INPEX

Ichthys Gas Field Development Project

SUPPLEMENT TO THE DRAFT ENVIRONMENTAL IMPACT STATEMENT

April 2011

Ichthys Gas Field Development Project: supplement to the draft environmental impact statement

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Ichthys Gas Field Development Project

SUPPLEMENT TO THE DRAFT ENVIRONMENTAL IMPACT STATEMENT

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How to use this EIS Supplement

This Supplement to the Ichthys Gas Development Project's draft environmental impact statement (Draft EIS) completes the preparation of environmental documentation by INPEX for the environmental impact assessment of the Project.

This Supplement serves the following purposes:

1. It accompanies the Draft EIS, and these two documents, taken together, constitute the "Final EIS" which is submitted to the responsible ministers in the Commonwealth and Northern Territory governments who will determine the environmental acceptability of the Project.
2. It provides responses to public submissions received through the public review and comment process that followed the publication of the Draft EIS in July 2010.
3. It provides additional information to support responses to public submissions, and to improve the quality of information and conclusions presented in the Draft EIS.

Public submissions received by INPEX in accordance with guidelines published in the Draft EIS as Technical Appendix 1 are provided with this document on the CD (located in the sleeve on the inside back cover), and are accessible on the INPEX web site at <www.inpex.com.au>.

Public submissions are reproduced as they were submitted, that is, comments have not been edited or altered in order to preserve the integrity of the original submission.

INPEX's responses to public submissions are provided in Section 5 of this document. Section 5.2.1 addresses the common issues raised in the majority of submissions and provides a summary response to these issues. Section 5.2.2 addresses responses to individual comments that warranted a specific response because of the unique or detailed nature of the comment.

Submitters may source the response(s) to the particular issues raised in their submissions in Annexure 1.

Technical appendices to this EIS Supplement are provided on the accompanying CD and also on the INPEX web site (as listed above). INPEX will provide hard copies of technical appendices upon request.

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Table of Contents

1 **Executive summary** ... **2**

2 **Introduction** ... **10**

3 **Project description and changes** ... **12**

3.1 Introduction ... 12

3.2 Ichthys Project overview ... 12

3.3 Changes to Project infrastructure ... 12

3.3.1 Orientation of the LNG trains ... 14

3.3.1.1 Layout and design of the ground-flare compound ... 14

3.3.1.2 Layout of the module offloading facility ... 14

3.3.2 "Manned facilities" relocation to combined operations complex ... 14

3.3.2.1 Alternatives considered ... 14

3.3.2.2 Gas export pipeline realignment ... 15

3.3.3 Road traffic ... 15

3.3.3.1 Background ... 15

3.3.3.2 Revised rock-and-fill traffic estimates ... 16

3.3.3.3 Personnel movements to and from the accommodation village ... 18

3.3.3.4 Miscellaneous personnel and materials transport ... 18

3.3.3.5 Other materials and waste transfer ... 18

3.3.3.6 Traffic impact assessment ... 23

3.3.4 Blaydin Point terrestrial footprint ... 23

3.3.5 Operational noise ... 23

3.3.6 Shipping channel depth reduction ... 24

3.3.7 Increase in condensate production rate from onshore facilities ... 24

3.3.8 Drill-and-blast reduction ... 24

3.3.9 Piledriving ... 28

3.3.10 Well-completion fluid management ... 29

4 **Supplementary information to the Draft EIS** 32
4.1 Marine 32
4.1.1 Studies summary 32
4.1.2 Benthic habitat mapping 34
4.1.2.1 Rationale for approach to benthic habitat mapping 34
4.1.2.2 Benthic habitat mapping methods 34
4.1.3 Benthic habitat impact assessment 44
4.1.3.1 Introduction 44
4.1.3.2 Conservatisms and assumptions in the dredging models 46
4.1.3.3 Overview of the benthic community impact assessment 49
4.1.3.4 Direct impacts 50
4.1.3.5 Indirect impacts 50
4.1.3.6 Development of suspended-sediment thresholds 51
4.1.3.7 Setting suspended-sediment concentration tolerances 53
4.1.3.8 Sedimentation thresholds 54
4.1.3.9 Mapping zones of impact and influence 56
4.1.3.10 Zones of impact and influence—area calculations 58
4.1.3.11 Benthic habitat risk assessment 67
4.1.4 Nearshore benthic community and habitat monitoring 71
4.1.5 Walker Shoal 72
4.1.5.1 Studies undertaken 72
4.1.5.2 Impact assessment 72
4.1.6 Gunn Reef Blue Holes 73
4.1.6.1 Studies undertaken 73
4.1.6.2 Impact assessment 80
4.1.7 Howard River 80
4.1.7.1 Studies undertaken 80
4.1.7.2 Impact assessment—effects of sediment on barramundi 81
4.1.8 Mud crabs 82
4.1.8.1 Studies undertaken 82
4.1.8.2 Impact assessment 82
4.1.9 Coastal dolphins 83
4.1.9.1 Studies undertaken 83
4.1.10 Other protected species (turtles and dugong) 87
4.1.10.1 Studies undertaken 87
4.1.10.2 Impact assessment 87
4.1.11 Underwater noise and vibration 92
4.1.12 Evaluation of acoustic monitoring techniques 100
4.1.13 Comparison of proposed management measures for protection of marine mammals to Australian and international practices 102
4.1.14 Nutrients in wastewater 107
4.2 Oil-spill contingency planning 108
4.2.1 Spill-trajectory modelling 108
4.2.1.1 Risks to Darwin Harbour, the Browse Basin and the Kimberley coastline 109
4.2.2 The Montara and Macondo (Deepwater Horizon) incidents 119
4.2.3 Operational and scientific monitoring program 120

4.2.4 Oil spill response plan development and approvals 120
4.2.5 Oil-spill response equipment and personnel 120
4.2.6 Financial penalties and performance bonds 121
4.3 Seabird distribution and abundance 121
4.4 Vegetation-clearing and changes to the terrestrial footprint 123
4.4.1 Corrected vegetation-clearing estimates 123
4.4.4.1 Revised vegetation-clearing estimates: relocation of manned facilities and GEP realignment 125
4.4.2 Revised vegetation-clearing estimates – plant layout amendments 126
4.4.3 Revised total vegetation-clearing estimates 126
4.5 Public safety 128
4.5.1 General 128
4.5.2 LNG Shipping in Darwin Harbour 128
4.5.3 Update on access to Lightning and Cossack creeks 130
4.6 Socio-economic issues 130
4.6.1 Aboriginal and Torres Strait Islander participation in the Ichthys Project 130
4.7 Heritage 131
4.7.1 Terrestrial Aboriginal cultural heritage 131
4.7.1.1 Aboriginal heritage site management 132
4.7.2 Maritime heritage: assessment of adequacy of marine heritage survey methods 132
4.8 Greenhouse gas 134
4.8.1 Reservoir CO_2 reinjection 134
4.8.2 Biosequestration assessment project 134
4.8.3 Combined-cycle power plant 135
4.8.4 Offshore power cable 135
4.8.5 Fire-management projects in the Northern Territory 136
4.8.6 Additional information on life-cycle emissions 136
4.9 Environmental offsets 137
4.10 Alternatives 139
4.10.1 Alternative shipping channels 139
4.10.2 Additional information on the selection of the product loading jetty option 150
4.11 Planning legislation 155
4.12 Ecologically sustainable development 156
4.12.1 Economic and social benefits 156
4.12.2 Maintaining ecological processes 157
4.12.3 ESD in decision-making 158
4.12.4 The precautionary principle 158
4.13 Cumulative impacts 160
4.13.1 Introduction 160
4.13.2 Legislation and industry practice 160
4.13.2.1 Environmental approval processes 160
4.13.2.2 Industry methods of cumulative impact assessment 160
4.13.3 Review of cumulative effects addressed within the Ichthys Project's Draft EIS 162
Marine impacts and management 162
Terrestrial impacts and management 162

Socio-economic impacts and management 163
Cumulative impacts from supporting facilities 163
4.13.4 Identification of other projects 163
4.13.4.1 Criteria for selection of projects 163
4.13.4.2 Identification of projects 164
4.13.4.3 Assessment of available information and likelihood of cumulative impacts 164
4.13.5 Conclusion 164
4.14 Summary of design-change impacts 165

5 DRAFT EIS public review and comment 168
5.1 Summary of submissions received 168
5.2 Response to submissions 168
5.2.1 Summary responses 168
5.2.2 Responses to individual comments 172
5.2.2.1 Air quality and air-quality modelling 172
5.2.2.2 Alternatives 176
5.2.2.3 Drilling 186
5.2.2.4 EIS content and management plans 189
5.2.2.5 Emissions, discharges and wastes 202
5.2.2.6 General and miscellaneous issues 223
5.2.2.7 Government approvals 247
5.2.2.8 Greenhouse gas 247
5.2.2.9 Heritage in the marine environment 260
5.2.2.10 Infrastructure risk 261
5.2.2.11 Marine 265
5.2.2.12 Monitoring 386
5.2.2.13 Offsets 392
5.2.2.14 Oil spill 406
5.2.2.15 Pipeline 415
5.2.2.16 Public safety 416
5.2.2.17 Quarantine 441
5.2.2.18 Socio-economic 443
5.2.2.19 Stakeholder consultation 462
5.2.2.20 Terrestrial impacts and vegetation-clearing 464

6 References 490

7 Glossary 510

8 Abbreviations 544

9 Contributors 556

LIST OF TABLES

Table 1-1: Summary of Project design changes and potential environmental impact 3

Table 1-2: Summary responses to key issues 6

Table 3-1 Indicative quantities of imported materials and timing during construction period 17

Table 3-2: Indicative summary of the duration of piledriving activities for three different construction scenarios .. 29

Table 4-1: Summary of studies undertaken since the publication of the Draft EIS in July 2010 32

Table 4-2: Data sources for the benthic habitat known-point data set 35

Table 4-3: Inferred habitats: percentage cover calculations and classification 40

Table 4-4: Benthic habitat area calculations in the study area 45

Table 4-5: Conservative assumptions in dredge-plume modelling 47

Table 4-6: Darwin Harbour long-term water-quality data (summary statistics for suspended sediment in milligrams per litre) 53

Table 4-7: Suspended-sediment tolerances for benthic communities in areas around Darwin Harbour 53

Table 4-8: Overview of values reported in the literature for maximum allowable sedimentation level for seagrasses recorded in Darwin Harbour 55

Table 4-9: Zones of high impact—benthic community and sediment calculations 64

Table 4-10: Zones of moderate impact—benthic community calculations 65

Table 4-11: Zones of influence—benthic community calculations 66

Table 4-12: Results of exposure of barramundi eggs and larvae to dredge spoil sediments 82

Table 4-13: Area (in hectares) of potential foraging habitat for turtles and dugong in Darwin Harbour 92

Table 4-14: Calculated distance from a confined blast of 50 kg for no injury, 1% mortality and 50% mortality to fish of differing body mass 93

Table 4-15: Threshold sound exposure level for protection of fish from a single piledriving pulse 94

Table 4-16: Proposed INPEX blast noise exposure criteria for marine animals and the predicted safe ranges for 50 kg confined charge 96

Table 4-17: Proposed INPEX piledriving noise exposure criteria for marine animals and the predicted maximum distance to safe range 99

Table 4-18: Existing nutrient pollutant annual loads into East Arm and percentage of Project contribution for construction and operations phases 107

Table 4-19: Darwin Harbour TN and TP current condition, INPEX inputs and annual load targets 108

Table 4-20: Risk of shoreline contact of more than $1 g \cdot m^{-2}$ for a blow-out in each season 118

Table 4-21: Seabird species likely to occur in the Browse Basin and in the area of the Ichthys Field 122

Table 4-22: Corrected vegetation-clearing estimates 125

Table 4-23: Revised Vegetation-clearing estimates 128

Table 4-24: Indicative dredge and hard-rock volumes for the alternative shipping channel options 146

Table 4-25: Detailed sustainability criteria for jetty selection process 153

Table 4-26: Summary outputs from the jetty selection process 154

Table 4-27: Summary of Project design changes and potential environmental impact 165

Table 5-1: Summary responses to key issues 169

LIST OF FIGURES

Figure 3-1: Revised layout of onshore development area infrastructure 13

Figure 3-2 Proposed routes for heavy-vehicle traffic for the supply of rock and fill from quarries at Mount Bundey or from a yet-to-be-determined quarry location south of Darwin 19

Figure 3-3: Likely route for bus transport between the accommodation village and Blaydin Point 20

Figure 3-4: Likely route for personnel movements between Darwin city centre and Blaydin Point 21

Figure 3-5: Proposed route for traffic between East Arm Wharf and Blaydin Point 22

Figure 4-1: Sources of the point data combined into the total known data set (*c*.38 000 points) 36

Figure 4-2: Habitat classification scheme hierarchical flow chart 37

Figure 4-3: Data collation process used to produce the sediment particle size map 38

Figure 4-4: Data classification and collation process used to produce the benthic habitat map 38

Figure 4-5: The substrate particle size distribution map 41

Figure 4-6: The benthic habitat distribution map in Darwin Harbour 42

Figure 4-7: The benthic habitat distribution map outer extent 43

Figure 4-8: Zones for suspended-sediment impact and influence 57

Figure 4-9: Zones of impact and influence from dredging-generated suspended sediment for Phase 4 59

Figure 4-10: Zones of impact and influence from dredging-generated suspended sediment for Phase 6 (with cutter-suction dredger) 60

Figure 4-11: Zones of impact and influence from dredging-generated sedimentation for Phase 6 (with cutter-suction dredger) 61

Figure 4-12: Zones of impact and influence from spoil-disposal-generated suspended sediment for Phase 5 62

Figure 4-13: Zones of impact and influence from spoil-disposal-generated sedimentation for Phase 5 63

Figure 4-14: Northern Blue Hole current rose 74

Figure 4-15: Turbidity, current and tide at the Northern Blue Hole—December spring tide 75

Figure 4-16: Turbidity, current and tide at the Northern Blue Hole—December neap tide 76

Figure 4-17: Turbidity, current and tide at the Northern Blue Hole—January spring tide 77

Figure 4-18: Turbidity, current and tide at the Northern Blue Hole—January neap tide 78

Figure 4-19: Predicted variation in total suspended solids concentrations (above background) at Howard River 81

Figure 4-20: Response of fish to suspended-sediment concentrations 81

Figure 4-21: Potential green turtle foraging habitat in Darwin Harbour 88

Figure 4-22: Potential hawksbill turtle foraging habitat in Darwin Harbour 89

Figure 4-23: Potential flatback turtle foraging habitat in Darwin Harbour 90

Figure 4-24: Potential dugong foraging habitat in Darwin Harbour 91

Figure 4-25: The modelled received root mean square sound pressure level contour for the scenario of a blasting operation at Walker Shoal 95

Figure 4-26: The modelled received root mean square sound pressure level contour for the piledriving operation at the product loading jetty 97

Figure 4-27: The modelled received root mean square sound pressure level contour for the piledriving operation at the module offloading facility 98

Figure 4-28: The predicted received sound pressure level against range from a piledriving operation at the product loading jetty (with a medium-grained sand seabed type) 99

Figure 4-29: Source spectrum level of a normal cutter-suction dredger 100

Figure 4-30: Gas export pipeline rupture (50 m^3) near Wickham Point—summer 109

Figure 4-31: Gas export pipeline rupture (50 m^3) near Wickham Point—autumn 110

Figure 4-32: Gas export pipeline rupture (50 m^3) near Wickham Point—winter 111

Figure 4-33: Gas export pipeline rupture (50 m^3) near Wickham Point—spring 112

Figure 4-34: Gas export pipeline rupture (50 m^3) in outer Darwin Harbour—summer 113

Figure 4-35: Gas export pipeline rupture (50 m^3) in outer Darwin Harbour—transition 114

Figure 4-36: Gas export pipeline rupture (50 m^3) in outer Darwin Harbour—winter 115

Figure 4-37: Eleven-week well blow-out at the Ichthys Field—summer 116

Figure 4-38: Eleven-week well blow-out at the Ichthys Field—transitional 117

Figure 4-39: Eleven-week well blow-out at the Ichthys Field—winter 118

Figure 4-40: Vegetation communities of the onshore development area at Blaydin Point 124

Figure 4-41: Vegetation communities impacted by the relocation of the manned facilities and the realignment of the gas export pipeline 127

Figure 4-42: LNG Tanker Containment 129

Figure 4-43: The Kirkwood plantation two years after planting 134

Figure 4-44: Schematic of a combined-cycle power plant 135

Figure 4-45: Indicative dredging footprint for the shipping channel 141

Figure 4-46: Cross-section profile of Walker Shoal 142

Figure 4-47: Surface geological features of Walker Shoal showing area of rock outcropping 143

Figure 4-48: Location of boreholes over the Walker Shoal geological feature 144

Figure 4-49: Inferred rock strength within the Walker Shoal geological feature 145

Figure 4-50: Alternative shipping channel Option 1 147

Figure 4-51: Alternative shipping channel Option 2 148

Figure 4-52: Alternative shipping channel Option 3 149

Figure 4-53: Short jetty concept 151

Figure 4-54: Long jetty concept 152

Figure 5-1: Bathymetry used in morphological assessment for the base case (top) and the modified case (bottom) 323

Figure 5-2: Comparison of peak ebb current speed and direction for the base case (top) and modified case (bottom) 324

Figure 5-3: Comparison of peak flood current speed and direction for the Base Case (top) and Modified Case (bottom) 325

Figure 5-4: A conceptual trophic model of the Kimberley Shelf subregion (from Brewer et al. 2007) 329

Figure 5-5: Habitat diagram of the Kimberley Shelf subregion showing selected important drivers and features (from Brewer et al. 2007) 330

Figure 5-6: Vector shift of corners of dredge spoil disposal Site 9 to Site 10 356

Figure 5-7: NDSF Fishing areas and zones in relation to the Ichthys Field and pipeline route 451

Figure 5-8: Area of the North West Slope Trawl Fishery in relation to the Ichthys Field and pipeline route (adapted from AMFA 2004) 452

Figure 5-9: Draft EIS Technical Appendix 16 – GHD Flora & Fauna Studies – Missing Page 488

TABLE OF ANNEXURES

ANNEXURE 1: LIST OF DRAFT EIS PUBLIC SUBMISSIONS 558

A.1 Petition submissions 558

A.2 Organisation submissions 558

A.3 Individual submissions 559

ANNEXURE 2: DRAFT EIS PUBLIC SUBMISSIONS 564

TABLE OF TECHNICAL APPENDICES

Technical Appendices S1-S7:

Technical Appendix S1: Ichthys Gas Field Development Project: the benthic environment of the Ichthys Project—invertebrate fauna, habitats and impacts

Technical Appendix S2: Ichthys Gas Field Development Project: marine hydrocarbon spill modelling. Addendum report—supplemental spill risk modelling

Technical Appendix S3: Ichthys Gas Field Development Project: literature review of seabirds in the vicinity of Ichthys Field infrastructure in the Browse Basin, Western Australia

Technical Appendix S4: Ichthys Gas Field Development Project: Gunn Reef Blue Holes and Howard River—water quality and coral survey

Technical Appendix S5: Ichthys Gas Field Development Project: the effect of simulated dredge material from Darwin Harbour on eggs and larvae of barramundi (Lates calcarifer)

Technical Appendix S6: Ichthys Gas Field Development Project: benthic habitat mapping of the Darwin region—methods of data collection, collation and map production

Technical Appendix S7: Ichthys Gas Field Development Project: potential effects of underwater blasting, piledriving and dredging on sensitive marine fauna in Darwin Harbour

Technical Appendices S8-S12:

Technical Appendix S8: Ichthys Gas Field Development Project: assessment of potential impacts on mud crabs in Darwin Harbour

Technical Appendix S9: Ichthys Gas Field Development Project: summary of the long-term water-quality program for Darwin Harbour

Technical Appendix S10: Ichthys Gas Field Development Project: nearshore development area—assessment of marine heritage survey methods

Technical Appendix S11: Marine archaeologist review of suitability of survey methods to identify submerged maritime heritage for the Ichthys Gas Field Development Project, Northern Territory, Australia

Technical Appendix S12: Ichthys Gas Field Development Project: summary report of dolphin surveys in the Middle Arm and West Arm of Darwin Harbour—January to March 2011

1 Executive Summary

1 EXECUTIVE SUMMARY

Introduction

INPEX Browse, Ltd. (INPEX), as Operator of the Ichthys Gas Field Development Project (the Project), together with its joint venture partner, Total E&P Australia (Total), is seeking the approval of the Northern Territory and Commonwealth governments to develop the Ichthys gas and condensate field (the Ichthys Field) to produce liquefied natural gas (LNG), liquefied petroleum gases (LPGs) and condensate for export to markets in Japan and elsewhere.

INPEX has prepared this document, the "EIS Supplement", in fulfilment of its obligations under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act) and the *Environmental Assessment Act* (NT) (EA Act). It takes into account comments submitted as part of the public review of the Draft EIS.

This EIS Supplement addresses several aspects of proposed Project activities to facilitate informed decision-making by the regulatory authorities as they assess the environmental acceptability of the Project. These aspects include the following:

- Project description and design changes: descriptions of significant changes to Project design since the Draft EIS was published in July 2010
- supplementary information: data, information, and research relevant to environmental impacts and the assessment process, provided in addition to that contained in the Draft EIS
- responses to submissions: INPEX's responses to the submissions made by interested parties during the public review and comment period for the Draft EIS.

This EIS Supplement, taken together with the Draft EIS, is the "Final EIS" and represents the finalisation of the environmental impact statement for the Ichthys Project by INPEX as required by Commonwealth and Northern Territory legislation.

INPEX extends a note of appreciation to all members of the public, government, non-government organisations and industry who invested in this assessment process through the review of the Draft EIS and preparation of submissions. Public involvement in this process has enhanced INPEX's understanding of community concerns and priorities, and has contributed to an improved proposal through this EIS Supplement to put before the respective environmental ministers for consideration.

Project description and changes

The Project description published in the Draft EIS in July 2010 represented the best information available at that time of the design of the Ichthys Project. As the Project continues to move towards a final design for the anticipated construction and operations phases, several design changes relevant to the environmental assessment process have been identified. These changes are described in Table 1-1 together with the consequences such changes may have on residual environmental impacts.

Table 1-1: Summary of Project design changes and potential environmental impact

Project aspect	Design change	Environmental impact of change
Dredging	Reduced dredge depth, with reduction in under-keel clearance of 0.5 m.	Positive—less dredging volume of approximately 1 Mm^3; less volume of spoil for disposal; reduced period of dredging.
Marine blasting	Commitment to use alternative methods to marine blasting for the removal of Walker Shoal. (A contingency of approximately 4 weeks for marine blasting is maintained should alternative methods be unable to completely remove all hard-rock material).	Positive—avoidance of blast impacts (or substantially reduced blast duration).
Changes to onshore infrastructure	Relocation of key plant infrastructure (e.g. reorientation of LNG trains, change to wastewater treatment plant and flare pad footprint for possible inclusion of enclosed flares).	Negative—net additional plant footprint and vegetation impact of around 5 ha to accommodate enclosed flares. Positive—reduced noise and light emissions from flaring during commissioning.
Relocation of manned facilities	Relocation of operations centre and the maintenance and warehouse facilities from the processing plant area to a location outside the plant boundaries; slight realignment of the gas export pipeline.	Negative—minor increase in area of mangrove impact (around 5 ha). Positive—protection of Aboriginal heritage sites which previously would have been disturbed.
Project traffic and rock transport requirements	Increase in rock and fill requirements.	Negative—increase in road traffic.
Operational noise	Noise levels may exceed 45 dB(A) in Palmerston during process upset flaring events a few times a year for a few minutes on each occasion.	Negative— short duration elevated noise above 45 dB(A) from operations.
Condensate export (onshore)	Increase in condensate production rate up to 20 000 barrels per day at Blaydin Point.	Negative—additional hydrocarbon liquids produced for export from onshore facilities (up from 15 000 barrels per day in the Draft EIS). This translates into a slight increase in the chance of an oil spill.
Piledriving	More detailed scenarios for piledriving operations provided.	Negative—coincident multiple piledriving plant likely, with commensurate increase in noise impacts. Positive—reduced duration of piledriving operations.

Supplementary information to the Draft EIS

In response to public submissions and in light of new information, INPEX commissioned a number of studies following the publication of the Draft EIS to provide additional information to assist the environmental assessment of the Project. A summary of these studies and a revised assessment of environmental impacts is provided below.

