



Appendix 24

Onshore and nearshore quantitative risk assessment study



Safety & Risk

TITLE: Onshore and offshore quantitative risk assessment summary report

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PROJECT: INPEX: Ichthys Gas Field Development Project—Doc. No. C036-AH-REP-0035

SUMMARY:

This report contains off-site safety risk results for risks from the Ichthys Project's onshore LNG plant and for the sections of the gas export pipeline within Darwin Harbour.

Revision	Description	Approved	Date
A	Drawings for comment	RPC	19 August 2009
B	Revisions by INPEX, further results and graphics from GL	RPC	26 August 2009
0	Final	P Cleaver (GL) P Hands (INPEX)	28 August 2009

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1 EXECUTIVE SUMMARY

INPEX has commissioned a preliminary quantitative risk assessment (QRA) to analyse the potential safety risks at its proposed new liquefied natural gas (LNG) plant at Blaydin Point in Darwin Harbour. This has included safety risks from the gas export pipeline in the Harbour, which connects the offshore gas reservoirs with the onshore processing plant. This report focuses on the potential off-site safety risks.

The results have been compared against government safety risk criteria. The current pipeline and plant designs have resulted in potential off-site safety risk levels that are below government safety risk criteria in all cases except on the northern tip of Blaydin Point where the LNG and liquefied natural gas (LPG) tankers will berth, and at the pipeline shore crossing.

For the small areas where the risks have been determined to be above the government criteria, INPEX and regulatory agencies will work together to investigate further risk reduction measures.

As this report was compiled at an early stage of plant design, subsequent refinements in the design are expected to lead to a lowering of future off-site risk levels. This is consistent with the regulatory requirement to manage risks to levels that are “as low as reasonably practicable” (ALARP). INPEX continues to investigate options to reduce risk throughout all Project phases. These developments will be more fully reported in subsequent documents, chiefly in the onshore safety report that INPEX is producing for assessment by NT WorkSafe as part of the regulatory regime that controls plant start-up and ongoing operations.

2 INTRODUCTION

INPEX Browse, Ltd. (INPEX) proposes to develop the natural gas and associated condensate resources contained in the Ichthys Field situated about 220 km off Western Australia's Kimberley coast and about 820 km west-south-west of Darwin. The field encompasses an area of 800 km² in water depths ranging from 235 to 275 m.

The two reservoirs which make up the field are estimated to contain 12.8 tcf (trillion cubic feet) of sales gas and 527 MMbbl (million barrels) of condensate. INPEX proposes to process the reservoir fluids to produce liquefied natural gas (LNG), liquefied petroleum gases (LPGs) and condensate for export to overseas markets.

For the Ichthys Project, the company plans to install offshore extraction facilities at the field and a subsea gas pipeline from the field to onshore facilities at Blaydin Point in Darwin Harbour. A two-train LNG plant, an LPG fractionation plant, a condensate stabilisation plant and a product loading jetty will be constructed at a site on Blaydin Point. Around 85% of the condensate will be extracted and exported directly from the offshore facilities while the remaining 15% will be processed at and exported from Blaydin Point.

In May 2008 INPEX referred its proposal to develop the Ichthys Field to the Commonwealth's Department of the Environment, Water, Heritage and the Arts and the Northern Territory's Department of Natural Resources, Environment and the Arts. The Commonwealth and Northern Territory ministers responsible for environmental matters both determined that the Project should be formally assessed at the environmental impact statement (EIS) level to ensure that potential impacts associated with the Project are identified and appropriately addressed.

Assessment will be undertaken in accordance with the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) and the *Environmental Assessment Act* (NT). It was agreed that INPEX should submit a single EIS document to the two responsible government departments in the Northern Territory and the Commonwealth for assessment.

This technical report, C036-AH-REP-0035, was prepared by INPEX and Germanischer Lloyd (GL) Industrial Services (formerly Advantica, and previously British Gas Research) to assess off-site safety risks from the proposed Ichthys Project operations in Darwin. The source material is derived from preliminary QRA work undertaken by GL for INPEX.

GL is an independent and reputable, long-established risk consultancy based in the United Kingdom. The consultants have performed similar risk assessment work for a number of large LNG projects around the world for many decades. Their capabilities can be viewed on their web site at <www.gl-group.com/en/is/9032.php>.

3 OVERVIEW

INPEX commissioned GL to carry out a QRA related to the Ichthys Gas Field Development Project (the Project). The QRA considered the risks from the following two sources:

- the gas export pipeline carrying the gas from the Ichthys Field to the LNG plant at its proposed location at Blaydin Point in Darwin
- the operations of the LNG plant.

The assessment covered the potential major accident hazards from the pipeline and the plant.

4 METHODOLOGY AND SCENARIOS SELECTED

Figure 1 gives an overview of the methodology used in the QRA and the steps in the analysis are described in more detail in the following sections. This is the same approach and methodology as was used in previous studies for the Project, and draws on the recognised Australian Standard AS/NZS 4360:2004, *Risk management*.

