Technical Appendix B4

Marine Spill Primary Risk Assessment

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CHEVRONTEXACO AUSTRALIA

GORGON DEVELOPMENT

MARINE SPILL PRIMARY RISK ASSESSMENT

Technical Appendix B4

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Environmental Risk Solutions Pty Ltd
ACN 071 462 247 ABN 54 071 462 247
3/16 Moreau Mews, Applecross, WA 6153.
Telephone (08): 9364 4832 Facsimile: (08) 9364 3737
Email: ers@ers.com.au
Web: www.ers.com.au

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ABBREVIATIONS

APASA	Asia–Pacific Applied Science Associates
DOMGAS	Domestic Gas
EIS/ERMP	Environmental Impact Statement/Environmental Review and Management Programme
ERS	Environmental Risk Solutions Pty Ltd
GV	Gorgon Venture
km	kilometre(s)
kmy	kilometre year
LNG	Liquefied Natural Gas
LOC	Loss of Containment
m	metre(s)
MEG	Monoethylene Glycol
MOF	Materials Offloading Facility
UKCS	United Kingdom Continental Shelf
y	year
/kmy	per kilometre year
/y	per year

1. SUMMARY

The Gorgon Venture (GV), the participants being ChevronTexaco Australia, Texaco Australia, Shell Developments Australia and Mobil Australia Resources Pty Ltd; proposes to construct and operate a number of pipelines and onshore plant as part of the Gorgon Development which is located off North Western Australia.

During the construction and operation phases of the project, there is potential for spills of fluid to the marine environment; the scenarios for which have been identified by others (APASA, 2004, Reference 1). Environmental Risk Solutions Pty Ltd (ERS) has been commissioned to undertake a Primary Risk Assessment for the identified scenarios as part of the Environmental Impact Statement/Environmental Review and Management Programme (EIS/ERMP) for the Gorgon Development.

There are 12 Spill Scenarios that have been identified, two of which relate to the discharge of hydrotest water which is an intended action, and was not considered further. With regards to the spill scenario due to work vessel collision within port approaches, it was concluded that this scenario is very unlikely to occur and result in a marine spill, and was not considered further.

In determining the primary risk for the Spill Scenarios, reference has been made to data that is available in the public domain, the majority of which is based on incident history for North Sea and European operations. The source of the data reflects a location where there are a number of large facilities with associated support infrastructure in terms of pipelines, support vessels, etc. The Gorgon Development is remotely located and although the data is applicable, the results in terms of primary risk represent a conservative approach. Data that is available in the public domain such as the Exploration & Production Forum, and Lloyd's Maritime Information Service has been used to determine the primary risk. Table 1.1 is a summary of the primary risk for the 10 Spill Scenarios.

Table 1-1 Primary Risks Table

Spill Scenario ID	Description	Primary Risk
1	Rupture at Central Manifold	1.5×10^{-4} /y
2	Rupture of the Feed Pipeline 14 km from Barrow Island along proposed Route 1	2.81×10^{-5} /kmy
3	Rupture of the Feed Pipeline 14 km from Barrow Island along proposed Route 2	2.81×10^{-5} /kmy
4	Rupture of the Feed Pipeline 200m from Barrow Island along proposed Route 1	2.81×10^{-5} /kmy
5	Rupture of Condensate Export Pipeline	1.48×10^{-4} /kmy
6	Refuelling accident during the supply gas pipe-laying	4.1×10^{-2}/y (1)
7	Refuelling or incident or spill of fuel from the port facilities	9.0×10^{-3}/y
8	Work vessel collision within port approaches	ruled out
9	Grounded export tanker	2.34×10^{-5}/y
10	Rupture of the MEG Pipeline	4.32×10^{-5} /kmy

Note: 1 This scenario is applicable for the year during pipe-laying only.

2. INTRODUCTION

2.1 Background

The Gorgon Venture (GV), the participants being ChevronTexaco Australia, Texaco Australia, Shell Developments Australia and Mobil Australia Resources Pty Ltd; proposes to construct and operate a number of pipelines and onshore plant as part of the Gorgon Development which is located off North Western Australia. A gas processing facility (ie a Liquefied Natural Gas (LNG) and Domestic Gas (DOMGAS) plant) located on the central-east coast of Barrow Island would process the gas. The production fluids from the Gorgon Fields will be transported to this plant via a pipeline known as the Feed Gas Pipeline. The liquid hydrocarbon product would then be transported by ship to international markets. Compressed domestic gas would be delivered via a sub-sea pipeline to the Western Australian Mainland for use in the industrial and domestic gas markets.