Benthic habitat surveys

Various surveys, (including aerial, tow-video camera and diving), contributed to an expansion of the marine benthic data sets for Darwin Harbour and its surrounds. INPEX subsequently collated and processed these and other ancillary data sets to produce a comprehensive habitat and benthic community map of Darwin Harbour. This allowed a more quantified assessment, through the derivation of zones of impact and zones of influence, of potential Project impacts on benthic habitats and communities. This process demonstrated relatively small areas of potential impact, and therefore low risk to benthic habitats and communities and trophic components of Darwin Harbour.

Darwin Harbour coastal dolphin surveys

The three species of coastal dolphin found in Darwin Harbour; the Indo-Pacific humpback, Indo-Pacific bottlenose and Australian snubfin dolphins coexist despite overlapping habitat ranges. It is generally accepted that this coexistence is made possible by fine-scale variations in distribution that arise due to species-specific habitat preferences and resource (food) partitioning.

INPEX initiated a pilot program in 2011 to establish the distribution and abundance of coastal dolphins and other large marine animals in Middle Arm and West Arm of the Harbour. This program is designed to act as a precursor to inform more extensive surveys which would be undertaken during the construction phase, and to complement the existing coastal dolphin surveys undertaken by the Northern Territory Government in other parts of the Harbour. Throughout the pilot program, various survey techniques and survey transect designs were trialled and amended as the survey program progressed. This structured pilot study has led to a final study design that is robust and, over the long term, is capable of detecting significant changes in marine mammal abundance and distribution.

Based on the surveys conducted to date the following conclusions can be drawn:

- The density of Indo-Pacific humpback dolphins observed in the western parts of the Harbour is comparable to that observed near East Arm and Blaydin Point over the two-year period from 2008 to 2010.
- The density of Indo-Pacific bottlenose dolphins observed in the western parts of the Harbour is comparable to that observed in the eastern parts of the Harbour but less than that observed in the northern parts of the Harbour.
- The density of snubfin dolphins observed in the western parts of Darwin Harbour is substantially higher than that observed near East Arm and Blaydin Point over the two-year period 2008 to 2010 (Palmer 2010a, 2010b). This is consistent with observations reported by Palmer (2010a), which indicated that the highest abundance was in the north-western parts of the Harbour.

Oil-spill contingency plans

INPEX conducted additional oil-spill modelling for scenarios involving gas export pipeline rupture and production well blow-out. Depending on various seasonal factors and locations of the potential pipeline ruptures, some model outputs resulted in shoreline contact while other scenarios resulted in no oil reaching the shoreline of Darwin Harbour.

Production well blow-out modelling at the Ichthys Field indicated that there was a moderate risk of shoreline contact for Browse Island and Scott Reef in all seasons. However the Kimberley coastline and the significant bird breeding colonies of Adele Island and Ashmore Reef were found to be at minimal risk.

INPEX is actively participating in the APPEA Montara Taskforce to facilitate Australian petroleum industry improvements to oil-spill prevention and response after the Montara incident in the Timor Sea in August 2009. INPEX, in cooperation with industry partners, is also developing an operational and scientific monitoring program to ensure that oil-spill combat efforts are effective and that timely and appropriate monitoring of environmental receptors at risk during a large oil spill is undertaken. Relevant lessons arising from the Montara and the Macondo (Deepwater Horizon) inquiries will be incorporated into INPEX's oil-spill contingency plans and into INPEX's selection, resourcing and positioning of oil-spill combat equipment and personnel.

Underwater noise scenarios

The Draft EIS presented a comprehensive review of underwater noise and the potential biological effects of underwater noise associated with Project activities (see the Draft EIS's Technical Appendix 15 *Review of literature on sound in the ocean and on the effects of noise on marine fauna*). The assessment of predicted effects was drawn from this work. A supplementary literature review of marine noise has been conducted and is provided as Technical Appendix S7 to this EIS Supplement. This latter review presents a synopsis of the most up-to-date available research, policies and field experiences and presents guidance concerning the evaluation and management of blast and in-water noise and its implications for potentially sensitive marine animals. In parallel with this literature review, numerical modelling was conducted to predict the propagation of underwater noise in the nearshore development area caused by blasting, piledriving, drilling, rock hammering and dredge-vessel movements. The data obtained from the numerical modelling of underwater noise propagation were then cross-referenced to sensitivity criteria for various marine fauna groups to calculate the "safe ranges" beyond which no significant risk of injury existed.

At all stages in the assessment where there was uncertainty, conservative assumptions have been made; this includes uncertainties in distribution and abundance of species, uncertainties in the physiological tolerance of species, and ranges in the physical parameters used in model calculations.

For marine mammals the assessment adopted the exposure criteria developed by a panel of international experts in acoustics and marine mammal science. These criteria were developed for cetaceans and pinnipeds and were based primarily on the levels at which "permanent threshold shift" (PTS) and "temporary threshold shift" (TTS) have been found to occur. For blasting activities the "safe range", for marine mammals, based on the potential for PTS was calculated to be up to 1000 m. For piledriving the safe range, based on potential for PTS was calculated to vary between 500 and 1 000 m depending on the piledriving scenario. To assess the potential for TTS it was conservatively assumed that the animal was stationary for 30 minutes during piledriving, and that this coincided with high tide, in which case the safe range for protection from TTS to marine mammals was calculated to be 2000 m. For drilling, rock-hammering and vessel movements, the noise emitted was determined to be less than the exposure criteria, therefore underwater noise from these activities is not predicted to present risk to marine mammals. A comparison has been made to national and international management practices for the protection of marine animals from stresses associated with vessel movements, dredging operations, piledriving and blasting (Section 4.1.13). This has resulted in some modifications of the proposed management measures for protection of marine mammals and ensures that the INPEX Project is consistent with national and international best practice.

For fish, the assessment adopted criteria that were based on empirical measurements correlating peak impulse with fish body mass. For blasting operations a 1-kg fish was calculated to have a 50% risk of mortality within about 125 m of a 50-kg confined blast; the risk decreases to "no injury" beyond a range of approximately 400 m. For smaller fish the range is increased and, conversely, for larger fish the range is reduced. For piledriving activities the maximum acceptable sound exposure levels were based on the derived values presented by Hastings and Popper (2005). For all piledriving scenarios it was calculated that the safe range for protection of fish from physiological damage was less than 50 m. For drilling, rock-hammering and vessel movements, the noise emitted was determined to be less than the exposure criteria, therefore underwater noise from these activities is not predicted to present risk to fish.

Other studies and investigations

A number of ancillary investigations assessed the potential Project impacts on mud crabs and barramundi, seabirds, the Howard River and the Gunn Reef Blue Holes and determined that the impact would be likely to be very low to negligible.

Other surveys were conducted that have contributed to the expansion of existing data sets that will ultimately contribute to environmental baselines and future monitoring and modelling programs.

Draft EIS public review and comment

The Draft EIS was released on 15 July 2010 for an 8-week public review and comment period. The official public review period concluded on Friday, 10 September 2010; INPEX, however, continued to accept submissions beyond this date until Friday, 17 September 2010.

In all, 1488 submissions were received. However, the overwhelming majority (n = 1353 or 91%) of these were template submissions generated from the Australian Marine Conservation Society web site. These are considered to constitute a "petition submission" which warrants only a single response to the common issues raised.

In this EIS Supplement INPEX has responded to all submissions received from the public review. A summary response to each of the key issues raised is provided in Table 1-2, with further detail provided on individual submissions in Section 5 of this EIS Supplement.

Table 1-2: Summary responses to key issues

Summary issue	INPEX response
1. Marine blasting Many submissions referred to the potential negative impact of a 57-week-long underwater drill-and-blast program to remove Walker Shoal in Darwin Harbour.	INPEX has committed to using methods other than drilling and blasting for the removal of Walker Shoal. The methods proposed are to use a specialised cutter-suction dredger with sufficient power to remove the greater part, if not all, of the hard material and, if necessary, to employ a hydraulic hammer or drop chisel. As INPEX cannot be completely certain that these methods will be fully effective, it is considered appropriate that a fall-back option is maintained within the environmental assessment and subsequent approval for the Project for drill-and-blast methods to be employed for approximately 4 weeks. Should it become necessary to use drill-and-blast methods, INPEX will have best-practice procedures and a monitoring plan in place to reduce risks to marine animals to a level that is as low as reasonably practicable.
2. Dredging Some submissions expressed concern about the scale of dredging and the impacts that dredging may have on marine environment aspects not discussed in the Draft EIS. Some respondents also queried the reliability of the dredge modelling presented in the Draft EIS.	INPEX has optimised the design of the shipping channel which has resulted in a lower volume of dredged material and a decrease in associated residual environmental impacts. The original shipping channel design presented in Section 4.4 in Chapter 4 *Project description* of the Draft EIS incorporated a dredge depth of 14 m below Lowest Astronomical Tide (LAT) to allow for safe navigation of the largest fully laden tanker. Further engineering and navigation studies (including navigation simulations) have explored opportunities to reduce the dredging footprint and dredge-spoil volumes. These indicate that a reduction of 0.5 m in under-keel clearance will still allow safe passage for ships. This 0.5-m reduction in overall dredge depth will result in a reduction in dredge volume of approximately 1 Mm^3. This approximate 6% reduction in dredge volume represents a reduction in the volume of fine material entering the water column and is considered to further reduce the current residual risks of damage to benthic marine habitats in Darwin Harbour from sediments. Work has also been undertaken to map the benthic habitats and communities of Darwin Harbour and areas of Shoal Bay, Gunn Point and Adam Bay in considerably greater detail, to establish zones of dredge and dredge-spoil impact and to provide further confidence in INPEX's assessment of residual risks to benthic communities and other marine animals. To create a greater degree of confidence in INPEX's dredge-modelling, additional information has been provided to explain INPEX's "conservative" approach to modelling and to the assumptions that underpin the models. The cumulative effect of these conservative assumptions means that dredge-model outputs are highly likely to overestimate the predicted environmental impacts as presented in the Draft EIS.
3. Protected marine species Some submissions pointed out areas in which INPEX could provide additional detail with regard to protected species known to inhabit Darwin Harbour.	INPEX has undertaken additional desktop research to provide further detail on the taxonomy, abundance, distribution and critical habitat for marine animals in Darwin Harbour. Furthermore, INPEX has undertaken field surveys to improve the level of knowledge with regard to the presence, absence, and distribution of these species in broader areas of the Harbour.
4. Underwater noise The noise impact on marine animals from construction activities, particularly the drill-and-blast operations at Walker Shoal, is a matter of concern to some submitters.	The levels and characteristics of underwater noise that will occur during the construction phase of the Ichthys Project have been the subject of detailed numerical modelling. The modelling completed has covered several different construction operations including dredging, piledriving and blasting. The results of this modelling are presented in this EIS Supplement along with a discussion of the potential risks to marine animals and the proposed management measures which will be required to reduce the risks to as low as reasonably practicable. Also refer to Summary issue 1 on marine blasting.

Summary issue	INPEX response
5. Greenhouse gas A number of submissions have suggested that INPEX should do more to reduce greenhouse gas (GHG) emissions and offset some or all of the GHG emissions that remain.	INPEX has considered and included numerous best-practice energy-saving measures in its designs which will reduce GHG emissions. For example, INPEX has gone beyond normal industry practice and now considers combined-cycle power generation as the base case for electricity production at Blaydin Point. The Draft EIS assumed open-cycle power generation as the base case. Combined-cycle power generation uses less fuel and creates less GHG to generate the same amount of electricity as open-cycle power generation. INPEX has also designed a subsea power-sharing cable to optimise energy use between the central processing facility and floating production, storage and offtake facility. This also goes beyond normal industry practice for GHG reduction. INPEX has indicated to the Northern Territory Government that it would like to commit to two savannah fire-management projects; one in the Daly River area and one in the Wagait area in the Northern Territory, south-west of Darwin. Besides a range of environmental and socio-economic benefits, these projects will result in a reduction of GHG emissions from these areas. INPEX will also continue to evaluate large-scale abatement and offset options such as biosequestration and reinjection of reservoir CO_2. However, these options involve large capital investments that impact the cost of the Ichthys Project. Therefore these options can only be considered if a well-designed and nationally consistent regulatory framework for GHG emission reduction is implemented and the options can be demonstrated to be commercially viable.
6. Vegetation-clearing A number of submissions expressed concern at the area of mangroves and monsoon vine forest to be cleared at Blaydin Point.	The footprint of the onshore processing plant and the areas of vegetation to be cleared have been revised since the publication of the Draft EIS to reflect design changes to the plant layout and the acquisition of additional information regarding the distribution of the different vegetation communities. During detailed design of the onshore plant, opportunities to minimise the final vegetation-clearing footprint will be investigated. However construction and engineering constraints will prevent any significant reductions in the size of the onshore development area, owing to the requirements for laydown areas and the design need to maintain safe distances between hazardous and non-hazardous areas. The protection of areas of monsoon vine forest could also be incorporated in fire management programs within the Daly River and Wagait areas.
7. Public safety A number of submissions questioned the impacts of the new facilities on public safety.	INPEX has already carried out extensive safety studies and risk reviews, and will continue to evaluate safety and risk as the Project design matures. The studies have considered and will continue to consider all Project infrastructure including the gas export pipeline, the facilities at Blaydin Point, and Project-associated ship traffic. The objectives are to ensure that the safety of the public and the Project's workforce is not compromised, and to safeguard all Project facilities. Safety aspects of the design, construction and operation of the LNG plant at Blaydin Point will be assessed by NT WorkSafe based on the provision of the facilities safety report. Acceptance of the facility safety report is a statutory requirement that must be in place prior to the commencement of operations at the site. Section 4.5.2 of this EIS Supplement contains additional safety information on shipping in Darwin Harbour.
8. Management plans A number of submissions questioned the level of detail provided in the provisional environmental management plans (EMPs) provided in the Draft EIS.	The Draft EIS stated clearly that the EMPs provided are provisional only, and that they will form the basis and framework for the development of the detailed EMPs that will be prepared as design, engineering and the award of contracts progress. This is because many of the details to be included will be developed in conjunction with the contractors engaged to manage or implement particular activities. The provisional EMPs were produced to provide an outline of the core information required to develop the detailed EMPS, including management measures and controls along with specific objectives, targets and indicators. They are based on the potential impacts documented in the Draft EIS's Chapter 7 Marine impacts and management, Chapter 8 Terrestrial impacts and management, and Chapter 10 Socio-economic impacts and management. The final (statutorily compliant) EMPs will be developed with regulatory-authority approval prior to the commencement of Project activities. These finalised plans will be publicly available at the appropriate time prior to execution.

Summary issue	INPEX response
9. Environmental (biodiversity) offsets A number of submissions suggested the application of environmental offsets to the Project.	INPEX has commenced dialogue with the Commonwealth's Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) and with the Northern Territory Government to outline a process for the development of an environmental offsets package for any significant residual environmental impacts arising from the Project. Significant residual environmental impact can only be determined by government after the submission of the "Final EIS", that is, the Draft EIS and this EIS Supplement taken together. In the interim, INPEX has made a number of voluntary environmental offset commitments which are outlined in Section 4.9 of this EIS Supplement. These include: • commiting to funding and participation in the proposed integrated marine monitoring and research program for Darwin Harbour • funding Australian Research Council Linkage projects involving Darwin-based scientists and institutions, firstly, to deliver a state-of-the art sediment transport model for Darwin Harbour estuaries, and, secondly, to develop rapid and sensitive impact assessment tools and a Darwin Harbour baseline using microbes • conducting research to improve understanding of coastal dolphin distribution, abundance and critical resource needs in Darwin Harbour • publishing extensive scientific data sets from INPEX's studies on turtles, corals, cetaceans and terrestrial flora and fauna in the Kimberley region.
10. Oil-spill modelling Many submissions raised concerns regarding INPEX's oil-spill modelling scenarios and oil-spill contingency plans, and mentioned the Montara and Macondo incidents. Scientific monitoring and equipment stockpiles were also areas where further clarification was sought.	INPEX has conducted additional oil-spill modelling for critical emergency situations including well blow-outs in the Ichthys Field and gas export pipeline ruptures in and around Darwin Harbour. With this additional modelling data as well as the findings of the Montara and Macondo inquiries available, INPEX, in consultation with the rest of the upstream petroleum industry including the Australian Petroleum Production & Exploration Association Limited (APPEA) and the Australian Marine Oil Spill Centre (AMOSC), is making significant amendments to oil-spill preparedness and response arrangements.

Conclusion

INPEX, together with its joint venture partner Total, is pleased to present this Supplement to the Ichthys Gas Field Development Project's Draft Environmental Impact Statement, thereby finalising the EIS. Through over three years of survey, research, consultation with communities, industry and governments throughout the Project's area of influence, INPEX is confident this document presents a sound case for the Project to be permitted to proceed to construction and operation.

2 Introduction

2 INTRODUCTION

INPEX Browse, Ltd. (INPEX), as Operator of the Ichthys Gas Field Development Project (the Project), together with its joint venture partner, Total E&P Australia (Total), is seeking the approval of the Northern Territory and Commonwealth governments to develop the Ichthys gas and condensate field (the Ichthys Field) to produce liquefied natural gas (LNG), liquefied petroleum gases (LPGs) and condensate for export to markets in Japan and elsewhere.

INPEX initiated formal environmental assessment of the Project in May 2008 under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act) and the *Environmental Assessment Act* (NT) (EA Act). In July 2010, INPEX published the draft environmental impact statement (Draft EIS) for the Project and invited all members of the public, businesses and interest groups to review and comment on the Draft EIS for a period of 8 weeks.

INPEX has prepared this document, the "EIS Supplement", in response to the comments received during the public review of the Draft EIS. The EIS Supplement, taken together with the Draft EIS, is the "Final EIS" and represents the finalisation of INPEX's submission of its environmental impact statement as required by Commonwealth and Northern Territory legislation.

INPEX extends a note of appreciation to all members of the public, government, non-government organisations and industry who invested in this assessment process through the review of the Draft EIS and preparation of submissions. Public involvement in this process has improved INPEX's understanding of community concerns and priorities, and has contributed to an improved proposal through this EIS Supplement to put before the respective environmental ministers for consideration.

Purpose of the document

In fulfilment of its obligations under the EPBC Act and the EA Act, INPEX is required to produce a supplement to the Draft EIS which takes into account comments submitted as part of the public review of the Draft EIS. Formal submission of the EIS Supplement to the Commonwealth and Northern Territory governments initiates the assessment of the Project prior to a final ministerial determination on the Project's environmental acceptability.

Under the Northern Territory's EA Act, the responsible minister is required to make a final determination on the Final EIS within 35 days, while under the EPBC Act, the Commonwealth Minister is required to make a decision within 40 business days. Either minister may exercise the right to extend this period or to seek further information from INPEX.

This EIS Supplement addresses several aspects of proposed Project activities to facilitate informed decision-making by the regulatory authorities as they assess the environmental acceptability of the Project. These aspects include the following:

- design updates: descriptions of significant changes to Project design since the Draft EIS was published in July 2010.
- supplementary information: data, information, and research relevant to environmental impacts and the assessment process, provided in addition to that contained in the Draft EIS.
- responses to submissions: INPEX's responses to the submissions made by interested parties during the public review and comment period for the Draft EIS.

This EIS Supplement, taken together with the Draft EIS, is the "Final EIS" and represents the finalisation of the environmental impact statement for the Ichthys Project by INPEX as required by Commonwealth and Northern Territory legislation.

A detailed description of the complete environmental assessment process may be found in Section 1.2 of the Draft EIS.

Section 3 of this EIS Supplement provides an update to the Project Description originally presented in the Draft EIS and includes significant Project design changes. Section 4 provides additional data, statistics, information, and research to that presented in the Draft EIS to facilitate a more informed assessment outcome. Section 5 addresses the public submissions received in response to the Draft EIS, and includes INPEX responses to the common issues raised, and individual responses to public comments that were more unique in content. Technical appendices and all public submissions are included on the enclosed CD or may be accessed at the INPEX web site: www.inpex.com.au.

3 Project description and changes

3 PROJECT DESCRIPTION AND CHANGES

3.1 Introduction

The Project description published in the Draft EIS in July 2010 represented the best information available at that time for the development of the design of the Ichthys Project. As the Project continues to move towards a final design for the construction and operations phases, several changes relevant to the environmental assessment process have been identified. These changes are described in this section, together with the consequences such changes may have on residual environmental impacts.

3.2 Ichthys Project overview

The Ichthys Field is located in the Browse Basin, around 450 km north-north-east of Broome and 820 km west-south-west of Darwin. The field encompasses an area of approximately 800 km^2 in water depths ranging from 235 to 275 m. Appraisal drilling and development studies suggest that the P_{50} resources[1] of the Ichthys Field are 12.8 tcf (trillion cubic feet) of sales gas and around 527 MMbbl (million barrels) of condensate[2,3], split between a Cretaceous reservoir in the Brewster Member and a Jurassic reservoir in the Plover Formation.

INPEX plans to install a floating central processing facility (CPF) for the extraction of natural gas and condensate at the Ichthys Field. The bulk of the condensate will be exported directly from the field at an average rate of up to 85 000 barrels per day (at the start of LNG production) after processing on a floating production, storage and offtake (FPSO) facility moored some distance from the CPF. Natural gas and LPGs from the field will be directed through a gas export pipeline from the field to onshore facilities at a site zoned for industrial development at Blaydin Point in Darwin Harbour in the Northern Territory. The gas will be processed through a two-train 8.4-Mt/a LNG processing plant. This production rate represents the average LNG plateau rate over about 20 years after production startup.

1 In the oil & gas industry, P_{50} resources (often called “proved plus probable”) are in effect a median estimate of the resources expected to be extracted from a hydrocarbon field. A P_{50} estimate refers to a value which has a 50% probability of being exceeded.

2 Note: the hydrocarbon resources reported in this document are based upon the “Statement of Hydrocarbon Resources” which was registered with Western Australia’s Department of Mines and Petroleum on 27 March 2009. The P_{50} resources notified were 12.8 tcf of sales gas and 527 MMbbl of condensate. These figures were INPEX’s best estimates at the time of preparation of this document, but are subject to subsequent review. Modelling and emission estimates are based upon the registered 2009 figures.

3 In metric measure this equates to 361 Gm^3 of gas and 83 GL of condensate.

Thereafter, LNG production will gradually decline as the Project slowly runs out of gas but continues to produce LNG at rates below 8.4 Mt/a. Total annual production will vary from year to year depending on factors such as the composition of the gas from the reservoir and the duration and frequency of maintenance activities.

The onshore processing plant will also produce up to approximately 1.6 Mt/a of LPGs and up to 20 000 barrels per day of condensate which will be carried to the plant as part of the gas stream through the gas export pipeline.

The construction phase of the Project will cover a period of 5 years from the final investment decision (FID) to the export of the first cargo of LNG. An additional year of construction is required to complete the second LNG train. Approval for the construction and operation of the Project requires environmental assessment by both the Commonwealth Government and the Northern Territory Government. It does not require assessment under Western Australia’s *Environmental Protection Act 1986* as Western Australia’s jurisdiction does not extend beyond the state’s coastal waters zone (which extends only 3 nautical miles seaward of the territorial sea baseline).

Further information regarding the Project proponent INPEX and the details of Project design may be sourced from the Draft EIS.

3.3 Changes to Project infrastructure

Since the publication of the Draft EIS, a number of changes have been made to the layout of the onshore processing plant and other aspects of onshore and nearshore infrastructure.

The key changes to the infrastructure are as follows:

- the reorientation of LNG trains 1 and 2
- minor adjustments to the footprint and/or layout of:
  - the area around the ground flares and the possible inclusion of five enclosed flares within the flare compound
  - the wastewater treatment plant (WWTP) has been relocated
  - the module offloading facility – inclusion of a "finger" wharf and mooring dolphins to allow for better access for berthing and offloading modules and materials from vessels.
- the relocation of the manned buildings, which includes the operations and maintenance buildings and the administration and warehouse complexes.

Figure 4-29 of Chapter 4 of the Draft EIS showed the onshore development area including the gas export pipeline and the plant layout; Figure 3-1 of this EIS Supplement shows the revised layout of the onshore development area. The vegetation-clearing impacts associated with these changes are discussed in Section 4.4.

