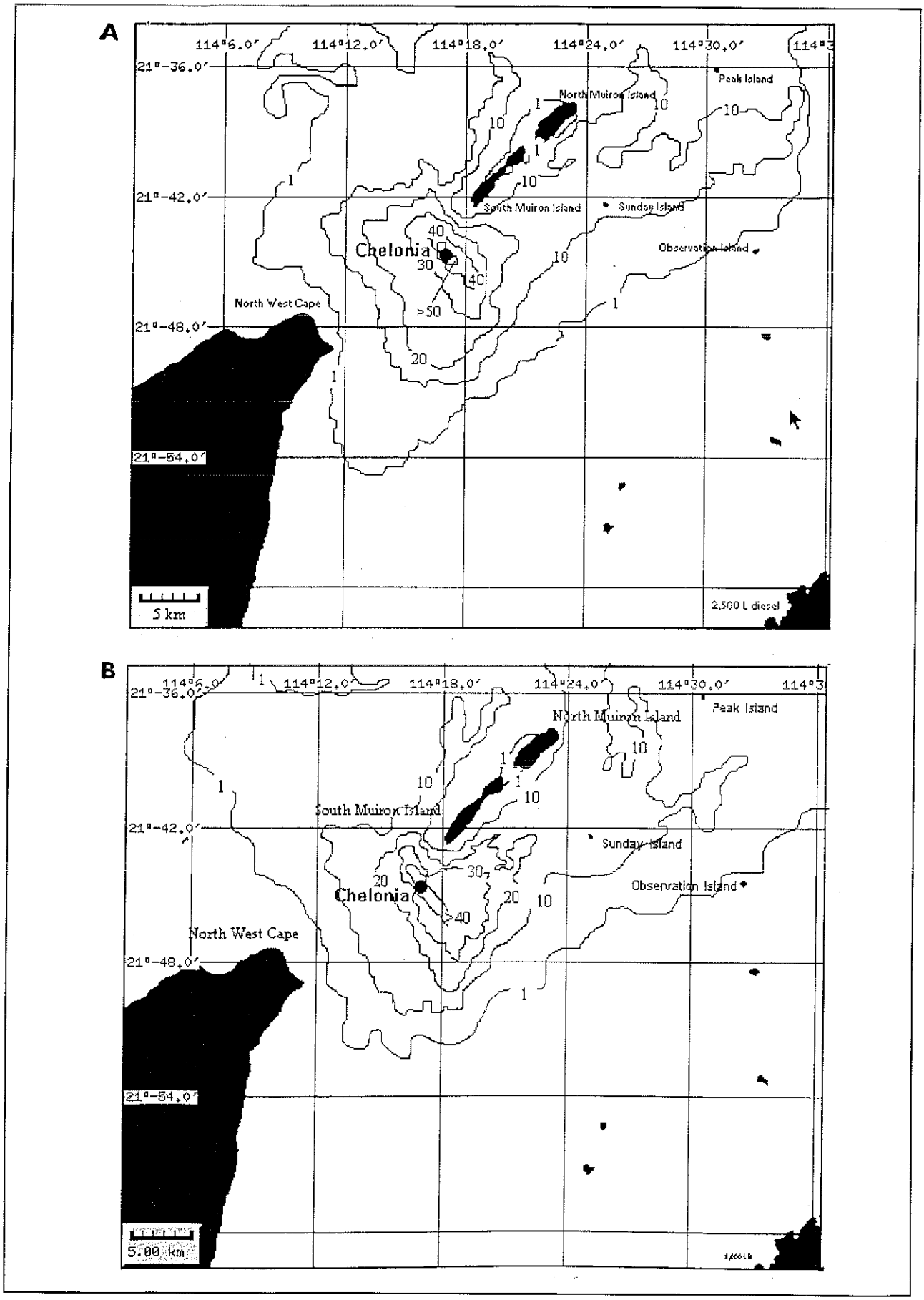


Figure 7. (a) Probability contours for a 2 500 L spill of diesel during winter, (b) Probability contours for a 8 000 L spill of crude oil during summer.

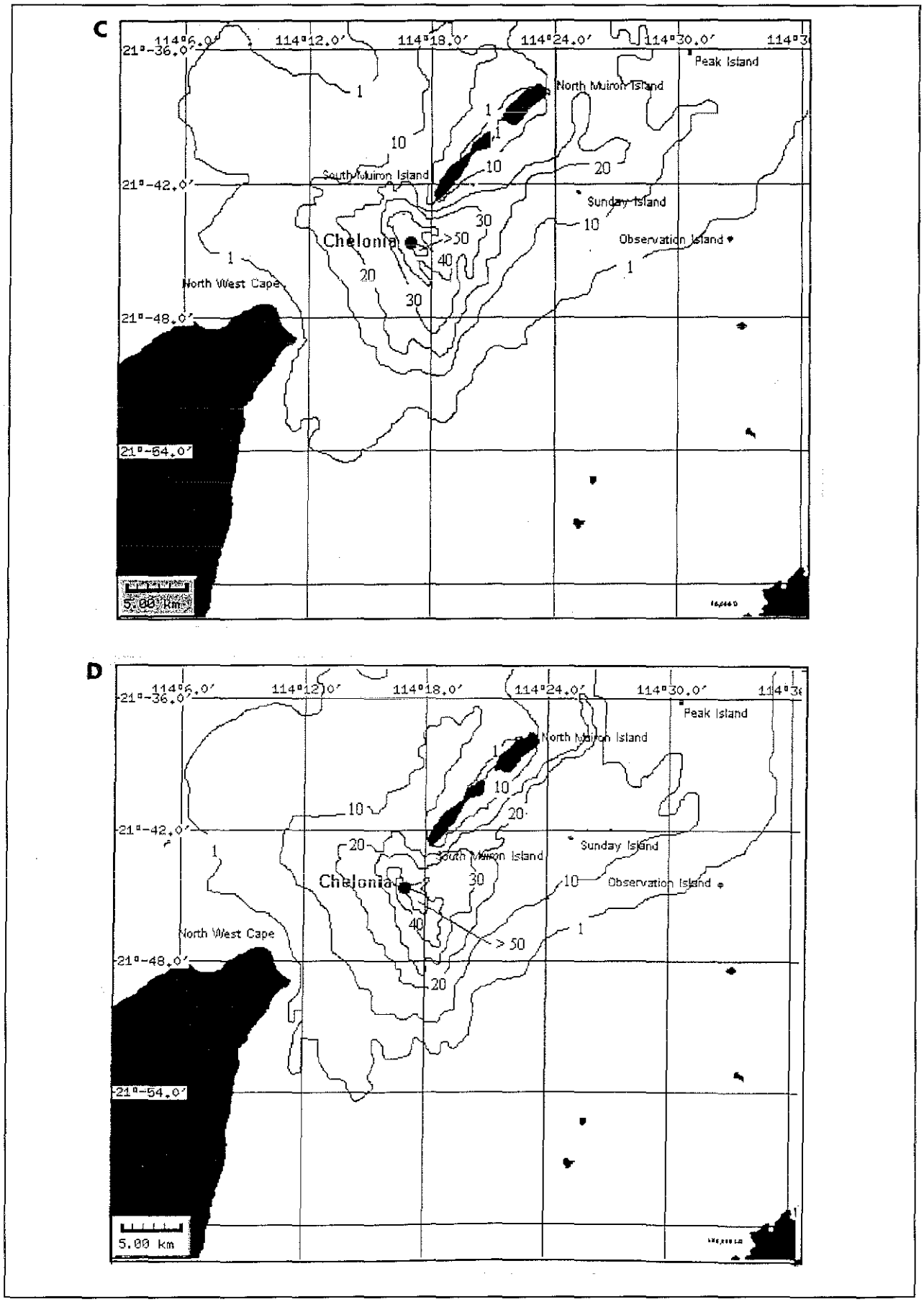


Figure 7. (c) Probability contours for a 80 000 L spill of diesel during winter, (d) Probability contours for a 600 000 L spill of crude oil during summer.

Table 5. Probability of contacting sensitive resources if spilled

Spill type/ volume	Primary probability (one well - 25 days)	Primary probability (two wells- 44 days)	Probability of contact if spilled - summer	Probability of contact if spilled - winter	Overall probability of contact - summer (one well - 25 days)	Overall probability of contact - winter (one well - 25 days)	Overall probability of contact - summer (two wells - 44 days)	Overall probability of contact - winter (two wells - 44 days)
Blowout 600 000 L crude oil	5.0×10^{-5}	7.5×10^{-5}	South Muiron Is: 1.3×10^{-1} North Muiron Is: 6.0×10^{-2} Pt Murat: no contact	South Muiron Is: 6.0×10^{-1} North Muiron Is: 7.0×10^{-1} Pt Murat: 1.0×10^{-1}	South Muiron Is: 6.5×10^{-6} that a max of 16 565 L will contact within a min time of 20 hrs. North Muiron Is: 3.0×10^{-6} that a max of 11 700 L will contact within a min time of 21 hrs. Pt Murat: $<5.0 \times 10^{-7}$ no contact recorded.	South Muiron Is: 3.0×10^{-5} that a max of 4 698 L will contact within a min time of 29 hrs. North Muiron Is: 3.5×10^{-5} that a max of 10 647 L will contact within a min time of 41 hrs. Pt Murat: 5.0×10^{-6} that a max of 26 716 L will contact within a min time of 15 hrs.	South Muiron Is: 9.8×10^{-6} North Muiron Is: 4.5×10^{-6} Pt Murat: no contact	South Muiron Is: 4.5×10^{-5} North Muiron Is: 5.2×10^{-5} Pt Murat: 7.5×10^{-6}

Spill type/ volume	Primary probability (one well - 25 days)	Primary probability (two wells- 44 days)	Probability of contact if spilled - summer	Probability of contact if spilled - winter	Overall probability of contact - summer (one well - 25 days)	Overall probability of contact - winter (one well - 25 days)	Overall probability of contact - summer (two wells - 44 days)	Overall probability of contact - winter (two wells - 44 days)
Support vessel fuel tank rupture 80 000 L diesel	7.0×10^{-5}	7.0×10^{-5}	South Muiron Is: 8.0×10^{-2} North Muiron Is: 3.0×10^{-2} Pt Murat: no contact	South Muiron Is: 6.0×10^{-2} North Muiron Is: 1.0×10^{-2} Pt Murat: 5.0×10^{-2}	South Muiron Is: 5.6×10^{-6} that a max of 11 351 L will contact within a min time of 21 hrs. North Muiron Is: 2.1×10^{-6} that a max of 5 959 L will contact within a min time of 40 hrs. Pt Murat: $<7.0 \times 10^{-7}$ no contact recorded.	South Muiron Is: 4.2×10^{-6} that a max of 14 547 L will contact within a min time of 36 hrs. North Muiron Is: 7.0×10^{-7} that a max of 1 032 L will contact within a min time of 41 hrs. Pt Murat: 3.5×10^{-6} that a max of 13 558 L will contact within a min time of 25 hrs.	South Muiron Is: 5.6×10^{-6} North Muiron Is: 2.1×10^{-6} Pt Murat: no contact	South Muiron Is: 4.2×10^{-6} North Muiron Is: 7.0×10^{-7} Pt Murat: 3.5×10^{-6}

Spill type/ volume	Primary probability (one well - 25 days)	Primary probability (two wells- 44 days)	Probability of contact if spilled - summer	Probability of contact if spilled - winter	Overall probability of contact - summer (one well - 25 days)	Overall probability of contact - winter (one well - 25 days)	Overall probability of contact - summer (two wells - 44 days)	Overall probability of contact - winter (two wells - 44 days)
Production test spillage 8 000 L crude oil	7.0×10^{-7}	7.0×10^{-7}	South Muiron Is: 6.0×10^{-2} North Muiron Is: 2.0×10^{-2} Pt Murat: no contact	South Muiron Is: 7.0×10^{-2} North Muiron Is: 4.0×10^{-2} Pt Murat: 7.0×10^{-2}	South Muiron Is: 4.2×10^{-8} that a max of 1 355 L will contact within a min time of 15 hrs. North Muiron Is: 1.4×10^{-8} that a max of 336 L will contact within a min time of 44 hrs. Pt Murat: $<7.0 \times 10^{-9}$	South Muiron Is: 4.9×10^{-8} that a max of 821 L will contact within a min time of 28 hrs. North Muiron Is: 2.8×10^{-8} that a max of 170 L will contact within a min time of 49 hrs. Pt Murat: 4.9×10^{-8} that a max of 445 L will contact within a min time of 15 hrs.	South Muiron Is: 4.2×10^{-8} North Muiron Is: 1.4×10^{-8} Pt Murat: no contact	South Muiron Is: 4.9×10^{-8} North Muiron Is: 2.8×10^{-8} Pt Murat: 4.9×10^{-8}

Spill type/ volume	Primary probability (one well - 25 days)	Primary probability (two wells- 44 days)	Probability of contact if spilled - summer	Probability of contact if spilled - winter	Overall probability of contact - summer (one well - 25 days)	Overall probability of contact - winter (one well - 25 days)	Overall probability of contact - summer (two wells - 44 days)	Overall probability of contact - winter (two wells - 44 days)
Refuelling spill 2 500 L diesel	9.0×10^{-4}	2.7×10^{-3}	South Muiron Is: 4.0×10^{-2} North Muiron Is: 1.0×10^{-2} Pt Murat: no contact	South Muiron Is: 3.0×10^{-2} North Muiron Is: 5.0×10^{-2} Pt Murat: 4.0×10^{-2}	South Muiron Is: 3.6×10^{-5} that a max of 472 L will contact within a min time of 16 hrs. North Muiron Is: 9.0×10^{-6} that a max of 33 L will contact within a min time of 52 hrs. Pt Murat: $<9.0 \times 10^{-6}$ no contact recorded.	South Muiron Is: 2.7×10^{-5} that a max of 270 L will contact within a min time of 39 hrs. North Muiron Is: 4.5×10^{-5} that a max of 69 L will contact within a min time of 54 hrs. Pt Murat: 3.6×10^{-5} that a max of 110 L will contact within a min time of 25 hrs.	South Muiron Is: 1.1×10^{-4} North Muiron Is: 2.7×10^{-5} Pt Murat: no contact	South Muiron Is: 8.1×10^{-5} North Muiron Is: 1.4×10^{-4} Pt Murat: 1.1×10^{-4}

The DME questioned the validity of the environmental risk assessment methodology and specifically whether it accurately reflects the actual risk of drilling exploration wells in the North West Shelf area. DME believes the actual risks for drilling exploration wells offshore the North West Shelf are likely to be lower than the data presented in the CER.

A number of other concerns and questions were raised regarding the methods and parameters utilised in the risk assessment and modelling, including that the:

- effects of tropical cyclones were not considered;
- insensitivity of the risk contour results to the volume of spill; and
- GCOM3D model validation tests were queried.

Assessment

The area considered for assessment of this factor is the area encompassing the Exmouth Gulf region, Ningaloo Marine Park, Muiron Islands and Sunday Island (Figure 1).

The EPA's objective in regard to this environmental factor is to protect the conservation, educational and recreational values, biodiversity and ecosystem functions of Ningaloo Marine Park and the Muiron Islands.