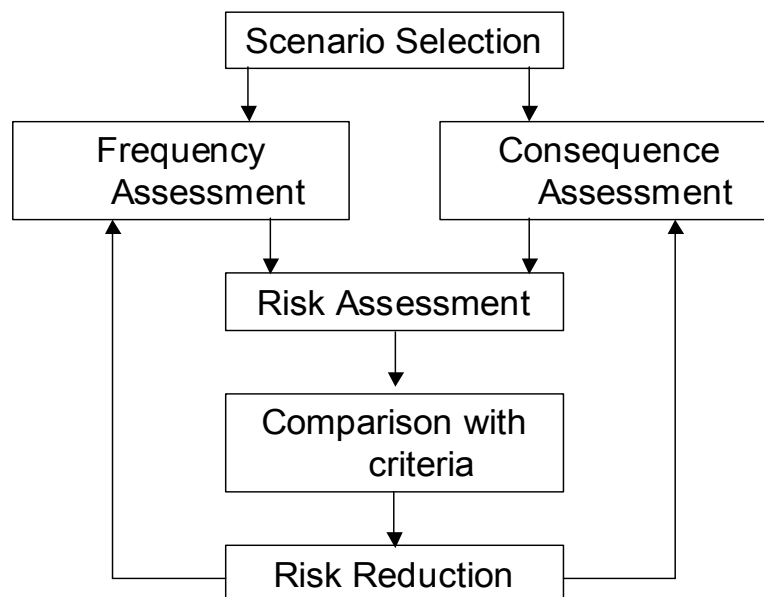


Figure 1: Overview of methodology

When the risk results were calculated, they were compared with the government safety criteria which are widely used by regulatory agencies for land-use planning. In this case, NT WorkSafe informally advised that Northern Territory criteria were still in the process of being developed and that Victorian guidance would be utilised in the interim. This requires that the off-site risks from INPEX's Darwin operations should not exceed a certain value. The maximum off-site "individual risk (of fatality) per annum" (IRPA) should not exceed 10 in a million per year at the site boundary for a new development. This is variously expressed also as " 1×10^{-5} per annum", "1 in 100 000 per annum", or "1.0E-5". These are all the same value, expressed in different ways. The use of land-use planning criteria has influenced the Northern Territory Government's zoning master plan, which has designated Middle Arm Peninsula (including Blaydin Point) for industrial use.

The major accident hazard releases selected for study were based on the output from detailed hazard identification (HAZID) sessions and workshops carried out for the gas export pipeline and the LNG plant. Such sessions and workshops were attended by experienced hydrocarbon plant design and operations personnel, with many years of collective experience in those areas. The scenarios identified are summarised overleaf.

Table 1: Scenarios considered for the LNG plant and the gas export pipeline

Area	Scenario number	Scenario name	Scenario description
Pipeline	P1	Offshore pipeline	Ruptures and punctures of the pipeline near to the platform and midline resulting in a release of natural gas. This scenario is not discussed in this report, as it lies outside Darwin Harbour. It will be discussed in documentation to be supplied to government regulatory agencies prior to operational start-up.
	P2	Pipeline in Darwin Harbour	Ruptures and punctures of the offshore part of the pipeline in Darwin Harbour resulting in a release of natural gas.
	P3	Incoming pipeline (below ground on land)	Ruptures and punctures of the onshore part of the incoming pipeline, upstream of the beach valve, up to and including the beach valve station.
	P4	Incoming pipeline (below ground on land)	Ruptures and punctures of the onshore part of the incoming pipeline from the beach valve station into the LNG plant.
Inlet	1	Inlet pipeline (above ground on site) and slug-catcher unit	<p>Ruptures and punctures of the incoming pipeline from within the site to inlet area, while above ground.</p> <p>Pipework rupture and small and medium natural gas releases from the slug-catcher unit, and small and medium condensate releases from the slug catcher.</p> <p>Pipework rupture of the natural gas pipeline from the slug catcher to the process trains.</p>
Process	2	Condensate stabilisation	<p>Failure of process vessels resulting in releases of condensate.</p> <p>Pipework rupture and small and medium condensate releases.</p>
	3	Gas processing	<p>Failure of process vessels resulting in releases of natural gas.</p> <p>Pipework rupture and small and medium natural gas or higher hydrocarbon releases.</p>
	4	Liquefaction	<p>Failure of process vessels resulting in releases of natural gas, product LNG, propane refrigerant or mixed refrigerant.</p> <p>Pipework rupture and small and medium releases of LNG, propane refrigerant or mixed refrigerant.</p>
	5	Refrigerant cycle	<p>Failure of process vessels resulting in releases of propane refrigerant or mixed refrigerant.</p> <p>Pipework rupture and small and medium releases of propane refrigerant or mixed refrigerant.</p>
	6	Fractionation	<p>Failure of process vessels resulting in releases of ethane, or of product propane or butane.</p> <p>Pipework rupture and small and medium releases of ethane, or of product propane, butane or condensate.</p>
Storage	7	Refrigerant storage	<p>Failure of storage vessels resulting in releases of ethane or propane refrigerant.</p> <p>Small and medium releases of ethane or propane refrigerant.</p>

