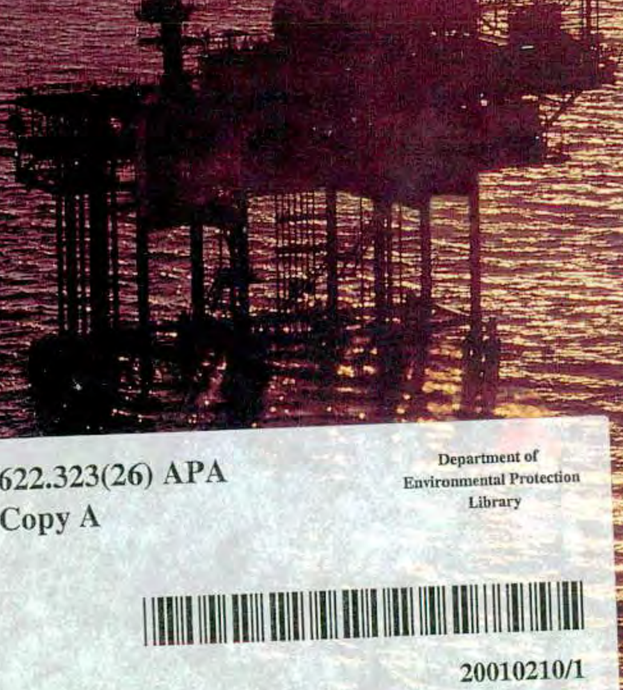
Apache ENERGY

Simpson Development

Public Environmental Report

EPA Assessment 1358



622.323(26) APA
Copy A

Department of
Environmental Protection
Library

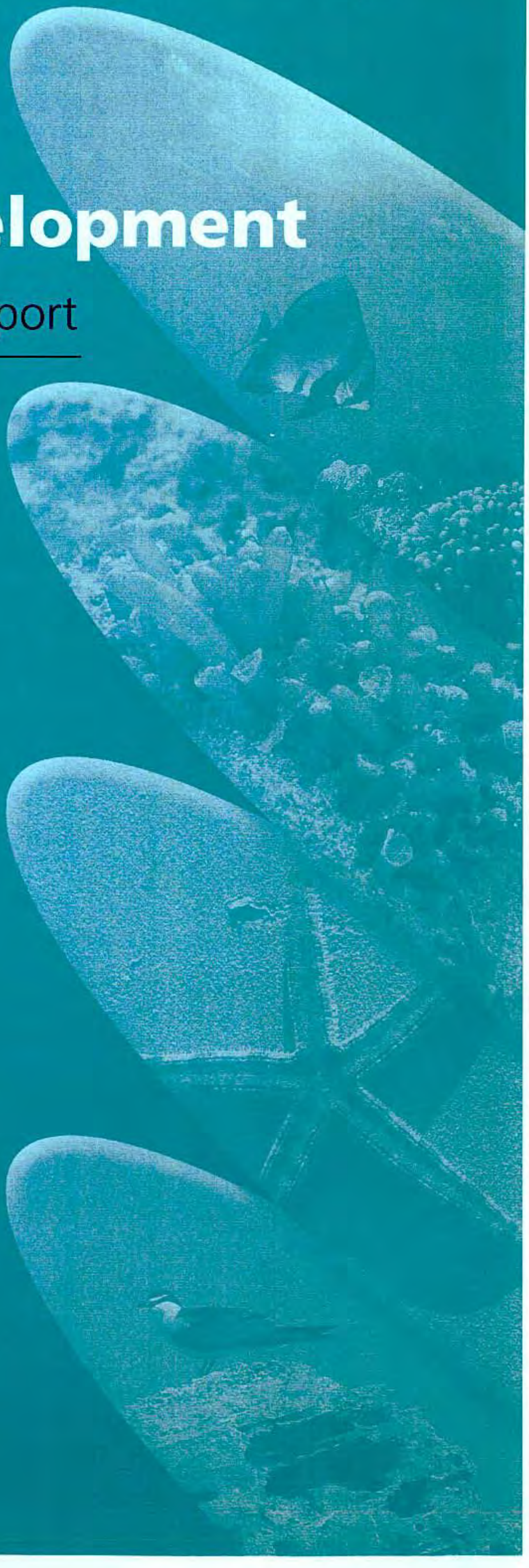
20010210/1

622.323 (26) APA
20010210/1

LIBRARY
DEPARTMENT OF ENVIRONMENTAL PROTECTION
WESTRALIA SQUARE
141 ST. GEORGE'S TERRACE, PERTH

Simpson Development

Public Environmental Report



EPA Assessment 1358

Apache Energy Pty Ltd
256 St George's Terrace, Perth
Western Australia 6000

23 April 2001
Report Number: EA-60-RI-110

Invitation to Make a Submission

The Environmental Protection Authority (EPA) invites people to make a submission on this proposal.

Apache Energy Ltd proposes to develop the Simpson field. In accordance with the Environmental Protection Act, a PER has been prepared which describes this proposal and its likely effects on the environment. The PER is available for a public review period of 4 weeks from 23 April 2001 closing on 21st May 2001.

Comments from government agencies and from the public will help the EPA to prepare an assessment report in which it will make recommendations to government.

Why write a submission?

A submission is a way to provide information, express your opinion and put forward your suggested course of action – including any alternative approach. It is useful if you indicate any suggestions you have to improve the proposal.

All submissions received by the EPA will be acknowledged. Submissions will be treated as public documents unless provided and received in confidence subject to the requirements of the Freedom of Information Act, and may be quoted in full or in part in the EPA's report.

Why not join a group?

If you prefer not to write your own comments, it may be worthwhile joining with a group interested in making a submission on similar issues. Joint submissions may help to reduce the workload of an individual or group, as well as increase the pool of ideas and information. If you form a small group (up to 10 people) please indicate all the names of the participants. If your group is larger, please indicate how many people your submission represents.

Developing a submission

You may agree or disagree with, or comment on, the general issues discussed in the PER or the specific proposals. It helps if you give reasons for your conclusions, supported by relevant data. You may make an important contribution by suggesting ways to make the proposal more environmentally acceptable.

When making comments on specific elements of the PER:

- Clearly state your point of view;
- Indicate the source of your information or argument if this is applicable;
- Suggest recommendations, safeguards or alternatives.

Points to keep in mind

By keeping the following points in mind, you will make it easier for your submission to be analysed:

- attempt to list points so that issues raised are clear. A summary of your submission is helpful;
- refer each point to the appropriate section, chapter or recommendation in the PER;
- if you discuss different sections of the PER, keep them distinct and separate, so there is no confusion as to which section you are considering;
- attach any factual information you wish to provide and give details of the source. Make sure your information is accurate.

Remember to include:

- your name;
- address;
- date; and
- whether you want your submission to be confidential.

The closing date for submissions is: 21st May 2001.

Submissions should be addressed to:

The Environmental Protection Authority
Westralia Square
141 St Georges Terrace
Perth WA 6000
Attention: Peter Walkington

Table of Contents

List of Tables

List of Figures

List of Appendices

Executive Summary

Project description

- This document is a Public Environmental Review (PER) submitted by Apache Energy Limited and the Joint Venture Participants to seek environmental approval to develop the Simpson field, located in Production Licences TL/1 and TL/6.
- Apache's operations are centred on Varanus Island, the largest of the Lowendal Islands. Apache is currently operating nine offshore oil and gas installations, ranging in distance from 5 – 63 km away from Varanus Island. All of these installations are brought together onto Varanus Island into a central operations area referred to as the Varanus Island Hub. The proposed Simpson development will become an additional installation of the Varanus Hub operations.
- The proposed Simpson development proposal will consist of:
  - the Simpson Alpha offshore mini-platform located at the Tanami-4 and Tanami-5 wells surface location;
  - the Simpson Bravo offshore mini-platform located at the Simpson-1 and Simpson 3H well locations; and
  - a sub-sea pipeline bundle linking the two mini-platforms to each other and to existing facilities on Varanus Island.
- The pipeline bundle will consist of:
  - a production pipeline transporting oil, produced formation water and natural gas;
  - a return water pipeline for disposal of produced formation water into a deep disposal well;
  - a return gas pipeline containing lift gas; and
  - an umbilical containing corrosion inhibitor chemicals and dry utilities gas.
- The proposed surface locations of Simpson Alpha and Simpson Bravo mini-platforms are approximately 1,000 m and 1,140 m respectively, from the southern tip of Varanus Island and a minimum distance of 400 m to the east of Abutilon Island, one of the smaller islands of the Lowendal group of islands. Water depth at the location is approximately 6 m LAT.
- The two mini-platforms will be unmanned and will accommodate a minimal amount of equipment limited to the well heads, testing equipment and emergency shut-down facilities.
- The installation of the Simpson Alpha and Simpson Bravo mini-platforms, and the associated pipeline bundle will take approximately 2 weeks. Work on the project is scheduled to begin in late September 2001, following the necessary environmental approval. Installation of the onshore portion of the pipeline bundle will also take about two weeks and will be carried out concurrently with the offshore installation.
- The Simpson field is expected to produce for a 10 year period.

Resources of the area

- The marine ecological habitats found within the region of the Lowendal Islands are: macroalgal beds, limestone pavement with a sand veneer, fringing and patch coral reefs, rocky shores, sandy beaches and mangroves. The water column supports a range of marine mammals, reptiles, pelagic and benthic fish and plankton. The sea surface also supports some species of seabirds that feed at sea.
- There are at least 78 listed species that may potentially be found in the region. The majority

of these species are migratory shorebirds and resident seabirds. There are no listed threatened ecological communities.

- Social, commercial and historical resources of the region include the towns of Onslow and Dampier, Onslow Prawn Fisheries Grounds, oil and gas industry, pearl fishery, limited tourist activity and recreational fishing, four historic shipwrecks and historic nuclear testing sites.
- The Lowendal Islands are classified as a C-Class reserve for the conservation of flora and fauna, and are vested in the Conservation Commission. The area is presently going through the planning process for a proposed Montebello/Lowendal/Barrow Islands marine conservation reserve.
- The seabed in the vicinity of the proposed Simpson development location is mainly limestone pavement with variable cover of macroalgae and sand with intermittent patches of small coral colonies and sponges.

Environmental risk assessment

- A detailed risk assessment was carried out to identify the sources of impact from installation activities, routine operations and accidental events. This was carried out through a workshop forum that consisted of Apache personnel, and government and community participants.
- The installation of the Simpson mini-platforms and pipeline bundle will cause a short-term, localised impact to the seabed, but will not cause a significant impact to the habitats, flora or fauna of the region. Installation will occur outside the peak turtle and seabird nesting period. It will also occur outside the whale migration period.
- Routine operations associated with producing oil from the Simpson field will not cause a significant impact to any of the habitats, flora or fauna found in the region. There will be no discharges from the Simpson development as produced formation water recovered from the field, along with process chemicals, will be disposed via a deep disposal well. The Simpson development will not increase oil tanker traffic above historical frequencies.
- The chance of an incident occurring that resulted in the spill of oil into the marine environment has been assessed as being a low probability event. The quantitative risk assessment indicated that the risk spill scenario is more likely to be a smaller volume leak associated with the pipeline than a potentially larger event associated with a production well.
- Should a spill occur offshore, there is a high probability that oil would reach a shoreline. The Lowendal Islands are at the greatest risk regardless of seasons and prevailing winds.
- From the biological and human resources identified in the review, the following were considered to be potentially the most sensitive to the effects an oil spill:
  - turtles and seabirds during the summer breeding season;
  - shallow, subtidal algal beds; and
  - intertidal and shallow subtidal coral areas.

Environmental management

- A number of mitigating factors will be put into place that will reduce the impact of the installation activities and routine activities. These include:
  - carrying out the installation of the facilities outside the peak turtle and seabird migration period;
  - providing detailed habitat maps and aerial photographs to the barge and support vessels to ensure anchoring will not damage corals; and
  - disposing produced formation water and process chemicals into deep disposal wells and not the marine environment.

- A number of engineering designs will be put into place that will reduce the risk of an oil spill from the mini-platforms and the pipeline bundle. These include:
  - putting into place a continuous corrosion control system;
  - trenching the pipeline where significant boat traffic occurs;
  - using a heavy walled pipe rated to the full well pressure possible from the production wells;
  - installing an automatic shut-down system that will have the capacity to shut-down production in less than 60 seconds; and
  - adhering to the relevant Australian and international engineering design standards.
- Apache will undertake the environmental guidelines, management and monitoring commitments given in this PER for the proposed Simpson development and will fulfil these commitments to the satisfaction of the appropriate statutory authorities.

Key Characteristics

Element	**Description**
Name of proposal	Simpson development
Name of proponent	Apache Energy Limited
Life of the project	10 years
Location	Lowendal Islands
List of major components	• The Simpson Alpha offshore mini-platform located at the Tanami-4 and Tanami-5 wells surface location; • The Simpson Bravo offshore mini-platform located at the Simpson-1 and Simpson 3H well locations; and • A sub-sea pipeline bundle linking the two mini-platforms to each other and to existing facilities on Varanus Island.
Area of disturbance	Temporary disturbance to about 1,800 m^2 of shallow marine, macroalgal habitat and 200 m^2 of terrestrial habitat with sparse vegetation.
Estimated production	Annual average production of 2,500 bbls per day at the commencement of the project in 2001. Peak annual average production of 8,037 bbls per day in 2002. Decrease in annual average production to 754 bbls per day by 2010.
Waste management	Produced formation water and production chemicals will be disposed of down a deep disposal well.

EPA Guidelines and Objectives and proposed management controls

Environmental factor	EPA Objective	Existing environment	Potential impact	Environmental management	Predicted outcome	Reference Section in PER
OIL SPILLS						
Spills from the development and pipeline bundle	Estimate the oil spill risk of the development over its lifespan. Estimate: • Probability of spill occurring • Probability of spill contacting sensitive areas • Probable ecological impacts in the event that a spill contacts sensitive areas • Probable time for, and implications of, environmental recovery/ rehabilitation/clean-up.	Oil and gas exploration and production have been undertaken in the immediate area since 1986. Apache operates nine offshore facilities, associated pipelines, and onshore facilities on Varanus Island. CALM approved lease to operate on Varanus Island. Shallow water marine environment, predominantly macroalgae, exposed sand and limestone pavement. Corals constitute small percentage of habitat type. Seventy-eight listed species found in region.	Dependent on size of spill, season and winds. Light crude oil produced at Simpson, evaporates quickly, with moderate to low toxicity. Shallow, subtidal habitats may be affected by toxic components of freshly spilled oil. Sandy beaches, turtles, and seabirds most vulnerable in summer during breeding season. Impact to marine mammals would be negligible due to low populations and transient nature.	Ensure minimal risk of leakage by identifying and managing risks. Put into place mitigating actions to reduce risk including: 1. continuous corrosion control program; 2. trenching the pipeline where boat traffic occurs; 3. using heavy walled pipe; 4. installing an automatic shutdown system with a shutdown capacity within 60 seconds; 5. complying with Australian and international engineering and design standards; and 6. ongoing maintenance inspections.	Risk of leakage reduced to as low as possible through engineering design and operating procedures. The risk of a spill occurring large enough to cause a significant impact is moderate (i.e. risk of 10^{-3}). Quantitative risk determined for a potential loss from the wells requires multiple failures being 2.0×10^{-6}. Potential loss from the onshore or offshore pipeline bundle quantified as 2.6×10^{-3}.	Section 6.1 (p.77)
	Investigate risk reduction options			Hazard identification (hazid) workshop on proposed project undertaken involving Apache as well as Government and Community representatives. Put into place mitigating actions to reduce risk including: 1. continuous corrosion control program; 2. trenching the pipeline where boat traffic occurs; 3. using heavy walled pipe; 4. installing an automatic shutdown system with a shutdown capacity within 60 seconds; 5. complying with Australian and international engineering and design standards; and 6. ongoing maintenance inspections.	Ongoing re-engineering and modifications to the development undertaken to address unacceptable ranked risks.	Section 6.2 (p.115)
	Update oil spill contingency plan (OSCP) to accommodate the Simpson development.			OSCP and Environmental Resource Atlas revised to include the Simpson development.		Section 6.3 (p.116)
	Provide information as to whether there will be increased tanker traffic as a result of the project			Oil tanker traffic as a result of production from the Simpson development will not increase above historical levels associated with Varanus Island.		Section 5.4.7 (p.73)

EPA Guidelines and Objectives and proposed management controls (cont.)

Environmental factor	EPA Objective	Existing environment	Potential impact	Environmental management	Predicted outcome	Reference Section in PER
	Provide a summary of oil spill risk management measures (including pre-qualification of ships) applied to shipping associated with the Apache base at Varanus Island.			Pre-qualification questionnaire for ships is used to assess suitability for loading at Varanus Marine terminal. Procedures set out in the International Safety Guide for Oil Tankers & Terminals are followed.	No incident from the tanker loading facility resulting in an oil spill.	Section 5.4.7 (p.73)
CONSTRUCTION IMPACTS						
Coral reefs	Select pipeline route so as to avoid coral reefs and other sensitive environments.	Unconsolidated sand on limestone pavement. Predominantly macroalgae, sparse epifauna. Marine animals such as fish, turtles, dolphins, invertebrates.	1,700 m^2 of impact to seabed. Potential for: - damage to macroalgae and epifauna. - increased water turbidity.	Detailed habitat maps and aerials generated and provided to site project manager. Selection of route along soft bottom, algal seabed. Pipeline bundle will be away from coral habitats.	Recovery of disturbed seabed within six months. No habitat fragmentation due to small pipeline bundle. No impact to coral habitats.	Section 5.2 (p.67)
	Adopt procedure to prevent damage to corals and other sensitive environments by work vessels and their anchor chains.	Unconsolidated sand on limestone pavement. Predominantly macroalgae, sparse epifauna. Patch coral reefs and bommies. Marine animals such as fish, turtles, dolphins, invertebrates.	100 m^2 of impact to seabed. Potential for: - damage to macroalgae and epifauna. - increased water turbidity.	Mooring/anchoring plan to be developed using detailed habitat maps & aerial photos. Anchoring guidelines issued to barge and support vessels.	Recovery of disturbed seabed within six months. No habitat fragmentation due to small pipeline bundle. No impact to coral habitats.	Section 5.6 (p.76)
	Phase pipeline and platform construction to avoid impacts during coral spawning time.	Patch coral reefs and bommies located to west of proposed mini-platforms. Corals scattered throughout macroalgal beds.	Construction of mini-platforms and pipeline to take two weeks.	No construction during coral spawning season (November).	No interference with coral spawning.	Section 5.6 (p.76)
Turtle and seabird breeding	Phase pipeline and platform construction so as to avoid interference with turtle and seabird breeding, where impacts are possible.	Three species of turtles use the sandy beaches for breeding. Important area for shearwater and tern breeding.	Construction of mini-platforms and pipeline to take two weeks.	No construction during the peak turtle or seabird breeding season (November - March).	No impact to turtle or seabird breeding cycle. No impact to other listed endangered species.	Section 5.6 (p.76)
Feral animals, weeds and other exotic species	Landings on Abutilon Island are not permitted.	Flora and fauna of islands.	Trampling of vegetation. Disturbance to birds. Collection of shells.	No access to any island except Varanus Island. If access required, permission to be given by Field Superintendent.	No disturbance to island flora and fauna.	Section 6.4.4 (p.121)
	Approved quarantine procedures to be implemented.	Island habitat.	Disruption to plants and animals on the offshore islands.	Quarantine procedures updated. Procedures incorporated into contract of construction contractor. Inductions given to all contractors.	No introduction of feral animals, weeds or other exotic species.	Section 6.4.4 (p.121)
Sand dunes and other coastal vegetation	Shoreline crossing on Varanus Island to be designed in consultation with CALM.	Rock boulders and cement blocks.	No vegetation as shoreline has been stabilised to ensure integrity of existing east wharf.	Negligible impact as there is no vegetation or coastal dunes. Pipeline bundle within CALM lease and previously disturbed area. CALM participation at hazid for the development.	No impact to shoreline.	Section 5.2.3 (p.69)

EPA Guidelines and Objectives and proposed management controls (cont.)

Environmental factor	EPA Objective	Existing environment	Potential impact	Environmental management	Predicted outcome	Reference Section in PER
	Rehabilitation (where disturbance is unavoidable) to be carried out in consultation with CALM.	Rock boulders and cement blocks.	No vegetation as shoreline has been previously stabilised to ensure integrity of existing east wharf.	Negligible impact as there is no vegetation or coastal dunes. Pipeline bundle within CALM lease and previously disturbed area. CALM participation at hazid for the development.	No impact to shoreline.	Section 5.2.3 (p.69)
Shoreline stability	In consultation with CALM, design Varanus Island shoreline crossing to prevent shoreline from erosion due to pipeline acting as groyne.	Rock boulders and cement blocks.	Shoreline has been previously stabilised to ensure integrity of existing east wharf.	Crossing area already stabilised for erosion protection. This will be added to. CALM participation at hazid for the development.	No impact to shoreline.	Section 5.2.3 (p.69)
EMISSIONS						
Liquid emissions	Develop a management plan for disposal of pipeline test chemicals (hydrotest waters and pickle liquors), pipeline treatment chemicals (biocides, corrosion inhibitors and antifouling used to maintain the pipeline) and produced formation water, to ensure low impact on the environment, consistent with international best practice.	Shallow water marine environment and terrestrial habitat.	Introduce chemical contaminants into the ocean. Spillage of contaminants onto terrestrial habitat.	No discharge into the marine environment. Hydrotest water will be disposed into the Alkimos deep disposal well. Pipeline treatment chemicals (corrosion inhibitors) will be contained within the produced formation water (PFW). PFW will be discharged to either the Alkimos or Tanami-5 deep disposal wells.	No impact to the marine environment.	Section 5.4.1 (p.71) Section 5.4.2 (p.71) Section 5.4.3 (p.71) Section 5.4.5 (p.72)
Introduced marine species	Assess risk of introducing exotic marine organisms via ballast water or hull fouling. Submit appropriate strategy to prevent introduction of such organisms.	Tanker loading facility in 27 m of water. Shallow water marine environment.	Introduction of marine species which may out-compete native species.	Reduce risk through compliance with AQIS ballast water guidelines. Majority of tankers coming to the Varanus Island loading terminal have already discharged ballast prior to entering the terminal, or have no need to discharge ballast once at the terminal.	No introduction of marine pest species into the Varanus Island port.	Section 6.4.4 (p.121)
Greenhouse gases	Assess the impact of the proposal on greenhouse emissions.	Atmosphere.	Introduction of about 6,000 tonnes of greenhouse gases from Simpson development. Reduction in greenhouse gases from other Varanus operating fields which are themselves declining.	Engines to run at most efficient capacity and on natural gas. Minimal sources of emissions. No venting or flaring unless under an emergency.	Negligible contribution to global greenhouse gases.	Section 5.4.6 (p.72)
	Develop a management plan to minimise greenhouse emissions.	Atmosphere.	Introduction of about 6,000 tonnes of greenhouse gases.	Inclusion of Simpson development into the greenhouse strategy for the Varanus Hub operations.	Strategy encompassing all operations associated with the Varanus Island Hub.	Section 5.4.6 (p.72)
Light overspill	Design lighting in consultation with CALM specialists.	Island and marine environment.	Only one pulsating navigational light to be installed on each platform. No significant impact to fauna species.	Maintenance visits to be undertaken during the day. No requirement to install lighting to the platforms.	No impact to the marine environment.	Section 5.4.4 (p.71)
Decommissioning	Decommissioning to be considered at design phase Submit decommissioning strategy as part of PER document.	Marine environment		Following the economic completion of the Simpson field all wells will be plugged and casings cut just below the level of the seabed. Platforms and pipelines will be removed or as directed by the relevant Minister(s).	Following decommissioning disturbed habitats will return to previous condition.	Section 5.5 (p.75)

1 Introduction

1.1 Background

In March 2000, Apache Energy Limited (Apache), representing the Joint Venture Participants in Production Licences TL/1 and TL/6, sought approval to drill two appraisal wells known as Tanami-4 and Tanami-5 into what was thought to be the Tanami field. The surface locations of the Tanami-4 and Tanami-5 appraisal wells were about one kilometre from the southern tip of Varanus Island and 400 m to the east of Abutilon Island (Figure 1). Tanami-4 and Tanami-5 were separate wells, drilled from surface locations immediately next to each other.

The Environmental Protection Authority (EPA) did not assess the drilling program as they considered the impact to be insignificant, and referred the matter to the relevant agency (the Department of Minerals and Energy, Western Australia) to ensure the drilling program was carried out in an environmentally sound manner.

The Department of Minerals and Energy (DME) granted approval to drill the two appraisal wells in May 2000. Tanami-5 was drilled between 7-18 June and Tanami-4 was drilled between 18-28 June 2000, both without incident.

Tanami-5 was a dry well, but Tanami-4 resulted in a hydrocarbon discovery in the Flag Sandstone. Electric logging indicated a 19.1 metre column of light crude oil.

Apache initially believed that the Tanami-4 and 5 wells would penetrate the same oil accumulation as the original Tanami oil discovery made in 1991, and the wells were named accordingly. However, drilling showed that the Tanami-4 well was located within a different accumulation and the name was changed to the Simpson field to reflect this difference.

Another appraisal well, Simpson-1, was submitted for approval to drill to help evaluate the extent of the Simpson field. Simpson-1 was located 140 m south south-west of the Tanami-4 and -5 surface location (Figure 1). Simpson-1 was not assessed by the EPA, but referred to the DME as with the Tanami-4 and -5 wells. The DME granted approval to drill Simpson-1 on 12 January 2001. Simpson-1 was drilled on 29 January - 13 February 2001 and confirmed an extension to the Simpson field. Logging indicated a column of 33 metres of light crude oil, of similar composition to Tanami-4.

Two additional wells will be drilled in early 2001 to further delineate the field: the Simpson-2 appraisal well and the Simpson-3H development well. Simpson-3H will only be drilled if hydrocarbons are encountered in the Simpson-2 well. Simpsons-3H will be used as a production well if it is drilled. These wells will be submitted to the DME for approval and drilling should be complete by mid-2001.

1.2 The Proposed Project

The proposed Simpson development will consist of the following (Figure 2):

- the Simpson Alpha (Simpson 'A') offshore mini-platform located at the Tanami-4 and Tanami-5 well surface location;
- the Simpson Bravo (Simpson 'B') offshore mini-platform located at the Simpson-1 and Simpson-3H development well surface locations approximately 140 m to the south-west of the Simpson 'A' mini-platform; and

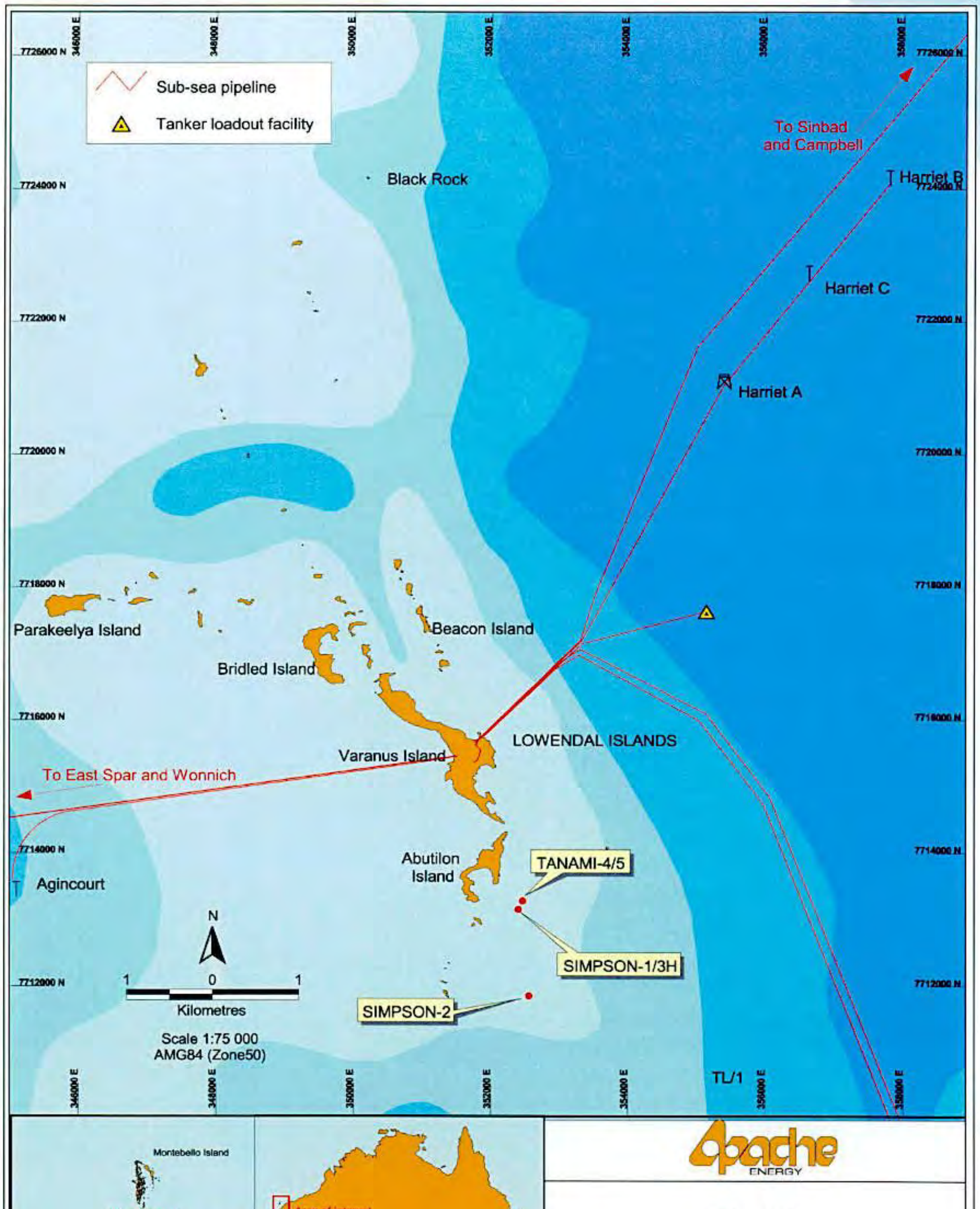


Figure 1

Location map of wells associated with the Simpson Development

PROPOSED SIMPSON DEVELOPMENT CONCEPT
GENERAL SCHEMATIC

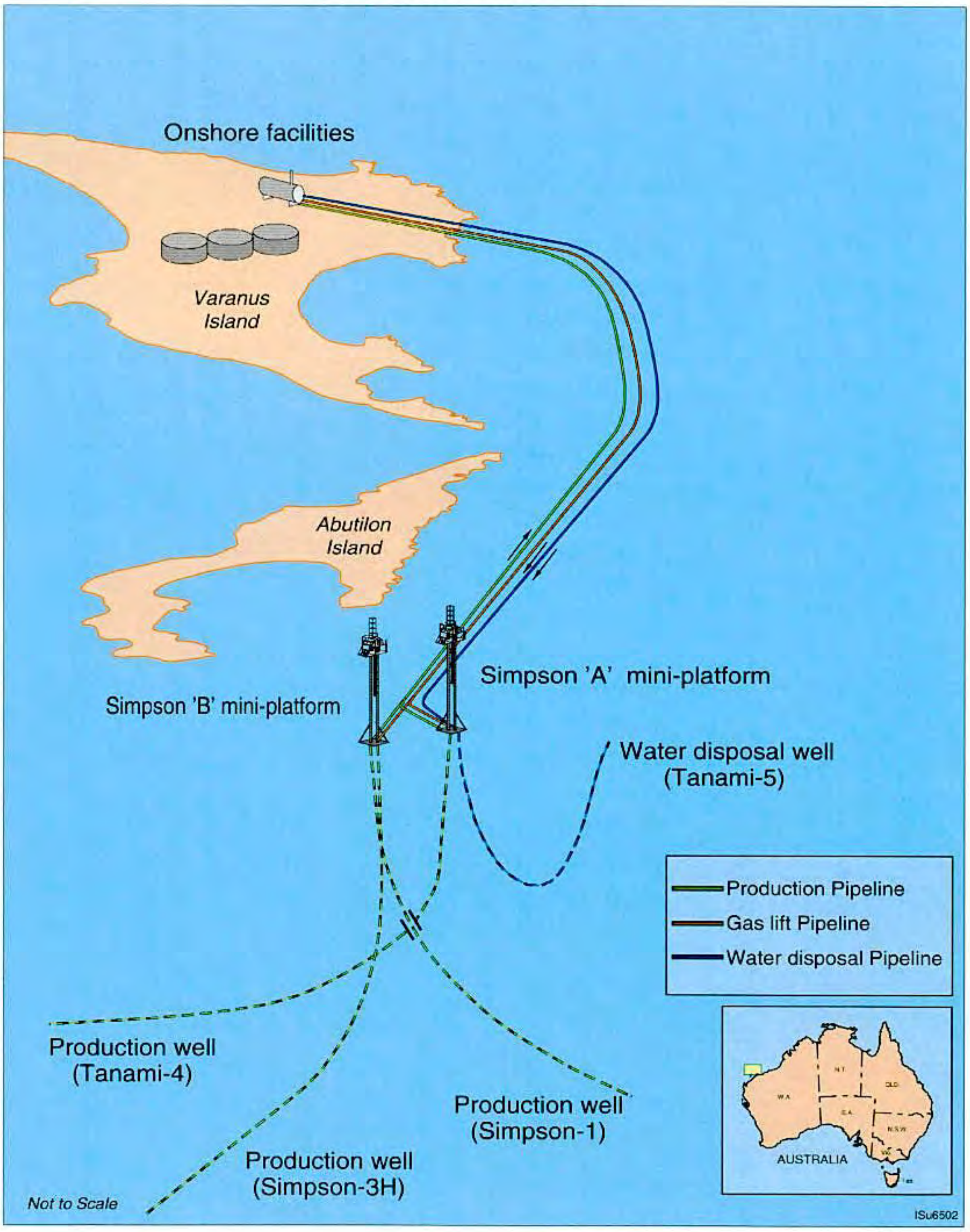


Figure 2

- a sub-sea pipeline bundle linking the Simpson 'A' and Simpson 'B' mini-platforms to each other and to existing facilities on Varanus Island.

The two mini-platforms will be unmanned and will accommodate a minimal amount of equipment limited to the well head, testing equipment and emergency shut-down facilities. The Simpson 'A' and Simpson 'B' mini-platforms will have dimensions of approximately 5 m x 5 m and will sit about 10 m above the water surface (Figure 3).

The pipeline bundle linking the Simpson 'A' and Simpson 'B' mini-platforms to the existing production facilities on Varanus Island will consist of:

- an 18" production pipeline (transporting the crude oil, produced formation water (PFW) and natural gas recovered from the Tanami-4 production well and the Simpson production wells to Varanus Island;
- a return water pipeline for disposal of PFW into a deep disposal well;
- a return gas pipeline containing lift gas; and
- an umbilical containing corrosion inhibitor chemicals and dry utility gas.

Existing processing equipment on Varanus Island will separate the oil, gas and PFW stream received from the incoming production pipeline. PFW will be reinjected either to an existing re-injection well (Alkimos) located on Varanus Island or pumped via the return water pipeline to the Tanami-5 well for disposal. The separated natural gas from the Simpson development will be combined with the existing natural gas streams from other Apache gas fields and exported as domestic sales gas. A small volume of this natural gas will be diverted from the collected gas streams into the Simpson return gas line where it will be used as lift gas for the Tanami-4 and Simpson wells.

The Simpson field is expected to produce economically for a 10 year period.

1.3 The Proponent

Apache Energy Ltd is the proponent for the Simpson development on behalf of the Joint Venture Participants in Production Licences TL/1 and TL/6.

The Joint Venture Participants in the project are:

Apache Northwest Pty Ltd (Operator)
Apache Harriet Pty Ltd
Apache Lowendal Pty Ltd
Apache Miladin Pty Ltd
Apache Nasmah Pty Ltd
Kufpec Australia Pty Ltd
Tap (Harriet) Pty Ltd

Apache Northwest Pty Ltd is a subsidiary of Apache Energy Ltd, an Australian operating subsidiary of Apache Corporation, an independent oil and gas company based in Houston, Texas. Apache and its predecessors have been operating on the North West Shelf since 1986. Apache Energy Ltd is the manager for Apache Northwest Pty Ltd.

Currently, Apache is operating nine offshore oil and gas installations, ranging in distance from 5- 63 km away from Varanus Island (Figure 4). All of these installations are brought together onto

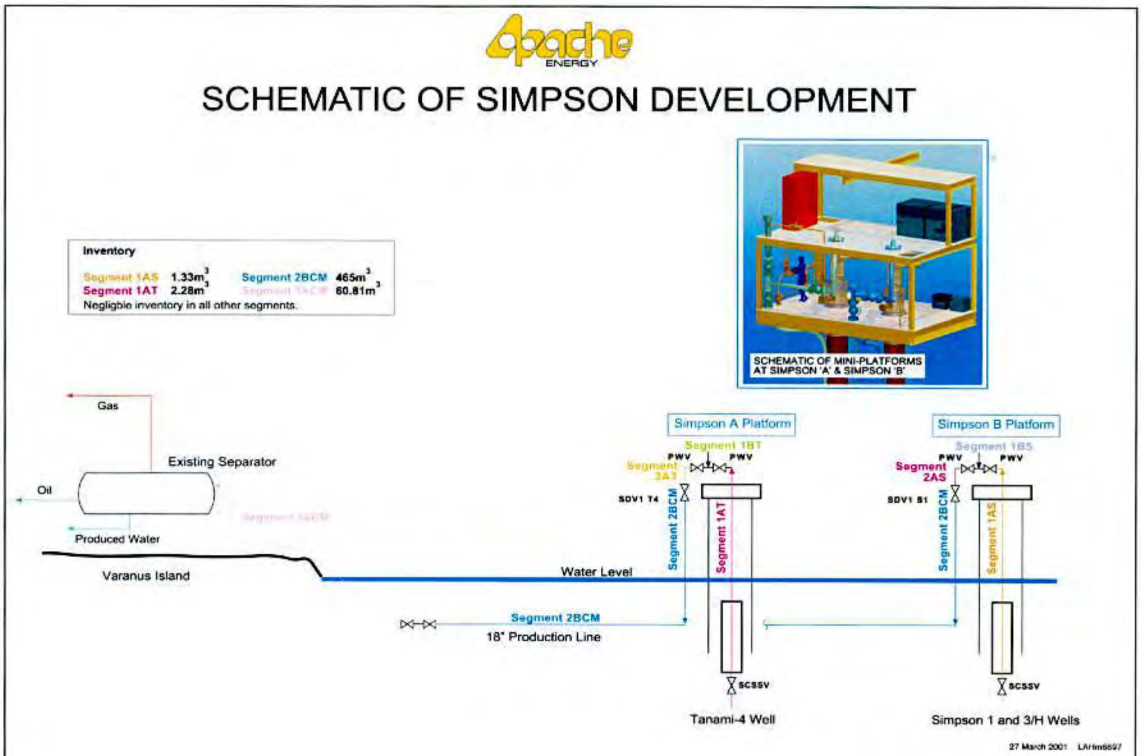


Figure 3

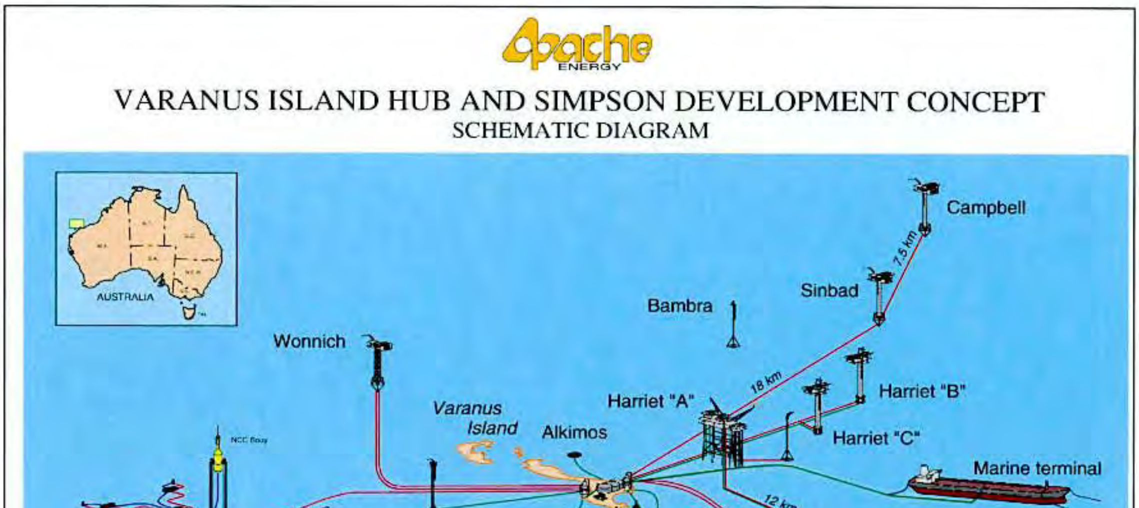


Figure 4

Varanus Island into a central operations area referred to as the Varanus Island Hub. The Simpson development will become an additional installation of the Varanus Hub operations.

The address for Apache is:
Apache Energy Pty Ltd
3rd Floor
256 St George's Terrace
PERTH WA 6000

The person nominated as representative of the proponent and their contact details are as follows:
Contact: Libby Howitt
Telephone: (08) 9422 7481
Fax: (08) 9422 7441
e-mail: libby.howitt@aus.apachecorp.com

1.4 Legislative Requirements and the Environmental Approval Process

The development of offshore petroleum resources in Western Australia is undertaken subject to a number of State and Commonwealth Government Acts. The principle State Act, the *Petroleum (Submerged Lands) Act* 1982 (PSLA), as amended, applies to projects located in State waters. The *Petroleum (Submerged Lands) Act* is administered by the DME.

The review of the environmental impacts of developments in Western Australia State waters, including petroleum developments, is controlled by the *Environmental Protection Act*, 1986 (EP Act). The EPA, acting under the provisions of the EP Act, determined that the Simpson development should be formally assessed under Part IV of the Act, and set the level of assessment at a PER, with a four week public review period. The EPA will provide a recommendation to the WA Minister for the Environment who is the final authority for granting environmental approval.

Apache also submitted a referral to Environment Australia (EA) under the *Environment Protection and Biodiversity Conservation Act* 1999, Commonwealth (EPBC Act). Under section 71 of the EPBC Act, the Commonwealth Minister for the Environment and Heritage decided that the Simpson project was a controlled action, with the controlling provisions being listed threatened species and communities as well as listed migratory species.

On 18 April, the Western Australian PER assessment process for the Simpson development was accredited under section 87 of the EPBC Act. Once the PER assessment process is complete, the WA Department of Environmental Protection will provide EA with a report on the environmental acceptability of the proposed development for approval by the Commonwealth Minister.

Guidelines for the preparation of this PER have been provided by the WA Department of Environmental Protection (DEP) and are set out in Appendix 1.

This PER:

- provides a description of the Simpson project and its benefits;
- describes the environmental setting in which the proposed development will take place;
- assesses the environmental impact of installation and production activities;
- presents a quantitative risk assessment of the project in relation to oil spills; and,
- details the management strategies to be adopted to minimise the actual and potential environmental effects arising from installation and production activities.

This document has been prepared in accordance with the guidelines provided by the DEP to facilitate the environmental review process and the issues raised. The EPA, DEP, Department of Conservation and Land Management (CALM), Department of Fisheries, other agencies, community groups and individuals will also review this document.

1.5 Development Options

The Tanami-4, Tanami-5 and the Simpson wells have been drilled and completed to access the Simpson hydrocarbon reserves and to allow a second deep water disposal well as back-up for all of the Varanus Island production. In order to utilise these wells it is necessary to link them to the existing Varanus Island infrastructure. The proposed Simpson development accomplishes this while minimising offshore equipment as well as construction and maintenance activities, thereby reducing environmental and safety risks.

Two options were investigated as alternatives to the proposal given in this PER: developing the field from Varanus Island and moving the locations of the mini-platforms farther away from Abutilon Island. These two options are discussed below.

Onshore development

The Rosette gas field and the Tanami oil field are accessed via deviated wells originating from Varanus Island. These fields lie within 1.5 km of the Varanus Island lease area. Access to the Simpson field from Varanus Island would involve drilling a deviated well up to 4 km in length. Drilling deviated wells from Varanus Island to access the Simpson field would entail drilling new wells with significant technical risks, as well as having to abandon two existing offshore production wells.

The Tanami-5 well would not be available for produced formation water (PFW) disposal if the Simpson development were located on Varanus Island. This disposal well is required as the Alkimos disposal well is reaching its capacity for receiving PFW.

An onshore development would preclude future tie-ins from satellite discoveries located south of Varanus Island. The only economic way these discoveries can be developed is by tying them into an offshore installation.

Moving the development location further offshore

A larger platform would be required as the development would be in deeper water and would therefore need a larger structure. Access to the Simpson field and satellite fields would probably be made using subsea tie-ins for each well. These subsea tie-ins entail a greater number of subsea flanges that may result in an increased risk of leakage. The tie-ins would be connected from the platform to each well surface location; these locations would be in shallow water. The additional pipelines and sub-sea locations would result in an increased overall risk of a leak occurring in the first instance and would not diminish the consequences of a leak.

A longer pipeline, holding more gas and liquids, would be required to transport the gas and liquids from the platform to Varanus Island. This could potentially increase the risk of a leak occurring in the first instance. In addition, the longer pipeline would yield a greater pipeline volume and this may increase the consequences should a large leak occur. A bigger platform would also result in more boat traffic for maintenance, longer installation time, and an increase in atmospheric emissions.

Present location

The present location of the Simpson mini-platforms will provide the most efficient and economic extraction of the hydrocarbon resources in the Simpson field. The present proposal would also make satellite discoveries easier to access and would make extraction economically viable.

Therefore, the two options investigated were not seen as viable alternatives that would allow access to the Simpson field wells.

1.6 Benefits of the Project

Petroleum exploration and production is the most significant economic activity in Australia's marine environment. The gross production value from Australia's petroleum industry generated $8.3 billion in 1998-1999, representing 1.4% of Gross Domestic Product. Of this, $2.4 billion was paid to the government in royalties, resources rents and income tax.

Oil and gas development on the North West Shelf of Australia is becoming increasingly important as the production from the Bass Strait fields continues to decline. Both the Australian Commonwealth and Western Australian Governments recognise the need for Australia to at least maintain present levels of self-sufficiency in oil and gas. The Western Australian Government regularly releases permit areas for tender to petroleum companies and consortiums to encourage both onshore and offshore hydrocarbon exploration.

The Carnarvon Basin, within which the Simpson development is located, accounts for more than 99% of the State's gas and condensate production and 98% of the total oil production. Production figures from Varanus Island to 1999 exceed 50 million barrels of oil and 4,000 million cubic metres of gas. The projects comprising the Varanus Island Hub make an important contribution to State royalties.

The proposal by the TL/1 and TL/6 Joint Venture Participants to develop the Simpson oil field is an integral component of Australia's commitment to develop its oil and gas reserves. The project will benefit the community through capital expenditure, payment of royalties and employment.

A decision not to develop the hydrocarbon resource of Simpson would be inconsistent with State policy for the development of its natural resources and would reduce revenue to the State and diminish project economics to the Joint Venture Participants.

1.7 Public Consultation

In keeping with Apache's policy of open communication with government and the community, all interested parties will be kept informed and up to date on the progress of the Simpson development and all concerns will be addressed.

Copies of this PER will be forwarded to parties who have an interest in the project (Appendix 2). Further presentations will be made to these parties prior to the commencement of the project.

1.8 Acknowledgments

The Joint Venture Participants thank the following organisations:

- Bowman, Bishaw and Gorham for the monitoring and scientific expertise they provided which was incorporated into this report;
- International Risk Consultants who facilitated the environmental hazard identification workshop and quantitative risk assessment;
- Global Environmental Modelling Systems (GEMS) who carried out the oil spill trajectory modelling; and
- Lindsay Webb from 4 L Design Group for the report layout and Don Ferguson from Optima Press for the printing services.

2 Project Description

2.1 History of Exploration and Development in the Lowendal Islands Region

The Lowendal Islands, which lie off Western Australia's northwest coast, have long been the unexplored cousins to their larger and better-known neighbours, Barrow Island and the Montebello Islands (Plate 1).

The Barrow – Lowendal – Montebello Islands region is currently subject to various onshore and offshore petroleum production licenses and exploration permits. West Australian Petroleum Pty Ltd (WAPET) drilled the first exploration wells on Trimouille Island, one of the larger of the Montebello Islands, in 1967. WAPET (now the Chevron operated Joint Venture) has since produced in excess of 250 million barrels of oil from Barrow Island, some 15 km to the south west of the Lowendal Islands.

Varanus Island, named after the goanna that inhabits the island, is the largest of 34 islands, islets and rocks that make up the Lowendal group (Plate 2). Varanus is 2.5 km long, 600 m wide at its widest point and reaches a height of 30 m above sea level. Abutilon is one of the adjacent islands which lies about 150 m to the south of Varanus Island. All the Lowendal Islands are a C-class reserve for the protection of flora and fauna.

Since 1985, a portion of Varanus Island has been leased from CALM for the facilities associated with Apache's oil and gas exploration and production activities.

Currently, Apache is operating nine offshore installations in the area, ranging in distance from 5-63 km away from Varanus Island. All of these installations are brought together into a central operations area referred to as the Varanus Island Hub (Figure 4).

Plate 1. The Lowendal Islands.

Plate 2. Varanus Island lizard.

The Harriet oil field, located eight kilometres north-east of Varanus Island, was discovered in 1983. It has been producing oil since 1986. Light crude oil is produced from wells tapped by three offshore platforms: Harriet Alpha, Charlie and Bravo. Light oil is also produced from the Tanami, Agincourt and Gipsy fields.

This oil is transported to Varanus Island by means of a network of subsea pipelines where it is stored in two 250,000 barrel tanks. The oil is transferred to a tanker berthed at a deep water loading terminal and shipped to Australian as well as overseas refineries as a source for petrol, diesel and aviation fuel.

Four relatively small gas fields were discovered between 1979 and 1990. Production of gas from three of these fields (Campbell, Sinbad and Rosette) together with associated gas from the Harriet oil field was the basis for the Harriet Gas Gathering Project. This project resulted in the selling and consumption of gas associated with the Harriet oil field that would have previously been flared and permitted Apache to economically develop other gas fields that would otherwise have remained undeveloped.

Gas from the Campbell, Sinbad, Rosette, and Wonnich gas fields, and associated gas from the Harriet oil field is processed in the low temperature separation plant located on Varanus Island. It is then transported via two sales gas pipelines to the mainland for domestic and industrial use.

Gas and condensate from the East Spar field, located some 63 km west of Varanus Island, are processed at a dedicated plant located to the south-west of the low temperature separation plant.

Additional facilities that support Apache's oil and gas production include a gas-fired power station, maintenance workshop, helipad, amenities building and accommodation units. A tennis court, gym and swimming pool are provided for recreation and fitness.

The production of oil and gas from the Varanus Island Hub is expected to continue well into the 21st century.

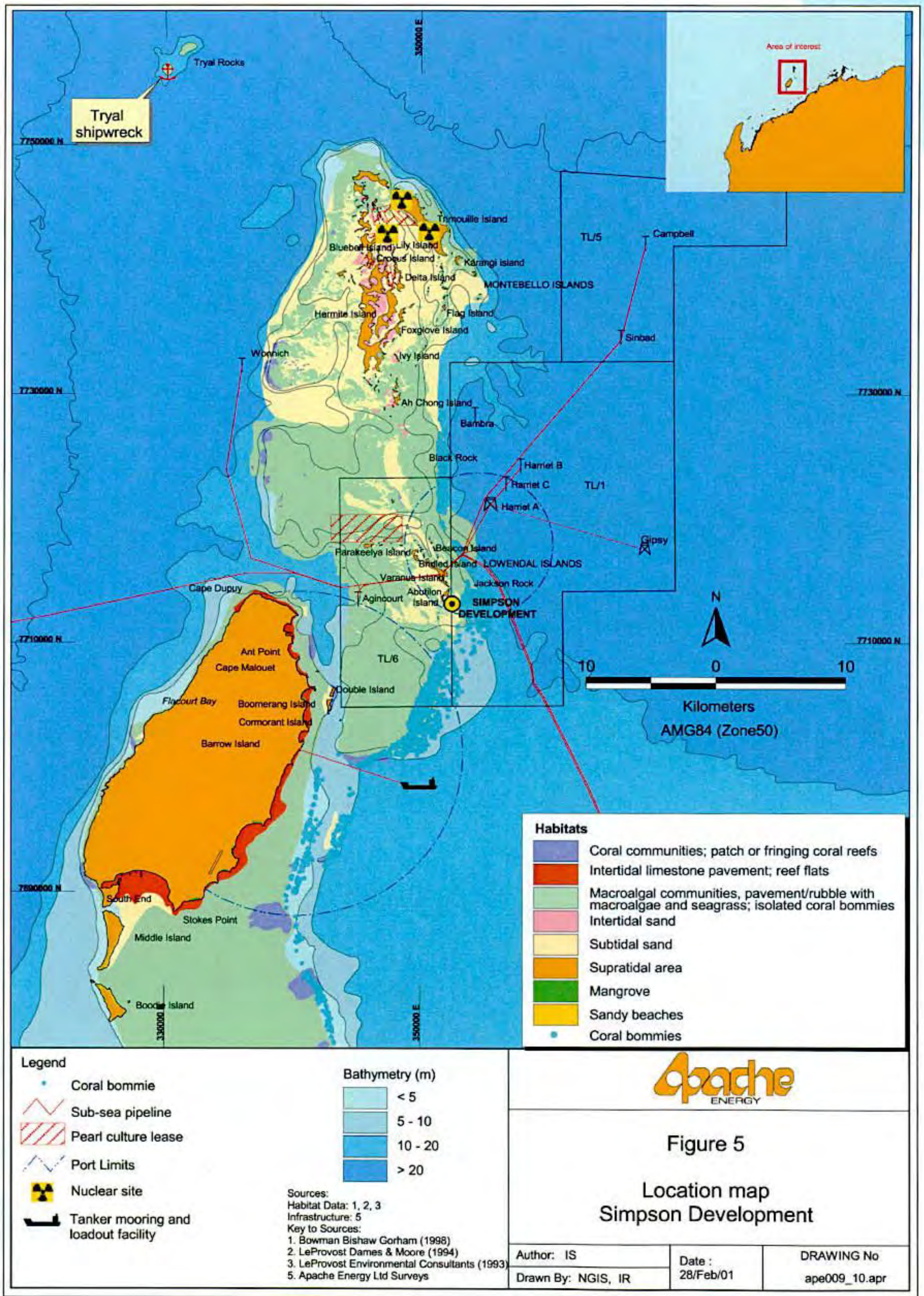
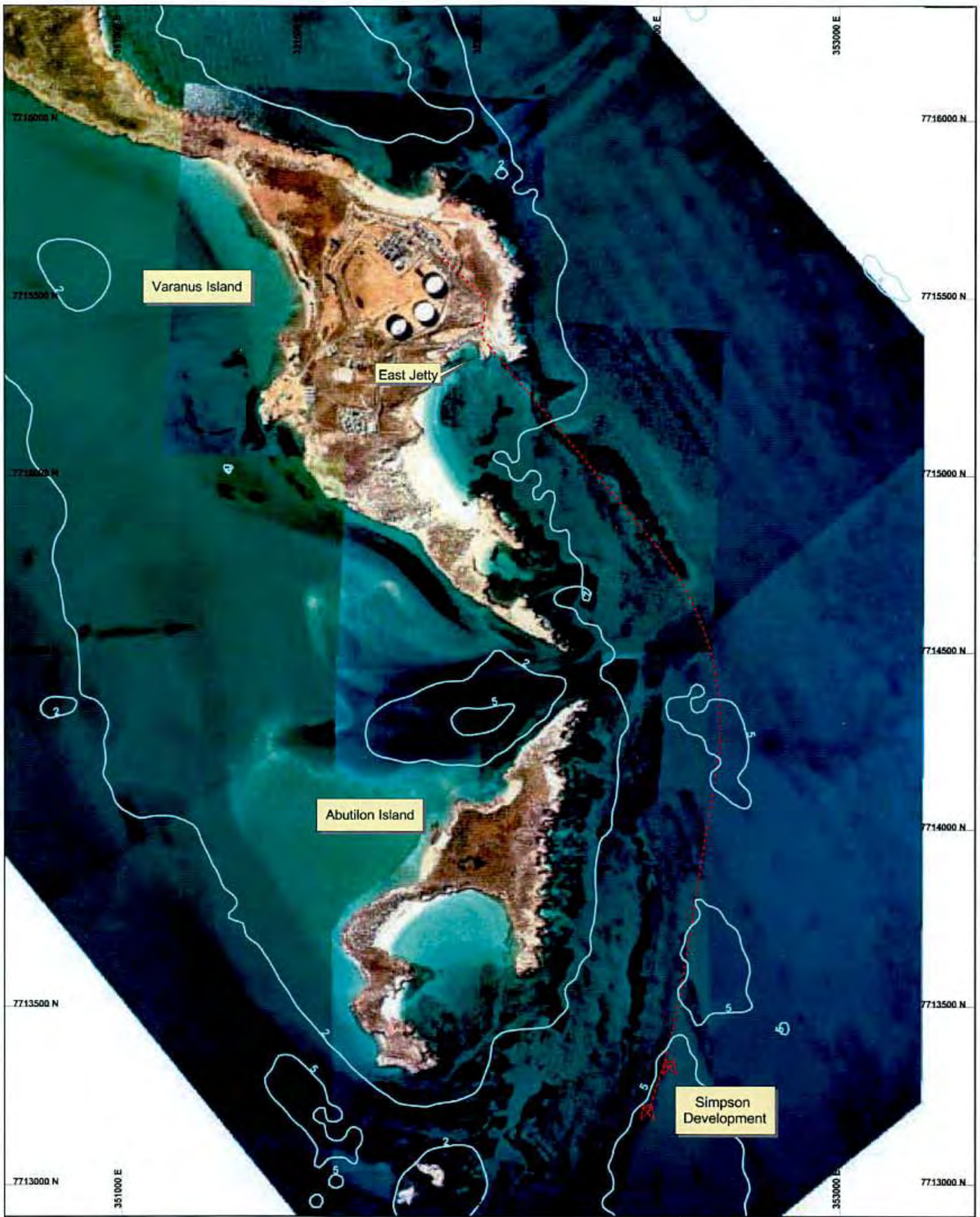


Figure 5

Location map Simpson Development



Legend

Proposed pipeline route

Bathymetric contour

200 0 200

Metres

AMG84 Zone 50

Apache ENERGY

Figure 6

Simpson Development - Location of the Mini-platforms and Offshore Pipeline Bundle Route

Author: IVS	Date: 15/Feb/2001	DRAWING No.
Drawn By: NGIS		ape005_62.apr

Plate 3. Sargassum habitat which is widely distributed throughout the region.

Plate 4. (Below) The seabed around the Simpson development consists of macroalgae and sparse epibenthos on sand.

2.2 Location of the Proposed Simpson Development

The proposed surface locations of the Simpson 'A' and Simpson 'B' mini-platforms are approximately 1,000 m and 1,140 m respectively, from the southern tip of Varanus Island and a minimum distance of approximately 400 m to the east of Abutilon Island. Water depth at this location is approximately six metres below mean sea level (Figure 5).

The seabed between the proposed locations of the two mini-platforms and the east side of Abutilon and Varanus Islands is mainly limestone pavement with variable cover of macroalgae (*Sargassum* and *Dictyopterus*), occasional small coral colonies and sponges, and sand veneer (Figure 6; Plates 3 and 4). A few low profile outcrops and an area of fringing coral occurs about 300 m to the east of Abutilon Island. The low profile outcrops slope up to approximately two metres above the surrounding pavement reef and are covered with a denser macroalgal assemblage. The fringing coral area consists of an assemblage of large coral bomboras (*Porites* and plate *Acropora*) along the eastern edge and numerous corymbose *Acropora* colonies covering approximately 20% of the pavement in the immediate area.

Rocky shores are the predominant shoreline habitat on Abutilon Island, which is immediately adjacent to the two mini-platform locations and pipeline bundle route. There are two small sandy beaches on the east side of the island. Turtles nest on these beaches in very low numbers and seabirds use them primarily for foraging and resting.

The pipeline bundle will come onshore at Varanus Island to the east side of the East Jetty (Figure 7). The onshore portion of the pipeline bundle will follow the road and then parallel the existing flowline from the Tanami-1 wellhead until it reaches the location of the separator and compressor in the existing processing plant. All the facilities will lie within the Apache CALM lease boundary. The onshore route will follow a previously disturbed area with sparse vegetation and will be located away from the eastern shearwater rookery.

2.3 Proposed Timetable

The installation of the Simpson 'A' and Simpson 'B' mini-platforms, and associated pipeline bundles is scheduled to begin in September 2001, following the necessary environmental approval. Installation will take approximately two weeks to complete followed immediately by commissioning and production of first oil from the development. The installation of the onshore portion of the pipeline will take about two weeks and will be carried out at the same time as the offshore installation work.

2.4 Description of the Major Components of the Project

The major components of the Simpson development are detailed below.

The Simpson 'A' facilities (Figure 2) will consist of:

- a two-well, mini-platform utilising the two well caissons as its base;
- the Tanami-4 hydrocarbon production well;
- the Tanami-5 produced formation water disposal well; and
- a pipeline bundle connection consisting of a production pipeline, a water disposal pipeline, a gas lift pipeline, and an umbilical connecting the offshore mini-platform with the primary pipeline bundle.

The Simpson 'B' facilities will consist of:

- a two-well, mini-platform utilising the two well caissons as its base;
- the Simpson-1 and Simpson-3H hydrocarbon production wells; and
- a primary pipeline bundle consisting of a production pipeline, a gas lift pipeline, and an umbilical connecting Varanus Island to the Simpson mini-platform.

The well fluids produced from the Tanami and Simpson wells will flow into a production pipeline connecting to the existing processing facilities on Varanus Island. These processing facilities include an oil/gas/water separator and a gas compressor. Produced formation water (PFW) will be injected into the Alkimos-1 deep disposal well or via the return PFW pipeline to the Tanami-5 water disposal well, as process conditions dictate. No PFW will be disposed of into the ocean.