Timing of drilling

A number of significant environmental 'events' occur in the North West Shelf area, including coral spawning, appearance of whale sharks, turtle breeding and humpback whale migration. These events follow an annual pattern, and the timing of each of these events is shown in Figure 8 below.

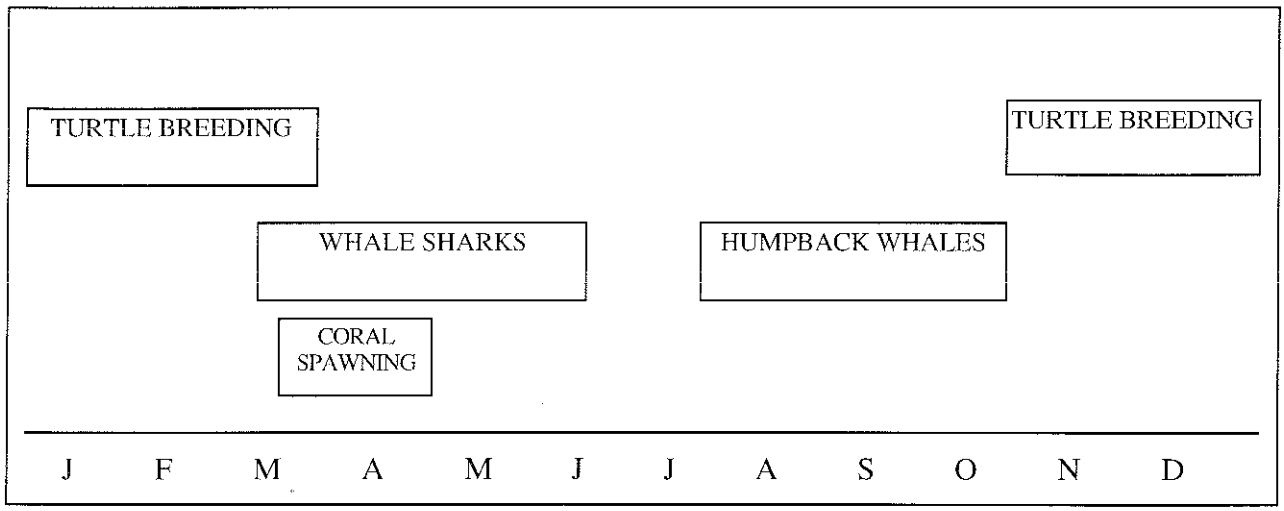


Figure 8. Timing of environmental 'events' on the North West Shelf.

As illustrated in Figure 8, the drilling of the Chelonia-1 and -2 wells is constrained by one or more of these environmental events at any time.

The results of risk assessment undertaken for this proposal, and summarised in table 5, indicate that the overall probability of contact with sensitive resources is generally higher in winter than in summer. This is particularly evident for Point Murat (Ningaloo Marine Park). Furthermore, trajectory modelling undertaken for the proposal predicts that, under summer conditions, spills would probably move towards the Muiron Islands and, under winter conditions, spills would probably move towards the Ningaloo Marine Park.

Apache Northwest proposes to drill during the summer months (1 November to 1 March) when the risk of spills impacting on the Ningaloo Maine Park is lowest. One of the main concerns in relation to a significant spill of either crude oil or diesel during summer is the potential for impacts on turtles and seabirds. During summer, the islands are an important breeding area for green and hawksbill turtles and are considered to be an internationally significant breeding area for the endangered loggerhead turtle. Additionally, the Muiron Islands are significant feeding areas for many species of seabirds and shorebirds, and are important nesting sites for the Wedge-tailed shearwater (Apache Energy, 1998). Migratory species, which are most abundant in summer and autumn, include the Wedge-tailed shearwater and nine other migratory bird species (Apache Energy, 1998).

Whilst the worse case scenario spills during summer may impact upon breeding turtles at the Muiron Islands, drilling during summer would avoid potential impacts on coral spawning, whale sharks and humpback whale migrations.

The proponent recognises that the area may be subject to cyclonic winds during summer months, however Apache has advised that, as required under DME regulations, a cyclone watch and preparation procedure will be in place and there will be complete shutdown of the drilling operation and isolation of the well in the event of a cyclone. Boats associated with the drilling rig would retreat to a safe harbour. Furthermore, the proponent has advised that the drilling rig is tested to ensure its integrity to resist severe weather conditions and impact loads, also as required under DME regulations.

Potential short-term consequences of a spill

General

As discussed above, Apache Northwest proposes to drill the Chelonia wells during summer when the risk of a spill contacting the Ningaloo Marine Park is reduced. This section therefore discusses the potential consequences of a spill in summer only.

As outlined above, the environmental values of the Muiron Islands include coral reef communities, intertidal platforms supporting macroalgal communities and sandy shorelines used for turtle and seabird nesting.

In general, the environmental impacts from an oil spill depend on a range of factors, including weather, sea and tide conditions; type of oil; toxicity of the oil; whether the oil is 'fresh', weathered or in a 'mousse' form; and the nature of the environment (IPIECA, 1992).

The exact characteristics of oil expected to be found at Chelonia are unknown, however, the proponent expects the oil to have characteristics similar to crude oil sampled from the adjacent Leatherback-1 well. Leatherback crude is a slightly weathered light crude with a high wax content (Apache Energy, 1998). Leatherback crude has depleted concentrations of monocyclic aromatic and polycyclic hydrocarbons (MAHs and PAHs), which are the compounds that contribute to the toxicity of oil (Apache Energy, 1998). Leatherback crude has a concentration of approximately 3% of MAHs and PAHs, as compared to lighter crudes such as Wonnich which contain 30-35%, and a small abundance of light end compounds, and can be regarded as slightly toxic to marine organisms (Apache Energy, 1998). PAH and MAH levels found in diesel are substantially higher than those found in Leatherback crude. Leatherback crude is also likely to form an oil-in-water emulsion (mousse), and form tar balls in a short time after contact with water (Apache Energy, 1998).

Given the characteristics of the crude oil expected to be encountered at the Chelonia site, the impacts of physical smothering from oil are likely to be more significant than impacts from the toxic components in the oil.

Potential impacts on coral reefs

According to the proponent's risk assessment modelling, the overall probability of contact during a 25 day drilling program (1 well) resulting from the worst case scenario (a blow-out resulting in a 600 000 L spill of crude oil) in summer is 6.5 x 10^{-6} that a maximum of 16 565 L will contact South Muiron Island within a minimum of 20 hours and 3.0 x 10^{-6} that a maximum of 11 700 L will contact North Muiron Island within a minimum time of 21 hours. The potential for contact with Point Murat is less than 5.0 x 10^{-7}, with no contact occurring during any of the model trajectories. Over the 44 day drilling program (2 wells) the probabilities of a blowout increase slightly to 9.8 x 10^{-6}, 4.5 x 10^{-6} and no contact for South Muiron Island, North Muiron Island and Point Murat respectively.

An 80 000 L diesel spill in summer would also result in significant amounts of diesel contacting the Muiron Islands. For both the 25 day and 44 day drilling programs, it is estimated that there is a probability of 5.6 x 10^{-6} that a maximum of 11 351 L will contact South Murion Island within a minimum time of 21 hours, and the probability of 2.1 x 10^{-6} that a maximum of 5 959 L will contact North Muiron Island within a minimum time of 40 hours. The potential for contact with Point Murat is less than 7.0 x 10^{-7}, with no contact occurring during any of the model trajectories.

The effects of oil pollution on corals may include sub-lethal effects involving tissue damage, growth and behavioural effects (Volkman et al, 1994). While severe acute impacts on coral reefs and the intertidal zone may occur if an oil spill reaches a reef exposed at low tide, generally there is little apparent damage to sub-tidal or submerged coral. However, impacts on other coral reef organisms, such as crustaceans and sea urchins may occur (IPIECA, 1992).

Seasonal factors must also be considered. Corals of Ningaloo Reef spawn synchronously 7 - 10 nights after the full moon in March and April. Recent experimental research indicates that coral spawn, which floats at the water surface, is sensitive even to very low concentrations of hydrocarbons (Harrison, 1994). Mass spawning of corals in 1999 is predicted to occur between 9 - 12 March (minor spawning event) and 7 - 10 April (major spawning event) (Andrew Heywood, Australian Institute of Marine Science, *pers comm*). The proponent has made a commitment to drill between 1 November and 1 March 1999 to avoid the mass spawning period (commitment 3).

The impact of a large oil or diesel spill on coral reefs surrounding the Muiron Islands and within the Ningaloo Marine Park would be dependent on the tide. There is likely to be significant impacts on the reefs if the oil or diesel contacted during low tide when the reefs are exposed. Less significant impacts are likely to occur if the reefs are covered by high water, however, there is likely to be substantial impacts as a result of breaking surf and oil and diesel dispersal into the water column.

Potential impacts on shorelines

As outlined above, large spills of oil (a blow-out resulting in a 600 000 L spill of crude oil) or diesel (tank rupture resulting in a 80 000 L diesel spill) are likely to result in significant quantities of hydrocarbons contacting the shorelines of the Muiron and Sunday Islands. Smaller volumes of hydrocarbons are likely to contact the shoreline of the North West Cape.

The proponent expects initial mortality of the fauna and flora which inhabit the shoreline through smothering and through the toxic effects of the hydrocarbons. Crude oil in a mousse form is expected to have the most significant smothering effect, while diesel is likely to prove most toxic to marine life.

The main concern in relation to contamination of sandy beaches from a significant spill of either crude oil or diesel is the potential for impacts on turtles and seabirds. As outlined above, the sandy beaches of the Muiron Islands and in the vicinity of Cape Vlaming on the North West Cape are important breeding areas for the loggerhead, green and hawksbill turtles. The Muiron Islands are considered to be an internationally important breeding area for the endangered loggerhead turtle (Dr R Prince, CALM, *pers comm*). Potential impacts on turtles include skin lesions; damage to eyes, mouth and respiratory tract; inhalation of volatile toxic fractions causing a narcotic effect; and oil ingestion causing organ damage, neurological disorders and irritation/destruction of intestinal linings (EPA, 1997).

The Muiron Islands are significant feeding areas for many species of seabirds and shorebirds (including migratory species during summer and autumn), and are important nesting sites for the Wedge-tailed shearwater (Apache Energy, 1998). Effects of hydrocarbon contamination on seabirds can include both lethal and sub-lethal effects. Birds could be impacted directly by contact with a spill, or indirectly by consuming fish or other prey contaminated with toxic components of a spill (Volkman et al, 1993). Sub-lethal effects may include impacts on reproduction. There is evidence that even a single dose of petroleum hydrocarbons ingested by a bird can result in altered yolk structure and reduced hatchability of eggs subsequently laid (Grau et al, 1977).

An oil spill may result in chronic (long term) contamination if oil becomes entrapped in fine sediments. Such entrapped oil may gradually release hydrocarbons over a period of months or years thereby causing ongoing pollution. A large diesel spill scenario may also result in chronic impacts from diesel fuel becoming entrapped in beach sand and seeping out over a prolonged period. Excavation and removal of sand would probably be required. Rocky shores are less susceptible to long term contamination due to the limited amount of sediment in which hydrocarbons could become entrapped and the higher wave energy which usually exists along rocky shores.

Potential impacts on intertidal and shallow subtidal zones

As outlined above, large spills of both oil and diesel are likely to result in significant quantities of hydrocarbons contacting the intertidal zone of the Muiron and Sunday Islands, and smaller volumes contacting the intertidal zone of the Ningaloo Marine Park (along the North West Cape). Should significant quantities of oil contact these areas, there would be lethal and sub-lethal impacts on the intertidal marine life.

The CER outlines that intertidal areas surrounding the Muiron and Sunday Islands and the North West Cape are dominated by limestone pavements supporting macroalgal communities and an assemblage of molluscs and crustaceans, limestone reefs supporting hard corals and areas of bare sand. As with coral reefs, severe acute impacts on the marine life of the intertidal zone may occur if an oil spill contacts the area at low tide. Macroalgae are susceptible to direct contact with oil, which causes death of the plant tissue. Fauna of the intertidal zone is expected to suffer high initial mortality and lowered community diversity, followed by a period of fluctuating community composition (Apache Energy, 1998).

The shallow subtidal zone is unlikely to be affected by a hydrocarbon spill, as it is unlikely that direct contact of oil with marine life would occur. However, should hydrocarbons disperse through the water column as a result of wave action (or use of dispersants), impacts on the biota of the shallow subtidal zone are likely to be similar to those impacts on the intertidal zone as described above.

Potential long-term consequences of a spill

General

The potential long-term consequences, including the potential for recovery (or quaternary risk) of a spill can only be estimated qualitatively. The rate of ecological recovery from an oil spill incident is affected by a number of factors, including the potential for 're-oiling' resulting from chronic contamination of sediments, the potential for toxic contamination of marine organisms and marine food chains, the ability of the ecosystem to recover from physical disturbances (such as cyclones) and the methods of oil spill clean-up (if any) applied (EPA, 1997).

The proponent has estimated the expected recovery times for a number of ecological 'resources', which are summarised in Table 14 of the CER document. The EPA considers that there is not enough information available to adequately predict expected recovery times.

Coral reefs

As outlined above, impacts of a spill on coral reefs in the vicinity of the Chelonia site would be dependent on the tide (low and high tide and spring and neap tides), especially given the fact that the most significant impacts of a spill of Leatherback crude are likely to be caused by physical smothering rather than from the toxic components in the oil. Additionally, the CER outlines that, given that Leatherback crude quickly forms mousse and tar balls, the potential for dispersal into the water column, and thus penetration of sediments, is reduced.

Significant impacts on corals, including excessive mucous production and tissue rupture and ultimately death of the coral colony, may result if the reefs are contacted at low tide. Oil contact may also occur as a result of waves breaking on the reefs, creating droplets of oil that disperse through the water column and contact corals (IPIECA, 1992). Leatherback oil is expected to be slightly toxic to marine organisms, therefore any dispersal of oil through the water column is likely to impact upon reef organisms. Over the longer term, algal growth is expected to increase in the event of coral death and death of herbivores such as sea urchins. Increases in algal abundance may ultimately change the habitat composition of the reef (Apache Energy, 1998).

Chronic (long term) contamination may result if oil becomes entrapped in fine sediments. Such entrapped oil may be released slowly into the environment over a period of months or years, thereby causing low levels of ongoing pollution. Chronic pollution can have significant effects on coral health and reproduction (Jackson et al, 1989; Loya and Rinkevitch, 1987). As mentioned above, the proponent considers that a spill of Leatherback crude is unlikely to result in significant sediment penetration due to the fact that this oil has a propensity to form mousse and tar balls and will therefore coat the surface of the beach and only penetrate into the sediment to a limited extent.

The observed rates of recovery of coral reef communities from damage differ widely (Volkman et al, 1994), and complete recovery is expected to be between one year and several decades depending on the severity of impact.

Shorelines

An oil or diesel spill may result in long term (chronic) contamination if oil or diesel becomes entrapped in fine sediments. Such entrapped oil may result in ongoing pollution by seeping out over a prolonged period. Excavation and removal of sand would probably be required. Rocky shores are less susceptible to long term contamination, however oil (especially in mousse form) may remain on rocks for months before weathering or being washed away by wave action.