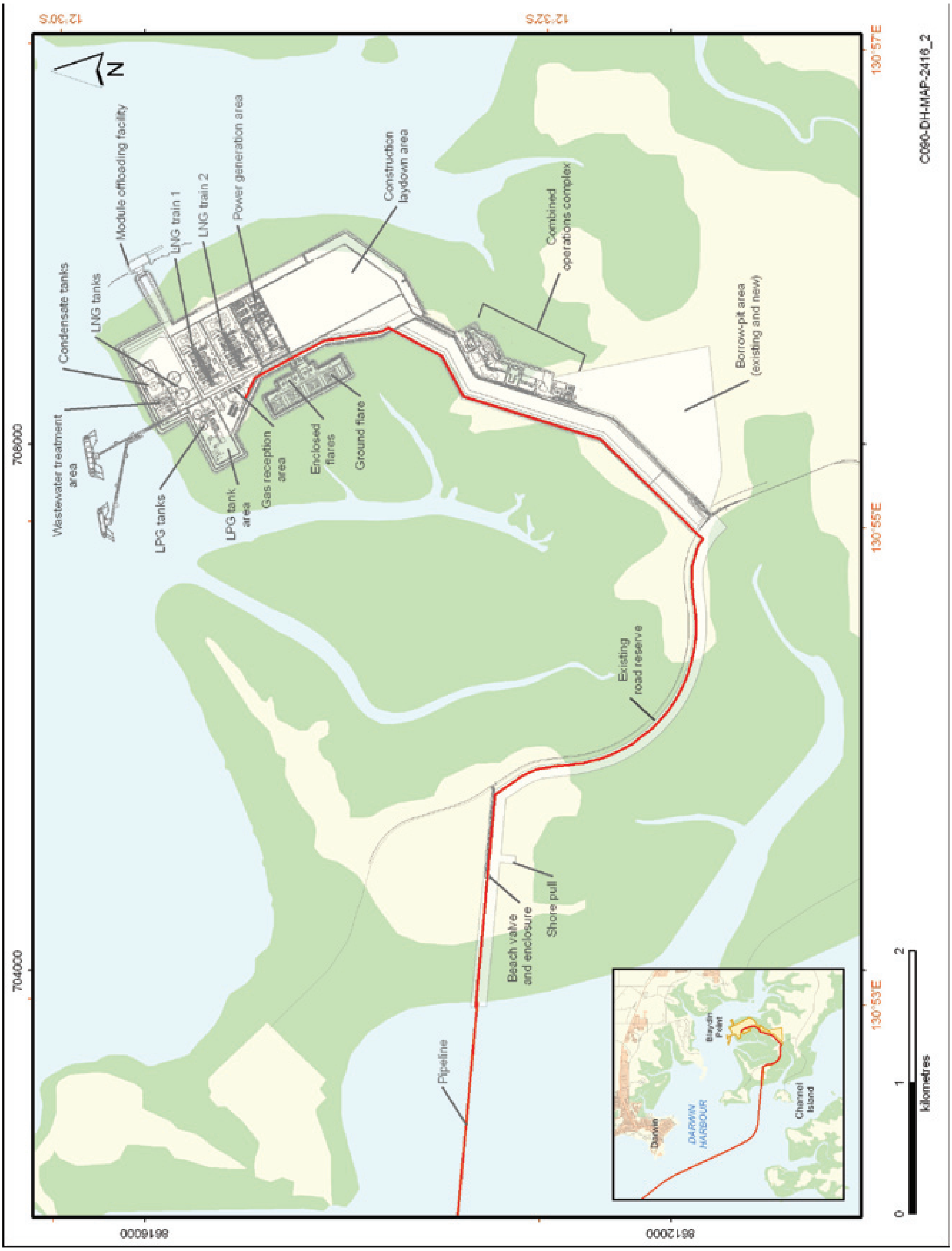

Figure 3-1: Revised layout of onshore development area infrastructure

3.3.1 Orientation of the LNG trains

In Figure 4-29 in Chapter 4 of the Draft EIS, the plant layout showed LNG trains 1 and 2 oriented in a north–south direction. Since the publication of the Draft EIS, however, a decision has been made to orient the LNG trains in an east–west direction. The new orientation, shown in Figure 3-1, provides advantages in terms of constructibility, future facilities installation, and safety.

3.3.1.1 Layout and design of the ground-flare compound

Figure 3-1 also shows a change in layout within the ground-flare area to incorporate up to five 50-m-tall enclosed flares. These new flares may be needed to dispose of gas generated during the commissioning phase of the onshore gas plant. As such, the area required for the flares may need to be increased by up to 5 ha from the area identified in the Draft EIS to accommodate the changes to the layout. The final design will minimise noise and light emissions during commissioning flaring.

3.3.1.2 Layout of the module offloading facility

The design of the module offloading facility has been refined and includes a finger wharf and mooring dolphins added to the end of the loading berth to improve accessibility for the period when modules and associated materials are being offloaded (see Figure 3-1).

3.3.2 "Manned facilities" relocation to combined operations complex

Following the publication of the Draft EIS, INPEX made a decision to relocate the processing-plant "manned facilities", which include the operations centre and maintenance and warehouse facilities, to a location outside the processing-plant boundary. It was also decided that the manned facilities should be amalgamated with the administration and service buildings.

Operations personnel will still access the processing-plant area, and there will be personnel on site at all times to operate and maintain the plant.

The objective was to provide a safer plant layout design in accordance with current practice in the design of other LNG plants in Australia.

In addition, co-locating all manned buildings in a common complex will enhance operational efficiency and promote the management–workforce interactions considered necessary to deliver the safety management and business responsiveness outcomes necessary for the Project's operations phase.

The proposed location selected for the combined operations complex is outside the processing-plant area but is closer to the plant than the original administration complex described in the Draft EIS. It is proposed that the new combined operations complex be located at the end of the Blaydin Point access road near the causeway area. It will include the operations centre, laboratories, administration and management buildings, warehouse and maintenance facilities, and the gatehouse.

3.3.2.1 Alternatives considered

The alternatives considered in the decision-making process were as follows:

Option 1—*Retaining the operations and maintenance complexes on the processing-plant site*. Although the original arrangement as shown in the Draft EIS was technically feasible, it presented a significant challenge in that INPEX would have to be able to demonstrate that risk could be kept to an "ALARP" ("as low as reasonably practicable") level with the operations and maintenance complexes so close to the plant. This is not only a requirement of INPEX's own health, safety and environment (HSE) and risk management process but it is a regulatory requirement for an industrial site classed as a "major hazard facility". A review of comparable projects, particularly in the North West Shelf region, indicated that manned facilities currently under design or being built, for example for the Pluto and Gorgon projects, were suitably distant from the processing plants.

Option 2—*Co-locating the operations and maintenance complexes with the administration complex shown in the Draft EIS at the junction of the Blaydin Point access road and Channel Island Road*. This option is also technically feasible, but presents some technical challenges, as some of the services delivered from the combined operations complex to the processing plant (e.g. firewater), or from the processing site to the operations complex (e.g. mains and emergency power), are approaching technical limits for the current designs. Furthermore the greater distance to the processing plant (as compared with Option 3) presents additional logistical challenges for the operations and maintenance personnel.

Option 3—*Relocating the operations and maintenance complexes and the administration complex to a new location halfway between the processing plant and the administration complex shown in Figure 4-29 in the Draft EIS*. This option is the preferred option, and the one selected as the revised base case for the plant and associated facilities. The advantages of the building relocation are as follows:

- Plant design is made safer by removing all manned facilities from the processing areas.
- Such a move is consistent with industry practice.
- All work groups and their facilities—operations, management, laboratory, administration and maintenance—are in one place, allowing consolidation and optimisation of common amenities.

The disadvantages or potential negative impacts of the building relocation are as follows:

- There is the potential for a minor impact to visual amenity.
- It is less efficient for the operations and maintenance personnel in terms of movements to and from the plant processing areas, and will require more vehicles than would otherwise be necessary if the operations and maintenance personnel were located directly on site.
- There would be an approximate increase of 5 ha in the mangroves to be cleared.
- Re-routeing of the gas export pipeline would be required to maintain a safe distance from buildings and to avoid heritage sites.
- There may be increased exposure of the workforce to biting insects.

Changes to the vegetation-clearing calculations from the building relocation are provided in Section 4.4.

3.3.2.2 Gas export pipeline realignment

Following the decision to relocate the manned facilities, it was determined that the pipeline should also be realigned to obtain optimal distances between the pipeline and the manned facilities and increase access to supratidal land area. In addition, by realigning the pipeline extra vegetation-clearing and land disturbance or stabilisation activities could be avoided. Figure 4-41 in Section 4.4 shows the change to the gas export pipeline alignment and associated vegetation communities.

Concurrently INPEX decided to pursue only those realignment options that avoided disturbance to Aboriginal heritage sites within the combined operations complex area. As a result some minor additional increases in the areas of mangrove and melaleuca woodland communities to be cleared will be made to accommodate the operations complex without the need to disturb Aboriginal heritage sites.

3.3.3 Road traffic

This section provides revised estimates of materials, road traffic volumes and likely traffic routes, and clarification of traffic estimates previously described in the Draft EIS. As the construction phase represents the most intense period of Project activity, this section is focused on this particular phase of the Project. INPEX acknowledges that the Project will contribute to some increases in road traffic during maintenance campaigns and for the duration of the operations phase. Impacts from such Project activities will however be substantially less than that associated with the construction phase described here.

3.3.3.1 Background

Four traffic-type categories and associated routes are described for the Project's construction phase. These are:

i) rock and fill materials transported by heavy vehicles from:
   - the Mount Bundey quarries to Blaydin Point and East Arm Wharf, and/or
   - alternative source locations to Blaydin Point and East Arm Wharf (for the purposes of this EIS Supplement, INPEX has assumed a location to the south of Darwin)

ii) material supplies and waste transported by heavy vehicles from
   - East Arm Wharf and nearby industrial area to and from Blaydin Point

iii) personnel movements to and from the accommodation village
   - Howard Springs to / from Blaydin Point

iv) personnel and materials transport from Darwin
   - buses and light vehicles from around Darwin to the onshore plant site at Blaydin Point.

Other road traffic types associated with the Project, but which do not constitute a large proportion of Project traffic include:

i) the transfer of personnel to and from Darwin Airport
ii) the transfer of wastes from the accommodation village and Blaydin Point to a yet-to-be-determined waste disposal or transfer location
iii) interstate transportation of equipment, materials and wastes.

Road transport options presented in the Draft EIS were based on the following assumptions:

i) Rock supplies for the Project will be sourced from a quarry (or quarries) at Mount Bundey. (Commercial aspects for this option were not verified.)

ii) Mount Bundey rock is suitable quality for the rock-armouring of the pipeline.

iii) The Shoal Bay landfill site was nominated as the likely location for waste disposal (subject to further assessment).

iv) Only existing sealed roads and the most direct transport routes were considered, as follows:

   – Accommodation village buses would use Howard Springs Road and Whitewood Road to access Lambrick Avenue to Chung Wah Terrace (through the Palmerston town and residential areas) to Channel Island Road

   – Trucks from Mount Bundey to Blaydin Point were also to use this route (this is no longer the case), while trucks from Mount Bundey to East Arm Wharf would turn on to Stuart Highway to Berrimah Road to reach East Arm Wharf.

Possible transport routes and projected traffic volumes are discussed in sections 3.3.3.2 to 3.3.3.6 below.

Draft EIS—road traffic and materials estimates

Initial estimates of material volumes and road traffic vehicle movements were provided in Table 10-4 of the Draft EIS. However, these estimates did not indicate the stage or duration that specific construction activities and associated traffic impacts would occur. Total traffic volumes will vary over the course of the construction phase and will depend on the sum of construction activities at any point in time. Further clarification of volumes and timings is provided in sections 3.3.3.2 to 3.3.3.6.

Draft EIS estimates for rock and fill requirements for the Project were as follows:

- gas export pipeline (offshore)
  - rock-armouring for the subsea pipeline and the pipeline shore crossing:
    - subsea pipeline—approximately 850 000 t of rock
    - pipeline shore crossing—approximately 30 000 t of rock.
- gas export pipeline (onshore):
  - requirements for pipeline berm were indicated but not estimated
- onshore processing plant:
  - rock and fill requirements were identified; however volume estimates were not able to be made due to the preliminary nature of geotechnical information available at the time of publication of the Draft EIS.
  - potential requirements for alternative fill or imported material were indicated but not estimated
- module offloading facility
  - rock-armouring and aggregate volumes for the causeway at the module offloading facility were not estimated.

Section 3.3.3.2 of this document provides revised estimates for materials requirements and traffic volumes.

Draft EIS—waste disposal traffic

Shoal Bay was identified in the Draft EIS as an option for a landfill disposal location for wastes for the construction and operations phases. However, as described in the *Provisional Waste Management Plan* in Chapter 11 of the Draft EIS, not all of the wastes identified would be taken to a landfill site such as Shoal Bay. Some waste streams will be recycled, reused, or managed on site, while other streams will require specialist treatment and/or disposal. For the purposes of planning logistics and providing estimates for the Draft EIS, a disposal location was required, and Darwin's landfill at Shoal Bay was nominated for this purpose.

It is recognised by INPEX that the Shoal Bay site is a municipal landfill site operated by Darwin City Council. INPEX will engage with the council regarding the potential use of Shoal Bay as a disposal site for some wastes; however INPEX is aware that Shoal Bay does not accept most listed, controlled or hazardous wastes. Currently most of such wastes generated in the Territory are shipped interstate. INPEX also recognises that Shoal Bay does not accept untreated acid sulfate soils (ASSs). The company is currently investigating ASS management and, as a priority, actual acid sulfate soils (AASSs) or potential acid sulfate soils (PASSs) will be managed *in situ* with disturbance and movement kept to a minimum or treated on site.

INPEX is assessing other existing waste-management options and service providers in the region to facilitate the safe and responsible disposal of them.

3.3.3.2 Revised rock-and-fill traffic estimates

During the Project FEED phase and following analysis of recently acquired geotechnical data, it was determined that additional rock and fill to that estimated in the Draft EIS would be required for the onshore plant site. This rock would be used in areas where the existing soil material is unsuitable and it may also be required for ground stabilisation, that is, to strengthen the substrate prior to the construction of the processing plant foundations and the installation of the plant modules. Additional materials will also be required to build protective berms for the onshore section of the gas export pipeline. These additional requirements have resulted in an increase in the associated heavy-vehicle traffic during parts of the construction phase (see Table 3.1). This table also illustrates the staggered nature of activities over the 5-year construction period and how traffic volumes will vary over that entire period.

The Mount Bundey quarries, located about 100 km south-east of Blaydin Point, are the only major quarried igneous deposits within the greater Darwin area. INPEX is investigating alternative sources of rock and fill from other existing quarry locations. It should be noted that alternative sources of the balance of the rock and fill materials are yet to be determined, and that final routes and traffic estimates cannot be provided at the time of preparation of this document. The selection process for sources of materials will consider source location(s), commercial aspects, availability and other conditions such as conflict with other potential projects. It is therefore likely that multiple sources of materials will be utilised.

The revised quantities of imported materials and the timing for their delivery are summarised as shown in Table 3-1.

Rock will be delivered to East Arm Wharf, and rock and fill to the onshore development area at Blaydin Point and the onshore gas export pipeline route. The large volume of fill materials required makes it likely that stockpile locations will have to be found near both of these sites.

In the preparation of the Draft EIS, INPEX considered using only existing sealed roads and the most direct transport routes. This created a situation whereby heavy vehicles might have driven through Lambrick Avenue and Chung Wah Terrace in Palmerston to reach Blaydin Point after exiting from the Arnhem and Stuart highways (as shown in Figure 10-1 of the Draft EIS). After further investigation of viable transport routes, INPEX now intends to route heavy-haulage vehicles[4] along Stuart Highway on to Jenkins Road. This removes the previous option to route heavy-haulage vehicles through Palmerston. INPEX will continue to work with NT Roads, the service group within the Department of Lands and Planning (DLP) responsible for managing the Territory's road network, to identify other existing road options and/or proposed road projects or upgrades that may need to be brought forward or undertaken to optimise traffic flow.

4 Heavy haulage class vehicles include B-double trucks up to and over 25 m long, short double road trains up to 27.5 m long and all combinations of a rigid truck and trailer exceeding 19 m in combined length.

Table 3-1 Indicative quantities of imported materials and timing during construction period

Imported material	Tonnes (approximate)	Timing (indicative only and may be subject to change)
Rock for dynamic replacement	382 000	2nd quarter 2012 – 3rd quarter 2013
Gravel/bulk fill	756 000	2nd quarter 2012 – 3rd quarter 2013
Base course	366 000	2nd quarter 2012 – 3rd quarter 2014
Sub-base for hardstand	525 000	2nd quarter 2012 – 3rd quarter 2014
Selected fill material for backfill	73 500	3rd quarter 2013 – 4th quarter 2014
Sand for backfill*	245 000	3rd quarter 2013 – 4th quarter 2014
Rock for shore protection*	241 000	3rd quarter 2012 – 4th quarter 2013
Aggregate for concrete	399 000	2nd quarter 2013 – 4th quarter 2014
Sand for concrete	176 000*	2nd quarter 2013 – 4th quarter 2014
Materials for onshore gas export pipeline	400 000	1st quarter 2013 – 3rd quarter 2013
Materials (rock-armouring) for the offshore gas export pipeline	850 000	4th quarter 2013 – 2nd quarter 2014
Total	**4 413 500**	

Note: These quantities are provisional figures for rock source and traffic impact assessment studies. They will be reviewed and updated as the detailed design and contracting process progresses.

* Rock for shore protection bulk density assumed to be 2.65 t/m^3; sand fill assumed to be 1.6 t/m^3; the bulk density for all other types is assumed to be 2.1 t/m^3.

Figure 3.2 shows the base case route provided in the Draft EIS and potential routes that may be used to transfer the alternative rock sources (to and from the Mount Bundey quarries on Arnhem Highway or a yet-to-be-determined potential site south of Darwin on Stuart Highway). The Jenkins Road option that is shown in Figure 3.2 is dependent upon the controlled management and maintenance of Jenkins Road. The following route codes have been used in Figure 3-2:

- Route 1: Mount Bundey to East Arm Wharf
- Route 2: Mount Bundey to Blaydin Point
- Route 3: yet-to-be-decided quarry location (south) possibly using Jenkins Road to Blaydin Point
- Route 4: yet-to-be-decided quarry location (south) using Stuart Highway to East Arm Wharf.

The anticipated traffic volumes from the source locations to Blaydin Point and East Arm Wharf are as follows:

i) bulk rock and gravel from Mount Bundey or alternative sources to Blaydin Point—potentially 170 heavy-vehicle round trips per day for up to 2 years from the start of site works and construction
ii) rock-armouring supply for the subsea gas export pipeline from Mount Bundey to East Arm Wharf—potentially 102 heavy-vehicle round trips per day for up to 1.5 years
iii) rock and fill material for the onshore section of the gas export pipeline—potentially 150 heavy-vehicle round trips per day for up to 9 months
iv) aggregate and fill material source(s) to be determined) to Blaydin Point—potentially 35 heavy vehicle round trips per day for up to 2 years from the second year of construction works.

A Project-wide traffic or transportation management plan will therefore be developed to account for different transport demands at different phases of the Project. Traffic modelling will be re-run on the basis of revised volumes, routes and timings, and model outputs will inform the decision-making process and the development of the traffic management plan.

3.3.3.3 Personnel movements to and from the accommodation village

The likely route and traffic volumes for buses from the proposed accommodation village at Howard Springs to the Blaydin Point site have remained unchanged from those proposed in the Draft EIS.

A possible alternative route could include the use of the extension of Roystonea Avenue associated with the new housing development at Bellamack, which would allow bus traffic to avoid entering Palmerston via the Lambrick Avenue – Chung Wah Terrace route. Other routes will also be investigated, including routeing buses to Blaydin Point via Stuart Highway and Jenkins Road.

Personnel traffic volumes remain unchanged from estimates presented in the Draft EIS.

Figure 3.3 shows the most likely accommodation-village bus transport route.

3.3.3.4 Miscellaneous personnel and materials transport

A number of early siteworks personnel and also supervisory, management and temporary specialist personnel who may live in residential areas other than the accommodation village will require transportation to and from the Blaydin Point site. INPEX is developing an accommodation strategy which will identify means of accommodating up to 450 additional people in facilities to be developed in conjunction with private developers. The aim is to minimise the impact of INPEX personnel on the local housing market. The number of personnel travelling from Darwin will vary depending on the type of activity being undertaken at site.

A central rendezvous point (or points) will be selected in Darwin where personnel will be able to park private vehicles and be collected by transit vehicles for transfer to Blaydin Point—in effect a park-and-ride arrangement. It is likely that they will leave the city area to connect with either Stuart Highway or Tiger Brennan Drive and from there to Berrimah Road, Wishart Road and Elrundie Avenue to Channel Island Road (see Figure 3-4).

The traffic to and from Darwin will mainly consist of buses for bulk personnel movements as required and light vehicles for other personnel.

A similar route is likely to be used for light-vehicle transport of small parcels and packages of materials.

3.3.3.5 Other materials and waste transfer

INPEX is proposing to access additional land near East Arm Wharf in the industrial area for use as a stockpile or holding area and also as a transfer and quarantine area to assist with the management of materials, equipment and waste. Most of the traffic associated with materials and equipment will be between East Arm Wharf and the nearby industrial area and Blaydin Point (see Figure 3-5).

Transfers will include the following:

- deliveries to and from East Arm Wharf
- transportation to and from laydown areas
- supplies of cement, concrete and asphalt
- deliveries of foundation piles and line pipes
- movement of heavy construction equipment to and from Blaydin Point
- movements of other equipment, consumables, and waste.