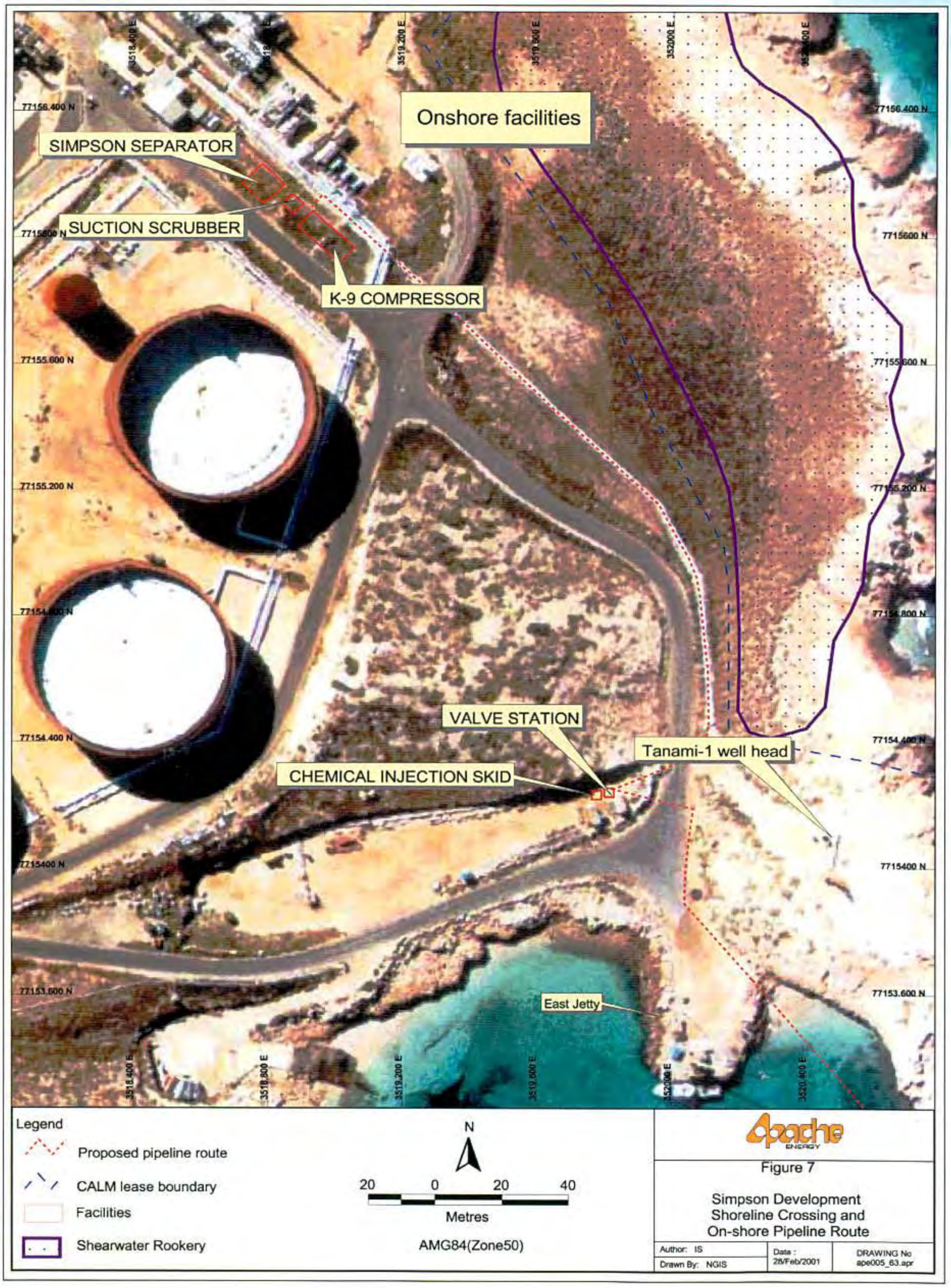

Onshore facilities
SIMPSON SEPARATOR
SUCTION SCRUBBER
K-9 COMPRESSOR
VALVE STATION
CHEMICAL INJECTION SKID
Tanami-1 well head
East Jetty
Legend
Proposed pipeline route
CALM lease boundary
Facilities
Shearwater Rookery
N
20 0 20 40
Metres
AMG84(Zone50)
Apache ENERGY
Figure 7
Simpson Development
Shoreline Crossing and
On-shore Pipeline Route
Author: IS
Drawn By: NGIS
Date: 28/Feb/2001
DRAWING No ape005_63.apr

Table 1: Base case production forecast of oil, gas and produced formation water for the Simpson development (Tanami-4, Simpson-1 & Simpson-3H wells).

Year	Annual average oil production (stb/d)	Annual average gas production (scf/ d*10[6])	Annual average water production (bbl/ d)
End 2001	2,500	0.6	306
2002	8,037	1.9	10,172
2003	4,820	1.0	19,290
2004	2,978	0.6	21,780
2005	2,144	0.5	23,272
2006	1,678	0.3	24,299
2007	1,357	0.3	25,099
2008	1,123	0.2	25,675
2009	929	0.2	26,127
2010	794	0.2	26,476

Any produced natural gas from the Simpson field will be recovered from the separator, compressed and delivered to the low temperature separation plant on Varanus Island. The processed gas will be sold as sales gas to domestic and industrial markets. No flaring or venting of the associated gas will occur unless under emergency conditions.

The oil produced from the Simpson field will be stored in the existing bulk storage tanks for loading to oil tankers via the Varanus Island offloading marine terminal. There will not be an increase in the frequency of historical tanker activity into the marine terminal.

To ensure that oil wells can produce at optimal rates, artificial lift in the form of gas lift will be made available to the Tanami-4, Simpson-1 and Simpson-3H wells. A return gas pipeline from the island to the two mini-platforms will contain natural gas to cater for the gas lift requirements.

A base case production forecast of oil, gas and produced formation water is given in Table 1. The annual average oil production will be 2,500 barrels per day at the commencement of the project in late 2001, increasing to an oil production rate of 8,037 barrels per day in 2002. Oil production will then decrease progressively to 794 barrels per day by year 2010. Average produced formation water production is estimated to be initially 306 barrels per day, with a maximum of 26,476 barrels per day by 2010. A comparison of the projected production rate of Simpson oil to oil produced from other Varanus Island Hub developments is given in Figure 8.

The Simpson project will comprise three major phases: installation, production and decommissioning. These phases are described in greater detail below.

2.4.1 Installation phase

The installation phase of the project entails the three activities:

- installation of the two offshore mini-platforms;
- laying the offshore portion of the pipeline bundles; and
- placement of the onshore portion of the pipeline bundle.

These activities will occur concurrently wherever practical.

Installation of the two mini-platforms

The mini-platforms will be installed on the substructures that consist of the specifically designed caissons of the Tanami-4 and -5 wells, and the Simpson-1 and Simpson-3H wells. The substructure engineering design has been confirmed against the 50-year storm criteria with the "air gap" (gap between the water level and the bottom of the topside) based on the 100-year storm wave height. The facility design will use the meteorological data applicable to the location of the mini-platforms and will be certified by an appropriate certifying authority. These substructures will have a minimum fatigue life of 20 years.

Installation of the offshore mini-platforms will be undertaken using small a crane barge and support vessels. This process will entail lifting the topsides, and setting and welding them to the substructures, all of which will take about one day to complete for each mini-platform. The tie-in of the pipeline bundle and process facilities will then occur on each mini-platform.

Each mini-platform design will have minimal process facilities consisting of:

- process piping, valves and instrumentation for the Tanami-4, Simpson-1 and Simpson-3H production wells;
- process piping, valves and instrumentation for the Tanami-5 water disposal well;
- two wellheads on each of the two mini-platforms;
- the wellhead control panels;
- solar power panels;

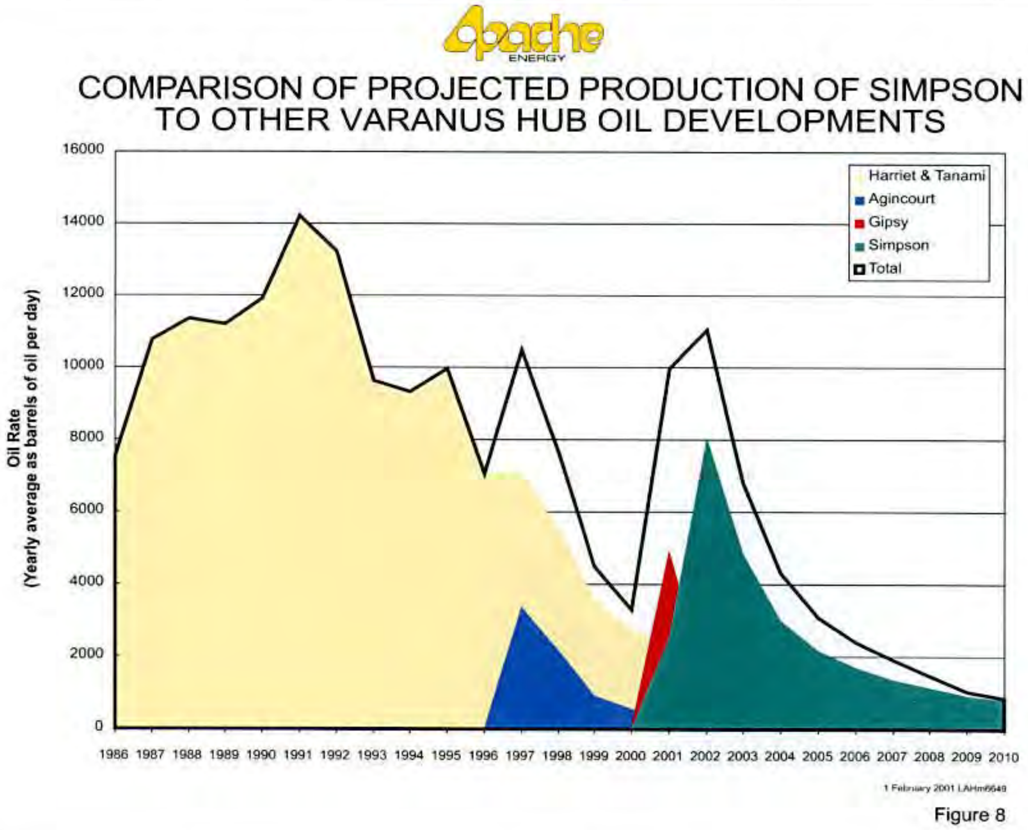


Figure 8

- telemetry facilities to enable remote collection of process data and allow process and emergency shut-down control from Varanus Island;
- a four tonne capacity winching and self-erecting wireline systems that enable the lifting of materials to the platform;
- marine access facilities; and
- safety equipment.

Installation of the offshore pipeline bundle

The Simpson development will require the installation of prefabricated pipelines between the Simpson 'B' mini-platform and the process facilities on Varanus Island. A short, connecting bundle of about 15 m will be required between the main pipeline bundle and the Simpson 'A' mini-platform.

The pipeline bundle between Varanus Island and the Simpson 'B' mini-platform will consist of:

- a production pipeline carrying oil, gas and PFW to Varanus Island; and
- a gas lift pipeline.

The pipeline bundle leading off the primary bundle to the Simpson 'A' mini-platform will consist of:

- a production pipeline;
- a gas lift pipeline; and
- a water disposal pipeline.

Each pipeline will be constructed to a design life of 25 years and engineered for a 100 year storm criteria using applicable meteorological data.

Two procedures are being investigated for the installation of the offshore portion of the pipeline bundle. One method involves using a general purpose, shallow water construction support barge that can accommodate up to 40 people. Eight anchors will hold the barge in place while the pipeline bundle is being laid. The barge will progressively winch itself along the pipeline alignment, laying the assembled bundle behind it.

The second method of installation involves pulling completed sections of the pipeline from Varanus Island onto the seabed using a small tug or winch barge.

The final stabilisation of the pipeline bundle will consist of traditional rock bolting at approximately 20 m intervals. About 600 m of the pipeline will be trenched and buried to the east of the East Jetty to decrease the risk of damage by vessel impact or anchors. Hydrotest water from the pipelines will be re-injected into the Alkimos deep disposal well and not into the marine environment.

Installation of the onshore portion of the pipeline bundle

The onshore portion of the pipeline bundle will come onshore on the eastern side of the East Jetty (Figure 6). This shoreline crossing area consists of large rocks and cement blocks that were used to stabilise the jetty. The bundle will follow the road and then parallel the existing Tanami onshore pipeline until it reaches the location of the separator and compressor.

2.4.2 Production phase

Production from the Simpson field will involve transferring oil, gas and produced formation water from the mini-platforms to Varanus Island via the pipeline bundle. Initial production will flow naturally due to reservoir pressure. Within two years of commissioning, the volume of produced formation water from the Simpson field will increase to a level where the liquids from the reservoir will not flow to the surface without the assistance of gas lift. This is due to the produced formation water being heavier than the oil and there being enough natural pressure in the reservoir to lift oil to the surface, but not enough pressure to lift oil combined with produced formation water to the surface. Simpson gas will be used, via the return gas lift pipeline from Varanus Island, to provide artificial lift and optimise production from the wells.

Processing the output from offshore hydrocarbon reservoirs primarily involves separating the liquid hydrocarbons from the gas and produced formation water. Separation of output from the Simpson development will occur on Varanus Island. The processing facilities on Varanus Island are currently being upgraded to include an additional separator, gas scrubber and gas compressor to increase the efficiency of production from the existing Tanami, Agincourt and Gipsy developments. Simpson will link into these new facilities when it starts producing.

The recovered Simpson natural gas will be compressed and fed to the low temperature separation plant facilities for final processing before being transported to the mainland via the sales gas pipelines. The separated oil will be stored and then offloaded to tankers via existing infrastructure. The produced formation water will be re-injected into either the existing Alkimos deep disposal well or into the Tanami-5 deep disposal well. Some further separation of oil from the water will occur via a separation tank prior to deep disposal. There will be no requirement for the construction of additional oil storage facilities on Varanus Island. Oil from the Simpson field will be piped to the existing crude oil storage tanks.

The only operational requirements for the pipeline bundles are routine inspections and corrosion control to prevent corrosion and the build-up of microbiological growth, and to aid in leak detection within the pipeline bundles. Corrosion control will consist of three methods:

- injection of corrosion and scale inhibitors from the dedicated site located on Varanus Island (Figure 7);
- continuous monitoring of pipeline thickness; and
- visual inspections on a routine basis.

Any residual inhibitor entrained in the reservoir fluids will be incorporated into the water stream. There will be no discharge into the marine environment.

2.4.3 Decommissioning

At the end of the project life, all wells will be plugged according to PSLA regulations and the casings cut just below the level of the seabed. The mini-platforms will be removed and taken away for reuse or recycling. The pipeline bundles will be removed from both the marine and terrestrial habitats unless otherwise approved by the appropriate Minister(s).

3 Description of the Environment

3.1 Regional Perspective

The Lowendal Islands lie approximately 120 km west-northwest of the Port of Dampier. The Lowendal Islands are a component of the Barrow-Lowendal-Montebello Islands complex that consists of an elongate, shallow submerged ridge supporting many islands of various sizes and shapes. The island complex has been recognised as a distinctive coastal type not present elsewhere in Australia's northwest coast (APPEA 1997). It supports a wide range of intertidal and shallow subtidal marine habitats.

The Lowendal group is comprised of about 34 islands that consist of Pleistocene limestones on a sublittoral limestone platform. Most of the islands are rocky islets only a few metres in diameter (Figure 9). The largest islands are Varanus Island, Parakeelya Island and Abutilon Island. Once attached to the mainland through a ridgeline extending from Northwest Cape, it is estimated that the islands have been separated by sea level rise from the mainland for approximately 8,000 years.

To the north and west of the Barrow-Lowendal-Montebello complex lie the deeper waters of the continental shelf edge. Shallower waters of the shelf are found to the south and the east. The marine habitats of the island complex are more oceanic than those of the coastal waters closer to the coast, with less turbid water (Marine Parks & Reserves Selection Working Group 1994). Cyclones and storms are a major cause of water turbidity in the region. An overview of the marine resources of the area is given in Table 2.

Table 2: Biological and social resources in the region.

Biological and Social Activity	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Dugong breeding		Breeding								Breeding		
Turtle nesting												
Turtle hatching												
Coral spawning			X *	X						X		
Whale migration						North			South			
Algae		Growing				Shedding fronds				Growing		
Seabird nesting (terns and shearwater)												
Prawn trawling												
Tourism												
Estimated installation of Simpson facilities												

* *split spawning occurs every three years.*

Key

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

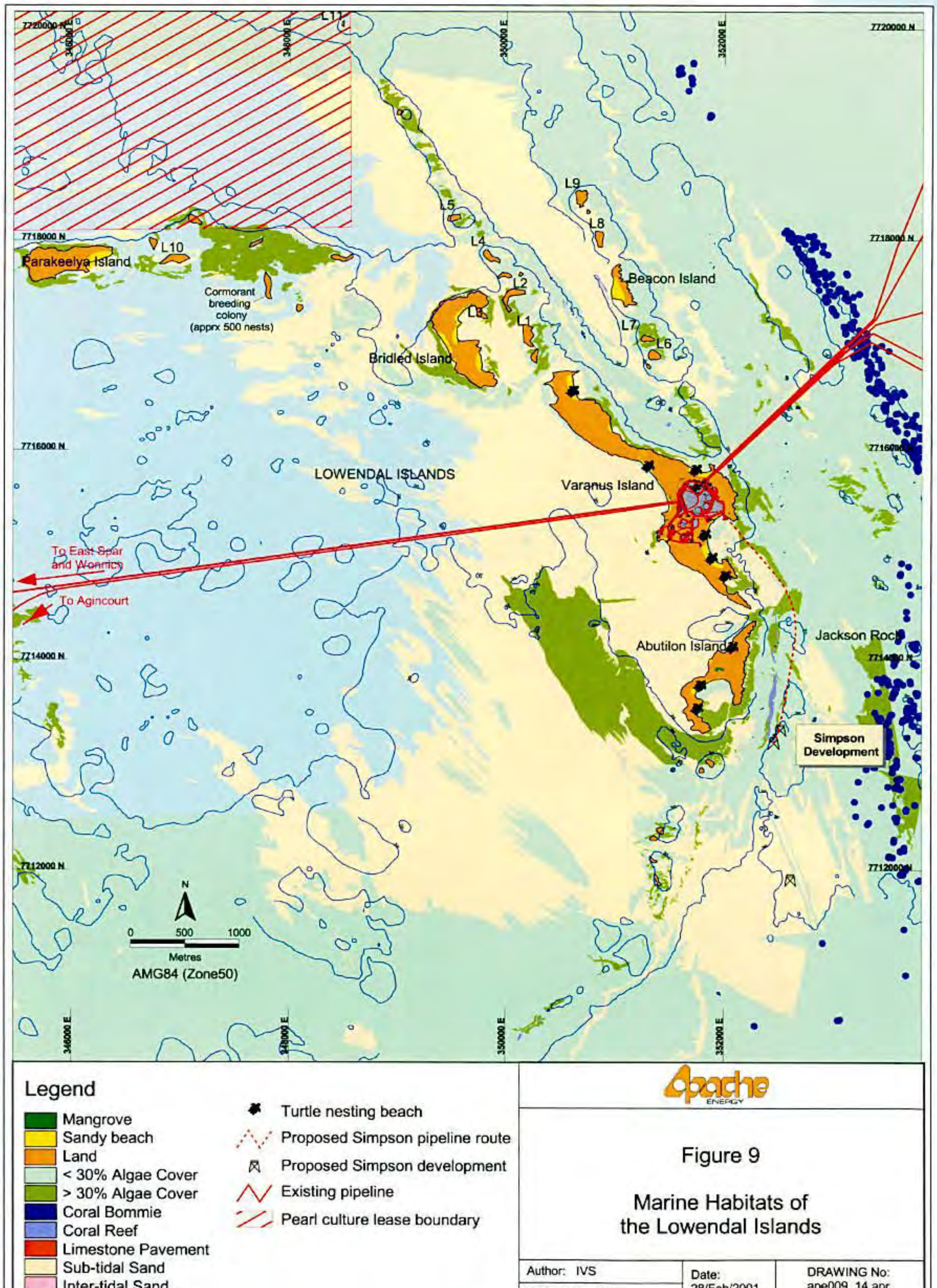


Figure 9

Marine Habitats of the Lowendal Islands

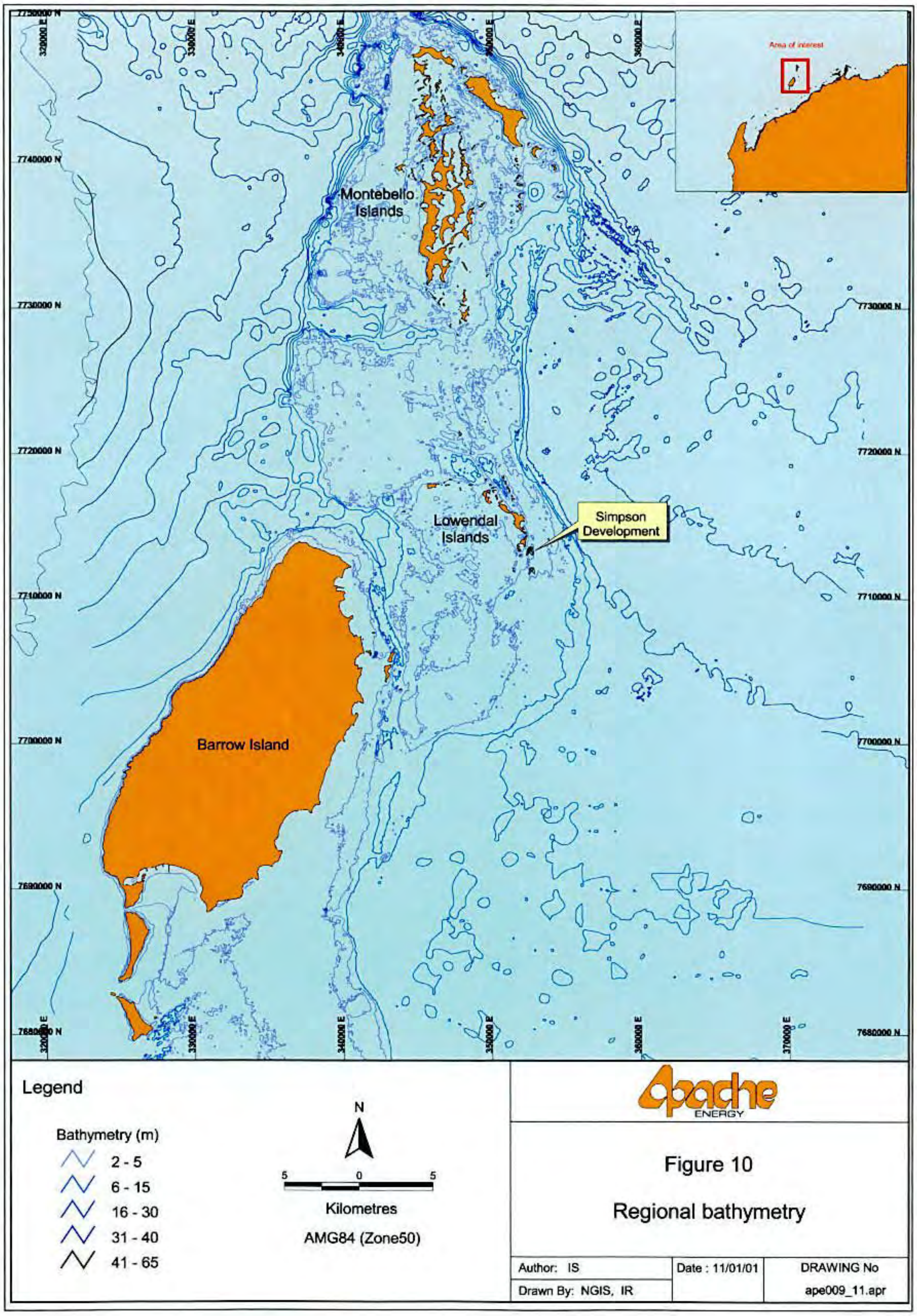


Figure 10

Regional bathymetry

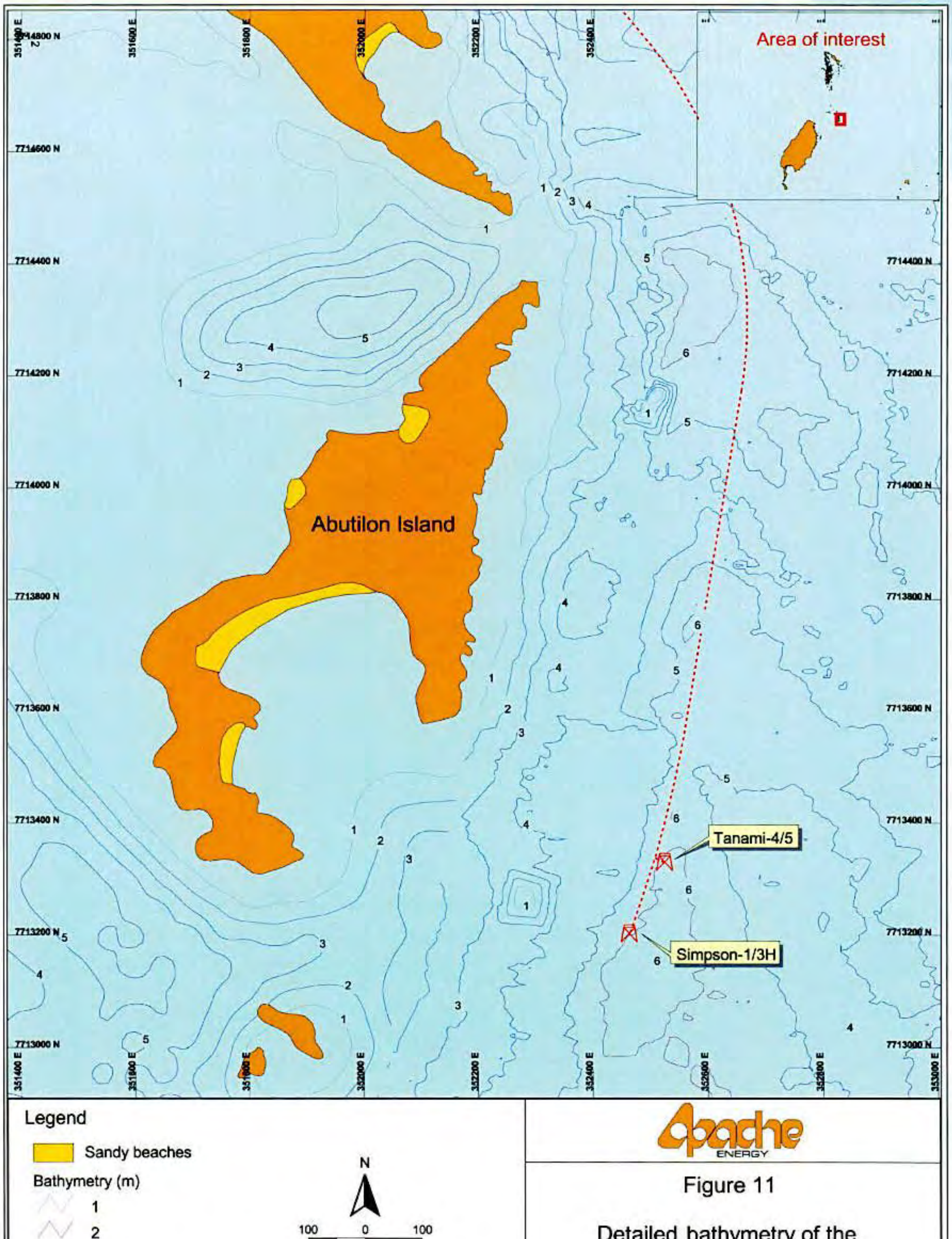


Figure 11

Detailed bathymetry of the seabed surrounding the Simpson development location

Author: IS	Date : 24/01/01	DRAWING No
Drawn By: NGIS		ape009_12.apr

3.2 Physical Environment

3.2.1 Bathymetry

The bathymetry of the region is shown in Figure 10. The detailed bathymetry of the proposed mini-platform locations is given in Figure 11. The information presented is based largely on information obtained during seismic surveys, data from scouting surveys of seabed features undertaken by RACAL Survey Australia Ltd at various times and limited navigational hydrographic survey data.

The bathymetry of the region is complex, encompassing sections of steep mid-shelf slopes to depths of 40 - 60 m, and extensive shallow and intertidal areas. Most of the seabed around the Lowendal Islands lies in less than 5 m of water.

3.2.2 Geomorphology

The proposed Simpson development is located within a region consisting of a shallow submarine ridge that extends north from the mainland near Onslow and includes Barrow Island and the Montebello Islands (IUCN 1988). The Simpson location lies on the western flank of this ridge adjacent to the south-eastern portion of the Lowendal Islands. This area is a shallow ocean environment that is comprised predominantly of limestone pavement at depths ranging from intertidal to in excess of 20 m. Sheets and ribbons of calcareous sands varying in thickness from less than 5 cm to greater than one metre frequently veneer the pavement. The sands are mobilised and dispersed as sand waves by water currents and storm events such as cyclones. Pavement in exposed areas is often swept clean of sand.

The nearest landfall to the development site is Abutilon Island (400 m) and Varanus Island (one kilometre away). These two islands are in close proximity to one another and are separated by a narrow channel that is about 10 m deep. These islands are composed of eroded Pleistocene limestone and cross-bedded sandstones, capped in places with consolidated or active sand dunes with elevations up to 30 m.

3.2.3 Climate

The climate of the Lowendal Island region is arid subtropical with hot summer temperatures, high evaporation, occasional cyclones and associated summer rainfall. The annual average rainfall of the Lowendal Islands is approximately 300 mm, mostly as a result of tropical cyclones.

The winds in the area show a marked seasonal variation. During winter (May - August), moderate to strong south-easterlies and north-easterlies to easterlies prevail, while during summer (October to March) moderately southerly, south-westerly and westerly winds dominate (Figure 12). April and September are transitional months where the wind can blow from the south-west to south-east.

Tropical cyclones may occur any time between November and April. The annual average frequency of cyclones passing within 360 km of the project area is 2.4 (LeProvost Dames & Moore 1996).

The frequency of occurrence of tropical cyclones is an important physical environmental factor influencing the marine fauna, particularly corals, in shallow water at the Lowendal Islands. Examination of cyclone tracks provided by the Bureau of Meteorology showed that between 1995 - 2000, eight cyclones passed within approximately 100 km of the Lowendal Islands (Figure 13). Recent damage may have resulted from these cyclones, e.g *Olivia* (95/96 season), *Vance* (98/99 season) and *John* (99/00 season).

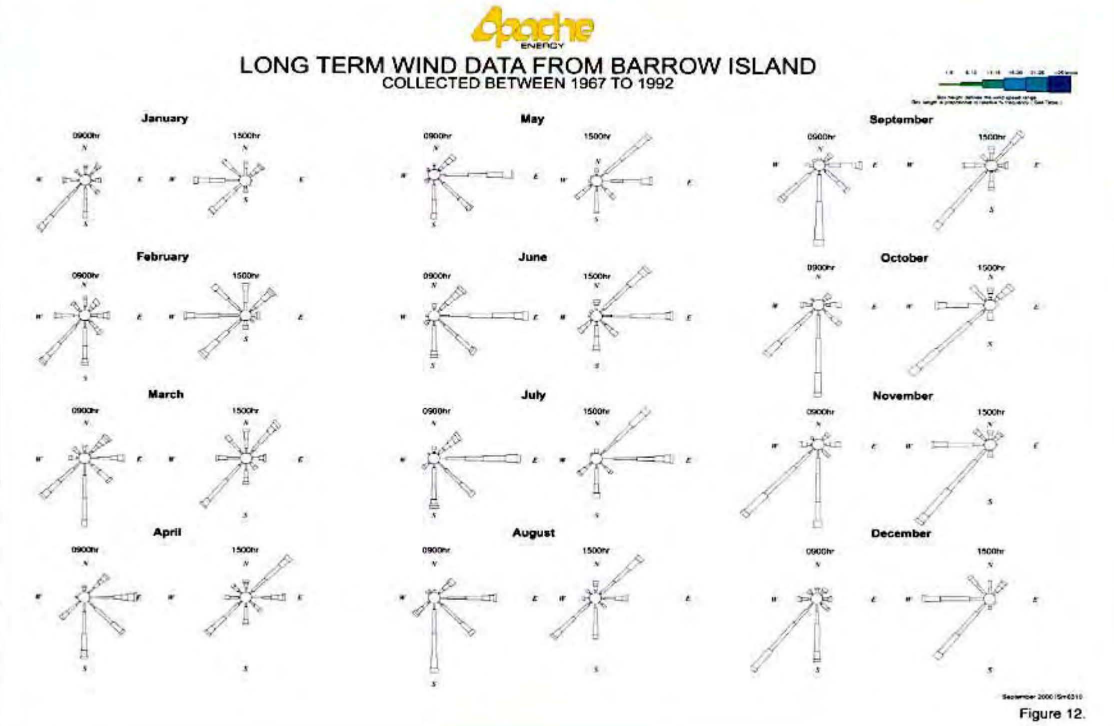


Figure 12.

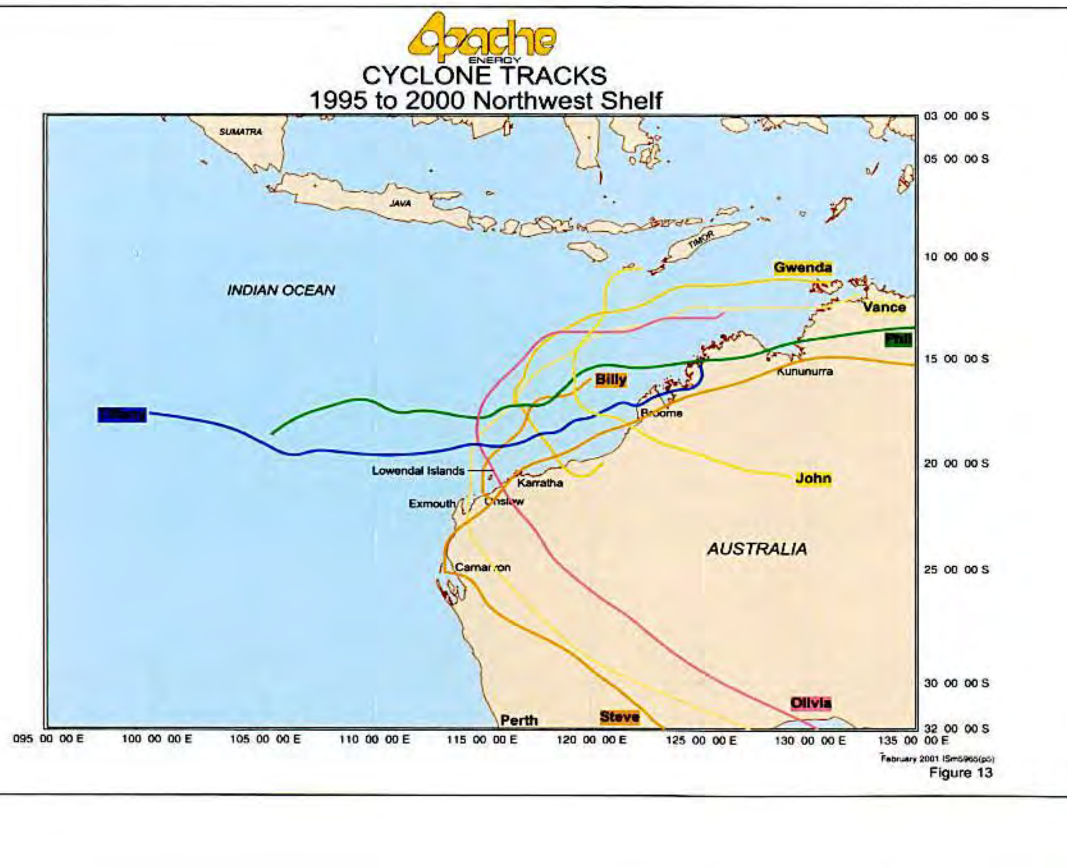


Figure 13

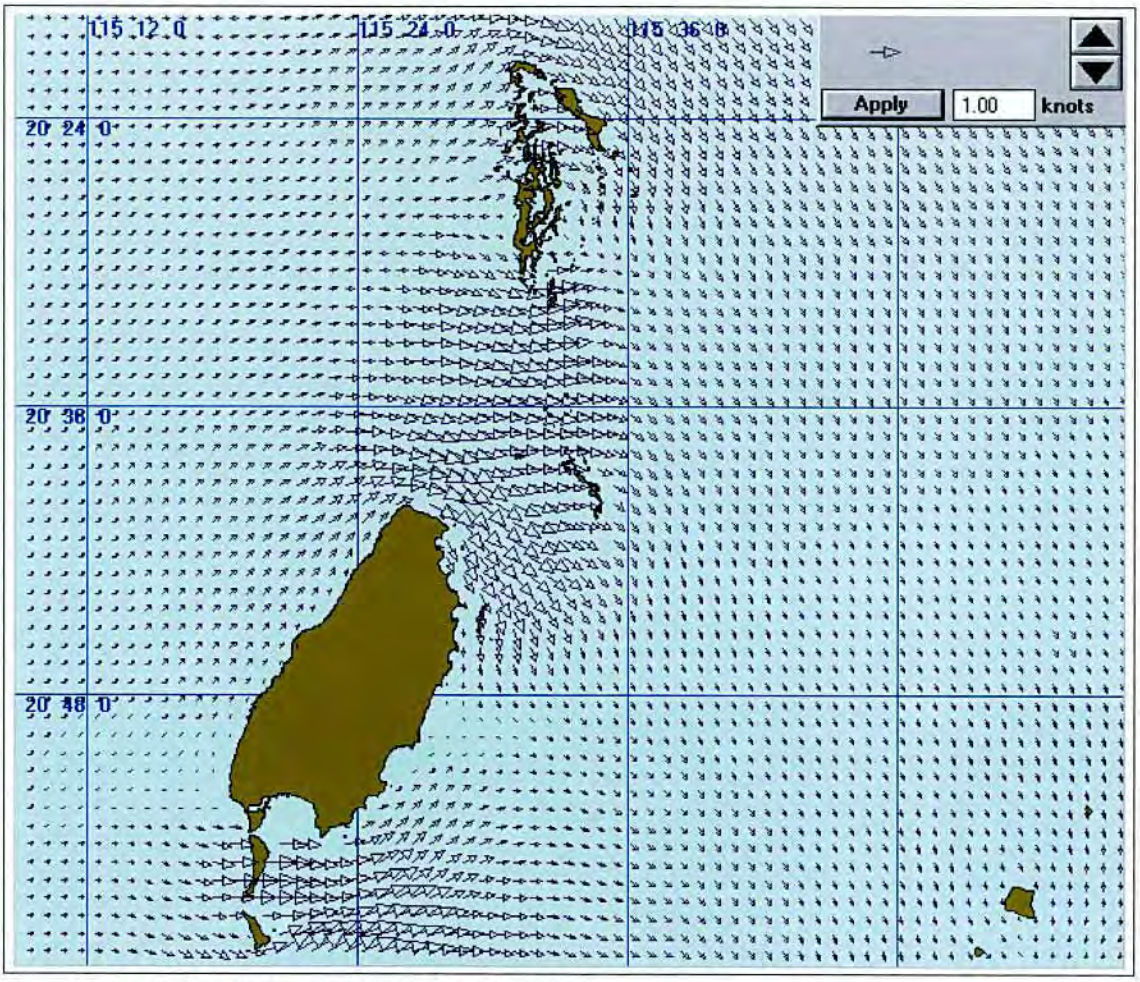


Figure 14. Example of regional tidal flow during a flood tide.

3.2.4 Tides and currents

Wind-modified tidal currents dominate the water movement in the area. Tides are semi-diurnal; there are two high and two low tides in each 24 hours, with water movement during spring tides far more influenced by tidal currents than by local wind stress. The spring tidal range is approximately 3.3 m. Tidal currents of up to 4 knots can be experienced in the shallow channels of the Lowendal group (Steedman Science & Engineering 1991).

Ocean currents around the Montebello and Lowendal Islands were measured in March 1996. Electronic current meters (acoustic current meters and acoustic current doppler profilers) were moored at 12 locations for periods of 24 to 96 hours, sufficient time to sample a number of tidal cycles at each site.

The field sampling showed that the region experiences a complex pattern of currents, with locally strong flows, due largely to the tidally-forced migration of water from the deep surrounding shelf (30 - 40m depth) across the shallow island chains (< 5 m deep). Adding to this complexity, is the influence of strong flows through inter-island channels. The overriding influence of tidal forcing on these currents is demonstrated by a diurnal cycle in the current velocity and direction that corresponds with the tidal cycle experienced in the area.

In general, tidal flood currents approach the Lowendal Islands from the west-south-west, before speeding up and splitting into a north-east flow and a south-east flow (Figure 14). Water travelling across the shallow western platform of the islands flows at up to one knot but local flows between the islands can be greater than five knots. Water travelling across the shallow ridge separating the Montebello and Lowendal Islands can attain speeds over five knots during spring tides. A common feature of this area is the presence of standing waves due to the speed of the water currents across the underlying reef. Moving further east, the speed of these flows diminishes and the currents begin to steer to the south south-west where the water depth is over 15 m.

Very strong currents (3-4 knots) are experienced across the northern end of the Lowendal Islands and across the shallow sandy areas surrounding them. Currents through the inter-island chains of the islands can attain speeds of 3 - 4 knots and have a local influence on the flow of water along the Islands.

Water flows during ebb tides are generally found to be the reverse of the flood tides, except for areas that are influenced by local jets of water directed through currents or around islands (Figure 15).

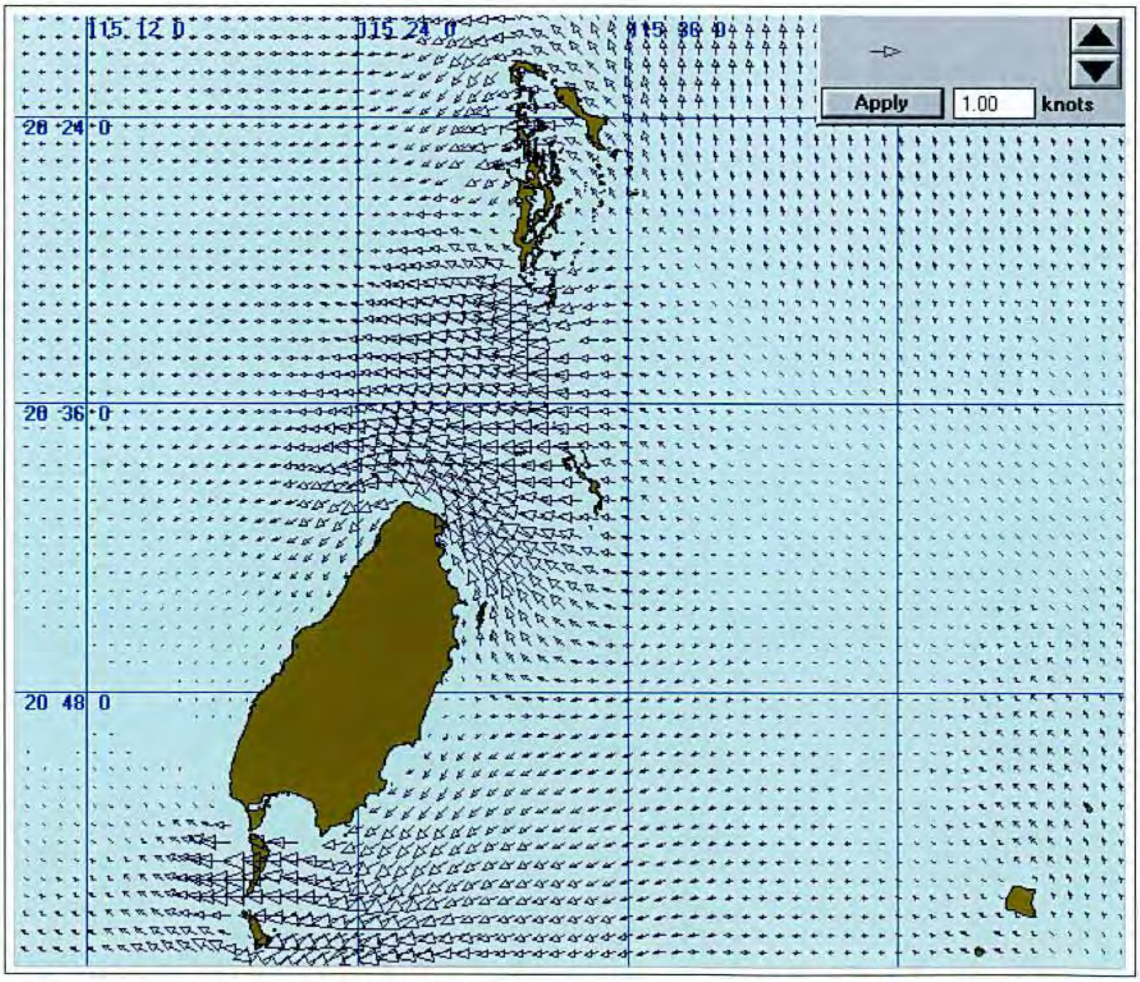


Figure 15. Example of regional tidal flow during an ebb tide.

The Leeuwin Current is a flush of water that originates in Indonesia and brings tropical, warm water south along the west coast of Western Australia and is strongest between February and July (Holloway & Nye 1985), although this can vary from year to year.

3.2.5 Water quality

The sea-surface water temperature around the islands ranges from 20° - 30°, with temperature reaching 33° in the shallowest areas. In terms of biogeographical provinces, the Lowendal Islands are placed within the Dampier or Northern Australian Tropical Province (Wilson and Allen 1987, in Western Australian Museum 1993).

Studies indicate that salinity is generally constant throughout the water column around the islands due to the tidal stirring in the shallow waters (Osborne *et al.* 1999).

The water in the Lowendal region is frequently turbid due to the combination of wave action, relatively high tidal range and the shallowness of the area. The turbidity of the waters is considered to be more typical of the mid-continental shelf than of the oceanic outer shelf edge (Western Australian Museum 1993).

3.3 Biological Environment

3.3.1 Habitat types

Apache has carried out detailed habitat mapping of the shallow waters surrounding the Lowendal Islands and Montebello Islands since 1997. Aerial photography and field work have shown that the shallow waters and intertidal areas of the region support a range of habitats and wildlife (Figure 9). The habitats include rocky shores, limestone pavement, fringing and patch coral reefs, algal beds, sand beaches, and mangroves. To date, the habitats found in 30,074 hectares of seabed have been ground-truthed and mapped.

Plate 5. Macroalgae bed consisting predominately of Sargassum.

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

Macroalgae and seagrass beds

Macroalgae beds, consisting primarily of *Sargassum*, are the most common habitat on the subtidal limestone pavement and knolls surrounding the Lowendal Islands. They make up 70% of the mapped marine habitat of the Barrow-Lowendal-Montebello Island complex. *Zonaria, Dictyopteris* and *Padina*, and the green algae *Halimeda*, *Caulerpa* and *Cladophora* were also noted (The Ecology Lab 1997). These algae are widely distributed across the Lowendal Islands and surrounding region (Plate 5).

Individual *Sargassum* plants undergo rapid growth during the warmer months of the year, followed by tissue breakdown and loss of primary lateral branches (senescence) after reproduction, which peaks towards the end of summer.

The sargassum name comes from a Spanish word meaning 'floating seaweed'. Large algal mats have been observed in the waters surrounding the Lowendal Islands towards the end of the summer period. Algal flotsam is potentially important as a means of dispersal for invertebrates, fish and birds, and as a source of nutrients as it breaks down.

Studies have indicated substantial changes through time of the areal extent of the macroalgae beds, which represents natural temporal variation that can result in either an increase or decrease in the spatial distribution of the macroalgae (The Ecology Lab 1997). The diversity and density of epifauna (such as amphipods, polychaetes and molluscs) associated with the macroalgae are influenced by complex and varied factors such as tidal flow and biological interactions among the inhabitants of the macroalgal bed.

Six seagrass species have been recorded in the area: *Cymodocea angustata, Halophila ovalis, Halophila spinulosa, Halodule uninervis, Thalassia hemprichii* and *Syringodium isoetifolium* (Kirkman and Walker 1989). They mostly occur in areas of sandy seafloor ranging from intertidal to shallow subtidal. They tend to form small patches from 1 to 10 m in diameter and are very sparsely distributed.

Seagrass beds, and possibly algae beds, are important feeding grounds for green turtles and dugongs, both of which are found in the area. They may also be important as nursery grounds for many fish and crustaceans.

Corals

Corals occur as patch coral reef, individual bommies and fringing reefs, and make up about 1% of the mapped marine habitat of the Barrow-Lowendal-Montebello Island complex (Plate 6). A total of 127 species comprised of 56 genera of corals have been recorded from the Lowendal Islands

Plate 6. Patch and fringing coral reefs are scattered throughout the region.

Table 3: Geographical variation in the number of coral genera and species.

Location	Genera	Species
Montebello Islands	60	235
Lowendal Islands	56	127
Ashmore Reef	56	255
Scott/Rowley Reefs	56	233
Barrow Island	17	32
Dampier Archipelago	57	216
Ningaloo Reef	54	217
Abrolhos Islands	42	201

during surveys carried out by Apache (LeProvost Dames & Moore 1994; 1996). This has been compared to available data from other Western Australian reefs: Montebello Islands, Rowley Shoals, Ashmore Reef, Dampier Archipelago, Barrow Island, Ningaloo Reef and Abrolhos Islands as presented in Western Australian Museum (1993) (Table 3).

The tropical reefs (with the exception of Barrow) have similar numbers of genera (54-60) but species numbers are apparently reduced on the more southerly reefs. Ningaloo, Scott/Rowley and Ashmore reefs, and the Dampier Archipelago have similar recorded levels of coral diversity to the Montebello Islands. By comparison, the diversity of the Lowendal Islands is lower. However, it should be noted that the differences in numbers of coral species might be a function of sampling effort.

Apache has carried out surveys of the species composition and community structure of patch reefs located between the Lowendal Islands and Montebello Islands since 1986. Many of the patch reefs are comprised of living and dead corals and are frequently derived from a number of large *Porites* spp colonies, with smaller areas of diverse coral communities on or around the base of each patch reef (LeProvost Dames & Moore 1996).

Veron (1995) identified three global latitudinal diversity sequences for the distribution of corals. One of these sequences occurs along the West Australian coast. The coral assemblages of Western Australia can be initially clustered into two groups: tropical reefs, and temperate non-reef communities. Tropical reefs form two groups, the offshore reefs of the North West Shelf, and the coastal islands and reefs of which the Lowendal Islands are a part. Within this sequence, coral species attenuate moving from north to south.

Veron (1995) proposed that no individual reef is a dominant source of larvae for the other reefs to the south. Instead, individual reefs are regarded as 'stepping stones' along the southern flowing Leeuwin Current that originates in the region of Indonesia. Many of the corals found on the North West Shelf have been found to have a greater similarity to those of the Barrier Reef than to the adjacent mainland coast with the point of connectivity being via Indonesia.

Along the West Australian sequence, the boundary current runs in a southerly direction taking entrained propagules towards the lower latitudes with little potential for dispersion in the opposite (northern) direction. Hence, the more southern reefs such as the Ningaloo Reef and those found on the Abrolhos Islands receive annual propagules from the northern reefs but there is little dispersion from these reefs back to the northern ones. This has lead to genetic isolation of some coral reefs. For example, the corals of the Abrolhos Islands are frequently dominated by species that are rare anywhere else pointing to genetic isolation of the Abrolhos Islands corals (Veron 1995).

To date there have been no detailed investigations into the natural temporal variability of the coral reefs of the region, although there is reason to believe that damage to corals has resulted from the passage of cyclones (Western Australian Museum 1993). The coral reefs of the Lowendal Islands, like those of the Dampier Archipelago, are subject to extensive damage by cyclones through physical disturbance and sedimentation (Heinsohn & Spain 1974; Van Woesik *et al.* 1991; Stejskal 1992) and therefore may be seen at different stages at different times. In August 1993, the WA Museum reported that large tabular *Acropora* plate corals located in back reef areas of the Montebello Islands appeared to be in a fairly advanced recovery stage. Fast growing *Acropora* species can recover from severe damage in a few years while slow growing massive species may take up to 30 years to recover from major damage (Western Australian Museum 1993). A survey of the corals of the Lowendal and Montebello Islands carried out in August 1996 showed that damage from cyclone *'Olivia'* was patchy and varied in the degree of damage (LeProvost Dames & Moore 1996).

Other natural events, such as sedimentation and predation by species such as the Crown ofThorns starfish, *Acanthaster planci,* and the corallivorous gastropods, *Drupella cornus* and *Drupella rugosa,* all of which have been recorded in the region, may also contribute to temporal variability.

Communities subject to frequent natural perturbation are likely to be either resilient or transient and highly dynamic in terms of cover and distribution (Western Australian Museum 1993). The ability of such species to re-colonise after large-scale natural or human perturbation is also likely to be high.

Coral spawning usually occurs in March and April with a smaller spawning sometimes occurring in October (Chris Simpson, CALM, pers. com.).

Rocky shore intertidal community

Rocky shores are the dominant shoreline type of the Lowendal Islands and other islands of the region. For the most part, they are of the vertical or undercut cliff type.

The abundance and distribution of intertidal epifauna on rocky shorelines of the Lowendal Islands has been monitored at nine locations between 1985 and 1996 (Apache 1999). The studies focused on rock oysters (*Saccostrea culcullata*) in the mid-intertidal zone but also included the barnacles (*Tetraclita squamosa* and *Tetraclita porosa*), the chiton (*Acanthopleura gemmata*), the false limpet (*Siphonaria* sp.) and the gastropod mollusc (*Morula* spp.). Monitoring has revealed large-scale variation in abundance between sites and between sampling times.

A description of the physical zonation which occurs on a typical rocky shore in the Lowendal and Montebello Islands is presented below. The rocky shore profile and the characteristic zonation of its fauna produces five distinct zones. The height of each zone is consistent with the tidal range data for the two closest hydrographic stations (Trimouille Island and WAPET landing at Barrow Island). The spring and neap tidal ranges at these stations are 2.4 m and 0.8 m (Trimouille Island) and 2.5 m and 0.6 m (Barrow Island), respectively. The five zones are as follows:

(i) Supratidal Zone

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

(ii) Upper Intertidal Zone

This is a relatively narrow zone located between MHWS and the top of the oyster bioherms, just above mean high water neaps (MHWN). The upper intertidal zone is typically 50 - 60 cm high (vertical range 30 - 100 cm and dominated by star barnacles (*Chthamalus malayensis*). Chitons (*Acanthopleura gemmata*) and limpets (acmaeids, patallids and *Siphonaria* spp.) are also commonly numerous in this zone, but at frequencies that are one or two orders of magnitude less than the star barnacles (Plate 7).

(iii) Mid-tidal Zone

This zone is relatively broad (up to 150 centimetre high), extends from 20 - 30 cm above MHWN to 20 - 30 cm below mean low water neap (MLWN), and is dominated by rock oysters (*Saccostrea cuccullata*) and their biohermic development.

The rock oyster bioherms frequently produce a bulge in the rocky shoreline profile, typically along the floor of the wave-cut notch when present. Apart from the oysters, the mid-tidal zone is also characterised by the presence of black mussels (cf. *Musculista glaberrima*) and drupes such as *Thais*

Plate 7. Example of rocky shore fauna.

aculeata and *Morula granulata*. False limpets (*Siphonaria* spp.) and barnacles (*C. malayensis* and *T. squamosa*) are common, but usually at lower abundances than in the upper intertidal zone.

(iv) Lower Intertidal Zone

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

(v) Lowest Intertidal Zone

The lowest intertidal zone extends from MLWS to LAT (lowest astronomical tide). It is approximately 40 cm high and usually remains submerged except during extreme low tides. This zone can have a steep or even vertical profile at headlands, but within small bays and notches it frequently comprises a narrow sloping platform (1 - 7 m wide) that extends from the cliff face. The platform is wider (up to 50 m) along the east side of Abutilon Island.

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

Sandy beaches

Sandy beaches occur between the rocky headlands on most of the larger islands (Plate 8). They support a limited range of resident fauna, principally small burrowing fauna such as polychaete worms, bivalve molluscs and amphipod crustaceans (LeProvost Semenuik & Chalmer 1986).

The sandy beaches and adjoining limestone pavements provide feeding grounds for wading birds and nesting sites for species of birds such as the Pied Oystercatcher and Beach Thick-knee as well as seabirds like the Caspian, Bridled and Fairy terns. During summer, three species of turtles use these beaches above the high water mark for nesting (see Section 3.3.2).

Mangroves

Six species of mangroves have been recorded in the Barrow-Lowendal-Montebello region. They are the white mangrove (*Avicennia marina*), ribbed-fruit orange mangrove (*Bruguiera exaristata*), yellow-leafed spurred mangrove (*Ceriops tagal*), red mangrove (*Rhizophora stylosa*), club mangrove (*Aegialitis annulata*) and river mangrove (*Aegiceras corniculatum*).

Small stands of mangroves occur in protected bays of all three island groups. The largest stands are on Hermite Island, one of the larger of the Montebello group of islands. The mangrove associations are not widespread in the Lowendal group (V & C Semenuik Research Group 1999), occurring in small patches on only three islands: *Avicennia* trees occur on the west side of Varanus Island, and on Bridled Island there are pockets of mixed *Avicennia* and *Rhizophora* communities. A

Plate 8. Sandy beaches usually lie between rocky shore headlands.

small stand of *Avicennia* occurs on Abutilon Island about 40 m inland in association with a shearwater rookery.

3.3.2 Fauna

Apache has been generating and maintaining fauna species lists since the inception of the Harriet project in 1986. Abundances for the majority of the species have not been recorded: presence-absence is the only available data, and this is limited, for the most part, to Varanus Island. The population status and life histories have been studied for a few of the species, namely turtles and seabirds.

Focus is given to key species in this report. These are defined as species that are present in the region on some sort of regular basis (e.g. seasonal or present year round), may have high abundances and are most likely to be affected by an oil spill. This would include birds, marine mammals and turtles. Details of life histories are not known for many of the species, but a brief overview of the animal groups that may be found in the region is given.

There are at least 78 listed species that could potentially be found in the region (Table 4). There are no listed threatened ecological communities in the region.

Seasnakes

There are seventeen listed species of seasnake (Table 4) that have a west shelf or pan-tropical distribution and may be found in the region (Heatwole 1999). Seasnakes have been sighted in the waters around the Lowendal Island (Bond Corporation 1985), but sightings are generally infrequent. The Western Australian Museum also observed seasnakes in the waters surrounding the Montebello Islands (Western Australian Museum 1993).

Table 4: List of species classified as threatened that may occur within the region of the proposed Simpson development.

Common name	Scientific name	THREATENED SPECIES LIST						Comments
		National List of Threatened Species (EPBC ACT)[1]	CALM Declared Threatened Fauna	ANZEEC Threatened Fauna List	Bonn Convention[2]	JAMBA[3]	CAMBA[4]	
Fish								
Three-keel pipefish	*Campichthys tricarinatus*	Listed marine species						• No site-specific or species specific information available. • Elaborate courtship during which female passes eggs to male. • Eggs incubated by male, hatch as juveniles. • Feed primarily on epifauna on shallow reefs e.g. crustaceans.
Short-bodied pipefish	*Choeroichthys brachysoma*	Listed marine species						
Cleaner pipefish	*Doryrhamphus janssi*	Listed marine species						
Ladder pipefish	*Festucalex scalaris*	Listed marine species						
Brock's pipefish	*Halicampus brocki*	Listed marine species						
Glittering pipefish	*Halicampus nitidus*	Listed marine species						
Grey nurse shark	*Carcharian taurus*	Vulnerable	Vulnerable	Vulnerable				• Precise timing of mating and pupping in Australian waters unknown. • No site specific information available. • Take 4 to 7 years to sexually mature, females reproduce every 2 years, produce 2 young after 9 to 12 month gestation. • Feed on fish, other sharks, squids, crabs and lobsters.
Seasnakes								
	Acalyptophis peronii	Listed marine species						• Pan-tropical distribution. • Occurs in sandy areas on coral reefs.
	Aipysurus apraefrontalis	Listed marine species						• Western shelf distribution. • Occurs on reef flat edges.
Duboi's seasnake	*Aipysurus duboisii*	Listed marine species						• Pan-tropical distribution. • Occurs on coral reefs, reef flats.
Spine-tailed sea snake	*Aipysuruseydouxii*	Listed marine species						• Pan-tropical distribution. • Occurs in turbid waters.
	Aipysurus foliosquama	Listed marine species						• Western shelf distribution. • Occurs on reef flats, edges, shallows.
	Aipysurus fuscus	Listed marine species						• Western shelf distribution. • Occurs on reef flats, edges, shallows.
Olive sea snake	*Aipysurus laevis*	Listed marine species						• Pan-tropical distribution. • Occurs on coral reefs.
	Aipysurus tenuis	Listed marine species						• Western shelf distribution. • Occurs on coral reefs.
	Astrotia stokesii	Listed marine species						• Pan-tropical distribution. • Occurs in turbid coastal water, coral reefs.
	Disteira kingii	Listed marine species						• Pan-tropical distribution. • Occurs in deep water on various substrates.
	Disteira major	Listed marine species						• Pan-tropical distribution. • Occurs in turbid, deep water.

Table 4: List of species classified as threatened that occur within the region of the proposed Simpson development (cont.).