Recolonisation and recovery rates of shoreline biota would depend on the area affected, extent of sediment contamination (if any) and recolonisation of the various species impacted. Typically, the recovery of rocky shore communities from an oil spill is marked by enhanced growth of macroalgae resulting from the death of herbivores such as sea snails and urchins (Volkman et al, 1994). Recovery can be expected to take a number of years (EPA, 1997). The flesh of surviving molluscs and other shoreline biota is likely to be contaminated to some extent with toxic fractions of the oil. It is not possible to estimate how long such contamination would

last or whether it is likely to result in significant contamination of the flesh of fish, birds and other animals which feed on the surviving biota.

In the unlikely event that a large oil spill were to occur and oil were to reach the turtle nesting beaches of the Muiron Islands, there is potential for significant impacts on nesting turtles. As turtles nest above high water, actual turtle nesting areas would not be directly affected. However, adult turtles and hatchlings would have to traverse oiled areas of sand, resulting in oiling of adults and oiling and possible entrapment of juveniles. The Muiron Islands are recognised as being an internationally significant nesting site for Loggerhead turtles. Contact by large volumes of oil is likely to have significant impacts on the Loggerhead turtle population. The proponent expects that there will be 'slow to medium' recovery of the turtle population depending on reproductive potential, number of animals affected and the weathered state of the oil (Apache Energy, 1998). The EPA considers that there is not enough information available to accurately predict expected recovery times. However, because turtles are long lived and slow to reach maturity, if there was a high mortality of adult breeding turtles, populations are expected to take several decades to recover.

The rate at which bird populations would recover from a spill event would depend on the severity and extent of impacts. Long term impacts on birds may result from contamination of foreshores and contamination of food sources of seabirds. Recovery of populations from a severe event could be expected to take a number of years (EPA, 1997).

Based on the above information, it is difficult to predict the rate of recovery of shoreline communities, turtles and seabird populations from a large spill of oil or diesel from the Chelonia proposal. In the very unlikely event of a large spill or crude oil or diesel, there would be severe ecological impacts. It is expected that shorelines and shore life would take several years at least, or several decades in the case of turtles, to recover.

Intertidal and shallow subtidal zones

Impacts on the shallow subtidal zone are likely to be reduced by the fact that Leatherback crude is considered unlikely to disperse through the water column. Where oil reaches the seabed, contamination of the sediments may result in long term contamination. Impacts on rocky intertidal areas are likely to be similar to those impacts on rocky shorelines, which are discussed above.

The proponent expects shallow subtidal communities to rapidly recover from impacts due to spatial movement of animals and high reproductive capacity of colonising species, and for intertidal areas to recover in 1 - 2 years (Apache Energy, 1998). The EPA considers that it is likely that there will be few impacts on the shallow subtidal marine life, however considers that there is not enough information available to accurately predict the rate of recovery.

Management measures and oil spill contingency responses

The probability calculations discussed above assume that there will be no management measures or oil spill contingency responses implemented by the proponent to minimise both the potential for a spill to occur, and the impacts of a spill should an incident occur.

Management measures

The proponent has made a commitment to implement a number of management measures to minimise the potential for hydrocarbon spills and to reduce the potential for such spills to impact upon the adjacent environment (most of these measures are standard DME safety requirements). Management measures include:

- engineering of well design in excess of conditions encountered in the region;
- four BOP's will be used;
- drilling fluids will be the correct weight for reservoir pressures;
- there will be routine pressure testing of BOPs and casing;
- trained personnel will be used on the oil rig;

- design of an Oil Spill Contingency Plan approved by the DEP and DME (commitment 4);
- oil spill equipment will be on standby at the rig at all times (commitment 5);
- an oil spill response exercise will be carried out (commitment 6); and
- methods used for production testing will reduce the risk of crude oil fallout during testing (commitment 8).

The proponent must also comply with other safety and environmental conditions relating to the drilling of Chelonia-1 and -2 set by DME.

In line with procedures adopted during the Wonnich drilling programs, the DEP recommends that the proponent be required to use the following additional management measures:

- prior to commencement of drilling, the proponent shall prepare a written prescription for contractor work practices covering drilling and support vessel operation to ensure that work practices are carried out at the level of international best practice; and
- to avoid the potential for hydrocarbon fall-out and smoke plumes, the proponent shall not carry out burning or flaring of hydrocarbons when production testing.

Oil spill response strategies

The proponent has made a commitment to prepare an Oil Spill Contingency Plan to the requirements of the DME and DEP prior to the commencement of drilling operations. This plan will outline specific oil spill response strategies to be implemented by Apache in the very unlikely case of an oil spill.

The proponent has outlined a number of response strategies which would be used in the case of the different oil spill scenarios. These strategies have taken the following factors into account:

- the fact that the proposed drilling location experiences high current and tidal energy (and usually winds);
- the projected behaviour of the oil based on Apache's modelling;
- the expected characteristics of the oil;
- the fact that the water depth at the drilling location is ~19 m;
- the effects of dispersed oil as compared to undispersed oil;
- the resources at risk during the proposed drilling time (1 Nov - 1 March);
- accepted guidelines for dispersant use.

The response strategies for each type of oil and spill size are very similar, however the proponent has outlined that the use of dispersants would be considered in the case of a large spill of crude oil. The proponent has outlined that, if open water conditions and safety considerations permit, the following response strategies after a spill will include:

- mechanical agitation of the water by all available boats;
- attempt to enclose and concentrate oil near the source of the spill using an ocean rated boom and commence skimming the oil off the water;
- commence aerial and surface surveillance of the oil that has escaped containment;
- run Apache's oil spill trajectory model to provide forward predictions of resources, particularly shorelines, at risk;
- identify all areas at risk of oil exposure and assign priorities for protection, based on the likelihood of exposure, sensitivity to exposure and potential recovery time;
- if escaped oil is moving out to sea and away from the main land and islands, prepare additional equipment and personnel, but take no immediate action. Allow for natural weathering;
- if oil starts moving to shoreline, shoreline booms are to be used for deflection where tide and wind conditions allow;

- sand barriers are to be constructed just above the high tide level to stop hatchlings from moving down the shore and as catchments for free oil coming onto the shore; and
- dispersant use will only be considered for a crude oil spill greater than >80 000 L if there is a risk of impact to the sandy beaches of the Muiron Islands. Dispersants will not be used for any diesel spills or small spills of crude oil. Only Ardrox 6120 or Corexit 9527 dispersants will be used, and will be applied within approximately 4 hours onto the thickest part of the slick. Approval for dispersant use must be obtained from the State Committee for Combating Marine Oil Pollution and the DME.

Comparisons with Wonnich Appraisal drilling program

The proposal by Apache Energy Limited to carry out a program of appraisal drilling on the Wonnich petroleum field within permit ares TP/8 was assessed by the EPA in 1997. Assessment of this proposal involved risk assessment, including consideration of both the probability of a spill and the potential environmental consequences. The EPA concluded that, with appropriate management, the risks associated with the Wonnich Appraisal proposal would be extremely low, and that it would be most unlikely that the EPA's environmental objectives would be compromised.

Table 6 below shows a comparison between the Wonnich Appraisal proposal and the current Chelonia proposal.

Table 6. Risk comparisons between Wonnich Appraisal and Chelonia for large hydrocarbon spills.

INCIDENT	WONNICH APPRAISAL	CHELONIA*
CRUDE OIL TYPE	Light volatile crude, high toxicity. Unlikely to form emulsion.	Unknown. Expected to be similar to Leatherback (light crude, likely to have low toxicity, likely to form emulsion).
OVERALL PROBABILITY OF CONTACT - BLOWOUT	• shoreline: 8×10^{-6} • coral reefs: 8×10^{-6}	• South Muiron: 9.8×10^{-6} • North Muiron: 4.5×10^{-6} • Pt Murat: no contact
OVERALL PROBABILITY OF CONTACT - LARGE DIESEL SPILL	• shoreline: 1.4×10^{-5} • coral reefs: 5.3×10^{-6}	• South Muiron: 5.6×10^{-6} • North Muiron: 2.1×10^{-6} • Pt Murat: no contact
MINIMUM TIME TO IMPACT SENSITIVE ENVIRONMENT	7 hours	20 hours

* note that probabilities given in this table are for two wells (44 days drilling) over summer.

It is evident that both proposals have similar probabilities of a large oil or diesel spill reaching sensitive environments. However, the time to contact was considerably less for the Wonnich Appraisal proposal, with minimum time to impact sensitive environments estimated as 7 hours compared to 20 hours for Chelonia. Time to impact has important implications for containment and management of a spill. The greater time to impact for the Chelonia proposal reduces the potential for significant impacts to result from a spill associated with the Chelonia proposal when compared to the Wonnich Appraisal proposal, as the oil will have undergone substantial weathering and there is time for Apache Energy to implement the containment and management measures outlined in the Chelonia Oil Spill Contingency Plan.

Summary

The EPA notes that the proposed drilling location is in close proximity to the environmentally significant Ningaloo Marine Park and Muiron Islands. The EPA recognises that there is public concern regarding the potential impacts that an operation of this type may have on these environments.

Having particular regard to:

- the fact that risk assessment has indicated that it is unlikely that hydrocarbon or Petrofree spills will contact upon the Ningaloo Reef or the Muiron Island reefs;
- the fact that drilling will be carried out in summer when the probability of a spill contacting the Muiron Islands or the Ningaloo Marine Park, and the potential for impacts on whales, whale sharks and coral spawning is reduced (commitment 3);
- the fact that the proponent will upgrade the existing Oil Spill Contingency Plan for the tenement to include the Chelonia drilling program (commitment 4) and that an oil spill response exercise will be carried out to ensure an efficient response in the case of an oil spill (commitment 6);
- the fact that an ocean-rated oil spill boom and a dedicated oil spill vessel will be on standby at the drilling location at all times (commitment 5);
- that fact that DME will set safety and environmental conditions which must be met by the proponent;
- the fact that operational measures to minimise the potential for spills will be utilised during drilling;
- the fact that the proponent holds insurance for liability, control and clean-up and that the Certification of Currency of Insurance will be drawn up in accordance with directions from the DME; and
- the proponent's commitments to minimise the likelihood of a spill of diesel and crude oil during refuelling and production testing (commitment 7, 8),

it is the EPA's opinion that the proposal can be managed such that it is highly unlikely that the EPA's environmental objective for Ningaloo Marine Park/Muiron Islands would be compromised, provided that:

- prior to commencement of drilling, the proponent shall prepare a written prescription for contractor work practices covering drilling and support vessel operation to ensure that work practices are carried out at the level of international best practice; and
- to avoid the potential for hydrocarbon fall-out and smoke plumes, the proponent shall not carry out burning or flaring of hydrocarbons when production testing.

4. Conditions

Section 44 of the *Environmental Protection Act 1986* requires the EPA to report to the Minister for the Environment on the environmental factors relevant to the proposal and on the conditions and procedures to which the proposal should be subject, if implemented. In addition, the EPA may make recommendations as it sees fit.

In developing recommended conditions for each project, the EPA's preferred course of action is to have the proponent provide an array of commitments to ameliorate the impacts of the proposal on the environment. The commitments are considered by the EPA as part of its assessment of the proposal, and following discussion with the proponent the EPA may seek additional commitments.

The EPA recognises that not all of the commitments are written in a form which makes them readily enforceable, but they do provide a clear statement of the action to be taken as part of the proponent's responsibility for and commitment to continuous improvement in environmental performance. The commitments, modified if necessary to ensure enforceability, then form part of the conditions to which the proposal should be subject if it is to be implemented.

The EPA may, of course, also recommend conditions additional to that relating to the proponent's commitments.

Having considered the proponent's commitments and the information provided in this report, the EPA has developed a set of conditions which the EPA recommends be imposed if the proposal by Apache Northwest Pty Ltd to drill the Chelonia-1 and -2 exploration wells is approved for implementation. These conditions are presented in Appendix 3. Matters addressed in the conditions include:

(a) the proponent shall fulfil the commitments in the Consolidated Commitments statement set out as an attachment to the recommended conditions in Appendix 3;

(b) prior to commencement of drilling, the proponent shall prepare a written prescription for contractor work practices covering drilling operations and support vessel operation to ensure that work practices are carried out at the level of international best practice;

(c) to avoid the potential for hydrocarbon fall-out and smoke plumes, the proponent shall not carry out burning or flaring of hydrocarbons when production testing; and

(d) prior to the commencement of drilling, the proponent shall develop contingency plans for alternative disposal of drill cuttings in the event that disposal of drill cuttings to the lost circulation zone is not possible.

5. Other Advice

Proximity to Ningaloo Marine Park and Muiron Islands

The EPA recognises that the proposed drilling location of the Chelonia wells in close proximity to the environmentally significant Ningaloo Marine Park and Muiron Islands.

The EPA has assessed the proponent's risk assessment and trajectory modelling, and has concluded that, in view of the short duration of the proposal and the management measures to be applied, the risk of oil or fuel spills from the proposed short-term exploration drilling project is considered to be extremely low. Furthermore, the risk of a spill occurring and contacting sensitive marine environments is comparable with the risks calculated for other exploration well drilling in the North West Shelf.

Impacts of artificial lights on turtles

In its submission on the CER, CALM raised the issue of potential impacts on nesting turtles resulting from the lights of the drilling rig. In response to this submission, the proponent advised that Apache contracted CSIRO to conduct an audit of the lights of the rig used for the drilling of the Leatherback-2 well, which was located approximately 2 km from the Muiron

Islands. The survey found that illumination from the lights on the rig had dissipated beyond 100 m, and was not measurable on South Muiron Island. Furthermore, Apache advised that reviews of literature have found that physically elevated sources or lights, such as the moon, are thought to have little effect on hatchling orientation. Once in the ocean, the hatchlings are thought to use waves and the earths' magnetic map to establish offshore orientation, rather than light.

Hydrocarbon production

This assessment has addressed petroleum exploration drilling only. Should hydrocarbons be found in commercially viable quantities, a separate environmental impact assessment would be required prior to any production drilling. Additional risk information, particularly on short and long-term consequences, would need to be provided for any future hydrocarbon production proposal.

6. Conclusions

The EPA has considered the proposal by Apache Northwest Pty Ltd to drill the Chelonia-1 and -2 Exploration Wells near the boundary of the Ningaloo Marine Park, North West Shelf.

The EPA notes the proximity of the proposed wells to environmentally sensitive areas, namely the Ningaloo Reef and Muiron Islands.

In view of the short duration and seasonal timing (summer) of drilling and the management and oil spill contingency measures to be applied, the risk of oil or fuel spills from the proposed short-term exploration drilling project is considered to be extremely low. Furthermore, the risk of a spill occurring and contacting sensitive marine environments is comparable with the risks calculated for other exploration well drilling on the North West Shelf which have been assessed by the EPA.

The EPA has concluded that, given the results of the risk assessment, the proposal can be managed in an environmentally acceptable manner such that it is highly unlikely that the EPA's environmental objectives would be compromised, provided that the conditions recommended in Section 4, and set out in formal detail in Appendix 3, are imposed.