Figure 3-2 Proposed routes for heavy-vehicle traffic for the supply of rock and fill from quarries at Mount Bundey or from a yet-to-be-determined quarry location south of Darwin

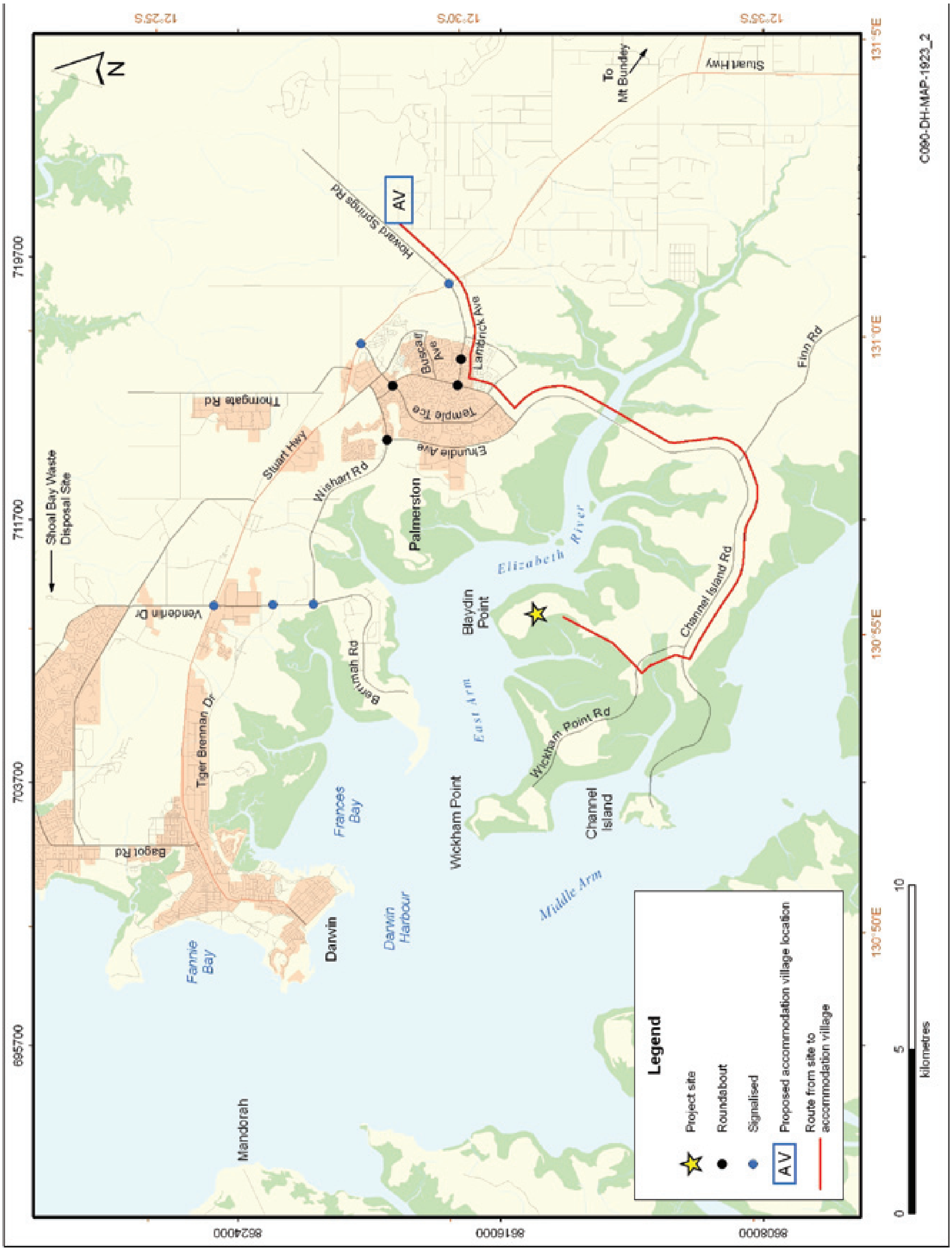

Figure 3-3: Likely route for bus transport between the accommodation village and Blaydin Point

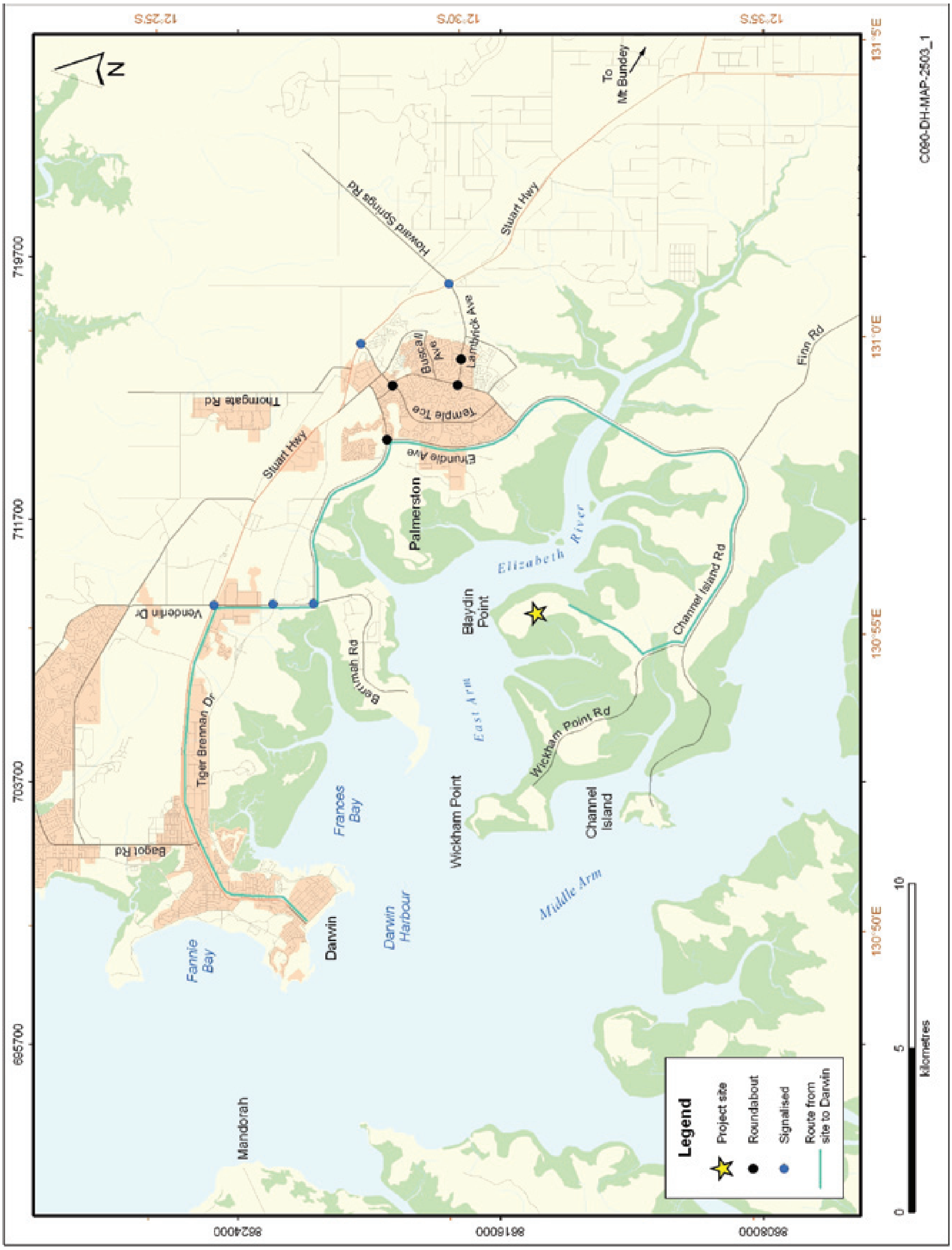

Figure 3-4: Likely route for personnel movements between Darwin city centre and Blaydin Point

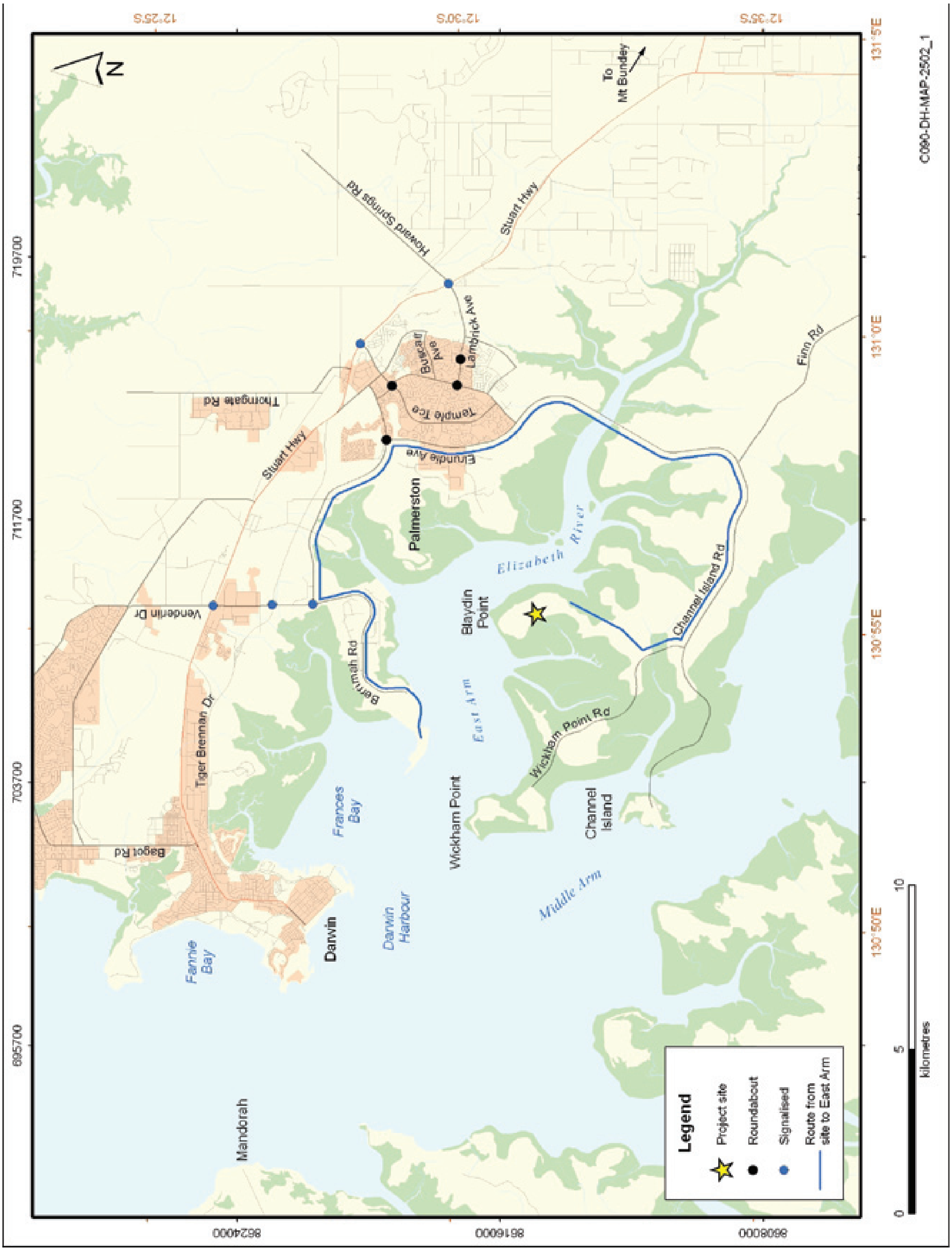

Figure 3-5: Proposed route for traffic between East Arm Wharf and Blaydin Point

Transfers of materials and supplies between East Arm Wharf and the nearby industrial area and Blaydin Point will most likely follow Berrimah Road, Wishart Road, Elrundie Avenue and Channel Island Road to the Blaydin Point site access road.

The anticipated traffic volumes from East Arm Wharf and nearby industrial area to Blaydin Point are as follows:

i) construction materials—potentially 170 light – and heavy-vehicle (approximately 85 of each) round trips per day through the early site-preparation and bulk-earthworks stages of the construction phase
ii) miscellaneous other materials (diesel supplies, equipment movements, laydown area transfers)—potentially 50–150 additional light – and heavy-vehicle movements at peak periods through the construction phase. (Note that the "150" movements for materials represents occasional peaks for pre-made concrete supply to site.)

3.3.3.6 Traffic impact assessment

INPEX is working with the Northern Territory Government to develop viable and practicable transport options, based upon the following principles:

- preserving public and personnel road safety
- minimising road traffic and maximising transport alternatives where practicable
- minimising impact on public infrastructure
- minimising public disturbance or inconvenience

To guide the development of an optimal transport outcome, INPEX is engaging specialist consultants to undertake further road traffic modelling based on the revised traffic volumes. This work will assess the impact of Project traffic on existing and projected traffic volumes and road networks and will identify any potential bottlenecks and pressure on infrastructure. Through ongoing discussions with NT Roads, INPEX will use the outcomes of the above assessment to identify proposed road projects that may need to be brought forward or upgrades that may need to be undertaken to optimise traffic outcomes. The potential viability of other transportation options, such as rail, will also be considered.

This work is under way at the time of preparing this EIS Supplement and INPEX will continue to liaise with the relevant regulatory authorities and stakeholders. The final traffic management plan will be subject to approval from the Northern Territory Government and will incorporate INPEX and contractor road traffic safety management practices.

3.3.4 Blaydin Point terrestrial footprint

With the changes to plant layout and the revision of its vegetation-clearing estimates, INPEX now estimates that the terrestrial footprint for the onshore development area is 413 ha. This includes areas to be cleared for the Project and land that has already been cleared or modified. The overall area of vegetation estimated to be cleared is 362 ha (see Table 4-23). The 413 ha includes the plant pad, corridors for the gas export pipeline and access roads, and the area around the borrow and fill pits.

3.3.5 Operational noise

Section 10.3.10 and Technical Appendix 20 of the Draft EIS state that, during both steady-state and process upset conditions, INPEX's Blaydin Point plant would not be expected to cause ambient noise levels in Palmerston to rise above around 40 dB(A).

However, further modelling by INPEX and flare vendors has shown that noise levels may exceed 45 dB(A) in Palmerston during process upset flaring scenarios if wind speed and wind direction are also unfavourable.

INPEX expects that noise levels in Palmerston, as a result of process upset flaring from Blaydin Point, could be 45–55 dB(A) three or four times per year for a few minutes during the operations phase, under certain meteorological conditions. For the rest of the time, ambient noise levels are expected to remain under the established criteria limits.

INPEX considers the residual risk of airborne noise as remaining at "medium", which is the level of risk documented in Table 10-17 of the Draft EIS.
Table 10-16 of the Draft EIS shows that at noise level of 40 dB(A) is equivalent to "quiet radio music", a noise level of 50 dB(A) is equivalent to "low conversation", and a noise level of 60 dB(A) is equivalent to "normal conversation".

3.3.6 Shipping channel depth reduction

Reduction in dredging volume

The original shipping channel design presented in the Draft EIS incorporated a dredge depth of 14 m below Lowest Astronomical Tide (LAT) to allow for safe navigation of the largest fully laden tanker. This depth included a conservative under-keel clearance of 2 m which took into account factors such as squat[5], vessel motions and accuracy of dredge completion. Further engineering and navigation studies (including navigation simulations) which explored opportunities to reduce the dredge footprint and dredge-spoil volumes have since been undertaken and indicate that a reduced clearance of 1.5 m will provide for sufficient under-keel clearance. This 0.5-m reduction in overall dredge depth, while still providing a safe navigation channel for tankers, will result in a reduction in overall dredge volumes of approximately 1 Mm^3. This approximate 6% reduction in dredge volume represents a reduction in the volume of fine material entering the water column and is considered to further reduce the current residual risks of damage to benthic marine habitats in Darwin Harbour.

This reduction in the dredge-spoil volume and the resultant change in post-dredge bathymetry will be included in the final sediment dispersion modelling to be undertaken once the dredging contract has been awarded and the final dredging and spoil disposal design has been finalised. This will feed into subsequent assessment under the relevant legislative requirements.

3.3.7 Increase in condensate production rate from onshore facilities

It was noted in Section 4.1.7 of Chapter 4 *Project description* of the Draft EIS that an estimated 15 000 barrels per day (bpd) of condensate would be produced from the onshore processing plant at Blaydin Point. This figure has since been revised and INPEX now seeks to produce up to 20 000 bpd of condensate at the plant.

The reason for the increase is that isopentane (one of the light condensate fractions), much of which would otherwise have been used for fuel in the power plant, can now be incorporated into the marketable condensate.

This increase in the average daily condensate production rate may increase condensate export vessel traffic commensurately, by approximately 30%.

5 The apparent increase in the draught of a ship caused by pressure changes in the surrounding waters resulting from the movement of the ship through the water.

3.3.8 Drill-and-blast reduction

INPEX has committed to using methods other than drilling and blasting for the removal of Walker Shoal. The methods proposed are to use a specialised cutter-suction dredger with sufficient power to remove the greater part, if not all, of the hard material and, if necessary, to employ a hydraulic hammer or drop chisel. As INPEX cannot be completely certain that these methods will be fully effective, it is considered appropriate that a fall-back option is maintained within the environmental assessment and subsequent approval for the Project for drill-and-blast methods to be employed for approximately 4 weeks. Should it become necessary to use drill-and-blast methods, INPEX will have best-practice procedures and a monitoring plan in place to reduce risks to marine animals to a level that is as low as reasonably practicable.

A progress update on marine mammal detection methods is provided in Section 4.1.12 of this EIS Supplement. The sections below provide the following explanatory information:

- a summary of additional data available since the publication of the Draft EIS
- a description of alternative methods for fragmenting high-strength rock in sufficient detail to allow a comparative environmental assessment of the methods
- a definition of potential rock-removal scenarios
- a statement of assumptions
- a comparative environmental assessment of rock-removal scenarios.

Additional data

To improve its understanding of the nature of the seabed and the underlying geology in the proposed shipping channel, and in particular around Walker Shoal, INPEX has carried out a number of geophysical and geotechnical investigations. Refraction and reflection surveys were undertaken to provide a broad overview of the subsurface soil strengths and their spatial distributions, and a geotechnical drilling program was undertaken in two phases to provide core samples of Walker Shoal for analysis. Results from the surveys were subsequently used to refine site selections for the second-phase geotechnical boreholes, allowing areas of high-strength material to be targeted to confirm the presence of rock.

It is only possible to get low-resolution data from reflection and refraction surveys and these tend to exaggerate the spatial distribution of high-strength material. This situation is exacerbated when high-strength material overlies weaker material (as is the case at Walker Shoal). For these reasons, INPEX's first estimate of the volume of high-strength material at Walker Shoal (and at two other sites within the proposed dredging footprint) was excessively conservative. Information from the second phase of the nearshore geological investigation was necessary to refine the calculations of the amount of high-strength material. However, because of the highly complex nature of the geology at Walker Shoal, the interpretation of the data took some considerable time.

An extensive borehole pattern was drilled over Walker Shoal in an attempt to better understand the nature of its geology and formation. In all, 68 boreholes were drilled on an approximate grid of 30 m over the entire area of the shoal. These were then subjected to a number of geotechnical tests to assist in the interpretation of, among other things, the potential dredgeability of the shoal.

It is this greatly increased knowledge of Walker Shoal that has allowed INPEX to substantially reduce the projected volume of hard rock to be removed. The unconfined compressive strength (UCS) of the conglomerate material encountered during these investigations ranged between low-strength material with UCS values less than 5 MPa through to extremely high-strength material with UCS values of approximately 80 MPa. There is an estimated volume of approximately 30 000 m^3 of material with a UCS of between 30 MPa and 50 MPa and a further 32 000 m^3 of conglomerate material with a UCS of over 50 MPa.

Traditional dredging techniques, such as using a large cutter-suction dredger (CSD), typically defined as having an installed cutter power of at least 3500 kW, are generally regarded as being suitable for material strengths of up to approximately 30–50 MPa when the dredge material is relatively confined in volume (and depending on the capability of the plant being employed).

It is expected that the high-strength material (i.e. >50 MPa UCS) will not be able to be dredged using traditional dredging plant, and will require the use of specialist techniques and/or equipment to fragment the material before it can be removed by the more traditional dredging methods.

Fragmentation methods

There are two basic methods of pretreatment for fragmenting high-strength rock material: mechanical and chemical. Mechanical fragmentation methods typically used in dredging applications are as follows:

- drop chisels
- mechanical chisels
- pneumatic or hydraulic vibratory rock breakers
- specialised CSDs.

Chemical fragmentation methods used in dredging applications include the use of expanding gas cartridges (sometimes referred to as "chemical splitting") and blasting using explosives.

Drop chisel

Underwater chisel-dredging may be used for rock fragmentation. In its most basic form, a chisel-dredging set-up consists of a pontoon or platform, on which is mounted a heavy chisel or "needle" (for example a heavy pile with a hardened tip). The chisel is hoisted and dropped vertically on to the rock to fragment it.

Little technical information is available for drop-chisel operations. KGL (2010) provides some theoretical calculations indicating that drop-chisel operations in rock strengths of up to 30 MPa may be viable: however there is no information for higher strength material, and potential difficulties with large tides and strong currents are noted. Given that it has not been possible to obtain detailed data pertaining to the productivity and effectiveness of drop-chisel operations (particularly in high-strength material), it is thought that drop-chisel operations would require further research before being considered for use at Walker Shoal.

Mechanical chisel

A more controlled version of chisel-dredging involves a chisel hung from a piledriving rig or similar where an impact hammer (anvil) is used to drive the chisel into the rock. The chisel is then pulled horizontally at the top to break the rock by levering. In some cases, a bank of chisels has been mounted on one vessel. As with the "drop-chisel" method, little technical information is available on this method. It is expected that fragmentation of thin layers may be possible, as the chisel is required to either penetrate or shatter the rock material. Given the thick layers at Walker Shoal and the difficulty in gauging the success or otherwise of this methodology it is not considered to be a viable option.

Vibratory rock breakers

Vibratory rock breakers are typically mounted on an excavator and are considered to be most suitable where there are only small areas requiring pretreatment, for example trenching operations where removal of isolated patches of consolidated material in the order of a few thousand cubic metres is required. However this methodology is unlikely to be suitable for the Walker Shoal environment. It is important to note the distinction between these rock breakers and hydraulic hammers, which are discussed further below. While similar operating principles are employed by vibratory rock breakers and mechanical chisels, the latter are larger and are able to impart a much greater impact energy (albeit at lower blow rates).

Hydraulic hammer

The "state of the art" in chisel-dredging is a mechanical chisel utilising a hydraulic hammer. Hydraulic hammers consist of an anvil and chisel which slide inside a sleeve. The hydraulic hammer may be mounted on the boom of an excavator (such as a backhoe dredge boom) allowing rock-breaking from various angles and movement of the chisel independently from the pontoon, resulting in more efficient operations. A hydraulic hammer has been successfully used on material with strengths of up to 80 MPa, and larger versions are available. See, for example, the information on the rock-breaking "hydrohammers" supplied by IHC Hydrohammer B.V. (IHC 2011). Given the reported success of this method in fragmenting high-strength material, it is considered that the use of a hydraulic hammer could be a feasible option for rock-breaking at Walker Shoal.

Specialised cutter-suction dredger

Ongoing research and development worldwide for specially modified cutterheads and cutter teeth is steadily increasing dredging capabilities for high-strength rock. In the Panama Canal Expansion Program 2006, a specialised CSD was employed for the removal of hard-rock material. Special cutterheads were developed, which in comparison with a standard cutter were twice as heavy and contained a larger number of teeth. In situations where a standard cutterhead was not powerful enough to break the rock and caused unacceptable vibrations while trying to dredge, the specialised cutterhead performed well, cutting basalt with a compressive strength of up to 150 MPa into small blocks approximately 250 mm in diameter (De Smet & Smets 2010).

By the end of 2011 it is expected that there will be seven specialised CSDs on the market with sufficient power to drive cutterheads capable of fragmenting rock with compressive strengths of 50–80 MPa such as occurs at Walker Shoal. Through its conversations with marketplace suppliers, INPEX has a high degree of confidence that a suitable specialised CSD capable of dealing with the rock material at Walker Shoal will be available for the Ichthys Project.

Chemical fragmentation

The use of expanding gas cartridges is generally applied to land-based operations where small volumes of material require fragmentation, for example quarry operations where large single boulders have to be broken up. A drawback of this method is that the high density of holes that need to be drilled for placement of the cartridges would necessitate a lengthy drilling program.

As INPEX is not aware of any instances of this method being used in any underwater operations on the scale of the proposed Walker Shoal dredging, it has not been considered further.

Blasting operations are generally undertaken by placing explosives in vertically drilled boreholes ("drill and blast") as described in the Draft EIS.

INPEX has committed to resorting to the use of drill-and-blast techniques as a fall-back option for the removal of high-strength rock material at Walker Shoal only once the other options considered have been proved not to be feasible or viable. This position is based on the following considerations:

- INPEX now has an improved understanding of the subsurface geology at Walker Shoal.
- The company has confidence that specialised CSD and other rock-fragmenting machinery will be available when required.
- The company also has a high degree of confidence that a specialised CSD, or a specialised CSD in combination with the other rock-fragmenting machinery described above, is capable of removing the high-strength rock material at Walker Shoal.
- There is sufficient time in hand to allow INPEX to persevere with low-production-rate methods without immediate detriment to the construction schedule.

It is prudent for INPEX to retain blasting as a fall-back option in case the other methods described prove unsuccessful in fragmenting the high-strength rock material. Should it become necessary to use drill-and-blast methods, then the expected worst-case scenario is that about half of the high-strength rock material would be left in place after exhausting other possible fragmentation methods. It is estimated that it would take approximately 4 weeks of drill-and-blast operations (using methods as described in the Draft EIS) to fragment this remaining rock material.

Should it happen that drill-and-blast methods will be required to fragment the high-strength rock, it is important to note that a number of management measures will be implemented to prevent unacceptable environmental effects. These will include the following:

- ensuring that the physical configuration and timing of charges is such that it optimises fragmentation while minimising release of energy into the water column
- marking the boundary of "safe zones" (which will be determined based on the modelling output presented in Section 4.1.11) and, prior to blasting, stationing marine mammal observers at sufficient locations to provide clear sight across the area within which adverse effects might be expected to occur
- utilising an appropriate combination of passive and active acoustic monitoring techniques with marine mammal observers to monitor the movement of large marine animals within the area of effect and the adjacent safe zone
- ensuring that no marine mammals are within the area of effect prior to the commencement of blasting.

Should drilling and blasting methods be required full details of the proposed management measures will be provided in the final blasting management plan which will be submitted to the regulatory authorities for approval prior to the commencement of operations.

Removal methods

There are two basic dredging methods available for the removal of the fragmented rock material—mechanical and hydraulic. Mechanical removal equipment typically used in dredging applications includes grab (or clamshell) dredgers (GDs) and/or backhoe dredgers (BHDs). Both GDs and BHDs are described in Section 4.4.4 of Chapter 4 *Project description* of the Draft EIS document and either a GD or a BHD is considered to be suitable for the removal of fragmented material at Walker Shoal. Grab dredgers are advantageous where very deep dredging or extensive horizontal reach is required; however for the Walker Shoal dredging, the shorter cycle time (and thus increased productivity) associated with a BHD is considered to favour this method.