Common name	Scientific name	THREATENED SPECIES LIST						Comments
		National List of Threatened Species (EPBC ACT)[1]	CALM Declared Threatened Fauna	ANZEEC Threatened Fauna List	Bonn Convention[2]	JAMBA[3]	CAMBA[4]	
Seasnakes (cont.)								
	Ephalophis greyi	Listed marine species						• Western shelf distribution. • Occurs in mangroves and estuarine mudflats.
	Hydrophis coggeri	Listed marine species						• Western shelf distribution. • Occurs on coral reefs and seagrass beds.
	Hydrophis czeblukovi	Listed marine species						• Western shelf distribution. • Occurs on coral reefs.
	Hydrophis elegans	Listed marine species						• Pan-tropical distribution. • Occurs in turbid, deep water.
	Hydrophis ornatus	Listed marine species						• Pan-tropical distribution. • Occurs on coral reefs, turbid inshore waters and estuaries.
Yellow-bellied sea snake	*Pelamis platurus*	Listed marine species						• Pan-tropical distribution. • Occurs on coral reefs.
Turtles								
Loggerhead turtle	*Caretta caretta*	Endangered	Vulnerable	Endangered	Endangered migratory species			• Rarely seen in this region. • Feeds on shellfish, sea urchins and jellyfish.
Green turtle	*Chelonia mydas*	Vulnerable	Taxa in need of monitoring	Vulnerable	Endangered migratory species			• Known nesting sites at Varanus, Abutilon, Montebello and Barrow Islands. • Egg laying October to February. • Hatchlings emerge December to March. • Feeds on algae and seagrass.
Hawksbill turtle	*Eretmochelys imbricata*	Vulnerable	Taxa in need of monitoring	Vulnerable	Endangered migratory species			• Known nesting sites at Varanus, Abutilon, Beacon, Montebello and Barrow Islands. • Egg-laying August to February. • Hatchlings emerge December to March. • Females re-migrate to nest at intervals of 1 to 6 years, averaging every 4 years. • Feeds on sponges, seagrass, algae, soft corals, shellfish.
Flatback turtle	*Natator depressus*	Vulnerable						• Known nesting sites at Varanus, Abutilon, Beacon, Montebello and Barrow Islands. • Egg-laying November to February. • Hatchlings emerge December to March. • Females re-migrate to nest at intervals of 1 to 6 years, averaging every 2 years. • Feeds on sea cucumbers, soft corals, jellyfish.

Table 4: List of species classified as threatened that may occur within the region of the proposed Simpson development (cont.).

Common name	Scientific name	THREATENED SPECIES LIST						Comments
		National List of Threatened Species (EPBC ACT)[1]	CALM Declared Threatened Fauna	ANZEEC Threatened Fauna List	Bonn Convention[2]	JAMBA[3]	CAMBA[4]	
Sireni								
Dugong	*Dugong dugon*	Listed marine species	Specially protected fauna		Migratory species subject to Agreements			• Females sexually mature at 15 to 17 years old, giving birth at 3 to 7 year intervals. • May live up to 70 years. • Can breed all year, possibly peak in May to October, with peak calving from August to January. • Eat seagrass and algae. • Larger migrations unknown.
Mammals								
Fin whale	*Balaenoptera physalus*	Vulnerable	Vulnerable	Vulnerable				• Usually solitary or groups up to 10. • Usually occur in deeper waters a voiding shallow and coastal waters. • Sexual maturity around 10 to 13 years. • Calves born at 2 to 3 year intervals. • Feeds on small crustaceans and pelagic schooling fish.
Sei whale	*Balaenoptera boreali*	Vulnerable	Vulnerable	Vulnerable				• Usually occur in deeper water. • Calves born after 12 months gestation, suckled for 9 months. • Feed on near-surface fishes and shrimp.
Humpback whale	*Magaptera novaeangliae*	Vulnerable	Vulnerable	Vulnerable	Endangered migratory species			• Often in groups of 4 to 12. • Occur in region in winter between June and October. • Calves born in winter every 2 to 3 years. • Feed only in cold water on krill, sardines and other small schooling fishes.
Indo-pacific humpback dolphin	*Sousa chinensis*		Taxa in need of monitoring					• Occur as individuals or in groups up to 20. • Prefers shallow coastal waters. • Calves born year round but peak in summer. • Feed on reef-dwelling fishes and crustaceans.
Spinner dolphin	*Stenella longirostris*		Taxa in need of monitoring					• Either close to shore or exclusively pelagic. • Little known about reproduction. • Feeds on squid and small fishers near the surface.

Table 4: List of species classified as threatened that may occur within the region of the proposed Simpson development (cont.).

Common name	Scientific name	THREATENED SPECIES LIST						Comments
		National List of Threatened Species (EPBC ACT)[1]	CALM Declared Threatened Fauna	ANZEEC Threatened Fauna List	Bonn Convention[2]	JAMBA[3]	CAMBA[4]	
Birds								
Wedge-tailed shearwater	*Puffinus pacificus*	Listed marine species				X		• Resident seabird. • Significant rookeries on Varanus and Bridled Islands. • Non-breeding season is May to August. • Return to islands in August for courting and copulation. • Egg laying from late October. • Juveniles fledge from late March. • During breeding season, forage at sea during the day and return at dusk to nests on ground.
Brown booby	*Sula leucogaster*	Listed marine species				X	X	• Resident seabird. • Usually at sea except when breeding in colonies. • Breeding season from February to November. • Feeds by diving for fish.
Australian pelican	*Pelecanus conspicillatus*	Listed marine species						• Resident seabird. • Nomadic except when breeding. • Breeding all year round.
Lesser frigatebird	*Fregata ariel*	Listed marine species				X		• Resident seabird. • No breeding sites on North West Shelf. • Piratic, mobs other seabirds to steal food.
Cattle egret	*Ardea ibis*	Listed marine species						• Resident seabird. • No breeding sites on North West Shelf.
Eastern Reef Egret	*Egretta sacra*	Listed marine species					X	• Resident seabird. • Intertidal zone: rocks, coral reefs, mangroves, mudflats. • Pairs defend feeding territory exposed at low tide.
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	Listed marine species					X	• Resident raptor. • Breeding from April to October. • Dives to secure fish, also eats terrestrial vertebrates and carrion.
Brahminy kite	*Haliastur indus*	Listed marine species						• Resident raptor. • Breeding from February to December. • Feeds mainly on carrion. • Builds nests with sticks and seaweed.

Table 4: List of species classified as threatened that may occur within the region of the proposed Simpson development (cont.).

Common name	Scientific name	THREATENED SPECIES LIST						Comments
		National List of Threatened Species (EPBC ACT)[1]	CALM Declared Threatened Fauna	ANZEEC Threatened Fauna List	Bonn Convention[2]	JAMBA[3]	CAMBA[4]	
Birds (cont.)								
Osprey	*Pandion haliaetus*	Listed marine species			Migratory species subject to Agreements			• Resident raptor. • Breeding from March to December. • Construct large nests in trees, rocky outcrops or ground. • Specialised fish catcher.
Peregrine falcon	*Falco peregrinus*				Migratory species subject to Agreements			• Resident raptor. • No breeding sites known on North West Shelf. • Feeds on birds and insects.
Brown falcon	*Falco berigora*				Migratory species subject to Agreements			• Resident raptor. • No breeding sites known on North West Shelf. • Feeds on birds and insects.
Nankeen kestral	*Falco cenchroides*	Listed marine species			Migratory species subject to Agreements			• Resident raptor. • Breeding season July to January. • Hover or perch in search of prey.
Beach Stone-curlew	*Esacus neglectus*	Listed marine species	Taxa in need of monitoring					• Resident shorebird. • September to December breeding season. • Lays single egg on sandy beaches or mangroves. • Forages over intertidal mud and sand flats. • Low densities, no flocks.
Grey plover	*Pluvialis squatarola*	Listed marine species			Migratory species subject to Agreements	X	X	• Migratory shorebird. • Non-breeding resident in winter in Australia. • Forages over intertidal mud and sand flats.
Eastern golden plover	*Pluvialis dominica*	Listed marine species			Migratory species subject to Agreements	X		• Migratory shorebird. • Non-breeding resident in winter in Australia.
Mongolian sand plover	*Charadrius mongolus*	Listed marine species			Migratory species subject to Agreements	X	X	• Migratory shorebird. • Non-breeding resident in summer in Australia. • Forages over intertidal mud and sand flats. • Occurs in mixed flocks.
Large sand plover	*Charadrius leschenaultii*	Listed marine species			Migratory species subject to Agreements	X	X	• Migratory shorebird. • Non-breeding resident in summer in Australia. • Forages over intertidal mud and sand flats. • Occurs in mixed flocks.

Table 4: List of species classified as threatened that may occur within the region of the proposed Simpson development (cont.).

Common name	Scientific name	THREATENED SPECIES LIST						Comments
		National List of Threatened Species (EPBC ACT)[1]	CALM Declared Threatened Fauna	ANZEEC Threatened Fauna List	Bonn Convention[2]	JAMBA[3]	CAMBA[4]	
Birds (cont.)								
Red-capped plover	*Charadrius ruficapillus*	Listed marine species						• Resident shorebird. • Adaptable, occurs on a wide range of wetland types. • Breeds from March to July in isolated pairs. • Surface feeder locating its prey by site.
Ruddy turnstone	*Arenaria interpres*	Listed marine species			Migratory species subject to Agreements		X	• Migratory shorebird. • Non-breeding resident in summer in Australia. • Forages on sandy ocean beaches, rocky shores and intertidal mudflats – searches strandline debris.
Whimbrel	*Numenius phaeopus*	Listed marine species			Migratory species subject to Agreements	X	X	• Migratory shorebird. • Non-breeding resident in summer in Australia • Forages on intertidal mud using its bill.
Grey tailed tattler	*Heteroscelis (Tringa) brevipes*	Listed marine species			Migratory species subject to Agreements	X	X	• Migratory shorebird. • Non-breeding resident in summer in Australia. • Roosts on mangroves and sandy beaches. • Forages over intertidal mudflats.
Common sandpiper	*Actitis hypoleucos*	Listed marine species			Migratory species subject to Agreements	X	X	• Migratory shorebird. • Non-breeding resident in summer in Australia. • Active feeder, probing to find food.
Greenshank	*Tringa nebularia*	Listed marinespecies			Migratory species subject to Agreements	X	X	• Migratory shorebird. • Non-breeding resident in summer in Australia. • Forages in shallow water.
Terek sandpiper	*Xenus cinereus*	Listed marine species				X	X	• Migratory shorebird. • Non-breeding resident in summer in Australia. • Forages over wet mud/sand.
Black-tailed godwit	*Limosa limosa*	Listed marine species			Migratory species subject to Agreements	X	X	• Migratory shorebird. • Non-breeding resident in summer in Australia. • Feeds by probing its bill into soft mud near the waters edge.

Table 4: List of species classified as threatened that may occur within the region of the proposed Simpson development (cont.).

Common name	Scientific name	THREATENED SPECIES LIST						Comments
		National List of Threatened Species (EPBC ACT)[1]	CALM Declared Threatened Fauna	ANZEEC Threatened Fauna List	Bonn Convention[2]	JAMBA[3]	CAMBA[4]	
Birds (cont.)								
Great knot	*Calidris tenuirostris*	Listed marine species			Migratory species subject to Agreements	X	X	• Migratory shorebird. • Non-breeding resident in summer in Australia. • Feeds mainly on intertidal mudflats by jabbing its bill into mud at edge of water.
Sharp-tailed sandpiper	*Calidris acuminata*	Listed marine species			Migratory species subject to Agreements	X	X	• Migratory shorebird. • Non-breeding resident in summer in Australia. • Feeds in mud or shallow water.
Red-necked stint	*Calidris ruficollis*	Listed marine species			Migratory species subject to Agreements	X	X	• Migratory shorebird. • Non-breeding resident in summer in Australia. • Forages on intertidal mudflats in flocks.
Sanderling	*Calidris alba*	Listed marine species			Migratory species subject to Agreements	X	X	• Migratory shorebird. • Non-breeding resident in summer in Australia. • Feeds on sandy ocean beaches, following receding waves and pecking in the wet sand for prey.
Silver gull	*Larus novaehollandia*	Listed marine species						• Resident seabird. • Ominvorous scavengers. • Can breed at any time of year but usually only once per year, up to 2 clutches. • Nests on ground.
Caspian tern	*Sterna caspia*	Listed marine species					X	• Resident seabird. • Feed offshore on small pelagic fish. • Breeding possible all year.
Common tern	*Sterna hirundo*	Listed marine species						• Migratory seabird, non-breeding in Australia. • Feed offshore on small pelagic fish.
Roseate tern	*Sterna dougallii*	Listed marine species						• Resident seabird. • Breeding from May to June (< 60 days) • Breed on Roseate and Mallet Islands. • Feed inshore.
Bridled tern	*Sterna anaethetus*	Listed marine species				X	X	• Resident seabird. • Breeding from December to February (90 days). • Breed on Varanus, Bridled and Abutilon Islands. • Feed offshore on small pelagic fish.

Table 4: List of species classified as threatened that may occur within the region of the proposed Simpson development (cont.).

Common name	Scientific name	THREATENED SPECIES LIST						Comments
		National List of Threatened Species (EPBC ACT)[1]	CALM Declared Threatened Fauna	ANZEEC Threatened Fauna List	Bonn Convention[2]	JAMBA[3]	CAMBA[4]	
Birds (cont.)								
Little tern	*Sterna albifrons*	Listed marine species	Taxa in need of monitoring			X	X	• Resident seabird. • Feed offshore on small pelagic fish.
Fairy tern	*Sterna nereis*	Listed marine species						• Resident seabird. • Feed offshore on small pelagic fish.
Crested tern	*Sterna bergii*	Listed marine species						• Resident seabird. • Breeding from April to May (< 60 days). • Breed on Beacon and Mallet Islands. • Feed inshore .
Lesser crested tern	*Sterna bengalensis*	Listed marine species					X	• Resident seabird. • Breeding from April to May (< 60 days). • Breed on Beacon Island. • Feed inshore .
Australian magpie lark	*Grallina cyanoleuca*	Listed marine species						• Terrestrial resident. • Breeds all year round. • Feeds on insects.
Richard's pipit	*Anthus novaeseelandiae*	Listed marine species						• Terrestrial resident. • Breeds all year round. • Prefers grassy habitats.
Tree martin	*Hirundo nigricans*	Listed marine species						• Terrestrial resident. • Breeds all year round. • Nest in tree or cliff holes lined with mud. • Gregarious.
Welcome swallow	*Hirundo neoxena*	Listed marine species						• Terrestrial resident. • Breeds all year round. • Nests on human made structures.

1. EPBC Act = Environment Protection and Biodiversity Act 1999 Cth
2. Bonn Convention = Convention on the Conservation of Migratory Species of Wild Animals, Bonn, 23 June 1979. Australian Treaty Series 1991 No 32.
3. JAMBA = Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment. Australian Treaty Series 1981 No 6.
4. CAMBA = Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds in Danger of Extinction and their Environment. Australian Treaty Series 1988 No 22.

Turtles

There are three species of marine turtles known to occur in the region: the green (*Chelonia mydas*), flatback (*Natator depressus*), and hawksbill (*Eretmochelys imbricata*). All three species are endemic to the tropical regions (Plate 9).

Some of the regionally significant nesting populations are given in Table 5 below. The data are derived from the Western Australian Marine Turtle Project, 1986 - 1992 (Prince 1993). Sampling effort was not standardised at each location; the data are therefore only indicative of numbers and not comparable between locations. There are also numerous areas that are yet to be surveyed or are currently being surveyed.

Important hawksbill nesting populations are found on Varanus Island and Rosemary Island in the Dampier Archipelago. Numbers on Rosemary Island are significantly higher than on Varanus Island as indicated by ongoing monitoring. Nesting populations also occur on the Montebello Islands, Barrow Island and on other islands within the Lowendal group of islands. Nesting is significantly higher on the Montebello Islands than on either the Lowendal Islands or Barrow Island (Kellie Pendoley, pers comm.).

The most important flatback rookery on the North West Shelf is Yacht Club beach on Barrow Island. Flatbacks also nest on Varanus Island and throughout the Montebello Island group. The largest green turtle rookeries are located on Barrow Island.

Table 5: Locations and numbers of nesting turtles, 1986 - 1992.

Area	Green	Flatback	Hawksbill	Total
Lacepede Islands	3,960	29	Nesting does occur	3,989
Barrow Is.	2,249	70	-	2,319
North West Cape	1,475	-	25	1,500
Muiron Is.	425	1	2	428
Varanus Is.	40	50	245	335
Rosemary Is.	22	34	120	176

Plate 9. Turtles are common in the region.

Apache has been monitoring all three species of turtle since 1986. The primary objective of the study was to provide data on the nesting dynamics of turtles that come to Varanus Island (Apache 1999). The most common species to Varanus Island and Abutilon Island is the hawksbill turtle. Flatback turtles are seen frequently while green turtles are the least common.

Turtle nesting is seasonal and the peak generally occurs between October and January. Not all species nest at the same time; hawksbill turtles start laying eggs between August to February, peaking in November and December; flatback turtles lay eggs between November to February; while green turtles lay eggs between October and February. Hatchlings emerge between December to March.

Turtles usually don't come back to their nesting sites every year to breed. Some data on re-migration of hawksbill and flatback turtles to Varanus Island is available. Re-migrants are the animals that have been tagged in previous seasons and have returned to nest. The re-migration interval for hawksbills ranged from one to six years, with the average being four years. The re-migration intervals for flatbacks ranged from one to six years with an average of two years. This means that female hawksbills returned to Varanus Island on average every four years to breed and nest.

All three species of turtles found in the region are classified as endangered on a world wide basis and Australia is one of the few countries still to have relatively large turtle populations (Limpus 1990). All three species are migratory and subject to exploitation in traditional fisheries in northern Australia and neighbouring countries. They may also incur significant mortality as a by-catch of commercial fishing in Western Australian waters (Prince 1990).

Birds

At least 64 species of birds feed and nest on the surrounding waters and islands within the region: 43 of these are listed species (Table 4). Of these, 26 are Australian resident species, and 15 are migratory species that breed in the arctic or sub-arctic areas of the Northern Hemisphere and spend their non-breeding season in Australia during the Australian summer. The remaining two species are migrants and spend their non-breeding season in Australia during the Australian winter.

Migratory species of shorebirds first arrive in northern Australia in large numbers in late August and early September, and start their northern migration in mid-February (Lane 1987). The north-west coast of Australia, between Broome and Port Hedland, is the most important wintering locations for many of these migratory birds compared to the Lowendal Islands (Lane 1987). Although a number of migratory species are observed on the beaches and intertidal shorelines of the Lowendal and Montebello Islands, none are known to breed on the islands.

The two key groups of birds found on the islands are the raptors and seabirds. These groups use the islands for breeding, nesting and feeding, either being present year round or appearing on a seasonal basis.

A brief overview of the raptors and seabirds is given below.

Raptors

Six species of listed raptors are found on the islands in the region. All six species breed and nest on many of the islands and rocky islets. Although abundances are not high for any of the species, the most commonly sighted are the Osprey and the Brahminy kite.

The osprey is a specialised fish-eater that constructs a stick nest on rocky outcrops or on the ground. Nests may be used for years and the main breeding season ranges from March to October.

The Brahminy kite feeds on fish, but they will also feed on other foods such as small mammals, reptiles and other birds. These kites construct nests of sticks and the main breeding season for this species ranges from March to September.

Seabirds

Fifteen species of listed seabirds have been observed on the Lowendal Islands since 1986. All are resident species. Abundances for the majority of the species have not been recorded: presence-absence is the only available data, and this is limited, for the most part, to Varanus Island. The most common seabirds are the terns, Pied Cormorants and Silver Gulls. Most of the islands are used for roosting and nesting (Plate 10) and no species is endemic to the region.

Research carried out on the Lowendal Islands on shearwaters and several species of terns indicate that these species are seasonal breeders (Lisa Nicholson, pers comm). These species also have the highest abundances of all the seabirds present on the Lowendal Islands, except for the silver gull. Listed below is the main breeding times within the Lowendal Island group, as well as their length of breeding period and location of breeding.

Species	Foraging	Breeding time breeding period	Length of locations	Island breeding
Wedge-tailed Shearwaters	Pelagic foragers	October to May	120 days	Varanus, Bridled and Abutilon
Bridled terns	Offshore foragers	December to February	90 days	Varanus, Bridled and Abutilon
Roseate terns	Inshore foragers	May to June	<60 days	Roseate, Mallet
Crested terns	Inshore forager	April to May	<60 days	Beacon, Mallet
Lesser crested terns	Inshore foragers	April to May	<60 days	Beacon

Plate 10. Roosting Bridled Terns on Abutilon Island.

The Wedge-tailed Shearwater, *Puffinus pacificus*, has significant rookeries on Varanus Island and Bridled Island (Astron 2000). During the non-breeding season (May - early August), shearwaters feed on fish and squid in open waters, some moving close to the equator. Adult birds start to return to the islands by August for the start of the breeding season. Once on the island, the adults begin their courtship behaviour following by copulation. The birds leave the islands about November to go out to sea to feed and build up their reserves of energy before returning to the islands to lay their eggs. Egg laying commences in late October and the fledglings leave the nests in late March to early April. During breeding season, the birds forage at sea during the day and return at dusk to the nests dug into the ground.

The Bridled Tern, Crested and Lesser Crested Terns are present in high abundances and nest on a number of the islands of the Lowendal and Montebello group of islands. For example, an estimated 3,000 - 4,000 breeding pairs were nesting in February 1995 on Bridled Island, located some 300 m to the north-west of Varanus Island (Dunlop 1996). Most species are ground nesters, laying eggs in small depressions under rocky outcrops or plants.

Little Rocky Island supports pelican nesting while a large cormorant colony is present on Bridled Island.

The prey taken by most of the seabirds can vary considerably, but each species tends to feed in particular zones or habitats. For example, shearwaters forage far offshore in the open sea, while terns feed closer to shores on smaller pelagic fish.

Marine mammals

Marine mammals, including dolphins, whales and dugongs, frequent the waters of the region.

The following cetacean species have been sighted in the region:

Baleen Whales (*Mysticeti*)

- Tropical Bryde's Whale
- Southern Minke Whale (winter only)
- Humpback Whale (winter only)

Toothed Whales (*Odontoceti*)

- Bottle Nosed Dolphin
- Common Dolphin
- Striped Dolphin
- Short-finned Pilot Whale
- False Killer Whale
- Killer Whale

Marine cetaceans known to occur in the region include six species of toothed and three species of baleen whales. The bottlenose dolphin, *Tursiops truncates*, is the most common species observed in the inshore waters of the region. Of notable interest, Humpback whales migrate through the North West Shelf region in the winter months between June and October. Annually between June and October, these whales migrate between Antarctica and the Kimberley region, travelling in the deeper continental shelf waters during both their northern and southern migrations. The migration route takes the animals along the edge of the shelf on the outside of the Montebello Islands and Barrow Island before cutting in towards the resting grounds in Exmouth Gulf. Humpbacks are occasionally sighted in the shallow waters east of the Lowendal Islands, but usually in low numbers.

Distribution maps indicate that Fin whales and Sei whales may occur in the region but are generally not seen close to shore as all three are deep-water species.

Dugong (*Dugong dugon*; Dugongidae) are known to occur in the shallow, warm waters around the islands, although not in the large concentrations seen further south in the Exmouth Gulf or Shark Bay (Prince 1989). Dugongs can form aggregations, but this has not been observed around the Lowendal Islands or Montebello Islands. Animals are usually in very low numbers as solitary individuals or in groups of two to three. Dugongs can breed all seasons, but it appears that there is a seasonal peak in March to October. Peak calving would be in August to January. The timing and degree of calving in the Barrow/Lowendal/Montebello region is unknown.

This animal is entirely herbivorous and feeds on the seagrass and algae meadows. Dugongs make short-range seasonal movements in and out of shallow water areas, which is apparently related to changes in tide, weather and food availability. Current knowledge on the size and distribution of dugong populations and their migratory habits in the region between North West Cape and the Dampier Archipelago is limited.

Dugongs are considered rare and endangered and are protected in Western Australia.

Fish

A diverse range of fish is found in the area (Plate 11). This includes commercially significant species such as sharks, snapper, Spanish Mackerel and Red Emperor, recreational species including sea perch and rock cod together with a variety of tropical reef species inhabiting coral areas. LeProvost Semeniuk & Chalmer (1986) described the fish fauna of the Montebello Islands as abundant around areas of limestone and coral reef, and moderate to low in seagrass patches and over limestone pavement.

Plate 11. Sweetlip in the vicinity of the Simpson development.

The survey carried out by the WA Museum details fish species found in the Montebello Islands. It reports that a total of 457 fish species in 76 families are found in the area, of which 6 species of pipefish are listed species (Table 4). Most of the species, with the exception of a few north-west regional endemics, have relatively wide distributions in the Indo-west Pacific Region. Nearly all species have either pelagic eggs or larvae and therefore are recruited as juveniles from areas outside the Montebello Islands (Western Australian Museum 1993). Many of the species are found in the shallower reef areas.

Two additional species of pipefish were recorded by the West Australian Museum during their survey of the Montebello Islands (Western Australian Museum 1993): *Phoxocampus belcheri* and *Doryrhamphus multiannulatus*. Neither of these are listed species.

Sharks are common throughout the waters of the North West Shelf. The only listed shark species occurring in the region is the Grey Nurse Shark (Table 4). This shark is found in tropical and temperate waters of Australia and has been recorded in all States except Tasmania.

Molluscs

Two commercially important species of bivalve molluscs occur within the waters of the Lowendal and Montebello Islands. Pearl oysters live on the seabed from the low water mark to a depth of 85 m, inhabiting a range of substrates from mud and sand through deep water reefs (Kailola *et al.* 1993). The largest species, *Pinctada maxima,* is harvested at depths from 10 - 37 m between Exmouth Gulf and King Sound. Collected shell is farmed to produce cultured pearls. Cossack Pearls Pty Ltd operates a pearl farm adjacent to Parakeelya Island.

The western saucer scallop, *Amusium balloti*, also occurs in waters between 10 - 75 m. There is no commercial fishing for scallops within the Lowendal or Montebellos, although there is a fishery based in Dampier.

In addition, there is one species of gastropod that is endemic to the area between Barrow Island and the Montebello Islands. This is the direct developing volutid *Amoria macandrewi* and its endemicity may indicate that this area has been isolated from other marine ecosystems for some time (Marine Parks and Reserves Selection Working Group 1994).

Crustaceans

A number of decapod crustaceans occur in the waters surrounding the Barrow-Lowendal-Montebellos Islands and some of these are fished commercially. The western king and tiger prawns are the main component of the catch. Both species burrow into the sediments, but the western king prawn prefer relatively coarse sediments while tiger prawns select muddy areas. Other species may be harvested as a by-catch including white banana prawns and the bay lobster or mud bug. Another species of lobster, the painted spiny lobster *Panulirus ornatus*, is the target of a small localised dive fishery around the islands and reef chains between the Muiron and Montebello Islands (Kailola *et al.* 1993).

Other benthic invertebrates

Unconsolidated sediments in the region are likely to support a diverse benthic infauna consisting predominantly of mobile burrowing species which include molluscs; crustaceans (crabs, shrimps and smaller related species); polychaetes; sipunculid and platyhelminth worms; asteroids (sea stars); echinoids (sea urchins) and other small animals.

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

3.4 Social Environment

3.4.1 Aboriginal history

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

3.4.2 European history

The existence of the Lowendal Islands has been known since 1817 when they were sighted by sailors on the colonial cutter *Mermaid*. However, they were rarely visited until recent times by turtle hunters, guano seekers and fishermen.

The English ship *Tryal* was wrecked on what are now known as the Tryal Rocks just north of the Montebello Islands in 1622 (Figure 5). This shipwreck is protected by the *Marine Archaeological Act* WA 1973 and has National Estate status.

A further uncharted wreck, that of the 19th century ship the *Wild Wave*, is understood to be located on the seaward side of the south-west section of the fringing reef adjacent to the Montebello Islands.

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

In 1952 and 1956, three British nuclear weapon tests were exploded on and near the Montebello Islands (Figure 5). One of these was on a vessel, the HMS *Plym*, moored close to the western shore of Trimouille Island, while the other two took place on land. Continuing radiation hazards limit the recommended length of occupation times on Trimouille and Alpha Islands, the sites of the land-based tests (Morris 1991). Remains of activities include scrap steel, relics of the nuclear tests and the former British operational headquarters foundations on the south of Hermite Island. Due to atomic testing, access is restricted on parts of Trimouille and Alpha Islands.

3.4.3 Present land use

Present uses of the Lowendal Islands include conservation reserves for flora and fauna, pearl cultivation, and oil and gas activities (Figure 9).

3.5 Site-specific Description of the Environment

The following descriptions were compiled from recent field investigations of the area around the proposed Simpson development (Bowman Bishaw Gorham 2000; 2001). Apache's annual marine monitoring programme includes a site near Abutilon Island for monitoring coral (International Risk Consultants 2001a).

3.5.1 Mini-platform locations

The water depth at the proposed mini-platform locations is approximately 6 m. To the west and north-west of the sites, the seafloor rises to become the shoreline of Abutilon Island. To the east the seafloor slopes away more gradually to reach depths of 50 m over a distance of some 10 km.

The seafloor at the mini-platform locations is characterised by sparse epibenthic assemblage on limestone pavement with sand veneers (Plate 12). The epibenthic assemblage is dominated by large, brown macroalgae (mainly *Sargassum* sp.), large solitary ascidians, occasional scleractinian corals (mainly *Turbinaria* sp.) and branched whip coral (Ellisellidae). The fish assemblage in the area is dominated by Threadfin Bream (*Pentapodus emyeryii*), Tuskfish (*Choerodon cyanodus*) and Lethrinids.

There is an area of coral reef, predominantly coral bomboras of *Porites* spp and plate *Acropora* spp, located off the north-east point of Abutilon Island. Scattered small coral colonies of *Acropora* sp. are also present on small boulders that occur on a limestone ridge about 250 m to the west of the Simpson 'A' platform location. This assemblage of corals is not significant from a conservation perspective, but were tagged and photographed prior to the Tanami-4 and -5 drilling program to allow for assessment of possible adverse impacts from the drilling program and development (Bowman Bishaw Gorham 2000).

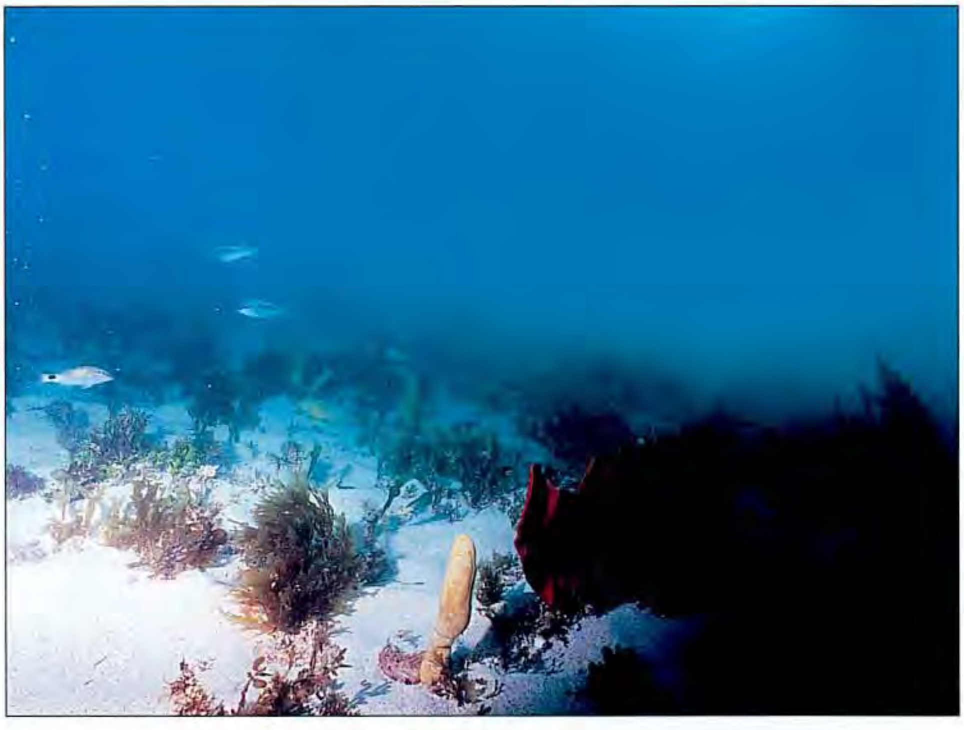


Plate 12. Sparse distribution of macroalgae and epibenthos at the Simpson development location.

3.5.2 Pipeline bundle route

The benthic habitats along and surrounding the proposed pipeline bundle route are shown in Figure 16. The benthos is comprised primarily of limestone pavement with a variable cover of macroalgae and sand veneers. The epibenthic assemblages tend to be sparser where the sand veneer is deeper (Plate 13). Predominant algae include *Sargassum* and *Dictyoptera*. Occasional corals and lithophagid sponges are present.

The macroalgal assemblage on the pavement is dominated by *Sargassum* interspersed with *Padina* and *Halimeda*. Corals were restricted to very occasional colonies, including one medium sized (~0.8 m diameter) *Astreopora* colony.

The depth of sand was not measured, but is probably a shallow veneer (<0.5 m) over limestone pavement.

Low profile reef areas occur on both sides of the proposed pipeline route. These areas generally slope up to approximately two metres above the surrounding pavement and support a denser epibenthic community.

3.5.3 Abutilon Island

Rocky shores are the major habitat type on Abutilon Island (Figure 17). The shoreline of the eastern bay, located some 400 m to the west of the Simpson 'A' mini-platform, comprises narrow intertidal rock platforms backed by low rocky cliffs and low sandy beaches backed by dunes.

Bridled Terns and Ruddy Turnstones roost on the rocky cliff tops throughout the bay during the summer season (Plate 14). Cormorants and Beach Stone-curlews are also found on the island. A small shearwater rookery is located amongst the small stand of *Avicennia* located in the central inland part of the island.

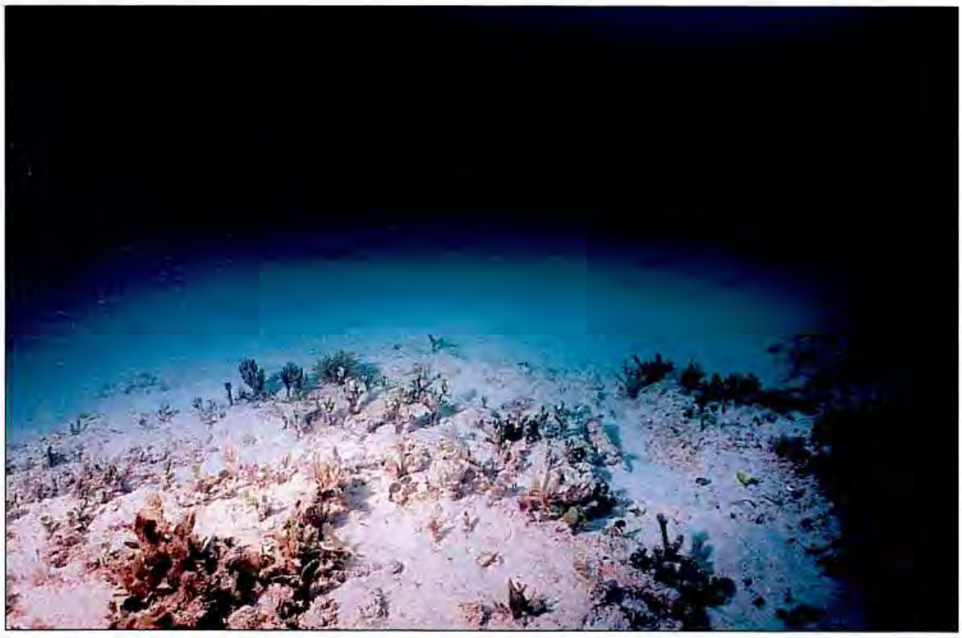
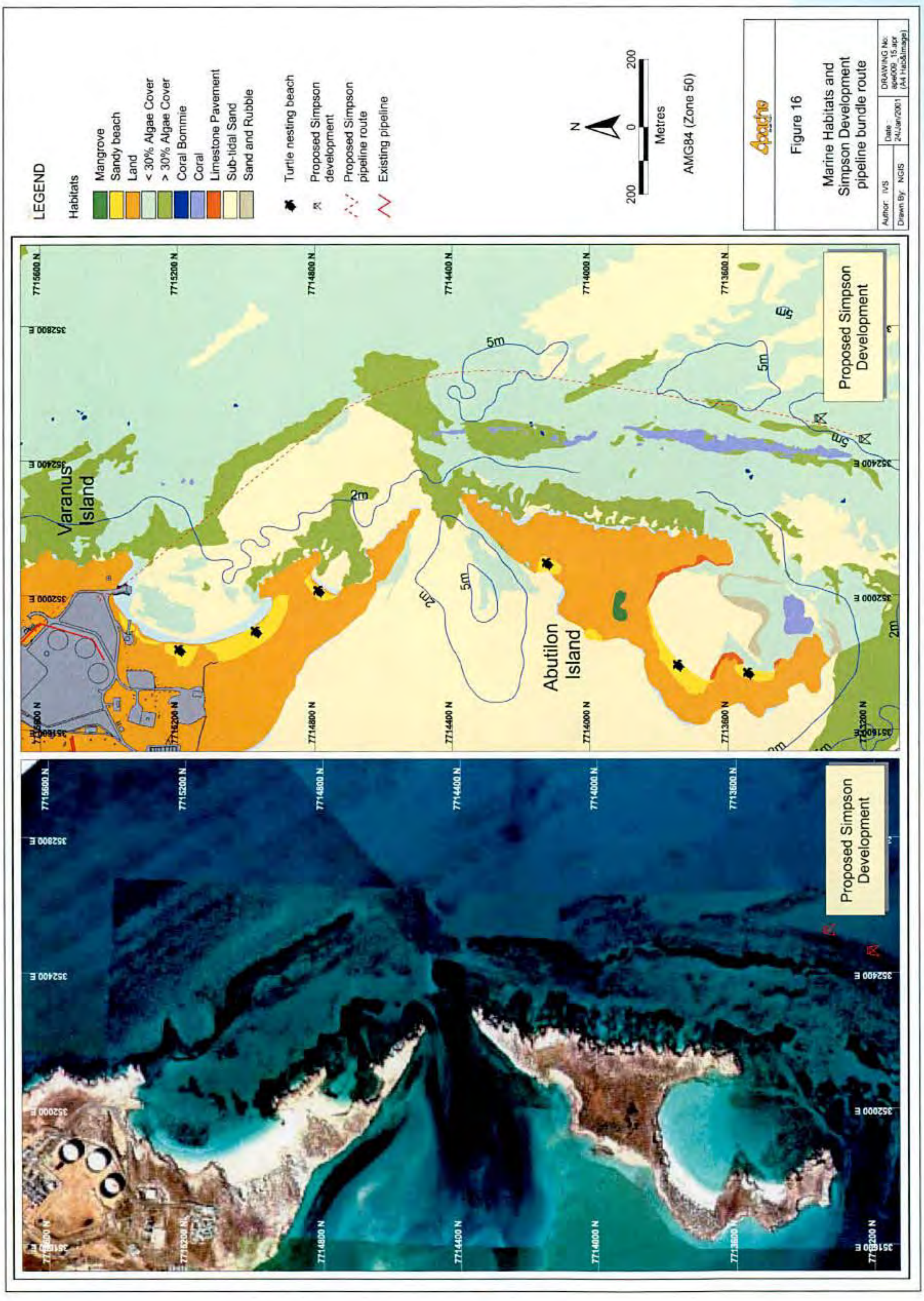


Plate 13. The seabed along the pipeline bundle route adjacent to Varanus Island.


LEGEND
Habitats
Mangrove
Sandy beach
Land
< 30% Algae Cover
> 30% Algae Cover
Coral Bommie
Coral
Limestone Pavement
Sub-tidal Sand
Sand and Rubble
Turtle nesting beach
Proposed Simpson development
Proposed Simpson pipeline route
Existing pipeline
N
200
0
200
Metres
AMG84 (Zone 50)
Figure 16
Marine Habitats and Simpson Development pipeline bundle route
Author: IVS
Drawn By: NGIS
Varanus Island
Abutilon Island
2m
5m
Proposed Simpson Development
Proposed Simpson Development
7715600 N
7715200 N
7714800 N
7714400 N
7714000 N
7713600 N
352800 E
352400 E
352000 E

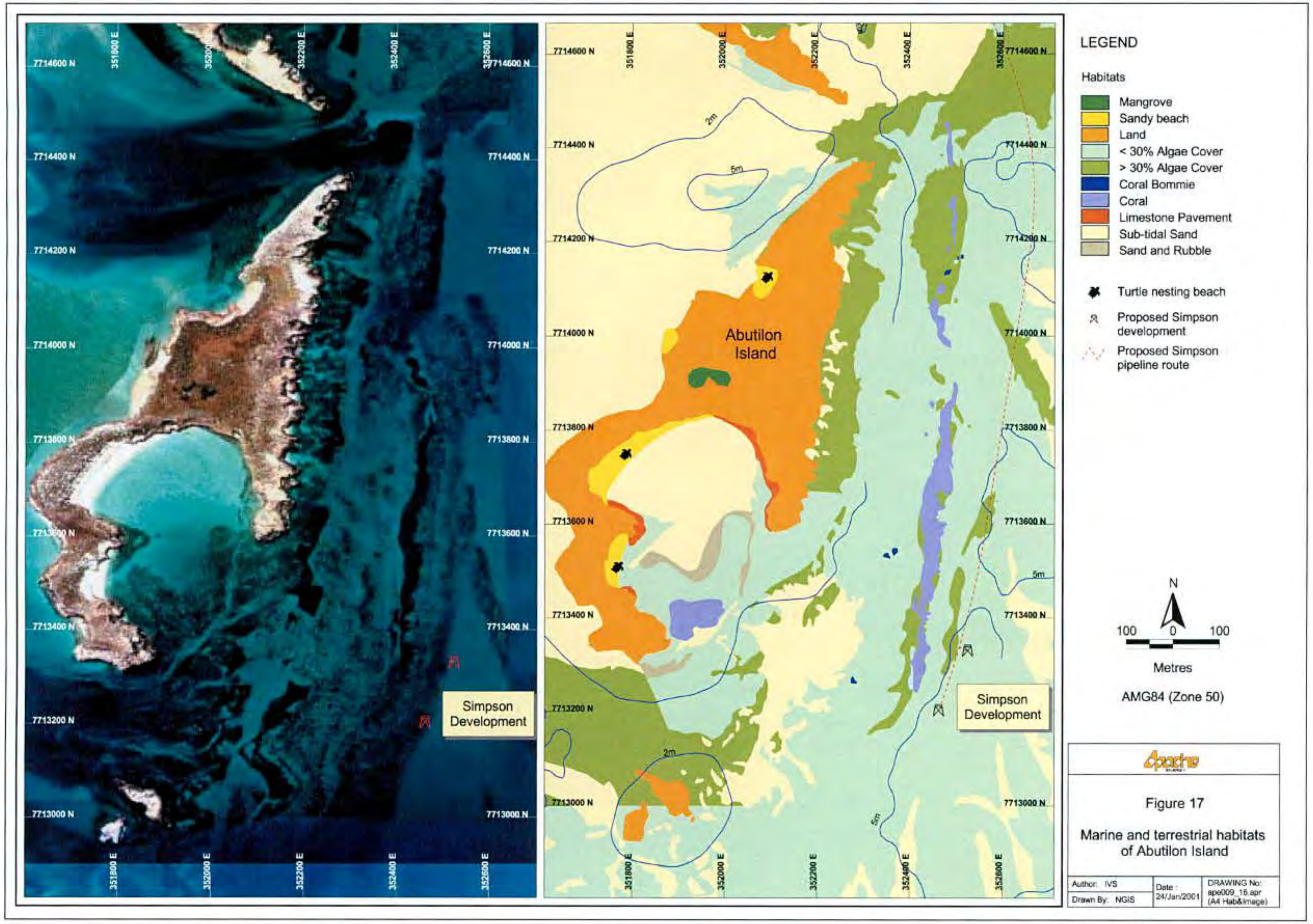


Figure 17

Marine and terrestrial habitats of Abutilon Island

The intertidal pavements and rocky cliff faces exhibit low habitat diversity and accordingly support a limited invertebrate community. The intertidal pavement habitat is the most extensive beneath the rocky headland between the beaches. The vertical rocky substrate in the upper intertidal supports a species-poor, but abundant assemblage of molluscs (mainly *Nodilittorina nodosa*) and rock crabs (*Leptograpsus* sp.). Rock oysters (*Saccostrea* sp.) dominate the mid-tide zone over an area approximately 1.2 m high. In addition to the oysters, invertebrates in this zone include barnacles, chitons (*Acanthopleura* spp.- especially *A. gemmata*) and molluscs including *Thais aculeata, Nodilittorina millegrana, Planaxis sulcatus, Nerita* sp., *Siphonaria* sp. and small Mytilid mussels.

The vertical rock face below the oyster zone is dominated by tube worms (*Spirorbidae*) and filamentous green algae. Areas of gently inclined rocky shore adjacent to the vertical rock faces supported a much less diverse and abundant assemblage dominated by large limpets.

The lower intertidal reef platform supported a depauperate assemblage of burrowing molluscs (*Lithophaga* sp.) and small macroalgae. At low tide, the temperature of the sea water over this reef platform was significantly elevated above ambient water temperatures. Rock pools in the reef platform supported small macroalgae (*Sargassum*, *Padina*, *Laurencia*).

The sandy beaches within the bay are used extensively by roosting Silver Gulls (*Larus novaehollandiae*) and terns. Turtles nest on the sandy beaches and a low level of nesting activity has been recorded on the southern beach.

There are four main subtidal habitats in the bay (Figure 17):

- bare sands
- mixed sand/rubble;
- macroalgae on pavement; and
- coral dominated pavement and bomboras.

Plate14. Bridled terns breed on various islands in the region.

A large area of bare sand extends from the sandy beaches, through the intertidal zone to a deeper basin in the centre of the bay. This area is largely devoid of epibiota. Large pelagic fish can be relatively abundant near the shore at high tide. These include blacktip reef sharks (*Carcharinus melanopterus*), spotted eagle rays (*Aetobatus narinari*), queenfish (*Scomberoides* sp.) and barracuda (*Sphyraena barracuda*).

An extensive strip of mixed sand and rubble, between the large area of bare sand and the pavement at the mouth of the bay, supports a sparse epibenthic assemblage. The assemblage is comprised of small macroalgae (mainly *Padina*), very sparse seagrasses (*Syringodium*, *Halodule* and *Halophila*) and occasional small corals (*Acropora* and *Pocillopora*) on more solid pieces of substrate.

Macroalgae on pavement is one of the most widespread habitats in the region and is abundant in and around the bay during the summer season. The dominant *Sargassum* macroalgae is interspersed with small corals and encrusting lithophagid sponges.

Coral dominated habitats are restricted to an area at the southern end of the bay (Plate 15). The coral assemblage is comprised of large mixed species bomboras, usually based upon large *Porites* colonies, and areas dominated by smaller branching, massive or encrusting species on low profile limestone reef. *Porites, Acropora, Goniopora, Merulina, Pocillopora* and faviids were the most common corals. This area supports an abundant coral reef fish assemblage, including numerous sweetlips (*Plectorhinchus* spp.), wrasse (Family Labridae), parrot fish (Family Scaridae) and damsel fish (Family Pomacentridae).

Strong tidal currents flowing through the deeper channel between Abutilon Island and the small rocky islet and surrounding reef approximately 200 m to the south, appear to create a natural boundary to the habitats within the bay. Habitats immediately outside the bay (south of the channel) were comprised of a high cover of large *Sargassum* thalli on pavement with minor sand veneers.

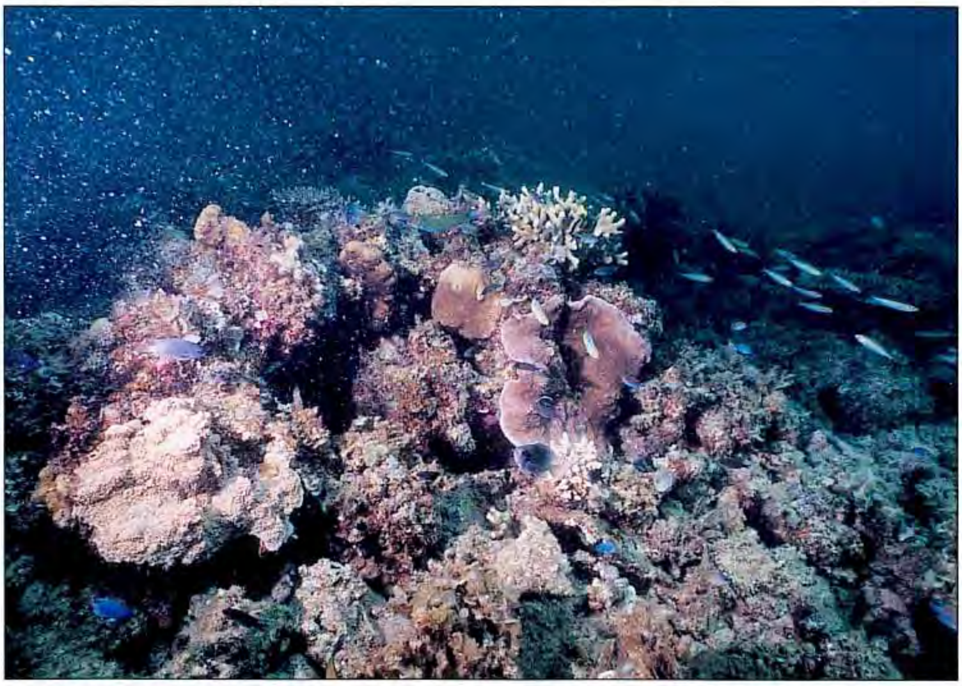


Plate 15. Mixed coral assemblage located off the shoreline of Abutilon Island.

3.6 Conservation Status of the Area

The Lowendal Islands are classified as a C-Class reserve (C-33902) for the conservation of flora and fauna and are vested in the Conservation Commission.

The conservation value of the Barrow-Lowendal-Montebello Islands region has been recognised in the report *A Representative Marine Reserve System for Western Australia,* (Marine Parks & Reserves Selection Working Group 1994). With respect to the Montebello Islands, the Working Group considered that "... appropriate protection and management can be achieved by reservation of parts of the area, combined with designation of the remainder as an environmentally sensitive area needing special management."

The area is presently undergoing the planning process for a proposed Montebello/Lowendal/Barrow Islands marine conservation reserve under the Western Australian New Horizons Policy.

There are at least 78 listed species that would be potentially found on and in the surrounding marine habitat of the Lowendal Islands. These species and the initiative under which they are listed are given in Table 4. There are no threatened ecological communities in the region.

From the biological and human resources identified in the sections above, the following would be considered potentially sensitive to the effects of disturbance from the Simpson development arising from either routine operations or accidental occurrences, in particular, oil spills:

- turtles and seabirds during the summer breeding season;
- intertidal and shallow sub-tidal algae beds; and
- corals, in particular those found on the intertidal and shallow subtidal reefs.

4 Risk Assessment Methodology

4.1 Background

Risk assessment is defined as the process of determining the frequency of occurrence of an event and the probable magnitude of adverse effects - economic, human safety and health, or ecological - over a specified period of time (Kolluru 1994) (Appendix 3).

The process of identifying the risks and likelihood of given events and the magnitude of their effects consists of several interrelated steps including:

- *risk identification:* recognising that hazards exist and identifying their characteristics;
- *risk determination*: determining the characteristics of risks either qualitatively or quantitatively. These may include frequency, magnitude, spatial scale, duration and intensity of adverse consequences;
- *resources at risk:* identifying the ecological and social resources at risk; and
- *risk control:* setting up a management system with procedures, guidelines and indicators to decrease or eliminate risk and to review performance.

The identification of environmental hazards is the first step of the environmental risk assessment process. Hazard identification is undertaken to identify all the environmental hazards associated with a project likely to occur from routine and accidental activities. The next step is to assign a potential risk to each identified hazard based on the likelihood of the risk occurring and its subsequent consequences.

4.2 Hazard Identification Methodology

The risk assessment method used was a hazard identification study or "what-if" analysis (International Risk Consultants 2001b). This method allowed a brainstorming exercise to be applied to the installation and production processes relevant to the Simpson development to identify potential hazards.

The hazard identification study was undertaken through a multi-disciplinary workshop comprising construction, operations and environmental personnel from Apache as well as government and community representatives (Appendix 3). The approach followed during the hazard identification workshop is illustrated in Appendix 3.

The workshop participants ranked all the hazards identified using the risk-ranking matrix given in Table 6. The risk is determined by assessing the likelihood and severity of the hazard. To categorise the relative likelihood and severity (consequences) of environmental risk, the qualitative measures defined in Tables 7 and 8 are applied.

Likelihood

The workshop team made a decision by consensus as to the likelihood of a hazard occurring based on relevant databases and professional judgement. The decision was based on the existing controls that are in place to prevent the effect, the nature of materials or substances that contribute to the effect, and the frequency with which the activity may occur. A frequency rating is allocated to the hazard according to the categories given in Table 7.

Table 6: Environmental risk matrix (also refer to Appendix 3).

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

Table 7: Guidance for determining likelihood of a hazard occurring.

LIKELIHOOD OF RISK OCCURRING	
Expected to Occur	Is expected to occur in most circumstances during the life cycle of an individual item or system.
Probably will Occur	Will probably occur in most circumstances during the life cycle of an individual item or system.
Moderate	Likely to occur at sometimes during the life cycle of an individual item or system.
Unlikely to occur	Unlikely, but possible to occur sometime in the life of an individual item or system.
Rare	May occur, but in exceptional circumstances.

Table 8: Guidance for determining environmental consequence.

CONSEQUENCE	
Serious	Large scale detrimental effect that is likely to cause a highly significant effect on local ecosystem factors such as water quality, nutrient flow, community structure and food webs, biodiversity, habitat availability and population structure (e.g. abundance, fecundity, age structure). Long-term recovery period measured in decades.
Significant	Detrimental effect that will cause a significant effect on local ecosystem factors. Recovery period measured in years to decades.
Moderate	Impact that will cause a detectable effect in local ecosystem factors. Recovery period measured in months to years.
Minor	Incidental changes to abundance/biomass of biota in the affected area, insignificant changes overall to the ecological function. Recovery measured in months.
Negligible	Short-term, localised and insignificant impacts to habitat or populations. Rapid recovery measured in days to months.

Table 9: Definitions of risk category and management response.

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

Consequences

The consequences of the identified hazard occurring were rated according to a matrix given in Table 8. The consequence is dependent on the potential impact of the event in the first instance. Quantities and concentration released, time scale of release and regulatory requirements are considered.

Risk

The environmental risk ranking is determined by a combination of the expected frequency of the hazard occurring and the consequence of its occurrence to arrive at a risk level from the risk matrix given in Table 6. Table 9 defines the different levels of risk given in Table 6. Risk evaluation helps to prioritize the risks: *i.e.* determining if the risk of an activity or incident is acceptably low or if management actions are required to reduce the risk to as low as reasonably practicable. The ranking determined from Table 6 was compared to Tables 10 and 11 to determine what additional actions, if any, were required to address the identified hazard.

5 Environmental Analysis of Routine Operations

This section of the PER describes the types of routine activities associated with the installation and operation of the Simpson development, any associated potential environmental effects and proposed controls to minimise or alleviate their occurrence.

The source or cause of ecological risks is referred to as an ecological stressor (Bartell 1996). Ecological stressors can be physical, biological or chemical in nature. The environmental hazard identification workshop identified the potential ecological stressors associated with the phases of the project: installation of the mini-platforms and pipeline bundles, and production of oil from the Simpson field. Table 10 details each stressor for each phase of the development during routine operations, the risk it poses and the mitigating actions to be taken to reduce the risk of impact. Further details of the key stressors associated with each phase are given below.

5.1 Installation of the Mini-platforms

5.1.1 Barge mooring and anchoring

The main source of physical impact associated with the installation of the Simpson 'A' and Simpson 'B' mini-platforms will be from the eight anchors used to anchor the barge in place whilst the topside structures are lifted from the barge onto the well caissons.

Marine surveys have been carried out to identify the habitat types in the vicinity of the mini-platforms and along the pipeline bundle route (Bowman Bishaw Gorham 2001). The benthic habitat is characterised by flat limestone pavement with variable cover of macroalgae and sandy veneers within a 250 m radius of each of the mini-platform locations (Figure 16). A small coral patch reef is located about 250 m to the west of the Simpson 'A' mini-platform location.

The anchors from the barge will only be placed on the sandy seabed habitat. No anchors will be placed on or near coral patch reefs or bommies. The placement of the anchors will be determined using the detailed habitat map and aerial photographs covering the development site. The Project Manager and the Environmental Manager will determine the final placement.

The placement of the barge anchors will result in a short-term, localised impact to the sandy seabed; however, re-colonisation of the disturbed areas is expected to occur within six months following the removal of the anchors. The anchoring plan will alleviate the risk of any impact to the coral patch reef or bommies.

Anchoring guidelines will be issued to the skippers of the support vessels (Appendix 4). The habitat maps and aerial photographs covering the entire development location will also be provided to further ensure that no anchoring occurs on any coral patch or fringing reef.

5.1.2 Noise

Machinery, boat engines, welding and grinding will cause noise during the installation of the mini-platforms. This may cause avoidance behaviour of the immediate area by seabird and marine fauna. The impact of noise on seabirds will not be significant as installation of the platforms will be conducted outside the seabird breeding season when population numbers are small. In addition, the disturbance will be of short duration as installation is expected to last approximately 24 hours for each platform.

Table 10: Environmental analysis of routine activities: **Installation of mini-platforms.**

Potential Environmental stressor	Source of stressor	Ecological value potentially affected	Management objective for ecological value	Likelihood of stressor occurring	Consequence of stressor occurring	Risk	Potential effect if stressor not managed	Mitigating actions to reduce risk	Predicted outcome
Barge mooring and anchoring	Topside and pipelay barge and support vessels.	Benthic communities.	Maintain biodiversity and cause minimal impact to marine flora and fauna.	Expected	Minor	B	Anchor dragging causing damage to corals. Small loss of algal seabed due to placement of anchors.	Mooring/anchoring plan to be developed using mapped habitat data. Anchoring guidelines issued to barge and support vessels.	Short-term disturbance to about 100 m^2 of soft-bottom algal and sand habitat. Rapid recolonization. No impact to corals.
Noise	Engines and generators on barge. Welding and grinding for platforms and pipeline bundles.	Turtles. Birds. Marine fauna (e.g. fish, dolphins, sharks).	To minimise disturbance to turtles, seabirds and marine fauna.	Expected	Minor	B	Disorientation. Avoidance of immediate area by some individuals.	Construction period outside turtle and seabird breeding season. Engines to run at most efficient capacity to help keep noise down. Duration of noise short-term.	No disruption to breeding cycle of turtles or seabirds. Minimal, short-term disruption to behaviour to some individuals of marine animals.
Lights	Lights on barge.	Turtles. Birds. Marine fauna.	To minimise disturbance to turtles, seabirds and marine fauna.	Expected	Minor	B	Attraction to lights resulting in aggregations of some animals.	Lights must be left on at all times by safety regulations. Short construction time will minimise period for aggregations to form. Areas where welding conducted will be shielded by tarpaulins. Construction period outside turtle and seabird breeding season.	No disruption to breeding cycle of turtles or seabirds. No attraction to light by seabirds, turtles or other marine fauna.
Sewage and grey water Galley wastes	By-product of human activities. Putrescible kitchen wastes.	Water quality. Pelagic marine fauna.	To maintain background water quality. To minimise risk of adverse impact to marine fauna.	Expected	Negligible	Negligible	Increase in nutrient concentration in water column.	No sewage will be discharged into the marine environment. Disposal will be through the sewage treatment system on Varanus Island. Minimal grey water will be generated as personnel will not overnight on barge. Kitchen wastes will be bagged and disposed through the Varanus Island incinerator.	No change to background ocean water quality characteristics. No increase in nutrient loading.
Contaminated drainage water	Deck washdown and rain.	Water quality. Pelagic marine fauna.	To maintain background water quality. To minimise risk of adverse impact to marine fauna.	Expected	Negligible	Negligible	Introduce oil-contaminated water into the water column.	Deck drainage collected via closed system and treated to less than 15 ppm. Low volumes and short duration of program will ensure minimal volume discharged.	No introduction of hydrocarbons or detergents into the marine environment.

Table 10: Environmental analysis of routine activities: Installation of mini-platforms. (cont.)

Potential Environmental stressor	Source of stressor	Ecological value potentially affected	Management objective for ecological value	Likelihood of stressor occurring	Consequence of stressor occurring	Risk	Potential effect if stressor not managed	Mitigating actions to reduce risk	Predicted outcome
Solid wastes	By-products of construction activities.	Seabirds and marine fauna.	To minimise risk of adverse impact to seabirds and marine fauna.	Expected	Negligible	Negligible	Waste and litter ingested by seabirds and marine fauna.	All solid wastes will be collected and segregated for onshore disposal. Rubbish skips will be covered. Education posters.	Small contribution to landfill.
Atmospheric emissions	Fuel burning equipment. Welding.	Atmosphere.	To maintain air quality.	Expected	Negligible	Negligible	Potential increase in greenhouse gases	Small volumes will be generated due to short construction period. Engines to run at most efficient capacity to reduce emissions.	Small contribution to global greenhouse gases.
Access to islands	People.	Vegetation. Seabirds. Turtles.	To maintain integrity of island flora & fauna.	Negligible	Negligible	Negligible	Tramping of vegetation. Disturbance to seabirds. Shell collecting.	No access to islands without permission from Field Superintendent.	No disturbance.

Table 10: Environmental analysis of routine activities: Installation of offshore section of pipeline bundle.

Environmental feature	Source	Ecological value potentially affected	Management objective for ecological value	Likelihood of stressor occurring	Consequence of stressor occurring	Risk	Potential effect if stressor not managed	Mitigating actions to reduce risk	Predicted outcome
Offshore pipeline bundle	Laying of pipeline bundle offshore and stabilisation.	Seabed.	Maintain biodiversity and minimise impact to marine flora and fauna. Maintain background water quality.	Expected	Minor	B	Pipelines being laid on corals causing damage. Small loss of algal seabed due to placement. Short-term increase in turbidity. Exposed sections of pipelines will form additional hard substrate for benthic growth.	Detailed habitat maps generated. Selection of route along soft bottom, algal seabed. Pipeline bundle route will be away from coral habitats.	Short-term disturbance to 1,700 m^2 of soft bottom, algal and sand habitat. Replacement of soft bottom habitat with hard substrate (=pipeline). No habitat fragmentation. No impact to corals. Short-term, localized increase in water turbidity.
Trenching	Burial of nearshore portion of pipeline bundle.	Seabed.	Maintain biodiversity and minimal impact to marine flora and fauna. Maintain background water quality.	Expected	Minor	B	Disturbance of 400 m^2 of soft bottom seabed. Localised, short-term increase in turbidity.	Work will be conducted outside turtle and seabird breeding period. Short-term disturbance to seabed and water quality outweighed by decreased risk to pipeline by anchor or boat damage which could potentially result in an oil spill.	Short term loss of 400 m^2 of benthic, soft bottom habitat. Recolonization by algae and epibenthos within 6 months. No impact to turtles, seabirds or other marine fanua.

Table 10: Environmental analysis of routine activities: Installation of offshore section of pipeline bundle.