7. Recommendations

Section 44 of the *Environmental Protection Act 1986* requires the EPA to report to the Minister for the Environment on the environmental factors relevant to the proposal and on the conditions and procedures to which the proposal should be subject, if implemented. In addition, the EPA may make recommendations as it sees fit.

The EPA submits the following recommendations to the Minister for the Environment:

1. That the Minister notes that the project being assessed is for the drilling of two oil exploration wells in a sensitive marine environment adjacent to the border of the Ningaloo Marine Park and near the Muiron Islands.
2. That the Minister considers the report on the relevant environmental factors of Hydrocarbons (from spills); Drilling fluids; Drill cuttings; Other operational discharges; and Ningaloo Marine Park/Muiron Islands as set out in Section 3.
3. That the Minister notes that the EPA has concluded that the risk of oil or fuel spills from the proposed short-term exploration drilling project is considered to be extremely low, and it is most unlikely that the EPA's objectives would be compromised, provided there is satisfactory implementation by the proponent of the recommended conditions set out in Section 4, including the proponent's commitments.
4. That the Minister imposes the conditions and procedures recommended in Appendix 3 of this report.

Appendix 1

List of submitters

Organisations:

Shire of Ashburton
Fisheries Western Australia
Department of Minerals and Energy
Department of Conservation and Land Management
Australian Heritage Commission
Marine Parks and Reserves Authority
Western Australian Tourism Commission
Shire of Exmouth
Conservation Council of Western Australia
Ningaloo Action Group

Individual:

Gwyneth R J Ingham

Appendix 2

References

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Appendix 3

Recommended Environmental Conditions and proponent's consolidated commitments

STATEMENT THAT A PROPOSAL MAY BE IMPLEMENTED (PURSUANT TO THE PROVISIONS OF THE ENVIRONMENTAL PROTECTION ACT 1986)

CHELONIA -1 AND -2 EXPLORATION WELLS
BOUNDARY OF NINGALOO MARINE PARK, NORTH WEST SHELF

Proposal: The drilling of two offshore exploration wells, Chelonia-1 and Chelonia-2, near the boundary of the Ningaloo Marine Park, Northwest Shelf, as documented in schedule 1 of this statement. Both wells will have the same surface location, and will be situated outside the Ningaloo Marine Park, approximately 100 metres from the boundary. The wells will be directionally drilled to reach a drilling target located below the Ningaloo Marine Park.

Proponent: Apache Northwest Pty Ltd

Proponent Address: P O Box 477, West Perth WA 6872

Assessment Number: 1170

Report of the Environmental Protection Authority: Bulletin 914

The proposal to which the above report of the Environmental Protection Authority relates may be implemented subject to the following conditions and procedures:

1 Implementation

1-1 Subject to these conditions and procedures, the proponent shall implement the proposal as documented in schedule 1 of this statement.

1-2 Where the proponent seeks to change any aspect of the proposal as documented in schedule 1 of this statement in any way that the Minister for the Environment determines, on advice of the Environmental Protection Authority, is substantial, the proponent shall refer the matter to the Environmental Protection Authority.

1-3 Where the proponent seeks to change any aspect of the proposal as documented in schedule 1 of this statement in any way that the Minister for the Environment determines, on advice of the Environmental Protection Authority, is not substantial, those changes may be effected.

2 Proponent Commitments

2-1 The proponent shall implement the consolidated environmental management commitments documented in schedule 2 of this statement.

2-2 The proponent shall implement subsequent environmental management commitments which the proponent makes as part of the fulfilment of conditions and procedures in this statement.

3 Work Practices

3-1 Prior to commencement of drilling, the proponent shall prepare a written prescription for contractor work practices covering drilling and support vessel operation, to ensure that work practices are carried out at the level of international best practice, to the requirements of the Environmental Protection Authority on advice of the Department of Environmental Protection and the Department of Minerals and Energy.

3-2 The proponent shall ensure that all drilling works and support vessel operations comply with the prescription referred to in condition 3-1.

4 Proponent

4-1 The proponent for the time being nominated by the Minister for the Environment under section 38(6) or (7) of the Environmental Protection Act 1986 is responsible for the implementation of the proposal until such time as the Minister for the Environment has exercised the Minister's power under section 38(7) of the Act to revoke the nomination of that proponent and nominate another person in respect of the proposal.

4-2 Any request for the exercise of that power of the Minister referred to in condition 4-1 shall be accompanied by a copy of this statement endorsed with an undertaking by the proposed replacement proponent to carry out the proposal in accordance with the conditions and procedures set out in the statement.

4-3 The proponent shall notify the Department of Environmental Protection of any change of proponent contact name and address within 30 days of such change.

5 Production Testing

5-1 To avoid the potential for hydrocarbon fall-out, the proponent shall not carry out burning or flaring of hydrocarbons when carrying out production testing of the hydrocarbon formation. The method of testing shall be to the requirements of the Environmental Protection Authority on advice of the Department of Minerals and Energy.

6 Disposal of Drill cuttings

6-1 Prior to the commencement of drilling, the proponent shall develop contingency plans for alternative disposal of drill cuttings in the event that disposal to a lost circulation zone is not possible, to the requirements of the Environmental Protection Authority on advice of the Department of Minerals and Energy

6-2 The proponent shall implement the contingency plans required by condition 6-1 in the event that disposal of drill cuttings to a lost circulation zone is not possible.

7 Commencement

7-1 The proponent shall provide evidence to the Minister for the Environment within five years of the date of this statement that the proposal has been substantially commenced.

7-2 Where the proposal has not been substantially commenced within five years of the date of this statement, the approval to implement the proposal as granted in this statement shall lapse and be void. The Minister for the Environment will determine any question as to whether the proposal has been substantially commenced.

7-3 The proponent shall make application to the Minister for the Environment for any extension of approval for the substantial commencement of the proposal beyond five years from the date of this statement at least six months prior to the expiration of the five year period referred to in conditions 7-1 and 7-2.

7-4 Where the proponent demonstrates to the requirements of the Minister for the Environment on advice of the Environmental Protection Authority that the environmental parameters of the proposal have not changed significantly, then the Minister may grant an extension not exceeding five years for the substantial commencement of the proposal.

8 Compliance Auditing

8-1 The proponent shall submit periodic Performance and Compliance Reports, in accordance with an audit program prepared in consultation between the proponent and the Department of Environmental Protection.

8-2 Unless otherwise specified, the Chief Executive Officer of the Department of Environmental Protection is responsible for assessing compliance with the conditions, procedures and commitments contained in this statement and for issuing formal clearances.

8-3 Where compliance with any condition, procedure or commitment is in dispute, the matter will be determined by the Minister for the Environment.

Note:

1 The proponent's Oil Spill Contingency Plan must be approved by the Department of Minerals and Energy to meet the requirements of the *Petroleum (Submerged Lands) Act.*

2 As a condition of approval of the Oil Spill Contingency Plan, the Department of Minerals and Energy will require the proponent to carry out a successful field trial of the oil spill boom at the project site before drilling commences. The Department of Minerals and Energy will also require the findings of the trial to be incorporated in the oil spill contingency plan as appropriate.

3 The Department of Minerals and Energy will require the proponent to take out adequate oil spill insurance to cover damage to third parties and the cost of oil spill clean-up operations, to meet the requirements of the *Petroleum (Submerged Lands) Act.*

Schedule 1

The Proposal

The proposal is to drill two offshore exploration wells, Chelonia-1 and Chelonia-2, in Permit Area EP342 which is located at the head of Exmouth Gulf, approximately four kilometres to the south south west of South Muiron Island. The Chelonia-1 well will be drilled initially and, if hydrocarbons are encountered, the drill string will be pulled back and sidetracked to drill the second well, Chelonia-2. The wells will have the same surface location, situated outside the Ningaloo Marine Park, approximately 100 metres from the boundary. Both wells will be directionally drilled to reach a drilling target located below the Ningaloo Marine Park.

The key characteristics of the proposal are described in the table below.

ELEMENT	DESCRIPTION	
	Chelonia-1	**Chelonia-2**
Surface location	21°44'38.87" S 114°17'3.88" E	21°44'38.87" S 114°17'3.88" E
Type of well	Directional	Directional
Proposed drilling period	Summer period (1 Nov - 1 March)	Summer period (1 Nov - 1 March)
Water depth	20 metres	20 metres
Drilling days	26	18
Drilling rig	Jack-up rig	Jack-up rig
Drilling fluid	Water based and Petrofree	Water based and Petrofree
Vertical depth	approximately 2 850 metres	approximately 2 850 metres
Measured depth	approximately 4 100 metres	approximately 3 500 metres
Volume of cuttings	approximately 450 cubic metres	approximately 350 cubic metres
Volume of cuttings on seabed (assuming annulus disposal)	approximately 16 cubic metres	None
Production testing	Yes	Yes
Reservoir access	6 days	3 days
Habitat type	Limestone pavement with sand veneer	Limestone pavement with sand veneer
Nearest landfall	Muiron Islands	Muiron Islands
Nearest sensitive resource	Intertidal sand and subtidal fringing reef South Muiron Island (4 - 6 kilometres)	Intertidal sand and subtidal fringing reef South Muiron Island (4 - 6 kilometres)

Maps

Figure 1: Surface location of the proposed Chelonia-1 and -2 exploration wells.

Figure 2: Vertical section of the proposed Chelonia-1 exploration well.

Figure 3: Vertical section of the proposed Chelonia-2 exploration well.

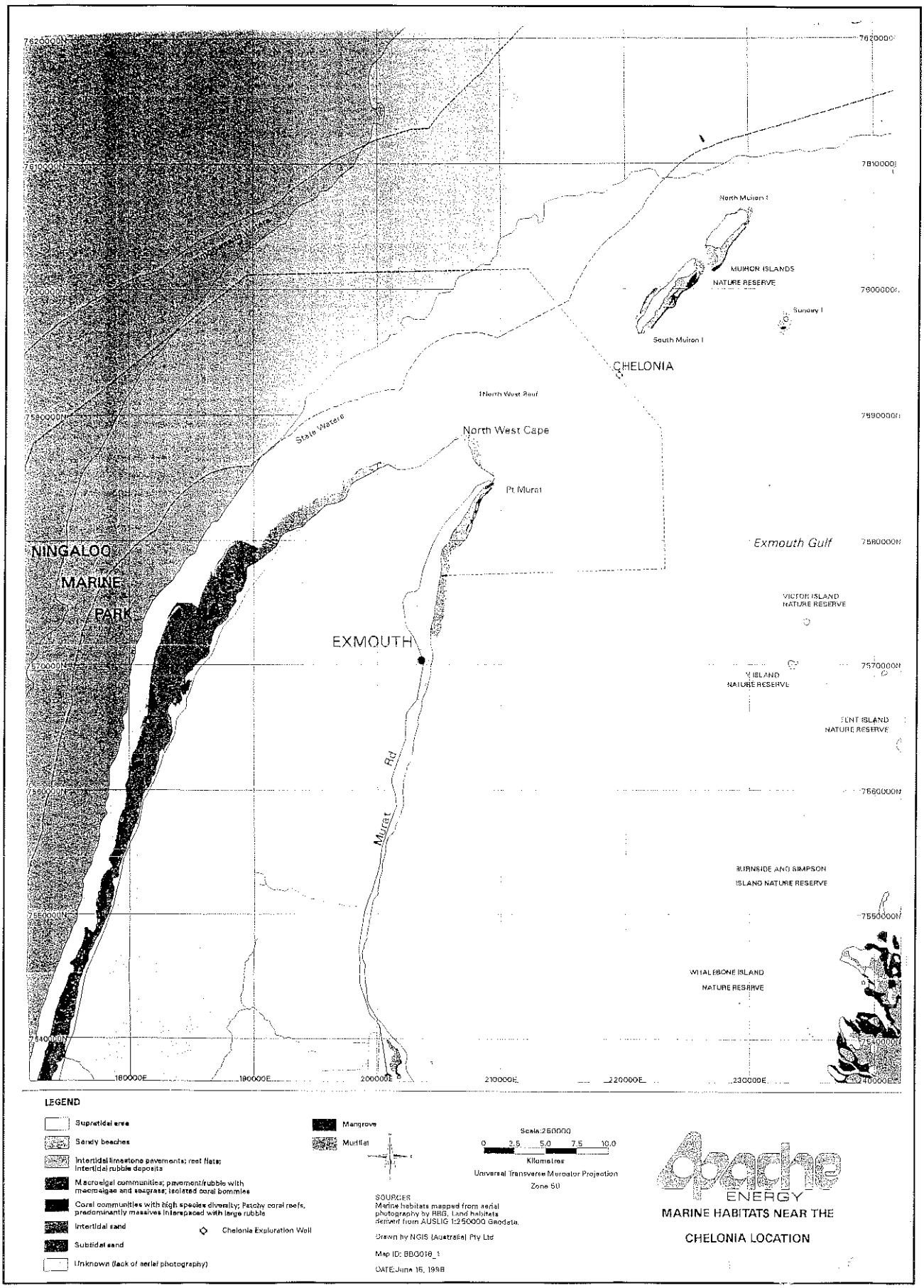
North Muiron I
MUIRON ISLANDS
NATURE RESERVE
Sunday I
South Muiron I
CHELONIA
North West Reef
North West Cape
State Waters
Pt Murat
NINGALOO
MARINE
PARK
Exmouth Gulf
VICTOR ISLAND
NATURE RESERVE
EXMOUTH
Murat Rd
BURNSIDE AND SIMPSON
ISLAND NATURE RESERVE
WHALEBONE ISLAND
NATURE RESERVE
7620000N
7610000N
7600000N
7590000N
7580000N
7570000N
7560000N
7550000N
7540000N
180000E
190000E
200000E
210000E
220000E
230000E
240000E
LEGEND
Supratidal area
Sandy beaches
Intertidal limestone pavements; reef flats; intertidal rubble deposits
Macroalgal communities; pavement/rubble with macroalgae and seagrass; isolated coral bommies
Coral communities with high species diversity; Patchy coral reefs, predominantly massives interspaced with large rubble
Intertidal sand
Subtidal sand
Unknown (lack of aerial photography)
Chelonia Exploration Well
Mangrove
Mudflat
Scale:250000
0 2.5 5.0 7.5 10.0
Kilometres
Universal Transverse Mercator Projection
Zone 50
SOURCES
Marine habitats mapped from aerial photography by RRG, Land habitats derived from AUSLIG 1:250000 Geodata.
Drawn by NGIS (Australia) Pty Ltd
Map ID: BB0018_1
DATE: June 16, 1998
Apache ENERGY
MARINE HABITATS NEAR THE
CHELONIA LOCATION

Figure 1.