Area	Scenario number	Scenario name	Scenario description
	8	Product storage	<p>Failure of storage vessels resulting in releases of LNG, propane product, butane or condensate.</p> <p>Pipework rupture and small and medium releases of LNG, propane product, butane or condensate.</p>
	9	Boil off gas	<p>Failure of process vessels resulting in releases of propane product or butane.</p> <p>Pipework rupture and small and medium releases of propane or butane product.</p>
Export	10	Export pipeline	Export pipeline rupture releases of LNG, propane or butane product or condensate during loading and recirculation.
	11	Jetty	<p>Pipework rupture and small and medium releases of LNG, propane or, butane product or condensate at the jetty head.</p> <p>Loading spill releases of LNG, propane or butane product at the jetty with and without pipe emergency release couplings (PERCs) operating from a single loading arm and without PERCs operating from the manifold.</p> <p>Loading spill releases of condensate.</p>
	12	Ships	Ship cargo releases of LNG, propane or butane product, or of condensate from a single cargo tank and from all cargo tanks.
Utilities	13	Fuel-gas usage	Small and medium leaks of natural gas used for fuel in the hot-oil area and in the power generation region.

5 LOCATION OF INFRASTRUCTURE IN DARWIN

The proposed locations of the incoming gas export pipeline in Darwin Harbour and on land are shown in Figure 2 and Figure 3.



Figure 2: The proposed in-Harbour route of the gas export pipeline

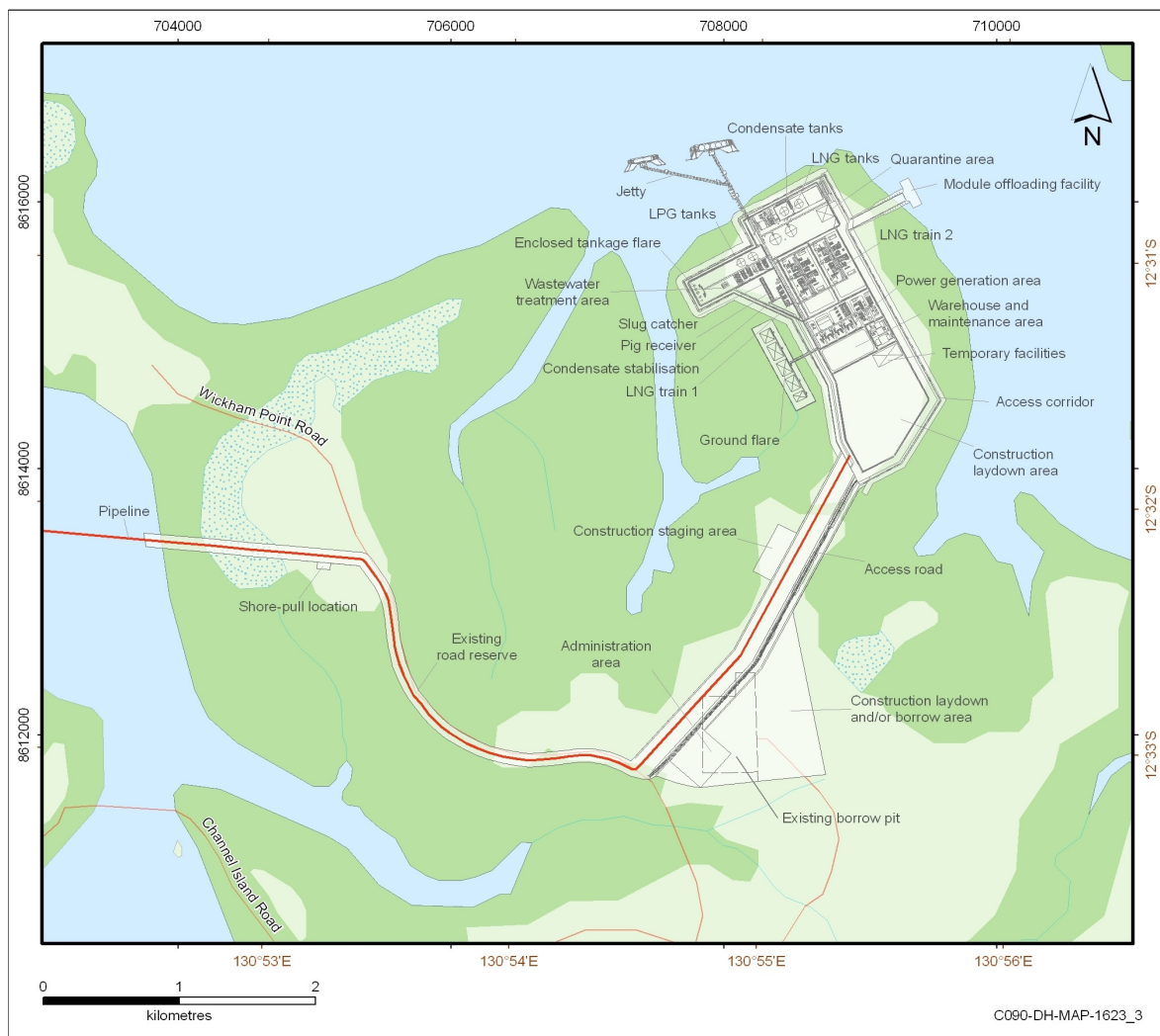


Figure 3: The onshore section of the gas export pipeline to the proposed onshore processing plant together with the plant location and layout

This report assesses the off-site risks in the Darwin area from the following:

- the approx 27-km-long section of the gas export pipeline in Darwin Harbour
- the short onshore section of the pipeline (approx 6 km) to the LNG plant on Blaydin Point
- the LNG plant itself (including the product export jetties).