Environmental feature	Source	Ecological value potentially affected	Management objective for ecological value	Likelihood of stressor occurring	Consequence of stressor occurring	Risk	Potential effect if stressor not managed	Mitigating actions to reduce risk	Predicted outcome
Hydrotest water	Disposal of hydrotest water after pressure testing of pipeline bundle.	Water quality. Marine pelagic fauna.	Maintain background water quality. To minimise risk of adverse impact to marine fauna.	Expected	Minor	B	Introduce chemical contaminants into the water column.	No discharge to the marine environment. Hydrotest water will be disposed down the deep re-injection well on Varanus Island.	No impact to background water quality. No impact to marine flora and fauna.
Shoreline pipeline bundle pull	Pulling of shoreline crossing portion of bundle.	Shoreline. Nothing of significance as shoreline crossing is comprised of rock and cement stabilisation fill.	Minimise disturbance to marine fauna in adjacent bay. Minimise impact to shoreline.	Expected	Negligible	Negligible	Attraction of marine fauna and seabirds to lights on shoreline crossing location. Disturbance to fauna due to noise.	Shoreline pull conducted outside turtle and seabird breeding season. Areas where welding conducted will be shielded by tarpaulins. Engines to run at most efficient capacity to help keep noise down.	No disturbance to turtles or seabirds. No damage to shoreline. No erosion.

Table 10: Environmental analysis of routine activities: Installation of onshore portion pipeline bundle and production facilities.

Potential environmental stressor	Source	Ecological value potentially affected	Management objective for ecological value	Likelihood of stressor occurring	Consequence of stressor occurring	Risk	Potential effect if stressor not managed	Mitigating actions to reduce risk	Predicted outcome
Access	Physical access of vehicles, pipelaying equipment and personnel.	Shearwater rookery.	To reduce the risk of impact to the east shearwater rookery.	Expected	Minor	B	Destruction of shearwater burrows.	Construction to be conducted outside the shearwater nesting and fledging period. No birds will be present. Construction area will be roped off to indicate no access to rookery.	No damage to shearwater rookery or vegetation in rookery.
Vegetation clearing	Clearing of vegetation along pipeline bundle route and for production facilities.	Terrestrial flora.	To minimise disturbance to the terrestrial vegetation.	Expected	Minor	B	Loss of small portion of sparsely distributed vegetation. Density of vegetation sparse due to regular clearing for safety reasons. Previously disturbed area.	Onshore pipeline route will parallel current Tanami flowline route. Pipeline route is outside shearwater rookery. Clear only necessary vegetation for production facilities.	Loss of about 200 m^2 of sparsely distributed vegetation. No impact to shearwater rookery vegetation.
Noise and lights	Engines and generators. Welding and grinding for pipeline bundle.	Shearwater rookery.	To minimise disturbance to the east shearwater rookery.	Expected	Minor	B	Disorientation of birds returning to rookery. Aggregations of birds around lights.	Construction to be conducted outside the shearwater nesting and fledging period. No birds will be present. Short construction period will minimise potential aggregations of seagulls.	No impact on shearwater population. No aggregations of seagulls.
Solid and liquid wastes work.	By-product of construction.	Terrestrial habitat of Varanus Island.	To minimise risk of adverse impact to terrestrial flora and fauna.	Expected	Negligible	Negligible	Litter unattractive and shows poor housekeeping. Ingestion by birds or lizards.	Current waste disposal facilities on Varanus Island to be used. Litter bins provided at installation site.	No impact to terrestrial flora or fauna.

Table 10: Environmental analysis of routine activities: Production phase for mini-platform and offshore section of pipeline bundle.

Environmental Feature	Source	Ecological value potentially affected	Management objective for ecological value	Likelihood of stressor occurring	Consequence of stressor occurring	Risk	Potential effect if stressor not managed	Mitigating actions to reduce risk	Predicted outcome
Produced formation water	Disposal of produced formation water.	Water quality. Marine fauna.	To maintain background water quality. To minimise risk of adverse impact to marine fauna.	Expected	Significant	Unacceptable	Long term introduction of low concentrations of hydrocarbons and scale and corrosion inhibitors.	Zero discharge to the marine environment. All produced formation water will be discharged into the Alkimos deep re-injection well located on Varanus Island. The Tanami-5 well will provide an alternative disposal well.	No change to background water quality of seawater.
Corrosion protection	Scale and corrosion chemical additives to production stream.	Water quality. Marine fauna.	To maintain background water quality. To minimise risk of adverse impact to marine fauna.	Expected	Minor	B	Long term introduction of low concentrations of scale and corrosion inhibitors contained in produced formation water stream.	Zero discharge to the marine environment. Excess inhibitors contained within the produced formation water which will be disposed down the Alkimos re-injection well.	No change to background water quality of seawater.
Noise	Production equipment. Gas driven pump for drain sump.	Turtles. Birds. Marine fauna (e.g. fish, dolphins, sharks).	To minimise disturbance to turtles, seabirds and marine fauna.	Expected	Minor	B	Disorientation. Avoidance of immediate area by some individuals.	No rotary machinery required. Minimum platform equipment to reduce maintenance visits. Exemption for the fitting of a foghorn.	No distruptions to breeding cycles of turtles, seabirds or other marine fauna. No disturbance to behaviour of turtles, seabirds or other marine fauna.
Lights	Navigation light.	Turtles. Birds. Marine fauna (e.g. fish, dolphins, sharks).	To minimise disturbance to turtles, seabirds and marine fauna.	Expected	Minor	B	Aggregation of some animals to lights: e.g. turtle hatchlings and seabirds.	No deck lighting except for single navigation light. Position and shield light so that no light falls on Abutilon Island. Use smallest light available but meeting navigation requirements.	No aggregations of seagulls. No attraction by turtle hatchlings. No disruption to breeding cycles of turtles, seabirds or other marine fauna.
Contaminated drainage water	Platforms washdown and rainwater.	Water quality. Marine fauna.	To maintain background water quality. To minimise risk of adverse impact to marine fauna.	Expected	Minor	B	Short-term introduction of low concentrations of hydrocarbons and detergents.	Deck drains to be collected to a sump that will be pumped out on a routine basis. Sump will have a level indication alarm. Deck of platforms has no opening to marine environment.	No contamination of ocean by hydrocarbons or detergents.
Atmospheric emissions	Use of methane as instrument gas.	Air quality.	To maintain air quality.	Expected	Negligible	Negligible	Potential increase in greenhouse gases.	Very small volumes will be generated. Engines to run at efficient capacity to most reduce emissions.	Small contribution to global greenhouse gases.

Table 10: Environmental analysis of routine activities: Production phase for onshore portion of pipeline bundle and production facilities.

Potential Environmental stressor	Source of stressor	Ecological value potentially affected	Management objective for ecological value	Likelihood of stressor occurring	Consequence of stressor occurring	Risk	Potential effect if stressor not managed	Mitigating actions to reduce risk	Predicted outcome
Access	Physical access to bundles for maintenance.	Shearwater rookery.	To reduce the risk of impact to the east shearwater rookery.	Expected	Negligible	Negligible	Destruction of shearwater burrows.	Boundary of shearwater rookery marked with steel pickets and rope. Signs erected. Education.	No physical disturbance to shearwater rookery or rookery vegetation. No impact on shearwater population.
Contaminated drainage water	Overflow from production facilities site.	Terrestrial vegetation.	To minimize the impact to the surrounding terrestrial vegetation.	Expected	Negligible	Negligible	Short-term introduction of low concentrations of hydrocarbons and detergents.	All facilities contained in bunds and sump system to be put into place.	No drainage of contaminated water outside bunded area or sump.
Atmospheric emissions	Use of methane as instrument gas.	Air quality.	To maintain air quality.	Expected	Negligible	Negligible	Potential increase in greenhouse gases.	Very small volumes will be generated. Engines to run at most efficient capacity to reduce emissions.	Small contribution to global greenhouse gases.

5.1.3 Artificial lights

Due to safety regulations, lights on the barge must remain on 24 hours a day. These lights will attract marine life and seabirds and, depending on the foraging range of a particular species, may result in a short-term concentration of animals in the immediate vicinity of the barge.

The short time required for installing the platforms will minimise the time for faunal aggregations to form. Lights will not have a significant impact on turtles and seabirds as the installation of the platforms will occur outside their peak breeding season. Tarpaulins will be used as shields in areas where welding and grinding operations will be carried out to lessen the amount of light visible.

5.1.4 Domestic wastes

The personnel working on the lay-barge will generate some domestic wastes. The low volumes generated in the short duration of the installation are unlikely to cause a significant increase in the nutrient loading of the ocean. However, the volume of domestic waste discharged into the marine environment will be minimised as much as possible.

Sewage will not be discharged into the marine environment while on location for the installation of the mini-platforms. Sewage will be collected in the sullage tanks and taken to Varanus Island for disposal through the island's sewage treatment plant.

A small volume of grey water will be generated from the use of hand basins located on the barge. Biodegradable soap will be used minimising the effect of the grey water discharged into the marine environment from the barge.

Food wastes will be bagged and taken to Varanus Island for incineration. No food wastes will be discharged into the marine environment.

5.1.5 Contaminated drainage water

Deck drainage consists mainly of wash-water from cleaning the decks of the barge and occasional rainwater. It may contain small amounts of spilt oil, cleaning chemicals and paint chips, which would result in contaminants entering the marine environment if deck drains were allowed to drain directly to the ocean.

Deck drains on the barge will be sealed. All runoff from the barge will be collected in a sump connected to an oily water separator. The water will be separated from any oil to levels not exceeding 15 ppm of oil in water. Once separated, oil will be transferred to drums and returned to shore for recycling. The treated water will either be discharged into the ocean once the barge is at least five km away from the Simpson location and in deeper water or transferred to the sullage tank for disposal with the sewage waste-water.

The oil water separator on the barge has an automatic shutdown system if the oil levels in the water exceed 15 ppm.

5.1.6 Waste oil

Waste oil consists of hydraulic and lubricating oils from the machinery on the barge. Should any maintenance of equipment be required, any used oil will be collected, stored within designated bunded areas and transported to Varanus Island for treatment or taken to the mainland for recycling.

5.1.7 Solid wastes

Minor amounts of solid waste will be generated during the installation phase as the majority of equipment will be prefabricated. Solid wastes likely to be generated would include paper, rags, packaging, scrap metal, empty drums and wood. All wastes will be segregated into marked skips prior to disposal at an appropriate site.

Drums and scrap metals will be reused or recycled when possible.

5.1.8 Atmospheric emissions

A small quantity of greenhouse gases, the principle being CO_2, will be generated during the installation program by machinery and engines. Engines will be tuned to maximum efficiency to minimise the production of greenhouse gases.

5.2 Installation of the Offshore Pipeline Bundle

5.2.1 Installation and stabilisation

The benthic habitat along the selected pipeline bundle routes is predominantly flat limestone pavement with variable cover of macroalgae and sandy veneer. Disturbance to the small area of substrate that would be directly affected by the pipeline bundle is insignificant on a regional scale.

The primary pipeline bundle from the Simpson 'B' mini-platform to Varanus Island will consist of a production pipeline carrying oil, gas and PFW, a gas lift pipeline and an umbilical. The short pipeline bundle leading off the primary bundle to the Simpson 'A' mini-platform will consist of a production pipeline, gas lift pipeline and water disposal pipeline.

It is anticipated that it will take about two weeks to install the offshore and onshore portions of the pipeline bundle. Work on the offshore section will be conducted over 24 hours a day to get the offshore component finished as soon as possible due to the small suitable window available at that time of the year due to weather and biological breeding seasons.

Two procedures are being investigated for the installation of the pipeline bundles.

1. Installation using conventional lay-barge

The process would involve welding 12 m lengths of pipe together on the lay-barge and then laying the welded portions directly to the seafloor for the majority of the route. About 600 m of the pipeline bundle, adjacent to Varanus Island, would be trenched for safety reasons (see Section 5.2.2). For the non-trenched section of the pipeline, the amount of sediment that will be temporarily suspended as a result of laying each new section of pipeline will be minimal.

A winch would be placed on the road leading to the East Jetty, which would be used to pull the pipeline bundle from the lay-barge over the shoreline crossing onto Varanus Island.

If the lay-barge method is used, the stressors described for the installation of the mini-platforms would be applicable along with the methods to manage these stressors (Section 5.1).

2. Installation from Varanus Island

This process would involve setting up a designated area within Apache's lease on Varanus Island as a temporary construction site. The pipes would be prepared for welding at this location and pulled into position using a small winch. Each section of pipe would be welded together. A small flat-top truck would be used to transport the sections of pipe from the pipeline storage area to the welding stations.

The pipeline bundle would be pulled across the shoreline crossing using a winch and cable system situated on the road leading to the East Jetty. A small tug would be used to pull the pipe into the pre-dug, subtidal trench and along the remaining section of the pipeline route to the Simpson 'A' and Simpson 'B' mini-platforms. No lay-barge would be needed if this technique were used.

The stabilisation of the pipeline bundles will consist of rock bolting the pipeline at approximately 20 m intervals to the seabed. There are no environmental resources along the pipeline alignment that will be adversely affected by a temporary, localised increase in turbidity caused by the pipeline bundle laying or rock bolting.

If the pipeline bundle is installed from Varanus Island, the stressors described for the installation of the onshore portion of the pipeline bundle would be applicable along with the methods to manage these stressors (Section 5.3).

5.2.2 Trenching

It is proposed to trench approximately 600 m of the pipeline bundle across the small bay adjacent to the East Jetty (Figure 16). This trenching is required because of the use of the East Jetty and surrounding bay for the following activities:

- support vessels and supply barges use the jetty to onload and offload supplies and personnel;
- vessels moor within this small bay as the bay provides protection from wind and wave action;
- support vessels pass through the break in the limestone pavement located on the outer edge of the bay on their way to Harriet Alpha and the other offshore facilities; and
- support barges between Varanus Island and the mainland take a course parallel to the pipeline bundle route before passing over the limestone pavement.

Trenching the pipeline in this area of vessel traffic will reduce the risk of impact to the pipeline bundle from vessels or anchors, and will prevent the pipeline from acting as a groyne.

The trench will be excavated prior to the pipeline bundle installation using a small barge with a front-hoe type mechanism bolted to the deck of the barge. The trench will be about one metre in width and the same size in depth to a length of 600 m.

Trenching will result in a localised, short-term increase in turbidity in the water column. It will also result in the physical disturbance to approximately 600 m of seabed. The dominant habitat along this portion of the pipeline route is macroalgae and exposed sandy bottom. There will be no physical disturbance to the limestone pavement located to the east of the proposed pipeline route. Trenching will be conducted outside the coral spawning season, turtle and seabird breeding period.

The following work will be carried out to monitor the impact of the trenching operations:

- a seabed survey will be carried out prior to the commencement of trenching and after the pipeline bundle has been installed. The survey data will be compared to the seabed survey carried out on 16 January 2001;
- an aerial survey using a helicopter will be carried out while the trench is being excavated to determine the spatial and temporal extent of the turbidity plume; and
- the 2000 aerial photo will be compared with the 2001 aerial photo and subsequent years to monitor habitat recolonisation.

5.2.3 Shoreline crossing

The pipeline bundle will cross the shoreline of Varanus Island on the eastern side of the East Jetty. This area consists of a small limestone cliff or escarpment and has been previously stabilised against erosion by the placement of boulders and cement blocks (Plate 16) There is a sparse distribution of rocky shore fauna, consisting of barnacles, crabs and limpets on and among the boulders.

The pipeline bundle will be placed within a trench excavated through the existing boulders and cement blocks, and bolted at the top and bottom of the short escarpment. This portion of the pipeline will be covered by a rock armory to protect the pipeline and shoreline against wave and splash activity, storm damage and erosion.

The proposed shoreline crossing is a previously disturbed site, and the pipeline bundle pull will cause negligible impact to the sparse fauna found on the boulders and concrete blocks. The boulders and cement blocks will continue to provide a rock armory against erosion by wind or waves.

Plate 16. The shoreline crossing where the Simpson pipeline will come ashore on Varanus Island.

5.3 Installation of the Onshore Pipeline Bundle

5.3.1 Access by construction personnel and equipment

Section 5.2.1, covering *Installation and Stabilisation*, describes the two techniques that may be used for installing the pipeline bundle from Varanus Island. The primary issue of concern for pipeline laying activities on Varanus Island is uncontrolled access outside of the pipeline bundle route by personnel and equipment in the area where the pipeline will run parallel to the east shearwater rookery (Figure 7).

All onshore pipeline installation work will be carried out within Apache's CALM lease area which is marked by star pickets and rope. The installation of the onshore section of the pipeline bundle will be conducted outside the peak shearwater breeding season, therefore minimal or no birds will be present in the rookery. In addition, no shearwater burrows are present in the area between the road and the rope defining the CALM lease boundary.

There will be no access to the shearwater rookery by personnel or equipment. This prohibition of access will prevent any physical damage to the rookery. This restriction will be covered in the environmental induction and is included in the environmental guidelines for the island. In addition, there are signs indicating the boundaries of the shearwater rookery.

5.3.2 Noise and lights

Noise will be generated by various sources while the onshore pipeline bundle is being put into place. It is unlikely that the noise generated during the installation period will exceed the background noise generated by the existing processing facilities. The noise impact on the neighbouring shearwater rookery will be negligible as the pipeline bundle installation work will be conducted outside the shearwater breeding season.

Work on the onshore pipeline bundle will only be carried out during daylight hours, therefore the impact from construction lighting will not be an issue.

5.3.3 Clearing of vegetation

Once the pipeline bundle crosses the shoreline, it will parallel an existing sealed road, dog-leg through a culvert under the service road to a laydown area to where the bunded chemical injection skid will be located. The pipeline route will then closely parallel the existing Tamami-1 onshore development flowline to the processing facilities (Figure 7). The pipeline bundle will be placed above ground on pipeline supports in a corridor previously disturbed by the construction of the flowline from the onshore Tanami-1 wellhead.

Approximately 200 m^2 of the vegetation along the pipeline bundle corridor may be cleared. A one metre corridor of cleared vegetation is maintained along the length of the Tanami-1 flowline and the Simpson development pipeline bundle will be placed within this corridor. However, safety considerations may result in the temporary widening of this corridor during the installation of the pipeline bundle. This area has been previously cleared and consists of sparsely distributed, low growing vegetation.

Despite some clearing of vegetation, installation activities will result in a very minor decrease in the total cover of vegetation on the island and will not impact the integrity of the shearwater rookery.

5.4 Operation of the Mini-platforms and Pipeline Bundle

5.4.1 Precommissioning - Hydrotest water

Hydrotest water will be injected into each pipeline for hydrostatic pressure testing prior to commissioning to ensure that the pipeline will meet pressure standards and that there are no leaks along the length of the pipeline. Hydrotest water will consist mainly of seawater with an anti-corrosion additive. The total volume of fluid that will be used to test all three pipe bundles will be about 420 m^3.

No hydrotest water will be discharged into the marine environment. Following the completion of the pressure testing, the hydrotest water will be disposed to the Alkimos deep disposal well on Varanus Island.

5.4.2 Produced formation water

The most significant potential source of impact from routine activities associated with the Simpson development relates to produced formation water (PFW), the fossil water associated with oil and gas. This water contains low concentrations of hydrocarbons, and scale and corrosion inhibitors that could cause a chronic impact to the shallow water marine flora and fauna, and water quality.

The PFW recovered from the wells will be transported in the oil production pipeline to the Varanus Island processing facilities where it will be separated from the oil and gas streams. The PFW will be discharged down the Alkimos deep disposal well. The Tamami-5 well on the Simpson 'A' platform will provide an alternative disposal.

No produced formation water will be discharged into the marine environment from the Simpson development.

5.4.3 Corrosion protection

Corrosion and scale inhibitors will be used to prevent corrosion and build-up of microbial growth, and aid in leak detection. These chemicals will be continuously introduced in small quantities into each of the producing wells via an umbilical line from the chemical dosing skid located on the island (Figure 7).

A significant feature incorporated into this development will be the continuous monitoring of corrosion levels in the production pipeline. This will be accomplished by utilising electrical resistance probes that measure the rate of corrosion in the pipeline. The rate of corrosion will be continuously monitored and recorded through the Varanus Island control room. Utilising this data, the corrosion inhibitor dosage rate will be adjusted to effectively eliminate corrosion in the pipeline.

Any residual inhibitor will be incorporated into the produced formation water stream and disposed to either of the two deep disposal wells (Alkimos or Tanami-5). No chemical inhibitor will be discharged into the marine environment.

5.4.4 Noise and lights

There will be minimum equipment installed on the mini-platforms, so the volume of noise emanating from the mini-platforms will be minimal. The noise generated will be a low droning sound.

Maintenance visits to the mini-platforms will be required about once a month and access will be by a small support vessel. Operational noise levels are not expected to have any impact on the fauna of Abutilon Island.

A single navigation light will be fitted to the mini-platforms as per government regulations. This single, pulsating source will have no significant impact on the fauna species that inhabit Abutilon Island or the surrounding beaches and waters. Apache is investigating the possibility of shielding the navigation light on the Abutilon Island side of the light, but this will depend on government requirements. No other light sources will be installed on the mini-platforms.

5.4.5 Contaminated drainage water and waste oil

Drainage water will consist of rainwater which may contain low concentrations of hydrocarbons.

There will be no other waste-water discharged into the marine environment from the mini-platforms. The deck of each mini-platform will be bunded to contain 500 kg (633 L) of liquid. All deck drainage will lead to a closed sump with a level indicator. Drainage water will be collected in the onboard sump which will be baffled to intercept and hold any oil within the sump, allowing uncontaminated water to drain from the sump. The entire contents of the sump will be pumped out on a routine basis. The waste-water will be processed using the existing oil and water separation facilities on Varanus Island.

The small amounts of waste oil generated by the machinery on each mini-platform will be collected, drummed and sent to the mainland for recycling.

5.4.6 Atmospheric emissions

The sources and volumes of greenhouse gas emissions generated from the Simpson development are given in Table 11 and includes:

- instrument gas that supplies the main control valve for the wells (well head choke control valve);
- purging of an actuator each time a valve is open and closed;
- operation of the sump pump;
- emissions from vessels visiting the platforms for maintenance activities; and
- the gas compressor on Varanus Island that compresses any collected natural gas from the wells prior to it being processed in the gas separation plant.

Table 11: Estimated greenhouse gas emissions from the Simpson development for each mini-platform.

Source of greenhouse gas	Emissions	Total CO_2 equivalent (tonnes/year)
Well head choke control valve on each mini-platform	730 m^3/year	6.9
Actuator purge on each platform	2.3 m^3/year	1.9×10^{-4}
Sump pump on each platform	3.6 m^3/year	0.034
Vessel movement to mini-platforms	0.28 tonnes per year	0.9
Gas compressor on Varanus Island	100 TJ/year	5,199
Total		**5,207**
Total Apache greenhouse emissions for 1998		**1,220,480**
% increase in greenhouse emissions from Simpson		**0.4%**

The CO_2 content in the natural gas produced at Simpson will be about 3%. This CO_2 will remain in the gas which is fed into the sales gas pipeline for use in the domestic market. None of this CO_2 will be extracted at Varanus Island.

The Simpson development will produce an estimated 10,414 tonnes of CO_2 equivalent per year based on the sources listed in Table 11. This equates to 0.8% of Apache's 1998 overall greenhouse gas emissions (1,220,480 tonnes). The addition of the Simpson development will not result in a significant net overall increase in Apache's greenhouse emissions due to the decline in production from existing fields and the resultant reduction in greenhouse emissions.

Apache is currently developing a Greenhouse strategy that will cover all the projects tied into the Varanus Island Hub. The Simpson development will be incorporated into this strategy.

Since 1997, Apache has been committed to providing its greenhouse emissions for all operations to APPEA as part of APPEA's commitment to the Commonwealth 'Greenhouse Challenge'.

5.4.7 Production levels and tanker activity

The Harriet oil field came into production in 1986. Oil production from this development peaked in 1991 and has since been declining (Figure 8). Two peaks in production occurred in 1997 and 2001 when the Agincourt and Gipsy developments came on stream, but total production never reached the 1991 levels (Figure 8).

Oil from the Simpson development will increase total oil production to approximately 11,000 barrels of oil per day (bopd) in 2002 returning it to levels comparable to those recorded in 1997. However, this level of production will drop off by 2003 to approximately 7,000 bopd as a result of the decline in the oil produced from the Simpson field and the other Varanus Hub oil fields.

Tankers that berth at the Varanus Island terminal offload either crude oil or condensate. Production of oil currently comes from the Harriet, Tanami, Agincourt and Gipsy oil developments. Condensate comes from the Sinbad, Campbell, Wonnich and East Spar developments.

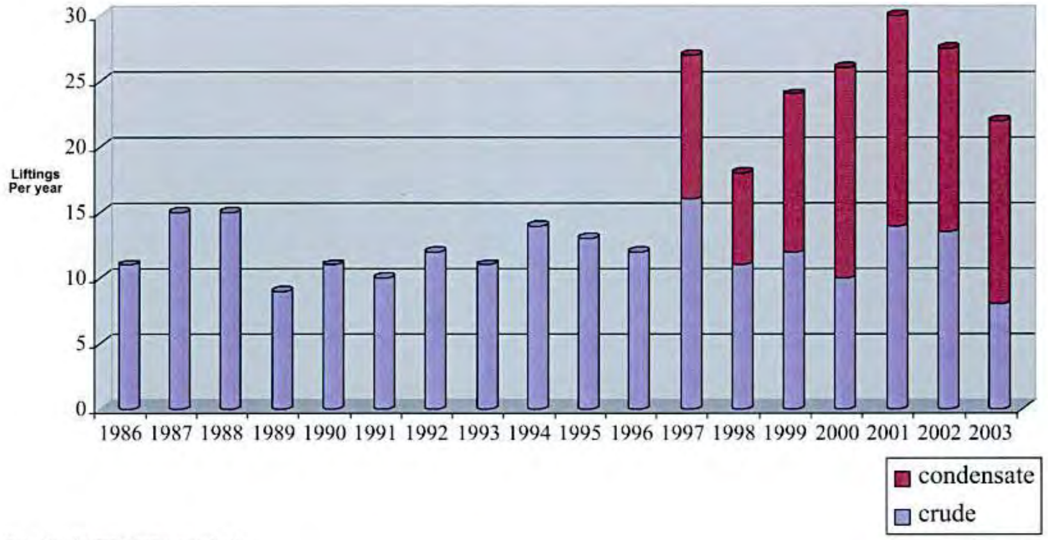
The total number of tankers that offload condensate and oil from the Varanus Island terminal is given in Figure 18. The frequency of tankers offloading only crude oil is given in Figure 19. This figure gives both the historical frequency and projects the number of oil tankers once the Simpson development comes on stream. Production from the Simpson development will not result in an increase in the frequency of oil tankers above historical levels. The tanker traffic associated with Simpson will only be replacing the declining Harriet, Tanami, Agincourt and Gipsy development shipping requirements due to the declining reserves in these fields.

The Simpson development will have no bearing on the number of condensate tankers that berth at the terminal.

Apache assesses all tankers for their seaworthiness prior to being allowed to berth at the Varanus Island terminal. The vetting procedure gathers information on a nominated vessel's condition and management, and allows an assessment of the risk in accepting a vessel for loading. Tankers coming to Varanus Island are vetted during three stages:

- nomination and acceptance;
- pre-loading checks and examinations; and
- the loading phase.

FREQUENCY OF TANKER LIFTINGS AT VARANUS ISLAND SINCE 1986 - OIL and CONDENSATE



Note: Data for 2001-2003 is an estimate

Figure 18

FREQUENCY OF TANKER LIFTINGS AT VARANUS ISLAND SINCE 1986 - Oil

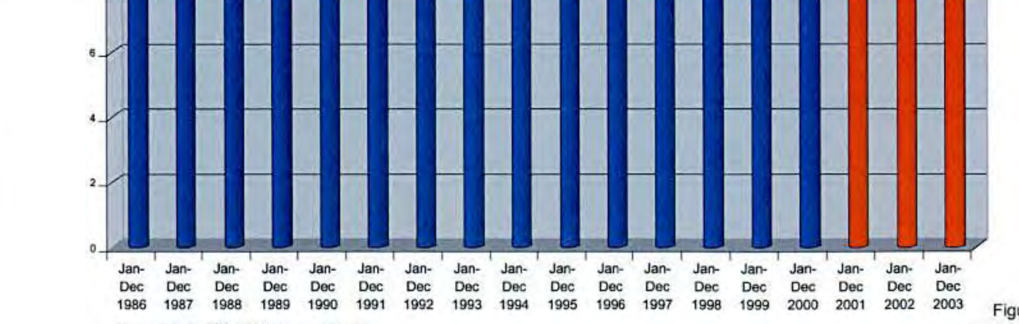


Figure 19

Note: Data for 2001-2003 is an estimate

Nomination and acceptance

When a vessel is nominated, the nomination proposal will contain the Standard Tanker Voyage Chartering Questionnaire 1988 and the Varanus Island Tanker Suitability Assessment Form. These forms provide information on the vessel's age, material and manpower condition, compliance and certification, and the factors laid out in the International Safety Guide for Oil Tankers and Terminals (ISGOTT) (International Chamber of Shipping 1991). The ship's capability to safely moor at the Varanus Island tanker mooring system is also confirmed in these forms.

These forms are assessed by the Varanus Island Field Superintendent and the Marine Pilot to ensure that the vessel is capable to berth and ascertain any potential problems: *e.g.* age, previous accidents, non-compliance or lack of information. If the vessel has visited the island previously, it is checked against the shipping database retained by the marine pilotage contractor.

The marine pilot checks insurance and certificates required under Australian law. These include civil liability for oil pollution, segregated ballast tanks as required by MARPOL, oily waste stowage and tank coatings.

Pre-loading checks and examinations

ISGOTT details the exchange of information and the checks and examinations required before and during the loading of an oil cargo. In addition, Apache provides a berthing information handbook and procedures manual for which each tanker Master signs, acknowledging procedures, practices and emergency measures in force at the Varanus Island loading terminal.

Apache supplies personnel to each tanker to fulfil the roles of Pilot, Loading Master and Tanker Safety Officer. These personnel are responsible for ensuring that each vessel is physically vetted for all terminal compliance factors.

In the event that a nomination has been made, if a vessel arrives and cannot comply with the loading terminal standards and requirements, Apache reserves the right to turn the tanker away.

Checks and observations during berthing and loading

An inspection of the vessel is carried out prior to loading oil. The ISGOTT Ship/Shore Safety Check List is used during the inspection of the tanker for physical, operational and safety factors. Structural defects, leaks of oil, and a problematic issue of vapour are some of the factors that are investigated. A 24 hour watch is maintained over the loading operation to ensure that best practice is used.

Following each loading, the Pilot prepares and submits a report to the Apache Operations Manager on the loading procedure. Any significant defects or problems noted during the loading operations are reported to the Australian Maritime Safety Association (AMSA).

5.5 Decommissioning

At the end of the project life, all wells associated with the Simpson development will be plugged according to requirements of the DME under the PSLA regulations to prevent leakage of hydrocarbons from the reservoir to the surface of the well. In general, this involves placing cement plugs within the casing at intervals along the length of the well. At a minimum this will include the bottom location of the well where the perforations in the casing allow hydrocarbons to enter the well, at a minimum of 30 m above the oil/gas/water zone, and at each casing string interval.

There will also be a plug placed just below the seabed surface across the top of the casing and annulus. It is required under the PSLA to verify the location and the integrity of each cement plug. The intervals between the cement plugs will be filled with drilling fluid to prevent the corrosion of the casings.

The mini-platforms will be removed and taken away for reuse or recycling. The pipeline bundles will be removed from both the marine and terrestrial habitats unless otherwise approved by the appropriate Minister(s).

A detailed plan assessing the potential risks of decommissioning the Simpson development will be generated at least one year prior to the actual dismantling of the facilities. This plan will take into account the latest government policies on decommissioning, and the latest technologies to ensure that the maximum recycling occurs and minimal damage is caused to the marine and terrestrial environments.

5.6 Mitigation Measures to Minimise Impact

A number of measures will be put into place to minimise the impact during the installation period and during routine operations. The major measures are given below.

Anchoring guidelines for the barge and the support vessels will be put into place to ensure that coral communities are not damaged during the installation of the two mini-platforms and the offshore portion of the pipeline bundle. Habitat maps and aerial photographs, showing the locations of fringing and patch coral reefs, will be given to the skippers.

Although installation will take only two weeks, this activity will occur outside the peak turtle and seabird nesting period to minimise any potential disturbance to their breeding cycles. There will be no installation and construction during coral spawning season.

No wastes will be discharged into the marine environment either during the installation phase or during routine operations. A waste management plan will be developed to ensure that no liquid wastes, except a small volume of sewage and hand basin water, will be discharged into the marine environment. All produced formation water and process chemicals will be discharged down a deep disposal well. The management plan will also cover the disposal of solid wastes.

No access will be allowed to any personnel onto Abutilon Island or the east shearwater rookery that lies adjacent to the onshore pipeline bundle route. This factor will be covered in the island safety and environment inductions, and in the environmental guidelines booklet for Varanus Island.

There will not be an increase in the number of oil tankers that berth at the Varanus Island tanker terminal. All tankers that come to Varanus Island will be vetted prior to arrival and must follow the procedures established for the management of tanker traffic berthing at the tanker terminal.

6 Environmental Analysis of Accidental Events

This section describes the potential accidental events that could occur during the installation and operation of the Simpson development, assesses their potential environmental effects and details the mitigating actions or controls that will be implemented to minimise or avert any adverse environmental outcomes.

The environmental hazard identification workshop identified accidental events associated with the installation of the mini-platforms and pipeline bundles, and production of oil from the Simpson field that may act as ecological stressors. Table 12 details each stressor, the risk it poses and the mitigating actions to be taken to reduce the risk of impact. Further details of the key stressors associated with each phase are given below.

6.1 Frequencies and Sources of Oil Spills

A leak frequency assessment was carried out for the Simpson development (IRC 2001c). The leak frequency analysis determined the volume of oil that could be accidentally released and the frequency with which releases could occur. The summarised results (leak frequency against specified ranges of liquid mass released for offshore and onshore locations) for the Simpson development are presented in Table 13.

The results show that the release of small quantities of hydrocarbons (<25 kg) is more frequent compared to larger releases. The main sources of potential release for any size are:

- loss of oil from the 18" production pipeline, either onshore or offshore; or
- loss of well control at the mini-platform.

6.1.1 Risk of a spill reaching sensitive resources

Weathering and dispersal characteristics

Fundamental to the determination of the consequences of spilled oil is an understanding of the behaviour and fate of oil. The nature and severity of environmental impacts from oil depends in part on the composition of the oil. The chemical and physical properties of spilled oil change with time. The rate of change depends both on the initial chemical composition of the oil and 'weathering' or ageing characteristics. Generally, the longer the spilled oil is weathered, the fewer ecologically damaging constituents it will contain. Weathering tends to reduce the toxicity of spilled oil because the toxic components are lost through evaporation, dissolution or degradation from photo-oxidation and microbial activity.

The physical and chemical characteristics of Harriet crude were used for the modelling as Simpson oil has a similar composition. Harriet is classified as a medium to light crude and its characteristics include:

- primarily low molecular weight saturated and aromatic hydrocarbons;
- a polycyclic aromatic (PAH) assemblage dominated by the low weight PAH's;
- rapid evaporative weathering which results in a rapid loss of most of the saturated alkanes and volatile aromatic hydrocarbons;

Table 12: Environmental analysis of accidental events: Installation of mini-platforms.

Potential Environmental Stressor	Source of stressor	Ecological value potentially affected	Management objective for ecological value	Likelihood of stressor occurring	Consequence of stressor occurring	Risk	Potential effect if stressor not managed	Mitigating actions to reduce risk
Oil spills (max. diesel spill of 100,000 L)	Rupture of support vessel fuel tank.	Pelagic marine fauna. Water quality. Turtles. Seabirds. Shoreline flora and fauna.	To maintain biodiversity and cause minimal impact to marine flora and fauna. To maintain background water quality values.	Rare	Significant	B	Transient regional change in water quality. Toxic effects on marine flora and fauna. Contact of oil with intertidal and shallow subtidal habitats. Installation period outside turtle and seabird breeding season.	Bathymetry of area has been surveyed in detail at 1m intervals, data to be used by skipper of vessel. In-house oil spill modelling for predictions of spill path. Trained personnel on vessels. Rigging equipment to be certified. Fast response oil spill vessel on standby.
Oil spills (< 50 L)	Leakage or spillage from machines and barge.	Pelagic marine fauna. Water quality. Turtles. Seabirds. Shoreline flora and fauna.	To maintain biodiversity and cause minimal impact to marine flora and fauna. To maintain background water quality values.	Unlikely	Minor	Negligible	Localised and transient change in water quality near platform. Spill volume small, minimal impact on marine flora and fauna.	Drip trays around machinery. Absorption materials on site for clean up of small spills. All waste oil disposed of via Varanus Island.
Chemical spills	Leaking hydraulic fluid. Handling of Chemical drums.	Pelagic marine fauna. Water quality. Turtles. Seabirds. Shoreline flora and fauna.	To maintain biodiversity and cause minimal impact to marine flora and fauna. To maintain background water quality values.	Unlikely	Negligible	Negligible	Localised and transient change in water quality. Spill volume small, minimal impact on marine flora and fauna.	Low volumes to be used and stored on Varanus Island. Inductions covering waste management to all project personnel.
Chemical spills	Burst hydraulic line or valve.	Terrestrial flora and fauna.	To maintain biodiversity and cause minimal impact to terrestrial flora and fauna.	Unlikely	Negligible	Negligible	Disturbance or damage to local flora and fauna.	Spill retained inside bunded area of platforms.
Litter	Loss of wastes/rubbish overboard.	Pelagic and/or benthic communities.	To maintain biodiversity and cause minimal impact to marine flora and fauna.	Moderate	Minor	B	Ingestion or entanglement by seabirds and marine fauna.	Inductions covering waste management to all project personnel. Litter bins provided.
Introduction of pests	Transport of materials to Varanus Island for Simpson development.	Terrestrial flora and fauna.	To maintain biodiversity and cause minimal impact to terrestrial flora and fauna.	Rare	Significant	B	Disturbance or displacement of local flora and fauna.	Quarantine procedures applied to all phases of project. Incorporated into contracts.
Dropped object	Lifting gear crane or sling failure, human error, loose objects.	Benthic communities	To maintain biodiversity and cause minimal impact to marine flora and fauna.	Unlikely	Negligible	Negligible	Localised impact on seabed; covering sand, limestone reef or macroalgae.	Certified rigging, crane and lifting procedures to be used.

Table 12: Environmental analysis of accidental events: Installation of offshore portion of the pipeline bundle.

Potential Environmental Stressor	Source of stressor	Ecological value potentially affected	Management objective for ecological value	Likelihood of stressor occurring	Consequence of stressor occurring	Risk	Potential effect if stressor not managed	Mitigating actions to reduce risk
Oil Spills (max. diesel spill of 100,000 L)	Rupture of support vessel fuel tank.	Pelagic marine fauna. Water quality. Turtles. Seabirds. Shoreline flora and fauna.	To maintain biodiversity and cause minimal impact to marine flora and fauna. To maintain background water quality values.	Rare	Significant	B	Transient regional change in water quality. Toxic effects on marine flora and fauna. Contact of oil with intertidal and shallow subtidal habitats. Installation period outside turtle and seabird breeding season.	No refuelling anticipated on site. Area has been surveyed in detail at 1m intervals, data to be used by skipper of vessel. Fast Response Vessel on-site. In-house oil spill modelling for predicting spill path.
Introduction of Pests	Transport of materials to Varanus Island for Simpson development.	Terrestrial flora and fauna.	To maintain biodiversity and cause minimal impact to terrestrial flora and fauna.	Rare	Significant	B	Disturbance or displacement of local flora and fauna.	Quarantine procedures applied to all phases of project. Quarantine procedures incorporated into contracts.

Table 12: Environmental analysis of accidental events: Production phase for mini-platforms and offshore portion of the pipeline bundle.

Potential Environmental Stressor	Source of stressor	Ecological value potentially affected	Management objective for ecological value	Likelihood of stressor occurring	Consequence of stressor occurring	Risk	Potential effect if stressor not managed	Mitigating actions to reduce risk
Oil Spills (<100 kg)	Piping/flange failure or small hole leak.	Pelagic marine fauna. Water quality. Turtles. Seabirds. Shoreline flora and fauna.	To maintain biodiversity and cause minimal impact to marine flora and fauna. To maintain background water quality values.	Unlikely	Moderate	B	Localised and transient change in water quality near platform or pipelines. Extent of toxic and smothering effects on marine flora and fauna dependent on spill volume, season, weather conditions and mitigating actions.	Floor of platforms bunded. Continuous corrosion control monitoring program. Oil Spill Contingency Plan. In-house Oil Spill Model for predictions of spill path. Fast response oil spill vessel on Varanus Island at all times.
Oil Spills (100 – 12,500 kg)	Loss of separator and onshore pipeline inventory.	Turtles. Seabirds. Shoreline flora and fauna. Terrestrial flora and fauna.	To maintain biodiversity and cause minimal impact to terrestrial flora and fauna.	Unlikely (3.1×10^{-4})	Moderate	B	Extent of toxic and smothering effects on terrestrial flora and fauna dependent on spill volume, season, weather conditions and mitigating actions.	Automatic and manual shutdown valves. Continuous corrosion control monitoring program. Oil Spill Contingency Plan. In-house Oil Spill Model for predictions of spill path. Adherance to engineering codes and standards. Heavy walled pipe. Fast response oil spill vessel on Varanus Island at all times.

Table 12: Environmental analysis of accidental events: Production phase for mini-platforms and offshore portion of the pipeline bundle (cont.).

Potential Environmental Stressor	Source of stressor	Ecological value potentially affected	Management objective for ecological value	Likelihood of stressor occurring	Consequence of stressor occurring	Risk	Potential effect if stressor not managed	Mitigating actions to reduce risk
Oil Spills (100 –12,500 kg) 500 kg and 12,500 kg spill modelled	Loss of inventory from offshore pipeline. Cyclones.	Pelagic marine fauna. Water quality. Turtles. Seabirds. Shoreline flora and fauna.	To maintain biodiversity and cause minimal impact to marine flora and fauna. To maintain background water quality values.	Unlikely (2.3×10^{-3})	Moderate (66 – 88% chance of reaching shorelines, depending on season and wind).	B Maximum overall risk for 12,500 kg spill in winter, 2.0×10^{-3}	Localised and transient change in water quality near platform or pipelines. Extent of toxic and smothering effects on marine flora and fauna dependent on spill volume, season, weather conditions and mitigating actions.	Routine inspections. Continuous corrosion control monitoring program. Oil Spill Contingency Plan. In-house Oil spill Model for predictions of spill path. Reduced number of flanges, valves and connection points. Fast response oil spill vessel on Varanus Island at all times.
Oil Spills (12,500 – 100,000 kg) 100,000 kg spill modelled	Loss of production well tubing or well control.	Pelagic marine fauna. Water quality. Turtles. Seabirds. Shoreline flora and fauna.	To maintain biodiversity and cause minimal impact to marine flora and fauna. To maintain background water quality values.	Rare (1.1×10^{-6})	Significant (85 – 97% chance of reaching shorelines, depending on season wind and spill volume.	B Maximum risk in winter, 1.1×10^{-6}	Localised and transient change in water quality near platform or pipelines. Extent of toxic and smothering effects on marine flora and fauna dependent on spill volume, season, weather conditions and mitigating actions.	Automatic and manual shutdown valves. Routine inspections. Continuous corrosion control monitoring program. Oil Spill Contingency Plan. In-house Oil Spill Model for predictions of spill path. Fast response oil spill vessel on Varanus Island at all times.
Vessel impact with platform, pipelines or anchor snagging	Leak of oil or diesel.	Pelagic marine fauna. Water quality. Turtles. Seabirds. Shoreline flora and fauna.	To maintain biodiversity and cause minimal impact to marine flora and fauna. To maintain background water quality values.	Unlikely	Moderate	B	Localised and transient change in water quality near platform or pipelines. Extent of toxic and smothering effects on marine flora and fauna dependent on spill volume, season, weather conditions and mitigating actions.	Heavy walled pipe. Amended navigation charts. Identified navigation route to platform.
Chemical Spills	Drums of diesel, rigwash, hydraulic fluid, acid etc.	Pelagic marine fauna. Water quality.	To maintain biodiversity and cause minimal impact to marine flora and fauna. To maintain background water quality values.	Unlikely	Minor	Negligible	Localised and transient change in water quality near platform or pipelines. Spill volume small, minimal impact on marine flora and fauna.	Bunding on deck and drainage to sump. Low volumes to be used and stored on Varanus Island. Inductions covering waste management to all project personnel.

apache ENERGY

Table 12: Environmental analysis of accidental events: Production phase for mini-platforms and offshore portion of the pipeline bundle (cont.).

Potential Environmental Stressor	Source of stressor	Ecological value potentially affected	Management objective for ecological value	Likelihood of stressor occurring	Consequence of stressor occurring	Risk	Potential effect if stressor not managed	Mitigating actions to reduce risk
Hydrotest procedures	Leak of hydrotest water from pipeline.	Pelagic marine fauna. Water quality.	To maintain biodiversity and cause minimal impact to marine flora and fauna. To maintain background water quality values.	Unlikely	Minor	Negligible	Localised and transient change in water quality near platform or pipelines. Installation period outside turtle and seabird breeding season.	Use of biocides and chemical inhibitors in lowest effective concentrations. Pumps would detect leak immediately minimising the volume lost.
Oil Spills	Vehicle impact with pipelines/ facilities. Internal and external corrosion. Cyclones.	Terrestrial flora and fauna	To maintain biodiversity and cause minimal impact to terrestrial flora and fauna.	Unlikely	Moderate	B	Damage to terrestrial flora and fauna.	Use of barriers and authorised access only. Certified rigging, crane and lifting procedures to be used. Continuous corrosion control monitoring programme. Designed for 100 year cyclonic events. Pipeline in culvert along road on east jetty.

Table 13: Summarised leak frequency results for the Simpson development.

Location	Estimated frequency for liquid release (per year)				
	<25 kg (<0.2 bbls)	25 - 100 kg (0.2 - 0.8 bbls)	100 – 12,500 kg (0.8 - 99 bbls)	12,500 - 100,000 kg (99 - 796 bbls)	>100,000 kg (>796 bbls)
Offshore	1.1×10^{-2}	7.8×10^{-4}	2.3×10^{-3}	1.1×10^{-6}	0.0
Onshore	1.9×10^{-4}	1.5×10^{-5}	3.1×10^{-4}	8.9×10^{-7}	0.0
Overall	**1.1×10^{-2}**	**8.0×10^{-4}**	**2.6×10^{-3}**	**2.0×10^{-6}**	**0.0**

- not forming a stable water-in-oil emulsion; and
- being readily amenable to dispersants for several days after spillage.

Approximately 24% of Harriet crude spilled on the sea surface would evaporate within 1-3 hours at an air temperature of 13 °C (Table 14). Over half of the oil would have evaporated within one week, however, the evaporation rates determined in the laboratory provide a very conservative estimate as the air temperatures on the North West Shelf are usually higher than 13 °C.

Table 14: Properties of Harriet crude oil.

HARRIET CRUDE	Fresh	Weathered		
		1-3 hours	1 day	1 week
Physical Characteristics:				
API gravity (classification)	36.9 (middle)			
Density (g/mL) @ 20° C	0.8352	0.860	0.870	0.879
Viscosity (cP) @ 20° C	3.54	3.65	24.51	83.07
Interfacial Tension (mN/m)	7.8	12	16.1	ND
Flash Point (°C)	38	126	142	ND
Pour Point (°C)	12	24	27	ND
Boiling Point (°C)	22.9			
Chemical Characteristics:				
Saturates (% by weight)	67.7	ND	ND	66
Aromatics (% by weight)	26.0	ND	ND	29.2
Resins (% by weight)	5.9	ND	ND	4.4
Asphaltenes (% by weight)	0.5	ND	ND	0.5
Waxes (% by weight)	5.1	7.4	8.2	13.9
Weathering:				
% loss after laboratory weathering (at 13°C)	-	24	38	52
Persistent in the environment	moderate			
Forms oil in water emulsions	yes, unstable	yes, unstable	yes, unstable	yes, unstable
- demulsifier effective?	yes	yes	yes	yes
Toxicity (laboratory tested):				
tropical clownfish (Amphiprion clarkii)	low	low	low	low
inland silverside fish (Menidia beryllina)	moderate	low	low	low
tropical prawn (Penaeus vannamei)	moderate	moderate	moderate	moderate
mysid shrimp (Mysidopsis bahia)	moderate high	moderate-high	moderate-	moderate
sea urchin larvae (Arbacia punctulata)	low-moderate	moderate	moderate	moderate
Sand dollar/sea urchin larvae (Dendraster excentricus/Strongylocentrotus purpuratus)	low	low	low	low
Amenable to Dispersant:	yes	yes	no	no

Toxicity testing carried out by Battelle (1998) and Neff *et al.* (2000), using the water accommodated fraction of Harriet crude, indicated that fresh oil had low toxicity to fish with the toxicity remaining unchanged with weathering. For laboratory reared crustaceans, toxicity was moderate, possibly decreasing slightly with weathering (Table 14).

Determination of spill trajectories and fates

The three-dimensional hydrodynamic model, GCOM3D, and the oil spill model, SIMAP, were used to quantify the potential for oil to contact shorelines and the water column, should an oil leak occur from the proposed Simpson development. The modelling was carried out at two spatial scales:

- regional (within a 50 km radius of Simpson 'A' mini-platform); and
- proximate or fine scale (less than a 5 km radius from Simpson 'A' mini-platform).

The spatial extent and water depth range of the regional scale modelling is shown in Figure 20. This allowed modelling to be carried out at 12 minute time steps and at 500 metre spatial resolution. Examples of the water circulation patterns predicted over the regional scale grid under flood and ebb tides are presented in Figures 21 and 22.

The proximate scale modelling was used to examine in more detail the potential for oil to contact habitats immediately surrounding the proposed location of the Simpson development. Bathymetric data obtained by 3D seismic surveys were used to define a bathymetric grid at a spatial resolution of 30 m for the Lowendal Islands. This allowed modelling to be carried out at a finer temporal (3 minute intervals) and spatial (20 metre intervals) scale. The spatial extent and the water depth range of the proximate scale modelling is shown in Figure 23. Examples of water circulation patterns predicted over the proximate grid under flood and ebb tides are presented in Figures 24 and 25.

Spill modelling considered three discharge sizes of crude, 500 kg, 12,500 kg and 100,000 kg, based on the leak frequency assessment. A minimum spill of 500 kg was modelled as both mini-platforms will be designed to hold up to 500 kg of liquid within a bunded area should a spill occur. Smaller spills, regardless of the source, would likely follow a similar trajectory pattern as a 500 kg spill.

The oil spill computer system was used to conduct stochastic (random) simulations for each of the spill sizes given. The simulations involved generating multiple (100) simulated spill events and predicting the trajectory of each for 96 hours at the regional scale and 24 hours at the proximate scale. Each spill event was started at a randomly selected time relative to the tide and run under a randomly selected portion of an historic wind time series for Varanus Island. Probability contours were generated for each accident scenario based on the frequency with which oil reached locations during the 100 spills.

Hydrodynamic circulation at the regional scale was modelled for three major wind seasons (summer, transitional and winter) using representative samples of wind and tidal conditions. Two wind seasons (summer and winter) were used for the proximate scale. Stochastic spill modelling was then conducted to quantify risks of contact of oil from the Simpson location under each sample of seasonal circulation.

Results of modelling at the regional scale

The results of modelling done at the regional scale are given in Figures 26 - 34.

Modelling indicated that should oil be discharged from the offshore portion of the Simpson development, there would be a relatively high potential of oil contacting a shoreline among the

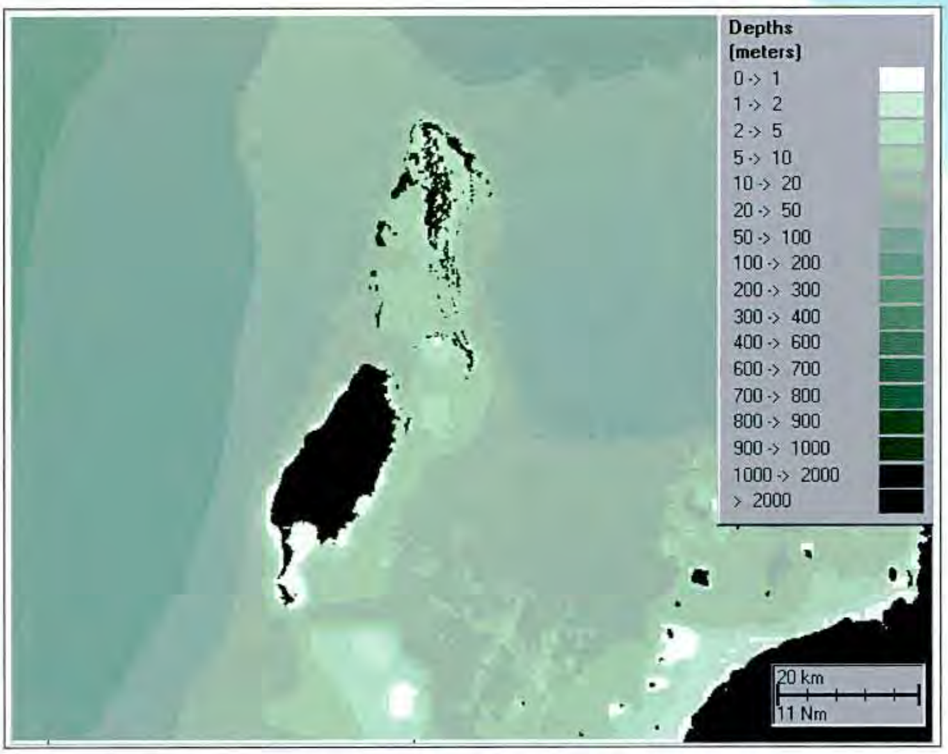


Figure 20. Spatial extent and water depth range for the regional scale oil spill modelling.

Figure 21. Flood tide flow modelled at the regional scale.

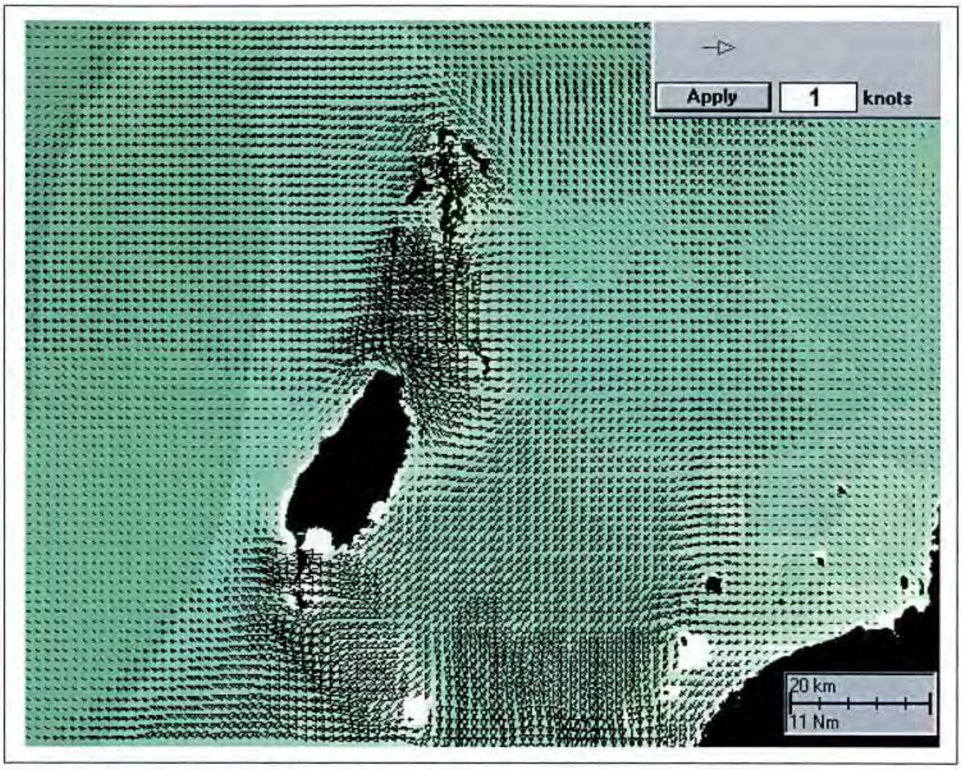


Figure 22. Ebb tide flow modelled at the regional scale.

Figure 23. Spatial extent and water depth range for the proximate scale oil spill modelling.

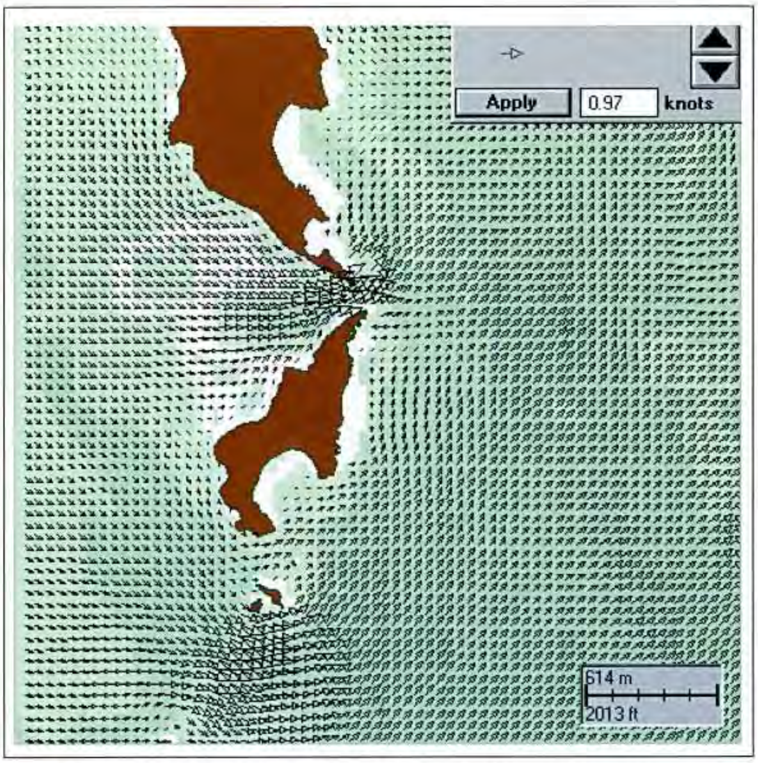


Figure 24. Flood tide flow modelled at the proximate scale.

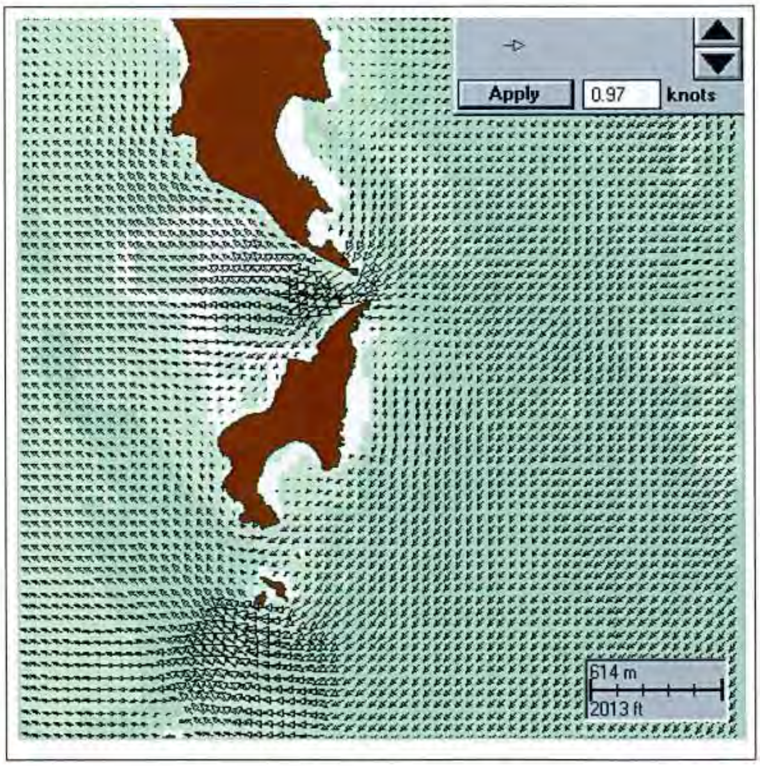


Figure 25. Ebb tide flow modelled at the proximate scale.

Lowendal, Barrow and Montebello Islands, irrespective of the wind season and size of the event. Estimated probabilities for contact ranged between 66% and 97% depending upon the release scenario and the wind season (Table 15).

The general trend was for:

- the largest discharge to consistently produce the highest potential risk of contact with shorelines; and
- the estimated potential for contact to be the highest in the winter and the lowest in the summer.

The probability contours also indicated seasonal differences in the probability of shoreline contact to each of the major island groups. Higher probabilities of shoreline contact for the Lowendal Islands were indicated for the summer wind season. In contrast, winter wind conditions are expected to generate a higher probability of shoreline contact at Barrow Island and the Montebello Islands. There was a low probability of shoreline contact indicated for the Montebello Island group under transitional wind conditions.

The minimum time to shoreline contact was about 2 hours regardless of discharge size or season. The Lowendal Islands were the earliest point of contact in each case. The time contours indicated

Table 15: Summary of risks predicted for offshore discharges of Harriet crude oil from Simpson development location during three major wind seasons, modelled at the regional scale.