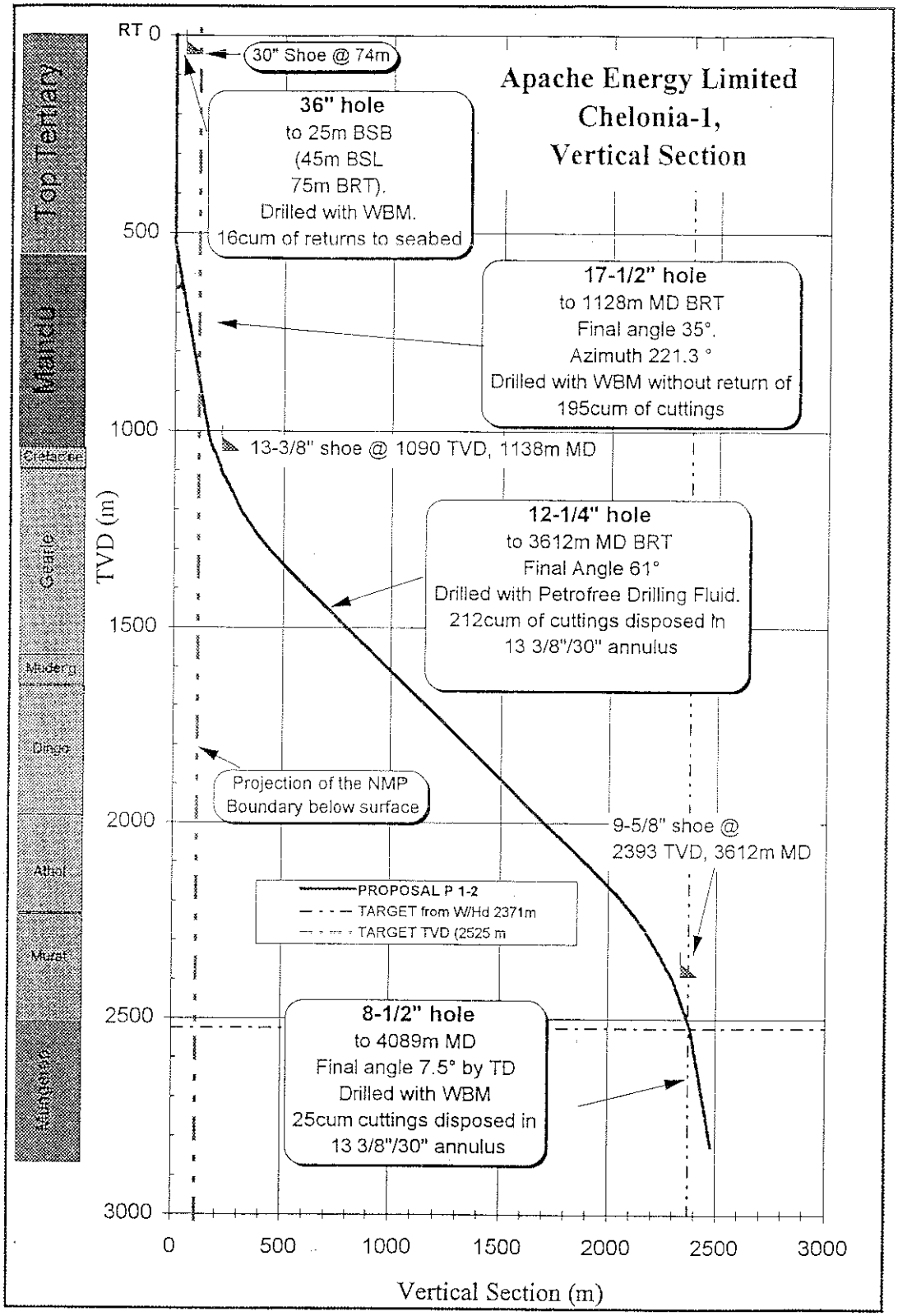
Apache Energy Limited
Chelonia-1,
Vertical Section
RT 0
30" Shoe @ 74m
36" hole
to 25m BSB
(45m BSL
75m BRT).
Drilled with WBM.
16cum of returns to seabed
17-1/2" hole
to 1128m MD BRT
Final angle 35°.
Azimuth 221.3 °
Drilled with WBM without return of
195cum of cuttings
13-3/8" shoe @ 1090 TVD, 1138m MD
12-1/4" hole
to 3612m MD BRT
Final Angle 61°
Drilled with Petrofree Drilling Fluid.
212cum of cuttings disposed In
13 3/8"/30" annulus
Projection of the NMP
Boundary below surface
9-5/8" shoe @
2393 TVD, 3612m MD
PROPOSAL P 1-2
TARGET from W/Hd 2371m
TARGET TVD (2525 m
8-1/2" hole
to 4089m MD
Final angle 7.5° by TD
Drilled with WBM
25cum cuttings disposed in
13 3/8"/30" annulus
Top Tertiary
Manu
Cretaceous
Gearle
Muderong
Dingo
Athol
Murat
Hutton
TVD (m)
0
500
1000
1500
2000
2500
3000
Vertical Section (m)

Figure 2.

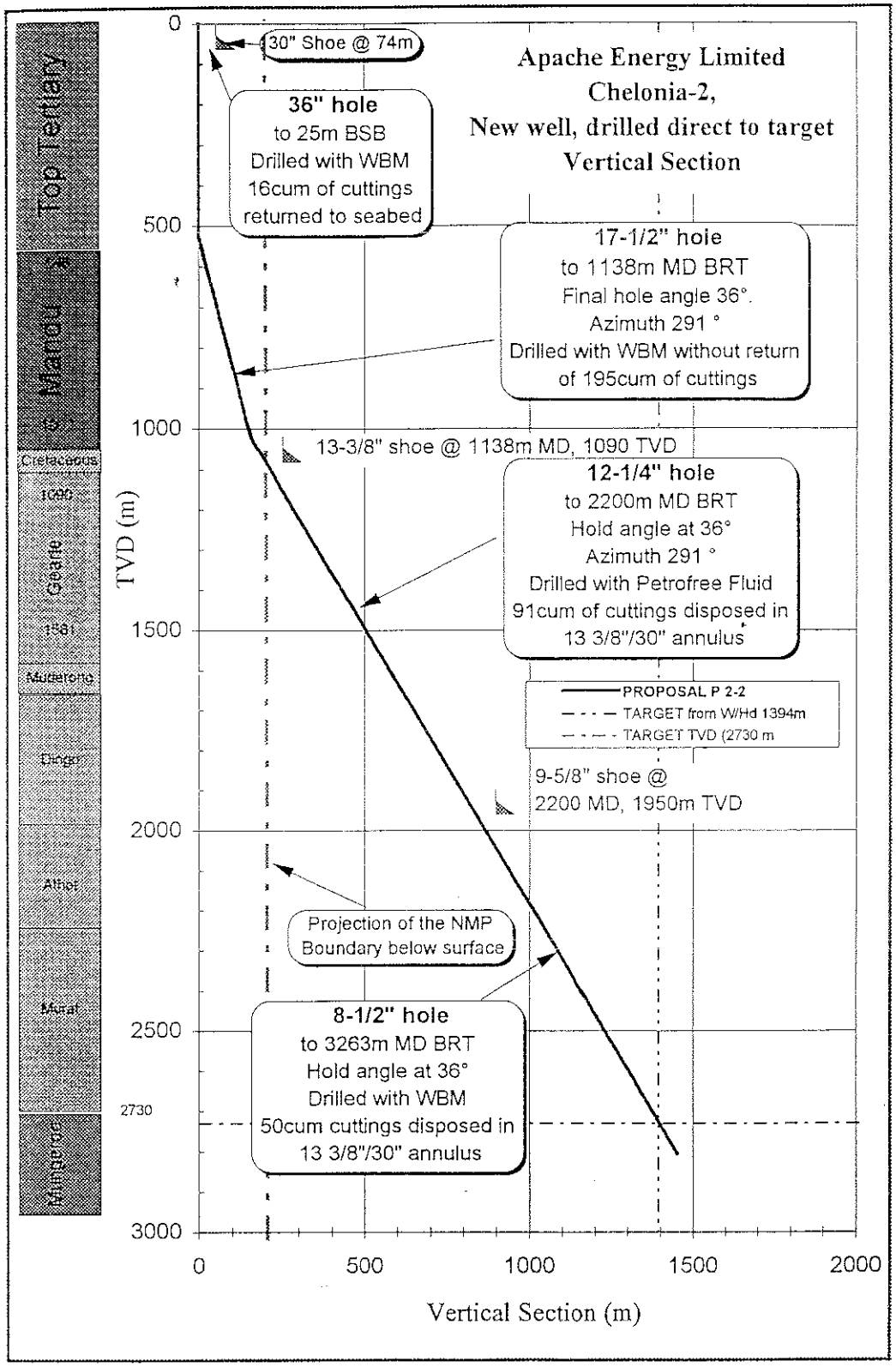
Apache Energy Limited
Chelonia-2,
New well, drilled direct to target
Vertical Section
30" Shoe @ 74m
36" hole
to 25m BSB
Drilled with WBM
16cum of cuttings
returned to seabed
17-1/2" hole
to 1138m MD BRT
Final hole angle 36°.
Azimuth 291 °
Drilled with WBM without return
of 195cum of cuttings
13-3/8" shoe @ 1138m MD, 1090 TVD
12-1/4" hole
to 2200m MD BRT
Hold angle at 36°
Azimuth 291 °
Drilled with Petrofree Fluid
91cum of cuttings disposed in
13 3/8"/30" annulus
PROPOSAL P 2-2
TARGET from W/Hd 1394m
TARGET TVD (2730 m
9-5/8" shoe @
2200 MD, 1950m TVD
Projection of the NMP
Boundary below surface
8-1/2" hole
to 3263m MD BRT
Hold angle at 36°
Drilled with WBM
50cum cuttings disposed in
13 3/8"/30" annulus
2730
TVD (m)
Vertical Section (m)
0
500
1000
1500
2000
2500
3000
Top Tertiary
Mangahewa
Cretaceous
1090
Gearle
1561
Muderong
Dingo
Athel
Murat
Mungaroo

Figure 3.

Schedule 2

Proponent's Consolidated Environmental Management Commitments

October 1998

Chelonia-1 and -2 Exploration Wells,

Boundary of Ningaloo Marine Park, North West Shelf

(Assessment number 1170)

Apache Northwest Pty Ltd

Commitment (what)	Objective (why)	Action (How/where)	Timing (when)	Whose advice (To whom)	Measurement criteria
1. An Environmental Management Plan (EMP) using ISO 14 000 principles will be prepared for the drilling program	To ensure compliance with commitments and Ministerial conditions using the principles of ISO 14 000.	The EMP will be made available to all personnel on the drilling rig. A list of guidelines and procedures as given in the CER will be (1) placed at appropriate locations on the drill rig, and (2) incorporated into the drilling contract.	Prior to the commencement of the drilling program.	DME, DEP	Letter from DME approving the EMP.
2. The proponent and each of the Participants will hold adequate insurance for liability, control of well land clean-up.	To ensure ample financial resources for clean-up and remedial action in the case of an oil spill.	Certification of currency of insurance in accordance with directions from the Minister for Mines.	Prior to the commencement of the drilling program.	DME	Certificates of Insurance from underwriters.
3. Drilling will be carried out in the summer period.	To minimise the risk of an oil spill impacting sensitive resources.	Drilling will be carried out between 1 November and 1 March (summer period) in any year.	During the drilling of the well.	DEP, DME	Letter of confirmation at the end of the drilling program.
4. An Oil Spill Contingency Plan (OSCP) will be prepared.	To develop strategies for the containment, deflection and clean-up of oil spills.	Upgrade the existing EP342 OSCP to include the Chelonia drilling program.	Prior to locating equipment at the drilling location.	DME, DEP, DoT	Letter from the DME approving the OSCP
5. An ocean-rated oil spill boom and a dedicated oil spill combat vessel will be on standby at the location at all times.	For rapid deployment response in the case on an oil spill.	The boom will be stored on the dedicated oil spill vessel which will be in the vicinity of the rig at all times throughout the life of the project.	Prior to the commencement of the drilling program.	DEP, DME, Australian Marine Oil Spill Centre (AMOSC)	Letter of confirmation to DME from the proponent stating that vessel was on site at all times.

Commitment (what)	Objective (why)	Action (How/where)	Timing (when)	Whose advice (To whom)	Measurement criteria
6. An oil spill response exercise will be carried out.	To ensure an efficient response in the case of an oil spill.	A desk-top and field exercise will be carried out to the point of deployment of equipment.	Within three days of spudding the well.	DME	Letter of confirmation to the DME from the proponent outlining the scope of the exercise and the results.
7. The risk of diesel spillage during refuelling will be minimised.	To protect the marine environment.	A refuelling procedure will be prepared and implemented, including a dry coupling system and carrying out refuelling when any spillage would be carried away from sensitive resources.	Before the commencement of the drilling program.	DEP, DME	Approval of the procedure by the DME. Letter from the proponent to DME with performance report.
8. The risk of crude oil fallout during production testing will be minimised.	To protect the marine environment.	Immediate shutdown if fallout occurs.	During production testing activities.	DME	Approval of the procedure by the DME. Letter from the proponent to DME with performance report.
9. If possible, drill cuttings and excess drilling fluids will be disposed of down the annulus.	Protection of the marine environment.	The procedure for disposing drill cuttings will be incorporated into the drilling program for the well.	Prior to locating equipment at the drilling location.	DEP, DME	Letter from DME for approval of drilling manual.

Commitment (what)	Objective (why)	Action (How/where)	Timing (when)	Whose advice (To whom)	Measurement criteria
10. A debris survey will be conducted.	To confirm that no debris has been left on the seafloor.	A remotely operated vehicle will be used. Report and video submitted to the proponent.	At the completion of the drilling program prior to the rig moving off-site.	DEP, DME	Letter of confirmation that all debris has been removed from the proponent to DME.
11. There will be no access to islands, and support vessel anchorage away from coral reefs will be provided.	Protection of the Muiron Islands and reef habitats.	Confirmation of anchoring positions in log of support vessel. Flight plans will be made for helicopters.	During the entire drilling program.	DEP, DME, CALM	Sighting of vessel and helicopter log books by DME.
12. A community consultation program will be carried out.	To inform the community of the drilling program and address their concerns.	A communication strategy will be developed.	Before the commencement of the drilling program.	DEP, DME	Letter to DME from the proponent outlining the actions carried out and when.
13. All personnel on-site will undergo an education and training program.	To give the personnel the means of identifying the risks and knowledge of the environmental implications of the drilling program.	Inductions to be given to all personnel. Posters and maps are to be provided to rig. Guidelines to be provided to rig.	Prior to the spudding of the well.	DME	No incidents.
14. An environmental audit of the drilling operations will be undertaken.	To ensure compliance with commitments.	An environmental audit will be carried out using ISO 14 000 as the standard.	Within two weeks after drilling has commenced.	DEP, DME	Results of audit will be submitted to DME by the proponent.

CHELONIA-1 AND -2 EXPLORATION WELLS, BOUNDARY OF NINGALOO MARINE PARK, NORTH WEST SHELF

RESPONSES TO SUBMISSIONS

Conservation and Land Management

Accepted techniques have been used for risk modelling.

The framework for environmental/ecological risk assessment is well established and forms the basis of impact assessment and management for most projects. Quantifying risk, particularly with respect to drilling, is still a developing science. Apache has been utilising the best available modelling methodologies to assist it with its risk assessment of the Chelonia drilling program. It must be noted that quantitative risk assessment, particularly the modelling aspect, is not an absolute science, but provides a tool for gaining the best estimate of potential impacts.