On-site risks to the workforce and the risks beyond Darwin Harbour will be covered in separate documentation, which will be delivered to government regulatory agencies for further assessment before operational start-up of the project, scheduled for 2015.

The proposed 885-km-long 42-inch-diameter gas export pipeline from the offshore Ichthys Field passes through Darwin Harbour, crosses the shore to the north of Channel Island, and enters the proposed LNG plant at its southern boundary alongside Wickham Point Road. The main part of the site will house the two LNG trains, associated utilities, and LNG, LPG, condensate and mixed refrigerant storage facilities. The central control building will be located just to the south of the utility area.

The site will also provide facilities for the offloading and handling of construction materials to and from marine vessels. It is estimated that the site will process 8.4 million tonnes per annum of LNG, 1.6 million tonnes per annum of LPG, and 15 000 barrels per day of condensate.

The analysis is presented in this report for the gas export pipeline to the Blaydin Point site and with LNG train 1 and LNG train 2 (each producing 4.2 million tonnes of LNG per annum) both in operation. The liquid products will be exported by ships at the two separate berths to the north-west of the site. The pipeline connecting the storage tanks to the jetty heads leaves the site on a single trestle structure, which then separates with lines going to the LPG and condensate export jetty to the west and straight on to the LNG jetty.

The processing facilities for the base case include the following:

- gas export pipeline reception facilities
- gas treatment
- gas liquefaction
- production of LPG and condensate
- storage and loading
- utility and support systems.

For a full description of the facilities, refer to Chapter 4 of the EIS.

6 SAFETY RISK RESULTS

Risks from the pipeline in the Harbour

The pipeline will be designed to the recognised engineering standard, Australian Standard AS 2885 Set-2008, *Pipelines—Gas and liquid petroleum (set)*. At the detailed design stage the risk assessment required by AS 2885 will be undertaken. The pipeline, like the onshore plant, will also be subject to an independent design validation as required by regulations. (These design validations are in addition to the scrutiny from NT WorkSafe of the onshore safety report, required for the plant licence).

The current design for the sections of the gas export pipeline in Darwin Harbour incorporates a number of protection features. This protection is in two parts—internal and external—and is designed to minimise the possibility of leaks from the pipeline and the consequential safety risks. If a leak should occur there is potential for gas to escape and to rise to the water's surface. Given that the primary component of the gas is methane which is lighter than air, it is likely that such a leak would disperse vertically without further incident. However, if the gas–air mixture were between 5% and 15% (methane in air) and if it encountered an ignition source, then a fire or explosion could result. In the Harbour context, a boat engine, for example, could be a potential ignition source.

Internal

The gas stream in the pipe will be actively controlled to minimise the risk of pipe failure due to corrosion, erosion, or other crack mechanisms which might lead to possible leaks through the pipe wall.

External

The 42-inch-diameter steel pipeline will be coated throughout its length by a concrete weightcoat. However, the pipeline is potentially exposed to impact damage, typically from ships' anchors being dropped on it in error, or from anchors being dragged over it and damaging it. The pipeline sections in the Harbour will thus be protected by trenching and rock dumping in high-exposure areas as shown in Figure 4 below. Parts of the pipeline route will have trenches excavated, into which the pipe will then be subsequently laid. Protective rocks will then cover the pipeline route. In this way, damage from anchors up to 17 tonnes in weight, the largest-sized anchors currently predicted to be used in the Harbour, will be minimised. There is no threat of damage to the pipeline from small recreational craft or their anchors.