The typical method for hydraulic removal is the use of a trailing suction hopper dredger (TSHD). Trailing suction hopper dredgers are also described in Section 4.4.4 of Chapter 4.

Scenarios for the construction of the shipping channel at Walker Shoal

For the purposes of assessment of the potential environmental risk from the construction of the shipping channel at Walker Shoal, four scenarios have been considered. These scenarios all assume the following:

- that overlying rock of strengths less than 50 MPa has been removed by either a BHD, a TSHD or a CSD, using the methods described in Chapter 4 of the Draft EIS, leaving approximately 32 000 m^3 of high-strength rock material of strengths greater than 50 MPa.
- that the high-strength rock material is removed after fragmentation by either a TSHD or BHD as described in Chapter 4 of the Draft EIS

The four scenarios are as follows:

1. A specialised CSD fragments all high-strength rock material.
2. A specialised CSD followed by a hydraulic hammer and/or a drop chisel fragments all high-strength rock material.
3. A hydraulic hammer and/or a drop chisel fragments all high-strength rock material.
4. A specialised CSD, a hydraulic hammer and/or a drop chisel are unable to fragment all high-strength rock material and a program of drill-and-blast is put in place to remove remaining high-strength rock material.

Assessment of scenarios

Sediment release

The release of sediment during the removal of overlying rock with strengths of less than 50 MPa and during the removal of fragmented rock material would be as described for the TSHD and BHD operations (phases 2, 3 and 8) in the Draft EIS.

- *specialised CSD*: The modelling of sediment transport from CSD operations presented in the Draft EIS has accommodated uncertainties in source data and information by incorporating conservative assumptions at each stage of the modelling process. The use of a specialised CSD does not introduce any significant increase or change in the predicted impact of sediment release from that discussed in the Draft EIS.

- *hydraulic hammer and drop chisel*: The action of fragmenting the rock material will inevitably release some sediment; however the potential environmental impacts of this are ameliorated by several factors. Firstly, the sediment released will be predominantly large in size and therefore stay in close proximity to the fracture, and secondly, because the overlying rock has been removed there would be no significant benthic community in the immediate vicinity to be affected.
- *drill-and-blast*: Sediment transport quantities from drill-and-blast operations are the same as those presented in the Draft EIS. There are no new impacts, or changes in the predicted level of impact from those discussed in the Draft EIS.

Underwater noise

- *specialised CSD*: The underwater noise intensity from a specialised CSD is not known. For the purpose of assessment it has been conservatively assumed that the noise source spectrum curve for a specialised CSD is the same as that for a normal CSD but with a 6-dB higher spectrum level. The results of modelling are presented in Technical Appendix S7 in this EIS Supplement and discussed in Section 4.1.11. The outcomes of noise exposure modelling have been compared with the noise exposure criteria presented in Section 4.1.11. It is predicted that noise from specialised CSD operations would not exceed the underwater noise criteria and therefore would not present any significant environmental risk to marine mammals, turtles or fish.
- *hydraulic hammer*: Noise from hydraulic hammering operations is released on each blow of the hammer. The source spectrum of a hydraulic hammer operation is presented in Technical Appendix S7 as are the results of modelling of underwater noise propagation. The results of the modelling have been compared with the noise exposure criteria presented in Section 4.1.11. At no point is it predicted that noise from hydraulic hammer operations would exceed the underwater noise criteria for marine mammals, turtles and fish.
- *drop chisel*: The noise source characteristics for drop-chisel operations are not known. The operation relies on the chisel falling through the water column, under the influence of gravity, rather than hammering, so noise released would be from the entrainment of air bubbles (if dropped from above the water surface) and impact on the rock seabed. Both of these would be considerably less than noise from the hydraulic hammering operations described above; therefore it is concluded that underwater noise from chisel operations would pose no risk to marine animals.
- *blasting*: The underwater noise predicted to occur from three different blasting operation scenarios are presented in Technical Appendix S7. The results of the modelling have been compared with the noise exposure criteria presented in Section 4.1.11. Marine mammals and turtles may be adversely affected if they are within a distance of 1000 m of the source, while fish may be adversely affected if they are within a distance of 400 m (for a 1-kg fish) of the source at the time of the blast.

Accidental discharges from dredge vessels

Accidental discharges from vessels operating in Darwin Harbour were considered in the Draft EIS. The most severe and relevant spill scenario is for a spill of diesel during refuelling at East Arm Wharf, which is described in the Draft EIS as Scenario 12 in Section 7.3.5 in Chapter 7 *Marine impacts and management*. Accidental discharges from the rock-removal scenarios considered will not cause any new or significantly different environmental risks from those described in the Draft EIS.

3.3.9 Piledriving

Piledriving for the construction of the module offloading facility (MOF) and the product loading jetty (PLJ) will be undertaken by contractors. INPEX has prepared a scope of works detailing the physical dimensions of the MOF and PLJ and the standards to which they are to be constructed. The final design, however, will be completed by the contractor and the exact number, configuration and types of piles that will be used can only be finalised at that time. INPEX has identified conservative and credible scenarios for piledriving operations, described below, and carried out the assessment of potential environmental impact based on these scenarios.

Piledriving is expected to take approximately 18 months for the PLJ and 8 months for the MOF if a single piledriving rig is used. In reality, however, it is likely that several rigs would be used. The credible piledriving scenarios considered in the assessment are shown in Table 3-2. These scenarios can be considered as conservative 'worst-case' (in terms of cumulative noise exposure) in that they assume a level of concurrent activities, however it should be noted that operations at the MOF and PLJ may be carried out sequentially.

Table 3-2: Indicative summary of the duration of piledriving activities for three different construction scenarios

Scenario		Month										
		1	2	3	4	5	6	7	8	9	10	11
A: Single contractor—3 piledriving rigs												
Product loading jetty	a											
	b											
Module offloading facility	c											
B: Single contractor—4 piledriving rigs												
Product loading jetty	a											
	b											
	c											
Module offloading facility	d											
	c											
C: Two contractors—5 piledriving rigs												
Product loading jetty	a											
	b											
	c											
Module offloading facility	d											
	e											

	= piledriving at the product loading jetty
	= uncertainty—might be finished or might still be piledriving
	= piledriving at the module offloading facility
	= uncertainty—might be finished or might still be piledriving

3.3.10 Well-completion fluid management

Section 7.2.5 of Chapter 7 *Marine impacts and management* of the Draft EIS states that excess well-completion fluids will not be discharged to the offshore marine environment but will be removed to the mainland for onshore disposal at an approved facility. To clarify this statement; unused chemicals and bulk well-completion fluids will not be discharged to the offshore marine environment; these will if possible be restocked by the vendor for use on other projects. If use elsewhere is not possible they will be removed to the mainland for disposal at an approved facility. However, well-completion fluids pumped into the well bores and associated subsea facilities will be produced back to the mobile offshore drilling unit (MODU) via the flare system, and will thus be flared during well testing. It would not be practical to segregate small amounts of completion fluids from reservoir fluids prior to well testing through a MODY flare.

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4 Supplementary Information to the Draft EIS

4 SUPPLEMENTARY INFORMATION TO THE DRAFT EIS

This section provides additional data, statistics, information, and research to that presented in the Draft EIS. It is designed to further inform the environmental assessment process, and address some of the issues raised within public submissions.

Additional studies outlined in this section were undertaken by INPEX as a result of stakeholder consultation, in response to public submissions, and/or the emergence of additional factors in consideration of environmental impacts. While this section largely presents supplementary information, it also provides the most recent environmental data either acquired since publication of the Draft EIS or through additional modelling (for example underwater noise modelling, and extended range of scenarios for oil spill modelling).

4.1 Marine

4.1.1 Studies summary

A range of studies were undertaken for this EIS Supplement. Table 4-1 describes the purpose for each study. The relevant findings and outputs of each study are presented in the main text of this supplement and where appropriate the full report is provided as a technical appendix to the supplement.

Table 4-1: Summary of studies undertaken since the publication of the Draft EIS in July 2010

Study topic	Summary	Purpose	Report
The benthic environment of the Ichthys Gas Field Development Project—invertebrate fauna, habitats and impacts	An extensive literature review of the benthic infauna, epifauna and filter-feeding communities of Darwin Harbour and benthic invertebrates of the Ichthys Field and the gas export pipeline route. Key areas addressed: Benthic ecosystems, habitat classification and taxonomic identification and INPEX survey effort Biodiversity and uniqueness Tolerance of infauna and epifauna of the Harbour to increased sedimentation and elevated suspended-sediment concentrations (SSC) Recovery of benthic systems to disturbance Maintenance of biodiversity and trophic structure in Darwin Harbour	To expand upon the information provided regarding impacts to these benthic communities in the Draft EIS.	Technical Appendix S1
Marine hydrocarbon spill modelling addendum report—supplemental spill risk modelling	Modelling of condensate spills from production well blow-out and gas export pipeline rupture scenarios	Provide an understanding of the risks associated with various spill scenarios in the Browse Basin and Darwin Harbour.	Technical Appendix S2
Literature review of seabirds in the vicinity of the Ichthys Field infrastructure in the Browse Basin, Western Australia	Literature review and survey data analysis of Browse Basin seabirds	Further evaluate the significance of seabird breeding and foraging activity at the Offshore Development Area, surrounding waters and islands of the Browse Basin, to support the impact assessment of seabirds.	Technical Appendix S3

Study topic	Summary	Purpose	Report
Gunn Reef Blue Holes and Howard River water-quality and coral survey	Collection of water-quality data at the Blue Holes and Howard River mouth; also video capture of coral communities and sediment collection in the Gunn Reef Blue Holes	To develop an understanding of natural water-quality and sediment characteristics, and of coral community composition, to support assessment of potential impacts from suspended sediments arising from spoil disposal	Technical Appendix S4
The effect of simulated dredge material from Darwin Harbour on eggs and larvae of barramundi (*Lates calcarifer*)	Effect of suspended-sediment loads on barramundi eggs and larvae	Sediment samples, representative of dredge material, from Darwin Harbour were used in a series of experimental studies to measure the effect of differing suspended-sediment loads on survival and feeding rates of barramundi eggs and larvae	Technical Appendix S5
Benthic habitat mapping	Collation and standardisation of new, existing and third-party benthic habitat data sources to produce a benthic habitat map	To increase the understanding of Darwin Harbour and surrounds and allow for impact assessment on the benthic habitats of the area.	Technical Appendix S6
Intertidal aerial survey	Flight over intertidal habitats between Fannie Bay and Adam Bay	To assist mapping of intertidal benthic habitats and communities	Technical Appendix S6
Tow-camera survey	Characterisation of benthic habitats and communities between Fannie Bay and Adam Bay	To assist mapping of intertidal and subtidal benthic habitats and communities.	Technical Appendix S6
Walker Shoal filter-feeder survey	Further characterisation of filter-feeder communities at Walker Shoal and at three similar habitats on the western side of Darwin Harbour	To assess the degree of similarity between the communities, to inform the assessment of the potential ecological implications of removing Walker Shoal	Technical Appendix S6
Potential effects of underwater blasting, piledriving and dredging on sensitive marine fauna in Darwin Harbour	Numerical modelling of underwater noise from construction activities and further underwater noise impact assessment	Update literature review of underwater noise effects Establish criteria to define the tolerable threshold underwater noise exposure limits for marine mammals, turtles and fish Provide comparison of estimated underwater noise levels and threshold exposure limits to delineate predicted areas of impact	Technical Appendix S7
Assessment of potential impacts to mud crabs in Darwin Harbour	A literature review and impact assessment to examine potential for dredging related impacts on mud crab populations in Darwin Harbour and Shoal Bay	To assess the risk to mud crabs from dredging and spoil disposal.	Technical Appendix S8
Darwin Harbour long-term baseline water quality	Measurement of water-quality characteristics at four coral community locations in Darwin Harbour	To inform the assessment of the extent of potential impacts arising from dredging and spoil disposal; to provide baseline data against which water-quality characteristics can be compared during dredging; and to enable calculation of turbidity criteria levels for reactive coral monitoring program	Technical Appendix S9

Study topic	Summary	Purpose	Report
Marine archaeology	Independent assessment of methods to detect marine heritage artefacts in Darwin Harbour.	To assess the suitability and limitations of the survey methods employed by INPEX within the nearshore infrastructure development footprint and offshore spoil disposal ground to detect maritime objects of heritage significance.	Technical Appendices S10 and S11
Darwin Harbour coastal dolphin surveys	Vessel-based survey to observe dolphins and other large marine animals in Middle Arm and West Arm in Darwin Harbour	To support assumptions that Middle Arm and West Arm in Darwin Harbour provide suitable habitat for populations of large marine animals and to evaluate various survey techniques for monitoring programs to evaluate dolphin population estimates and habitat use.	Technical Appendix S12
Metocean survey	Acquisition of current and tidal data in Beagle Gulf and Van Diemen's Gulf.	To allow further refinement and spatial extension of the offshore hydrodynamic model for final dredge modelling.	Study in progress

4.1.2 Benthic habitat mapping

4.1.2.1 Rationale for approach to benthic habitat mapping

INPEX's benthic habitat surveys and habitat maps were designed to identify and describe the major benthic community types and their spatial extent within the main impact areas from the Ichthys Project in Darwin Harbour. The surveys were not designed to quantitatively examine the difference in species diversity and abundance within the same community type. As is discussed further in the benthic invertebrate fauna literature review (see Technical Appendix S1 in this EIS Supplement), the taxonomic resolution required for a study depends on the objective of the study. In the context of assessing the potential impacts of disturbances at an ecosystem level an analysis based on the distribution of habitats and functional groups is meaningful and provides insights into biodiversity, trophic structure, interconnectivity and resilience, and it is questionable if information from "family level" identification is superior to the insights that can be derived from habitats and functional group data (Wilson 1998).

The benthic invertebrate fauna literature review (see Technical Appendix S1) compared the type and comprehensiveness of benthic community surveys completed in INPEX's Draft EIS with 11 other recent major resource projects around Australia. This comparison of the various impact assessment documents for projects relevant and comparable to the Ichthys Gas Field Development Project show that INPEX's investigative effort to collect information on benthic habitats and their fauna is very similar to that of other major environmental impact assessments and the information provided in INPEX's Draft EIS is of a similar quality. Further details regarding assessment study comparisons can be reviewed in Section 9 of Technical Appendix S1.

4.1.2.2 Benthic habitat mapping methods

In order to describe the distribution of habitats and functional groups, INPEX has conducted additional studies of the benthic environment of Darwin Harbour, Gunn Reef and the inshore waters from Fannie Bay to Adam Bay to develop detailed sea floor (benthic) habitat maps. These additional studies included qualitative and quantitative subtidal and intertidal surveys of the hard-coral, macroalgae, filter-feeder and seagrass biological communities and sediment particle size surveys. Summaries of these additional studies are included in Section 4.1.1 of this EIS Supplement.

The data collected during these additional studies were collated with the existing habitat data to produce a total known-point data set of available habitat data in the Darwin region. The known-point data were used to improve the resolution and accuracy of the existing benthic habitat maps to quantify the spatial distribution of the biological communities and substrates found in the Darwin region. All of the data sources that were combined to produce the known-point data set are listed in Table 4-2 and displayed in Figure 4-1. The habitat maps provided here form the basis of the benthic habitat impact assessment described in Section 4.1.3 of this EIS Supplement.

Table 4-2: Data sources for the benthic habitat known-point data set

Data source	Survey	Methods	Numbers of observations	
			Sediment	Community
NRETAS	Casuarina Beach survey	Qualitative intertidal seagrass survey	0	1408
NRETAS	Fannie Bay survey	Qualitative intertidal seagrass survey	0	725
URS	Intertidal aerial survey	Qualitative analysis of video and still images captured at spring low tide	34	0
URS	Coral sites	Qualitative description of substrate and community	3	0
URS	Dive locations completing ROV	Qualitative description of substrate and community	21	24
URS	First diving survey locations	Qualitative description of substrate and community	15	15
URS	ROV sampling record	Qualitative description of substrate and community	74	74
URS	Walker Shoal filter-feeder survey (November 2010)	Qualitative description of substrate and community	6	5
Geo Oceans	Towed video survey	Qualitative analysis of towed-video footage	36 000	36 106
Smit, Billyard And Ferns (2000)	Beagle Gulf sediment survey	Quantitative sediment survey using particle size distribution (PSD) analysis	158	0
Dames and Moore, 1982	Channel Island survey	Quantitative sediment survey using PSD analysis	6	0
Parry and Munksgaard 1997	Grain size of sediment in Darwin Harbour survey (1993)	Quantitative sediment survey using PSD analysis	114	0
URS	Wickham Point, Frances Bay and Stokes Hill Wharf	Quantitative sediment survey using PSD analysis	29	0
Total numbers of observations			**36 423**	**38 394**

The known-point data set consisted of substrate and habitat data that were used to define and classify the habitat composition and distribution (see figure 4-2). The data sets were classified and collated to produce sediment particle size and benthic habitat maps.

The process of data classification and processing to produce the sediment particle size and benthic habitat maps are illustrated in the flow diagrams in Figure 4-3 and Figure 4-4. The data collated into the known-point data set were collected using both quantitative and qualitative survey methods across different spatial and temporal scales. To combine the data from the different data sources the INPEX habitat classification scheme was adapted to reclassify the total point data set using consistent decision rules and classification definitions. This allows data collected with different levels of detail to be combined to produce substrate and community distribution maps at different scales. The classification scheme is a hierarchical classification scheme that groups low-level (i.e. level 3) classes into broader high-level classes (i.e. level 1), allowing fine-scale data (i.e. quantitative data) to be combined with broad-scale data (e.g. qualitative data). The classification scheme was adapted from a national intertidal and subtidal benthic habitat classification scheme (Mount, Bricher & Newton 2007) and was developed in consultation with the Department of Natural Resources, Environment, the Arts and Sport. The decision rules and habitat classification definitions are provided in Technical Appendix S6 in this EIS Supplement.

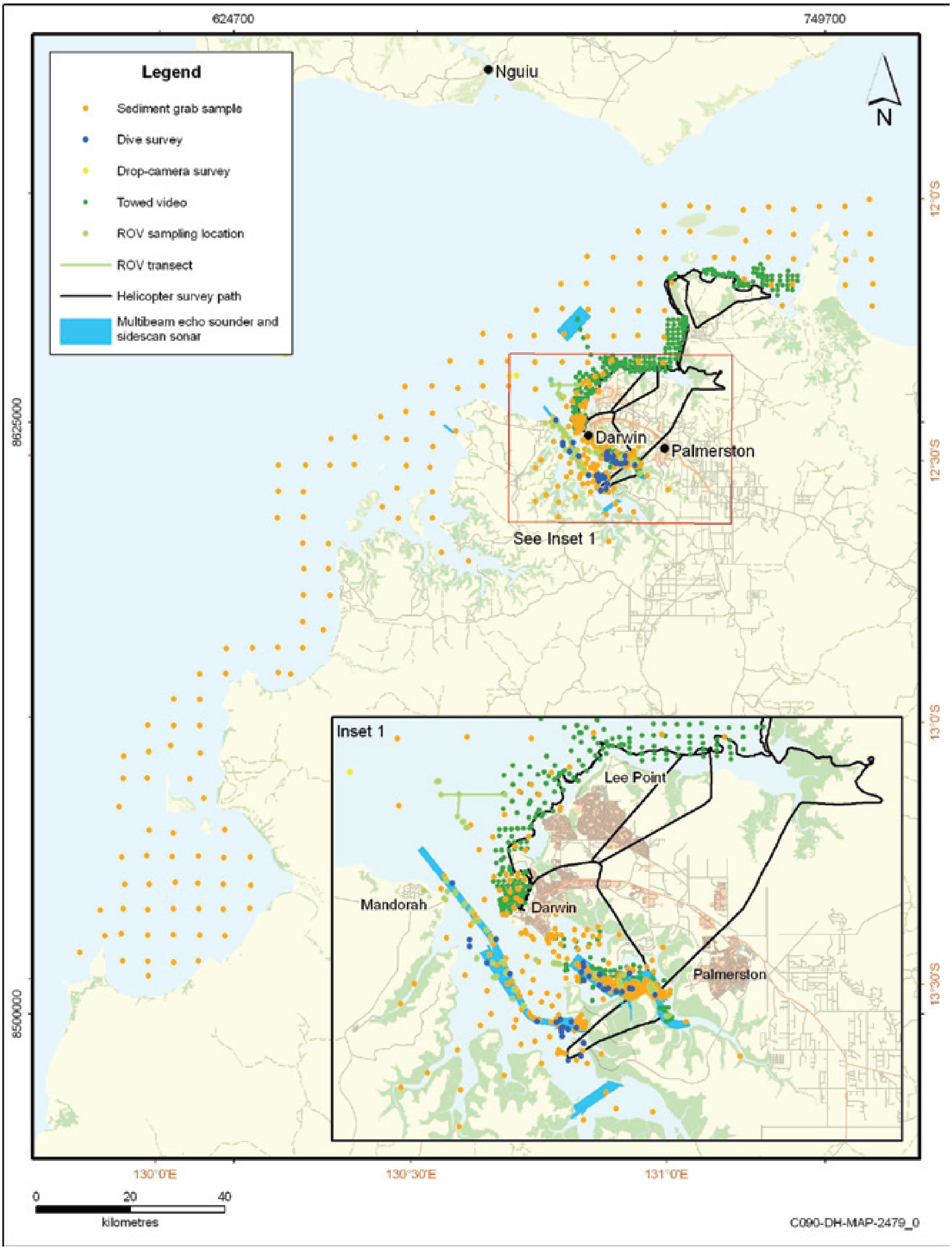


Figure 4-1: Sources of the point data combined into the total known data set (*c*.38 000 points)