While risk assessment shows summer period is preferred for well drilling, this is not the ideal for nesting turtles.

Apache contracted CSIRO to conduct an audit of the lights on the jack-up rig the 'Ron Tappmeyer' in December 1998 while the rig was located on the Leatherback-2 site, some 2 km south of the Muiron Islands. The survey found that illumination from the lights on the rig had dissipated beyond 100 m, and was not measurable on South Muiron Island.

A review (Lohman *et al.* [1]) of the literature on the impacts of artificial lights on sea turtles has found that hatchlings respond primarily to visual clues within a restricted zone of acceptance to the horizon. Therefore, physically elevated sources of lights, such as the moon, often have little effect on orientation. Once in the ocean, the hatchlings are thought to use waves and the earths' magnetic map to establish offshore orientation, rather than light.

An outcome of the 'Ron Tappmeyer' light audit was recommendations to minimise the amount of light reaching the water surface. These recommendations are being incorporated into the current rig tender document and the rig contract, bearing safety requirements.

Dispersants should be avoided for mangroves.

Should an oil spill occur at the Chelonia site, dispersants would not be used as modelling has indicated that the oil would be carried out into open water. We believe that dispersants should be avoided. However, in the very remote case that oil is being carried into the mangroves in the southern section of Exmouth Gulf, we believe it would be prudent to at least consider the use of dispersants. Booms, deflection and shore clean-up would be the main techniques used. Should dispersants need to be considered approval would be obtained from the DME as per their letter (attached).

[1] Lohmann, K.J., Witherington, B.E., Lohmann, C.M.F. and Salmon, M. (1996). Orientation, navigation and natal beach homing in sea turtles. In: Lutz. P.L. and Musick, J.A. (eds) *The Biology of Sea Turtles. CRC Marine Science Series.* 107 – 130.

Ningaloo Action Group

NAG is concerned about the possibility of a drilling fluid or oil spill affecting the Ningaloo Reef or the coral and rocky shore communities of the Muiron Islands.

The risk assessment indicates that the overall chances of oil from a 600,000 L spill reaching the Muiron Islands during the summer months is 6.5×10^{-6} for South Muiron Island and 3.0×10^{-6} for North Muiron Island (Table 13). This equates to approximately 1 in 150,000 for South Muiron Island and about 1 in 330,000 for North Muiron Island. In other words, if we had 150,000 similar operations, all things being equal, we would expect one incident.

It was estimated that the chances of oil reaching the Muiron Islands was less than 15% during the summer season, without taking into the account the chances of a 600,000 L spill occurring in the first instance. The risk of a blowout is deemed to be extremely small which would make the risk to the Muiron Islands very small. Risk reduction measures would be put into place to further minimise the risk.

NAG is concerned that the discovery of a significant amount of oil and gas would result in a well or wells being established at the site and we consider this absolutely unacceptable considering the close proximity of the Ningaloo Marine Park.

Should a hydrocarbon discovery be made, an assessment would be made of its economic viability. Should the discovery prove to be economic, any development proposal would be subject to another full environmental assessment.

Finally, whilst NAG recognises the legal right of Apache to conduct directional drilling under the Ninagloo Marine Park, we consider that this is not within the spirit of the ban on drilling within the Marine Park and violates the inherent right of the organisms living within the Park to live in a safe and protected environment.

Apache recognises the conservation value of the Ningaloo Marine Park, particularly the Ningaloo Reef and Bundegi Reef. However, we believe that the risk to the park and its natural resources is very small. We also stand by the performance of the company and believe that we carry out our drilling activities using best practice mechanisms. Given the management actions we would commit to, we believe that impact to the flora and fauna of the park would be extremely minor. The proposed Chelonia exploration program and the management actions that will be put into place must be put into context with all the other activities that are carried out in and around the park.

The Loggerhead-1 well, which was drilled in 1991 was located only 50 m away from the proposed Chelonia location and surveys carried out for the last five years have indicated that there is no longer any evidence of the Loggerhead-1 well or the cuttings disposed on the seafloor.

Conservation Council of Western Australia

The Conservation Council of WA is concerned about the proximity of the proposed exploration wells to the boundary of the Ningaloo Marine Park Boundary. We believe that there should be a buffer around the marine park to ensure that oil spills and other potential contaminants from exploration do not impact the park.

On of the intents of the existing marine park boundary when it was first formulated was to provide a buffer to the Ningaloo Reef and Bundegi Reef. We do not believe that an additional buffer zone outside the existing park boundary will increase the protection of the park and is therefore warranted. We believe that the risk to the park and its resources from the Chelonia drilling program is very small. Apache has an excellent performance record as we carry out our drilling activities using best practice mechanisms. Given the management actions we would commit to, we believe that impact to the flora and fauna of the park from the proposed drilling program would be extremely minor. The planned exploration program and the management actions that will be put into place must be put into context with all the other activities that are carried in and around the park.

We oppose production wells being established so close to the park boundary.

The purpose of the present CER is to assess the impact of the Chelonia exploration drilling program. The assessment options for any production wells is beyond the scope of the CER and would involve a new and independent assessment process.

The assessment does not highlight the values of the Muiron Islands adequately, in particular the fact that there are proposals for marine conservation of the area.

We believe that we have described the resources found around the Muiron Islands adequately in Chapter 3 of the CER.

Apache does not dispute the conservation value of the Muiron Islands and surrounding waters. However, there are presently no marine conservation proposals for the waters surrounding the Muiron Islands. The report generated by the Marine Parks and Reserves Selection Working Group has recommended the area as being worthy of reservation status.

We are concerned that the CER does not deal adequately with drilling fluids and cuttings. What happens if there is no 'lost circulation zone'?

All endeavours will be made to dispose of cuttings and fluid down the annulus. The Loggerhead-1 well encountered partial loss of returns over the interval 90 m to 320 m and lost circulation completely from 320m to 490 m. We expect similar geology at the Chelonia location that is about 50 m away from the Loggerhead-1 site. There will be some disposal of cuttings on the seafloor until the 30" casing is set and annular disposal will be established at 320 m depth to ensure full loss.

The fate of the cuttings disposed on the seabed at the Loggerhead-1 location has been detailed in Sections 3.10 and 4.2 of the CER.

We are particularly concerned given that 'pipe dope' containing heavy metals may be included with the fluids.

Pipe dope containing the lowest possible concentrations of heavy metals will be used. Pipe dope was used for the Loggerhead-1 well and there were no traces of heavy metals in the sediments by 1997.

We are also concerned about the potential to create a plume from the cuttings that adversely impacts on the marine environment, particularly the Ningaloo Marine Park which is only 111 m away.

Sedimentation is a natural process that the local biota is normally subjected to. A common feature of the Exmouth Gulf is the presence of sediment plumes generated by strong tidal currents. All attempts will be made to dispose of excess water based fluid down the annulus. Should this not be possible, the plume generated by the fluid plume will be temporary and localised and result in minimal impact.

Is there a requirement to ensure that the lost circulation zone is confined? We are concerned to ensure that the material pumped into the zone will not leak into the marine environment over time.

Extensive knowledge and experience of the geology of the area gives us the confidence that drill cuttings and fluid will can be discharged into the lost circulation zone and not seep back up through the seabed into the marine environment. A layer of limestone rock of up to 90 m depth lies over the porous lost circulation zone that will provide a barrier to any seepage.

Anonymous

Although the risks of oil spills as outlined in the CER may be low, should oil be discovered then the increased shipping would increase the likelihood of an oil spill, and also bring the added risk of introduction of marine pests through ballast water.

The purpose of the present CER is to assess the impact of an exploration drilling program. The assessment options for any development options is beyond the scope of the CER and would involve a new and independent assessment process.

Shire of Ashburton

The Shire of Ashburton requires an assurance that any potential disaster that impacts on both lands and waters located within the Shire of Ashburton will be adequately rectified by the proponent.

Apache holds extensive insurance for liability, control of well and clean-up. The Certification of Currency of Insurance will be drawn up in accordance with directions from the DME.

Fisheries Western Australia

It is essential that the company keep local commercial and recreational fishing bodies aware of the drilling procedures and any emergency response that might arise.

Apache proposes to drill the Chelonia exploration wells outside the prawn fishing area. However, we are aware that recreational fishing occurs year round.

We have been carrying out an extensive community consultation process with the relevant groups and agencies in the Exmouth area. Meetings were carried out on 8-10 July to answer any questions about the proposed program: these meetings included Fisheries WA and Kailis Fisheries.

Australian Heritage Commission

The Commission is interested in whether Apache Energy has considered the effects of discharge of formation water.

The Chelonia drilling program will probably extend through the layer of formation water that may be present in the reservoir. However, no formation waster will come to surface as the drilling fluid will create a pressure greater than the reservoir pressure: this will keep all hydrocarbons and formation water within the reservoir and therefore no formation water will be discharged into the marine environment.

Disposal of drill cuttings

All endeavours will be made to dispose of cuttings and fluid down the annulus. The Loggerhead-1 well encountered partial loss of returns over the interval 90 m to 320 m and lost circulation completely from 320m to 490 m. We expect similar geology at the Chelonia location which is about 50 m away from the Loggerhead-1 site. There will be some disposal of cuttings on the seafloor until the 30" casing is set and annular disposal will be established at 320 m depth to ensure full loss.

The fate of the cuttings disposed on the seabed at the Loggerhead-1 location has been detailed in Sections 3.10 and 4.2 of the CER. Basically, there were no traces at the site within five years after drilling had ceased.

All requirements with respect to setting and testing casing will be in accordance with the Schedule to the P(SL)A.. Apache will also adhere to any additional conditions set on the drilling program.

Spill modelling

Apache has committed to carrying out the drilling program during the summer season when the risk to the west side of NW Cape is extremely low. Modelling has estimated that no oil will reach the NW Cape in the summer due to the prevailing winds in combination with the tidal action.

Oil Spill Contingency Plan

The EP342 Oil Spill Contingency Plan will be updated to cover the Chelonia program. It will be submitted after all the final conditions of the project have been formulated to ensure that all aspects (e.g. additional equipment) have been included in the Plan.

Auditing

This requirement can be incorporated into the audit commitment (Management commitment 14).

Monitoring

We will carry out an ROV inspection of the well site at the completion of drilling. We do not believe that any additional work at this site is warranted due to all the previous work carried out at the Loggerhead location which showed a rapid recovery of the site.

Environmental Risk Assessment

The database used for the quantitative risk assessment used in the Chelonia CER was an international database which included incident data from the Dutch North Sea sector, the UK North Sea sector, the Gulf of Mexico, Norway and the Netherlands. We have noted in previous documents (e.g. Wonnich CER) that care must be taken in extrapolating overseas

data to Australia. Operational procedures, weather conditions, equipment and regulatory systems are different between countries and will result in different frequencies of spills. Australia has a very strict safety regime that must be adhered to by industry and this is reflected in the low number of spills that have occurred in Australian waters. We used the best available international database in our risk assessment as there is a lack of data to statistically determine the risk of oil spills from the Australian oil and gas industry. We believe that even using overseas data, we have shown that the risk of spillage of oil from drilling activities is very low.

We note the comments made by the DME about the presentation of the risk to the public. We accept that this is difficult and open to improvement, and that there is no easy way of expressing the risk of an oil spill from drilling operations. However, we do not support the concept of expressing the risk in relation to tankers spills or human risk factors as:

- comparing a drilling program with tanker incidents would only increase any negative public perception as most major oil spills, and the emotive images portrayed, have been from tankers;
- human health and ecological oil spill risks are not similar and therefore not comparable;
- there would be a general lack of belief by the public if we compared the risk of an oil spill to human health risk;
- there are differences in opinion on the value of an attribute (i.e. human being vs an ecosystem).

We believe that the risk of the project should be presented as a package incorporating:

- an open, transparent assessment process;
- a public management plan;
- building trust, integrity and credibility with the public and government through consultation;
- involving the community in the development of the management plan; and
- providing information to the community.

We question the degree of media attention that this proposal has generated. We are only aware of a request by the ABC Regional Radio for a two minute overview of the Chelonia project which was aired on 24 June 1998 (transcript attached). Other than the radio story, there has only been reference to the Chelonia CER in the local Exmouth paper (also attached). If government is aware of more media attention, we would be very interested in obtaining the information. In terms of community consultation, we visited Exmouth during the third week of the public assessment period to ensure that the community was well aware of the program and to answer any questions.

6.4.2

MEDIA MONITORS

BROADCAST TRANSCRIPT

TRANSCRIPT NO: TP175083 ORDER NO: 10580

STATION: ABCR **DATE:** 24/6/98 **TIME:** 6.40am

PROGRAMME: Resource Report

ITEM: Apache Energy

RUSSELL WOOLF (Compere):

And finally today onto Apache Energy's proposal to drill a well near the North West Cape, about forty kilometres east of Ningaloo Marine Park. The company has completed an environmental review on its proposal and in light of yesterday's rally opposing onshore drilling at a nearby location, Apache Energy's Deputy Managing Director, Eve Howell, told the ABC's Tanya Nolan, she also expects some opposition.

EVE HOWELL (Deputy Managing director, Apache Energy):

Yes we do expect to have opposition and I guess we have already advised the people of Exmouth some months back about this proposal and it is our intention to visit Exmouth again in the next two to three weeks and be prepared to answer questions or concerns.

The other thing we have tried to do, we have sent copies of this environmental review to all the people that we believe will have a real interest in this program and that includes a number of the conservation groups such as the Cape Conservation Group, the Ningaloo Action Group, Greenpeace and so on. Those copies have been sent out to all those organisations, they should be received if they haven't got them already, in the next day or so and then it is our intention to have an open meeting and allow people to come and ask questions and find out about the program.

NOLAN:

Now Eve to explain the process of proposing exploration, if in fact you don't find what you are looking for, where does the process go from there?

HOWELL:

Well we have, we have a full exploration permit, EP342, which lies in that outer Exmouth gulf area from north east of Exmouth right across towards Onslow. We have already drilled nine wells in that permit since 1991. To date we haven't had any commercial success. If the Chinonie* Well is a failure then that prospect will most likely not, you know, wouldn't be drilled again. But we would continue to explore within the EP342 permit, just as we have since the early nineties.

WOOLF:

The deputy managing director of Apache, Eve Howell.

* unconfirmed spelling

* * END * *

PERTH (09) 9228 5800 BRISBANE (07) 3259 2100 SYDNEY (02) 310 3155 MELBOURNE (03) 9348 9191 CANBERRA (06) 251 5611 NEWCASTLE (049) 421 888 TOWNSVILLE (077) 795 279

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Editor – Leonie Horak

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Public comment sought on oil exploration on marine park boundary

When the then Minister for Mines, George Cash came to Exmouth in July 1993 to espouse the Coalition policy on oil exploration within the Ningaloo Marine Park he was given a very clear message by hundreds of concerned locals and visitors that oil exploration was not an option within the Park, or for that matter anywhere near it. The anti-oil ethic is still very strong in this area today.