During the construction and operation phases of the project, there is potential for spills of fluid to the marine environment; the scenarios for which have been identified in work by others (APASA, 2004). Environmental Risk Solutions Pty Ltd (ERS) has been commissioned to undertake a Primary Risk Assessment for the identified scenarios as part of the Environmental Impact Statement/Environmental Review and Management Programme (EIS/ERMP) for the Gorgon Development. This document reports said risk assessment.

2.2 Scope

One of the preliminary phases of the Marine Spill and Discharge Risk Assessment was the undertaking of the identification of spill scenarios as reported in the Marine Spill and Discharge Risk Assessment Report (Reference 1). These are:

Hydrocarbon Spill Scenarios:

1. Rupture at Central Manifold.
2. Rupture of the Feed Pipeline 14 km from Barrow Island along proposed Route 1.
3. Rupture of the Feed Pipeline 14 km from Barrow Island along proposed Route 2.
4. Rupture of the Feed Pipeline 200m from Barrow Island along proposed Route 1.
5. Rupture of Condensate Export Pipeline.
6. Refuelling accident during the supply gas pipe-laying.
7. Refuelling or incident or spill of fuel from the port facilities.
8. Work vessel collision within port approaches.
9. Grounded export tanker.

Non-hydrocarbon Spill Scenarios:

10. Rupture of the MEG Pipeline.
11. Discharge of hydrotest water from the supply manifold at Production Manifold (M2) at a depth of 200m.
12. Discharge of hydrotest water from the DOMGAS Line on the east coast of Barrow Island supply manifold at Production Manifold (M2) at a depth of 2m.

The likelihood (i.e. the Primary Risk) of each of the above spill scenarios is to be determined. Given that the discharge of hydrotest water (Spill Scenarios 11 and 12 above) is an intended action, then these are not considered further.

3. ANALYSIS

3.1 Overview

In determining the primary risk for the Spill Scenarios, reference has been made to data that is available in the public domain, the majority of which is based on incident history for North Sea and European operations. The source of the data reflects a location where there are a number of large facilities with associated support infrastructure in terms of pipelines, support vessels, etc and where weather conditions are more severe from those. The Gorgon Development is remotely located and although the data is applicable, the results in terms of primary risk represent a conservative approach.

3.2 Pipeline Primary Risk

Of the 10 Spill Scenarios that are identified in Section 2.2, five are due to the rupture of a submarine pipeline; i.e.;

- spill scenario ID No 2 - rupture of the Feed Pipeline 14 km from Barrow Island along proposed Route 1;
- spill scenario ID No 3 - rupture of the Feed Pipeline 14 km from Barrow Island along proposed Route 2;
- spill scenario ID No 4 - rupture of the Feed Pipeline 200m from Barrow Island along proposed Route 1;
- spill scenario ID No 5 - rupture of Condensate Export Pipeline; and
- spill scenario ID No 10 - rupture of the MEG Pipeline.

A source of submarine pipeline risk data is provided by PARLOC (Oil Industry International Exploration and Production Forum, 1992 (Reference 2)), which is prepared for the United Kingdom's Health and Safety Executive (HSE) and is internationally recognised. PARLOC provides data for flexible and steel pipelines and risers for various sizes and is primarily focussed on pipelines in the North Sea. The frequency data from the North Sea incorporates data from incidents that are due to a very high number of ship movements when compared to the environs of the Gorgon Field and Barrow Island. Therefore, the primary risk data used in this study reflects a very conservative approach. In the absence of other publically available data that is equally regarded, then this data is used for the Gorgon submarine pipelines.

The data is presented in terms of a Loss of Containment (LOC) for pipelines in operation due either to;

- anchor and impact incidents; or
- corrosion and material defects.

In the calculation of frequencies, PARLOC assumes that the number of incidents follows a mathematical binomial distribution known as a Poisson Distribution. The best estimate, as used in this study, repeats this distribution with an upper 95% and lower 5% confidence limits.

With regards to the Condensate Export Pipeline, it is proposed to use the existing Barrow Island Oil Export Line, and therefore in determining the Primary Risk, the upper bound is used. This provides a conservative approach to accommodate the age of the existing pipeline, whilst recognising that, as reported by PARLOC, it is difficult to draw firm conclusions on trends in LOC primary risk with age.