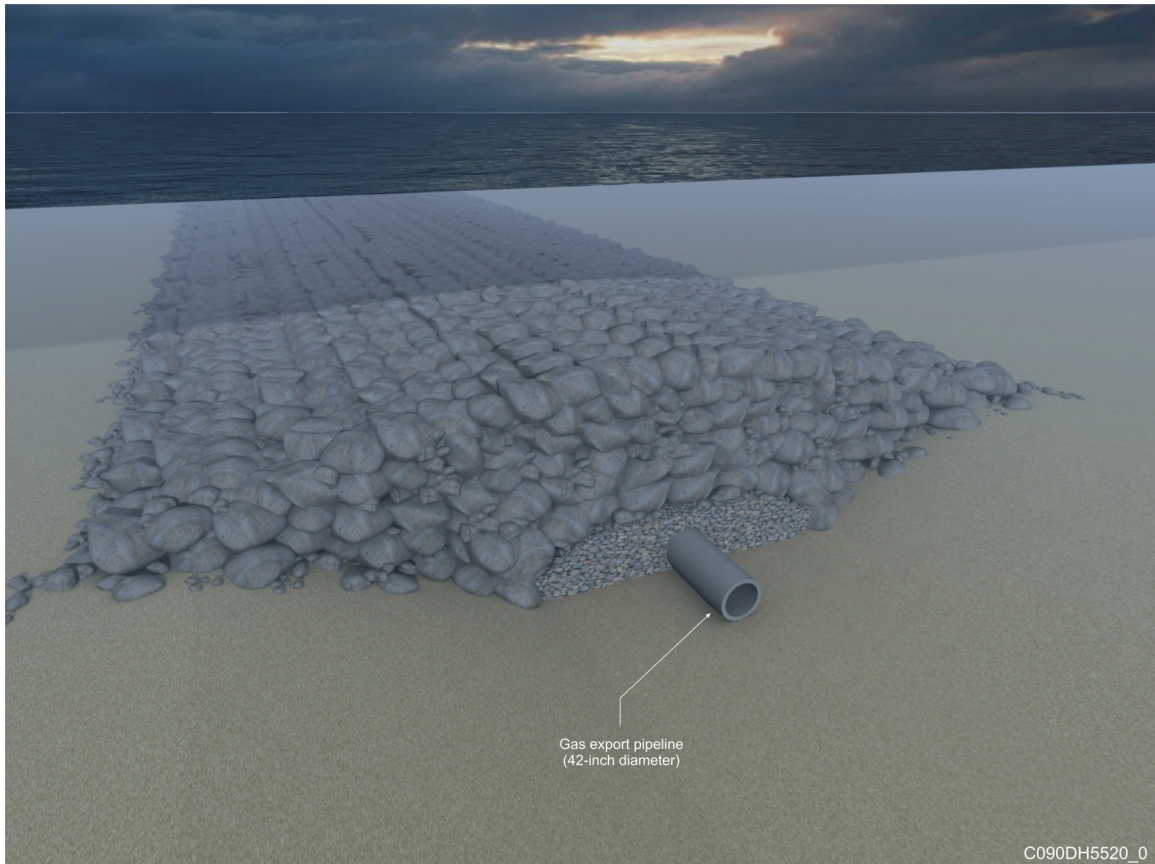


Figure 4: Illustration of rock-dumping protection of the gas export pipeline in Darwin Harbour

The pipeline route through the Harbour will be marked on marine charts. An anchoring and mooring prohibition zone will also be marked and large vessels entering or leaving the Harbour will be escorted by tugs to provide safe navigation.

The following figure shows how the proposed pipeline in the Harbour has been split into discrete segments for the purposes of the risk assessment. The segments are based on geographical location and potential exposure factors, for example water depth, failure mechanisms, and vessel traffic frequency.



Figure 5: The described segments of the gas export pipeline in Darwin Harbour

From the segmenting of the in-Harbour sections of the gas export pipeline described above, the off-site individual risk levels in the harbour were calculated. The safety risks are presented in the form of a graph of individual risk, for the transects (lines) perpendicular to the midpoint of the pipeline segment. These transects are shown in Figure 6.