Back in 1993, following the presentation of a giant petition (on a roll of wallpaper) to Parliament by Phil Lockyer, and meetings with local groups Premier Richard Court subsequently announced that there would be no oil drilling within the Ningaloo Marine Park.

Apache Energy are poised to begin oil exploration almost on the Ningaloo Marine Park boundary. (A consultative environmental review (CER) is open for public comment until July 20th, see advertisement page 11). Apache have plans to drill two wells 14km to the north-east of Point Murat, North West Cape.

Sun Resources are presently drilling a well just behind the Lighthouse Caravan Park 1.2km from the Ningaloo Reef.

The drilling programme is presently behind schedule having become bogged down in a thick belt of sand.

Cape Conservation Group members, students from Exmouth District High School and others (pictured below) attended a peaceful protest at the drilling site. Group Chairman, Susie Bedford said that concerned members wanted to show the Government that they would not sit back and let the Cape's unique environment be destroyed.

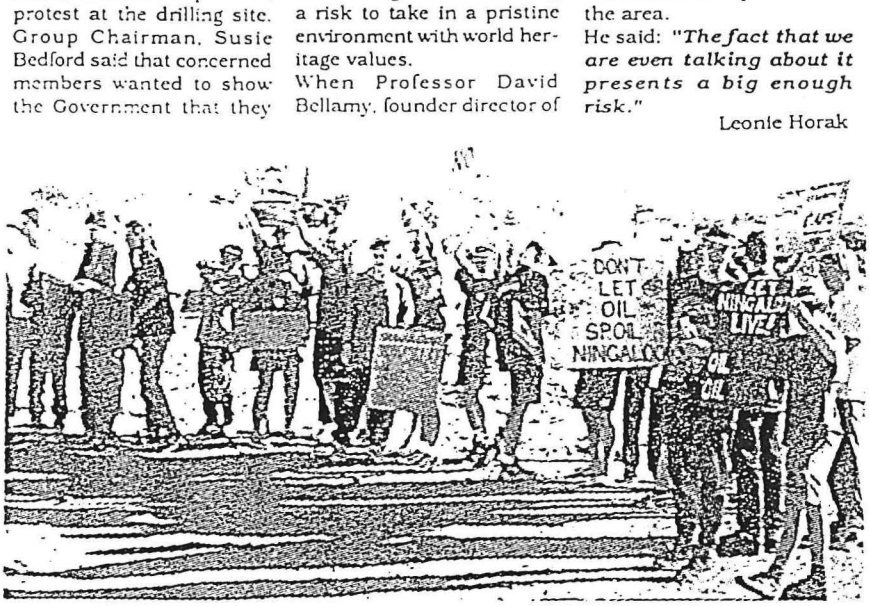
Even a slight risk is too big a risk to take in a pristine environment with world heritage values.

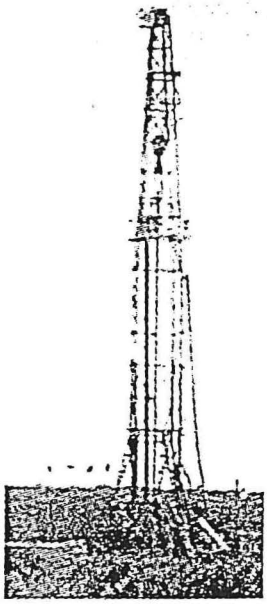
When Professor David Bellamy, founder director of the conservation foundation, visited Exmouth in June 1993, he was asked about the risk of oil exploration in the area.

He said: *"The fact that we are even talking about it presents a big enough risk."*

Leonie Horak

MELANIE 1





Oil exploration well Melanie 1, just south of Vlaming Head Lighthouse on the tip of North West Cape, forms the backdrop for a peaceful protest against the presence of oil exploration activities on North West Cape and in the adjacent waters surrounding Exmouth.

Department of Environmental Protection

1. Risk during tropical cyclones

The favoured time for the Chelonia exploration drilling program is between November and March due to the lower risks that were predicted for Ningaloo Reef, based on non-cyclonic wind conditions. While it is true that the area may also be subject to cyclonic winds during these months, the risk that a spill will occur due to a cyclone is considered negligible for the following reasons:

1. Based on historical records, cyclones have come within 370 km of the proposed location an average of 1.3 times per annum (34 cyclones in 26 years; Steedman Science & Engineering 1992). It should be noted, however, that the wind speeds experienced over the Chelonia area during most of these cyclones were relatively low compared to conditions routinely experienced on the North West Shelf during normal operations. Relatively few of these cyclones have generated more severe conditions. Of the above 34 cyclones, 11 were hind-cast to generate peak 10 minute average wind speeds greater than 20 m s^{-1} (approximately 40 knots) or peak significant wave heights greater than 2 m at the Chelonia location. This equates to a rate of 0.4 per year. Five cyclones were hind-cast to generate peak 10 minute average wind speeds greater than 25 m s^{-1} (approximately 50 knots) or peak significant wave heights greater than 2.5 m, a rate of 0.2 per year (Steedman Science & Engineering 1992).

2. A cyclone watch and preparation procedure is in place and is strictly enforced and scrutinised for safety as well as environmental reasons (Apache Energy Emergency Response Manual, Cyclone Alert Procedure 1994). This procedure includes constant monitoring of all cyclones and tropical lows that have the potential to develop into cyclones. The procedure sets down a requirement for: (a) complete shutdown of the drilling operation, (b) isolation of the well and (c) staged evacuation of personnel and support vessels from the rig after this rig is secure and prior to the approach of winds of gale-force (> 33 knots), which precede a tropical cyclone. This procedure ensures that sufficient time is given to securing the rig prior to a critical distance from the arrival of severe winds. At any stage of drilling, a blow-out preventer will be fitted, drilling gear retracted and locked off, all fuel and mud tanks sealed, decks cleared of materials, equipment stowed, water tight doors secured and the rig elevated upon its legs to above the potential wave height. If the well has entered a reservoir where hydrocarbons may be present, the procedure requires setting at least a 30 metre thick plug of cement in addition to the precautions given above. Consequently, the risk of reservoir fluid leakage is removed. Allowance for sufficient time for support vessels to seek shelter is included in the critical time calculations so that risks of a vessel-based spill at the site are also removed.

3. The drilling rig is designed and regularly tested to have sufficient structural integrity to resist severe weather conditions and impact loads. These are required in order to meet operational clearances provided internationally by the American Bureau of Shipping (ABS). The rig hull is to be a jack-up type which is raised above wave height and secured by an array of anchors when on station. Consequently, the hull is not subject to wave action. In the extreme elevated position (for water depths to 64 metres), the leg-system is designed to withstand wind speeds on the hull which exceed those generated by 1 in 100 year storm events (peak 10 minute average wind speeds exceeding 36 m/s) after head-on collision with one leg by a 5000 tonne vessel travelling at 2.0 m/sec (Reading & Bates Vessel Safety Case for the Ron Tappmeyer subsection 1.2.3, approved by DME, June 1996). The leg system is tapered and reduces in strength with elevation. Consequently, the leg system will have greater structural integrity at the shallower water depths at Chelonia. No episodes of rig capsize due to severe storms have occurred on the North West Shelf despite the history of operations during the cyclone season.

4. In the unlikely case of capsize, the rig is designed to maintain water-tight integrity and will be held on station by the anchoring system. Fuel and other fluids on board will remain contained within sealed tanks.

2. Petrofree Spill Simulations

The modelling approach taken to estimate the fate of drilling mud solids is considered the most rigorous method currently available for modelling the behaviour of particulate material. Unlike OILMAP, the MUDMAP model (and alternative models of this type) does not have the capacity to carry out a statistical assessment of plume distributions. An alternative approach was taken to randomly select a reasonable sample of potential spill times (when different conditions would be expected). The only restraint placed on start times was that they be at the start of ebb or flood flows. In this way, maximum excursions of the cuttings towards resources of concern were indicated under each of these different conditions. No claim has been made that these provide a definitive distribution. However, the results do indicate a number of general trends. Overall, these suggest that relatively light sedimentation loads could reach potentially sensitive habitats surrounding the Muiron Islands and North West Cape. These loads were predicted to be low relative to natural sedimentation loads.

3. Influence of spill volume on probability contours.

A concern was expressed that spill risk appeared to be relatively insensitive to initial spill volume. This concern appears to be based on a lack of understanding of what the spill risk contours represent, and how they are generated. More detail is provided here to better explain these aspects.

Probability contours summarise the contact of parts of simulated oil slicks with water and shoreline locations over a large sample of spill trajectories. It is therefore important to understand how each trajectory is modelled. Each spill trajectory was modelled by considering the spill as initially consisting of 100 equal parts (referred to as spillets). Both the position (centre point) and composition (volume, viscosity, thickness, water content, etc.) of each spillet is constantly recalculated as each spill progresses (these recalculations were performed at 10 minute time steps for the Chelonia assessment).

Calculations for each spillet are made independently to account for spatial and temporal variation in factors controlling the transport and fate of the oil within the model area. Consequently, while the spillets may initially have the same position (for a discrete spill point) and composition, the spillets tend to separate due to dispersive forces and will potentially have different fates (some may strand, some may be spread further and be evaporated faster, etc). This approach is analogous to observations of real spills, which typically break up into independent patches.

OILMAP uses separate algorithms to represent major processes influencing the movement and size of the spillets of oil:

- *Horizontal advection* is the lateral transport of the patches due to the combined physical forces of water motion and windage on the oil. OILMAP calculates this process at the scale of the model grid. A Lagrangian formulation (available on request) is used to determine a trajectory of each spillet to transport them from cell to cell. Input data for horizontal advection for the Chelonia assessment included surface current data, wind data and a coefficient for additional windage on the oil (0.5% of wind speed).

- *Random walk diffusion* is the tendency for an oil slick to be broken up by the energy of the receiving water. This process will be greater under storm conditions and in the open sea than where water flow is smooth and laminar. The algorithm adds horizontal dispersion to account for dispersive processes below the scale of resolution of the input current field. King & McAllister (1997) determined a value of approximately 0.1 m^2 /sec for an area near the Lowendal Islands with similar depth and subject to similar tidal currents to the Chelonia area. A more conservative value of 0.5 m^2/sec was used for the Chelonia assessment. Consequently, a greater spread of patches over time will have been predicted.

- *Spreading* is the increased area of a slick as it spreads out to a film due to its relative gravity and viscosity. OILMAP uses the formulation given in Mackay *et al.* (1980) for thick/thin spreading of an oil slick to calculate the radius of each spillet at each time step. Spillet radii will increase during the initial time steps to account for the initial spread of an oil slick due to gravity/viscosity, and decrease over time to account for evaporation or other losses. The radius of the spillets will therefore reflect the volume of the initial spill (all other factors being equal).

It is important to note that the influence of spreading on the stochastic predictions is relatively small compared to the increase in the areal extent of the slick due to diffusion and advection. This is due to the smaller influence of the former processes on the areal extent of a slick, as well as inherent conservatism within the model.

Gravitational/viscosity spreading acts only during the early phases of the spill and over a small scale, while diffusion and advection are ongoing processes that continue to increase the areal extent of a slick at a larger scale. For example, the mean patch radius and thickness for a 1,000 L and 100,000 L spill of diesel were calculated by OILMAP to be 3.5 m x 0.067 mm and 79.5 m x 3.15 mm respectively after 24 hours (using identical conditions). By contrast, the radius for the whole slicks were calculated to be 500 m and 1500 m. This point is also illustrated in Figure 1, which shows the spread of the spillets after time due to advection and diffusion.

As individual spill trajectories are modelled, OILMAP records a hit when a spillet passes into a grid cell. In addition, grid cells falling within the path of the aerial extent of a slick but not contacted (falling between gaps separating spillets) are still treated as a hit when the probability contours are calculated. This conservative approach allows for random error in the local positioning of spillets within the slick. From this, it follows that the areal extent of the slick has the most influence on the predictions for the probability of contact. Figure 2 illustrates the process used to generate probability contours. Each set of trajectories are modelled independently and the rate of contact of spill patches (i.e. spillets) with water and shoreline grid cells summarised by colour code. Coded areas with the same values are then enclosed by contour lines. Areas which lie outside of the 1% contour line are not contacted by any spillets during any of the trajectories. Areas enclosed by the 1% and 10% contour line are contacted by at least 1 spillet ($1/100^{th}$ part of a spill) during between 1 and 10 individual spill trajectories, and so on.

Note the following points in this example:

1. Slicks are predicted to vary widely in shape, areal extent and orientation, both between and during each trajectory, depending on the time-history of environmental conditions. They do not simply grow in diameter at a constant rate. Also, although the larger spill volume often generated a wider slick, this was not always the case.

2. Spills passed over some areas more often than other areas during both scenarios, giving a similar frequency distribution for the two spill volumes. In addition, trajectories may pass over some areas repeatedly. Differences in the contour areas for the scenarios may therefore reflect both different aerial extent and different persistence relating to the initial spill volume.

3. Grid cells that are missed by the trajectories but are surrounded by hits are still indicated as hits in the contours, providing a measure of conservatism.

Conservative values were used as input values controlling the diffusion and evaporation rates of the oils during the Chelonia assessment. Consequently, the predictions are considered to be worse case. Predictions for the smaller spills will be more conservative still for two main reasons: (a) spill radii will be small and intervening patches large relative to the aerial extent of the slick, and (b) the model continues to track spillets until they have zero volume. Consequently, spillets with very small volumes (as low as 0.0001 L) will continue to invoke grid hits, indicating higher probability of contact.

4. Model Validation

The DEP acknowledged that predictions of the hydrodynamic model showed good agreement with observations from both mat tracks and current metering around the Chelonia location and elsewhere but raised two concerns:

1) that observation periods were relatively short so that it was possible that model predictions may become unreliable over longer periods; and

2) that observations may be unreliable under combinations of wind and tide conditions that had not been present during the validation periods.

Mat-tracking is only practical during daylight hours (a vessel is required to keep sight of the mats to monitor their positions). This limited each period of observation to less than about 12 hours. Current metering, using an ADCP at the Chelonia site, was measured over 440 hours (18 days) and addresses the above concerns as (a) the current observations are about 5 times longer than the spill simulations used for risk assessment (96 hours), (b) they encompassed spring and neap tide conditions and (c) were made under widely varying wind conditions. Comparisons with this data also provides an opportunity to determine the reliability of the model results using wind data from the source of wind data used in the risk assessment (Thevenard Island). Wind data was previously only available from the wind station on Thevenard Island up until 5th April 1998 (covering 60 hours of these observations). However, data is now available for the full period and the following comparisons were generated.

Figure 3 illustrates the wind conditions observed at Thevenard Island during the study period. Figure 4 shows a comparison of the observed (red) and modelled (blue) East to West component of the current speed over the full 440 hours. Figure 4 shows the comparison for the North to South component. Note that a variety of wind conditions occurred under both the spring and neap tide periods.

The model predictions match the observations exceptionally well in both current speed and timing for the full period of measurement. A comparison of the data indicated a mean error in speed of 0.08 m s^{-1} and a mean error in direction of 6 degrees. Further, there was no tendency for the model predictions to lose phase with observations over time. Consequently, timing of tidal flow changes remained tightly predicted. The model also continued to predict current speeds over time very well, with generally small errors only at the times of maximum current speeds. There is no tendency for

this error to increase over time or for either the model predictions or observations to be consistently larger, suggesting random variation due to conditions at each time.