Modelling outcomes for summer wind season			
Quantity Released (kg)	**500 (Figure 26)**	**12,500 (Figure 29)**	**100,000 (Figure 32)**
Assumed rate of release (kg hr^{-1})	500	6,250	25,000
Probability of contact with shoreline (%)	83	66	85
Minimum time to contact shoreline (hrs)	2	2	2
Maximum mass to reach shoreline (kg)	360	9,430	67,300
Percentage of original mass to reach shorelines (%)	72	75	67
Shorelines potentially impacted#	Mont, Low, Barr	Mont, Low, Barr	Mont, Low, Barr
Modelling outcomes for transitional wind season			
Quantity Released (kg)	**500 (Figure 27)**	**12,500 (Figure 30)**	**100,000 (Figure 33)**
Assumed rate of release (kg hr^{-1})	500	6,250	25,000
Probability of contact with shoreline (%)	70	78	91
Minimum time to contact shoreline (hrs)	2	2	2
Maximum mass to reach shoreline (kg)	320	8,140	69,100
Percentage of original mass to reach shorelines (%)	64	65	69
Shorelines potentially impacted#	Mont, Low, Barr	Mont, Low, Barr	Mont, Low, Barr
Modelling outcomes for winter wind season			
Quantity Released (kg)	**500 (Figure 28)**	**12,500 (Figure 31)**	**100,000 (Figure 34)**
Assumed rate of release (kg hr^{-1})	500	6,250	25,000
Probability of contact with shoreline (%)	86	88	97
Minimum time to contact shoreline (hrs)	2	2	2
Maximum mass to reach shoreline (kg)	240	8,030	10,770
Percentage of original mass to reach shorelines (%)	48	64	10.8
Shorelines potentially impacted#	Mont, Low, Barr	Mont, Low, Barr	Mont, Low, Barr

\# Mont = Montebello Islands
Low = Lowendal Islands
Barr = Barrow Islands

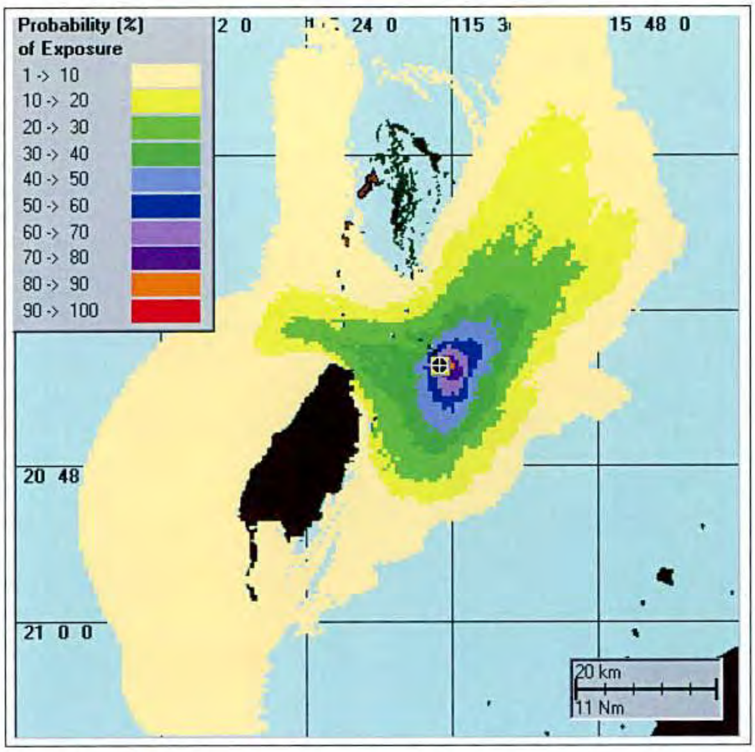


Figure 26a. Regional modelling results; 500 kg spill, summer, probability of contact.

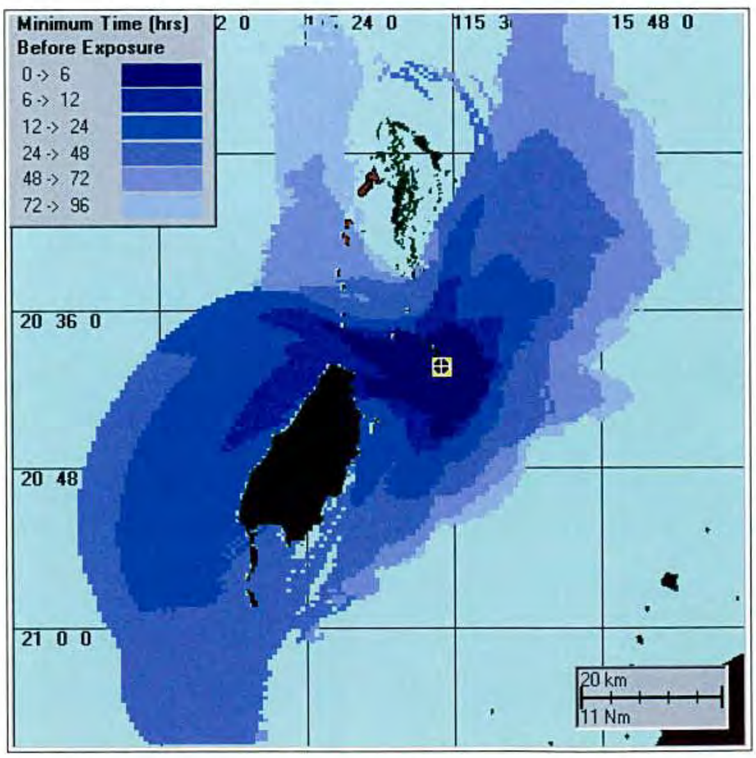


Figure 26b. Regional modelling results; 500 kg spill, summer, minimum time to contact.

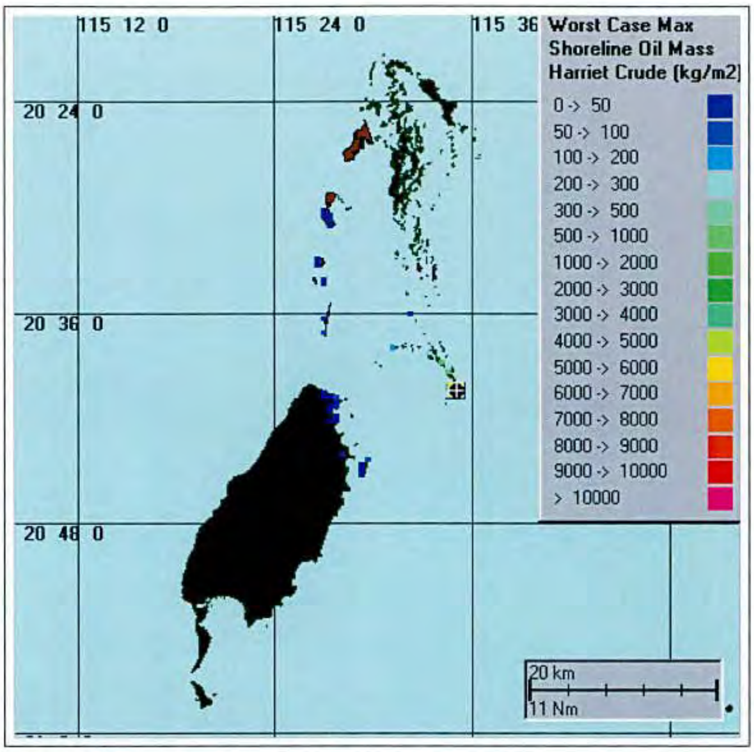


Figure 26c. Regional modelling results; 500 kg spill, summer, mass on shorelines.

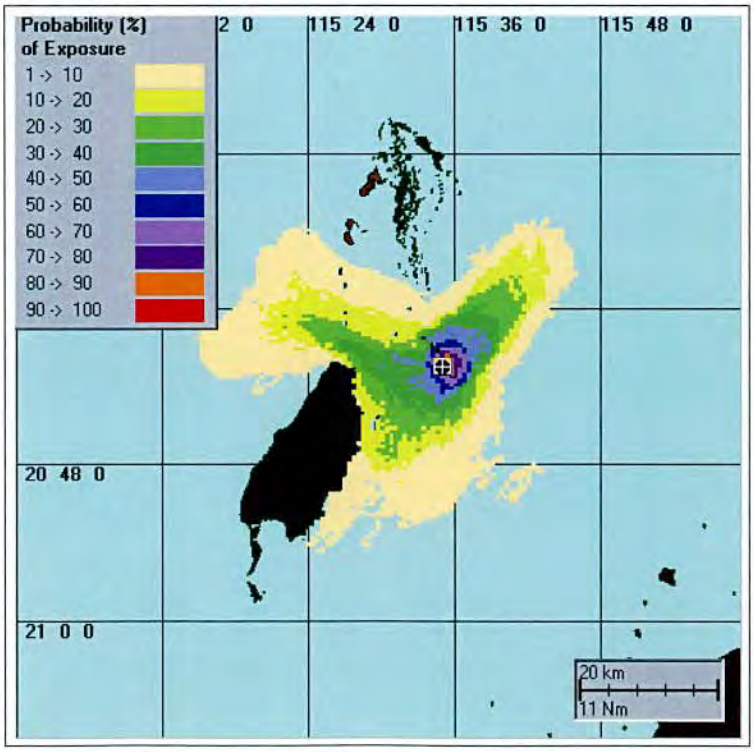


Figure 27a. Regional modelling results; 500 kg spill, transitional, probability of contact.

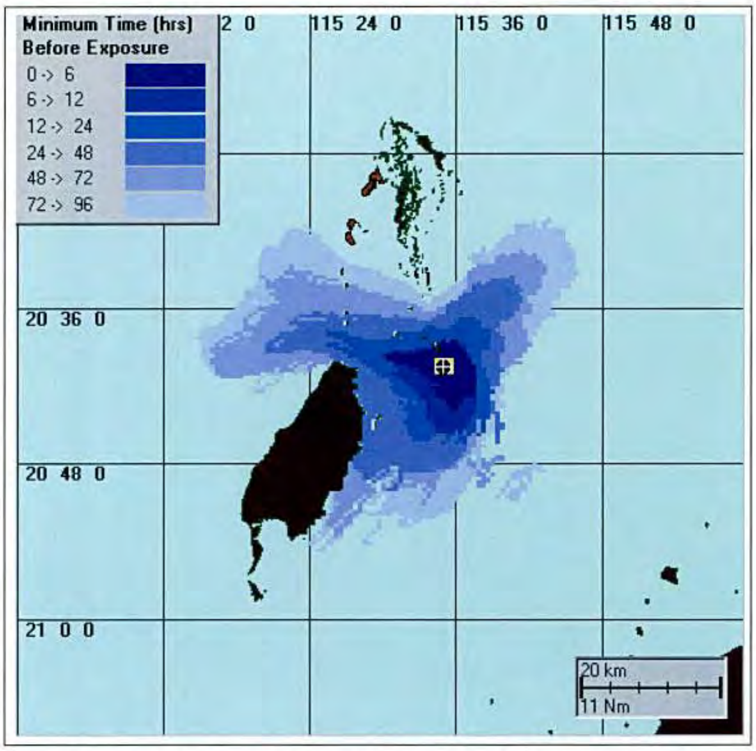


Figure 27b. Regional modelling results; 500 kg spill, transitional, minimum time to contact.

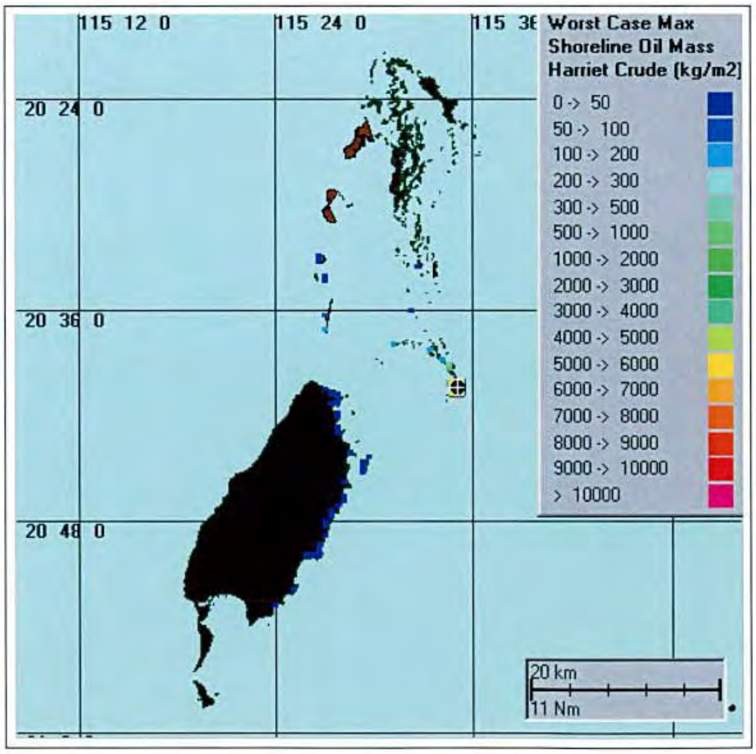


Figure 27c. Regional modelling results; 500 kg spill, transitional, mass on shorelines.

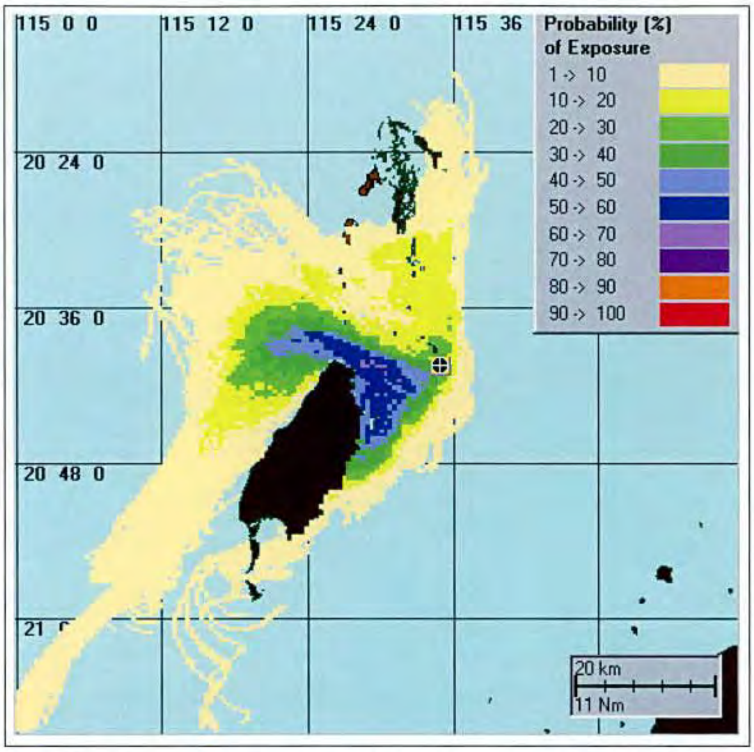


Figure 28a. Regional modelling results; 500 kg spill, winter, probability of contact.

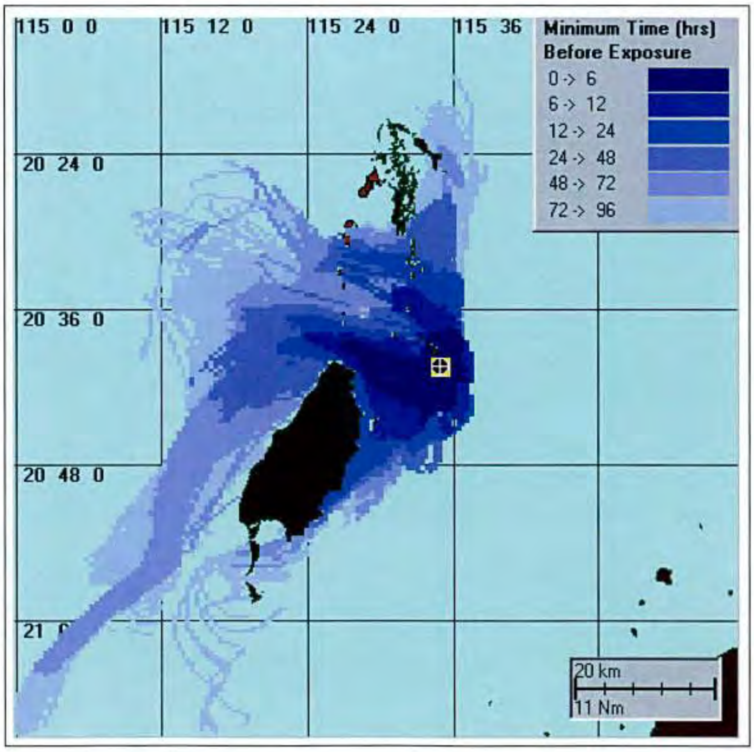


Figure 28b. Regional modelling results; 500 kg spill, winter, minimum time to contact.

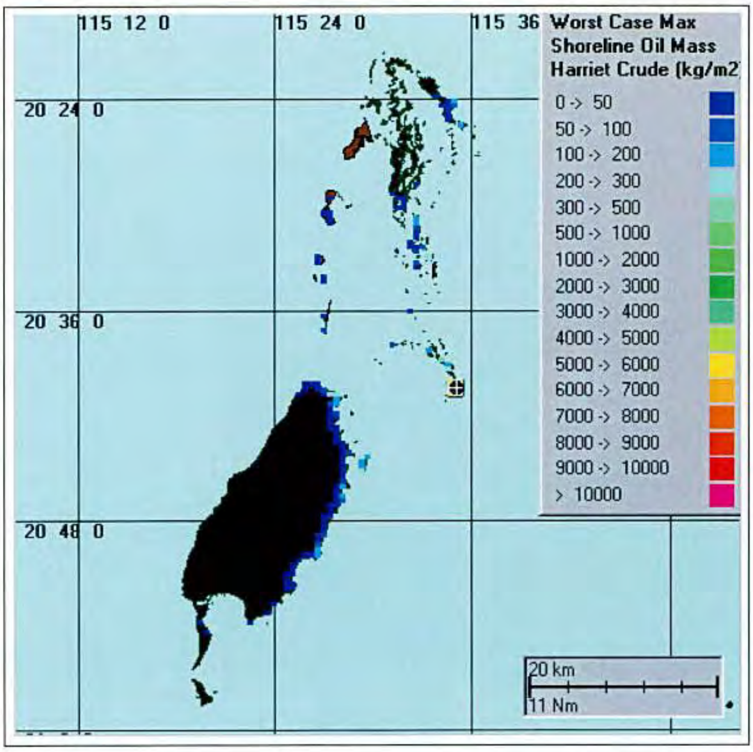


Figure 28c. Regional modelling results; 500 kg spill, winter, mass on shorelines.

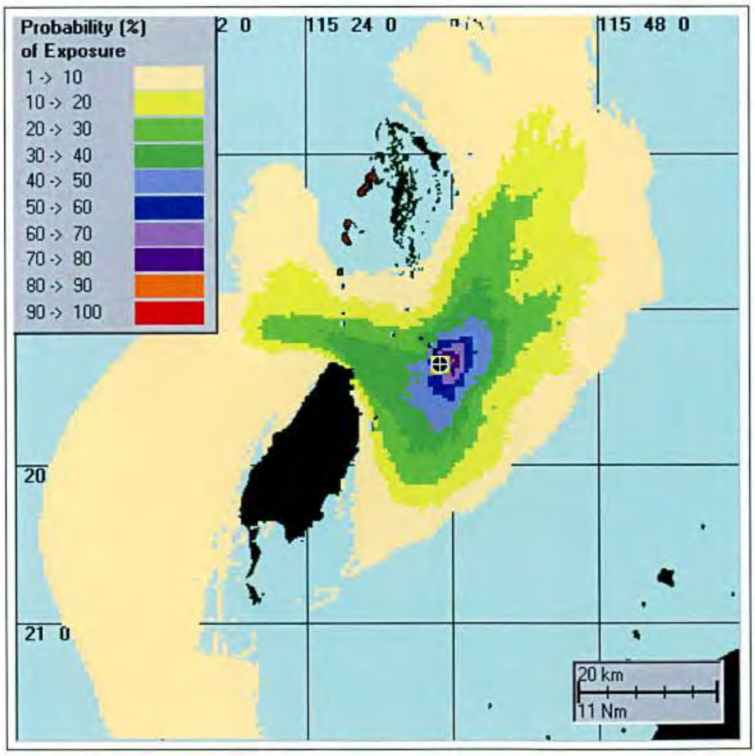


Figure 29a. Regional modelling results; 12,500 kg spill, summer, probability of contact.

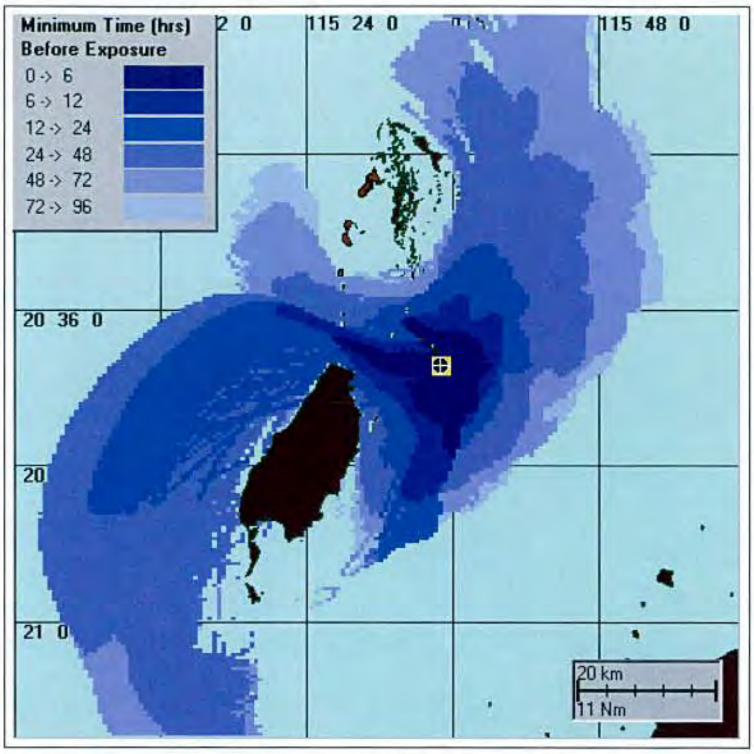


Figure 29b. Regional modelling results; 12,500 kg spill, summer, minimum time to contact.

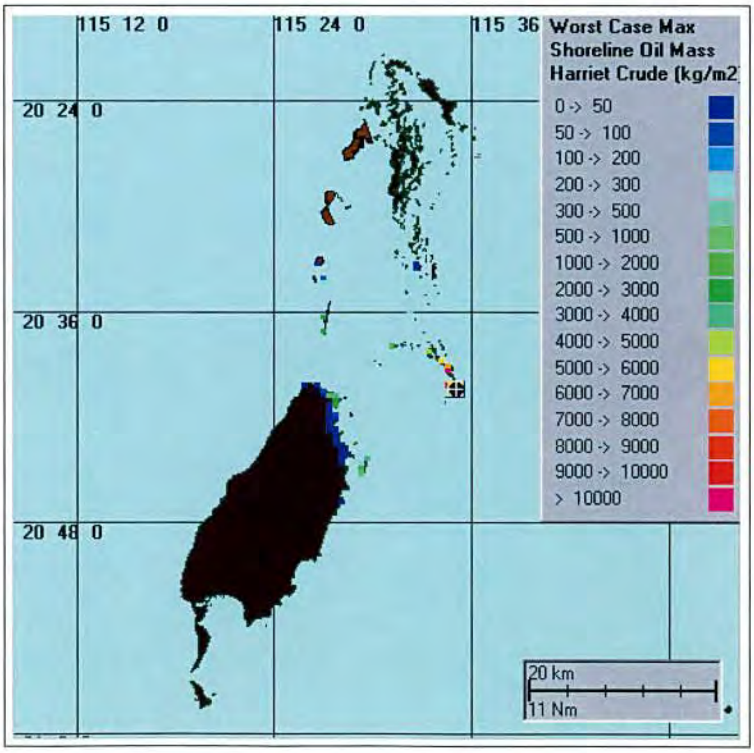


Figure 29c. Regional modelling results, 12,500 kg spill, summer, mass on shorelines.

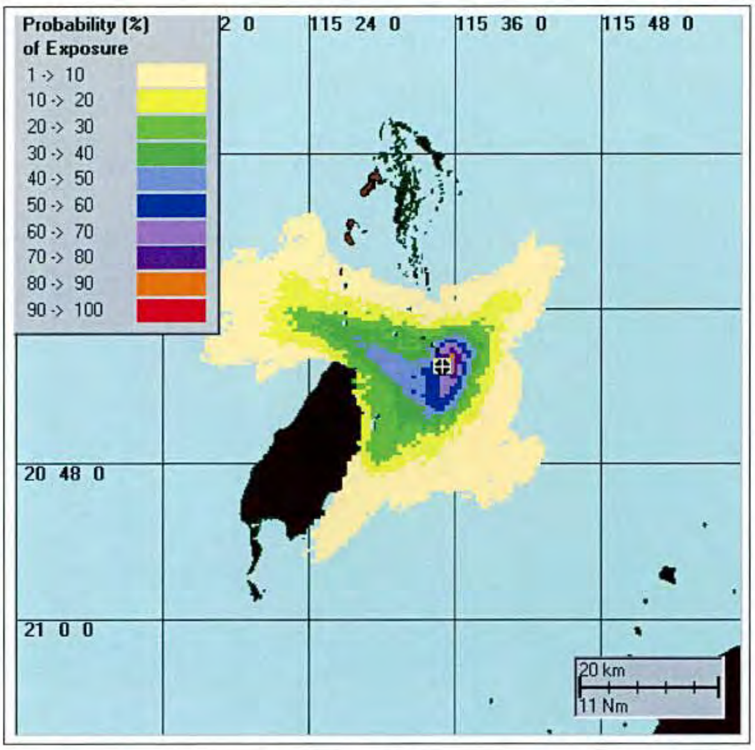


Figure 30a. Regional modelling results; 12,500 kg spill, transitional, probability of contact.

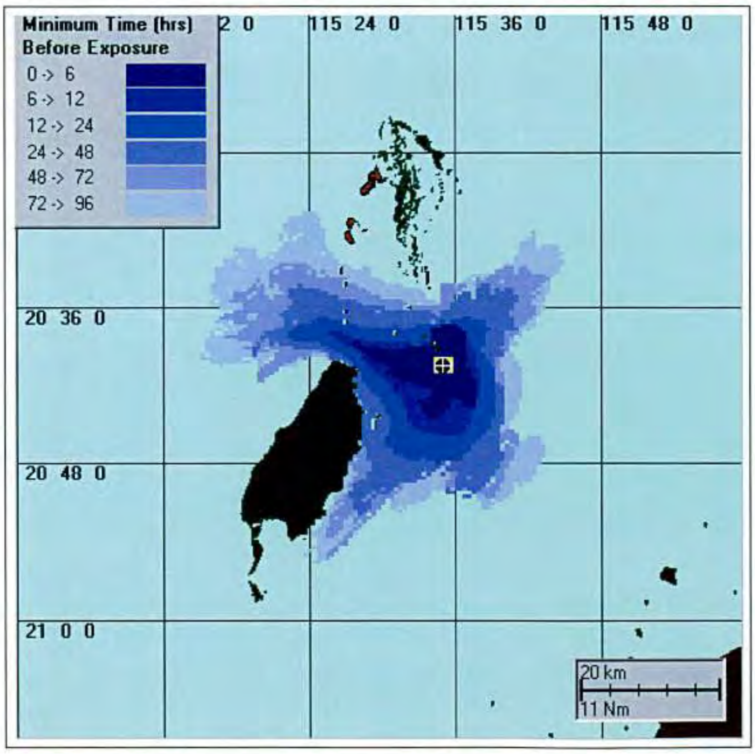


Figure 30b. Regional modelling results; 12,500 kg spill, transitional, minimum time to contact.

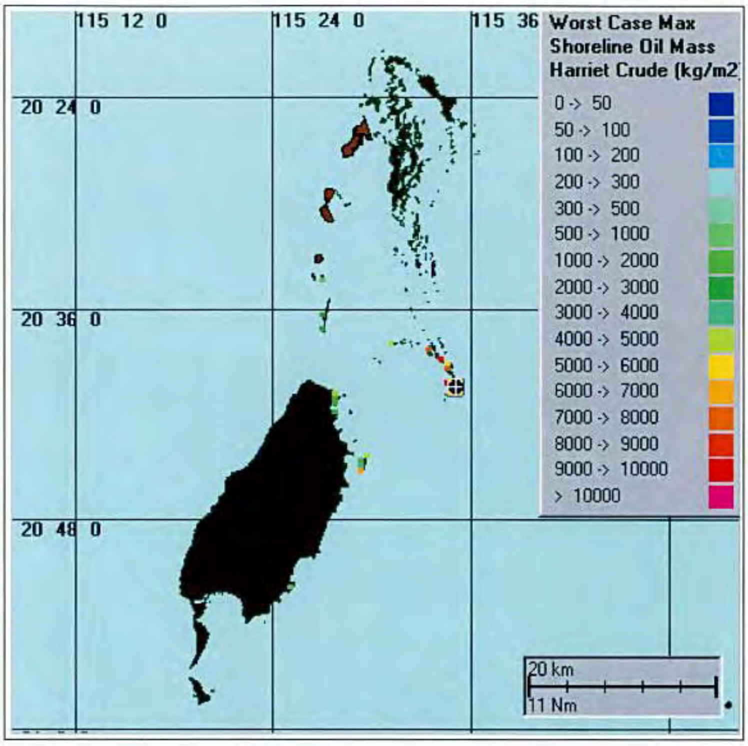


Figure 30c. Regional modelling results; 12,500 kg spill, transitional, mass on shorelines.

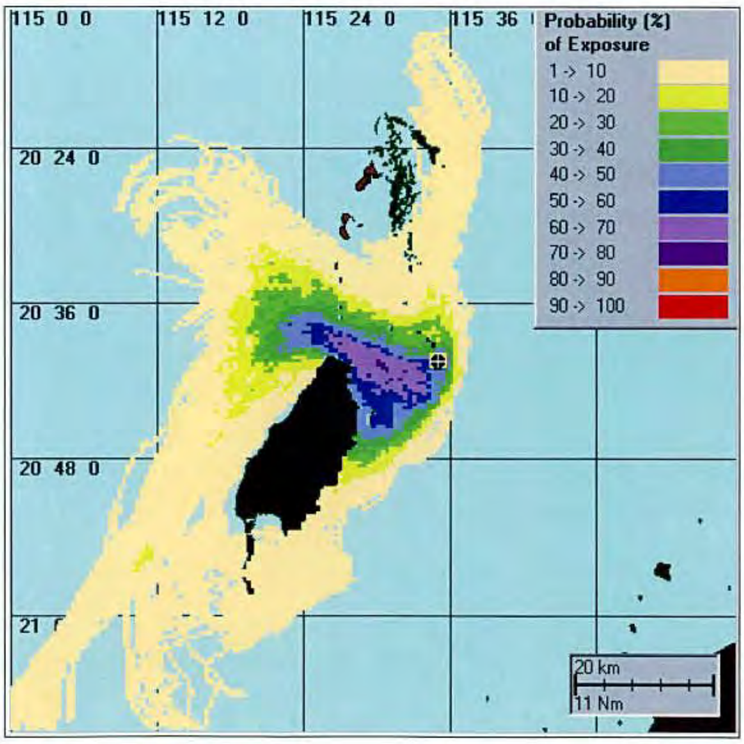


Figure 31a. Regional modelling results; 12,500 kg spill, winter, probability of contact.

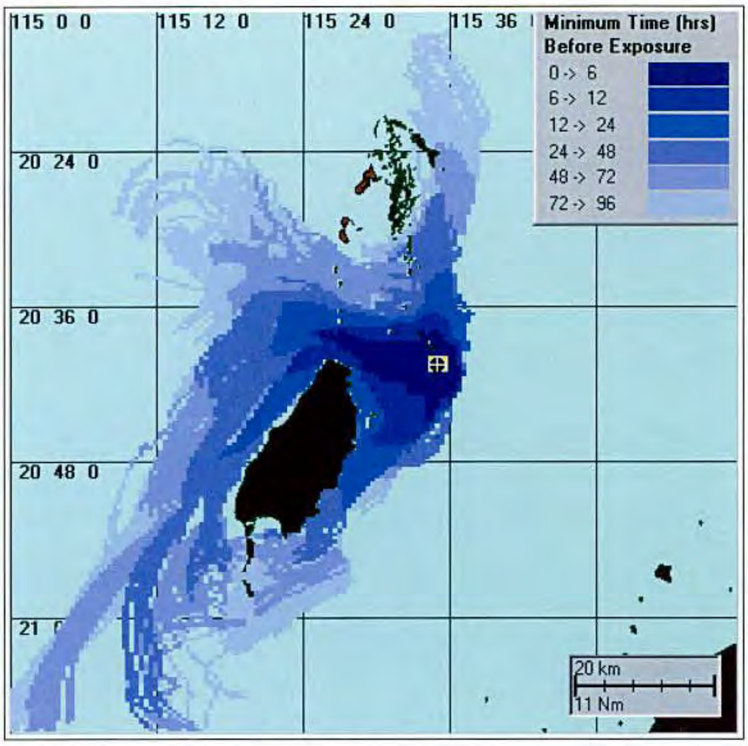


Figure 31b. Regional modelling results; 12,500 kg spill, winter, minimum time to contact.

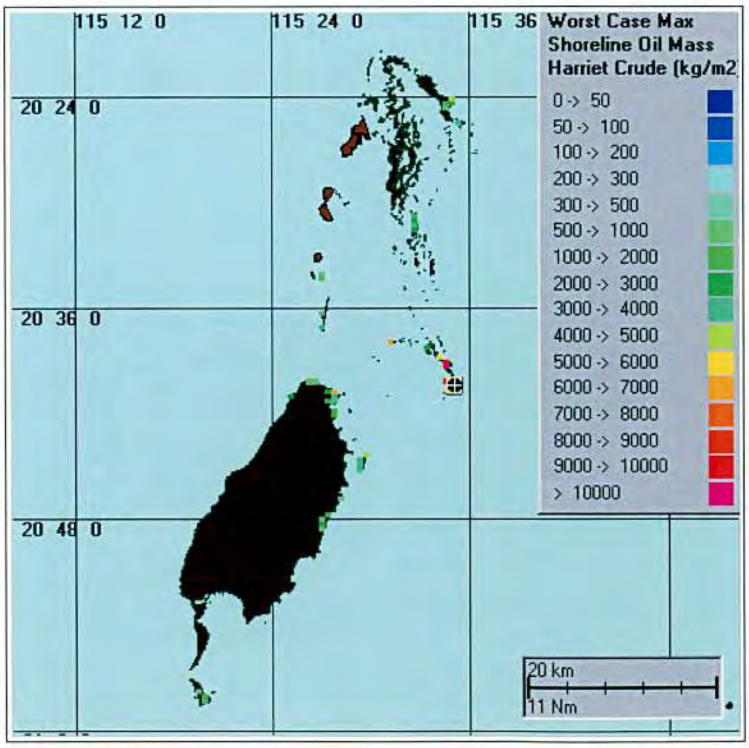


Figure 31c. Regional modelling results; 12,500 kg spill, winter, mass on shorelines.

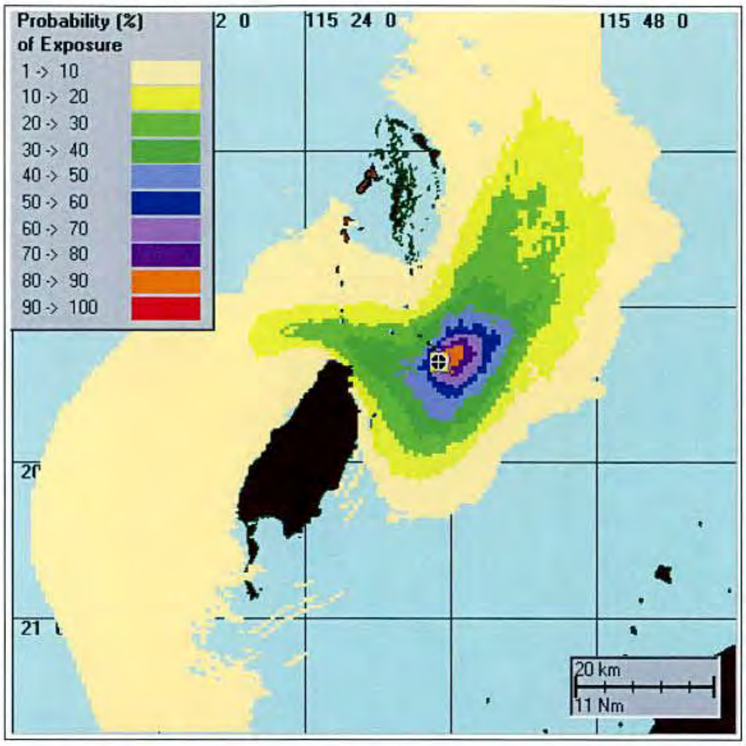


Figure 32a. Regional modelling results; 100,000 kg spill, summer, probability of contact.

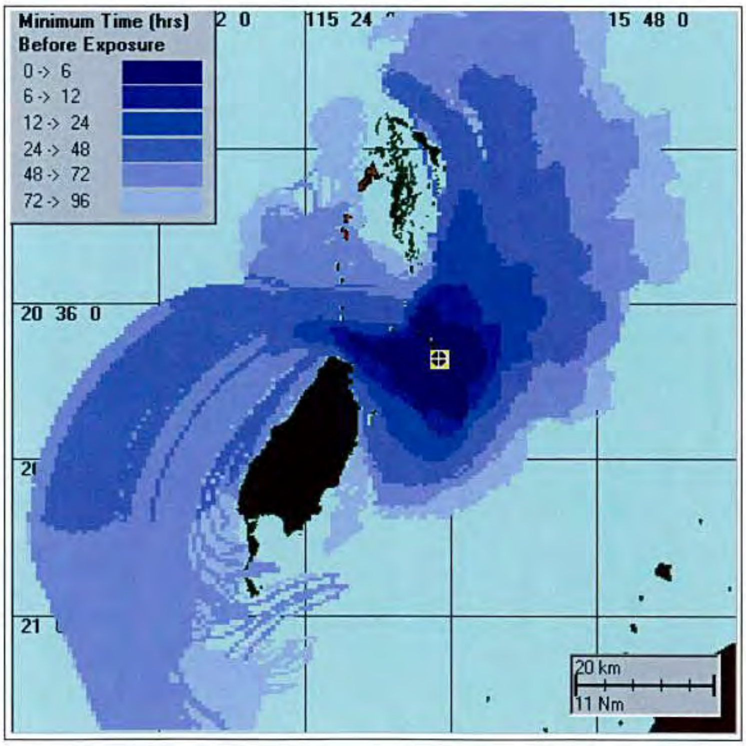


Figure 32b. Regional modelling results; 100,000 kg spill, summer, minimum time to contact.

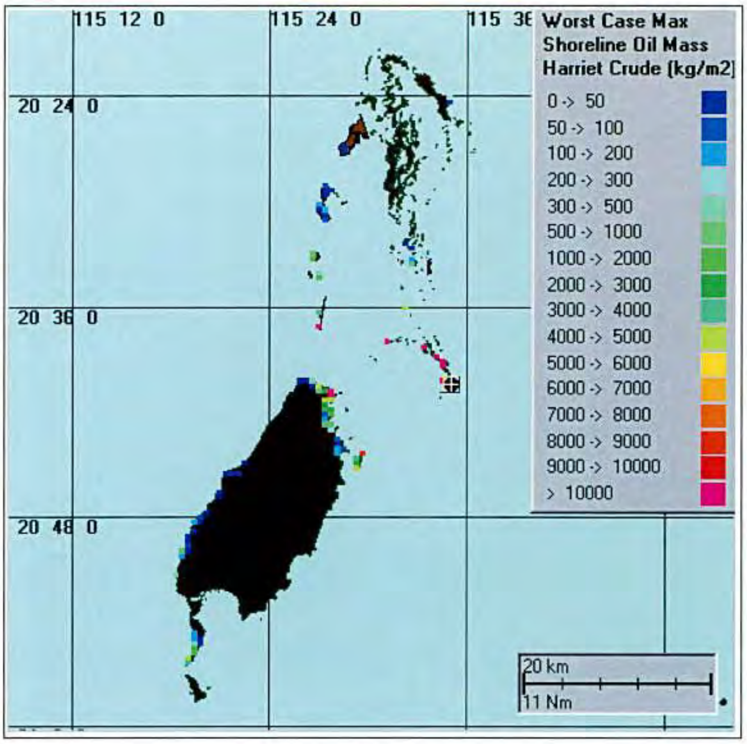


Figure 32c. Regional modelling results; 100,000 kg spill, summer, mass on shorelines.

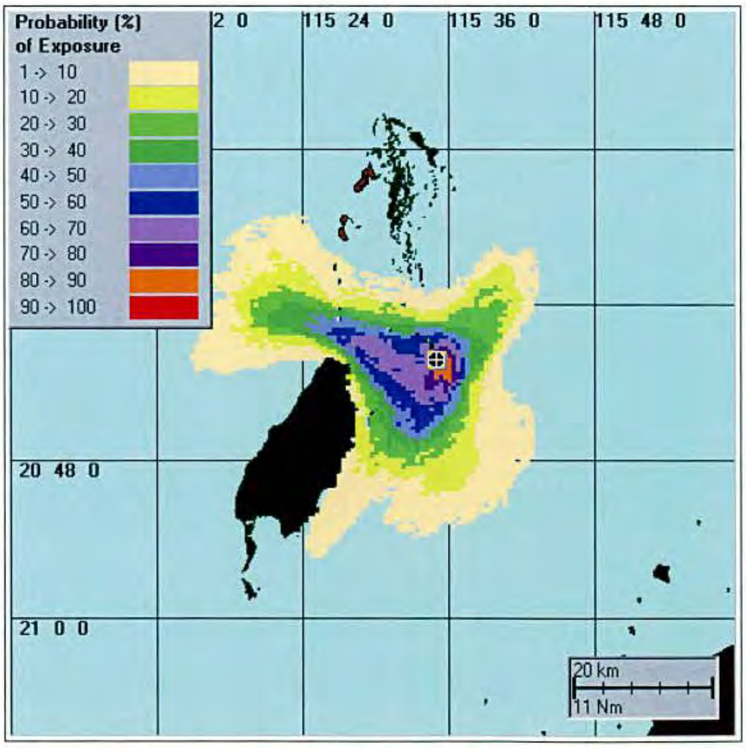


Figure 33a. Regional modelling results; 100,000 kg spill, transitional, probability of contact.

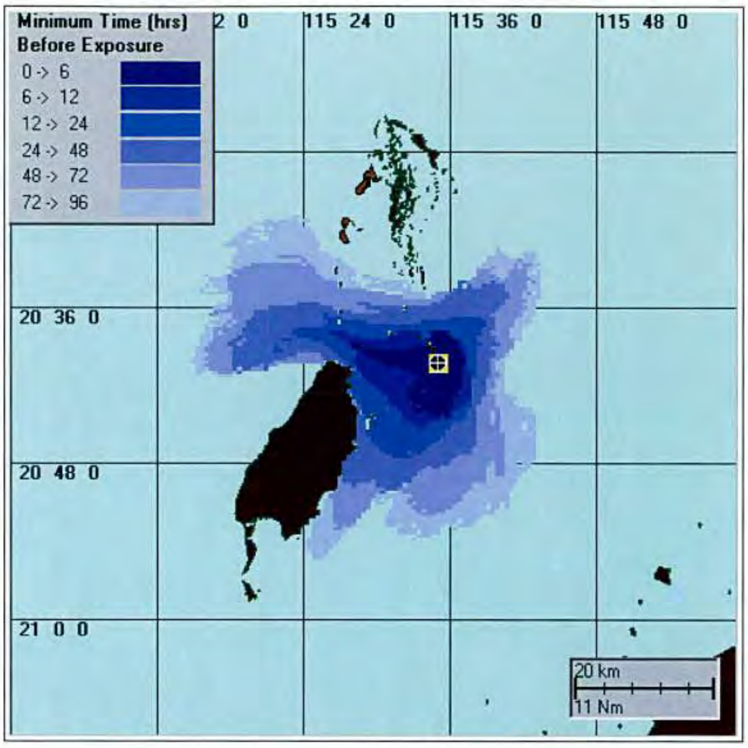


Figure 33b. Regional modelling results; 100,000 kg spill, transitional, minimum time to contact.

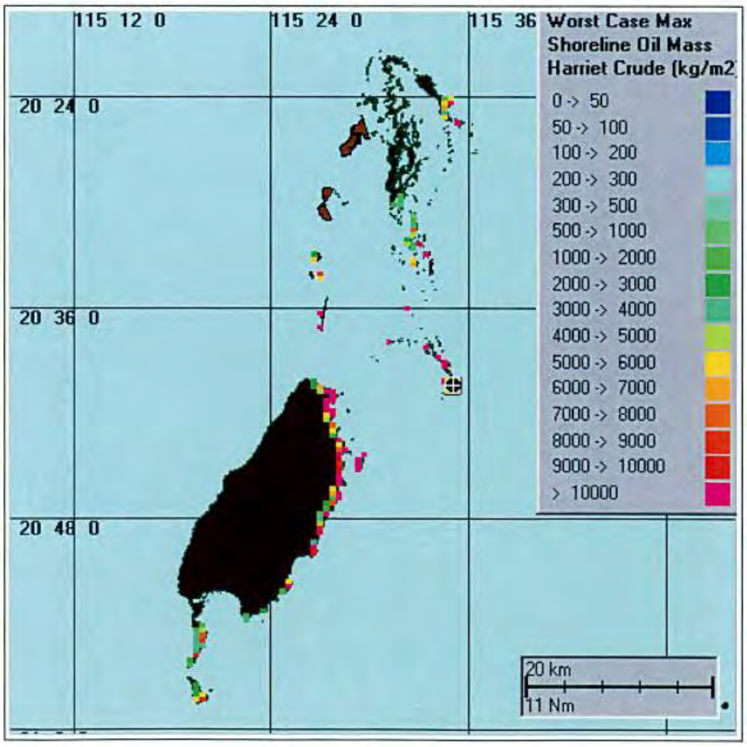


Figure 33c. Regional modelling results; 100,000 kg spill, transitional, mass on shorelines.

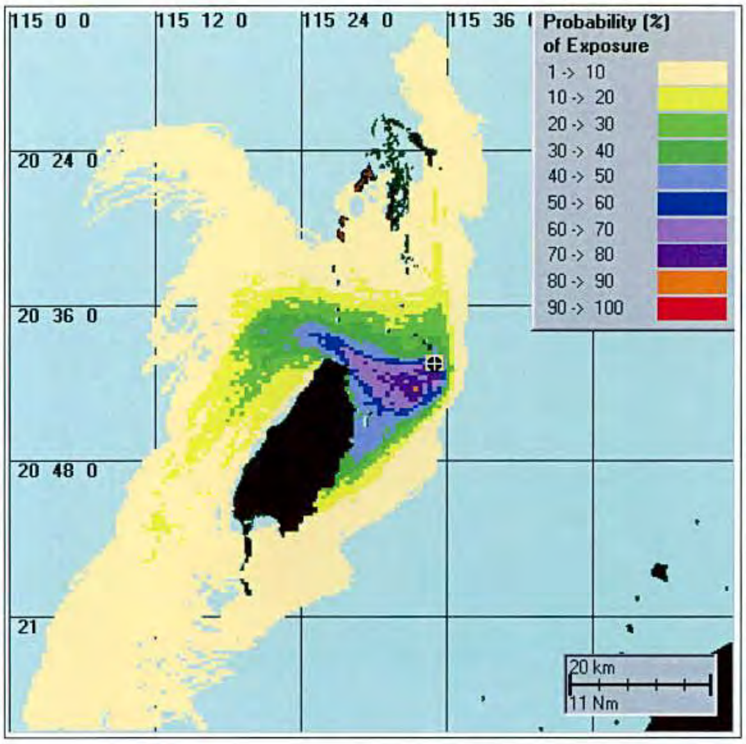


Figure 34a. Regional modelling results; 100,000 kg spill, winter, probability of contact.

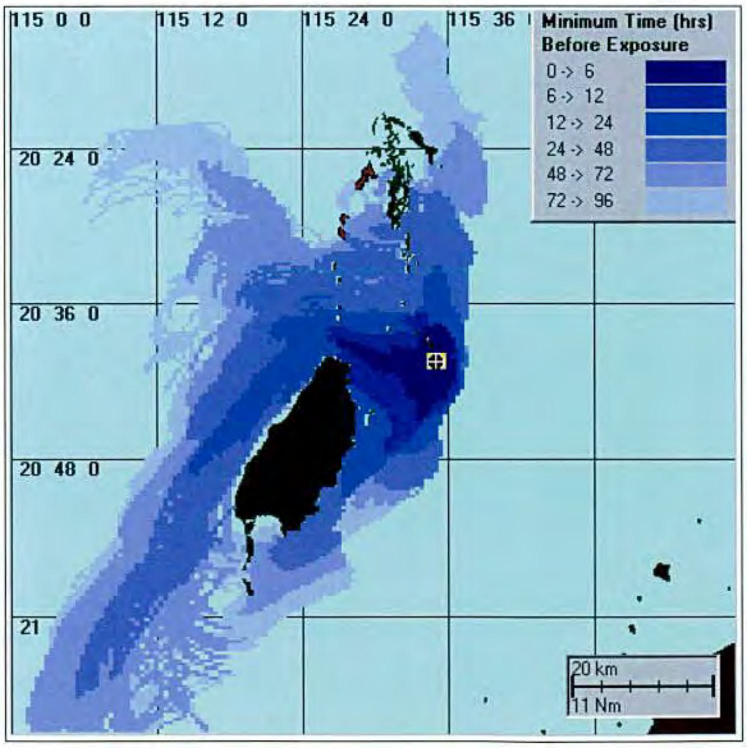


Figure 34b. Regional modelling results; 100,000 kg spill, winter, minimum time to contact.

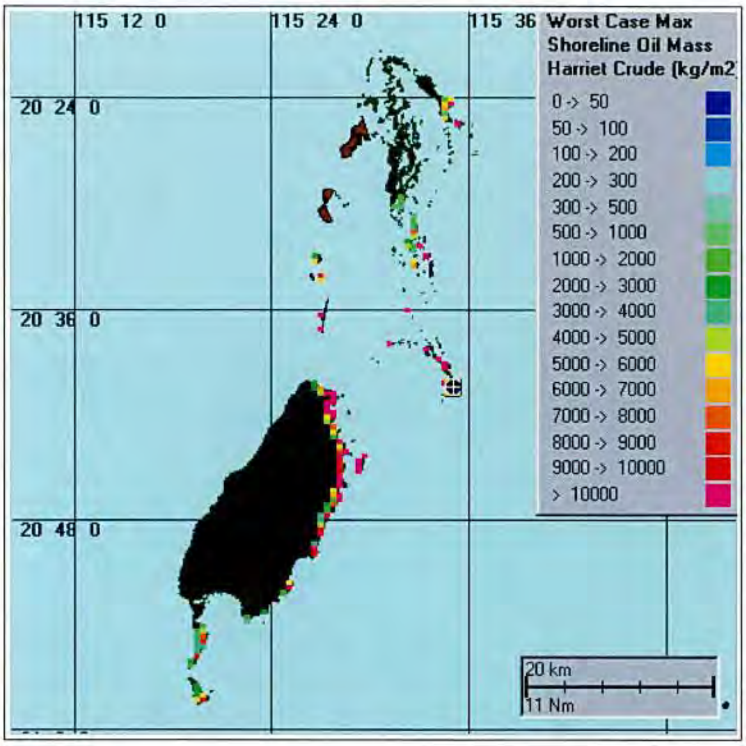


Figure 34c. Regional modelling results; 100,000 kg spill, winter, mass on shorelines.

that the time to contact other island groups would vary seasonally. Barrow Island was within the 12-hour contour under winter and summer winds, and within the 24-hour contour under transitional winds. The Montebello Islands were within the 24-hour contour under summer winds, the 48-hour contour under winter winds and the 96-hour contour under transitional winds.

Modelling indicated that a relatively large proportion of spilled oil could potentially strand on shorelines under worst-case conditions during each wind season. Up to 75% of the initial spill quantity was predicted to reach shorelines for the summer wind cases, 69% for the transitional wind cases and 64% for the winter wind cases (Table 15). The predictions indicated that shorelines of the Lowendal Islands and Barrow Island could receive the highest loads during winter and the transitional wind season. In contrast, similar potential loads were predicted for parts of all three of the island groups during summer.

The overall probability that oil would reach island shorelines for each size of release was subsequently calculated for each of the three seasons as:

Overall risk = [probability of leak occurring] x [probability of contact during the season].

The results of the leak frequency analyses combined with the predicted probabilities of contact from spill modelling at the regional scale are summarised in Table 16. The potential sources of leaks and a summary of the mitigating factors to be used are also given.

Table 16: Outcome of risk analysis. Note that results are worse case as the oil quantity in the pipeline decreases after year one as the produced formation water quantity increases.

Size of spill	Example of potential cause of loss of oil	Examples of management measures	Risk of leak occurring* (per year)+	Risk of oil reaching shorelines	Overall risk	Overall risk in percent	Risk of leak occurring*	Risk of oil reaching shorelines	Overall risk	Overall risk in percent	Risk of leak occurring*	Risk of oil reaching shorelines	Overall risk	Overall risk in
			Summer conditions				Transitional conditions				Winter conditions			
25 - 100 kg	Piping flange failure or small hole leak offshore.	Floor of platform bunded. Any spillage contained within bunded area. Welded valves rather than flanged connections. Continuous corrosion control monitoring program.	7.8×10^{-4} unlikely to occur.	No oil spill trajectories carried out for this spill size due to similar risk of occurrence of larger spills. Modelling of larger spills provides a very conservative risk for this spill size.			7.8×10^{-4} unlikely to occur.	No oil spill trajectories carried out for this spill size due to similar risk of occurrence of larger spills. Modelling of larger spills provides a very conservative risk for this spill size.			7.8×10^{-4} unlikely to occur.	No oil spill trajectories carried out for this spill size due to similar risk of occurrence of larger spills. Modelling of larger spills provides a very conservative risk for this spill size.		
100 - 12,500 kg	Loss of onshore pipeline inventory.	Automatic shutdown valve with back-up manual shut down valve. Flowline above ground with frequent inspections. Bund around separator. Corrosion monitoring.	3.1×10^{-4} unlikely to occur.	No oil spill trajectories carried out as spill point on land.			3.1×10^{-4} unlikely to occur.	No oil spill trajectories carried out as spill point on land.			3.1×10^{-4} unlikely to occur.	No oil spill trajectories carried out as spill point on land.		
100 - 12,500 kg	Loss of offshore pipeline inventory.	Corrosion monitoring. Welded valves rather than flanged connections. Routine inspections	**500 kg spill** 2.3×10^{-3} moderate **12,500 kg spill** 2.3×10^{-3} moderate	0.83 0.66	1.9×10^{-3} 1.5×10^{-3}	0.19 0.15	**500 kg spill** 2.3×10^{-3} moderate **12,500 kg spill** 2.3×10^{-3} moderate	0.70 0.78	1.6×10^{-3} 1.7×10^{-3}	0.16 0.17	**500 kg spill** 2.3×10^{-3} moderate **12,500 kg spill** 2.3×10^{-3} moderate	0.86 0.88	2.0×10^{-3} 2.0×10^{-3}	0.20 0.20
12,500 – 100,000 kg	Loss production well tubing or well control.	Automatic shutdown values with manual shutdown values as back-up on platform and seabed. Corrosion monitoring. Routine inspections.	**100,000 kg spill** 1.1×10^{-6} rare	0.85	0.9×10^{-7}	0.00009	**100,000 kg spill** 1.1×10^{-6} rare	0.91	1.0×10^{-6}	0.0001	**100,000 kg spill** 1.1×10^{-6} rare	0.97	1.0×10^{-6}	0.0001

* Regardless of source, only based on the size of the spill. See Appendix 3 for definitions of risk.

+ Another means of expressing the probability of a leak is to take the inverse of the annual leak frequency. For example: the risk of a 500 kg leak per year is 1/4.1 x 10-2 or 1 in every 24 years.

Conversions: kg/0.79 = L
L/159 = bbls
1 m^3 = 6.292 bbls

Results of modelling at the proximate scale

The results of modelling done at the proximate scale are given in Figures 35 - 40.

Modelling indicated that the fate of spills released at the Simpson development site would be strongly influenced by both wind and tidal forces. To the west of the Lowendal Islands, strong tidal flows move roughly south-east on the flood and north-west on the ebb over the study area (Figures 21 and 22). These flow patterns are modified by the island barriers so that currents bend to follow the coast of Varanus Island on both the east and west sides. Current speeds are particularly high (> 4 knots) through the channels to the north and south of Abutilon Island. Modelling indicated that under both summer and winter winds there was a trend for some oil to be carried by these channel currents to the western side of the island chain.

The potential for contact with any shoreline was relatively high during both seasons (Table 17, Figures 35 to 40). Seasonal variation in the prevailing wind directions was predicted to affect the probability of contacting individual island shores. Under summer winds, which are predominantly from the south-west, spills most commonly contacted areas to the north-east of Simpson but oil also tended to be carried through the channel separating Varanus and Abutilon Islands. Oil passing to the east of the island chain into areas of slower tidal currents was predicted to have a relatively high probability of contacting the eastern shores of the Lowendal Islands, or moving through to the northern parts of the island chain. Oil passing to the west of the island chain was predicted to have a relatively high potential of being captured by the longshore tidal currents passing along Varanus Island and depositing oil on the western shorelines.

Table 17: Summary of risks predicted for offshore discharges of Harriet crude oil from Simpson development location during two major wind seasons modelled at the proximate scale.

Modelling outcomes for summer wind season			
Quantity Released (kg)	**500 (Figure 35)**	**12,500 (Figure 37)**	**100,000 (Figure 39)**
Assumed rate of release (kg hr^{-1})	500	6,250	25,000
Probability of contact with shoreline (%)	64	74	86
Minimum time to contact shoreline (hrs)	1	1	1
Maximum mass to reach shoreline (kg)	222	7,679	23,763
Percentage of original mass to reach shoreline (%)	44	61	24
Shorelines potentially impacted	Abutilon, Varanus, Beacon & Bridled Islands	Abutilon, Varanus, Beacon & Bridled Islands	Abutilon, Varanus, Beacon & Bridled Islands
Modelling outcomes for winter wind season			
Quantity Released (kg)	**500 (Figure 36)**	**12,500 (Figure 38)**	**100,000 (Figure 40)**
Assumed rate of release (kg hr^{-1})	500	6,250	25,000
Probability of contact with shoreline (%)	70	76	94
Minimum time to contact shoreline (hrs)	1	1	1
Maximum mass to reach shoreline (kg)	234	5,349	30,936
Percentage of original mass to reach shoreline (%)	47	43	31
Shorelines potentially impacted	Abutilon, Varanus, Beacon & Bridled Islands	Abutilon, Varanus, Beacon & Bridled Islands	Abutilon, Varanus, Beacon & Bridled Islands

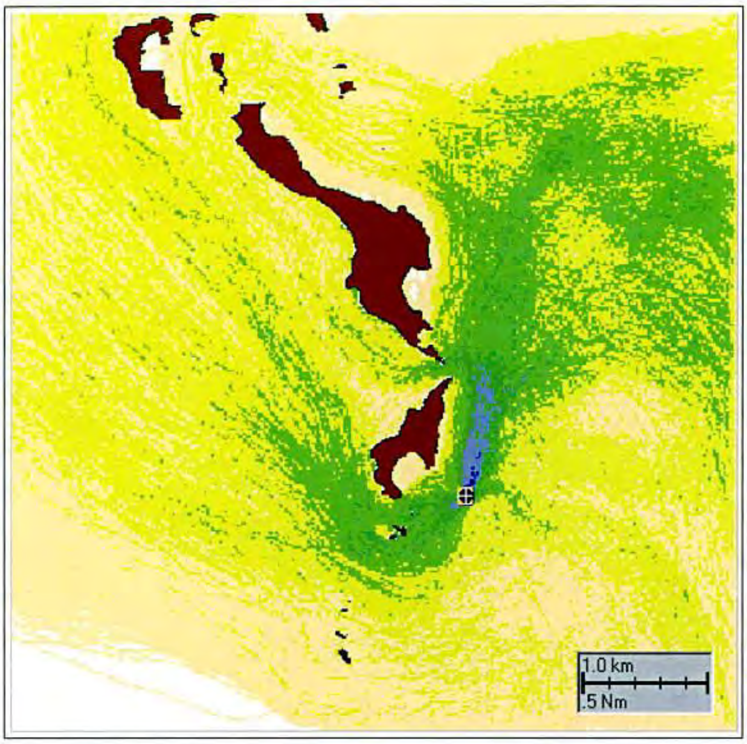


Figure 35a. Proximate modelling results, 500 kg spill, summer, probability of contact.

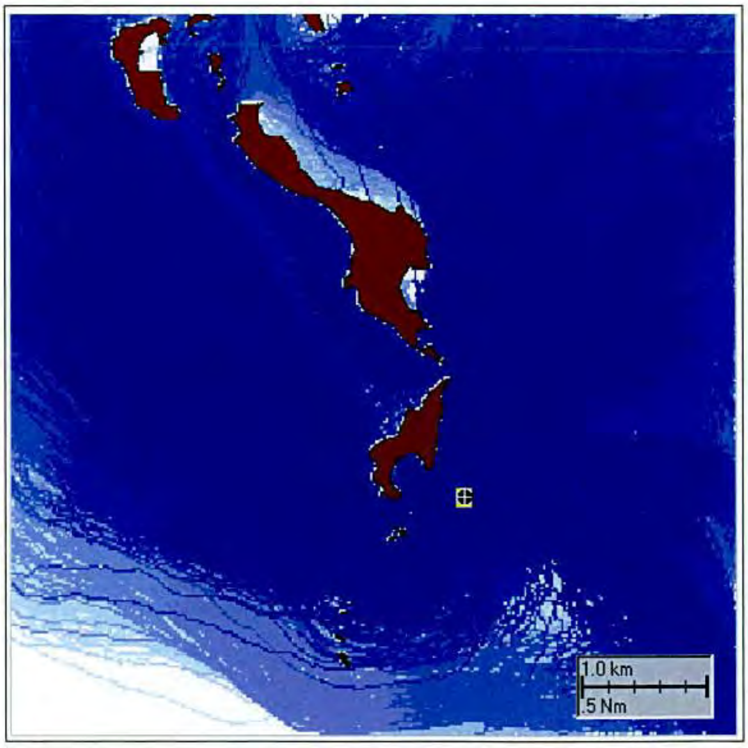


Figure 35b. Proximate modelling results, 500 kg spill, summer, minimum time to contact.