The MEG Pipeline will be one of the lines included in the Umbilical Bundle. PARLOC concludes that the reporting of incidents involving umbilicals is not considered to be comprehensive. Therefore, relevant data is not available pertaining specifically to the MEG Pipeline. Given that this pipeline's route will be parallel to the Feed Pipeline and provided with the same protection mechanisms, then PARLOC's data for this size pipeline is assumed to be applicable.

The PARLOC data provides the distribution of the leak sizes including the scenario for pipeline rupture. For pipelines with a diameter greater than 16 inches, (i.e. the Feed Pipeline, and the Condensate Export Pipeline) the distribution of pipeline ruptures is 1/3 of the total likelihood for all pipeline LOCs for this size pipeline. For the MEG Pipeline, the distribution is 14.7% for pipeline ruptures when compared to the total likelihood for all pipeline LOCs. These distributions are applied to the total likelihoods to provide the primary risk for the rupture spill scenarios. These are listed in Table 3.1.

Table 3-1 Pipeline Primary Risks Table

Spill Scenario ID	Description	Primary Risk (per kmy)
2	Rupture of the Feed Pipeline 14 km from Barrow Island along proposed Route 1	2.81×10^{-5}
3	Rupture of the Feed Pipeline 14 km from Barrow Island along proposed Route 2	2.81×10^{-5}
4	Rupture of the Feed Pipeline 200m from Barrow Island along proposed Route 1	2.81×10^{-5}
5	Rupture of Condensate Export Pipeline	1.48×10^{-4}
10	Rupture of the MEG Pipeline	4.32×10^{-5}

3.3 Rupture of Central Manifold

It has been identified that there is potential for a rupture to occur at the Central Manifold which is a sub-sea installation.

The HSE hydrocarbon release database is a comprehensive collection of all significant hydrocarbon releases in the UK offshore sector from 1992 to 1997. The Centre for Marine and Petroleum Technology (Reference 3) reports this database and includes the major event LOC frequencies for installation type (i.e. fixed manned, unattended, sub-sea, semi-sub and jack-up). The reported likelihood of a LOC for a sub-sea installation is 1×10^{-2} per installation year.

The HSE hydrocarbon database includes a distribution of hole sizes and the probability of that hole size. For this scenario, it is assumed that rupture is equivalent to hole sizes greater than 100mm in diameter; the probability of which is 0.015.

Therefore the primary risk for rupture of the Central Manifold is 1.5×10^{-4} per year.

3.4 Refuelling accident during the supply gas pipe-laying

It has been identified that a spill of fuel used by vessels during the pipe-laying construction phase could occur. This spill could occur during the refuelling of the pipe-laying vessels from dedicated barges, with the likely cause being the failure of the transfer hose.

The E & P Forum (Reference 2) provides data from the United Kingdom Continental Shelf (UKCS) offshore loading statistics on Department of Trade and Industry pollution reports over the years 1977 to 1993. This data has been broken down into separate factors for the different components of the loading system. For transfer hoses, the likelihood of a LOC is 4.1×10^{-3} per cargo transfer.

It is assumed that the Feed pipelines will be installed by a single pipe-laying barge over an 8 month period. During that time, the pipe-laying barge will require approximately 10 refuellings. It is anticipated that the pipe-laying will require a supply vessel/tender to support the pipe-laying barge, the refuelling of which will be at Dampier. Therefore to determine the annualised primary risk during the year of construction for the supply gas pipeline, the 10 refuellings for the pipe-laying barge are applicable. The primary risk is 4.1×10^{-2}/y and is only applicable for the period during pipe-laying.

3.5 Refuelling or incident or spill of fuel from the port facilities

This spill source includes the spills that may occur during a transfer of fuel to and from the Material Offloading Facility (MOF) port facilities during the construction phase. The probable spill source includes the fuel pipeline along the wharf and transfer hoses.

The above UKCS statistics published in the E & P Forum (Reference 2) provide data by which the likelihood of a LOC, due to pipeline and transfer hoses, is determined to be 3.0×10^{-3} per cargo transfer.

It is anticipated that the facilities on Barrow Island will be refuelled twice per year. The refuelling of vessels is assumed to occur at Dampier where there is existing infrastructure for both the project's construction and operational phases. During the operational phase, it may be necessary to refuel a vessel, but this is considered to be an infrequent event. Nevertheless, a conservative assumption is made that a total of 3 refuellings will occur per year and the primary risk is determined to be 9.0×10^{-3}/y.

3.6 Work vessel collision within port approaches

During the construction phase of the project, there is potential for work vessels to collide within the port approaches. The construction phase will involve approximately 7 support vessels that will be approximately 20m in size. The approaches to Barrow Island are in a Designated Port Area and are subject to the controls for that area which include low speed and good communications. It is not expected that a collision between vessels will occur given the low number of vessels in the large port area and the port control.