Under most conditions, there is less than 0.05 m s^{-1} error in the current speed throughout most of the tidal cycle, and less than 0.2 m s^{-1} error at the times of peak flow speeds. A few exceptions are the predictions for a number of days during the first neap tide, when the peak speeds were in error by up to 0.3 to 0.4 m s^{-1}. This is possibly due to local wind conditions, as currents during the start of the second neap period are well predicted.

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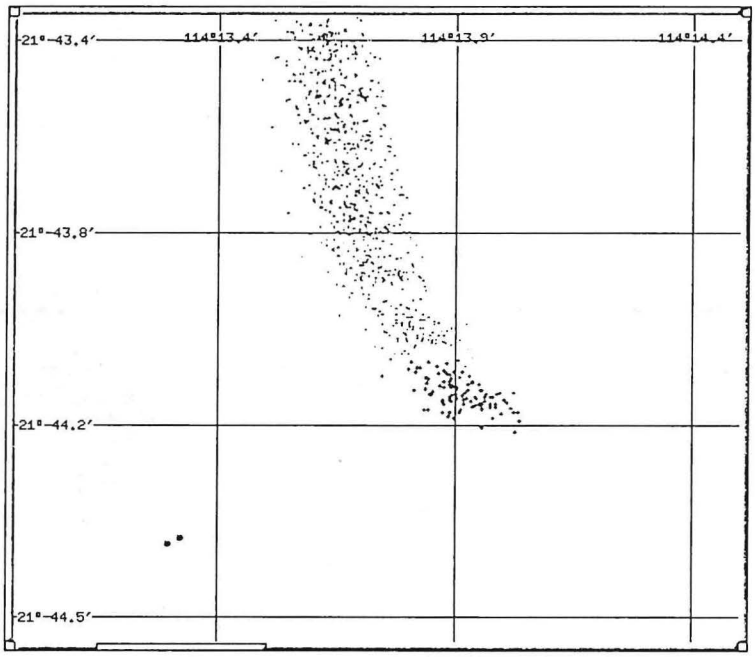

Figure 1: Magnified view of an OILMAP simulation of a 5,000 L spill of diesel 8 hours from release showing the "spillets" (black crosses) used to represent the centre-points of slick patches. The spacing of spillets is subject to random-walk diffusion, dispersion and advection (see text). Note that, as for real spills, the areal extent of the slick (red dots) will become greater than the actual surface area as patches will be interspersed by open water. This will be particularly true for small spills, where each patch has a relatively small surface area relative to the distance between patches.

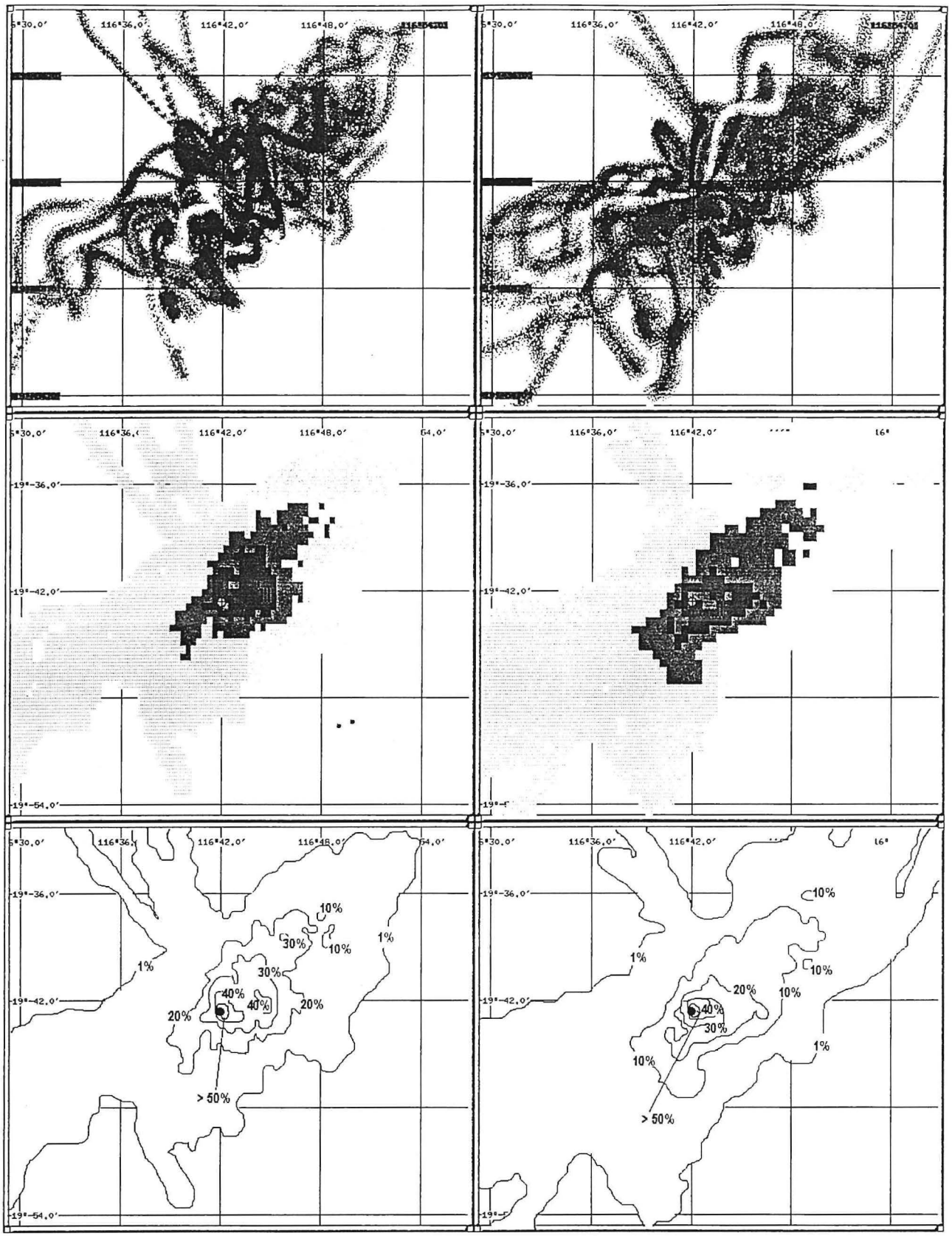

Figure 2: **Comparison of the results of stochastic predictions for two spill sizes: left hand set =2,000 L of diesel; right hand set = 20,000 L of diesel. The top panels show the predicted paths of 100 individual spill trajectories under randomly selected conditions. The middle panels summarise the results for all trajectories as a rate of contact of patches with water surface grid cells. The bottom panels show the summaries reduced to contour lines. Note that the contour areas for the larger spill volumes are slightly larger.** ***Note that the model area and predictions are shown for illustrative purposes only and do not relate to the Chelonia risk predictions in any way.***

Figure 3: Vector plot showing a time-series of wind records recorded at Thevenard Island during the observation and modelling period. Line lengths indicate the relative speed. Line direction indicates the direction that the wind was blowing to. Note that a wide variety of wind speeds and directions occurred during both neap and spring tides during this period.

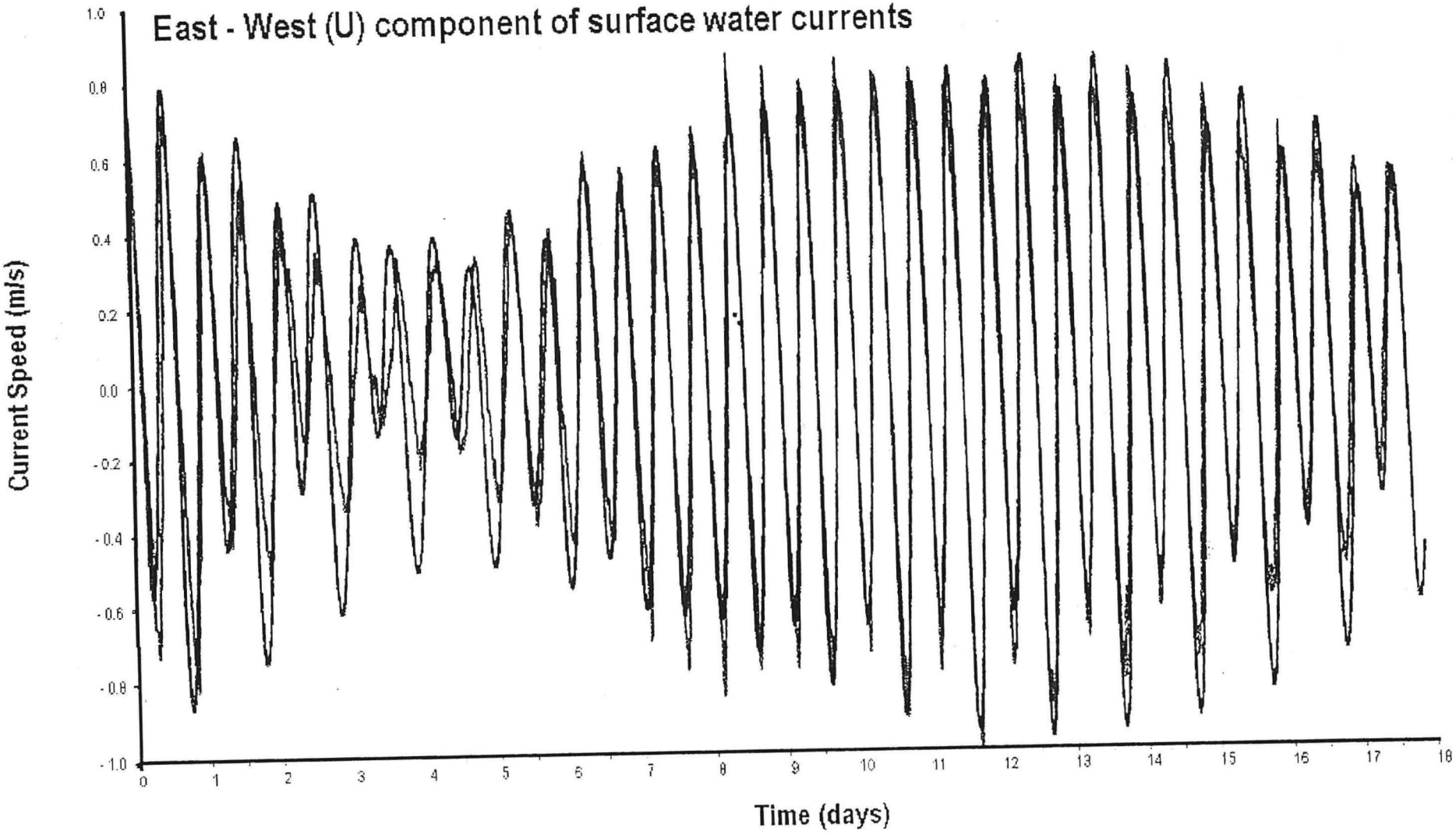

Figure 4. East to West (U) component of the surface water currents observed (red line) and predicted (blue line) for 440 hours in April 3/4/98 to 20/4/98.

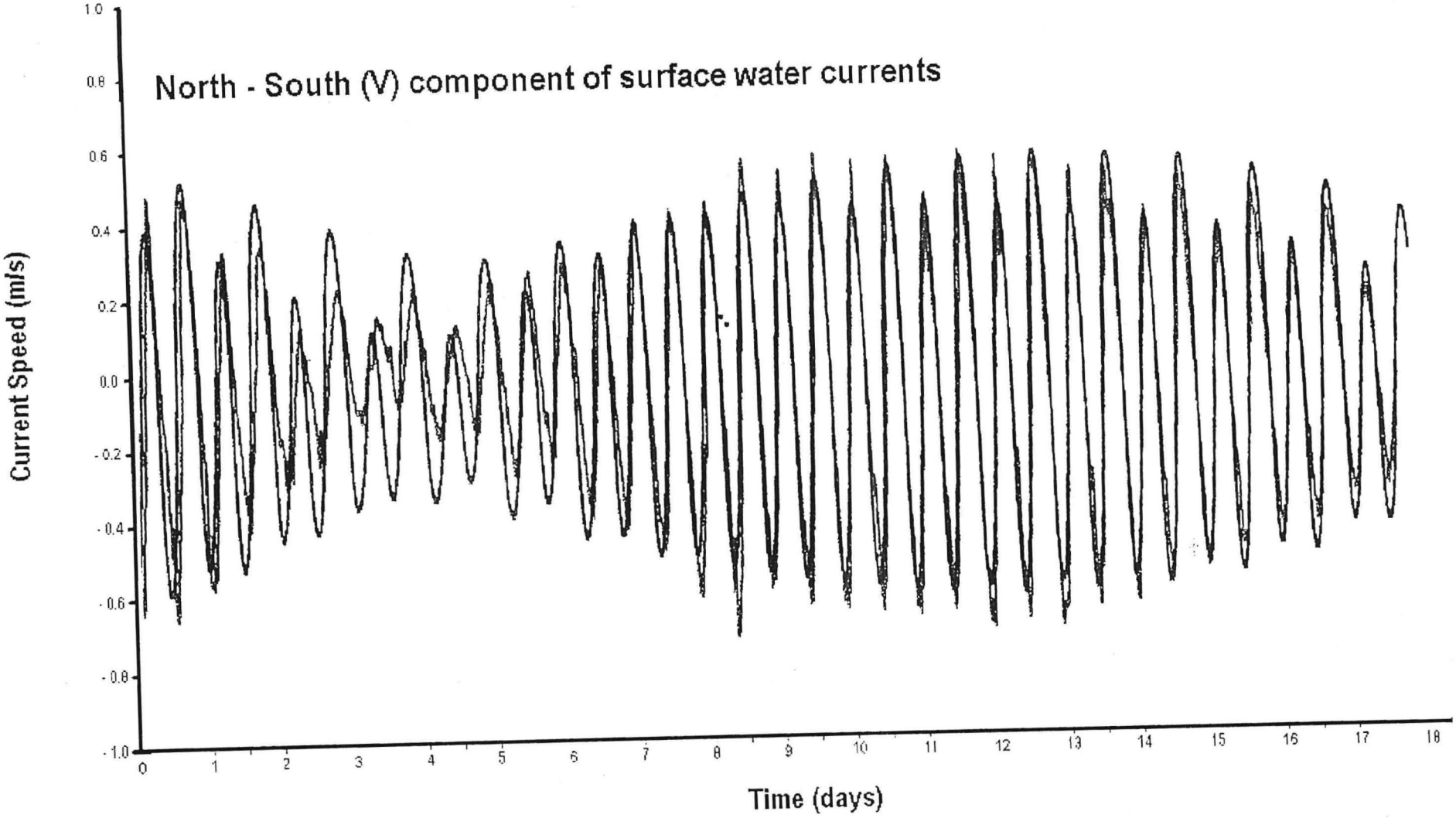

Figure 5. North to South (V) component of the surface water currents observed (red line) and predicted (blue line) for 440 hours in April 3/4/98 to 20/4/98.