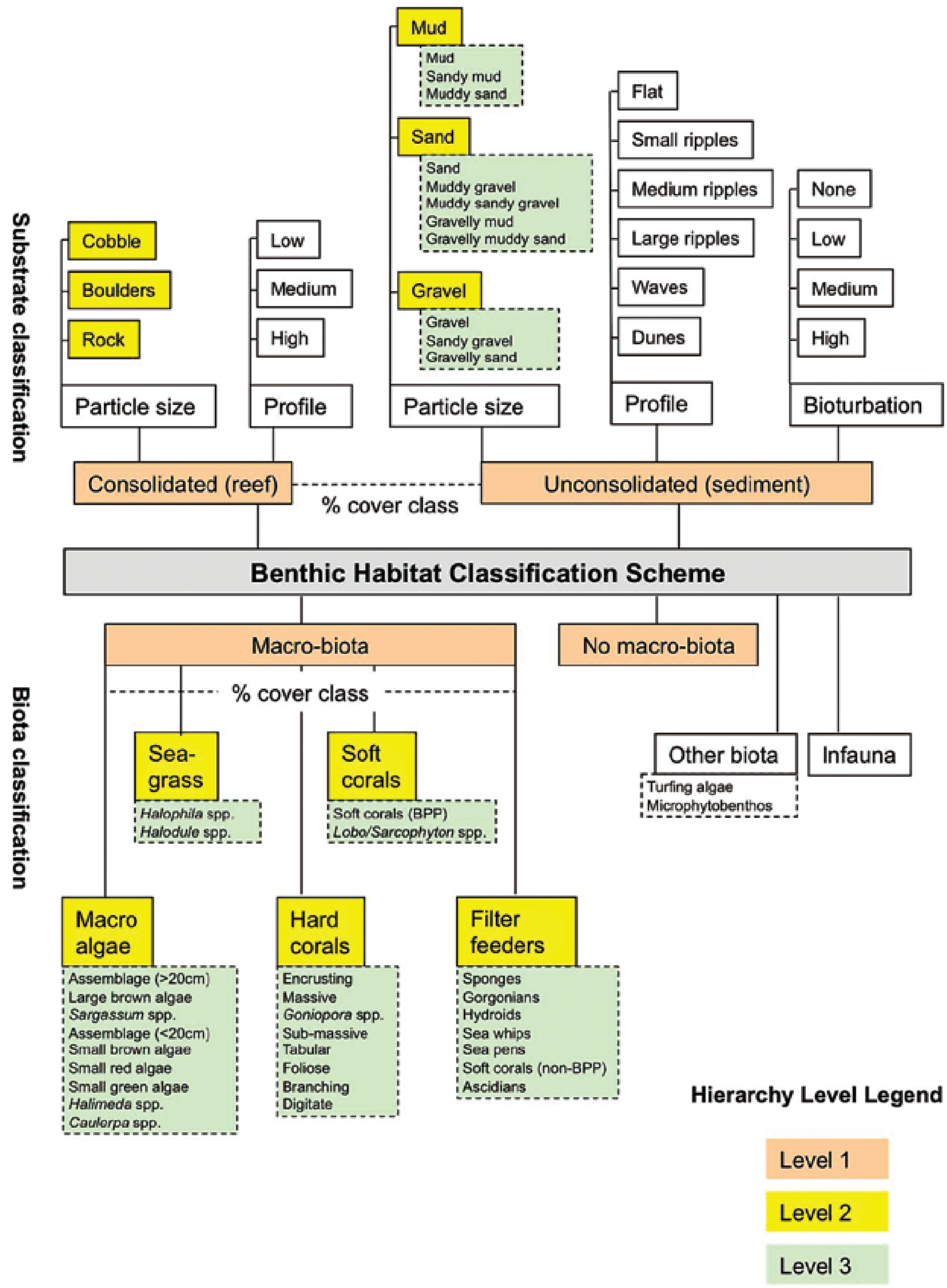


Figure 4-2: Habitat classification scheme hierarchical flow chart

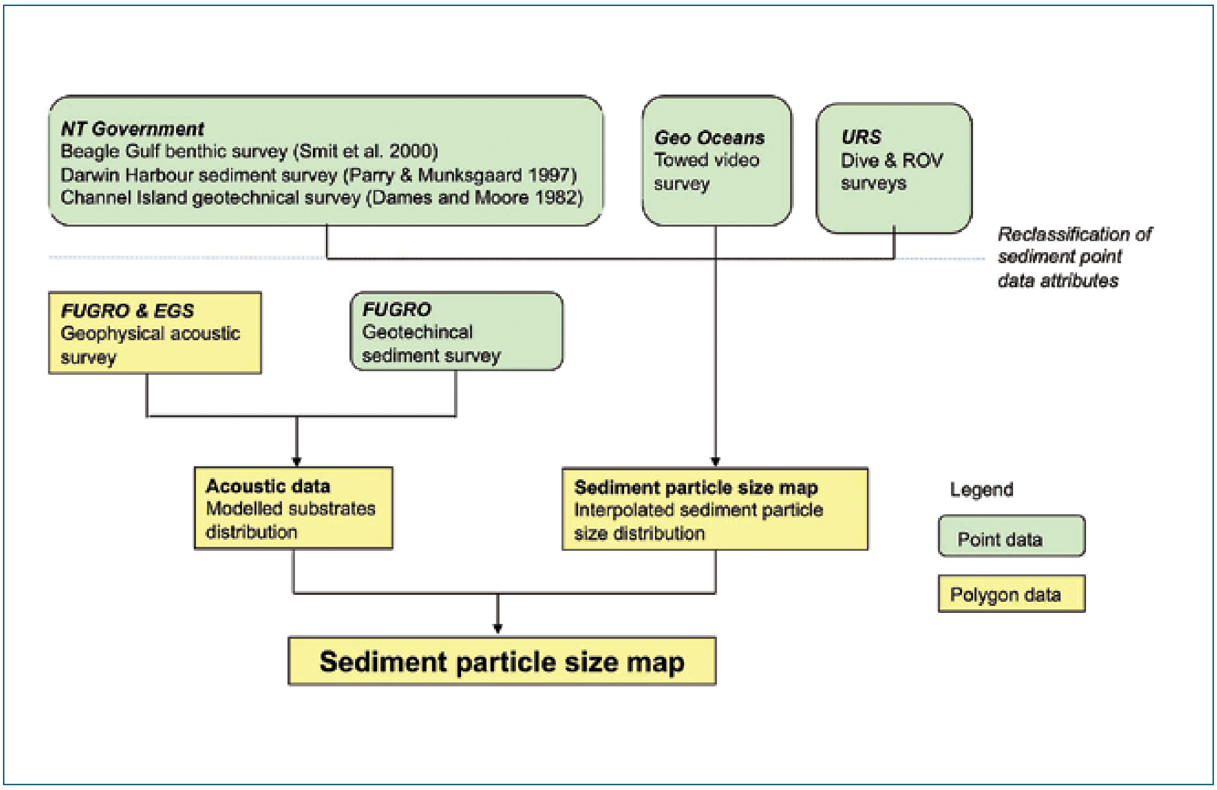


Figure 4-3: Data collation process used to produce the sediment particle size map

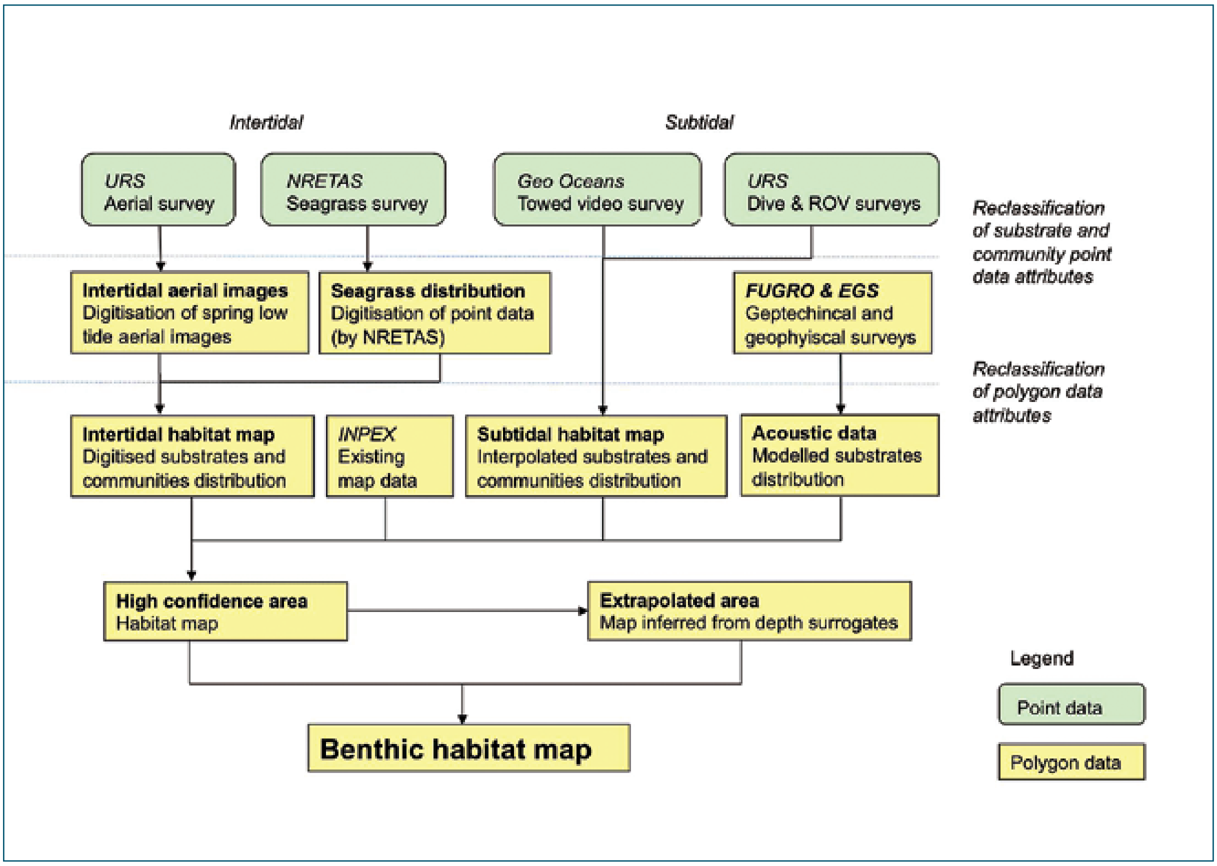


Figure 4-4: Data classification and collation process used to produce the benthic habitat map

Sediment particle size map

The sediment particle size point data were classified into the level 2 sediment particle size classes in the INPEX habitat classification scheme (i.e. mud, sand, gravel and rock) (see Figure 4-2). The point values were interpolated using geographic information system (GIS) software to produce broad-scale maps that predict the spatial distribution of the sediment particle sizes. The interpolated sediment particle size distribution (PSD) map was combined with geophysical acoustic survey data (Fugro 2008) to produce a sediment particle size map (see Figure 4-5).

Benthic habitat map

The habitat point data included percentage cover values for the level 3 biological community and substrate classes in the INPEX habitat classification scheme (see Figure 4-2). The biological community and substrate percentage cover (point) values were between 0 and 100% cover (see Technical Appendix S6 in this EIS Supplement) and were interpolated using GIS software to produce maps predicting the percentage cover of the biological communities and substrates throughout the survey areas. The interpolation creates a continuous surface of cell values (i.e. 0 to 100) across the survey area. The biological communities were defined as present according to the INPEX habitat classification scheme (see Technical Appendix S6) (i.e. hard-coral, macroalgae and filter-feeder communities greater than 10% cover over 10 m^2 and seagrass greater than 1% cover over 10 m^2).

The interpolated subtidal substrate and biological community maps were combined with an intertidal habitat distribution map that was digitised using spring-low tide imagery (sourced from the Northern Territory Government) and classified using the URS aerial survey data. These maps were combined with the existing INPEX habitat map (Figure 3-16 in Chapter 3 *Existing natural, social and economic environment* in the Draft EIS) and the acoustic survey data (Fugro 2008) to produce a habitat map in the surveyed ("high-confidence") areas. The high-confidence areas are the areas that were surveyed with adequate data to produce a high-confidence areas habitat map using the methods described in Technical Appendix S6.

The reef substrates with a mix of biological communities present (i.e. coral, macroalgae and filter-feeder community assemblages greater than 10% cover) were classed as mixed communities. The proportion of each biological community in the mixed communities class was calculated using the percentage composition of the community groups in the high-confidence area on all reef substrates, to a depth of 5 m below LAT. The calculation defined the ratio of biological communities on mixed reef as:

Mixed reef = no macrobiota (<10% cover) 47% : coral 15% : macroalgae 8% : filter-feeders 29%.

The proportion of benthic habitats in the survey area between Fannie Bay to Lee Point (high-confidence area) were used to represent the remaining areas outside the high-confidence area, to produce "inferred habitat" areas. The percentage cover of the benthic habitats in the inferred habitat areas was classified using the percentage cover of the biological communities and substrate types (benthic habitats) in the high-confidence area for different water-depth classes (see Table 4-3).

The relationship between water depth and the type of benthic habitats present was determined by counting the occurrence of the biological communities present on reef and sediment substrates within defined depth classes, using the known data in the high-confidence area. The biological communities changed composition from a mix of photosynthetic and heterotrophic communities to a heterotrophic dominant habitat at a water depth of approximately 5 m below LAT. The photosynthetic macroalgae and coral communities and heterotrophic filter-feeder communities were all present in the intertidal and shallow subtidal zones from 2 m above to 5 m below LAT. However, only heterotrophic filter-feeder communities were present on reef substrates in water depths greater than 5 m below LAT. Seagrass was recorded on mud and sand sediments in the intertidal and shallow subtidal zones from 2 m above to 5 m below LAT. Macroalgae, coral and filter-feeders were attached to reef substrate.

Benthic sampling in the high-confidence areas showed that the seagrass communities were only present on the sand substrates in the shallow bays from Fannie Bay to the south-west side of Shoal Bay and were not found in the inner sections of Darwin Harbour or Adam Bay. The oceanographic conditions in those areas where seagrass was present in the high-confidence areas is similar to the coastal waters between Mandorah and Charles Point. Therefore, the inferred habitat areas likely to contain seagrass communities were mapped as the sand substrates in the intertidal and subtidal zones from 2 m above to 5 m below LAT between Mandorah and Charles Point.

The inferred habitat area in Shoal Bay was classified as "soft-bottom benthos; sediment" with no macrobiota communities present. This inferred habitat was classified using the known-point data in the adjacent high-confidence area and the geophysical survey data in the dredge spoil disposal ground. The inferred habitat boundary (area) was digitised using the areas of Shoal Bay where the Australian Hydrographic Service's "Seafarer" bathymetry charts showed consistent bathymetry contours indicating a flat, featureless seafloor.

Table 4-3: Inferred habitats: percentage cover calculations and classification

Inferred habitat	Depth class	Habitat class	Percentage of area	Benthic habitat ratio
Seagrass; sediment	Intertidal	Seagrass; sediment	22%	Seagrass; sediment 22%:88%
Seagrass; mixed reef; sediment	0 to 5 m below LAT	Seagrass; sediment	18%	Seagrass; mixed reef; sediment 18%:5%:77%
		Mixed community; reef	5%	
Mixed reef; sediment	0 to 5 m below LAT	Mixed community; reef	5%	Mixed reef; sediment 13%:87%
		No macrobiota (<10% cover); reef	4%	
		Hard coral; reef	1%	
		Filter-feeders; reef	2%	
		Macroalgae; reef	1%	
Filter-feeders; sediment	more than 5 m below LAT	Filter-feeders; reef	29%	Filter-feeders; sediment 29%:71%

The inferred habitat benthic habitats percentage cover and depth range is summarised in Table 4-3.

The spatial coverage of the habitats in the inferred habitat areas was defined by extrapolating the inferred habitats (see Table 4-3) throughout the areas outside the high-confidence areas, using the depth data from the Australian Hydrographic Survey charts. The inferred habitat and high-confidence habitat maps were combined to produce a benthic habitat map showing the distribution of the benthic communities and substrates throughout the mapped areas (see Figure 4-5 and Figure 4-6).

4.1.2.3 Description of benthic habitats

The aim of the benthic habitat maps is to describe the distribution of the benthic habitats in the waters in and around Darwin Harbour. The benthic habitats are defined using broad biological community classes (e.g. hard coral; macroalgae; seagrass; macrobiota <10%; soft-bottom benthos) and substrate type (i.e. reef and sediment). The habitat map consists of high-confidence and inferred habitat areas that can be used to calculate the area of each of the benthic habitat types in the study area (see Figure 4-6). The study area includes the waters within Darwin Harbour with an outer extent from Lee Point to Charles Point including the extent of seagrass mapped on the south coast of Shoal Bay and the inferred seagrass habitats between Mandorah and Charles Point (see Figure 4-7). This section gives a broad description of the spatial area and typical composition of each of the biological communities and benthic habitats in the surveyed area, particularly the habitats mapped in the high-confidence area.

The benthic habitats, seabed features and sediment distribution in the surveyed areas are highly influenced by the strong tidal currents that flow through Darwin Harbour, particularly in the inner Harbour areas.

The prevalence of strong tidal currents flowing over the uneven bedrock surface appears to have had a major contributing influence on the form and composition of the reef substrates and the sediments deposited over that surface. The seabed topography in the inner areas of Darwin Harbour varies from smooth and gently undulating with slope gradients of less than 0.5° to locally very uneven over outcropping ridge features, on the sides of channels and over sandwaves and sandbanks, with measured slope gradients greater than 1:2 (Fugro 2008).

The majority of the benthic habitats in the East Arm extension of Darwin Harbour consist of soft-bottom benthos communities living in unconsolidated sediments. The surficial sediments and thicker sediment deposits consist of fluvial muds (i.e. clays, and silts) sands and gravels, with the finer fractions becoming more dominant in the intertidal zones and in areas of more sheltered waters. The actual composition of these sediments is expected to vary considerably throughout the surveyed areas both laterally and vertically because of the active depositional environment. The presence of sandbanks, sand waves and megaripples indicates that there is a significant degree of sediment mobility. No seagrass or other macrobiota were recorded growing in the sediments in East Arm.

The reef substrates in the inner Harbour (including East Arm) consist of outcropping bedrock that varies from relatively smooth to uneven because of the presence of slopes and ridges. Many of the ridges are inferred to indicate the presence of steeply dipping beds of harder sandstone and quartzite that are more resistant to weathering and erosion (Fugro 2008). The exposed reef substrates are dominated by filter-feeding communities composed of gorgonians (sea fans (family Gorgonia) and sea whips), soft corals

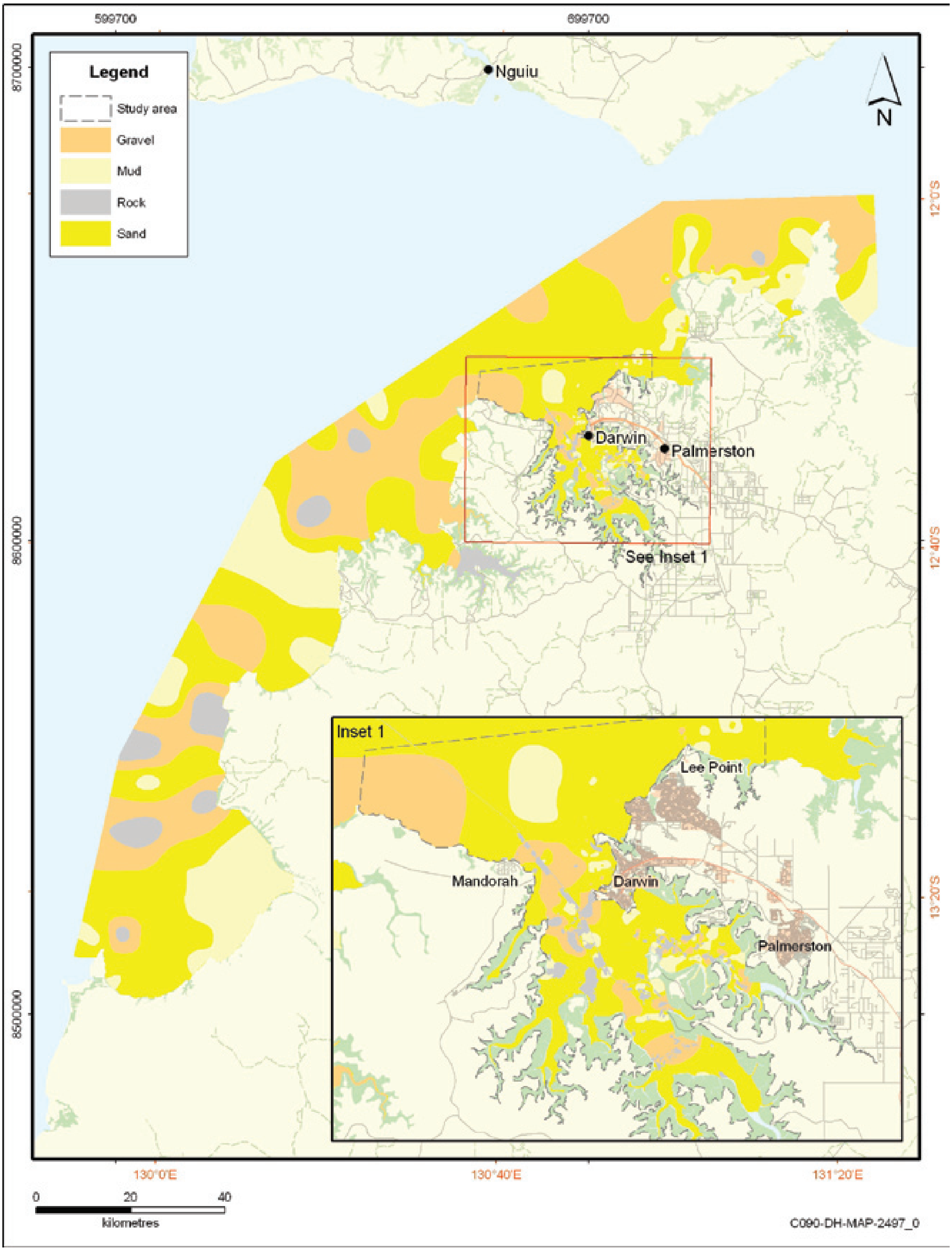


Figure 4-5: The substrate particle size distribution map

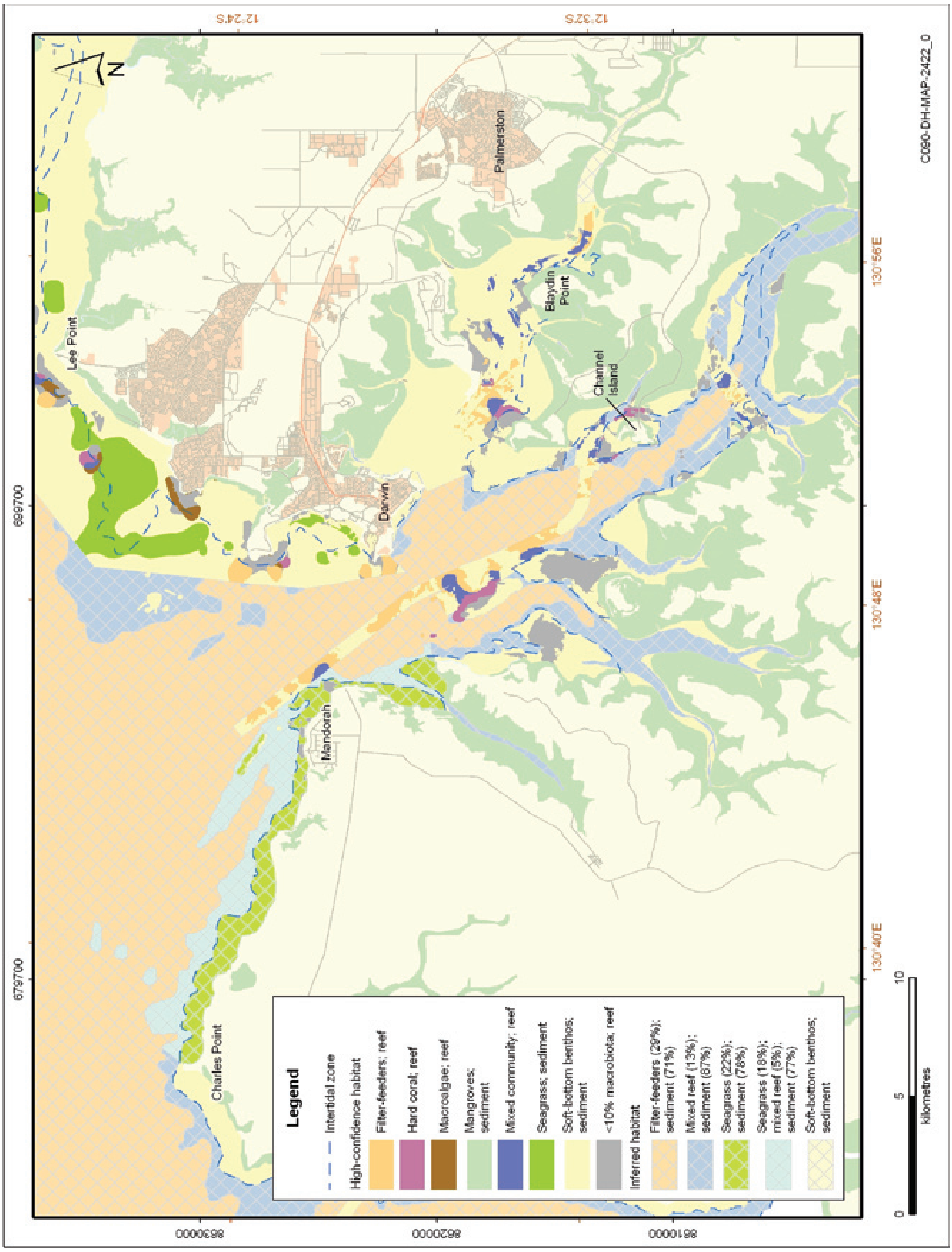


Figure 4-6: The benthic habitat distribution map in Darwin Harbour

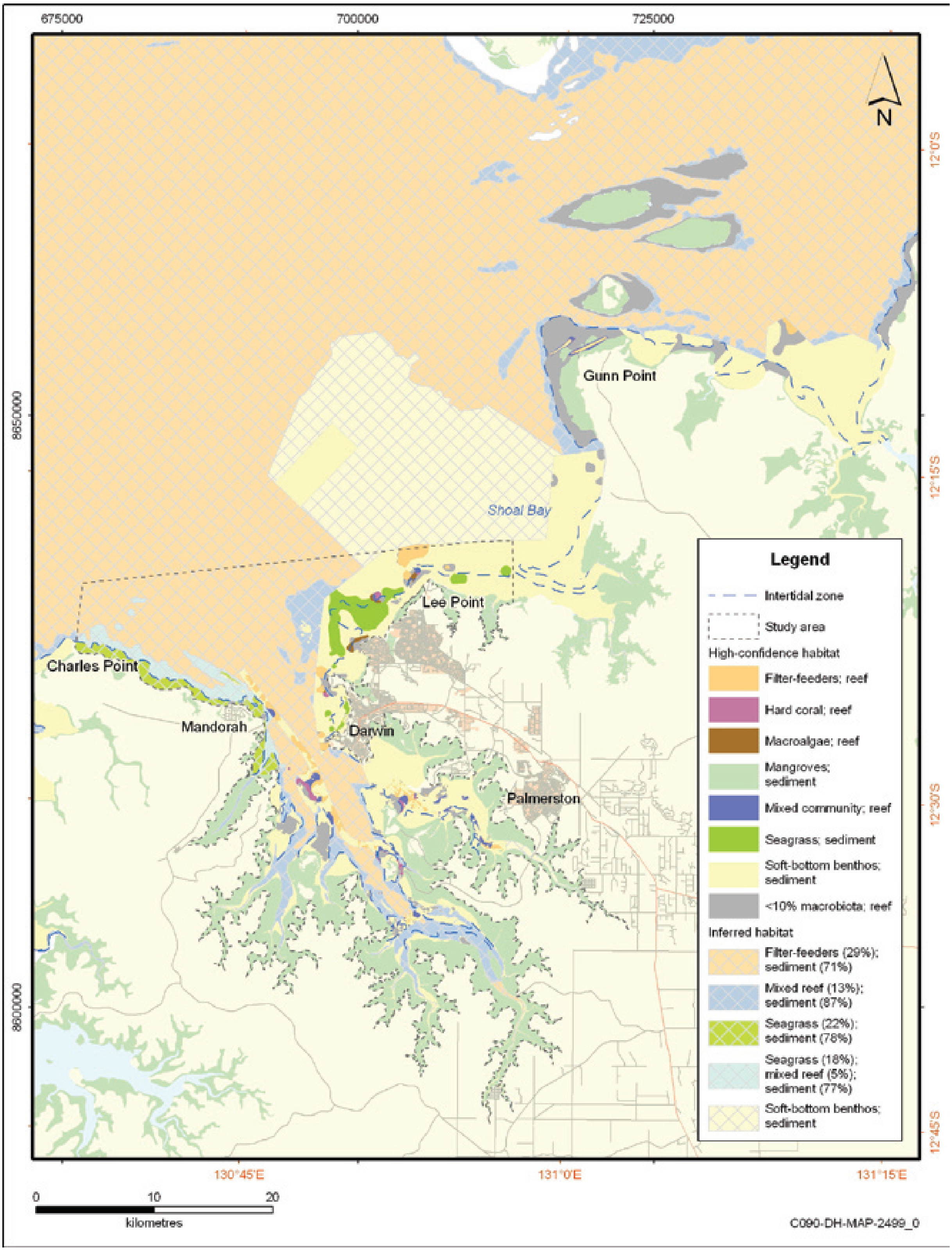


Figure 4-7: The benthic habitat distribution map outer extent

(family Alcyonica) and sponges which thrive on the food provided by the strong currents and highly turbid waters. Small communities of hard corals are found in the shallow subtidal and intertidal reefs adjacent to East Arm Wharf mixed with the filter-feeder communities. The hard-coral communities consist of massive and encrusting corals of, for example, the family Faviidae and foliose corals of, for example, the genus *Turbinaria* (family Dendrophyllidae).