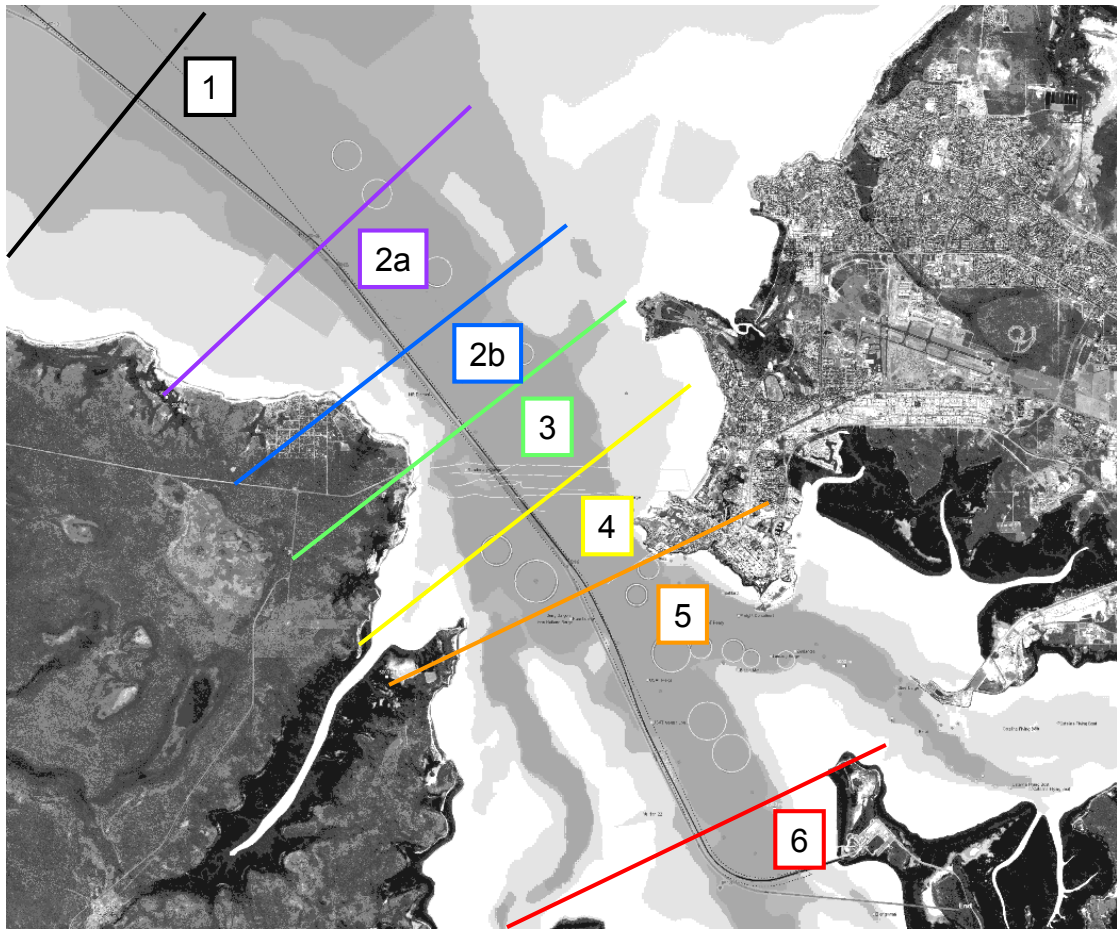
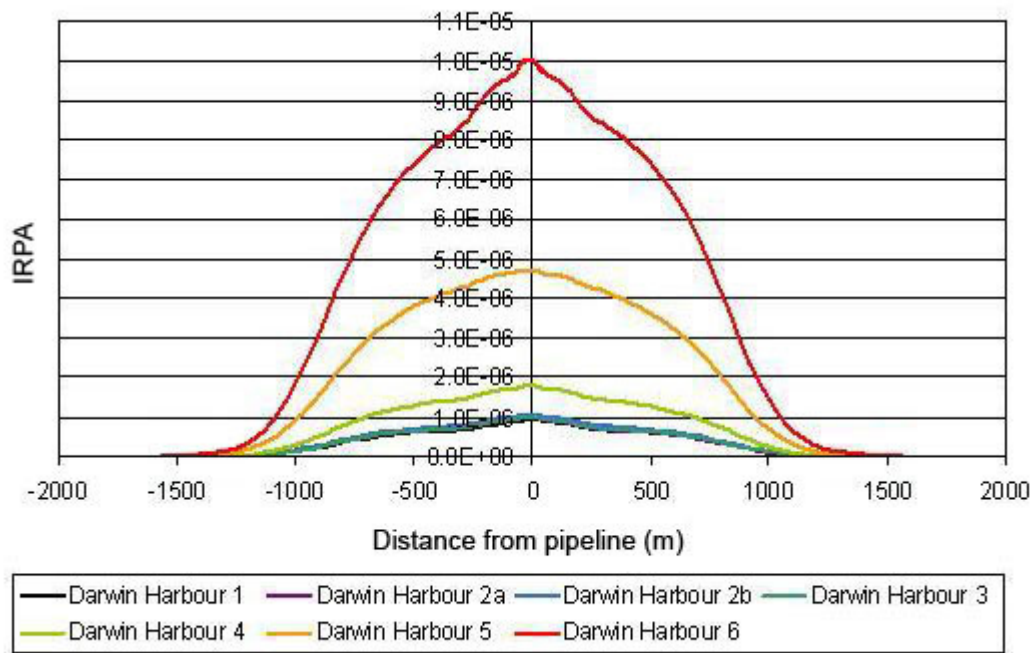


Figure 6: Risk transects for the gas export pipeline in Darwin Harbour

The term “individual risk” is used by several Australian state government agencies when establishing risk criteria. It is based on the premise that an individual is present at a location 24 hours a day for 365 days a year. The person is not provided with any protection (that is, is wearing standard clothing) and does not take any evasive action (that is, does not flee from the scene after an event).

Referring to the graph in Figure 7 below, a person who was outdoors in a boat directly above the pipeline (0 metres) at transect red 6 all year round, has an individual risk of fatality of 10 in one million per year, (The 10 in one million figure is marked as “1.0E-5” on the vertical scale of the graph, equivalent to 10×10^{-6} per annum, or 1×10^{-5} per annum.) This risk is at the same level out to a position approximately 700 metres on either side of the pipe along the red 6 transect, after which it begins to decrease with increasing distance away from the pipeline, falling to around 1 in 100 million per annum at around 1000 metres away from the pipeline.



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Figure 7: Individual risk in Darwin Harbour at various positions around and above the gas export pipeline

It can be seen that the in-Harbour risks are at their maximum on the transect red 6, followed by transect orange 5—all other positions along the pipeline and its transects are approximately a factor of 5 to 10 times less than the maximum, that is, with a risk of fatality of 1 in a million, (“1.0E–6” on the vertical scale), for distances beyond 700 metres from the pipeline.