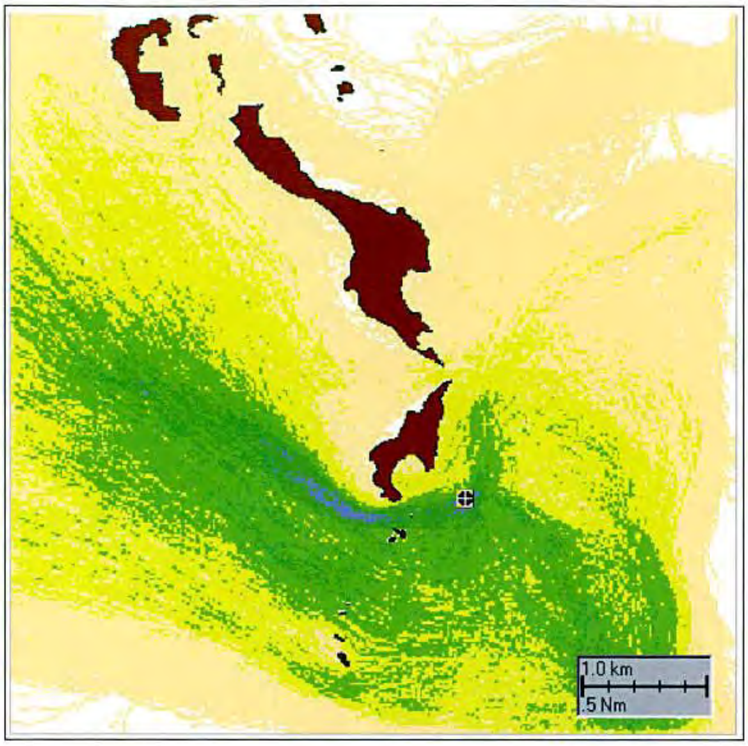


Figure 36a. Proximate modelling results; 500 kg spill, winter, probability of contact.

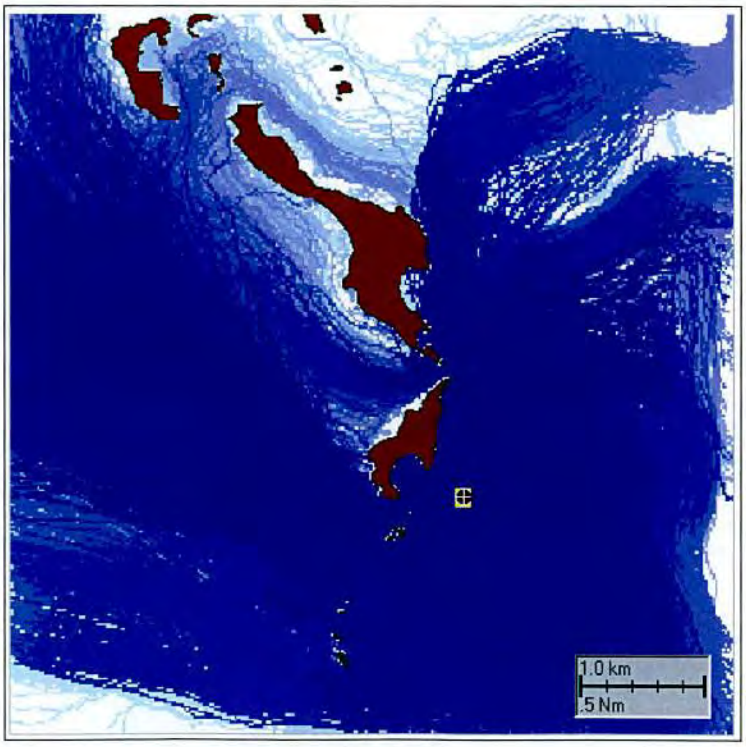


Figure 36b. Proximate modelling results; 500 kg spill, winter, minimum time to contact.

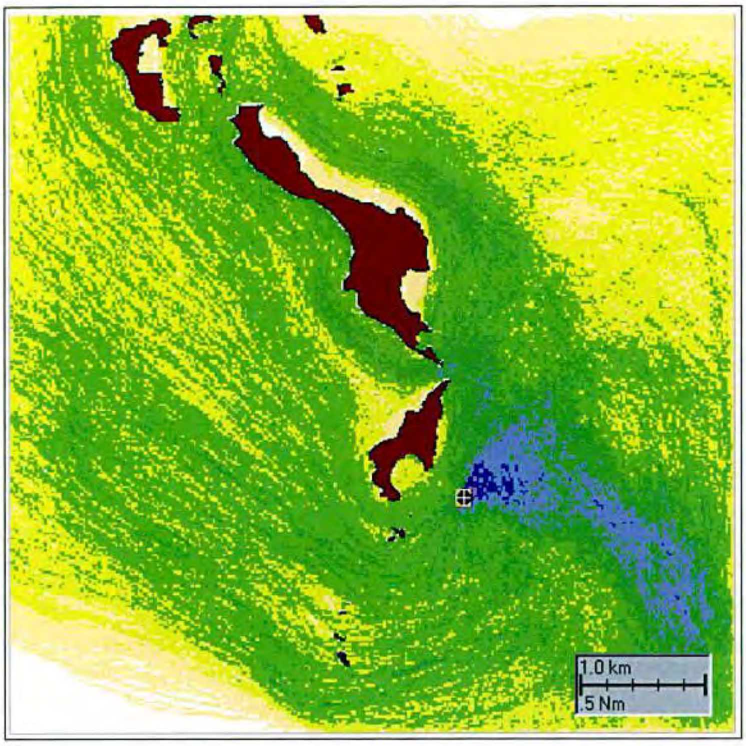


Figure 37a. Proximate modelling results; 12,500 kg spill, summer, probability of contact.

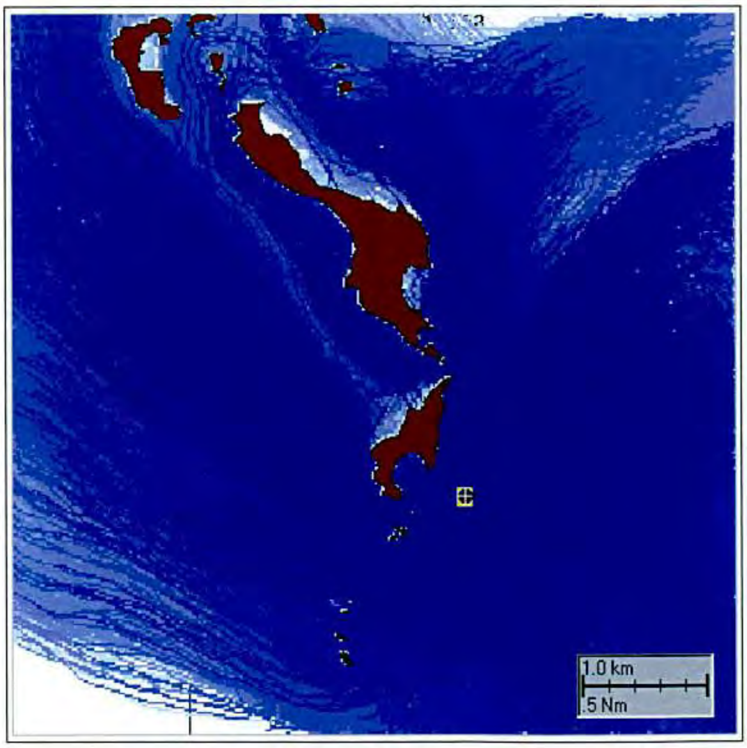


Figure 37b. Proximate modelling results; 12,500 kg spill, summer, minimum time to contact.

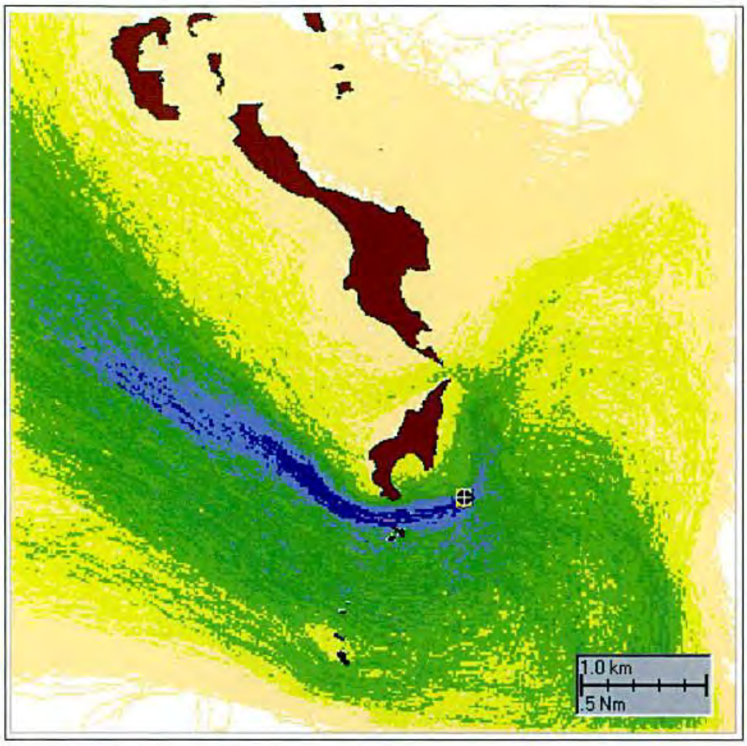


Figure 38a. Proximate modelling results; 12,500 kg spill, winter, probability of contact.

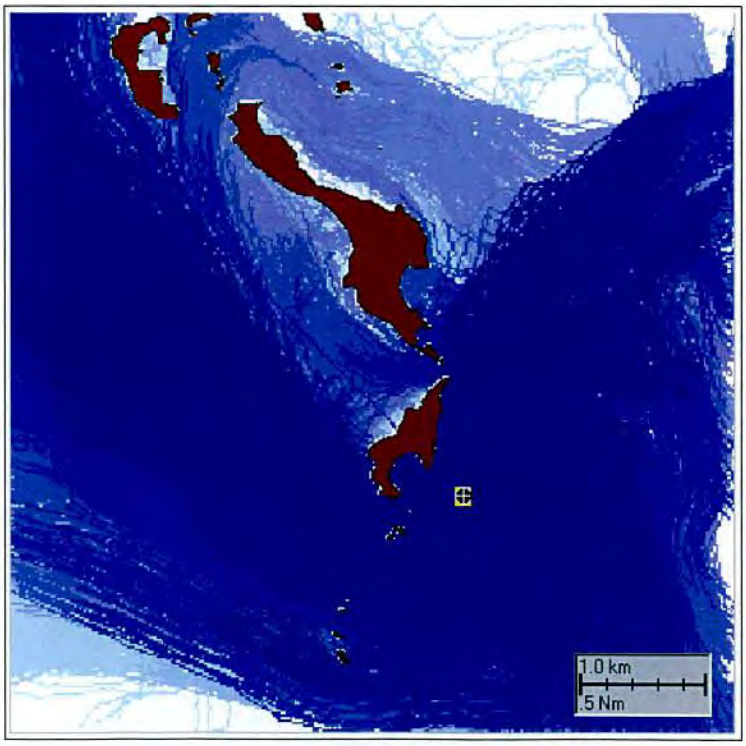


Figure 38b. Proximate modelling results; 12,500 kg spill, winter, minimum time to contact.

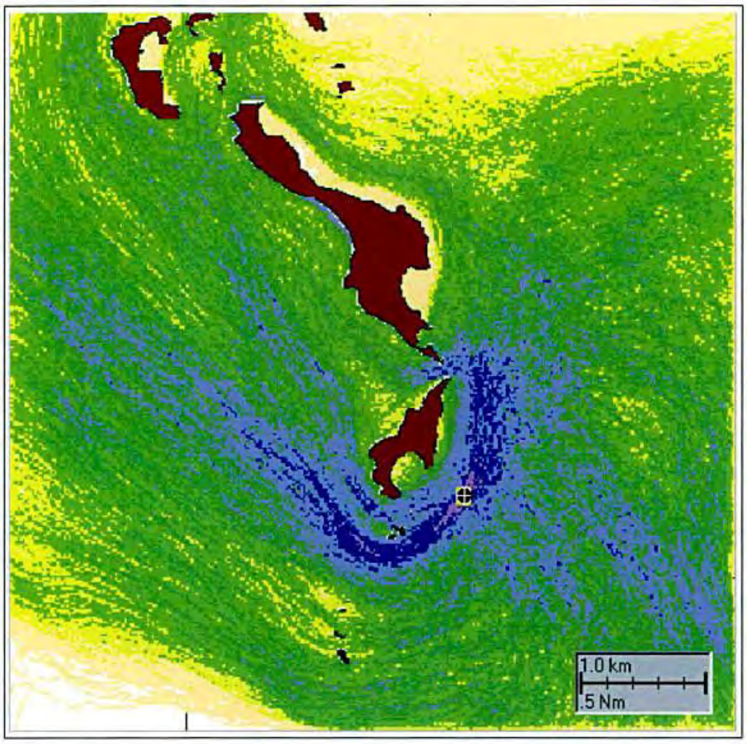


Figure 39a. Proximate modelling results; 100,000 kg spill, summer, probability of contact.

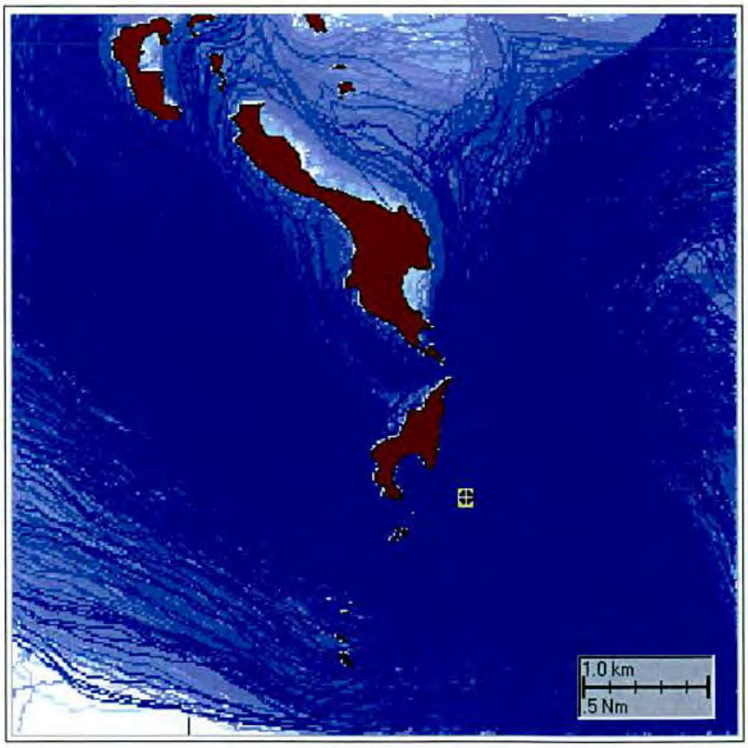


Figure 39b. Proximate modelling results; 100,000 kg spill, summer, minimum time to contact.

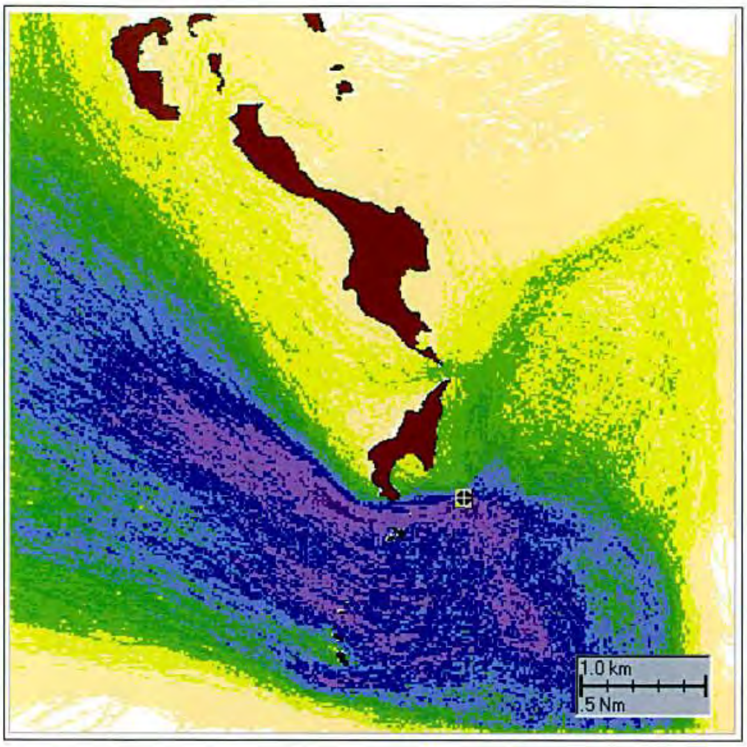


Figure 40a. Proximate modelling results; 100,000 kg spill, winter, probability of contact.

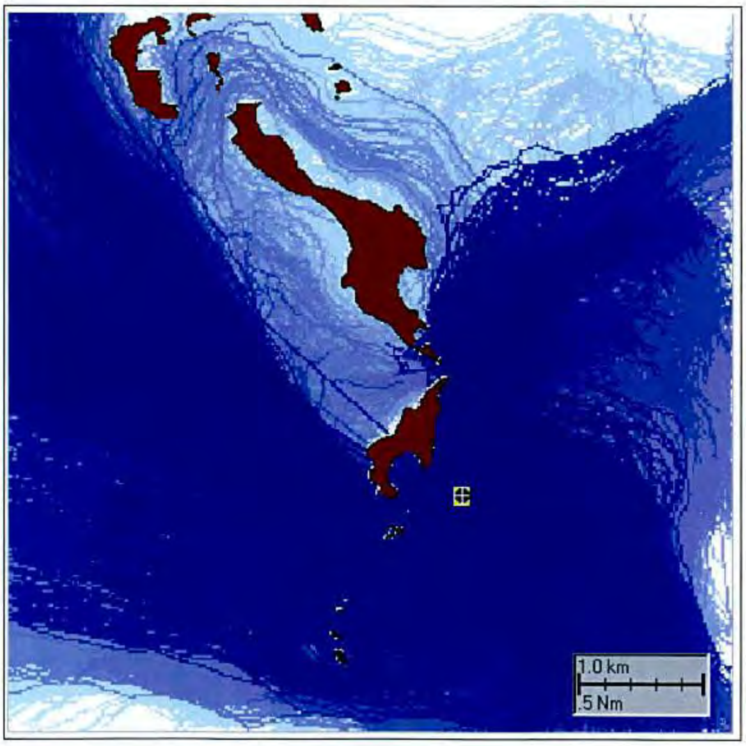


Figure 40b. Proximate modelling results; 100,000 kg spill, winter, minimum time to contact.

Under winter winds, which are predominantly from the east, spills were predicted to most commonly drift into the influence of the strong tidal currents running around the southern end of Abutilon Island, where they were entrained by the currents running between Barrow Island and the Lowendal Islands. A spill within these currents would tend to oscillate backwards and forwards with the tide but with a net down-wind drift towards Barrow Island (see large-scale modelling results). The probability of exposure with the Lowendal Islands, especially the eastern shore of Varanus Island, appears to be to be significantly lower during winter (compare Figure 37a with 38a). However, risks for Barrow Island may be higher.

During both seasons, the minimum time before contact was predicted to be approximately one hour, with Abutilon Island and the southern tip of Varanus Island being the most likely points of contact within this period. The minimum time before oil was predicted to reach individual shores varied with the seasons. For example, the eastern and western shorelines of Varanus Island were predicted to be within two hours of contact during summer winds and within 3-4 hours of contact during winter.

6.1.2 Consequences of an oil spill

The environmental effects of hydrocarbon spills to a marine ecosystem will vary, amongst other things, on the volume of the oil spilt, the toxicity of the oil, the concentration and nature of dissolved or dispersed hydrocarbons, the length of exposure of the hydrocarbons to the weather and ocean, and the sensitivity of individual marine species. Oil degrades naturally in the environment and ecosystems impacted by even a large spill usually recover in a decade or less, particularly in high energy areas.

The environmental effects of a hydrocarbon spill can be manifested as:

- mortality through direct smothering;
- mortality through toxic effects;
- physiological stress that does not lead to mortality;
- bioaccumulation of hydrocarbons for a period after the spill; or
- physical or chemical alteration of habitats that may induce longer term changes in population or community structure.

It is important to place any such changes in context with the natural variation observed in undisturbed marine communities. Such communities are highly dynamic, and change constantly due to natural fluctuations in physical and biological factors such as temperature, cyclone frequency, sand movement, predation, competition and recruitment success.

The complexity and uncertainty of the above factors make it difficult to predict the impacts of an oil spill on biota and habitats. Detailed information of the impact of oil on various resources as found in the scientific literature is given in Appendix 5. An overview of the consequences is summarised in Table 18. We have based the predictions given below on the findings in the scientific literature and reports detailing the outcomes of oil spills in the marine environment.

In determining the effects of an oil spill from the Simpson development, the primary focus is on Abutilon Island and the east side of Varanus Island due to their proximity to the proposed development location. However, the effects are dependent on the size of the spill. The potential effects of a large oil spill (e.g. 100,000 kg) are given below, but note that the probability of such a large spill occurring in the first instance is very low. The chances of a small spill (e.g. 500 kg) are higher, but the impacts would be minor and short-term.

The effects of a large oil spill on the other islands of the Lowendal group, Barrow Island and the

Table 18: Overview of the consequences of an oil spill of light crude on natural and social resources.

Resource	Importance	Impact	Recovery Time
Plankton	Component of marine food chain. Primary producers. Many marine species have larval form in plankton.	Major impact will be to plankton on surface of water where oil is located. Plankton in water column may be affected as light crude is somewhat soluble.	Immediate Spatial movement and effective reproductive strategies will result in rapid recovery.
Subtidal seabed communities	Potentially high biological productivity. Feeding grounds for turtles, dugongs and fish.	Effect minimal except in shallower waters where oil may reach the seabed. Toxic components in oil may affect flora and fauna. Heavier oil may persist in sand sediment for period of time.	1 year Rapid recovery due to spatial movement of animals and high reproductive capacity of colonising species.
Rocky intertidal shores	Dominated by oysters and barnacles. Includes array of other fauna and flora. Rock platforms used by birds.	Damage by smothering or toxic effects. Oil may not adhere to rock for long period of time. Low potential for oil accumulation except in crevices and pools. Natural cleansing by waves reduces persistence of oil.	1-2 years
Mud tidal flats	Supports mangrove communities. High productivity. Feeding grounds for wading birds.	Oil may not penetrate very deep due to fine sediment. Burrows of animals may act as pathways for oil, assisting penetration. Severe impact to fauna may lead to reduced food supply for wading birds.	2-10 years Dependent on penetration of oil and tolerance of animals.
Sandy beaches	Turtle nesting grounds, associated fish species in shallow waters off sandy beaches.	Accumulated oil may affect nesting turtles or hatchlings on their way to the ocean. Some oil may penetrate into sand and persist for a period of time. Seepage of accumulated oil may impact fauna.	2-10 years Dependent on penetration and accumulation of oil.
Algae and seagrass beds	Stabilise shoreline and seabed. Highly productive. Food source for turtles and dugongs. Nursery grounds for marine invertebrates. Provide shelter.	Algae is considered to be relatively resilient to oil. Intertidal seagrass beds most prone to damage. Tolerance to oil varies amongst species. Depressed growth rate, leaves turning brown, covering by algae are reported responses. Animals associated with seagrasses could be heavily impacted.	Algae – 1 year Seagrass – 1 year – decades
Corals	Provide habitat for high density and diversity of animals. Nurseries for many fish. Importance for tourism.	Minimal impact if coral remains submerged and oil is mixed in the water column. Localised tissue rupture, increased algae growth, excessive mucous production are potential responses. If coral dies, habitat composition may change to predominantly algae. Some corals long lived and slow growing Recovery dependent onrecruitment success.	1 year – decades
Mangroves	Highly productive. Source of food and shelter for wide diversity of organisms. Nursery grounds for some marine species. Stabilise shoreline.	Oil may persist for long time in sediment, especially where penetration has occurred (*i.e.* down animal burrows). Response range from defoliation, chlorosis and death of trees due to toxic impact. Infauna may be decimated by oil due to its toxicity.	Trees – 10-50 years Fauna – 2-5 years

Table 18: Overview of the consequences of an oil spill of light crude on natural and social resources (cont.).

Resource	Importance	Impact	Recovery Time
Fin fish	Commercial and recreational value. Contribute to food chain.	Low risk of impact to adults in open water due to mobility. Toxic component may cause tainting or death to fish in sheltered waters. Larvae and eggs floating on surface prone to impact.	Years in enclosed waters
Seabirds	Lovely to observe. Add to biodiversity of area.	Damage to plumage and ingestion.	Slow to medium recovery depending on reproductive potential.
Turtles	Add to conservation status and biodiversity to area. Food source to indigenous people.	May be prone to eye infections if contact madewith oil. Mobile and can therefore avoid oil. Greatest impact will be to nesting turtles and hatchlings. May ingest oil while feeding.	Slow recovery
Marine animals	Add to conservation status and biodiversity of area.	Appear to be able to avoid oil. However, if come into contact, may suffer eye infections, skin irritations, inhalation of fumes, ingestion of oil. Dugongs may be affected if food source impacted.	Slow recovery
Fin fish	Economic value	Oil which contacts fin fish or invertebrate fisheries (crabs, crayfish, prawns) can cause direct mortality or sublethal effects that may inhibit growth and reproduction.Decimation of stocks may result in economic impact.	Slow to medium
Tourism	Economic value	Access to oiled beaches to be avoided, fishing may be restricted and some natural resources used for diving may be restricted for access.	Medium

Montebello Islands are less likely to be compared to Abutilon Island and Varanus Island. This is because there would be greater time for the oil to weather to the degree that the majority, if not all, of the toxic components will have evaporated.

Effects of a large oil spill on the habitats of Abutilon Island and Varanus Island

Spilled oil will disperse into the water column as oil droplets while the soluble components will dissolve into the water column. Photo-oxidation, microbial action and evaporation will contribute to the breakdown of the oil and will start immediately after the spill occurred. However, although the natural break-down of oil commences immediately, the complete breakdown of the oil takes time. Studies carried out by Battelle (1998) on Harriet crude have shown that under mild conditions, with little physical dispersion of hydrocarbons into the water column, volatile monocyclic aromatic hydrocarbons (MAHs) dissolving from the surface slick would be the main contributors to any toxicity observed in the water column. This toxicity would persist from within a few hours to a day after the spill. After the oils weathered on the sea surface for more than a day, nearly all the MAHs would be lost, mainly by evaporation and any remaining toxicity to water column organisms would be caused primarily by dissolved polycyclic aromatic hydrocarbons (PAHs) and phenols.

The depth of water in the vicinity of the Simpson development is an important factor. An oil spill may cause an adverse impact on sensitive species that are found in shallow, subtidal waters. Hydrocarbons may become entrained in the water column in high concentrations before becoming dispersed. Sheltered bays are also vulnerable as hydrocarbons may accumulate for an extended time. Deeper, subtidal habitats will be protected from hydrocarbons due to the overlying water column.

The minimum time to impact to Abutilon Island for any size spill from the Simpson mini-platform location has been estimated to be one hour. This implies that the oil will not be highly weathered and will still retain a high concentration of the toxic components of the oil. Given the shallow depth of water (<6 m), oil droplets and dissolved hydrocarbons may reach the seabed in the shallower waters surrounding the development location, thereby impacting the algal and coral habitats.

Should the algal and coral habitats be adversely impacted, recovery is expected to commence immediately. Algae senescences at the end of each summer in the Lowendal region and re-establishes again in the spring. Recovery of the algal communities may therefore take from one to several growing seasons, depending on the extent and timing of the damage. The epifauna associated with the algae would also recover rapidly once the algae re-establishes itself. The majority of the epifauna have planktonic larvae that would assist in rapid re-colonisation.

Corals located in shallow, subtidal areas exposed to dissolved hydrocarbons are more likely to exhibit sub-lethal responses such as reduced growth rate or inhibited reproductive capacity, rather than mortality. Replacement of corals in habitat impacted by an oil spill would probably be by recruitment of corals from undamaged areas rather than regeneration of any live coral. Coral planulae would be available for re-colonisation from surrounding non-impacted patch and fringing reefs after the spawning season. Potential sources could also be from distant reefs although the specific pathways of larval replenishment are unknown.

The initial result of shoreline oiling is often large scale mortality of plants and animals that live in the intertidal zone. In general, shorelines exposed to high energy waves and strong near-shore currents will recover more quickly than sheltered bays or shallow, subtidal habitats.

The rocky shorelines of Abutilon and Varanus Islands are exposed to high-energy waves and currents that will help break down the light oil that will be produced from the Simpson development. The wave and tidal energy will also help clean the shoreline. It is expected that re-colonisation of the intertidal shorelines by the pre-spill species of fauna and algae will be rapid. Field work carried out during the *Exxon Valdez* spill in Alaska and the *Sea Empress* spill off the coast of Wales have shown that recruitment of the rocky shore fauna started immediately and recovery occurred within a few years (Stoker *et al.* 1992; SEEEC Report Summary 1998).

The small bay to the eastern side of Abutilon Island may be adversely impacted if large quantities of oil get entrained within the bay. This is a sheltered bay so degradation of the oil would occur primarily through evaporation and microbial action. A certain proportion of any free oil present on the water surface within the bay would dissolve into the water column causing a short-term degradation of the water quality and contact with the benthic habitat. In addition, some of the free oil could potentially contact the sandy beaches, soaking into the sand.

Degradation of oil in sandy, intertidal sediments is rapid compared to muddy, finer sand sediments (Baker 1971), but any oil retained in the sand would enter the marine environment during each tide cycle until the oil degraded. Any oil entrained in the sand on the beaches would degrade fairly rapidly given the light characteristics of the oil and the porous nature of the sandy beach sediments.

The impact to the sandy beaches on the eastern side of Varanus Island would be less due to the increased distance to the beaches from the development site allowing weathering of the oil. These beaches are also more exposed to wave and tidal action which would further assist in the degradation of the oil.

Effects of a large oil spill on animal populations

An oil spill from the Simpson development is expected to have little impact on regional adult fish populations. With respect to fish larval kills and consequential impact on population levels, large numbers of larvae would have to be destroyed to affect recruitment (Hurlbut *et al.* 1991). Large scale impact to fish larvae is unlikely given that larvae tend to have a patchy distribution over a large spatial scale. Only a small portion of the fish population or larvae would be impacted and this would probably be confined to the shallower waters in close proximity and immediately following a spill. Hydrocarbons are unlikely to bioaccumulate in fish due to the low concentrations expected in the water column and rapid rate of breakdown of the oil.

The effects of an oil spill on bird, turtle and mammal populations would be dependent on the time of year the spill occurs and the impact of the oil spill on their food source. With respect to the Barrow/Lowendal/Montebello region, a spill that occurs in the summer breeding season will have the greater impact, as the animal abundances are the highest during that time. There are fewer animals present during the winter months, so a lesser impact would be expected.

Birds are often the most conspicuous casualties of an oil spill. The most vulnerable time for birds in the Lowendal area is during the summer breeding period and the species most likely to be impacted are the seabirds such as shearwaters, terns and silver gulls.

While wedge-tailed shearwaters feed more than 40 km from breeding colonies, many shearwaters raft at dusk within sight of the islands they breed on. Significant oiling could occur if they are rafting during the chick-rearing period when the males and females change over. Small amounts of crude oil on the feathers have been found to significantly reduce breeding success in Hawaiian wedge-tailed shearwaters (Fry *et al.* 1986). Trace oil can destroy the water-proofing of adults, be ingested by preening adults and be fed from adult to chick.

Wedge-tailed shearwater populations in the Pilbara have been in decline over the last decade due to oceanographic changes driven by the El Nino Southern Oscillation (ENSO). The prolonged ENSO event between 1991 and 1994 significantly reduced the number of shearwaters excavating burrows on a number of the islands on the NW Shelf (Astron 2000). Population numbers have recovered slightly but they have not regained their pre-1991 numbers.

If an oil spill occurred which adversely impacted the shearwater populations breeding on the Lowendal Islands, the recovery rate would depend on the size and age structure of the pre-breeding pool (Fry *et al.* 1986). Given the decline in the Pilbara population (including the populations breeding on the Lowendal Islands) recovery would be slow. Recovery could potentially occur to pre-spill numbers through breeding and new recruits.

The potential impact of an oil spill on the various tern populations would again be dependent on the time of year the spill occurred. The highest population numbers occur in the summer months, and only part of the population would probably be affected in the event of a major oil spill. If one season's population collapsed due to an oil spill, the local populations would still recover over time through breeding and new recruits recolonising the area.

Little is known about the impacts of oiling on turtles. Females would be the most vulnerable during the summer egg-laying period. Males would be less vulnerable as they stay offshore and can move away from a spill. Hatchlings would be vulnerable in the late summer months when they emerge from their nests and head to the water. An oil spill is not likely to cause a collapse of the local or regional population should a spill adversely affect the female population that nests on Lowendal Islands during one season, as not all turtles come back to the beaches every year. Thus, turtles that did not breed one year would be available for breeding in subsequent years. An ongoing pool of females will contribute to the recovery of the local populations. In addition, Abutilon Island is not a major nesting beach. Beaches on Varanus Island are more important as nesting sites and a spill originating from the proposed Simpson location will have a lesser effect on these beaches as the oil will have had time to weather prior to reaching these beaches.

It is anticipated that a spill from the Simpson location will have a minor, if any, impact on cetaceans and dugongs. These animals are found in very low numbers and have the ability to move away from an oil spill. Minor or no impact to mammals was recorded from the *Exxon Valdez* or the *Sea Empress* spills (Stoker *et al*. 1992; SEEEC Report Summary 1998).

6.2 Mitigation Measures to Prevent Accidental Oil Spills

The quantitative risk assessment indicated that the chance of an incident occurring that resulted in the spill of oil into the marine environment is very low. A smaller volume leak associated with the pipeline is more likely to occur than a potentially larger event associated with a production well.

As part of the Environmental Hazard Identification Workshop, safeguards for the proposed Simpson development were identified which would minimise the risk of an event occurring or minimise the impact of an event. The key safeguards are summarised in Table 13 and discussed below.

6.2.1 Pipeline bundle safeguards

A continuous corrosion control system will be put into place. This will be accomplished by utilising electrical resistance probes that measure the rate of corrosion in the pipeline. The rate of corrosion will be continuously monitored and recorded through the Varanus Island control room. By utilising this data, the corrosion inhibitor dosage rate will be adjusted to effectively eliminate corrosion in the pipeline. In addition, all relevant personnel will undergo a corrosion awareness training program. The aim of this program is to train the relevant personnel about the causes of corrosion, how to identify its sources and its management. This training program applies to all operations of the Varanus Island Hub, which includes the Simpson development.

The pipeline will be trenched where significant boat traffic occurs. Although the trenching activities will result in a short-term localised impact to the seabed and water column, it will reduce the risk of anchor damage.

A heavy walled pipe, rated to the full well pressure possible from any of the production wells will be used to carry the hydrocarbons and produced formation water. This pipe will be designed and tested as per the relevant codes and standards for pipelines. These include standards set by the Australian and British Standards, Australian Petroleum Institute, American Institute of Steel Construction, the International Maritime Organisation, and Apache construction specifications.

Automatic shutdown valves will be installed at the exit of the production pipeline from the mini-platforms and at the point where the offshore production pipeline crosses the shoreline (Figure 3). These pipelines will have the capacity to shutdown within 60 seconds. A manual shut down system will act as a back-up.

The number of potential leak points along the pipeline carrying liquid hydrocarbons and produced formation water will be minimised by reducing the number of connection points, valves and flanges to as few as possible.

A routine inspection program will be developed under the requirements of the PSLA. The onshore portion of the pipeline will be places on brackets to keep the pipeline off the ground. This will aid in maintenance as will as corrosion control.

6.2.2 Wells and topside safeguards

The overriding philosophy used in designing the wells is that for any hydrocarbons to escape from the well would require the hydrocarbon to break through two pressure tested barriers. These two barriers include an inner casing which contains the production tubing sitting inside the outer, thick-walled casing. This type of facility design will minimise the risk of an uncontrolled release to an estimated 1.1×10^{-6}.

Other mechanisms used in minimising the risk of a large oil spill include the type of material used and the construction design. For example, the hydrocarbons and produced formation water will flow through tubing that is made of chromium steel that is basically impervious to corrosion. The christmas trees atop each well are forged from a single stainless steel block to minimise the number of connection points and increase its strength.

A fail-safe automatic shutdown system will be put into place that includes a series of shutdown valves at the well and along the pipeline (Figure 3). Shutdown valves will be placed within each well, on top of each well, at the inlet to the production pipeline and at the valve station at the shoreline crossing. Loss of pressure due to process upset, for example, a leak from the pipeline or a loss of well control, would automatically shut down all these valves in less than 60 seconds.

6.3 Oil Spill Response Actions and Strategies

Details of response actions and strategies to be taken in the event of an oil spill from any of Apache's activities in the Varanus Island Hub are detailed in Apache's North West Shelf Oil Spill Contingency Plan (OSCP) Volume 1 – Operations (Apache Document AE-00-EF-008/Rev1).

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

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

Response strategies to spillage include the following principal options:

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

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

The path of any spill would be modelled using Apache's in-house oil spill trajectory modelling programme, SIMAP. This would be undertaken in conjunction with aerial helicopter surveys and vessel surveys. In addition, an effort to contain, redirect or divert any spillage away from the beaches of Abutilon Island and the nearby coral assemblages should they be likely to be impacted.

Given the presence of corals in the immediate area, no dispersants would be used if the oil moved towards the shorelines. The shorelines are most at risk in summer due to turtle breeding and nesting, and seabird roosting and nesting. Containment and recovery, and shoreline deflection and/or clean-up would be used in the event that the oil approaches or reaches sensitive resources from the Simpson development.

Apache has recently purchased an 8.5 m shallow draft, diesel powered fast response vessel for oil spill contingency purposes. This vessel is suitable for access to shallow water areas in the vicinity of Varanus Island. It is designed to carry and deploy zoom booms and shallow water shoreline booms. The vessel will be trailer launched and access to any of the Lowendal or Montebello Islands will be rapid. For example, the travel time between Varanus Island and Abutilon Island is less than 10 minutes. This fast response vessel will be in addition to the Varanus Island support vessel that is capable of deploying the sea curtain boom in deeper waters.

Table 19 details the response strategies to the various natural resources within the immediate area of the proposed Simpson platform sourced from Apache's OSCP, Volume 2 – Environmental Atlas (Apache document AE-00-EF-008/2).

Apache's OSCP Environmental Atlas details the response strategies and natural environmental resources for the North West Shelf. An example of the information contained in the atlas for Abutilon Island is presented in Table 20 and Figure 41.

6.4 Other Accidental Events

6.4.1 Dropped objects

Objects may be dropped accidentally from the Simpson mini-platforms or vessels associated with pipe-laying. Such events are unlikely and if they occurred they would, at worst case, result in a small, localised impact to the seabed. This impact would be negligible as the seabed consists of sand, limestone reef and macroalgae. Any dropped objects would be removed from the seabed and the area would be re-colonised by marine flora and fauna.

6.4.2 Chemical spills

Chemical spills may result from the accidental leakage of hydraulic fluid or chemical inhibitors used in the wells. Such an event would likely result in a localised and transient change to water quality near the platforms or pipelines because the spill volume would be small. Measures to reduce the risk of chemical spills include;

- bunding and drainage to a sump on each of the platforms;
- the use of small volumes of chemicals and the practice of installing minimal storage capacity on Varanus Island rather than on the platforms; and
- inductions to all project personnel covering chemical management.

Table 19: Classification of resources to sensitivity codes and oil response and clean-up options.

Coastal Feature	Sensitivity	Comments	Protective Measures	Clean-Up Methods		
				Preferred	Possible	Avoid
Mangroves Intertidal Sand & Mudflats	S1	Low energy areas. Oil may penetrate substrate and persist for long time. Important nursery and spawning areas. These areas should receive high priority for protection & clean-up.	2,3	1,7	3,14	5,8,10, 11,12, 13
Coral Reefs	S1	High sensitivity to oil. High priority to be given to barrier reefs which may be exposed to floating oil. No dispersants to be used.	2,3	1,3,7	8	5,9,10, 11,12
Pearl Leases	S2	Oil pollution can cause severe economic damage, but resource can be replaced.	2,3	7	3,13	5
Intertidal and shallow subtidal Limestone Platform	S3	Some short term reduction in macroalgae and abundance of animals may occur – should recover quickly after oil weathered.	2,3	7	3,8	9,10,11, 12,13
Sandy Beaches	S3	Clean-up priority to be given to turtle nesting beaches. S1 priority to be given during peak turtle nesting season (Nov-Feb).	1,2,3,4	1,3,6,7,8	9,14	5,10,13
Jetties, Piers	S3	Short-term disruption to amenity. To be cleaned as a priority.	2,3	1,3,6,7,8	9,12	5
Exposed Rock, Shores & Cliffs	S4	Wave reflection may keep oil offshore. Landed oil will weather quickly. Animals will recolonise quickly. Oil may accumulate in cracks & tide pools.		7	9,12,13	10,11
Open Water	S4	Monitor direction and spread of spill.		7 *5 if oil may return to shore*		

Protection & Clean Up Option

1 Containment & recovery using booms
2 Divert to less sensitive area or shore
3 Sorbant materials
4 Earth/sand barriers
5 Chemical dispersant
6 Skimmers, vacuums
7 Natural cleansing (leave alone)
8 Manual clean-up of oil
9 Low pressure seawater flushing
10 High pressure seawater flushing
11 Hot water steam cleaning
12 Low pressure warm seawater wash
13 Mechanical cleaning of oil or substrate removal
14 Bioremediation

Sensitivity Code

S1
Extreme Sensitivity
High protection & cleanup priority

S2
High Sensitivity
Protection & clean-up priority as resource use & circumstances dictate

S3
Moderate Sensitivity
Protection & clean-up priority as resource use & circumstances dictate

S4
Low Sensitivity
Low protection & clean-up

6.4.3 Litter

Apache will undertake to reduce packaging and other potential waste material through the prefabrication and fit-out of the platforms at the place of construction, prior to transporting the facilities to site. Installation wastes, being predominantly used welding rods and grinding disks, will therefore be minimal. All wastes during the short installation phase will be collected and returned to Varanus Island for disposal. Inductions covering waste management will be given to all project personnel and waste disposal bins will be provided. The operation and maintenance of the platforms will not result in the generation of any waste that has the potential to become litter in the surrounding marine environment.

Table 20: Example of resource and response information for Abutilon Island contained in Apache's Environmental Atlas.

Abutilon Island

Atlas map reference: D.2.1

DESCRIPTION	
Shoreline/Intertidal Habitats	• Rocky undercut cliffs and intertidal limestone platforms. • Few sandy beaches and sand spits.
Shallow Subtidal Habitats	• Limestone pavement and reefs. • Isolated corals and coral bommies offshore. • Macroalgal beds.
Key Natural Resources	• Rocky reef fauna. • Macroalgae and associated fauna. • Sandy beach fauna and habitat for nesting turtles. • Seabird nesting (terns). • Mangroves. • Corals.
Timing of Significant Ecological Events	• Sept to March: turtles nesting/hatching on beaches. • March/April: coral spawning. • Nov to Feb: bridled terns nesting. • Mar to Aug: crested terns nesting.

RESPONSE STRATEGY	
Spill Response	• Deflection of oil away from shoreline towards open sea. • Oil may be deflected to a sacrificial rocky shore to protect nesting beaches. • Propeller wash to disperse oil at sea allowing dilution of oil before entering shallows.
Dispersant Use	• No dispersant use on or close to shore, avoiding exposure to intertidal and shallow subtidal habitats.
Access to Area	• Helicopter • Shallow draft vessels only.
Clean-up methods	• Sorbent booms and materials to sop up oil on rocky shores. • Mechanical collection of stranded tar balls or oily films using rakes and shovels. • Use of heavy equipment only if turtle nests and hatchlings and seabirds are not threatened. • Removal of contaminated sand layers to bunded area on Varanus Island. • Natural cleansing.

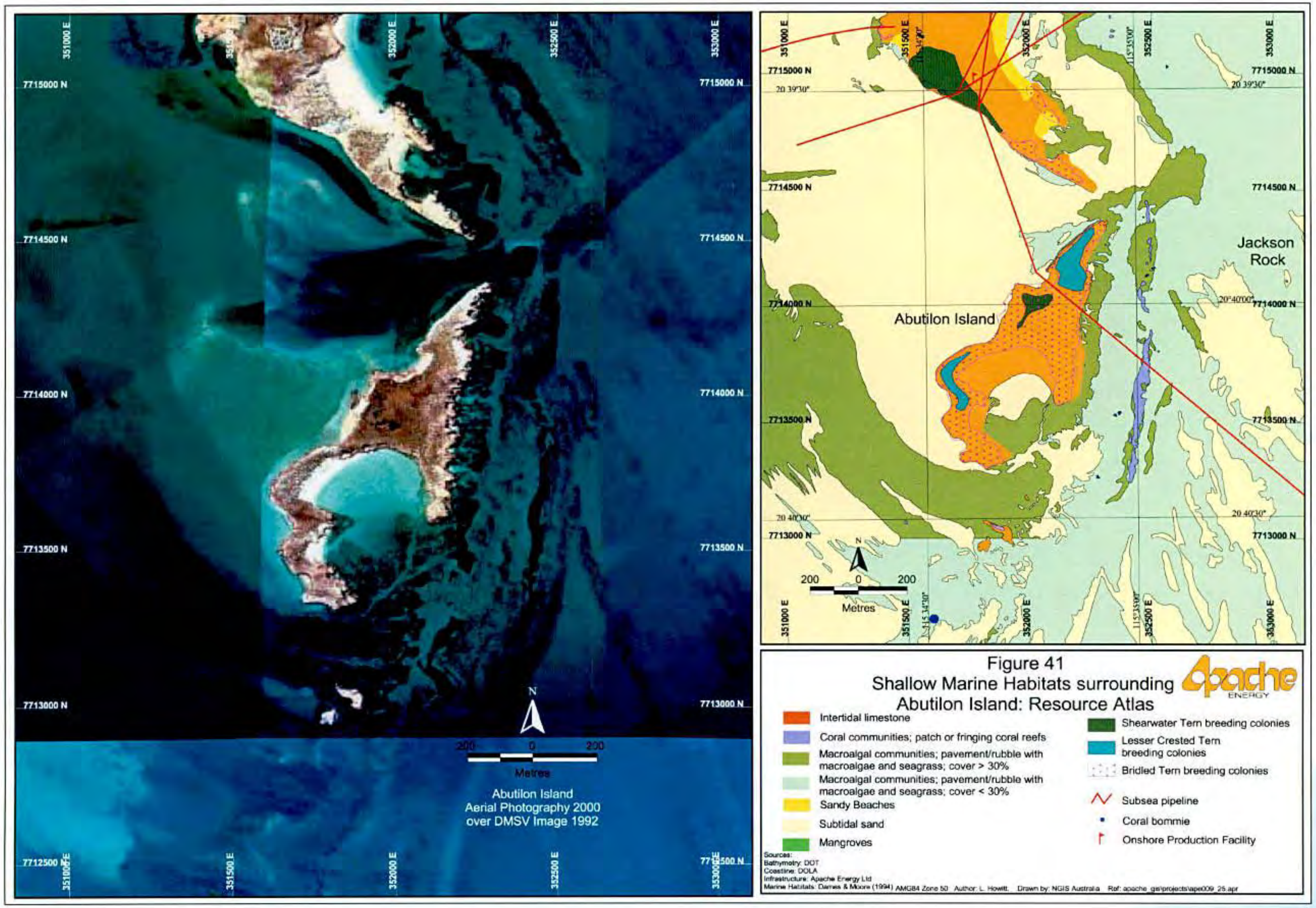


Figure 41
Shallow Marine Habitats surrounding Abutilon Island: Resource Atlas

6.4.4 Introduction of pest species

Islands

The Lowendal Islands are a declared nature reserve for the conservation of flora and fauna and are managed to prevent the introduction of pest species such as;

- vermin – house mouse, black rat and cat;
- insects – European bees, ticks and wood borers; and
- weeds – e.g. buffel grass, kapok.

A quarantine procedure to manage this risk is required under the terms of CALM's lease for Apache's operations on Varanus Island. Apache's quarantine procedure involves controls to prevent the transportation of such pests from the mainland to the islands. These controls help to ensure that Apache's contracted warehouses in Perth and Dampier, as well as the freight stored within them, is free of any such pests and weeds. The quarantine procedure will be strictly adhered to by all activities associated with the Simpson development.

Abutilon Island is a declared reserve for the conservation of flora and fauna. No access to Abutilon Island will be permitted during the installation and operation phases of the Simpson development.

Ballast water

Ballast water may be carried by tankers travelling to the Varanus Island marine loading terminal in order to provide stability to the vessel and to adjust the vessel's trim to assist with steering and propulsion.

An unladen vessel will pump seawater into the vessel's ballast tanks prior to departure from a port or loading terminal. This ballast water is then either released at sea, along coastlines or in other port systems during the vessel's reloading with cargo. A mix of marine organisms is subsequently transported and released into marine environments as a result of the uptake of ballast water in one region and the discharge of this seawater at another. The risk associated with the exchange of ballast water is the unintentional introduction of marine species that could cause adverse ecological impacts.

Presently, ballast water exchange is the only effective management tool to reduce the possible risk of introduction of deleterious marine species. Ballast water exchange involves replacing coastal water from harbours with open-ocean water during the voyage. This process reduces the density of coastal harbour organisms in ballast tank waters with oceanic organisms that have a lower chance of survival in nearshore marine environments.

The Australian Quarantine and Inspection Service (AQIS) Australian Ballast Water Guidelines list the voluntary procedures for the discharge of ballast water and sediment from ships entering Australian waters from overseas. From July 2001, all vessels arriving at their first Australian port of call must provide a vessel's agent with the AQIS ballast water pre-arrival report form. The information that must be provided includes the last location of ballast uptake, the method of ballast water exchange and its location, and the volume of ballast water discharged at the first Australian loading port.

The ballast report must be submitted to AQIS 12-24 hours prior to arrival of the vessel at the port, which will help AQIS identify if the ballast water will pose a risk of introducing exotic marine pests. High risk ballast water will require management by methods acceptable to AQIS before ballast can be discharged within an Australian port.

The majority of the oil tankers that come into Apache's marine loading terminal originate from Australian ports and not all discharge ballast water. Table 21 lists the vessels that offloaded oil or condensate at the Varanus Island terminal in 2000. The table also lists the last port prior to arriving at Varanus and the tonnage of ballast discharged. Only two vessels, from Vietnam and Japan, discharged ballast water at Varanus. These two vessels departed from the northern hemisphere and exchanged ballast in the open seas south of Singapore and north of Western Australia prior to arriving at the Varanus loading terminal.

The remaining vessels that arrived at Varanus carried part loads and did not need to discharge ballast. The coastwide trade of crude oil usually results in vessels arriving at Varanus already partially loaded with crude oil taken on board from other Australian oil loading terminals. Ballast is usually not carried by such vessels that are partially loaded above approximately 45 –50 % of the vessel's cargo tonnage as this onboard cargo provides enough weight for stabilisation. Therefore, most vessels do not discharge ballast at the Varanus marine terminal as they have previously discharged their ballast at another port.

The risk of unintentional introduction of marine pest species through the exchange of ballast water to the surrounding marine waters of Varanus Island is not considered to be a significant risk. This is due to the majority of Apache's trade of crude oil being within Australian waters and the ongoing management of this issue through the AQIS guidelines and compulsory ballast reporting requirements.

Table 21: Crude oil tanker visits to Varanus Island marine loading terminal and discharge of ballast water in 2000.

Date	Vessel name	Last port of call	Ballast exchanged at	Ballast (Tonnes) Discharged at Varanus)
February	MT *Shilla Spirit*	Vietnam	Open seas south of Singapore	1,822
March	*Banda Sea*	Brisbane	Not required	0
April	MT *British Spirit*	Kwinana	Not required	0
May	MT *Koyagi Spirit*	Barrow Is.	Not required	0
June	MT *Torres Spirit*	Northern Endeavour FPSO	Not required	0
August	MT *Leyte Spirit*	Barrow Is.	Not required	0
September	MT *British Success*	Brisbane	Not required	0
October	MT *Olympic Spirit*	Japan	Open sea south 1,000 km NW of West. Aust.	6,740
December	Mt *Leyte Spirit*	Barrow Is.	Not required	0

7 Summary of Impacts from the Proposed Simpson Development

7.1 Summary of Impacts from Installation and Routine Activities

The impacts associated with the installation and routine operational activities of the Simpson development are summarised as follows.

7.1.1 Installation of facilities

The installation of the Simpson mini-platforms and the laying of the pipeline bundle will not cause a significant impact to the habitats, flora and fauna found in the region. There are no listed threatened ecological communities as defined in the EPBC Act.

Installation will take about two weeks and will result in a short-term, localised impact to the seabed. Installation activities for the Simpson development will restrict habitat disturbance from anchoring and marine pipeline laying activities to areas that are predominantly sand veneer overlaying limestone pavements. This habitat is well represented within the surrounding marine environment (70% or roughly 21,000 hectares of the area ground-truthed and mapped by Apache) and is not a listed community. It is estimated that there will be a short-term disturbance to 1,700 m^2 (0.17 hectare) of soft bottom, algal and sand habitat during the laying of the pipeline bundle. The short-term, localised disturbance caused by the laying of the pipeline bundle is insignificant on a regional scale.

No impact to any coral habitats in the adjacent areas to the west or north of the mini-platform and pipeline bundle locations will occur. Anchoring and pipeline laying activities will be managed by developing an anchoring plan using mapped habitat data which will control the placement of all anchor sites and pipeline bundle route locations being placed away from patch and coral reef areas. Work will be done outside the coral spawning period.

Trenching of the small section of the pipeline bundle in the vicinity of the East Jetty will result in an increase in turbidity that will be localised and for a short duration. Trenching is expected to take two days. The seabed along the portion of the pipeline bundle to be trenched consists of bare sand. The seabed adjacent to the proposed route consists of limestone pavement that is covered with macroalgae, patches of lithophagid sponges and an occasional singular coral. Trenching is not expected to result in any long-term impact. Once the trenching is complete, subsequent tide movements will re-establish sediment conditions similar to pre-disturbance conditions which will allow re-colonisation of the area. Trenching will also prevent the pipeline from acting as a groyne.

The installation activities for the Simpson development will not significantly impact any of the listed endangered species or non-listed species found in the region. These activities will not affect the life histories of any of the local populations: that is, there will not be a marked change in the size of the local populations, existing populations will not be fragmented, and the breeding cycles of the key species will not be disrupted.

It is proposed to carry out the installation of the mini-platforms and pipeline bundle in late September. The mild winds at this time of the year provide the best weather window to carry out the installation activities; strong winds while working in shallow water can prolong the time needed to carry out the work. The proposed installation time is before the peak seabird breeding season and turtle nesting season. In addition, personnel will not be allowed to access any of the islands.

Other species, such as cetaceans and dugongs, will be present at this time of the year, but their population numbers around Abutilon and Varanus Islands are low and it is unlikely that they will be impacted by the installation activities. It is unlikely that the installation of the mini-platform and pipeline bundle will affect the fish populations.

Noise generated during the installation of the mini-platforms is not considered to be a significant impact as this disturbance is estimated to only last for a day at each mini-platform and will occur outside the summer seabird and turtle breeding period. The noise is not expected to impact any other fauna. Fish and dolphins may approach the barge out of curiosity, but no impact is expected to these animals.

Similarly, the effect from light sources associated with the installation of the mini-platform pipeline bundle will be of short, temporary duration and is not expected to impact marine or terrestrial animals.

No wastes will be discharged to the marine environment. These wastes consist of sewage, domestic wastes, oily water, hydrotest water, and produced formation water. The only exception will be a small volume of grey water associated with hand basin washings from the barge.

The installation of the pipeline bundle at the shoreline crossing will entail placing the bundle within a trench excavated through the existing boulders and cement blocks and covered by a rock armory. This will protect the pipeline bundle and shoreline against wave activity and storm damage. The rocky shore fauna will use the rock armory.

The onshore pipeline bundle will traverse previously disturbed areas and will not impact upon the east shearwater rookery. Pipeline laying will occur at the time when shearwaters only start to arrive on the island for the breeding season. Pipeline laying will only occur during daylight hours and will therefore not affect the birds nightly courting behaviour.

7.1.2 Operational activities

The routine activities associated with producing oil from the Simpson field will not cause a significant impact to habitats, listed endangered species or non-listed species found in the region.

Produced formation water will be separated by the processing plant on Varanus Island and disposed either via the Alkimos or Tanami-5 deep disposal well. No PFW recovered from the Tanami and Simpson wells will be disposed to the open ocean. Any residual process chemical required for scale, microbiological or corrosion control will remain mixed within the PFW and similarly be disposed to the deep wells.

Noise levels associated with the operation of the two mini-platforms will be minimal. Noise generated from the operation of the mini-platforms is restricted to breakout noise from pipes on the platform, closing and opening of valves and the occasional operation of an instrument air operated pump associated with the sump drain on the platforms. It is expected that operational noise levels will have no impact on the wildlife on Abutilon Island.

The mini-platforms will not be visited by operational or maintenance personnel during the night. Therefore, there is no requirement to install lighting on the platform. The only light source will be a single pulsating navigation light required by maritime regulations. This light source is unlikely to cause a significant impact to turtle, seabird or other animals.

No waste-water will be generated from the day to day operation of the mini-platforms. Rainwater collected from each of the mini-platforms will be directed to a sump that is baffled to act as an oil interceptor containing any hydrocarbons. Periodical maintenance visits to the mini-platforms will pump any contained liquids in the sump back to Varanus Island for treatment via the oil processing circuit.

There are no significant atmospheric emissions associated with the Simpson development. The main emission source is the gas compressor to be installed on Varanus Island, which pressurises the separated gas stream prior to it entering the existing gas processing plant. This compressor will be fuelled by natural gas. The contribution of the Simpson development to increasing Varanus Island greenhouse gases is not considered significant as the increase in greenhouse emissions from the Simpson development is more than compensated for by the reduction in greenhouse emissions from existing, declining fields.

Production from Simpson will not increase oil tanker traffic above levels previously recorded from the Varanus Hub operations as the introduction of the Tanami and Simpson wells will be replacing production from other declining oil fields.

The mini-platforms will probably become fish attraction devices (FADs). No fishing will be allowed on or near the mini-platforms, so these areas will, in essence, become fish habitat protection areas for the duration of the project.

The decommissioning of the Simpson development will require the production and disposal wells to be plugged; the platforms and pipelines removed unless otherwise approved by the appropriate Minister(s); and the casings cut just below the seabed. A decommissioning plan will be prepared one year prior to the proposed dismantling of the project and submitted to government for approval.

7.2 Summary of Impacts from an Accidental Event

7.2.1 Oil spill risk assessment overview

The chance of an incident occurring that resulted in the spill of oil into the marine environment has been assessed as being a low probability event. Although the overall probability of a spill occurring is small, the quantitative risk assessment indicated that a smaller volume leak associated with the pipeline is more likely than a potentially larger event associated with a production well.

There is a high probability that oil will contact a shoreline should a spill occur offshore. The Lowendal Islands are at the greatest risk regardless of season and prevailing wind conditions. The overall risk to shorelines, that is, the probability of a leak occurring in the first instance that would result in contacting a shoreline, ranged between 0.9×10^{-7} to 2.0×10^{-3}, which is considered a low risk.

Technical and management mechanisms such as:

- bunding the floor of the platforms;
- using automatic shut-down valves;
- conducting routine inspections and maintenance checks;
- installing a continuous corrosion monitoring system;
- carrying out an education and training program; and
- having a detailed oil spill response plan in place

have been incorporated into the engineering design and operating procedures for the Simpson development to reduce the chances of a leak incident occurring in the first instance and minimising the impact should a leak occur (see Section 6.2 and Table 12).

7.2.2 Effects of an oil spill on habitats and endangered species

A small oil spill is likely to result in localised, short-term impacts whereas a large spill may potentially result in an adverse impact to the habitats and biota of the area surrounding the Lowendal Islands. The oil spilt would be a light oil that would begin to degrade immediately. After the oil has weathered for more than a day, most of the toxic components contained within the oil would be lost.

The shallow, subtidal habitats may be affected by the toxic components of the oil should a large oil spill occur. This could impact the algal and coral habitats, and their associated biota. Recovery of the algal communities would be rapid due to the fast growth rate of algae and re-colonisation potential of the epibenthos. Recovery of corals would be slower. Neither of these two habitats or their associated species is confined to the immediate area of the Simpson development. No listed endangered or non-listed species populations would be adversely affected if these habitats were impacted in the immediate area of a spill.

Abutilon Island has the potential to be adversely impacted by a large oil spill. The rocky shores, the sheltered bay on the east side and the sandy beaches located within the bay would be detrimentally affected if oil contacted or accumulated in these areas. Rocky shore biota are expected to recover rapidly. The water quality of the bay would be affected until the oil and its toxic components had weathered and degraded. Oil that was entrained within the sediments on the sandy beaches would enter the marine environment until the oil had been cleansed out of the sediment by tide and wave action.

Varanus Island would also be impacted by a large oil spill. Most of the shoreline on the eastern side is rocky shore that is exposed to high energy tide and wave activity. The beaches are less sheltered and there is less chance of oil accumulating within the bays. These beaches would be exposed to wave and tide action that would accelerate the degradation process.

It is difficult to predict the effect of an oil spill on fish and sharks. The degree and extent of impact would depend on the length of time before the toxic component was lost and their ability to move away from the oil slick. Overall, a large oil spill is expected to have little impact on adult fish and shark populations of the region.

Birds will be affected by an oil spill if their habitat and food supplies are affected. The birds most affected would be the shearwaters, terns and silver gulls if the spill occurred during their summer breeding season. All of these species feed on fish and the main impact to them would come from the contamination of their food source and getting oiled plumage while they forage. Migratory shorebirds may lose some of the beach habitats they feed on but as they do not breed on the islands, an oil spill would not cause an adverse impact to their overall populations. The north-west coast of Australia, between Broome and Port Hedland, is the most important wintering locations for migratory birds compared to the Lowendal Islands (Lane 1987).

The raptors on the island may be affected through the contamination of their food sources; the young could be affected by a spill in the winter months when they fledge and if they are fed contaminated fish. Recovery of any impacted species of bird that breeds on the islands of the region would be slow, but would occur in time through breeding and new recruits.

The impact of an oil spill to cetaceans and dugongs is expected to be low due to the low population numbers in the region and their ability to move away from an oil spill.

A large oil spill may result in the decrease in the population of some of the listed endangered species; seabirds and turtles are the two faunal groups that would be the most adversely affected, particularly if the spill occurred during the summer breeding season. A spill during the summer months would potentially disrupt their breeding season, resulting in a loss of at least one generation. None of the species found in the area are endemic to the area and recovery through breeding would commence in the following season. Recovery would be assisted by ensuring the beaches and rocky shorelines were clean of oil before the next breeding season. In time, the local populations would recover through new recruits and breeding.