The inshore waters between Fannie Bay and Shoal Bay consists of rocky points that extend into intertidal and subtidal reef platforms, interspersed by bays of soft sediments.

The soft sediments in the sheltered bays of Fannie Bay and Casuarina Beach support seagrass communities that are dominated by *Halodule* spp. (e.g. *Halodule uninervis*) with *Halophila* spp (i.e. *H. decipiens*, *H. spinulosa* and *H. ovalis*) and a *Syringodium* sp. The greater part of the seagrass was found in the lower littoral intertidal zone between 0 and 1 m above LAT but sparse communities extended out to 3 m below LAT into the subtidal zone.

The reef communities between Fannie Bay and Shoal Bay had a similar community structure that changed with increasing water depth from a mixed community of macroalgae (e.g. *Caulerpa* spp., *Halimeda* spp. and *Sargassum* spp.), hard corals (e.g. Faviidae spp. and *Turbinaria* sp.) and filter-feeders in the lower-littoral intertidal zone and shallow subtidal to a filter-feeder dominated habitat at approximately 3 m below LAT. Old Man Rock supports a dense community of branching *Acropora* corals on the northern aspect, but on the southern aspect is dominated by the mixed communities of macroalgae, coral and filter-feeders that are typical of the shallow reefs in the region. The mid-littoral to the upper-littoral intertidal reef substrates from Fannie Bay to Lee Point did not support any significant macrobiota communities (macrobiota <10% cover).

4.1.3 Benthic habitat impact assessment

4.1.3.1 Introduction

A number of Draft EIS submissions were related to concerns about the process of, and assumptions made in, the assessment of impacts to benthic habitats from dredging and spoil disposal. To address those concerns, the following sections discuss the impact assessment process with specific regard to impacts from suspended sediment and sedimentation associated with dredging and spoil disposal activities. This section draws on data collected from recent benthic habitat surveys and utilises habitat maps generated from these surveys (see Section 4.1.2) as a basis for determining spatial impacts. Discussion of assumptions and conservatisms in dredging modelling that underpins the assessment is also included and information is also drawn from the benthic invertebrate fauna literature review (see Technical Appendix S1 of this EIS Supplement).

Predicting indirect impacts from dredging and spoil disposal on benthic habitats and communities

Once the requirement for dredging of a marine area has been established, there are a number of steps in the process to determine the potential impacts to the marine environment from sediments suspended and subsequently deposited from dredging activities.

The initial process to identify and limit areas and degree of impact and influence is as follows:

1. An indicative dredging and spoil disposal design is developed. An iterative process takes place involving modelling experts, marine environment professionals and dredging and civil engineers to arrive at an indicative design that is practicable from an engineering perspective and represents an acceptable risk to the marine environment; the principles of ALARP are continuously applied.
2. Once a final indicative design is developed, modelling is undertaken to determine the areas affected and the potential suspended solid load and sedimentation that may occur.
3. If necessary, adjustments are made to the dredge plan (e.g. substitution of methods) and modelling is recast.
4. The acceptability of the area affected is then assessed through consultation and the Draft EIS phase of the project.

Table 4-4: Benthic habitat area calculations in the study area

	Habitat type	Habitat subtype	Area (ha)	Hard coral	Filter-feeder	Macroalgae	Seagrass	Sand	Mud	Gravel	Sediment	Mangroves
Benthic habitat data	Filter-feeders; reef		1258		1258							
	Hard coral; reef		219	219								
	Macroalgae; reef		134			134						
	Mangrove; sediment		21456									21456
	Mixed community; reef		433	65	126	35						
	No macrobiota (<10%); reef		1749									
	Soft-bottom benthos; Sediment		16377								16377	
	Seagrass; sediment		1734				1734					
	Inferred	Filter-feeders (29%); sediment (71%)	21516		6240						15276	
	Inferred	Mixed reef* (13%); sediment (87%)	6640	129	250	69					5777	
	Inferred	Soft-bottom benthos; Sediment	551								551	
	Inferred	Seagrass (22%); sediment (78%)	1770				389				1381	
	Inferred	Seagrass (18%); mixed reef* (5%); sediment (77%)	2203	17	38	9	397				1696	
Sediment particle size data	Gravel		11193							11193		
	Mud		5728						5728			
	Rock		2900									
	Sand		35409					35409				
Total inferred area (ha)				146	6528	78	786				24681	
Total high-confidence area (ha)				284	1384	169	1734	35409	5728	11193	16377	21456
Total study area (ha)			76042	430	7912	247	2520	35409	5728	11193	41058	21456

* Mixed Community; Reef = no macrobiota 47%: hard coral 15%: filter-feeder 29%: macroalgae 8%

After contract award, a finalised dredge program is developed that incorporates any changes to the dredge plan and the modelling is repeated. Water-quality thresholds are finalised at this time, as are the management practices and monitoring plans (which are contained in the final dredging and dredge spoil disposal management plan).

4.1.3.2 Conservatisms and assumptions in the dredging models

To stochastically model the behaviour of currents, waves and sediment transport, assumptions need to be made. While these assumptions are based on collected data wherever possible, it is not possible to measure all aspects of a complex marine environment especially over relatively large areas. For example, while the nature of the sediment to be dredged is characterised (from field studies) for a representative area of the dredge footprint, it is necessary to make some assumptions about the consistency of the sediment characteristics in areas that are not measured. Modelling undertaken for INPEX by HR Wallingford (see the Draft EIS's Technical Appendix 13 *Dredging and spoil disposal modelling*) to predict the transport of sediment associated with dredging therefore incorporates a number of necessary assumptions. While the veracity of the assumptions will be borne out during validation (i.e. the comparison of measured sediment plumes and deposition during dredging against the modelled predictions), all assumptions are considered either appropriate (and are based on peer-reviewed literature or measured data) or are conservative. Table 4-5 provides details of conservative assumptions made during the development of modelling for the Project.

To support assumptions and provide further confidence in model outputs, a number of sensitivity tests were also undertaken. Technical Appendix 13 referred to above provides descriptions of sensitivity-testing undertaken, including testing the effects on assumptions by varying the following:

- dredging plant type: combinations of plant and the influence of these on the fine sediment entering the water column.
- loss rates from the dredging plant: variation of assumptions regarding loss of sediment from the dredge plant (through sediment particle size distribution information and operation of the plant) and qualification of the values used in testing by reference to loss values for BHD, CSD, TSHD and disposal activities in the literature.
- model coefficients: varying the settling velocity, drag coefficient of the mangroves, and mass of fines (at the offshore disposal ground) available for resuspension.

The hydrodynamic and wave models were also robustly calibrated and validated; see the Draft EIS's Technical Appendix 12 *Description and validation of hydrodynamic and wave models for dredging and spoil disposal* for discussion on the validation and calibration of the models.

In summary, the outputs presented in the Draft EIS's Chapter 7 *Marine impacts and management* and Technical Appendix 13 *Dredging and spoil disposal modelling* showing suspended-sediment and sedimentation intensity and distribution are considered to overestimate the potential magnitude of environmental impacts because:

- conservative assumptions were made throughout the modelling process
- appropriate values were used based on measured data or from the literature
- supporting assumptions were made through sensitivity-testing
- there was thorough and accurate calibration and validation.

Table 4-5: Conservative assumptions in dredge-plume modelling

Model	Parameter	Value	Justification	Reference
Dredging Research Simulation Models	Losses from CSD cutterhead	36 kg/s continuous release	Losses at the cutterhead – Literature values for loss of material from CSD cutter heads is around 15.5 kg/sec however modelling for the Project has assumed a conservative loss of 36 kg/sec. This value was based on conservative weekly production rates and continuous release of fines from the cutter head; a continuous release of fines from the cutter head was assumed rather than a more realistic 110 hours per week (which accounts for the loss in working hours as a result of maintenance work, crew changes, etc.)	Vlasblom (2005)
	Losses from BHD	3% of the total dredged: 0.26 kg/s, 0.83 kg/s, 1.6 kg/s or 2.18 kg/s continuous release depending on activity and material type	Few measurements of resuspension of dredge material around backhoes have been made. Kirby and Land (1991) suggest an "S" factor of 12 kg/m^3 for the larger backhoes. However, it is likely that this loss rate was generated in more benign hydrodynamic conditions than Darwin Harbour, so the loss rate is likely to be somewhat higher. A more appropriate comparison may be the grab-dredging that was undertaken in the River Tees, in the United Kingdom in May 2000 in an area of strong currents. Measurements made during the work indicated a loss rate of some 3.35% of the total dredged. Taking account of the larger bucket size proposed for the Project dredging and the fact that a backhoe dredger as opposed to a grab dredger is to be used, a loss of 3% of the total dredged is considered to be conservative.	HR Wallingford (2002) Kirby and Land (1991)
Flow	Saltwater intrusion vs freshwater flows	Freshwater flows from rivers not accounted for	The amplitude of tidal oscillations in Darwin Harbour varies between about 2 m (neap tides) and over 7 m (spring tides). It is anticipated that the tidal oscillations would drive saltwater into all the arms and creeks of Darwin Harbour and so it was assumed that the water column is well mixed at the proposed dredging site; however, this does not account for freshwater flushes associated with heavy-rainfall events. These flushes may have an impact on the nature of the flows in the upper parts of East Arm. Under modest freshwater flows there would be a greater tendency to disperse fines seaward in East Arm. Under the most extreme flows a degree of stratification may occur which would tend to enhance seaward dispersion of surface waters and landward dispersion of near-bed waters. Any such effects are not likely to overall enhance fine sediment supply to the intertidal margins compared with the assumption that the waters are well mixed.	n.a.

Model	Parameter	Value	Justification	Reference
Fine sediment transport	Threshold of erosion Threshold of deposition	0.2 N/m^2 0.1 N/m^2	The erosion formulation used was the standard formulation usually attributed to Partheniades (1965). Deposition was calculated using Krone's equation (Krone 1962). The specific threshold for erosion was set at 0.2 N/m^2 and the threshold for deposition was set at 0.1 N/m^2. These values have been defined in accordance with observed measurements and accepted values, which have been observed to range between 0.02 N/m^2 and 5.0 N/m^2 for erosion and 0.06 N/m^2 and 0.1 N/m^2 for deposition. Note that Whitehouse et al. (2000) suggest that the erosion value of cohesive material is typically about half the value of the threshold bed shear-stress for erosion, but is not directly related. A threshold of erosion value of 0.2 N/m^2 is at the lower end (and thus conservative for environmental impact assessment modelling in terms of resuspending material and transferring it to the upper intertidal areas) of the values given by Whitehouse et al. (2000). The value of 0.1 N/m^2 is at the upper end of the range for deposition values and thus promotes accretion processes. The assumptions are conservative when considering the potential for deposition in the mangrove areas. They are not necessarily conservative when considering subtidal deposition.	Partheniades (1965) Krone (1962) Whitehouse et al. (2000)
	Schem-atisation	Various	The schematisation of each scenario is summarised in Table 15 and Figure 4 of the Draft EIS's Technical Appendix 13 *Dredging and spoil disposal modelling*. All dredging phases are rounded up to the nearest 0.5 months. One month is equivalent to two spring neap cycles (just over 29 days). It is further assumed that all plant components are working continuously, without stoppage for crew changes, maintenance, weather or bunkering. Thus the mass of material that is included in the Draft EIS plume modelling is conservative.	n.a.
	Rainfall and erosion	Rainfall and erosion not accounted for	The modelling did not account for the redistribution and potential transport of sediment as a result of precipitation. Typical annual rainfall values of 1700 mm at Darwin Airport (Bureau of Meteorology) with a distinct seasonality indicate that the mangrove and intertidal areas experience a freshwater input. While it is not possible to say how this freshwater input is dealt with in the intertidal system (i.e. through runoff, percolation and evapotranspiration), it is considered possible that the rainfall will: a) agitate surface sediments during impact; and b) contribute to additional run off during times that the intertidal is exposed, which in combination may lead to an additional mechanism for the redistribution of fines over the intertidal area. Arguably this will represent an additional erosive mechanism in the upper intertidal/mangrove areas thereby reducing sedimentation levels within mangrove communities.	n.a.

Model	Parameter	Value	Justification	Reference
Fine sediment transport	Density of mangroves	Wave action within mangrove areas	The numerical model area within Darwin Harbour includes the representation of mangroves based on a description of the types of vegetation found in the mangrove areas and their density and strength; the analysis of which yielded a map of spatially varying friction coefficients. Mangroves occur generally above mean sea level in East Arm. Sensitivity tests showed that mangrove density had little effect on levels and velocities in the main channels of Darwin Harbour. Wind-wave action was included in the model at water levels below mean sea level. Above mean sea level wind-wave action was excluded—broadly representing the effect of mangroves on limiting wave propagation. This assumption promotes the transfer of suspended and recently settled material from the lower intertidal mudflats upslope into mangrove areas over higher water periods when currents and waves act to maintain fine sediment in suspension over the intertidal areas.	n.a.
Coarse sediment transport	Grain size	150 μm	The coarser fraction of the material placed at the offshore disposal ground has been represented in the sand transport model by sand of uniform grain size. The value used for the Draft EIS modelling was 150 μm. Sensitivity tests were also performed for material of larger grain size (350 μm). Sand of 150 μm diameter is described as "fine sand", and the dispersion of this material can be expected to be at the higher end of the coarse size fractions placed at the offshore disposal ground. While the results from the larger grain-sized material indicated similar patterns of dispersion, the magnitude of flux from the disposal site was approximately half that for the 150-μm material. It is anticipated that the greater part of the coarse fraction material that will be disposed of at the offshore disposal ground will have a larger grain size than 150 μm, and thus using a grain size of 150 μm is considered to be conservative.	Sensitivity tests

n.a. = not applicable.

4.1.3.3 Overview of the benthic community impact assessment

Impacts from dredging and other marine construction activities associated with the Project fall into two main categories:

- direct impacts: this includes the removal, burial or replacement of existing substrate and is considered a permanent impact. Direct impact areas are the dredging footprint in East Arm, the pipeline footprint and the dredge spoil disposal ground.
- indirect impacts: these are areas impacted as a result of persistent and relatively intense suspended-sediment concentration (SSC) and/or sedimentation (i.e. above a particular duration and intensity threshold). This impact is considered temporary in that the substrate is not altered permanently and recovery, at varying time scales, of benthic communities is expected.

The assessment of direct impacts (Section 4.1.3.4) is a relatively straightforward process involving the calculation of the area of benthic habitat and/or substrate removed, buried or replaced as a proportion of the existing areas.

For indirect impacts, it is possible to predict the indicative zones of impact and influence expected (from sediments generated by dredging) on a range of benthic communities via derivation of thresholds and then interrogation of the model to determine where these thresholds will be exceeded (this process is presented in sections 4.1.3.5 to 4.1.3.10). It is important to note that these predictions are intended to enable an assessment of the potential impacts from dredging on these communities and that development of water-quality thresholds for monitoring within the zones will be developed once the final dredging design is determined (and modelled) and the background water-quality data to derive thresholds is fully interpreted.

The conservatism associated with establishing the thresholds used to determine the spatial extent of the indicative zones presented below, in combination with the conservatisms in model assumptions (described above) produces an assessment of benthic community impact that, while being based on a number of assumptions, can be considered conservative. It should also be noted that impacts to particular community types does not necessarily equate to a detrimental effect on the ecosystem. Assessment of the consequences of impacts to benthic community habitats is included below and includes the consideration of area of habitat at risk and the potential for subsequent impacts at an ecosystem level.

4.1.3.4 Direct impacts

As previously discussed, the direct impact areas are the dredging footprint in East Arm, the pipeline footprint and the offshore spoil disposal ground; these include areas of soft (unconsolidated) and hard (consolidated) substrate.

Hard substrate: The areas of permanent loss of hard substrate include Walker Shoal and other areas within the dredge footprint and pipeline route. These hard areas are colonised by an established community of sponges and soft corals (see Section 4.1.5 for a discussion on the Walker Shoal benthic communities and an impact assessment). The loss of hard substrates must be considered as more significant than the loss of soft substrates because they are less widespread, have a more patchy distribution, and their loss in most cases will be permanent as they cannot easily be replaced. This situation also highlights the vulnerability of hard-substrate benthic communities such as soft corals, macroalgae and filter-feeders and their associated fauna that depend on this type of habitat. However, only a small percentage of these habitat types in Darwin Harbour will be lost (see Section 4.1.3.10). It is therefore not likely that hard-substrate habitats and their communities will be diminished to such an extent that their ecological function and the role they play for the ecosystem's integrity will be lost.

Soft substrate: Section 4.1.3.10 presents the proportions of available soft sediment habitat that will be directly impacted within the East Arm dredging footprint, the pipeline footprint and the dredge spoil disposal ground.

It is worth noting that the inclusion of the spoil ground in the category of direct/ high impact is considered conservative given the likelihood of recolonisation by soft-sediment infauna; see Section 4.1.3.11 for further discussion of recolonisation and recovery.

4.1.3.5 Indirect impacts

Physiological responses of biota to physical variables, including indirect impacts from suspended sediment and sedimentation, occur on a gradient from a minimum requirement to a maximum tolerable level or threshold. In essence there are two types of method for determining a threshold; these are as follows:

1. *Dose response*: This method determines the effect of a dose of the contaminant or of physical impact through a study of the particular species of concern; from this a threshold dose is formulated (note that "dose" often includes a measure of duration of exposure).
2. *Percentage of existing conditions*: This method is based on an assumption that the species present in an area are able to tolerate the normal fluctuations in the physical variables to which they are exposed.

In circumstances where the biological community that is to be protected is composed of many different species, the dose response method, while arguably more accurate, is logistically difficult (if not impossible) to conduct for each of the species present (although by considering only the more sensitive species in the community this difficulty can be overcome to some degree). The dose response method is also dependent on:

- having locally derived knowledge of how local biota respond to sediments that have similar characteristics to those that would be introduced to the water column by dredging
- having an understanding developed from regionally relevant background data where local data are unavailable.

Suspended-sediment threshold approach (see Section 4.1.3.6 for details): With the exception of soft-sediment infauna, the percentage-of-existing-condition approach has been applied to develop suspended-sediment thresholds for benthic communities (corals, seagrass, filter-feeders and macroalgae). As discussed in Section 4.1.3.6, suspended-sediment concentration (SSC) thresholds for soft-bottom infauna are not considered relevant.

Sedimentation threshold approach (see Section 4.1.3.8 for details): A dose-response sedimentation threshold for seagrass has been derived from the literature. As discussed in Section 4.1.3.8, sedimentation thresholds have not been set for other benthic communities (filter-feeders, macroalgae, corals and infauna communities).

4.1.3.6 Development of suspended-sediment thresholds

No information is available specific to Darwin Harbour on suspended-sediment dose-response thresholds for local biota although, as outlined in Annexe 6 *Provisional dredging and dredge spoil disposal management plan* in Chapter 11 of the Draft EIS, this information will be gathered for hard corals in East Arm where there are potential impacts predicted from suspended sediment during dredging.

In addition, because of the lack of suitable scientific data on this topic and the variability in intra– and interspecies responses, it is not considered appropriate to derive a literature-based dose-response SSC tolerance limit or threshold for benthic communities. For example the results of a comprehensive benthic invertebrate fauna literature review (see Technical Appendix S1 in this EIS Supplement), relating to tolerance levels and the development of thresholds for increased sedimentation and SSC on soft-bottom benthic fauna and filter-feeding communities, reveal a wide range of variability in the tolerance of different species to SSC.

A filter-feeding organism captures its food directly from the water column using its feeding apparatus. As its feeding apparatus comes into direct contact with the suspended-sediment particles, it is susceptible to changes in SSC. Particles can clog or damage the filtration apparatus and reduce the feeding efficiency of the organisms. This ultimately reduces growth rates and reproductive potential. Suspended sediments can also cause stress to marine filter-feeding organisms by interfering with their food sources and reproduction. The exact effect of this interaction depends on the morphology of the species' feeding apparatus and the type and amount of the suspended-sediment particles.

The severity of this impact and whether it causes mortality is, however, difficult to predict. Impacts on filter-feeding communities can range from mortality to changes in the community structure. Darwin Harbour is a naturally turbid environment, with SSC in the Harbour reported to average 15 mg/L with a range of 1.5–83 mg/L (see Section 7.3.2 of Chapter 7 *Marine impacts and management* of the Draft EIS). Tolerances to SSC reported in the literature indicate that some species such as mussels exhibit very high tolerance, up to several hundred milligrams per litre in some studies, while other species such as sponges have lower tolerances in the tens of milligrams per litre. This reported high variability would mean that some filter-feeding organisms in Darwin Harbour could already be stressed by the naturally occurring sediment loads. Alternatively, it could indicate that the resident fauna in Darwin Harbour is well adapted to high turbidity.

Depending on the dredging phase and the locations of dredging operations, elevated SSC levels will persist in the Harbour at varying levels for approximately four years. The dredge-plume modelling conducted by INPEX predicts that after Phase 6 of the dredging program (the most intensive dredging phase in the program), backhoe dredging will elevate SSC levels to 5–20 mg/L above background while cutter-suction dredging will produce an elevation of 200 mg/L in some locations for 6 weeks of the Phase 6 dredging.

Aside from the short, intense cutter-suction dredging during Phase 6, dredging will normally generate SSC concentrations above 10 mg/L only in close proximity to the dredging vessels. Under some tidal conditions, SSC plumes of 10 mg/L or higher may be transported up to 10 km from the dredging vessels. However most of the suspended sediments caused by dredging will remain within the upper-estuary waters in East Arm and will rarely reach the main body of the Harbour (figures 7-10 to 7-20 of the Draft EIS). After completion of the dredging program, SSC levels are expected to return to their natural levels.