The acceptable risk criteria from the Victorian guidelines is for the annualised individual risk at the site boundary of a new facility not to exceed 10 in a million per year. This can also be stated as 1 in 100 000 per year or 1.0E–5 on the graph; all these numbers are equal, but stated in different ways. The Victorian criteria do not explicitly address a pipeline-based scenario as they are focused on onshore industrial plants. However, treating the in-Harbour sections of a pipeline in similar fashion to an onshore plant, the maximum off-site individual risks for the in-Harbour sections of the gas export pipeline are equal to the Victorian public safety criteria at point 6, and below criteria at other points.

Off-site risks around Blaydin Point plant

The LNG plant site was analysed for various potential hazards that its design, construction, and ongoing operations could present off site.

This report is focused on the off-site risks, but several of the potential on-site hazards could also affect the off-site areas, so it is necessary to examine those particular scenarios in the QRA and to assess the off-site potential from such on-site risks.



Figure 8: Indicative individual risk contours for risks from onshore plant

Figure 8 provides indicative off-site risk levels for the plant based on the current design. As the design work progresses, the risk analyses will be refined which should lead to further reductions in off-site risk.

In a similar manner to the gas export pipeline results, the Victorian interim individual risk criteria require the annualised individual risk at the plant boundary for a new plant to be no more than 10 in one million (10 in 1 000 000, also equal to 1 in 100 000). This is shown by the yellow risk contour above.

It can be seen that part of the yellow contour extends into Darwin Harbour around the proposed jetty heads for the export tanker ships. INPEX is in dialogue with the various government agencies responsible for safety (for example Darwin Port Corporation, the NT Police and Commonwealth Government bodies) to identify remediation measures.

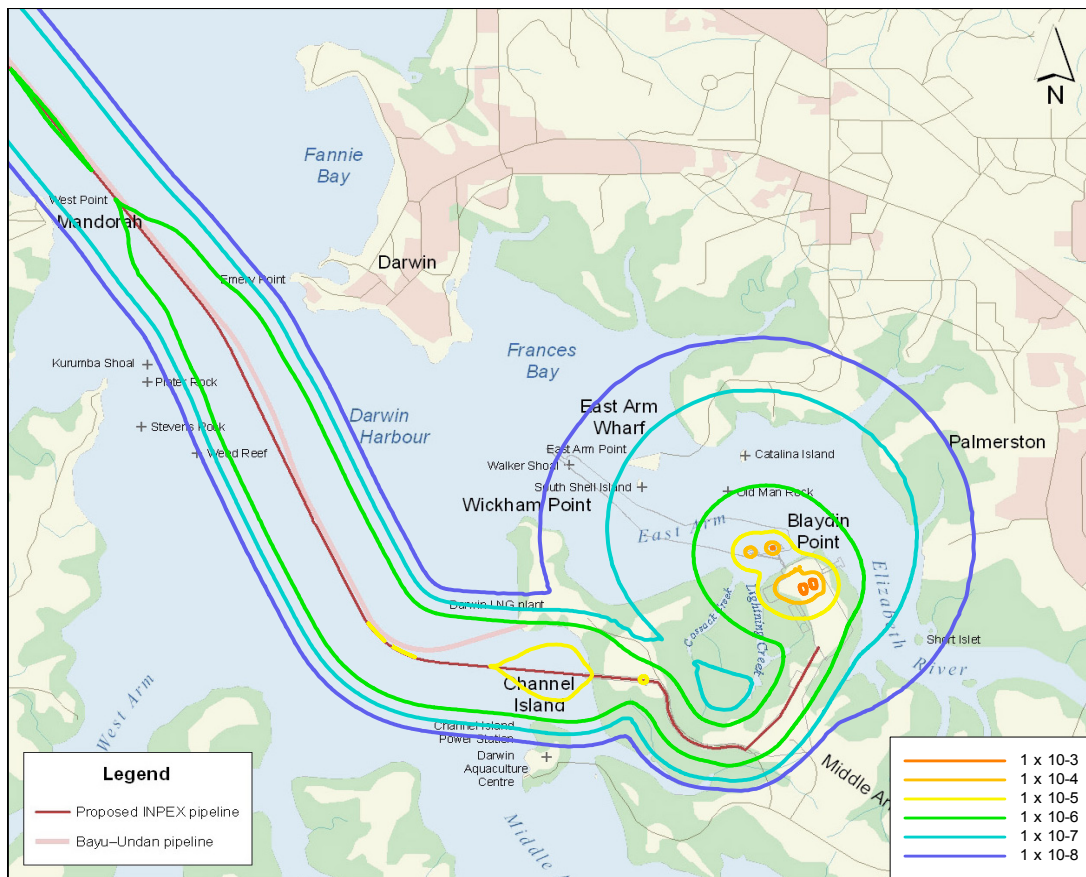


Figure 9: Indicative combined risk results for off-site risks from the onshore plant, the onshore section of the gas export pipeline, the beach valve, and the in-Harbour sections of the pipeline

Combining the off-site risk results from the in-Harbour sections of the gas export pipeline with the off-site risks emanating from onshore plant operations gives an overall off-site risk picture for the Darwin area.