In the unlikely event of a vessel collision, given the low speed, then it is considered that any damage incurred, if any, will be minimal. Therefore it is highly unlikely that fuel tanks (either the vessel's own tanks or tanks used to transport fuel to other vessels) would suffer damage that could result in a spill.

From the anecdotal evidence of the operations at Dampier Port with a larger number of vessel movements, there have been no incidents of vessel collisions resulting in spills to the marine environment between support vessels, and support vessels and ships within the Woodside port approaches. It is therefore concluded that this scenario is very unlikely to occur and result in a marine spill, and will not be considered further.

3.7 Grounded export tanker

It has been identified that a spill could occur during the operational phase of the project as the result of an export condensate tanker or LNG tanker being grounded in the port area. The spill could either originate from the tanker's fuel tanks or the condensate on-board the condensate tanker. The following examines the likelihood of such an event resulting in an LOC of approximately 10 to 100m^3.

The primary source of ship accidents data is the ship casualty database maintained by Lloyd's Maritime Information Service. The probability of a loss can be obtained by combining the historical data with fleet data as provided by Lloyd's Register, which, covers all self-propelled sea-going merchant vessels over 100 gross tonnes. In its analysis of this data for the period of 1991 to 1995, DNV reported (Reference 4) the frequency in terms of per ship year for a ship grounding and the probability of an oil spill due to grounding.

The data provided segregates the groundings between a powered grounding where the vessel is under-way by its own engines, and a drift grounding where the vessel is drifting without propulsion from its engines. The likelihood of a powered grounding is higher than a drift grounding. This likelihood is used in this study, as the vessels will be under-way during transits to and from the export berth. This represents a conservative approach which is in keeping with good practice. Further levels of conservatism are incorporated into this analysis by;

- the historical data from Lloyd's Maritime Information Service is significantly influenced by the number of incidents involving single hull vessel versus doubled hull vessels. The latter have been in service for a relatively short period when compared to single hull vessels and the benefits of double hull vessels include the reduced likelihood of a LOC to the marine environment being incurred given an incident occurs (i.e. collision, grounding, etc.). Given that in the future, the number of double hull vessel will increase and single hull vessels will decrease as per the requirements of the International Maritime Organisation, then it is expected that the probability of an oil spill occurring due to powered grounding will decrease; and

- the schedule of LNG Tankers is one every 3 days (i.e. 122 vessels per year), and condensate exports are scheduled at one per month (i.e. 12 vessel per year). Therefore the LNG Tankers dominated the analysis. LNG tankers are generally constructed so that the ship's fuel tanks are located at the stern of the vessel. Given that the likelihood of grounding whilst under power is higher than a drift grounding, then in the scenario for grounding whilst under power, it is more likely that other sections of the LNG Tanker will come into contact with a reef than the stern. Therefore, given the location of the ship's fuel tanks, it is considered to be the least likely scenario by which an LOC to the marine environment could occur.

The likelihood of a tanker vessel being grounded whilst under power is 2×10^{-3} per ship year, and the probability of an oil spill occurring due to the grounding whilst under power is 0.2. Therefore the likelihood of an oil spill from grounding whilst under power is 4×10^{-4} per ship year.

This assumes that the vessel is in the port area continually throughout the year. It is therefore necessary to account for the actual proportion of time that a vessel is in transit in the port area so as to reflect the actual level of primary risk due to each vessel. The sum of all scheduled vessel transits within the Barrow Island Port Area as a proportion of the total hours per year, together with the likelihood of an oil spill from grounding whilst under power will determine the annual primary risk of an oil spill from grounded export tankers.

It is assumed that a condensate tanker will require 1 hour per transit for berthing, and an LNG Tanker will require 2 hours to transit the 8km in the designated channel until it is tied up along-side its station. It is assumed that similar periods of time are required for the outward transit. The schedule of LNG Tankers is one every 3 days (i.e. 122 vessels per year), and condensate exports are scheduled at one per month (i.e. 12 vessel per year). Therefore the total number of hours that vessels are in transit in Barrow Island Port Area per year is 512, which equates to:

$$\frac{512}{365 \times 24} = 0.058 \text{ of a year.}$$

Therefore the primary risk of an oil spill from a grounded export tanker is determined to be $4 \times 10^{-4} \times 0.058 = 2.34 \times 10^{-5}$/y.

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