7.2.3 Effects of other accidental events

Accidental events such as dropped objects, litter and small chemical spills are unlikely to have significant impacts on marine or terrestrial biota because of their local and transient nature. The impacts from the introduction of pests onto the islands would be far more significant; however, as personnel and equipment will be restricted from landing on Abutilon Island it makes this event very unlikely. The existing quarantine procedures will similarly prevent any possible outbreaks on Varanus Island.

Similarly, the risk of introducing exotic marine species to the waters of the Lowendal Islands is low. This is due to the fact that the majority of tankers that come to the Varanus Island loading terminal do not discharge ballast water. In addition, Apache has made it a requirement that every vessel will comply with the AQIS ballast water guidelines, as long as it is safe to carry out the procedure.

8 Environmental Management Plan

The objectives of this management plan are:

- to achieve and demonstrate best environmental practice by managing all activities of the development which may have an impact on the natural environment; and
- where an impact is unavoidable, minimise, ameliorate and manage the damage.

In accordance with these objectives the components listed below will be used for the management of the Simpson development.

- Environmental policy and leadership commitment

  Ensures that an environmental policy is in place and addresses the top down commitment and responsibilities of the key people involved in the Simpson development.

- Legislation, conditions and commitments

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

- Routine and emergency response procedures

  Generates risk reduction measures, work instructions, procedures and emergency response plans.

- Ecological indicators

  Defines the ecological indicators that can be measured to be able to assess the environmental impact of the project and how well management techniques are working.

- Communication and education

  Ensures knowledge and acknowledgment of the natural environment and environmental commitments to the workforce and the community.

- Incident reporting, reporting and audits

  Ensures the reporting and investigation of environmental incidents and performance reports, and ensures compliance with procedures, commitments and conditions.

These components comprise the management plan and are detailed overleaf.

8.1 Component 1: Environmental Policy and Leadership Commitments

At a broad scale, the Simpson development will be managed to comply with Apache's Environmental Policy (Appendix 6).

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

Managing Director	• Ensure compliance with Apache's Environmental policy. • Assume responsibility for providing adequate resources for environmental management. • Implement an emergency response strategy in the case of a spill incident. • Maintain communication with company personnel, government agencies and the media.
Operations Manager	• Ensure compliance with Apache's environmental policy. • Ensure overall compliance with the Simpson development Environmental Management Plan with guidance from the Project Manager and Environmental Manager. • Report environmental incidents to the Environmental Manager. • Assist the Managing Director in the development of a response strategy in the event of a spill incident.
Project Manager	• Ensure compliance to all relevant environmental legislative requirements, procedures, commitment and conditions as given in the Simpson development Environmental Management Plan. • Report environmental incidents to the Operations Manager and ensure that follow-up actions are carried out. • Ensure follow-up actions from the environmental audit have been carried out.
Site Project Manager	• Implement and ensure compliance to all relevant environmental legislative requirements, procedures, commitments and conditions as given in the Simpson development Environmental Management Plan. • Communicate hazards and risks to the workforce and their implications, and the importance of following good work practices. • Apply appropriate enforcement mechanisms to prevent breaches of the Simpson development Environmental Management Plan. • Report environmental incidents to the Project Manager. • Carry out follow-up actions from the environmental audit.
Field Superintendent	• Ensure contractor personnel are following the environmental guidelines for Varanus Island. • Develop a response plan in the event of a spill incident in close liaison with the Operations Manager.

Environmental Manager	• Liase with the Project Manager and Site Contactor Manager to ensure compliance to legislation, procedures, commitments and conditions. • Carry out environmental education and inductions. • Participate in oil spill response strategy. • Develop and carry out relevant monitoring. • Conduct an environmental audit during the installation phase to ensure compliance.
Masters of vessels	• Implement and ensure compliance to all relevant environmental legislative requirements, procedures, commitments and conditions as given in the Simpson development Environmental Management Plan. • Communicate hazards and risks to the crew and the implications and importance of following good work practices. • Maintain the vessels in a state of preparedness for emergency response. • Report environmental incidents to the Project Manager and ensure that follow-up actions are carried out. • Apply appropriate enforcement mechanisms to prevent breaches of the Simpson development Environmental Management Plan.
Apache personnel, contractors and crew of support vessels.	• Apply the Simpson development Environmental Management Plan in letter and spirit. • Follow good housekeeping procedures and work practices. • Encourage improvement wherever possible. • Report incidents to the Site Project Manger.

8.2 Component 2: Legislation and Company Commitments

8.2.1 Environmental legislation

The three primary Acts that pertain to the Simpson development are:

- *Environmental Protection Act* 1986 WA: The State Act under which environmental assessment is carried out and approval obtained, and under which Ministerial conditions are administered.
- *Environment Protection and Biodiversity Conservation Act* 1999 Cth: The Commonwealth Act under which the State government was granted accreditation to assess the Simpson development. The Commonwealth Minister will grant Commonwealth approval and set Ministerial conditions.
- *Petroleum (Submerged Lands) Act* 1982 WA: The Act and its associated *Schedule of Specific Requirements as to Offshore Petroleum Exploration and Production* (1995) govern offshore oil and gas production activities.

8.2.2 Company commitments

The commitments made by Apache for the Simpson development are given in Table 22. The commitments made for the production phase and decommissioning phase of the project will be amalgamated into the Varanus Island Hub Environmental Management Plan (Apache 1997; document EA-00-RI-084).

8.3 Component 3: Guidelines and Procedures for Routine Operations and Emergency Response

The major environmental risks associated with all phases of the Simpson development have been detailed in Sections 5 and 6. The procedures identified for routine operations and emergency response to accidental events to ensure proper environmental management, derived from the hazard identification workshop, are given below.

8.3.1 Routine operations

The project manger and site project manager are responsible for ensuring that the guidelines are available to personnel and that the guidelines are carried out properly (Table 23). Any deviation from the guidelines or procedures that results in an environmental incident will be reported immediately to the relevant person.

The following specific guidelines and procedures must be adhered to, to protect both marine and terrestrial flora and fauna:

- Quarantine Procedure Apache Document EA-00-II-002.
- Australian Quarantine Inspection Services Ballast Water Guidelines.
- Anchoring Guidelines Apache environmental fact sheet.

These three items will be distributed to the Site Project Manager to pass on to the appropriate personnel.

Apache also subscribes to the Australian Petroleum Production and Exploration Association (APPEA) Code of Practice. In addition, the contractor may develop its own job specific work guidelines and procedures that address environmental management issues.

8.3.2 Emergency response procedures

It is recognised that an accidental spillage of oil may occur during the installation of the Simpson mini-platform and pipeline bundle, or during production. Emergency response manuals have been prepared in the event an oil spill occurring. The four relevant documents are given in Table 24.

These documents will be available at the relevant locations on Varanus Island and support vessels.

8.4 Component 4: Ecological and Management Indicators

The environmental performance of the contractors and Apache personnel, and the environmental impact occurring during the installation of the Simpson development and subsequent production can be measured, benchmarked and reported on by the development of ecological and management indicators. These indicators are objective and verifiable data that are measured, calculated or estimated providing Apache with the means of:

Table 22: Company commitments for the Simpson development.

No.	Topic	Commitment (What)	Objectives (Why)	Action (How/Where)	Timing	Advice to	Measurement criteria
1	Environmental management	An Environmental Management Plan (EMP) will be prepared for the installation phase of the proposed.	To ensure compliance with the company commitments made in the PER and to Ministerial conditions.	The EMP will be made available to all personnel involved in the installation phase. A list of guidelines given in the PER will be incorporated into installation contracts.	Prior to the commencement of the installation phase.	DME CALM	Letter from DEP approving the EMP.
2	Environmental management	The proponent and each of its Participants will hold extensive insurance for liability, and clean-up.	To ensure ample financial resources for clean-up and remedial action in the case of a spill.	Certification of currency of insurance in accordance with directions from the Minister for Minerals and Energy.	Prior to the commencement of the installation phase.	DME	Certificate of Insurance from the Underwriters.
3	Environmental management	All personnel going on site will undergo an education and training program.	To give personnel the means of identifying the risks and knowledge of the environmental implications of the development program.	Inductions to be given to all personnel. Habitat maps and guidelines to be provided.	At all times.	DME CALM	Records of all personnel undergoing training will be kept.
4	Environmental management	An environmental audit of the installation phase of the proposal will be carried out.	To ensure compliance with commitments, guidelines and procedures.	An environmental audit will be carried out against the EMP.	During the installation phase.	DME	The propenent will submit results of the audit to DME.
5	Environmental management	The proposal will be incorporated into the Varanus Hub Environmental Management Plan.	To ensure compliance with commitments, guidelines and procedures.	Conditions and commitments will be incorporated into the Varanus Hub environmental database.	Prior to the production phase.	DME	Conditions and commitments to be added to existing list for Varanus Island Hub.
6	Environmental management	The proposal will be incorporated into Apache's regional monitoring program.	To assess longer-term impacts of the development.	Simpson ecological indicators will be incorporated into the regional monitoring program (see Table 25).	During the production phase.	CALM	Results to be incorporated into the annual report required under the CALM lease.
7	Oil spills	The Oil Spill Contingency Plan (OSCP) will be prepared.	To develop strategies for the containment, deflection and clean-up of oil spills.	The Oil Spill Contingency Plan will be updated to meet current NatPlan format and will incorporate this proposal.	Prior to the commencement of the installation phase.	DME Dot	Letter from DME approving the OSCP.

Table 22: Company commitments for the Simpson development. *(cont.)*

No.	Topic	Commitment (What)	Objectives (Why)	Action (How/Where)	Timing	Advice to	Measurement criteria
8	Construction impacts	A pipeline route avoiding coral patch reefs and bommies will be selected.	To protect the corals.	Detailed habitat maps and aerials will be provided to the site project manager. Selection of route will be along soft bottom habitat.	Prior to the commencement of the installation phase.	DME CALM	Pipeline bundle route mapped on habitat maps. Aerial photos of pipeline bundle route.
9	Construction impacts	A pipeline route avoiding coral patch reefs and bommies will be selected.	To protect the corals.	A post-installation survey will be carried out and compared to a pre-installation survey.	Prior to the commencement of the installation phase. After the pipeline bundle has been laid.	DME CALM	Close-out report containing visual observations and photos of the pipeline bundle route.
10	Construction impacts	Procedures to be adopted to minimise damage by anchors.	To protect corals and soft bottom benthos.	An anchoring plan will be developed using detailed habitat maps and aerial photos. Anchoring guidelines will be issued to the barge and support vessels.	Prior to the commencement of the installation phase.	DME CALM	Marine monitoring to determine recovery rate. No impact to corals.
11	Construction impacts	Access to islands.	To protect island flora and fauna.	No access by construction personnel to any island except Varanus Island.	During the installation phase.	DME CALM	Number of times any of the islands was accessed by personnel to be recorded as an environmental incident.
12	Construction impacts	Access on Varanus Island.	To protect the east shearwater rookery.	Access will only be allowed between the road and the CALM lease boundary rope.	During the installation phase.	DME CALM	Number of times shearwater rookery was accessed by personnel to be recorded as an environmental incident.
13	Construction impacts	Clearing of vegetation will be minimised.	To protect the vegetation in the east shearwater rookery.	Only vegetation adjacent to the Tanami flowline, but within the CALM lease boundary, will be cleared.	During the installation phase.	DME CALM	Close-out report with photos on the extent of clearing that was carried out.
14	Construction impacts	Installation activities will not occur during coral spawning period.	To avoid impacts to the corals.	No installation during the April coral spawning season.	During installation activities.	DME CALM	Close-out report confirming no installation occurred during the coral spawning season.
15	Turtle and seabird breeding	Installation activities will not occur during peak turtle and seabird nesting period.	To avoid impacts to turtles and seabirds.	Intallation activites will occur outside the peak turtle and seabird breeding period of November - March.	During installation activities.	DME CALM	Close-out report confirming no installation occurred during the peak turtle and seabird nesting period.

Table 22: Company commitments for the Simpson development. *(cont.)*

No.	Topic	Commitment (What)	Objectives (Why)	Action (How/Where)	Timing	Advice to	Measurement criteria
16	Feral animals, weeds and other exotic species	No access will be permitted on Abutilon Island.	To protect island flora and fauna.	No access to any island will be permitted except with the permission of the Field Superintendent.	At all times.	DME CALM	Close-out report confirming no access to islands by installation personnel.
17	Feral animals, weeds and other exotic species	Approved quarantine procedures will be implemented.	To protect island flora and fauna.	Quarantine procedures updated. Procedures to be incorporated into contracts of installation contractor. Inductions given to all personnel.	At all times.	DME CALM	Close-out report confirming no introduction of weeds or pest species.
18	Marine pest species	Risk of introduced pest species to be minimised.	To protect the marine environment.	All tankers coming to the tanker loading terminal will comply with the Australian Quarantine Inspection Guidelines.	At all times.	DME CALM	All tankers to submit AQIS Ballast Water reporting form to Apache and to AQIS.
19	Shoreline stability	The shoreline will be protected against erosion.	To protect the shoreline crossing and maintain the integrity of the pipeline bundle.	The pipeline bundle will be rock bolted to the existing stabilised shoreline.	During installation of pipeline bundle.	DME CALM	Close-out report confirming rock bolting carried out as per engineering plan.
20	Liquid emissions	No discharge of sewage adjacent to Abutilon Island.	To protect the marine environment.	Sewage will not be discharged from the lay-barge within 5 km of the proposal.	During the installation phase.	DME CALM	Report from the skipper confirming the location of the discharge.
21	Liquid emissions	Hydrotest water will not be disposed into the marine environment.	To protect the marine environment.	The development will be designed so that hydrotest water is disposed down a deep disposal well.	During hydrotesting of the pipeline bundle.	DME CALM	Close-out report confirming that hydrotest water has not been disposed into the marine environment.
22	Liquid emissions	Produced formation water will not be disposed into the marine environment.	To protect the marine environment.	The development will be designed so that produced formation water is disposed down a deep disposal well.	At all times during the production phase.	DME CALM	Location of disposal of Simpson produced formation water incorporated into annual DEP licence report.

Table 22: Company commitments for the Simpson development. *(cont.)*

No.	Topic	Commitment (What)	Objectives (Why)	Action (How/Where)	Timing	Advice to	Measurement criteria
23	Liquid emissions	Corrosion and scale inhibitors will not be disposed into the marine environment.	To protect the marine environment.	The corrosion and scale unit will be located within a bunded area that can hold the volume of a potential spill.	During the production phase.	DME CALM	Letter of approval for the bund design and capacity from DME and CALM.
24	Solid wastes	Solid wastes will be disposed of in an appropriate manner.	To protect the island flora and fauna.	Solid wastes will be segregated and disposed of as detailed in the Varanus Hub Waste Management Plan.	At all times.	DME CALM	Report to be submitted recording the volume of waste disposed of and disposal method. Data included in DEP licence report.
25	Introduced marine species	The risk of introducing marine pest species will be minimised.	To protect the marine environment.	Compliance with the Australian Quarantine and Inspection Services Ballast water guidelines.	At all times during the production phase.	CALM	Quantity of ballast water, last port of call to be reported in annual report required under CALM lease.
26	Greenhouse gases	Minimise greenhouse emissions.	To protect the atmosphere.	Best available technology to be used to minimise greenhouse gases. No flaring. Engines to run at most efficient capacity.	During the installation and production phases.	DEP DME	Sources and quantity of emissions to be incorporated into DEP annual licence report and NPI report.
27	Light overspill	Minimise lights overspill.	Minimise disturbance to turtles and seabirds.	Tarpaulins to be used to shield light during welding and grinding. Navigation light design that will generate least amount of light but meeting navigational safety standards.	During the installation and production phases.	DME CALM Dot	Report describing the type of navigational light to be used.
28	Decommissioning	The mini-platforms and pipeline bundle will be removed at the end of the project life or as per Ministerial conditions.	To protect the marine and terrestrial environment.	A detailed decommissioning plan for the mini-platforms and pipeline bundle will be developed.	At least 1 year prior to decommissioning.	DME CALM	Decommissioning plan and closeout report that plan has been followed.

Table 23: Environmental guidelines.

Oil and chemical spills	• Sufficient clean-up materials will be stored on the support vessels to clean up small spills. • Drainage from the vessel where oil or cleaning materials are used or stored will be bunded. • Spill on the deck will be cleaned up immediately. • Oil will be prevented on support vessels and the mini-platforms from going down a drain by ensuring that drains are closed to the environment. • Drip trays will be used under all machinery drip tubes and fuel points. • Separation equipment will have an automatic shut-down capability of oil exceeds 15 ppm. • Vessels will not discharge bilge water at the development site or along the pipeline route. Bilge water can be discharged no less than 10 km from a shoreline or reef. • Oil spills greater than 80 L will be reported to the Project Manager immediately. Apache will forward the report to DME. A record will be made of spills less than 80 L and submitted to the Project Manager for internal reporting.
Waste management	• Hazardous materials will be stored in a safe manner. Material Safety Data Sheets will be available for all chemicals used on the project. • Oil and chemical drums will be stored in bunded areas and on top of pallets where possible. • Waste will be segregated and the appropriate disposal method for each type of waste generated will be used. • Solid wastes from the support vessels will be taken to Varanus Island for proper disposal. • Biodegradable soaps and detergents will be used on the support vessels. • There will be no discharge of sewage into the marine environment. • Kitchen wastes will be bagged and taken to Varanus Island for incineration. • No disposal of debris, garbage or litter will occur to the sea or terrestrial environments. Particular care will be taken for synthetic materials such as styrofoam cups and plastic bags. • Waste oil and grease from machinery will be returned to shore for recycling at an approved site. A log of these wastes will be kept. • Chemicals having minimal environmental toxicity and bioaccumulation characteristics, but which meet safety requirement, will be used. • Engines will be run at the most efficient capacity.
Conservation	• The booklet detailing the environmental guidelines for Varanus Island will be distributed to all personnel working on the project. • All personnel will undergo an environmental induction. • Rules defining access will be strictly adhered to. • Quarantine procedures for Varanus Island will be strictly adhered to. • The anchoring guidelines will be strictly adhered to.

Table 24: Emergency response documents.

Document title	Document number
Oil Spill Contingency Plan Volume 1. Operations.	AE-00-EF-008 REV 1
Oil Spill Contingency Plan. Volume 2. Resource Atlas.	AE-00-EF-008/2
Emergency Response Management Manual	AE-00-ZF-025
Procedure for Varanus Field Cyclone Response	AE-91-IF-005
Incident Reporting Procedure	AE-91-IF-002

- demonstrating compliance with regulatory requirements and standards;
- measuring the level of impact from the various phases of the development; and
- achieving and demonstrating best practice to the regulators and the public.

The indicators developed for routine activities of the proposed Simpson development are detailed in Table 25. Should an accidental event such as an oil spill occur, a specially designed monitoring program would be developed covering such aspects as concentration of hydrocarbons in water and sediment, intertidal fauna counts, degree of fauna mortality and coral monitoring.

A program will be developed that will monitor the indicators listed in Table 25 to assess the impact of the installation phase of the Simpson development on the biological, chemical and physical environment.

A program to assess the impact of the production phase of the Simpson development will be incorporated into the regional monitoring and research program established by Apache in 1986. Some of the ecological values that will be monitored are turtles, seabirds, corals, macroalgae and water quality. Apache commenced a turtle genetics program in 2000 to determine the uniqueness of the Hawskbill turtle population that nests on the Lowendal and Montebello Islands.

A separate program to assess the impact of decommissioning and identify relevant monitoring will be designed at least one year prior to the commencement of decommissioning.

8.5 Component 5: Communication and Education

8.5.1 Communication

To date, consultation has been held with the following organisations:

6 October 2000	Conservation Council Western Australia The Marine and Coastal Community Network
11 October 2000	WA Fisheries Industry Council
17 October 2000	Conservation and Land Management - WA
19 October 2000	Morgan Pearls
25 October 2000	Presentation to : Conservation Council Western Australia The Marine and Coastal Community Network
2 February 2001	Department of Transport

The principal focus of the consultations was to inform the various community groups and government agencies of the Simpson development proposal and the status of the approval process. No formal documentation of these consultations was made, as the intent was to provide an awareness of the project in the first instance and to get an indication of the areas of concern.

The primary concerns expressed by these various groups were:

- the impact of an oil spill;
- the impact of the project on the biodiversity of the area; and
- shipping and ballast water.

An environmental hazard identification workshop was carried out in December 2000. The Apache, government and community personnel that participated in this workshop are given in Appendix 3.

Table 25: Ecological and management indicators for the Simpson development. The monitoring program will be developed using some of the ecological indicators.

Stressor	Ecological value at risk			Key potential environmental impacts			Measuring impact
	Value description	**Spatial extent of value**	**Characteristics**	**Spatial extent of impact**	**Duration of activity causing impact**	**Recovery time**	**Indicators for measurement**
Anchoring	• Benthic soft bottom Communities • Water quality • Corals • Marine fauna	Regional scale. No localised species.	Unconsolidated sand on limestone bedrock. Predominantly macroalgae, sparse epifauna. Patch coral reefs. Marine animals are mobile, transitory, in small numbers.	100 m^2 area of impact to seabed. Potential for: - damage to macroalgae and epifauna. - rapid recovery potential. - increased water turbidity.	2 weeks	Recolonisation of soft bottom seabed within 6 months. Suspended solids leading to turbidity will settle out rapidly. No impact to corals.	- Area of disturbance to seabed (m^2) - Recovery time (months) - Damage to marked corals
Noise and lights	• Turtles • Seabirds • Other marine fauna (dugongs, fish, dolphins, invertebrates marine)	Regional scale. No localised populations.	Turtles and seabirds are mobile, transitory, and seasonal. Other marine fauna in water column is mobile and transitional.	Noise may be heard up to 2 km away. No lights during installation phase (working daylight hours only). Navigation light will be small, possibly shaded on one side.	Noise: 2 weeks Navigational light: 10 years	Noise: Immediate. Light: Should have no impact.	- Seabird aggregations (presence or absence) - Number of turtles tagged - Number of shearwater burrows
Laying of pipeline bundle – offshore	• Benthic soft bottom communities • Water quality • Corals • Marine fauna	Regional scale. No localised populations.	Unconsolidated sand on limestone bedrock. Predominantly macroalgae, sparse epifauna. Patch coral reefs. Marine animals are mobile, transitory, in small numbers.	1,700 m^2 area of impact to seabed. Potential for: - damage to macroalgae and epifauna. - rapid recovery potential of seabed. - increased water turbidity.	2 weeks	Recolonisation of soft bottom seabed within 6 months. Suspended will settle out rapidly, so only temporary increase in turbidity. No impact to corals.	- Area of disturbance to seabed (m^2) - Recovery time (months) - Damage to marked corals. - Correct placement of pipeline bundle - Qualitative observation of any sediment plume - Waste disposed of (number of skips) - Waste disposed of (disposal location)
Trenching of pipeline bundle – offshore	• Benthic soft bottom communities • Water quality • Corals • Marine fauna	Regional scale. No localised populations.	Unconsolidated sand on limestone bedrock. Predominantly macroalgae, sparse epifauna. Patch coral reefs. Marine animals are mobile, transitory, in small numbers.	400 m^2 area of impact to seabed. Potential for: - damage to macroalgae and epifauna. - rapid recovery potential of seabed. - increased water turbidity.	3 days	Recolonisation of soft bottom seabed within 6 months. Suspended solids leading to turbidity will settle out rapidly. No impact to corals.	- Area of disturbance (m2). - Recovery time of seabed (months). - Spatial and temporal extent of sediment plume

Table 25: Ecological and management indicators for the Simpson development. The monitoring program will be developed using some of the ecological indicators. (cont.)

Stressor	Ecological value at risk			Key potential environmental impacts			Measuring impact
	Value description	Spatial extent of value	Characteristics	Spatial extent of impact	Duration of activity causing impact	Recovery time	Indicators for measurement
Installation of pipeline bundle – onshore	• Shoreline habitat • Terrestrial flora • Shearwaters	Regional scale. No localised populations.	Shoreline habitat: rock boulders and cement blocks. Terrestrial habitat: low growing, sparsely distributed vegetation.	200 m2 of impact to terrestrial vegetation.	2 weeks	Vegetation kept to a minimum under and immediately adjacent to pipelines for safety reasons.	- Unauthorised access to rookery (number times) - Damage to shearwater burrows (number burrows) - Area of disturbance to vegetation (m^2) - Waste disposed of (no. ships) - Waste disposed of (disposal location)
Production of oil	• Open water • Marine animals • Atmosphere	Regional scale. No localised populations.	Marine environment.	1,700 m^2 of disturbance to seabed. Replacement of soft bottom seabed with hard substrate (pipeline bundle).	10 years	Settlement of hard bottom fauna on pipeline bundle.	- Number of turtles tagged - Number of shearwater rookeries - No change in water quality (ANZECC water quality criteria used) - No change in adjacent coral communities - Volume of atmospheric emissions - Simpson oil toxicity study - Turtle population genetic study (no disruption to population) - Detailed tide/current validation study - Aerial photo at 1500m altitude - Number introduced marine species (Fisheries booklet as guide) - Number of spills

Ongoing consultation with relevant community groups and government agencies will continue throughout the assessment and approval process.

8.5.2 Education

Qualified members of staff will give personnel and contractors involved in the Simpson development an environmental induction. The topics covered will include:

- an overview of this assessment and management plan;
- regulatory and procedural requirements;
- environmental policy principles;
- environmental resources at risk; and
- environmental guidelines and procedures to be used; and
- an overview of the conditions and commitments for the project.

Issues covered at an induction

Resource Sensitivity	– Resource maps are available in the amenities building and briefing room on Varanus Island. – Describe the sensitive resources located nearby. These resources include islands, corals and shallow water shoals. Fact sheets on these resources available in briefing room. – Islands important for turtle breeding - three species breed on the beaches, all species are listed as an endangered species. – Numerous animals are found in the open water environment - dolphins, whales, seabirds, turtles. Many of these are listed species. – Oil can be devastating to marine life. Must avoid any sort of spillage.
Pertinent legislation, guidelines and procedures	– Bring Environmental Policy to everyone's attention. – Everyone must be aware of the legislation that pertains to the development program and where these acts can be found. – Commonwealth PSLA is the main legislation during installation and production. – Everyone must be aware of the environmental guidelines and procedures relevant to the project. – We are working under commitments and conditions that are legally binding. – Environmental Assessment and Management Plan is legally binding.
General guidelines	– Any spillage of oil or other chemicals is reportable to Apache. Spills >80 L to DME under the P(SL)A. – Report all spills to relevant person. – If smaller spills occur, these must be reported - not to reprimand, but to ensure that procedures are checked to make sure they don't happen again. – General housekeeping to be kept to a high standard: keep decks and construction area clean of litter, rags gloves, etc. – Nothing is to be thrown or dumped overboard from support vessels. – All precautions must be made to avoid spillage of anything into the marine environment or onto the ground on Varanus Island. If oil or chemicals are spilt,

they must be cleaned up immediately and the soiled clean-up materials disposed of in skips. Don't hose spillage overboard from any vessel.

- Emphasise the importance of proper storage of chemicals and drums. The integrity of the drums should be checked to make sure they are not leaking. Drums of liquid must be within bunded areas.
- Put drip trays under anything that may drip oil or chemicals and clean these up on a regular basis.
- Segregate wastes into clearly marked bins/skips and recycle wherever possible. Use minimal volume of chemicals.
- Waste associated with the Simpson development must be recorded.

8.6 Component 6: Incident reporting, Reporting and Audits

The people responsible for reporting incidents, recording and reporting the various environmental performance indicators and conducting audits are listed below.

8.6.1 Incident reporting

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

All spills to the marine and terrestrial environment will be reported. All spills over 80L will be reported to the Department of Minerals and Energy. Any smaller spills will be reported for internal reference.

8.6.2 Recording and reporting

The Environmental Manager or their delegate will generate a report on the compliance to the conditions and commitments set for the project and the ecological standards. The report will be distributed to the company and government either immediately upon completion of the installation phase or on an annual basis, whichever is appropriate.

8.6.3 Audits

The Environmental Manager (or delegate) and Site Project Manager will carry out an environmental compliance audit to this plan during the installation phase of the development. The Site Project Manager will be responsible for any follow-up actions as a result of the audit.

The production phase will be incorporated into the quarterly Varanus Island Hub environmental audits. The Field Superintendent will be responsible for any follow-up actions as a result of the audits.

References

Apache Energy Pty Ltd (1997). Environmental Management Plan Varanus Island. Apache report V195.

Apache Energy Ltd (1999). A review of the Harriet Oilfield Marine Monitoring and Management Programme. Internal report by Environment Department, March 1999.

Astron (2000). Integrated Shearwater Monitoring Program - 2nd Triennial Report. Report for Apache Energy Ltd.

Australian Petroleum Production and Exploration Association (1997). Potential Arrangements for Multiple Use Management in the Montebello Islands - Barrow Island Region: A Petroleum Industry Perspective. Published by APPEA, Canberra.

Baker, J.M. (1971). Season effects. In: E.B. Cowell (ed) The Ecological Effects of Oil Pollution on Littoral Communities. Institute of Petroleum, London: 44-52.

Bartell, S.M. (1996). Ecological/Environmental Risk Assessment. Principles and Practices. In: Kolluru, R., Bartell, S., Pitblado, R. and Stricoff, S. (eds) Risk Assessment and Management Handbook for Environmental, Health and Safety Professionals. McGraw Hill, New York: pp 10.3 - 12.21.

Battelle (1998). Weathering, Chemical Composition and Toxicity or Four Western Australian Crude Oils. A report for Apache Energy. Project No. N002239. 21 August 1998.

Bond Corporation Pty Ltd (1985). Harriet Oilfield Development Notice of Intent. Supplementary Report Appendices. Apache report V5.

Bowman Bishaw Gorham (2000). Baseline survey of Tanami 4/5 rig access route and well-site. Letter report to Apache Energy Ltd.

Bowman Bishaw Gorham (2001). Marine habitats at southern Abutilon Island, Simpson-1 and the Simpson development trenched pipeline route. Letter report to Apache Energy Ltd.

Dunlop J.N. (1996). Habituation to human disturbance by breeding Bridled Terns *Sterna anaethetus*. Corella 20(1): 13-16.

Fry M.D., Swenson, J., Addeigo L.A., Grau, C.R. & Kang, A. (1986). Reduced reproduction of Wedge-tailed Shearwaters exposed to weathered Santa Barbara Crude Oil. Arch. Environ. Contamin. Toxicol. 15: 453-463.

GESAMP (IMO/FAO/UNESCO/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Pollution (1993). Impact of Oil and Related Chemicals and Wastes on the Marine Environment. Reports and Studies No. 50: 180 pp.

Heatwole, H. (1999). Sea Snakes. Australian Natural History Series. University of New South Wales Press, Sydney.

Heinsohn, G.E. and Spain A.V. (1974). Effects of a Tropical Cyclone on Littoral and Sub-Littoral Biotic Communities and on a Population of Dugongs (*Dugong dugong* (Muller)). Biological Conservation 6(2):143-152.

Holloway, P.E. and Nye, H.C. (1985). Leeuwin Current and Wind Distributions on the Southern Part of the Australian NW Shelf between Jan 1982 & July 1983. Aust. J. Mar. Freshw. Res. 36:123-137.

Hurlbut, S.E., French, D. and Taylor, B.J. (1991). Evaluation of potential effects of major oil spills on Grand Banks commercial fish species as a result of impacts on eggs and larvae. Report prepared fro Environmental Research Fund by SAS Consulting Ltd. Box 2625, Dartmouth East, N.S. B2W 3X8.

International Chamber of Shipping and Oil Companies International Marine Forum (1991). International Safety Guide for Oil Tankers & Terminals. Witherby & Co. Ltd, London.

International Risk Consultants (2001a). Annual Marine Monitoring Program. Report for Apache Energy Ltd. In production.

International Risk Consultants (2001b). Simpson Development Environmental Hazid Workshop Report. Report to Apache Energy Ltd. Project J00-117. Document number RS-REO-00-117-003 Rev 3.

International Risk Consultants (2001c). Simpson Development Leak Frequency Assessment Report. Report to Apache Energy Ltd. Project J00-117. Document number RS-REO-00-117-001 Rev 4.

IUCN (World Conservation Union) (1988). Lowendal Islands Nature Reserve, Montebello Islands and Adjacent Reefs. In Wells, S.M. (ed) Coral Reefs of the World. Vol 2: Indian Ocean, Red Sea and Gulf. IUCN Conservation Monitoring Centre, Cambridge, in collaboration with the United Nations Environment Programme.

Kailola, P.J., Williams, M.J., Stewart, P.C., Reichelt, R.E., McNee A. & Grieve, C. (1993). Australian Fisheries Resources. Bureau of Resources Sciences, Department of Primary Industry & Energy, and the Fisheries Research & Development Corporation, Canberra, Australia.

Kirkman, H. & Walker, D.I. (1989). Regional Studies - Western Australian Seagrass. In: Larkum, A.W.D., McComb, A.J. & Shepherd, S.A. (eds) Biology of Seagrasses. Elsevier New York.

Kolluru, R.V. (1994). Environmental Strategies Handbook. McGraw Hill Inc., New York.

Lane, B.A. (1987). Shorebirds in Australia. Nelson Publishers, Melbourne.

LeProvost Dames & Moore (1994). Harriet Oil & Gas Fields Development Marine Management and Monitoring Programme. Report for Apache Energy Ltd. Report No V110. September 1994.

LeProvost Dames & Moore (1996). Harriet Oil & Gas Fields Development Marine Management and Monitoring Programme Report of the 1996 Field Survey. Report for Apache Energy Ltd. Report No. V179.

LeProvost Environmental Consultants (1992). Harriet Oilfield Marine Biological Monitoring Programme - Second Triennial Review June 1989 - June 1991. Report to Hadson Energy Ltd. Report No. V35.

LeProvost Environmental Consultants (1993). Harriet - Marine Management and Monitoring Programme - 7th Annual Report June 91 - August 92. Report to Apache Energy Ltd. Report No. V78.

LeProvost Semeniuk & Chalmer (1986). Harriet Oilfield Marine Biological Monitoring Programme. Environmental Descripiton, Establishment of Baseline and Collection of First Data Set. Unpublished Report to Bond Corporation Pty Ltd. Report No. V11.

Limpus, C.J. (1990). Preface. Proceedings of the Australian Marine Turtle Conservation Workshop. Sea World Nara Resort, Gold Coast, 14-17 November 1990, Australian Nature Conservation Agency. Pp ii-iv.

Marine Parks & Reserves Selection Working Group (1994). A Representative Marine Reserve System for Western Australia; A Report of the Marine Parks & Reserves Selection Working Group. Draft document published by the Department of Conservation and Land Management, Perth, Western Australia.

Morris K.D. (1991). Management Proposals for the Montebello Islands and Surrounding Waters. Department of Conservation and Land Management Occasional Paper No 3/91, Perth, Western Australia.

Neff, J.M., Ostazeski, S., Gardiner, W. and Stejskal, I. (2000). Effects of weathering on the toxicity of three offshore Australian crude oils and a diesel fuel to marine animals. Environmental Toxicology and Chemistry 19(7): 1809-1821.

Osborne, S., Bancroft, K., D'Adamo, N. and Monks, L. (1999). Montebello/Barrow Islands Regional Perspective 2000. Report by Marine Conservation Branch of Department of Conservation and Land Management.

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

Prince, R.I.T. (1990). Status of the Western Australian Marine Turtle Populations: The Western Australian Marine Turtle Project 1986 - 1990. Proceedings of the Australian Marine Turtle Conservation Workshop. Sea World Nara Resort, Gold Coast, 14-17 November 1990, Australian Nature Conservation Agency. Pp 1-11.

Prince, R.I.T. 1993 Western Australian Marine Turtle Conservation Project: An outline of scope and an invitation to participate. Marine Turtle Newsletter 60: 8-14.

SEEEC Report Summary (1998). The Environmental Impact of the Sea Empress Oil Spill. Summary. http://www.official-documents.co.uk/document/seec/impact

Steedman Science & Engineering (1991). Normal and extreme environmental design criteria - Campbell and Sinbad locations, and Varanus Island to mainland pipeline. Volume 1. A report for Hadson Energy. Steedman Science & Engineering report No. R486.

Stejskal, I. (1992). The Environmental Monitoring of Natural Events and Industry Activity in Mermaid Sound, Dampier Archipelago. APPEA Journal 32:420 - 427.

Stoker, S.W., Neff, J.M., Schroeder, T.R. & McCormick D.M. (1992). Biological Conditions in Prince William Sound, Alaska Following the Valdez Oil Spill: 1989-1992. Published by the Principle Participating Companies Beringian Resources, Arthur D. Little, Inc., Cook Inlet Fisheries Consultants and Woodward-Clyde Consultants. Anchorage, Alaska.

The Ecology Lab Pty Ltd (1997). Macroalgal Habitats of the Lowendal/Montebello Island Region. Report to Apache Energy Ltd. Report No. V178.

Van Woesik, R., Ayling, A.M. and Mapstone, B. (1991). Impact of Tropical Cyclone 'Ivor' on the Great Barrier Reef. Australian Journal of Coast. Res. 7(2):551-558.

Veron, J.E.N. (1995). Corals in Space and Time: The Biogeography and Evolution of the Scleractinia. UNSW Press, Sydney. 321 pp.

Veth, P. (1993). The Aboriginal Occupation of the Montebello Islands, Northwest Australia. Australian Aboriginal Studies 2:39-50.

V & C Semeniuk Research Group (1999). Summary Report Mangroves of the Lowendal Islands and Montebello Islands. Report to Apache Energy Ltd. Report No.240.

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

Glossary

AMSA	Australian Marine Safety Authority
APPEA	Australian Petroleum Production & Exploration Association
AQIS	Australian Quarantine Inspection Services
Associated gas	Natural gas found in association with oil, either dissolved in the oil or as a cap of free gas above the oil.
bbl	Barrel. The unit of volume measure used for petroleum products. 1 bbl = 159 litres 6.29 bbls = 1 cubic metre
Blowout	The situation that occurs when gas, oil or water escapes in an uncontrolled manner from a well. Containment equipment is used to keep the pressure of the reservoir in check.
bopd	Barrels of oil per day
CALM	Department of Conservation and Land Management
Casing	The steel pipe that is cemented into the well to prevent the wall from collapsing and stop unwanted fluids from entering the hole from the surrounding rocks.
Christmas tree	An array of pipes and values fitted to a production wellhead to control the flow of oil and gas, and prevent a possible blowout.
CO_2	Carbon dioxide, a greenhouse gas.
DME	Department of Minerals and Energy, Western Australia
Deviated well	A well drilled in a way that its controlled direction departs progressively from the vertical during drilling.
EA	Environment Australia
EP Act	*Environmental Protection Act 1986* (WA)
EPA	Environmental Protection Authority
EPBC	*Environmental Protection and Biodiversity Conservation Act* 2000 (Cth)
FADs	Fish Attraction Devices
ISGOTT	International Safety Guide for Oil Tankers and Terminals
MAH	Monocyclic aromatic hydrocarbons
MARPOL	International Convention for the Prevention of Pollution from Ships 1973
OSCP	Oil Spill Contingency Plan
PAH	Polycyclic aromatic hydrocarbons
PER	Public Environmental Review
PFW	Produced formation water
Produced formation water	The fossil water associated with the oil and gas present in a hydrocarbon reservoir.
PSLA	*Petroleum (Submerged Lands) Act* 1982 (WA)
Reservoir	A geological stratum in which oil or gas is present
Tj	Terajoules

Conversions
$1m^3$ = 6.29 bbls
kg / 0.79 = L
L / 159 = bbls

Appendices

Appendix 1

Environmental Protection Authority

GUIDELINES

SIMPSON OIL FIELD DEVELOPMENT

(Offshore Abutilon Island, Lowendal Islands, North West Shelf)
(Assessment Number 1358)

Part A	Specific Guidelines for the preparation of the Public Environmental Review
Part B	Generic Guidelines for the preparation of an environmental review document
Attachment 1	Example of the invitation to make a submission
Attachment 2	Advertising the environmental review
Attachment 3	Simpson Development location map

These guidelines are provided for the preparation of the proponent's environmental review document. The specific environmental factors to be addressed are identified in Part A. The generic guidelines for the format of an environmental review document are provided in Part B.

The environmental review document must address all elements of Part 'A' and Part 'B' of these guidelines prior to approval being given to commence the public review.

The environmental review document must also address any requirements of the Commonwealth Government under the Environment Protection and Biodiversity Conservation Act 1999.

Part A: Specific Guidelines for the preparation of the Public Environmental Review

1. The proposal

The proposed Simpson development will consist of:

- 2 mini- platforms positioned at the surface locations of the production wells;
- a sub-sea pipeline bundle linking the mini-platforms to each other and to existing facilities on Varanus Island approximately 1500m to the north of the field.

The mini-platforms will:

- measure approximately 5m x 5m and will sit about 10 m above the water surface;
- be unmanned;
- contain a minimal amount of equipment limited to the well head, testing equipment and emergency shut-down facilities.

The pipeline bundle will consist of pipelines for:

- transporting the crude oil, produced formation water (PFW) and natural gas recovered from the production wells;
- disposal of PFW into a deep disposal well;
- lift gas; and
- corrosion inhibitor chemicals and process control.

Existing and upgraded processing equipment on Varanus Island will separate the oil, gas and PFW stream received from the incoming production pipeline.

Produced formation water (estimated to be 306 barrels per day in 2001, increasing to 26,476 barrels per day by year 10) will be reinjected either to existing deep disposal well(s) for disposal. No water will be disposed of into the marine environment.

Natural gas separated from the Simpson development will be:

- combined with the natural gas streams from other existing gas fields and exported as domestic sales gas; and/or
- used as lift gas by re-injection into the reservoir to enhance recovery.

No flaring or venting of the associated gas will occur unless under an emergency.

Crude oil produced will be stored in the existing bulk storage tanks for loading to tankers via the Varanus Island offloading marine terminal. The annual average oil production will be 2,500 barrels of oil per day (bopd) in 2001, peaking at 8,037 bopd and progressively decreasing to 794 bopd by 2010.

Tanker activity will not increase over the historical frequency of the Varanus Island marine terminal as the Simpson field will only be replacing some of the declining Harriet and Agincourt oilfield reserves.

2. Environmental factors relevant to this proposal

At this preliminary stage, the Environmental Protection Authority (EPA) believes the environmental factors, objectives and work required are as detailed in the table below:

Environmental Issue	Objective(s)
HYDROCARBON SPILLS	• Prevent hydrocarbon spills from all sources. • Ensure oil spill contingency plans are in place.
Environmental factor	**Scope of work**
Spills from the development and pipeline	Estimate the oil spill risk at the development over its lifespan: • probability of spill occurring; • probability of spill contacting sensitive areas; • probable ecological impacts in the event that a spill contacts sensitive areas such as coral reefs, mangroves, turtle nesting beaches or aquaculture facilities; potential implications for endangered/migratory species such as turtles, dugongs and sea birds; • probable time for, and implications of, environmental recovery / rehabilitation / cleanup. Investigate risk reduction options including siting the development further offshore. Risks should be assessed on the basis of International Best Practice for petroleum developments in environmentally sensitive areas and the principle of ALARP (As Low as Reasonably Practicable). Update oil spill contingency plan to accommodate the new development (at international best practice level).
Spills from Shipping	Provide information as to whether there will be increased tanker traffic as a result of the project. Provide a summary of oil spill risk management measures (including pre-qualification of ships) applied to shipping associated with the Apache base at Varanus Island.
CONSTRUCTION IMPACTS	• Select pipeline route so as to protect the environment. • Avoid interference with turtle/bird breeding. • Protect offshore and island ecosystems from introduction of feral animals, weeds and other exotic species.
Environmental factor	**Scope of work**
Coral reefs	Select pipeline route so as to avoid coral reefs and other sensitive environments. Adopt procedures to prevent damage to corals and other sensitive environments by work vessels and their anchor chains. Phase pipeline and platform construction to avoid impacts during coral spawning time.
Turtle/bird breeding	Phase pipeline and platform construction so as to avoid interference with turtle/bird breeding, where impacts are possible.

Environmental Issue	Objective(s)
Feral animals, weeds and other exotic species	Approved quarantine procedures are to be implemented. (Note: Landings on Abutilon Island are not permitted by CALM other than in emergency conditions.)
Sand dunes and coastal vegetation	Shoreline pipeline crossing on Varanus Island to be designed in consultation with CALM. Rehabilitation (where disturbance is unavoidable) to be carried out in consultation with CALM.
Shoreline stability	In consultation with CALM, design Varanus Island shoreline crossing to prevent shoreline from erosion due to pipeline acting as a groyne.
EMISSIONS	• Protect environment from pollution • Prevent introduction of exotic marine organisms from ballast water and hull fouling • Minimise greenhouse gas emissions • Protect turtles and other wildlife from the effects of light overspill ("photo pollution")
Environmental factor	**Scope of work**
Liquid emissions	Develop a management plan for disposal of pipeline test chemicals (hydrotest waters and pickle liquors), pipeline treatment chemicals (biocides, corrosion inhibitors, and antifouling used to maintain the pipeline) and produced formation water, to ensure low impact on the environment, consistent with international best practice.
Introduced marine organisms	Assess risk of introducing exotic marine organisms via ballast water or hull fouling. Submit appropriate strategy to prevent introduction of such organisms.
Greenhouse gases	Assess the impact of the proposal on greenhouse emissions. Develop a management plan to minimise greenhouse emissions.
Light overspill	Design lighting in consultation with CALM specialists.
DECOMMISSIONING	• Decommissioning strategy to be prepared consistent with international best practice and as appropriate for shallow tropical marine environment.
Environmental factor	**Scope of work**
Decommissioning	Decommissioning to be considered at design phase. Submit decommissioning strategy as part of PER document.

These issues/factors should be addressed within the environmental review document for the public to consider and make comment to the EPA. The EPA expects to address these issues/factors in its report to the Minister for the Environment.

The EPA expects the proponent to fully consult with interested members of the public and take due care in ensuring any other relevant environmental factors, which may be of interest to the public, are addressed.

3. Availability of the environmental review

3.1 Copies for distribution free of charge

Supplied to DEP:	• Library/Information Centre	9
	• EPA members	6
	• DEP (Perth)	6
	• DEP (Karratha)	1
Distributed by the proponent to:		
Commonwealth Government	• Environment Australia	3
State Government departments	• Department of Conservation & Land Management	2
	• Fisheries WA	2
	• Department of Minerals and Energy	2
	• Department of Transport	1
Local Government authorities	• Shire of Roebourne	2
Libraries	• J S Battye Library	3
	• The Environment Centre	1
	• Shire of Roebourne libraries (Karratha)	2
	• Shire of Ashburton libraries (Onslow)	2
Other	• Conservation Council of WA	1
	• The Marine & Coastal Community Network	1

3.2 Available for public viewing

- J S Battye Library;
- Shire of Roebourne library (Karratha);
- Shire of Ashburton libraries (Onslow);
- Department of Environmental Protection Library; and
- DEP Karratha

Part B: Generic Guidelines for the preparation of an environmental review document

1. Overview

All environmental reviews have the objective of protecting the environment. Environmental impact assessment is deliberately a public process in order to obtain broad ranging advice. The review requires the proponent to describe:

- the proposal;
- receiving environment;
- potential impacts of the proposal on factors of the environment; and
- proposed management strategies to ensure those environmental factors are appropriately protected.

Throughout the assessment process it is the objective of the Environmental Protection Authority (EPA) to help the proponent to improve the proposal so the environment is protected. The DEP administers the environmental impact assessment process on behalf of the EPA.

The primary purpose of the environmental review is to provide information on the proposal within the local and regional framework, with the aim of emphasising how the proposal may impact the relevant environmental factors and how those impacts may be mitigated and managed.

The language used in the body of the environmental review should be kept simple and concise, considering the audience includes non-technical people, and any extensive, technical detail should either be referenced or appended to the environmental review. The environmental review document will form the legal basis of the Minister for the Environment's approval of the proposal and therefore should include a description of all the main and ancillary components of the proposal, including options where relevant.

Information used to reach conclusions should be properly referenced, including personal communications. Such information should not be misleading or presented in a way that could be construed to mislead readers. Assessments of the significance of an impact should be soundly based rather than unsubstantiated opinion, and each assessment should lead to a discussion of the management of the environmental factor.

2. Objectives of the environmental review

The objectives of the environmental review are to:

- place this proposal in the context of the local and regional environment;
- adequately describe all components of the proposal, so that the Minister for the Environment can consider approval of a well-defined project;
- provide the basis of the proponent's environmental management program, which shows that the environmental impacts resulting from the proposal, including cumulative impact, can be acceptably managed; and
- communicate clearly with the public (including government agencies), so that the EPA can obtain informed public comment to assist in providing advice to government.

3. Environmental management

The EPA expects the proponent to have in place an environmental management system appropriate to the scale and impacts of the proposal including provisions for performance review and a commitment to continuous improvement. The system may be integrated with quality and health and safety systems and should include the following elements:

- environmental policy and commitment;
- planning of environmental requirements;
- implementation and operation of environmental requirements;
- measurement and evaluation of environmental performance;
- review and improvement of environmental outcomes.

A description of the proposed environmental management system should be included in the environmental review documentation. If appropriate, the documentation can be incorporated into a formal environmental management system (such as AS/NZS ISO 14001). Public accountability should be incorporated into the approach on environmental management.

The environmental management program (EMP) is the key document of an environmental management system that should be adequately defined in an environmental review document. The EMP should provide plans to manage the relevant environmental factors, define the performance objectives, describe the resources to be used, outline the operational procedures and outline the monitoring and reporting procedures which would demonstrate the achievement of the objectives.

4. Format of the environmental review document

Proponents should be encouraged to maintain close contact with the DEP officer during the preparation of the environmental review. The draft environmental review should be provided to the DEP officer for comment. At this stage the document should have all figures produced in the final format and colours.

The proponent and DEP officer/Manager should agree on the time to be taken to review the draft, taking into account the level of consultation during the environmmental review preparation, DEP officer's availability and the need for external review. Revision of the document may be requested to ensure that it addresses all topics and issues in these guidelines, can be read by the educated lay-person, contains no significant error of science and meets the required format.

Under Section 40 (3) of the Environmental Protection Act, the EPA has responsibility to determine the "form, content, timing and procedure of any environmental review required to be undertaken". This responsibility has been delegated to the Director of the Evaluation Division for PERs and ERMPs, although it is advisable to liaise with the EPA Chairman for the latter. (Responsibility remains with the EPA Chairman for EPSs and PUEAs).

When the DEP officer is satisfied with the standard of the environmental review document (s)he will provide a written sign-off (through the Manager and Assistant Director as required) from the Director, Evaluation Division to the proponent giving approval to advertise the document for public review. The review document may not be advertised for release before written approval is received.

The proponent is also requested to provide the final document to the DEP in electronic format (Microsoft Word 2000 compatible), along with any scanned figures. Where possible, figures should be reproducible in black and white.

5. Contents of the environmental review document

The contents of the environmental review should include an executive summary, introduction and at least the following:

5.1 The proposal

A comprehensive description of the proposal including its location (address and certificate of title details where relevant) is required.

Justification and alternatives

- justification and objectives for the proposed development;
- the legal framework, including existing zoning and environmental approvals, and decision making authorities and involved agencies; and
- consideration of alternative options.

Key characteristics

The Minister's statement will bind the proponent to implementing the proposal in accordance with any technical specifications and key characteristics[1] in the environmental review document. It is important therefore, that the level of technical detail in the environmental review, while sufficient for environmental assessment, does not bind the proponent in areas where the project is likely to change in ways that have no environmental significance.

Include a description of the components of the proposal, including the nature and extent of works proposed. This information must be summarised in the form of a table as follows:

Table 1: Key characteristics (example only)

Element	Description
Life of project (mine production)	< 5yrs (continual operation)
Size of ore body	682 000 tonnes (upper limit)
Area of disturbance (including access)	100 hectares
List of major components • pit • waste dump • infrastructure (water supply, roads, etc)	refer plans, specifications, charts section immediately below for details of map requirements
Ore mining rate • maximum	 200 000 tonnes per year
Solid waste materials • maximum	 800,000 tonnes per year
Water supply • source • maximum hourly requirement • maximum annual requirement	 XYZ borefield, ABC aquifer 180 cubic metres 1 000 000 cubic metres
Fuel storage capacity and quantity used	litres; litres per year
Heavy mineral concentrate transport • truck movements (maximum)	 75 return truck loads per week

[1] Changes to the key characteristics of the proposal following final approval, would require assessment of the change and can be treated as non-substantial and approved by the Minister, if the environmental impacts are not significant. If the change is significant, it would require assessment under section 38 or section 46. Changes to other aspects of the proposal are generally inconsequential and can be implemented without further assessment. It is prudent to consult with the Department of Environmental Protection about changes to the proposal.

Plans, Specifications, Charts

Adequately dimensioned plans showing clearly the location and elements of the proposal which are significant from the point of view of environmental protection, should be included. The location and dimensions (for progressive stages of development, if relevant) of plant, amenities buildings, accessways, stockpile areas, dredge areas, waste product disposal and treatment areas, all dams and water storage areas, mining areas, storage areas including fuel storage, landscaped areas etc.

Only those elements of plans, specifications and charts that are significant from the point of view of environmental protection are of relevance here.

Figures that should always be included are:

- a map showing the proposal in the local context - an overlay of the proposal on a base map of the main environmental constraints;
- a map showing the proposal in the regional context; and, if appropriate,
- a process chart / mass balance diagram showing inputs, outputs and waste streams.

The plan/s should include contours, a north arrow, a scale bar, a legend, grid co-ordinates, the source of the data, and a title. If the data is overlaid on an aerial photo then the date of the aerial photo should be shown.

Other logistics

- timing and staging of project; and
- ownership and liability for waste during transport, disposal operations and long-term disposal (where appropriate to the proposal).

5.2 Environmental factors

The environmental review should focus on the relevant environmental factors for the proposal, and these should be agreed in consultation with the EPA and DEP and relevant public and government agencies. Preliminary environmental factors identified for the proposal are shown in Part A of these guidelines.

Further environmental factors may be identified during the preparation of the environmental review, therefore on-going consultation with the EPA, DEP and other relevant agencies is recommended. The DEP can advise the proponent on the recommended EPA objective for any new environmental factors raised. Minor matters which can be readily managed as part of normal operations for the existing operations or similar projects may be briefly described.

Items that should be discussed with each environmental factor are:

- the EPA objective for this factor;
- a clear definition of the area of assessment for this factor;
- a description of what is being affected - why this factor is relevant to the proposal;
- a description of how this factor is being affected by the proposal - the predicted extent of impact;
- a description of where this factor fits into the broader environmental / ecological context (only if relevant - this may not be applicable to all factors);
- a straightforward description or explanation of any relevant standards / regulations / policy;
- environmental evaluation - does the proposal meet the EPA's objective as defined above;

- if not, environmental management proposed to ensure the EPA's objective is met;
- predicted outcome.

The proponent should provide a summary table of the above information for all environmental factors with separate category headings for each environmental issue:

Table 2: Environmental factors and management (example only)

EPA Objective	Environmental Factor	Existing environment	Potential impact	Environmental management	Predicted outcome
BIODIVERSITY					
Maintain the abundance, species diversity, geographic distribution and productivity of vegetation community types	vegetation community types 3b and 20b	Reserve 34587 contains 45 ha of community type 20b and 34 ha of community type 3b	Proposal avoids all areas of community types 20b and 3b	Surrounding area will be fully rehabilitated following construction	Community types 20b and 3b will remain untouched Area surrounding will be revegetated with seed stock of 20b and 3b community types
EMISSIONS					
Ensure that the pollution levels generated by the proposal do not adversely impact upon welfare and amenity or cause health problems by meeting statutory requirements and acceptable standards	Dust	Light industrial area - three other dust producing industries in close vicinity Nearest residential area is 800 metres	Proposal may generate dust on two days of each working week	Dust Control Plan will be implemented	Dust can be managed to meet EPA's objective
VISUAL AMENITY					
Visual amenity of the area adjacent to the project should not be unduly affected by the proposal	Visual amenity	Area already built-up	This proposal will contribute negligibly to the overall visual amenity of the area	Main building will be in 'forest colours' and screening trees will be planted on road	Proposal will blend well with existing visual amenity and the EPA's objective can be met

5.3 Environmental management commitments

The final stage of the Environmental Impact Assessment (EIA) process is reached when the Minister for the Environment issues the Ministerial statement for the project, which is a set of legally enforceable conditions and procedures for the implementation of the project. One of the standard procedures is a requirement for the proponent to implement the commitments which it has made during the EIA process. It is accepted practice for a consolidated list of the proponent's commitments to be attached to the Minister's statement.

Commitment formatting

1. Commitment components

Commitments which address key environmental factors will be audited by the DEP, together with the environmental conditions. Unless the commitments are framed in a standard format, it may become difficult in practice to implement or audit them. By applying the principles of quality management, a standard format for the commitments has been arrived at. The format ensures that a chain of responsibility is established to facilitate compliance and that redundant, overlapping or non-enforceable commitments are avoided.

The required standard format for all commitments comprises a number of components as follows:

The proponent (**who**) will undertake an action (**what, how, where**) to meet an environmental objective (**why**) to a time frame (**when**), and on advice of somebody (**to whom**, eg. third party, government agencies such as Department of Conservation and Land Management, Department of Minerals and Energy, Water and Rivers Commission, Shire Council). With regard to 'whom' this need only be included if the expertise of a third party is relevant to implementing the commitment.

It is important for the consolidated list of commitments to be numbered correctly for easy reference in the implementation and auditing stages of the project. These should therefore be sequentially numbered 1, 2, 3, ... without use of subgroups such as 1.1, 1.2 or 2(i) or 2(a), 2(b).

2. Paragraph format

In applying the standard components (who, what, why, how, where, when, to whom) an example of a commitment in paragraph form is as follows:

The proponent will prepare and implement a Dust Control Program which will minimise dust generation on-site and prevent dust emission from construction of the foreshore extension in order to protect the amenity of nearby land users. The Program will be prepared during the design (project planning) phase and will meet EPA dust control criteria (EPA, 1996), on advice of the Shire of Widgiemooltha. The approved Program will be implemented during the construction phase.

However in writing the commitment in paragraph form, a confusing or clumsy sentence structure can result that may be difficult to interpret for future auditing purposes. Also it is difficult to verify that all components have been incorporated into every commitment. A paragraph format is therefore not the preferred format.

3. Tabular format

Due to the limitations of the paragraph format, it is preferable to format a commitment in tabular form. It is recommended that the table column headings be ordered as: 'commitment number', 'topic', 'action', 'objective', 'timing' and 'advice'. However table headings can be re-ordered if necessary.

The example in paragraph form on page 1 can therefore be written in tabular form as per examples 1 and 2 below. Note that the tabular format makes it easier to ensure that no component of the commitment is left out and that each action is recognised as a separate commitment. This format also permits the inclusion of additional clauses or more precise wording of clauses which can be difficult in a sentence structure. It is acceptable for table columns to be re-ordered if necessary. Finally, the tabular format provides an immediate audit framework for use by the proponent and the DEP, enabling efficient administration of environmental approvals.

Examples 1 & 2.

The proponent is committed to the following:

No.	Topic	Action (What/How/Where)	Objective/s (Why)	Timing (When)	Advice (Agency)
1.	Dust management	Prepare a Dust Control Program for the foreshore construction site which addresses: 1) abc 2) xyz	• Minimise dust during the construction phase • Maintain the amenity of nearby land users • To meet EPA dust control criteria	Pre-construction	Shire
2.	Dust management	Implement the approved Dust Control Program	Achieve the objectives of Commitment 1	Construction	-

Example 3.

No.	Topic	Action	Objective/s	Timing	Advice
3.	Fauna protection	Undertake a trapping programme for capturing and relocating the Southern Brown Bandicoots	Minimise impact on Southern Brown Bandicoots	Pre-construction (prior to commencement of ground disturbance)	CALM

Example 4.

No.	Topic	Action	Objective/s	Timing	Advice
4.	Vegetation	Revegetate disturbed areas with vegetation types indigenous to the area	• To minimise impact on local flora • To achieve the completion criteria stated in CER (Section 5.1.1)	Post-construction (progressively during operations)	Kings Park Board

Example 5.

No.	Topic	Objective	Action	Timing	Advice
5.	Groundwater	Minimise impact on groundwater levels, surface water levels and surrounding vegetation	Groundwater drawdown shall not exceed 0.5 m at any boundary of the mine site	Operation	Water and Rivers Commission

Example 6.

No.	Topic	Action	Objective	Timing	Advice
6.	Clean-up	Post-clean up activities will only proceed after demonstrating to (and gaining approval from) the DEP that the site clean-up criteria identified in the 1993 CER have been met	To achieve the soil quality objectives in the Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites, Jan 1992	Post-clean up (On completion of cleanup and prior to commencement of post-cleanup activities)	

5.4 Public consultation

A description should be provided of the public participation and consultation activities undertaken by the proponent in preparing the environmental review. It should describe the activities undertaken, the dates, the groups/individuals involved and the objectives of the activities. Cross reference should be made with the description of environmental management of the factors which should clearly indicate how community concerns have been addressed. Those concerns which are dealt with outside the EPA process can be noted and referenced.

5.5 Other information

Additional detail and description of the proposal, if provided, should go in a separate section.

Attachment 1

The first page of the proponent's environmental review document must be the following invitation to make a submission, with the parts in square brackets amended to apply to each specific proposal. Its purpose is to explain what submissions are used for and to detail why and how to make a submission.

Invitation to make a submission

The Environmental Protection Authority (EPA) invites people to make a submission on this proposal.

[the proponent] proposes [the rezoning of land and the development of a Marina Complex in the City of Bunbury]. In accordance with the Environmental Protection Act, a [PER] has been prepared which describes this proposal and its likely effects on the environment. The [PER] is available for a public review period of [8] weeks from **[date]** closing on **[date]**.

Comments from government agencies and from the public will help the EPA to prepare an assessment report in which it will make recommendations to government.

Why write a submission?

A submission is a way to provide information, express your opinion and put forward your suggested course of action - including any alternative approach. It is useful if you indicate any suggestions you have to improve the proposal.

All submissions received by the EPA will be acknowledged. Submissions will be treated as public documents unless provided and received in confidence subject to the requirements of the Freedom of Information Act, and may be quoted in full or in part in the EPA's report.

Why not join a group?