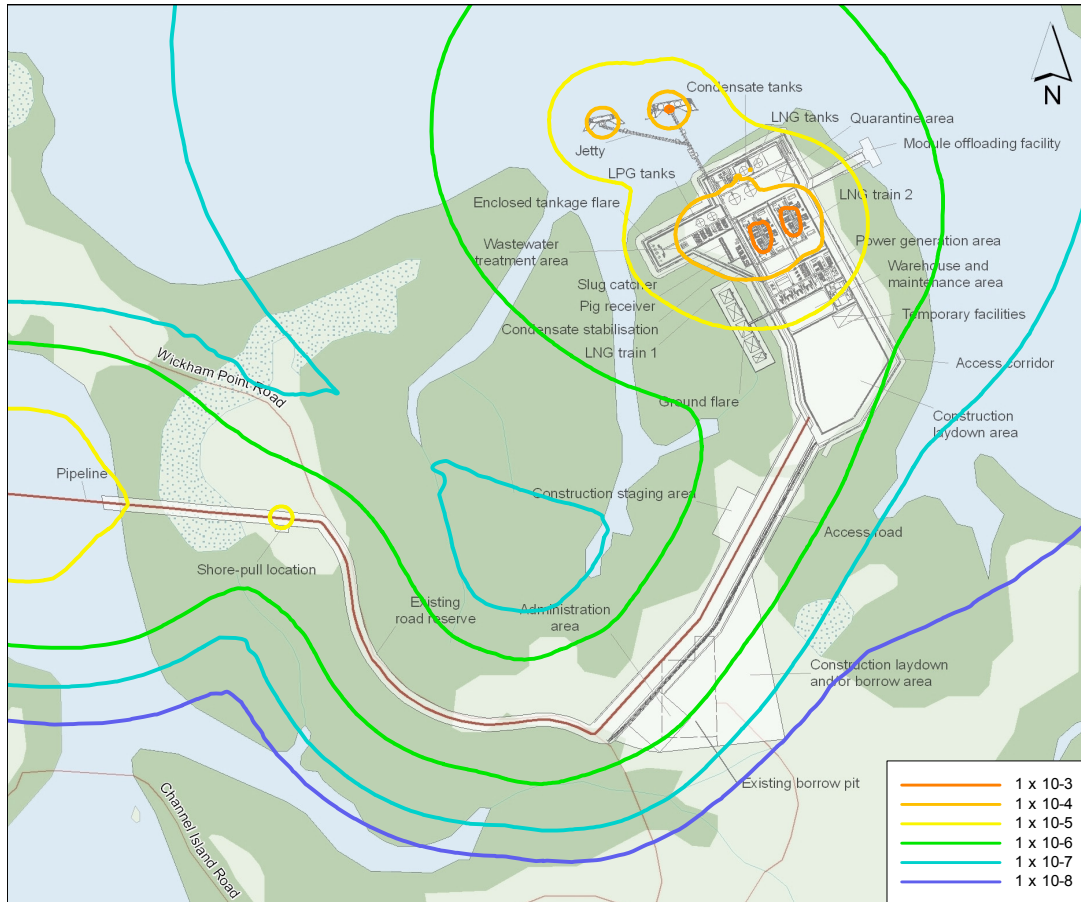


Figure 10: Indicative risk contours from the pipeline, the processing-plant site and the beach valve station, assuming different escape speeds for people on land and on water in the Harbour. This figure is the same as Figure 9 but on a larger scale

The figure above shows that in addition to the proposed exclusion zone around two jetty heads and the jetties themselves, a small area of the pipeline shore crossing, and a small area around the beach isolation valve onshore are above government safety criteria. However, the risks at these criteria points are overstated since these locations are not permanently occupied; people at these locations will have some capacity to flee, and in the case of the nearshore pipeline crossing, the shallow water at this point will prevent the access of large vessels that could otherwise damage the pipeline.

The Project is committed to investigating and implementing further risk reduction measures at these points, consistent with the ALARP principle.

7 CONCLUSION

This report has summarised the indicative quantitative risk assessment (QRA) work conducted on behalf of INPEX by consultants GL Industrial Services for the proposed Ichthys facilities in Darwin. It has examined the off-site risks to the public from INPEX's proposed operations around Blaydin Point.

The methodologies used in the work follow recognised and reputable processes and were carried out with information supplied by INPEX to a recognised, independent and experienced consultancy which has performed similar studies worldwide. The facilities themselves will be designed to recognised standards, by personnel and companies with considerable expertise in these matters. The designs will be subject to ongoing risk studies and independent validation by recognised bodies. Finally, the total risk results will form a key part of the onshore safety report which will be prepared by INPEX for submission to NT WorkSafe in 2014. Following NT WorkSafe's assessment of the proposals, which will follow nationally agreed guidelines, a decision will be made regarding licensing the plant for start-up of operations.

The indicative off-site results available and reported herein are compliant, in the main, with interim government criteria. Where such criteria are not met, further work is ongoing to minimise such risks to ALARP in accordance with regulatory requirements.

The design of the Ichthys Project's Blaydin Point facilities is ongoing and these risk results will be updated as the Project progresses.