If you prefer not to write your own comments, it may be worthwhile joining with a group interested in making a submission on similar issues. Joint submissions may help to reduce the workload for an individual or group, as well as increase the pool of ideas and information. If you form a small group (up to 10 people) please indicate all the names of the participants. If your group is larger, please indicate how many people your submission represents.

Developing a submission

You may agree or disagree with, or comment on, the general issues discussed in the [PER] or the specific proposals. It helps if you give reasons for your conclusions, supported by relevant data. You may make an important contribution by suggesting ways to make the proposal more environmentally acceptable.

When making comments on specific elements of the [PER]:

- clearly state your point of view;
- indicate the source of your information or argument if this is applicable;
- suggest recommendations, safeguards or alternatives.

Points to keep in mind

By keeping the following points in mind, you will make it easier for your submission to be analysed:

- attempt to list points so that issues raised are clear. A summary of your submission is helpful;
- refer each point to the appropriate section, chapter or recommendation in the [PER];
- if you discuss different sections of the [PER], keep them distinct and separate, so there is no confusion as to which section you are considering;
- attach any factual information you may wish to provide and give details of the source. Make sure your information is accurate.

Remember to include:

- your name;
- address;
- date; and
- whether you want your submission to be confidential.

The closing date for submissions is: **[date]**

Submissions should be addressed to:
The Environmental Protection Authority
Westralia Square
141 St George's Terrace
PERTH WA 6000

Attention: Peter Walkington

Attachment 2

Advertising the environmental review

The proponent is responsible for advertising the release and arranging the availability of the environmental review document in accordance with the following guidelines:

Format and content

The format and content of the advertisement should be approved by the DEP before appearing in the media. For joint State-Commonwealth assessments, the Commonwealth also has to approve the advertisement. The advertisement should be consistent with the attached example.

Note that the DEP officer's name should appear in the advertisement.

Size

The size of the advertisement should be two newspaper columns (about 10 cm) wide by about 14 cm long. Dimensions less than these would be difficult to read.

Location

The approved advertisement should, for CER's, appear in the news section of the main local newspaper and, for PER's and ERMP's, appear in the news section of the main daily paper's ("The West Australian") Saturday edition, and in the news section of the main local paper at the commencement of the public review period and again two weeks prior to the closure of the public review period.

Timing

Within the guidelines already given, it is the proponent's prerogative to set the time of release, although the DEP should be informed. The advertisement should not go out before the report is actually available, or the review period may need to be extended.

Example of the newspaper advertisement

Apache Northwest Pty Ltd

Public Environmental Review

SIMPSON OILFIELD DEVELOPMENT

(Public Review Period: [date] to [date])

Apache Northwest Pty Ltd is planning to construct a bipod mini platform 0.4 km offshore of Abutilon Island in the Lowendal group of islands.

A Public Environmental Review (PER) has been prepared by the company to examine the environmental effects associated with the proposed development, in accordance with Western Australian Government procedures. The PER describes the proposal, examines the likely environmental effects and the proposed environmental management procedures.

Apache Northwest Pty Ltd has prepared a project summary which is available free of charge from the company's office address.

Copies of the PER may be purchased for $10 from:

Apache Northwest Pty Ltd

3rd Floor 256 St Georges Terrace

PERTH WA 6000

Telephone: (08) 9422 7205

Copies of the complete PER will be available for examination at:

- Department of Environmental Protection (Perth and Karratha offices);
- Shire of Ashburton (Onslow) libraries;
- Shire of Roebourne (Karratha) libraries;
- Library Information Centre
  8th Floor, Westralia Square
  141 St Georges Terrace
  PERTH WA 6000

Submissions on this proposal are invited by **[closing date]**. Please address your submission to:

Chairman

Environmental Protection Authority

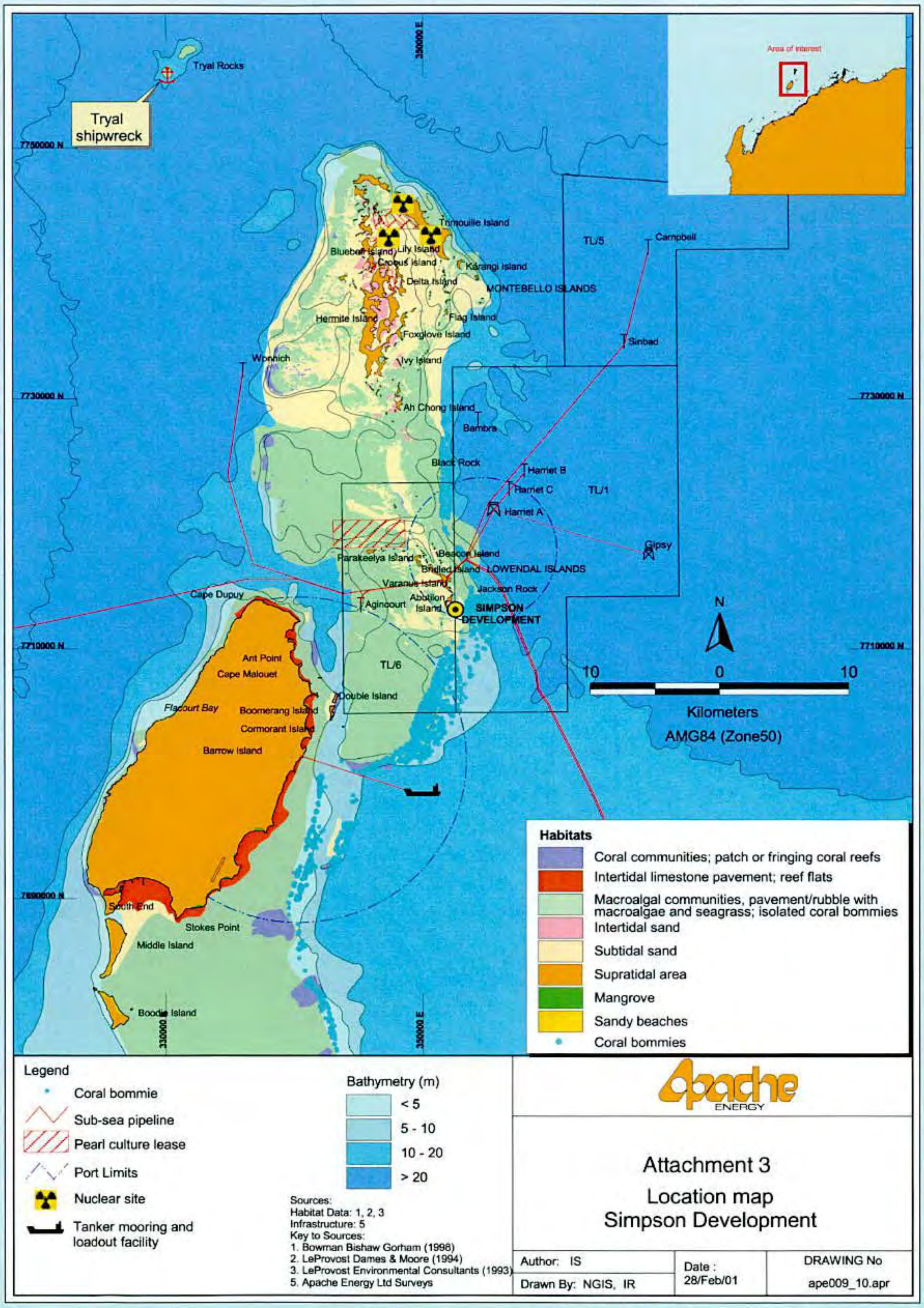
8th Floor, Westralia Square

141 St Georges Terrace

PERTH WA 6000

Attention: Peter Walkington

If you have any questions on how to make a submission, please ring the project officer, Peter Walkington, on (08) 9222 7097.



Tryal Rocks
Tryal shipwreck
7750000 N
7730000 N
7710000 N
7690000 N
350000 E
330000 E
Area of interest
Trimouille Island
Bluebell Island
Lily Island
Crocus Island
Karangi Island
Delta Island
MONTEBELLO ISLANDS
Hermite Island
Flag Island
Foxglove Island
Wonnich
Ivy Island
Ah Chong Island
Bambra
Black Rock
Harriet B
Harriet C
Harriet A
TL/5
TL/1
TL/6
Campbell
Sinbad
Gipsy
Parakeelya Island
Beacon Island
Bridled Island
LOWENDAL ISLANDS
Varanus Island
Jackson Rock
Cape Dupuy
Agincourt
Abutilon Island
SIMPSON DEVELOPMENT
Ant Point
Cape Malouet
Double Island
Flacourt Bay
Boomerang Island
Cormorant Island
Barrow Island
South End
Stokes Point
Middle Island
Boodie Island
N
10
0
10
Kilometers
AMG84 (Zone50)
Habitats
Coral communities; patch or fringing coral reefs
Intertidal limestone pavement; reef flats
Macroalgal communities, pavement/rubble with macroalgae and seagrass; isolated coral bommies
Intertidal sand
Subtidal sand
Supratidal area
Mangrove
Sandy beaches
Coral bommies
Legend
Coral bommie
Sub-sea pipeline
Pearl culture lease
Port Limits
Nuclear site
Tanker mooring and loadout facility
Bathymetry (m)
< 5
5 - 10
10 - 20
> 20
Sources:
Habitat Data: 1, 2, 3
Infrastructure: 5
Key to Sources:
1. Bowman Bishaw Gorham (1998)
2. LeProvost Dames & Moore (1994)
3. LeProvost Environmental Consultants (1993)
5. Apache Energy Ltd Surveys
Apache ENERGY
Attachment 3
Location map
Simpson Development
Author: IS
Drawn By: NGIS, IR
Date: 28/Feb/01
DRAWING No
ape009_10.apr

Appendix 2

Interested Parties

Shire Clerk
Ashburton Shire Council
Onslow WA 6710

Mike McCarthy
Curator of Maritime Archaeology
Western Australian Maritime Museum
Cliff Street
Fremantle WA 6160

Rochelle Smith
Department of Minerals & Energy
Mineral House
100 Plain Street
East Perth WA 6003

Norm Caporn
CALM
50 Hayman Road
Como WA 6152

Director
Morgan & Co Pty Ltd
7/55 Hampden Road
Nedlands WA 6009

Dr P Berry
WA Museum
Francis Street
Perth WA 6000

Gary Kirby
Department of Transport
1 Essex Street
Fremantle WA 6160

Guy Leyland
WAFIC
Suite 6, 41 Walters Drive
Osborne Park WA 6017

Rachel Siewart
Conservation Council of WA
Lottery House
2 Delhi Street
West Perth WA 6005

Edwina Ward-Davies
Marine & Coastal Community Network
Lottery House
2 Delhi Street
West Perth WA 6005

John Griffiths
Dept. of Industry, Science & Resources
GPO Box 858
Canberra ACT 2601

Julian Page
Invest Australia
GPO Box 9839
Perth WA 6848

Rod Evans / Peter Kioses
Department of Resources & Development
PO Box 7606
Cloisters Square WA 6850

Shire Clerk
Shire of Roebourne
PO Box 219
Karratha WA 6714

Barry Wilson
Marine Parks Reserve Authority
C/- Conservation Commission
Cnr Hackett & Australia II Drive
Crawley WA 6009

Rhys Brown
Fisheries Western Australia
Locked Bag 39
Cloisters Square WA 6850

Dave Osborne
Kufpec Australia Pty Ltd
18 Richardson Street
West Perth WA 6005

Dan Kirisits
Kufpec Australia Pty Ltd
Essa Al-Saleh Commercial Building
Fahad Al-Salem Street
Block No. 3
Salhia, Kuwait

Paul Underwood
Tap Oil NL
Level 1, 47 Colin Street
West Perth WA 6005

Cossack Pearls
1/10 Johnston Street
Peppermint Grove WA 6011

Bob & Lita Way
Onslow Tourism & Progress Assocation
Onslow Sun Chalets
Second Avenue
Onslow WA 6710

Director
Pearl Producers Association
PO Box 55
Mt Hawthorn WA 6016

Director
WA Tourism Commission
GPO Box XW261
Perth WA 6001

Linley Thomas
Montebello Island Safari's
13 Sexton Court
Kardinya WA 6163

Appendix 3 Environmental Hazid Workshop: Approach and Participants

Overview

Risk assessment is defined as the process of determining the frequency of occurrence of an event and the magnitude of adverse effects – economic, human safety and health, or ecological – over a specified period of time (Kolluru 1994). The process of identifying the risks and likelihood of given events, and the magnitude of their effects consists of several interrelated steps including:

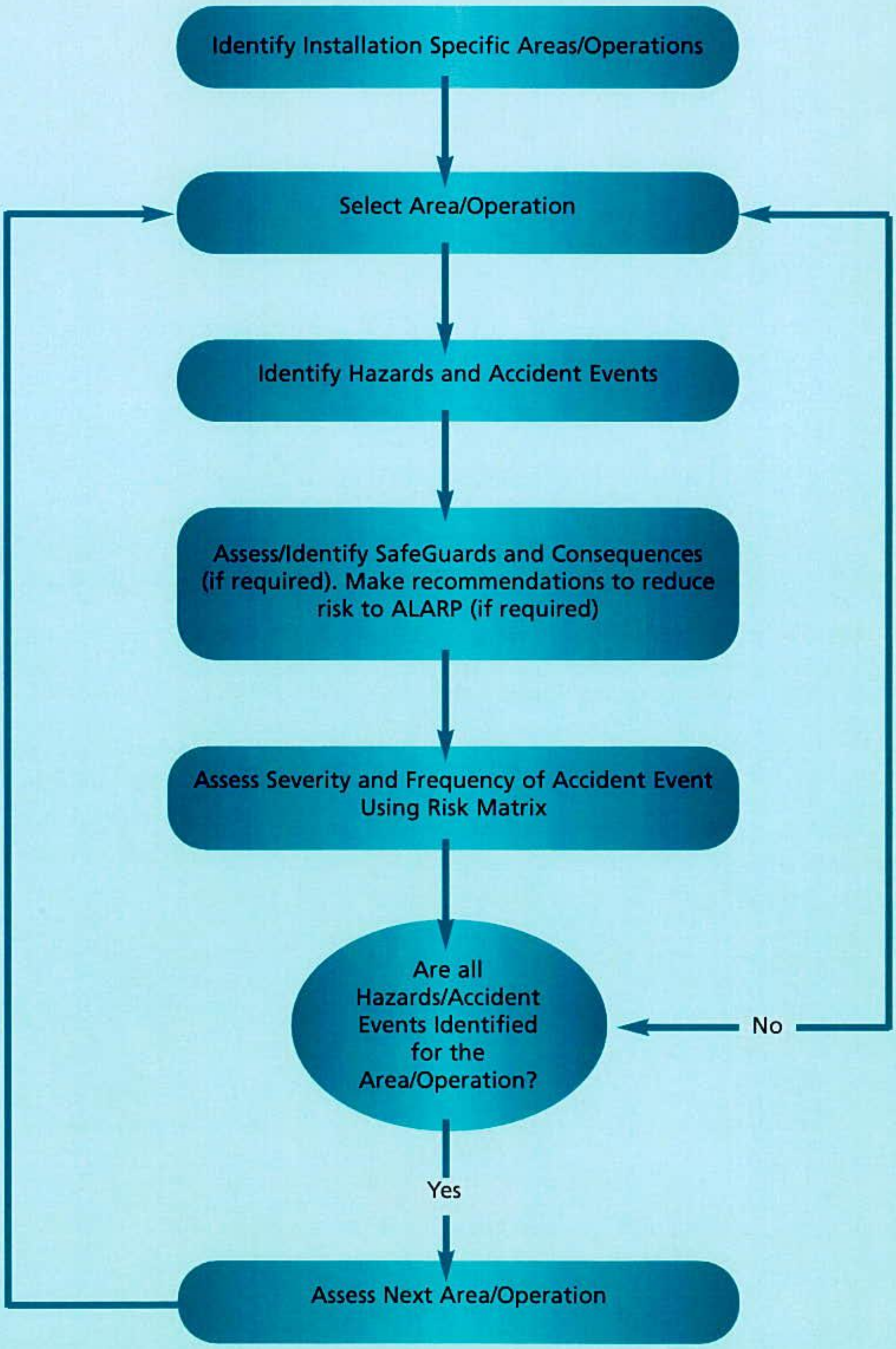
A.	Hazard identification:	recognizing that hazards exist and identifying their characteristics;
B.	Risk determination:	determining the characteristics of hazards either qualitatively or quantitatively. These include leak frequency analysis; and
C	Risk control:	setting up a management system with standards, procedures, guidelines, etc. to decrease or eliminate risk and to review performance.

A. Hazard Identification Methodology

The risk assessment method used was a hazard identification study of what-if analysis. This method allows a brainstorming exercise to b applied to the installation, operation and accidental processes to identify potential hazards for the Simpson development.

The identification of environmental hazards is the first step of the environmental risk assessment process. Hazard identification is undertaken to identify all the environmental hazards associated with a project likely to occur from routine and accidental activities, and assign a potential risk to each hazard. The hazard identification study is undertaken through a multi-disciplinary workshop comprising construction, operations and environmental personnel. The process followed during the workshop is illustrated in the figure overleaf.

Risk Assessment Workshop Method



A.1 Determination of likelihood and consequence

The workshop participants ranked all the identified hazards based on their likelihood of occurrence and their potential consequences according to the tables below, which show the criteria used to determine the likelihood or consequence of the identified hazards. The workshop facilitated a consensus decision on the likelihood or consequences of a hazard, and promoted brainstorming and open discussion for complex hazards for which information was not readily available.

Guidance for Determining Likelihood of a Hazard Occurring

Likelihood Of Hazard Occurring	
Expected to	Is expected to occur in most circumstances during the life cycle of an individual Occur item or system.
Probably will Occur	Will probably occur in most circumstances during the life cycle of an individual item or system
Moderate	Likely to occur at sometimes during the life cycle of an individual item or system.
Unlikely to occur	Unlikely, but possible to occur in sometime in the life of an individual item or system
Rare	May occur, but in exceptional circumstances

Guidance for Determining Environmental Consequence

CONSEQUENCE	
Serious	Large scale detrimental effect that is likely to cause a highly significant effect on local ecosystem factors such as water quality, nutrient flow, community structure and food webs, biodiversity, habitat availability and population structure (e.g. abundance, fecundity, age structure). Long-term recovery period measured in decades.
Significant	Detrimental effect that will cause a significant effect on local ecosystem factors. Recovery period measured in years to decades.
Moderate	Impact that will cause a detectable effect in local ecosystem factors. Recovery period measured in months to years.
Minor	Incidental changes to abundance/biomass of biota in the affected area, insignificant changes overall ecological function. Recovery measured in months.
Negligible	Short-term, localized and insignificant impacts to habitat or populations. Rapid recovery measured in days to months.

The workshop team made decisions by consensus as to the likelihood of a hazard occurring based on relevant databases and professional judgement. The decisions are based on the existing controls that are in place to prevent the effect, the nature of materials or substances that contribute to the effect, and the frequency with which the activity may occur.

The consequences are dependent on the potential impact of the event in the first instance. Quantities and concentration released, time scale of release, and regulatory requirements are considered.

A.2 Risk Ranking

The table below shows the risk ranking matrix used to assess the severity (or consequences) and likelihood (or frequency) of any identified accidents.

Environmental risk matrix.

		CONSEQUENCES				
		Serious	Significant	Moderate	Minor	Negligible
LIKELIHOOD	Expected to Occur $<10^{-1}$	Unacceptable	Unacceptable	Unacceptable	B	Negligible
	Probably will Occur 10^{-1} to 10^{-2}	Unacceptable	Unacceptable	A	B	Negligible
	Moderate 10^{-2} to 10^{-3}	Unacceptable	A	B	B	Negligible
	Unlikely to occur 10^{-3} to 10^{-4}	A	A	B	Negligible	Negligible
	Rare 10^{-4} to 10^{-6}	A	B	Negligible	Negligible	Negligible

10^{-4} to 10^{-6}: 1in 10,000 years to 1 in 1,000,000 years

10^{-3} to 10^{-4}: 1 in 1,000 years to 1 in 10,000 years

10^{-2} to 10^{-3} : 1 in 100 years to 1 in 1,000 years

10^{-1} to 10^{-2} : 1 in 10 years to 1 in 100 years

$<10^{-1}$: less than 1 in 10 years

The matrix was based on five classifications of severity and five for the likelihood of a hazard. Through this ranking procedure, consideration was given to the magnitude of the consequences and the likelihood of a hazard. Risk evaluation helps to prioritise the risks: i.e. determining if the risk of an activity or incident is acceptably low, or if management actions are required to reduce the risk to as low as reasonably practicable. The table below shows the criteria used during this workshop for evaluating the acceptability of risks. Recommendations were made to reduce the risk levels to ALARP, where appropriate.

Definitions of risk category and management response.

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

A.3 Checklist

A checklist, given below, was used for the workshop as a framework to identify potential hazards associated with the construction and operation of the offshore and onshore components of the development.

Equipment Failures	Environment	General
Mechanical failure	Visibility	MOB
Communications failure	Cyclone	Diving (eg umbilical fouling)
Hydraulic failure	Strong tides	Vessel impact (with pipeline or vessel)
Mooring line failure	Seabed conditions	Spillage
Rig failure	Noise pollution	Incorrect position of vessel/drill rig
Dropped objects	Sea state weather deterioration	Movement over pipeline
Swinging loads	Lighting	Personnel transfer
Crane failure		Emergency response
Loss of control of vessel		PPE
Vessel anchor failure — dragging, dropped		
Anchor chain abrasion		
Loss of sea fastening		

A.4 Attendance

The environmental risk assessment workshop was held at the AEL offices in Perth during December 2000. The table below provides a list of the participants and the sessions attended.

Hazid Workshop Attendance List

Name	Title	Organisation	Session 1 *Construction*	Session 2 – *Operations/ Production*
Daniel Apai	Environmental Engineer	IRC	Not present	Attended
John Nielsen	Principal Environmental Consultant / Scribe	IRC	Attended	Attended
Peter Jernakoff	Principal Environmental Consultant / Scribe	IRC	Not present	Attended
Richard Pocock	Principal Risk/Safety Engineer & Facilitator	IRC	Attended	Attended
Clive Richards	Project Engineer	AEL	Attended	Not present
Iva Stejskal	Environmental Manager	AEL	Attended	Attended
Mike Dworkin	Petroleum Engineer	AEL	Attended	Attended
Myles Hyams	Environmental Engineer	AEL	Attended	Not present
Ross Paton	Operator	AEL	Not present	Attended
Simon Bingham	Project Manager/ Chief Facilities Engineer	AEL	Part Time	Not present
Doug Macleod	Lead Process Engineer	IGL	Attended	Attended
Kim Buhler	Safety & Risk Analyst	WA DME	Attended	Attended
Rochelle Smith	Environmental Assessor	WA DME	Attended	Attended
Tim Gentle	EIA Officer	DEP	Attended	Not present
Peter Walkington	EIA Officer	DEP	Attended	Attended
Edwina Davies Ward	Environmental Scientist/ WA Coordinator	Marine & Coastal Community Network	Attended	Attended
Norm Caporn	Liaison Officer	CALM	Not present	Attended

B. Leak Frequency Analysis

The leak frequency analysis was based on a count of the system components and application of failure rate data from the E&P Forum 1996, PARLOC 1996 and SINEF databases. An overview of these three databases is given below.

B.1 Databases

E&P FORUM: Quantitative Risk Assessment Datasheet Directory, 1996

The E&P (Oil Industry International Exploration & Production) forum Quantitative Risk Assessment Datasheet Directory provides a catalogue of international upstream petroleum industry incident information. E&P's objective was to improve the quality and consistency of risk assessments. A database was compiled to facilitate this aim with benchmark data and references for common incidents analysed in upstream production operations worldwide. This historical data provides a basis for incident frequency prediction.

The datasheets were compiled by E&P forum members utilising expertise within their organisations and external consultants where required. This process commenced in 1994.

An independent expert reviewed the draft datasheet directory before final issue in 1996. The directory represents the best reliability data source in the public domain for upstream oil and gas production equipment.

AME PARLOC 96: The Update of Loss of Containment Data for Offshore Pipelines

The PARLOC 96 database provides statistical data to assess the generic frequency of pipeline loss of containment that is associated with a number of incident causes. The database was compiled by Advanced Mechanics & Engineering (AME) Limited under contract from the United Kingdom Health & Safety Executive (HSE).

The pipeline and incident information was compiled for operations in the North Sea up to the end of 1995. The information was compiled into two databases (pipeline and incident) from the following sources:

- UK, Norwegian, Danish, Dutch and German regulatory authorities;
- operators in the UK, Dutch and Danish sectors;
- PARLOC 94; and
- published sources (including trade journals and Lloyd's list).

The compiled data represents an equivalent operating experience of 195,690 km-years. Combining the information from both the pipeline and incident databases enables the frequency of incidents to be related to the pipeline population as a whole in terms of incidents per year or per km-year, as appropriate. The calculated loss of containment frequencies can be applied for reliability analysis of similar pipeline populations. The PARLOC 96 database represents the most up to date and applicable data source for reliability of offshore pipelines.

SINTEF: Reliability of Well Completion Equipment – Phase II, 1996

This report was compiled by The Foundation for Scientific and Industrial Research (SINTEF) at the Norwegian Institute of Technology. SINTEF publications are the leading industry sources for well completion equipment reliability data, which includes surface controlled sub-surface safety value (SCSSV) performance data and blowout probabilities, causes and consequences.

The research project involved analysis of years of equipment performance data and included active participation from the petroleum industry. The report was completed in 1996 and released publicly in 1999. The data is widely accepted as a very robust foundation for the reliability analysis of well completion equipment. It contains the most recent and applicable SCSSV reliability data in the public domain.

B.2 Leak frequency approach

The leak frequency analysis required an approach that determined both the inventories that could be released and the frequency with which these releases could occur. The focus of the study was on determining the frequency and mass of liquid hydrocarbon releases to determine their environmental impact.

The release frequency assessment was based on the number of components and length of pipe in each segment and a release frequency per component. The potential for failure of each component and the relevant release frequency was derived using historical data generated from the three databases listed above.

To calculate the inventory released during a leak, the duration of the leak was calculated. This was done using event trees for each segment that determined the potential for failure of the automatic shut down values to isolate the segment concerned from adjacent segments. Event trees were constructed for each release case.

Using the times for either successful automatic or manual isolation, together with the calculated outflow rates, the released masses and frequencies were calculated for each event tree outcome.

C. Risk Control

The table given below presents the overall results (leak frequency for hydrocarbon liquid mass released) for the proposed Simpson development. The table gives a comparison of the risk values where no mitigating factors were taken into account and the risk values where mitigating measures were taken into account. Mitigating factors are features that are incorporated into a design to reduce the risk of a leak occurring in the first instance. Some of the mitigating features used for the Simpson development include (see Sections 5.0 and 6.0 for full details):

- reducing the number of flanged connections;
- using welded valves instead of flanged valves;
- using connectors which have substantially lower release frequencies; and
- installing a continuous corrosion control program.

Table 3.1: Leak frequency summary comparison.

	Frequency for mass of liquid release (per year)				
	<25 kg	25 - 100 kg	100 - 12,500 kg	12,500 - 100,000 kg	>100,000 kg
Overall risk without mitigating factors	5.1×10^{-2}	8.2×10^{-3}	1.2×10^{-2}	2.0×10^{-6}	0.0
Overall risk with mitigating factors	1.1×10^{-2}	9.3×10^{-4}	2.5×10^{-3}	2.0×10^{-6}	0.0

The risk values given in the table present the average frequencies for a ten year operating life. A detailed description of the failure rate for each individual component used in the risk assessment is given in the report generated by International Risk Consultants (IRC 2001).

References

Advanced Mechanics and Engineering (1998). PARLOC 96: The Update of Loss of Containment Data for Offshore Pipelines. AME OTH 551. Issued 1998.

E&P Forum (1996). Quantitative Risk Assessment Datasheet Directory. E&P Report 11.8/250. October 1996.

IRC (2001). Simpson Development - Environmental Hazid Workshop. IRC Report to Apache Energy Number RS-REP-00-117-003 Rev 0. January 2001.

IRC (2001). Simpson Development Leak Frequency Assessment. IRC Report to Apache Energy Number RS-REP-00-117-001 Rev 4.

The Foundation for Scientific and Industrial Research (1996). Reliability of Well Completion Equipment - Phase II. SINTEF Norway, Molnes Einar and Sundet Inge, STF75 F95051. 1996.

Appendix 4

GUIDELINES FOR SAFE ANCHORING

ANCHOR IN SAND, NOT IN THE CORAL

Look before you drop the anchor

Make sure the anchor is in sand and the chain is clear of any corals.

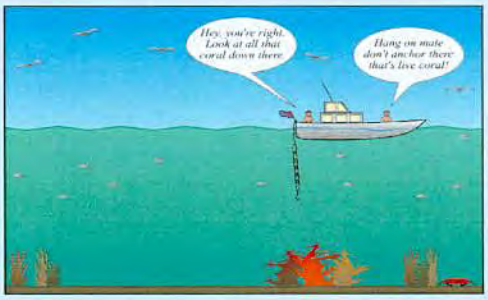
And if you can't see the seabed...

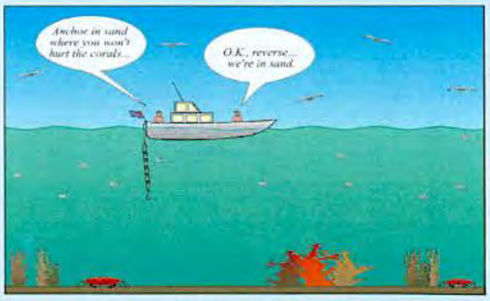
-**Anchor deep**

-Feel the anchor line as the boat drifts; if the chain 'grumbles' or catches, motor over the anchor, ease it out of the coral, and move.

Anchoring in coral is like parking in a flower bed. An anchor or dragging anchor chain can do enormous damage to a coral community: turning over or breaking corals, and damaging the polyps which make up the surface of living corals.

In any case, coral is not an ideal anchoring material. Most anchors are designed to be used in mud or sand and have been tested under these conditions. Coral in calm anchorages is often brittle, and easily fouls anchors while other corals are as hard as concrete, and can make anchors impossible to retrieve.





16 March 1998 Taken from ISm1027(a) ISm5243

Appendix 5

EFFECTS OF OIL ON NATURAL AND SOCIAL RESOURCES

1. Introduction

There is no clear-cut correlation between the size of the spill and extent of damage. The environmental effects of oil pollution on marine organisms varies greatly depending on the volume of oil, the type and physical state of the oil, the capacity of sediment penetration, location of the spill, climate and seastate, the life history of the species involved and the level of exposure. Impacts can be caused by physical contamination, smothering, toxicity bioaccumulation, and tainting (Jones 1986). These effects can be short term or long-term, lethal or sublethal. Damage by oil can result in changes in behaviour, biochemical attributes, physiological attributes which may impact the flora and fauna at an individual level through to the ecosystem level (Sheehan 1984). Commercial, recreational and social interests can be impacted.

An overview of the impacts of a light crude oil on various resources is presented in Table 4-1.

Oil pollution will exert its most severe consequences in shallow, sheltered waters where dilution and dispersion is limited. The impact is of a lesser degree in open water or areas of high energy.

As there have been no significant spills of Western Australian oils which have reached nearshore or onshore resources, predictions for the potential impact of spills on the local marine communities has been based on spill incidents referred to in the literature.

2. Sources of Disturbance

In evaluating the potential impacts of an oil spill, it is necessary to place the impact of a spill within the context of existing disturbances as it is against these variables that the consequences of an-oil spill must be compared.

Potential anthropogenic and natural sources of disturbance are listed in Table 4-2.

3. Biological Recovery Process

The biological recovery of an ecosystem which has been damaged by oil begins as soon as the toxicity of the oil has degraded to a level which is tolerable to the most robust colonising organism (Baker *et al*. 1990). This recovery time can vary from a few days to more than a decade, but recovery will occur. Considerable variations in tolerances and sensitivities to oil have been observed among different species and different life stages. Generally, the effects increase in intensity and persistence from pelagic (open ocean) to subtidal to intertidal communities. The reproductive strategy of each type of animal is also an important factor in the recovery of a species.

The water mass is dynamic and rarely static. It moves with the wind, tides and currents. Large scale oceanic processes such as the Leeuwin current and local processes such as tides influence and affect the distribution, recruitment and survival of marine flora and fauna.

The majority of marine plants and invertebrate animals produce millions of gametes (eggs and sperm)

Table 4.1 Overview of the consequences of an oil spill on natural and social resources. A light crude oil is used as the source of impact.

Resource	Importance	Impact	Recovery Time
Plankton	Component of marine food chain. Primary producers. Many marine species have larval form in plankton. as light crude oil is somewhat soluble.	Major impact will be to plankton on surface of water where oil is located. Plankton in water column may be affected, effective reproductive strategies will result in rapid recovery.	Immediate Spatial movement and
Subtidal seabed communities	Potentially high biological productivity. Feeding grounds for turtles, dugongs and fish.	Effect minimal except in shallower waters where oil may reach the seabed. Toxic components in oil may affect flora and fauna. Heavier oil may persist in sand sediment for period of time.	1 year Rapid recovery due to spatial movement of animals and high reproductive capacity of colonising species.
Rocky intertidal shores	Dominated by oysters and barnacles. Includes array of other fauna and flora. Rock platforms used by birds.	Damage by smothering or toxic effects. Oil may not adhere to rock for long period of time. Low potential for oil accumulation except in crevices and pools. Natural cleansing by waves reduces persistence of oil.	1-2 years
Mud tidal flats	Supports mangrove communities. High productivity. Feeding grounds for wading birds.	Oil may not penetrate very deep due to fine sediment. Burrows of animals may act as pathways for oil, assisting penetration. Severe impact to fauna may lead to reduced food supply for wading birds.	2-10 years Dependent on penetration of oil and tolerance of animals.
Sandy beaches	Turtle nesting grounds, associated fish species in shallow waters off sandy beaches.	Accumulated oil may affect nesting turtles or hatchlings on their way to the ocean. Some oil may penetrate into sand and persist for a period of time. Seepage of accumulated oil may impact fauna.	2-10 years Dependent on penetration and accumulation of oil.
Algae and seagrass beds	Stabilise shoreline and seabed. Highly productive. Food source for turtles and dugongs. Nursery grounds for marine invertebrates. Provide shelter.	Algae is considered to be relatively resilient to oil. Intertidal seagrass beds most prone to damage. Tolerance to oil varies amongst species. Depressed growth rate, leaves turning brown, covering by algae are reported responses. Animals associated with seagrasses could be heavily impacted.	Algae: 1 year Seagrass: 1 year – decades
Corals	Provide habitat for high density and diversity of animals. Nurseries for many fish. Importance for tourism.	Minimal impact if coral remains submerged and oil is mixed in the water column. Localised tissue rupture, increased algae growth, excessive mucous production are potential responses. If coral dies, habitat composition may change to predominantly algae. Some corals long lived and slow growing. Recovery dependent on recruitment success.	1 year – decades
Mangroves	Highly productive. Source of food and shelter for wide diversity of organisms. Nursery grounds for some marine species. Stabilise shoreline.	Oil may persist for long time in sediment, especially where penetration has occurred (ie. Down animal burrows). Response range from defoliation, chlorosis and death of trees due to toxic impact. Infauna may be decimated by oil due to its toxicity.	Trees: 10-50 years Fauna: 2-5 years
Fin fish	Commercial and recreational value. Contribute to food chain.	Low risk of impact to adults in open water due to mobility. Toxic component may cause tainting or death to fish in sheltered waters. Larvae and eggs floating on surface prone to impact.	Years in enclosed waters.
Seabirds	Lovely to observe. Add to biodiversity of area.	Damage to plumage and ingestion.	Slow to medium recovery depending on reproductive potential.
Turtles	Add to conservation status and biodiversity to area. Food source to indigenous people. hatchlings. May ingest oil while feeding.	May be prone to eye infections if contact made with oil. Mobile and can therefore avoid oil. Greatest impact will be to nesting turtles and	Slow recovery.
Marine animals	Add to conservation status and biodiversity of area.	Appear to be able to avoid oil. However, if come into contact, may suffer eye infections, skin irritations, inhalation of fumes, ingestion of oil. Dugongs may be affected if food source impacted.	Slow recovery.
Fin fish	Economic value	Oil which contacts fin fish or invertebrate fisheries (crabs, crayfish, prawns) can cause direct mortality or sublethal effects that may inhibit growth and reproduction. Decimation of stocks may result in economic impact.	Slow to medium.
Tourism	Economic value	Access to oiled beaches to be avoided, fishing may be restricted and some natural resources used for diving may be restricted for access.	Medium.

Table 4.2 Potential Man-Induced and Natural Stressors.

Anthropogenic Sources	**Potential Impact – Comments**
Shipping Tourism	Accidental spillage of oil. Illegal operational discharges. Tourism to the islands is still fairly limited due to their distance from the shore. Visitors come to the islands mainly in the winter and seek sheltered anchorage in the sheltered bays.
Recreational fishing	Overfishing and depletion of stocks. Damage to coral reefs from anchoring. Charter vessels visit the islands on a regular basis, but numbers are relatively low compared to other offshore islands.
Pearl farming Global warming	Increased organic matter load in sheltered waters Increase in water temperature and water level. Increased temperatures may be cause of mass coral bleaching
Natural Sources	**Potential Impact**
Crown-of-Thorns Starfish	Destruction of coral through feeding. A recent outbreak is thought to have occurred on the west fringing reef of the Montebello Islands. Some have been observed on the Lowendal Islands also. No reason for outbreaks determined as yet.
Drupella cornus	Mortality of coral through feeding. Another coral predator (gastropod) which aggregates in large numbers and causes death of coral. The cause of outbreaks is unknown. *Drupella* has been observed on the reefs around the Lowendal Island.
Phytoplankton blooms	Invertebrate animals and fish mortality due to oxygen depletion or release of toxins. Occurs mainly in shallow, sheltered waters.
Insect infestation Boring organisms	Defoliation. Loss of branches Death Affects predominantly mangrove trees.
Parasitic protozoans	A naturally occurring protozoan causes 25-50% mortality to oysters by destroying connective tissue in gastric system.
Cyclones	Extensive physical damage to corals and mangroves. Beach erosion. Algal blooms due to release of nutrients in resuspended sediments.
Cyclonic rainfall	Short-term reduction in salinity of shallow waters. Freshwater run-off from land.

which drift and develop in the water mass. Marine species with planktonic larvae are rarely site dependent: similar benthic communities are likely to occur wherever appropriate conditions are present. Such locations may be miles away, but the communities are likely to be closely related genetically and in community structure. Species with planktonic larvae are most likely to recover quickly after an oil spill.

A few marine invertebrate species reproduce by generating and caring for a relatively small number of eggs or young. These species may become endemic to a particular habitat. If the habitat has been destroyed, the local population may take a long time, if ever, to recover.

The initial phase of recovery after some disturbance or organic enrichment, is characterised by a small number of species, but in very high abundances (Pearson and Rosenberg 1978; Kingston 1987). As conditions improve, other less hardy species are able to establish themselves, and by competition, reduce the numbers of the initial colonizers. In time, the flora and fauna characteristic of the area are restored.

Marine communities, whether they are soft sandy bottom, rocky shore, coral reef or mangrove, are in a constant state of flux and change due to natural physical and biological factors such as predation, competition, recruitment success, cyclones and sandwave migration. Studies investigating the temporal trends in marine soft bottom and rocky shore habitats have reported wide variations in population abundances and diversity from season to season (Lewis 1972; *Gray et al.* 1984). This complicates predicting or assessing the impact of oil as is it difficult to distinguish oil induced effects from natural fluctuations.

Much of the work carried out to date on the effects of oil has concentrated on single species. However, no one species lives in isolation. Ecosystems are composed of a multitude of different plants and animals which have developed a relationship between themselves and the physical attributes which surround them (air, water, soil). An oil spill could cause a major disruption to this relationship resulting in changes in the composition and functioning of the ecosystem, or in key processes such as primary production or nutrient cycling.

The re-establishment of a biological community after some perturbation is unpredictable as it depends on various factors including the availability of recolonising organisms, biological interactions and climatic variables, food availability and suitable substratum for settlement.

Recovery is marked by the re-establishment of a healthy biological community in which the plants and animals characteristic of the community are present and are functioning normally (Clark 1989). A re-established community may not have exactly the same composition, diversity, biomass or age structure as that which was present before the damage. This change does not necessarily diminish the biological importance of that community. It must also be considered that it is impossible to determine if a community which has recovered from an oil spill is the same or different from the community which would have persisted had the spill not occurred.

4. Impacts of Oil on Natural Resources

A brief overview of the impact oil would have on the different types of resources found in and around the Lowendal and Montebello Islands is given below.

In general, the effects of hydrocarbons on marine life may include:

- lethal toxic effects - where death of an organism results from direct interference of a component of the oil;
- sub-lethal effects - chronic, biological effects of oil through disruption of physiological

and/or behavioural responses, but not resulting in immediate death;

- bioaccumulation - where oil may be transferred through the food web;
- tainting - uptake of oil or certain fractions of oil;
- direct smothering and suffocation;
- physical or chemical alteration to a habitat resulting in a change in population or
- community structure.

4.1 Plankton

Plankton are the minute animals and plants floating about in the oceans, forming a component of the food chains, in the marine environment. Plankton provide an important source of food to animals living in all types of marine habitats: mud, sand, coral reefs, mangroves, rocky shores. Suspension feeders (eg. barnacles, corals, some polychaete worms) feed on live and dead particles suspended in the water column. Other animals feed on the dead plankton which has settled on the seabed (eg. crabs, sea urchins, prawns). The larvae of many marine organisms spend time in the plankton during the early stages of their life cycle (eg. corals, fish, crayfish). Plankton exhibit high natural mortality and are very patchy both spatially and temporally.

In the event of an oil spill, the plankton within the immediate area of the spill would undoubtedly suffer high mortality but repopulation is likely to be rapid due to high reproductive rates and immigration from areas outside the impacted area (Davenport 1982). Plankton is free floating and abundant in surface waters and so can be swept into previously contaminated areas from neighbouring unpolluted waters by surface currents. In open waters, populations may return to normal within days of a spill, although recovery may take longer in enclosed bays where water movement is less and oil may persist.

From a literature review, Volkman *et al.* (1994) concluded that there was general agreement that oil toxicities to plankton showed little or transient effects in both experimental and field experiments.

4.2 Benthic and Intertidal Communities

Subtidal communities

The risk of an oil spill affecting the seabed of offshore waters is minimal, but in shallow water, oil droplets may reach the bottom, particularly in rough weather. Fresh crude with a high proportion of toxic light components can cause local damage to the flora and fauna of shallow benthic habitats. The incorporation of heavier oil into the sediment can lead to a residence time of several years. However, sediment resuspension from tide, current and storm activities will help in the degradation process and allow recovery of the community. If the oil is not persistent, the recovery time can be within a few years, depending on the reproductive strategy of the various marine organisms.

Rocky Shores

Many of the animals of the rocky shore lay eggs directly into the sea. These eggs develop into larvae and become a component of the plankton. The larvae may eventually settle onto a suitable substratum and develop into an adult. As a part of the plankton, larvae can move great distances as they are swept by currents, tides and winds and hence their numbers are highly variable from both temporally and spatially (Underwood and Chapman 1995).

The effect of oil on the rocky shore tend to be minimal and recovery rates are rapid (2 to 4 years) due to the high energy level which helps break down the oil and because oil does not stick easily to rock (IPIECA 1991). The recovery of rocky shore plants and animals depends on the settlement of the young stages out of the plankton. Settlement and subsequent growth depends on adequate reduction in the volume and toxicity of oil residues.

Mudflats and Sand Beaches

The faunal diversity of mud and sand beaches can be correlated to the size and composition of the sediment, and the tide and wave energy. In general, mudflats consist of small particles and low energy, but of a range of sizes while sandy beaches consist of larger particles and higher energy and a small range of sizes. In terms of diversity, mudflats will generally have a higher diversity of animals than sandy beaches.

There is a characteristic fauna of fish that are usually associated with sand beaches which includes bait fish and juvenile fish. Infauna will be low in diversity and abundance and consist mainly of amphipods and ghost crabs. Some of this fauna is a source of food for some species of seabirds, and turtles use the sand beaches for nesting.

The main impact from oil results if the hydrocarbon is stranded on the beach. Sheltered shores, or low energy coastal habitats may retain oil for long periods of time affecting the recovery rate. Tidal flushing, currents and fauna which turn the sediment over (bioturbation) will help to decrease the amount of time for the oil to degrade.

Algae and Seagrasses

Algae and seagrasses are photosynthetic organisms which use the energy of sunlight to reduce carbon dioxide to organic compounds which they use as food. Unlike seagrasses, algae do not have roots. They receive all their nutrients directly from the water. Algae do not produce flowers, but rather spores which are released directly into the water by the adult plant. Algae provide food for a host of different marine organisms and some species form large floating mats which act as habitats for a flotilla of marine animals. Both are important as sediment stabilizers and fauna habitats.

The effects of oil on algae will be dependent on its distribution. Intertidal species in low energy, sheltered sites are the most at risk due to direct contact and the potential residence time of the oil. The response to seagrass to oil spills appears to vary considerably (Thorhaug 1987).

Seagrass beds and algae will survive a spill provided there is no actual coating. Coating causes considerable destruction (Thorhaug and Marcus 1987) but reasonably rapid recovery of these areas through recolonisation (algae) or regeneration (seagrass) has been observed following oil spills (AGC Woodward-Clyde 1992).

The fauna associated with seagrass beds appear to be quite susceptible to oil (Jackson *et al.* 1989). Intertidal and shallow subtidal assemblages are most at risk, due to the direct effects of coating. Shallow sediments may also be affected, damaging the rhizomes of seagrasses and so preventing long-term recovery. Deeper assemblages will escape the effects of surface oil in all but extreme weather conditions or where oil is heavy.

Corals

The response of corals to oil spills varies according to geographic locations and the species of coral (Harrison 1993; Guzman *et al.* 1994).

Few causal relationships have been established between corals and oil despite a number of laboratory and field experiments (Guzman and Holst 1993). Experimental studies have shown that direct contact with oil is generally not immediately fatal to corals, but it may lead to rapid necrosis of contacted tissue (Johannes 1972). Laboratory studies have documented a number of lethal and sublethal responses of coral to oil exposure. Sub-lethal responses include uptake of oil in mucous (Neff and Anderson 1981), zooxanthelle expulsion (Neff and Anderson 1981), impaired sediment clearance (Bak *et al.* 1976) and larval death (Rinkevish and Loya 1977).

Translation of these sub-lethal effects measured in the laboratory to field situations has generally proved difficult. Studies from oil spills in a number of regions have shown a range of coral species to be sensitive to oil, with emergent corals being more vulnerable due to the potential for direct contact with the floating oil. Sensitivity to oil has been found to vary from species to species with factors such as structural complexity and natural mucous production effecting oil response.

Under field conditions, subtidal corals have been found to be less sensitive to oil, with corals at depths greater than three metres exhibiting no significant differences in cover over time when compared to control sites (Jackson *et al.* 1989).

Mangroves

Mangrove communities are potentially the most sensitive of the marine environments to coating by oil (Lai *et al.* 1984; Wardrop 1987). Oil spills may result in the immediate destruction of all flora and fauna within the community. The mangroves themselves are highly susceptible to even light coating by oil and suffer permanent damage and mortality due to loss of leaves through chemical burning, or smothering of the breathing pores (lenticels) or the aerial roots (pneumatophores). Mangroves are also known to take up the light end component from the oil through their roots and leaves, causing tissue damage and eventual death (Woodside 1989; Klekowski *et al.* 1994). Oil retained in the sediment may also inhibit the germination of mangrove propagules, resulting in the slow recovery of the affected area.

Mangrove communities typically occur in sheltered areas of low wave energy, making retention of oil within the sediments a potentially long term problem. The retention of oil in the substrate may result in chronic exposure to oil due to the flushing of retained oil out of the sediment over each tidal cycle. The burrows of organisms and the roots of trees also act as a conduit for light oils, allowing the penetration of oil deep into the sediment.

In open, aerobic sediments, the loss of light oil appears to take about 18 months (Woodside 1989). However, in areas where the sediments were anaerobic, with a high organic content and poorly flushed, degradation is slow and the oil persists over 20 years or more (Burns *et al.* 1994). Re-emergence of young trees will be unlikely until at least the toxic components of the oil are lost. Estimates of recovery rates range from tens to hundreds of years to regain a mature forest (Burns *et al.* 1993).

Fish

The death of adult fish has been attributed to toxic effects after water or tainted food, ingestion and to suffocation caused by clogging of the gills (Clark 1982; Jones 1989). Large kills of adult fin fish in open water would not be expected due to their mobility and ability to avoid oil contaminated water. Mortality of adults in sheltered, enclosed bays, especially demersal fish, would be higher if oil became mixed through the water column or settled in the bottom substratum.

The greatest damage to fin fish would be during and just after the spawning period when the more sensitive eggs and larvae may float on the surface of the ocean. This may result in a short term decrease in fish stocks. However, the literature indicates that mortalities among pelagic fish and larvae are limited in size and will have no measurable impact on fish stocks. For example, 10 months after the Exxon Valdz spill, there was a record catch of pink salmon. The reason for this increase was attributed to the oil acting as a fertiliser, helping to prolong an algal bloom which provided food for the fry (Anon 1990). On the negative side, the oil spill killed off diving seabirds which fed on the salmon fry.

4.3 Seabirds, Marine Reptiles and Mammals

Seabirds

The most serious effect of oil is on the birds plumage. Birds rely on the air trapped in their feathers to provide insulation and buoyancy and oiled feathers mat down and lose their water repellent properties. This leads to death by drowning or hypothermia.

Lightly oiled birds are able to clean themselves by preening within two weeks (Birkhead *et al.* 1973) but in doing so ingest oil. This ingested oil may cause liver, kidney and other tissue damage, may reduce the fertility of eggs that are laid (Grau *et al.* 1977), or result in death.

Although highly mobile and potentially capable of avoiding polluted areas, seabirds may be attracted to dive into oil slicks, mistaking the sheen for fish.

Many pelagic tropical species feed by picking or snatching prey from at or near the sea surface without settling on the water (eg. Bridled Terns, Sooty Terns, noddies, frigatebirds). Wedge-tailed Shearwaters, Bulwar' s Petrel:, gadfly petrels, storm petrels feed while paddling on the surface of the water. Boobies and Tropic birds plunge dive to about a metre or so below the surface.

On the North West Shelf, seabirds are often associated with large floating rafts of the brown algae *Sargassum*. A range of juvenile and larval fish, crustaceans and terrestrial insects shelter in the rafts and act as a food source for the birds. Bridled Terns in particular appear strongly reliant on *Sargassum* (Wooller 1995). In the event of an oil spill, oil may become entrained into the rafts with the potential of toxic effects (Butler *et al.* 1983).

The movement of pelagic predatory fish, particularly tuna, are important to many seabirds. Species such as the Sooty Tern may be totally dependent on tuna to bring prey to the surface of otherwise deep ocean. Platforms and monopods function as fish aggregators, attracting fish such as tuna and mackerel. As a consequence, the seabirds also tend to concentrate to varying degrees around these structures where they may be vulnerable to localised spills (Dunlop *et al.* 1995).

Many seabirds have a yearly, single egg clutch and chicks with relatively long fledgling periods (eg. Wedge-tailed Shearwater, Bridled Terns). In Bridled Terns, the minimum age of first breeding is four and a reproductive life extending 6-15 years. Wedge-tailed shearwaters have a reproductive life of 10-20 years.

In terms of impact from an oil spill, the concern in not the deaths brought on by oiling, but the number and fate of the survivors. Recovery of a population depends either on (i) the existence of a reservoir of young breeding adults from which breeding colonies can be replenished or (ii) a high reproductive rate. Animals with a large breeding potential may rapidly regain their losses. Mortality is only significant if it results in a substantial decrease in the breeding population.

Turtles

Little is known about the direct effects of oil on turtles. Eye infections may result from direct contact with oil, however most animals would be expected to avoid polluted areas. The lighter oils produced by the Varanus Island Hun operations may be capable of penetrating the sandy sediments found on nesting beaches and subsequently interfering with egg-laying or egg development. However egg laying and development usually occur high on the beach beyond the reach of stranded oil. Nesting females and young hatchling turtles might be coated with beached oil as they emerge from and enter the water.

Marine Mammals

Information on the impact of oil on marine mammals is limited. However, Baker *et al.* (1990) believe that these species appear to ignore floating oil and are unharmed when they encounter it.

Like turtles, marine mammals may suffer eye infections after direct contact with oil (NRC 1985). Other potential effects include surface fouling, direct and indirect ingestion and inhalation of toxic fumes (Volkman *et al.* 1994). Whales and dolphins have been observed to avoid surface oil slicks and dugongs are presumed to be able to do so, although no information on their response to oil is currently available (Baker *et al.* 1989). As marine mammals move freely in open water, they would not be exposed to prolonged or sustained exposure to oil.

Work carried out by Hellou *et al.* (1990) found low concentrations of polycyclic aromatic hydrocarbons (PAHs) in the skeletal tissue of ten species of marine mammals in eastern Canada, implying that PAHs can accumulate in mammalian tissue. However, the data must be interpreted with caution as the concentration and retention of hydrocarbons will depend on the level of exposure, sex, body organ and ability of the animal to depurate.

Dugongs may be indirectly affected by ingestion of coated seagrass leaves.

5. Effects of Oil Spills on the Social Environment

5.1 Commercial Fisheries

A large oil spill could have significant effects on local fisheries, but because most fishing activity occurs south of the permit area and most surface water movement is offshore, this risk is minimal. The prawn fishery operating adjacent to Onslow may be at risk from an oil spill. The pelagic larval stages and the benthic juvenile and adult stages of prawns are more sensitive to oil than fin fish or molluscs and catches may be reduced due to mortality or to reduced fishing effort in polluted areas. Pelagic fish are able to avoid spills but benthic fish may suffer from pollution of substrates.

In the event of an oil spill under appropriate conditions, there could be some impact on pearl farming to the northeast of the island group. As filter feeders, pearl oysters will ingest oil particles if they sink through the water column and this may cause mortality

5.2 Tourism

An oil spill spreading to the south of the permit area may have a temporary effect on the operations charter boats and recreational fishing. The actual recreational fish stocks are unlikely to be affected as game fish are highly mobile and so able to avoid the effects of a spill. An oil spill spreading to the Lowendal or Montebello Islands would similarly disrupt recreational fishing and day trips in those areas.

6. Bacteria

This group of organisms is given separate recognition due to their natural occurrences and their potential to help in the remediation process after an oil spill.

Biodegradation is a natural process whereby bacteria or other micro-organisms breakdown the organic molecules of oil.

The natural population of bacteria found in the marine environment has the potential to degrade hydrocarbons very rapidly, especially if additional nutrients are added. These bacterial populations have been found to be very complex and a number of different species work together to degrade the hydrocarbons. Extensive bioremediation techniques were developed after the Exxon Valdez spill and results have been very promising. One finding was that background microbial degradation occurred at very fast rates (Hoff 1993) supporting the claim that under certain circumstances natural cleansing may be the best clean-up option. However, the technique still needs refining before it can be used as a large scale clean-up technique.

References

Anon (1990). After the Exxon Valdez. Mar. Poll. Bull. 21(10):462.

AGC Woodward Clyde (1992). EP342 and EP364 Offshore Permit Wide Drilling

Programme, Consultative Environmental Review. Report for Command Petroleum Holdings NL.

Bak, R.P.M. (1987). Effects of chronic oil pollution on a Caribbean coral reef. Mar. Poll. Bull. 18(10):534-539.

Baker, J.M, Clark, R.B., Kingston, P.F. and Jenkins, R.H. (1990). Natural recovery of cold water marine environments after an oil spill. A report presented at the Thirteenth Annual Arctic and Marine Oilspill Program Technical Seminar, June 1990.

Birkhead, T.R., Lloyd, C. and Corkhill, P.(1973). Oiled seabirds successfully cleaning their plumage. Brit. Birds 66:535-537.

Burns, K.A., Gravity, S.D. and Levings, S.C. (1993). How many years until mangrove ecosystems recover from catastrophic oil spills. Mar. Poll. Bull. 26:239-248.

Butler, J.N., Bryon, F.M., Cadwallader, J. and Stone, A.W. (1983). Studies of Sargassum and the Sargassum community. Bermuda Biological Research Station, Special Publication No. 22.

Clark, R.B. (1982). The impact of oil pollution on marine populations, communities and ecosystems: a summing up. Phil. Trans. R. Soc. Lond. 297:433-443.

Clark, R.B. (1989). Marine Pollution. Oxford Science Publications. 220 pp.

Davenport, J. (1982). Oil and planktonic ecosystems. In: Clark, R.B. (ed) The Long-Term Effects of Oil Pollution on Marine Populations, Communities and Ecosystems. The Royal Society, London. pp 195-200.

Dunlop, J.N., Surman, C.A. and Wooller, R.D. (1995). Distribution and abundance of seabirds in the eastern Indian Ocean: An analysis of potential interactions with the offshore petroleum industry. A report for the Australian Petroleum Production and Exploration Association and Australian Nature Conservation Authority, Canberra.

Grau, C.R., Roudybush, T, Dobbs, J. and Wathen, J. (1977). Altered yolk structure and reduced hatchability of eggs from birds fed single doses of petroleum oils. Science 195:779-781.

Gray, J.S., Valderhaug, V and Ugland, K.I. (1984). The stability of a benthic community of soft sediment. In: P.E. Gibbs (ed) Proceedings of the Nineteenth European Marine Biology Symposium, Plymouth. Cambridge University Press, Cambridge.

Guzman, H.M. and Holst, I. (1993). Effects of chronic oil sediment pollution on the reproduction of the Caribbean reef coral *Siderastrea siderea*. Mar. Poll. Bull. 25(5) 276-282.

Guzman, H.M., Burns, K.A. and Jackson, J.B.C. (1994). Injury, regeneration and growth of Carribean reef corals after a major oil spill in Panama. Mar. Ecol. Prog. Ser. 105:231-241.

Harrison, P.L. (1993). Coral spawning on the Great Barrier Reef. Search 24(2):45-48.

Heliou, J., G. Stenson, I-H Ni and Payne, J.F. (1990). Polycyclic aromatic hydrocarbons in muscle tissue of marine mammals from the northwest Atlantic. Mar. Poll. Bull. 21(10):469-472.

International Petroleum Industry Environmental Conservation Association (1991). Guidelines on biological impacts of oil pollution. IPIECA Report Series, Volume One. London.

Jackson, J., 1. Cubit, D. Keller, V. Batista, K. Buffs, H. Caffey, R. Caldwell, S. Garrity, C. Getter, C. Gonzalez, H. Guzman, K. Kalfmann, A. Knap, S. Levings, M. Marshall, R. Stegar, R. Thompson and E. Well (1989). Ecological effects of a major oil spill on Panamanian coastal marine communities. Science 243:37-44.

Jones, H.E. (1986). Marine Resource Map of Western Australia. Part 2. The influence of oil on marine resources and associated activities with and emphasis on those found in Western Australia. Report Number 74. Fisheries Department of Western Australia, Perth.

Kingston, P.F. (1987). Field effects of platform discharges on benthic macro-fauna. Phil. Trans. R. Soc. Lond. B 3 16:545-565.

Klelowski, E.J., J.E. Corredor, J.M. Morell and C.A. del Castillo (1994). Petroleum pollution and mutation in mangroves. Mar. Poll. Bull. 28(3): 166-169. 4

Lai, H.C., K.H. Lim and C.P. Lim (1984). The effects of oil on mangroves in field conditions. 4

In: Lai, H.C. and M.C. Feng (eds) Fate and Effect of Oil in Mangrove Environment. University Sains Malaysia. pp 67-100.

Lewis, J.R. (1972). Problems and approaches to baseline studies of coastal communities. InRuivo, M. (ed) Marine Pollution and Sea Life. Fishing News (Books) Ltd, London. pp 401.

Neff, J.M. and Anderson, J.W. (1981). Response of Marine Animals to Petroleum and Specific Petroleum Hydrocarbons. Applied Science, London.

National Research Council (1985). Oil in the Sea, Inputs, Fates and Effects. National Academy Press, Washington.

Pearson, T.H. and Rosenberg R. (1978). Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. Oceangr. Mar. Biol. Ann. Rev. 16:299-311.

Sheehan, P.J. (1984). Effects on community and ecosystem structure and dynamics. In: Effects of Pollution at the Ecosystem Level. SCOPE Eds P.1. Sheehan, D.R. Miller, G.C. Butler and P. Bourdeau. pp 51-99. John Wiley and Sons, New York.

Thorhaug, A. (1987). The effects of oil and dispersed oil on global tropical seagrasses and mangroves In: Spillcon '87 Proceedings, Australian National Oil Spill Conference, Melbourne, 7-9 October. Australian Institute of Petroleum Ltd and Federal Department of Transport, Canberra. pp 4.0-4.14.

Thorhaug, A. and 1. Marcus, J. (1987). Effects of dispersants and oil on subtropical and tropical corals. In: Proceedings, 1987 Oil Spill Conference. p 223. American Petroleum Institute, Washington.

Underwood, A.J. and Chapman, M.G. (1995). Introduction to coastal habitats. In: Underwood, A.J. and M.G. Chapman (eds) Coastal Marine Ecology. University of South Wales Press, Sydney. pp 1-15.

Volkman, J.K, G.J. Miller, A.T. Revill and D.W. Connell (1994). Oil spills. In: Swan, J.M., J.M. Neff and P.C. Young (eds) Environmental Implications of Offshore Oil and Gas Development in Australia. The Findings of an Independent Scientific Review. Australian Petroleum Exploration and Association, Sydney. pp 409-506.

Wardrop, J.A. (1987). The effects of oils and dispersants on mangroves: A review and I bibliography. Centre for Environmental Studies, University of Adelaide. Occasional Paper No. 2.

Woodside Offshore Petroleum (1989). The effects of condensate on mangroves and the degradation process of condensate in sediments. A presentation to Chemistry International incorporating the 1St Environmental Chemistry Divisional Conference, 10th Australian Symposium on Analytical Chemistry and 3rd Chemical Congress. September 1989.

Wooller, R. (1995). Seabirds of the North-West. E+P Magazine. The Australian Petroleum Production and Exploration Association. Number 7.

Appendix 6

ENVIRONMENTAL MANAGEMENT POLICY

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

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

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

This leadership will be achieved by:

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

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

Jim K Bass, Managing Director

LIBRARY
DEPARTMENT OF ENVIRONMENTAL PROTECTION
WESTRALIA SQUARE
141 ST. GEORGE'S TERRACE, PERTH