Based on the benthic invertebrate fauna literature review (see Technical Appendix S1) reported tolerances to SSC and INPEX's proposed dredging program, filter-feeding communities, particularly in East Arm, are likely to be impacted by the planned dredging activities. However, based on the currently available knowledge only general assumptions about predicted impacts can be made.

Filter-feeder communities consist of a variety of different species and each community at each impact site may differ in its composition and density and hence in its response. But even if all of the species in these communities were known, this would still not allow for a more accurate prediction. Taxonomic knowledge does not inform on the sensitivity profile of the various species. In addition the same sponge species, for example, can have different morphotypes and it could be shown that tolerance levels are related to morphotype (Maldonado, Giraud & Carmona 2008). Experiments with sponges demonstrated that tolerance levels can vary greatly between sponge species.

There is also little information on how communities and species from high turbidity areas such as Darwin Harbour react to elevated levels. It remains speculation whether communities from turbid background conditions are well adapted to such elevated levels or whether they exist at their physiological tolerance limit.

Exposure duration is another parameter that has not been researched to any great extent. Experimental studies on sponges have only monitored organisms for a few days to a maximum of two weeks which provides limited suitable background for impact assessments for dredging campaigns which generally extend for much longer periods.

Thresholds from the existing published literature established through field– and laboratory-based experimentation for corals (Anthony 1999; Anthony & Connolly 2004; Anthony & Fabricius 2000; Gilmour 1999; Humphrey et al. 2008; Te 1997) vary widely, are based on species with wide-ranging SSC tolerances, and use varying response end points, making the derivation of a threshold from these studies difficult. Literature thresholds for seagrass (Dennison 1987; Dennison et al. 1993; Duarte 1991; Schwartz et al. 2000; Williams & Dennison 1990) are typically based on light availability (e.g. percentage surface irradiance) and do not allow a threshold for SSC to be developed.

Based on the currently available information that could support the development of dose-response thresholds for the effects of SSC on the benthic communities of Darwin Harbour, it must be concluded that the development or application of such thresholds would not be scientifically sound.

It should also be noted that a review of SSC thresholds for hard corals and seagrasses applied to dredging projects in Western Australia and Queensland was undertaken to determine whether existing SSC thresholds for these regions might be applied to Darwin Harbour hard corals, filter-feeders and seagrasses.

While thresholds used and/or proposed for other projects generally rely on the percentage for existing conditions approach, the thresholds themselves were considered unsuitable as they typically rely on site-specific baseline water-quality data and do not typically include season-specific thresholds. Turbidity in Darwin Harbour shows significant variation between wet and dry seasons and is heavily influenced by current strength associated with tidal regimes. Turbidity levels recorded from Darwin Harbour highlight the considerable disparity between the wet and dry season (Table 4-6). Using thresholds derived from background water quality for other areas with different seasonal and tidal regimes is considered an inappropriate and probably inaccurate basis for development of thresholds for benthic communities in Darwin Harbour.

The percentage of existing conditions approach allows for season-specific SSC thresholds to be derived specific to Darwin Harbour for benthic communities including coral, seagrass, macroalgae and filter-feeders. It was therefore deemed the most appropriate method in determining SSC thresholds for Darwin Harbour benthic communities.

Season-specific SSC thresholds for hard corals, filter-feeders, seagrass and macroalgae were based on the 95th percentile SSC of ambient water-quality data collected from sites in Darwin Harbour. Table 4-6 presents summary statistics for the data collected over a 12-month period from February 2010 to January 2011 (see Technical Appendix S9 in this EIS Supplement for a summary report of the water-quality program).

The 95th percentile SSC represents the SSC upper limit above which benthic communities may experience stress if exposed to for extended durations or above a particular frequency. In order to account for duration and frequency of elevated SSC events the dredge plume model outputs are interrogated to determine (spatially) where the threshold is met or exceeded infrequently and for short durations (this is discussed in further detail later). This aligns with the method for calculation of triggers for reactive hard-coral monitoring in accordance with McArthur, Ferry and Proni (2002) discussed in the Annexe 6 *Provisional dredging and dredge spoil disposal management plan* to Chapter 11 *Environmental management program* of the Draft EIS.

Table 4-6: Darwin Harbour long-term water-quality data (summary statistics for suspended sediment in milligrams per litre)

	Data source (turbidity logger location)	Season	Min.	Max.	95th percentile	90th percentile	50th percentile	Mean
East Arm	South Shell Island North East Wickham Point	Wet	7.2	83.0	36.5	26.4	11.3	14.9
		Dry	7.1	46.4	19.7	15.5	9.5	10.9
Middle Arm	Channel Island	Wet	6.4	110.8	43.2	27.9	10.6	15.7
		Dry	6.3	46.7	26.0	19.6	9.3	11.6
Mid Harbour	Weed Reef	Wet	6.3	148	63.1	46.9	12.5	20.6
		Dry	6.3	33.0	17.6	15.0	8.8	10.0

N.B. Data were recorded in NTU and converted to SSC using site-specific linear regression relationships derived from collected suspended-sediment samples; see Technical Appendix S9 in this EIS Supplement for details.

Note that all data are suspended-sediment concentrations in milligrams per litre and are simple rolling averages.

4.1.3.7 Setting suspended-sediment concentration tolerances

A dredging generated SSC tolerance is defined for the Project as the SSC that can be contributed to the system by dredging or spoil disposal without exceeding the threshold SSC. The SSC tolerances are then combined with model outputs to delineate the zones of impact (discussed later).

SSC tolerances were calculated by subtracting the median (50th percentile) SSC (considered here to reflect typical background SSC) from the 95th percentile SSC for each area presented in Table 4-7; for example, water-quality data from loggers at North East Wickham Point and South Shell Island were used to calculate tolerances for East Arm benthic communities. Tolerances are presented in Table 4-7.

Table 4-7: Suspended-sediment tolerances for benthic communities in areas around Darwin Harbour

	Data source (turbidity logger location)	Season	Tolerance (mg/L)
East Arm	South Shell Island North East Wickham Point	Wet	25.2
		Dry	10.5
Middle Arm	Channel Island	Wet	32.6
		Dry	17.3
Mid Harbour	Weed Reef	Wet	50.6
		Dry	7.9

Note that the dry-season tolerances in this table are based on slightly differently defined wet– and dry-season periods and therefore represent the difference between the 95th and 50th percentile SSC for a different dry-season data set than that summarised in Table 4-6. The differences in tolerances between the two data sets are less than 1 mg/L for each area and are considered insignificant for the purpose of this impact assessment.

A potential limitation with this approach is that on occasions where ambient SSC exceeds the median (which will theoretically occur 50% of the time), the addition of sediment load up to the tolerance SSC will in fact exceed the threshold SSC. For the purposes of delineating areas of influence this is not, however, considered a significant limitation, nor does it compromise the conservativeness of the general approach. In using the median as background, in areas where the SSC tolerance is reached for half of the time the threshold SSC will be exceeded; however, given the method to determine where the threshold is met is based on the percentage of occurrences over a multi-month or even multi-year period (i.e. the intent is not to try to determine where thresholds are exceeded for a particular tidal phase), the median SSC is considered an appropriate measure of background SSC for the purpose of determining zones of impact and influence.

To apply further conservatism to delineation of zones of impact, only the dry-season SSC tolerances have been used, which in all cases (all areas) are lower than those of the wet season. That is, where model predictions of dredging plumes are based on wet-season conditions, the dry-season SSC tolerances are still applied despite the background water-quality data indicating that SSC tolerances during the wet season are higher.

It should be noted that the thresholds and tolerances are at this stage considered indicative and have been calculated for the purposes of impact assessment; they may differ to those to be used for reactive monitoring of Channel Island coral communities. Further interpretation of the data is to be undertaken and will be the basis upon which season – and possibly tidal-specific tolerances and thresholds will be determined for the reactive monitoring of Channel Island corals.

4.1.3.8 Sedimentation thresholds

Sedimentation thresholds have been based on dose-response thresholds from the literature. Mangrove thresholds have been dealt with in the Draft EIS. As previously discussed, a dose-response sedimentation threshold for seagrass has been derived from the literature and is presented below. Sedimentation thresholds have not been set for other benthic communities (filter-feeders, macroalgae, coral and infauna communities).

Mangroves: Development of conservative sedimentation thresholds for mangroves was undertaken and discussed in the Draft EIS (pages 320–321). This is paraphrased in the following paragraph.

While Ellison (1998) noted that there are insufficient data available to establish specific tolerances, on the basis of existing literature it is considered that sedimentation levels of up to 50 mm would be generally tolerable by the mangrove communities throughout East Arm, regardless of the species affected. Above this level of sedimentation, *S. alba* and *A. marina* would be most at risk of decreased growth or death. At sedimentation levels above 100 mm, tree deaths in *S. alba* and *A. marina* are considered likely. *Rhizophora* trees can be expected to tolerate higher levels of accretion, up to 200 mm.

Table 7-31 of the Draft EIS summarises the impact assessment and residual risk for mangroves from sedimentation caused by dredging. Impacts to mangroves are not considered further in this section.

Seagrass: studies on the tolerance of seagrasses to sedimentation invariably examine the effects on seagrass from sudden sediment burial to depths in the order of centimetres and often in conjunction with effects from turbidity (Cabaço, Santos & Duarte 2008; Erftemeijer & Lewis 2006). Duarte et. al. (1997) examined the effect of burial as a result of sudden sediment loading in a mixed-species Philippine seagrass meadow. The response in shoot density, vertical growth and branching of the species present were assessed 2, 4 and 10 months following disturbance. Shoot density responses were strongly species-specific. The morphologically large *Enhalus acoroides* maintained shoot density at all burial treatments, and only showed evidence of decline by the end of the experiment. *Thalassia hemprichii* and to a lesser extent, *Cymodocea rotundata* showed a sharp decline in shoot density even at moderate burial treatments, from which they failed to recover. The accompanying species (*Halodule uninervis*, *Syringodiurn isoetifolium*, and *Cymodocea serrulata*) showed an initial decline in shoot density followed by recovery. The small *Halophila ovalis* actually showed an opportunistic growth in plots receiving intermediate (buried by 4 and 8 cm sediment) disturbance, reaching shoot densities well in excess of those on control plots.

Vermaat et al. (1997) reported sedimentation rates of 100–130 mm/a as maximum threshold values for seagrasses in the Philippines and Spain. Manzanera Perez and Romero (1995) reported significant mortality of shoots of the seagrass *Posidonia oceanica* in response to experimental over sedimentation at burial levels around 5 cm. Mills and Fonseca (2003) observed >50% mortality of *Zostera marina* in field burial treatments of 4 cm (corresponding with 25% of plant height) for 24 days. Plants responded similarly to burial in either sand or silt. Plants buried 75% or more of their height (16 cm) experienced 100% mortality.

Sediment dispersion modelling for the Project predicts that rates of deposition in seagrass areas will generally be in the order of millimetres per annum rather than centimetres of sediment instantaneously placed on seagrasses in the experiments discussed here, including those summarised in Table 4-8.

It is considered a reasonable assumption, based on the reported ability of seagrasses to survive instantaneous sedimentation in the order of centimetres, that at rates of sedimentation predicted from dredging, seagrass rhizomes will continue to grow at the same or greater rates as that of the sediment level increase and will therefore be un-impacted. However, in general it is considered difficult to separate the effects of turbidity and sedimentation in field studies (Erftemeijer & Lewis 2006) and settlement of suspended material on leaf blades of seagrasses may interfere significantly with photosynthesis.

This appears especially significant in low wave energy environments where fine sediments are present and can settle out (Shepherd et al. 1989). While there are no seagrass areas predicted to experience both sedimentation and an exceedance of SSC thresholds as a result of dredging (i.e. no seagrass areas fall within zones of suspended-sediment impact as discussed later), a conservative approach has been adopted to account for the possibility of fine material settling on seagrass leaves and the potential for this to occur, albeit intermittently over a three – to four-year period. The lowest threshold reported in the literature for a seagrass species that has been recorded in Darwin Harbour was that of *Cymodocea rotundata* at 15 mm, and this has therefore been adopted as a sedimentation threshold for seagrass. Sedimentation under this threshold in seagrass areas predicted to be also affected by suspended sediment is also considered in Section 4.1.3.11.

Table 4-8: Overview of values reported in the literature for maximum allowable sedimentation level for seagrasses recorded in Darwin Harbour

Species	Recorded in Darwin Harbour	Location in Darwin Harbour	Reported sedimentation level threshold (mm)	Reference	Location of tolerance study
*Cymodocea nodosa**	No	n.a.	50	Marbà & Duarte 1994	Mediterranean
*Cymodocea serrulata**	No	n.a.	130	Vermaat et al. 1997	Philippines
Cymodocea rotundata	Yes	Casuarina Beach (N. Smit pers. comm. 2009 (from data collected in 2006))	15	Vermaat et al. 1997	Philippines
Halophila ovalis	Yes	Casuarina Beach (N. Smit pers. comm. 2009 (from data collected in 2006)) Geo Oceans (2011)†	20	Vermaat et al. 1997	Philippines
Halophila decipiens	Yes	Casuarina Beach (N. Smit pers. comm. 2009 (from data collected in 2006)) Geo Oceans (2011)†	–	–	–
Halophila spinulosa	Yes	Casuarina Beach (N. Smit pers. comm. 2009 (from data collected in 2006)) Geo Oceans (2011)†	–	–	–
Halodule uninervis	Yes	Casuarina Beach (N. Smit pers. comm. 2009 (from data collected in 2006)) Geo Oceans (2011)†	40	Duarte et al. 1997	Philippines
Syringodium isoetifolium	Yes	Casuarina Beach (N. Smit pers. comm. 2009 (from data collected in 2006)) Geo Oceans (2011)‡	80	Duarte et al. 1997	Philippines

* Species not recorded in Darwin Harbour, but included here as other species of the same genus (with similar morphologies) are present.

† Observations of *Halophila* from Geo Oceans (2011) were reported to genus level only. The species may be *H. decipiens or H. ovalis*—both species have similar morphology and are likely to have similar sedimentation tolerances.

‡ The genus *Syringodium* contains only two species, *S. isoetifolium* and *S. filiforme*. Observations of *Syringodium* from Geo Oceans (2011) were reported to genus level only and therefore could be *S. filiforme*; however both species have similar morphology and are likely to have similar sedimentation tolerance.

n.a. = not applicable.

Infauna: application of sedimentation thresholds for infauna in Darwin Harbour with respect to dredging effects are not considered appropriate or necessary. The range of tolerances of infauna to burial from increased sedimentation identified in the benthic invertebrate fauna literature review (see Technical Appendix S1 in this EIS Supplement) show that, although there is a high variability in response thresholds to burial, most species are able to cope with burial depths of greater than 10 cm, and many can tolerate 200 mm or more. The literature review also showed that species present in muddy sediments or in high-energy or dynamic sediments are well adapted to changes in their substrate (Bijkerk 1988). Metcalfe (2007) also found that in Darwin Harbour invertebrate diversity and abundance did not decline in response to moderate levels of anthropogenic disturbance.

INPEX's predictive sediment accretion modelling forecasts more than 100 mm of sediment accretion over 2 ha of mangrove habitat and 50–100 mm over 28 ha of mangrove habitat over four years. Generally sediment depositions of 17–35 mm thickness per year are expected in these areas (Section 7.3.2 of the Draft EIS). Mangrove habitats are predicted to receive the greater part of the sedimentation, which consists of fine silty material that can only settle out in protected calm areas.

In light of these predictions for accretion levels and the assumption that the invertebrate fauna of local mangrove and mudflat habitats will respond in a similar way as documented for the same functional groups in the literature, it is concluded that the impacts on the resident invertebrate faunal communities to be slight to moderate. Tolerance levels indicated in the literature far exceed the accretion rate predicted as a result of INPEX's dredging program. Although total accretion may amount to 100 mm thickness, the build-up over four years will be slow, allowing the majority of invertebrate fauna to escape (dig up to the surface through the newly deposited sediment layer) or adapt. It is therefore unlikely that effects from sediment deposition will be lethal for most invertebrates in the accretion areas. Therefore, a threshold has not been derived for sedimentation/burial of infauna.

Other benthic communities: A sedimentation threshold for macroalgae, hard-coral and filter-feeder communities is not presented here for the following reasons:

- Literature values for sedimentation thresholds for macroalgae, hard-coral and filter-feeder communities vary widely and are dependent on species within each community, morphology within species and duration and rate of sedimentation.
- Sedimentation typically occurs in areas of low energy and thus typically occurs in depositional environments where the existing substrate is soft sediment. The areas of each community predicted to receive levels even as low as 3 mm (over 4 years) are small (see Table 4-11). Areas of macroalgae, hard-coral and filter-feeder communities predicted to receive 15 mm or more are smaller still (Table 4-10); note that for these communities an assessment against a 15 mm or more sedimentation level is intended to highlight the small areas exposed to low levels of sedimentation; 15 mm is not proposed here as a threshold for these communities.
- Those areas that are predicted to receive sedimentation at levels in the order of 3–14 mm over four years are considered unlikely to experience impact given this rate is likely to be well within natural rates of accretion and erosion for Darwin Harbour.

4.1.3.9 Mapping zones of impact and influence

Zones of impact and influence are defined as follows:

Zone of High Impact: this zone includes the dredged area, the spoil disposal ground and the nearshore pipeline footprint (in Darwin Harbour) and a 20 m buffer extending outwards from each of these footprints. Impacts in these areas are predicted to be severe and often irreversible. Zones of High Impact are those areas that will experience the "direct impact" discussed in Section 4.1.3.4). Note that to assess impacts on soft-bottom epifauna and infauna, a determination of the amount of each sediment type (namely mud, sand and gravel) in the zone of high impact as a percentage of the available sediment type with Darwin Harbour (for the dredging and pipeline footprint) and Shoal Bay (for the spoil ground) has been undertaken.

Zone of Moderate Impact: this zone abuts on and lies immediately outside the Zone of High Impact. Within Zones of Moderate Impact damage to key benthic communities can be predicted, but the disturbed areas will recover and there is no long-term modification of the seabed. For suspended sediment, the outer boundary of this zone is delineated by the 90th percentile SSC contour plot (from the dredge plume modelling) reflecting areas where for 90% of the time the SSC is below the tolerance for key benthic communities. The 10% of the time during which SSC thresholds are met or exceeded reflect mid-flow tidal states, particularly the spring tides and will equate to no more than an hour or two of exceedance for any one exceedance event. For sedimentation, the zone of moderate impact is defined as areas predicted to receive 15 mm or more of sediment over the dredging program.

Zone of Influence: this zone includes the areas which at some time during the proposed dredging and spoil disposal activities will experience changes in sediment-related environmental quality outside the natural ranges that might be expected; however the intensity and duration is such that effects on benthic biota or their habitats are insignificant in scale and reversible in the short term. For suspended sediment, the outer boundary of this zone is delineated by the 95th percentile SSC contour plot (from the dredge plume modelling) reflecting areas where for 95% of the time the SSC is below the tolerance for key benthic communities. For sedimentation effects on seagrass and macroalgae, the zone of influence is defined as areas predicted to receive 3–14 mm.

Zone of No Effect – the areas beyond which there should be no detectable dredging or spoil disposal related changes from natural conditions. This is the area were it would be most appropriate to establish suitable reference sites for the purpose of monitoring potential effects of dredging in the zones of high impact, moderate impact and influence (Weed Reef falls within this area and will be the reference site for the coral monitoring programs during dredging (see Annexe 6 of Chapter 11 in the Draft EIS)).

A conceptual illustration of zones of suspended-sediment impact and influence is presented in Figure 4-8.

Figure 4-9 presents zones of impact from elevated suspended sediment for a typical phase (Phase 4) of the dredging program (see Technical Appendix 13 of the Draft EIS for dredge-plume figures for all phases) The High and Moderate Impact Zones are limited to East Arm; in these areas there is potential for benthic biota to experience stress and mortality at a localised scale. The Zone of Influence is predominantly within the boundaries of East Arm with small isolated areas of elevated suspended sediment predicted outside East Arm; these small areas are expected to experience detectable changes in turbidity but not at a level likely to result in significant effects to biota.

Figure 4-10 present High and Moderate Zones of Impact and the Zone of influence from elevated suspended sediment for the worst-case phase of the dredging program (Phase 6 with CSD) and shows the greater part of East Arm falling within the Zone of Moderate Impact. While this phase is atypical of the dredging program in terms of its relatively high extent and intensity of suspended-sediment plume, it provides further conservatism in determination of the zones of impact and influence which are the basis for calculations of impact areas. The impact areas in turn, underpin the benthic habitat impact assessment in the following sections.

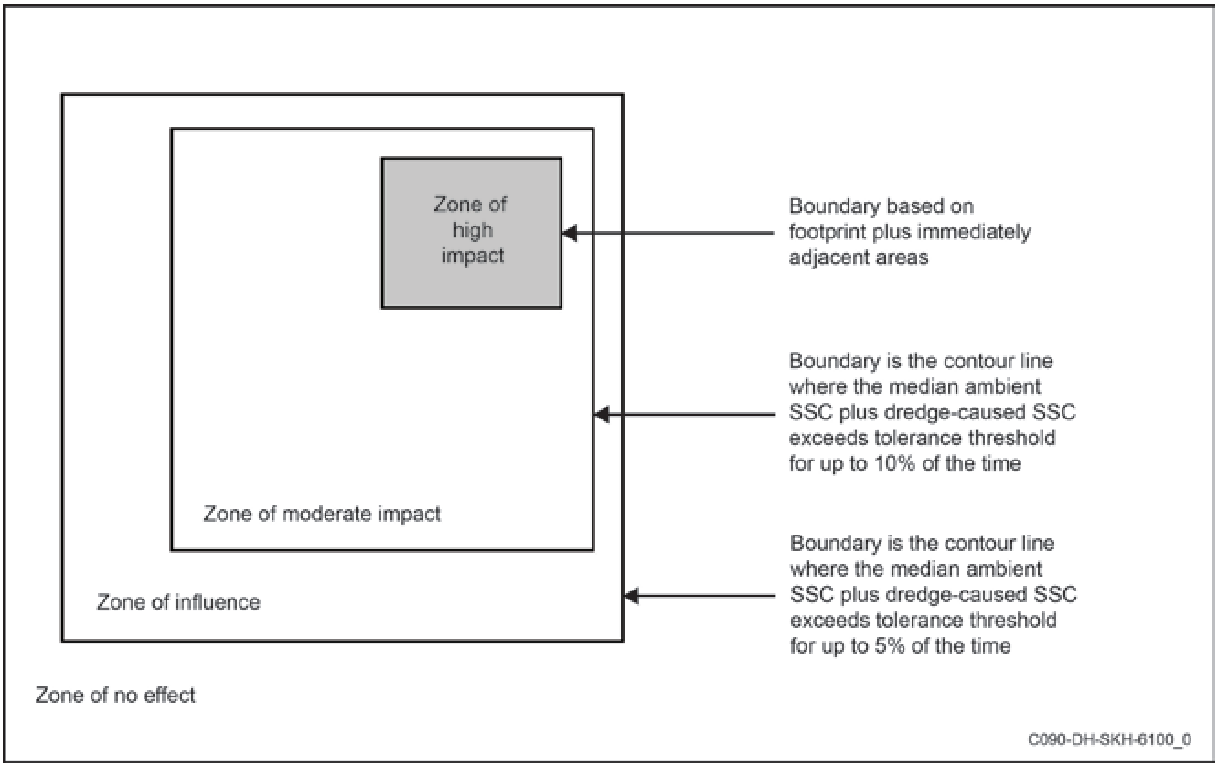


Figure 4-8: Zones for suspended-sediment impact and influence

Figure 4-11 presents areas of sedimentation from dredging at levels relevant to seagrass thresholds. Figure 4-12 and Figure 4-13 present High and Moderate Zones of Impact and the Zone of influences resulting from spoil disposal for elevated suspended sediment and sedimentation respectively.

For spoil disposal, these figures present zones based on the worst-case spoil disposal phase (Phase 5) and Figure 4-13 shows small areas proximate to the spoil ground falling within the Zone of Moderate Impact. In this zone, there is potential for benthic biota to experience stress and mortality at a localised scale. Areas at the mouth of Howard River and around Gunn Reef also lie within this zone; these areas are, for the most part, soft-sediment areas with no or minimal light-dependent benthic communities and are therefore not expected to be significantly impacted. Discussion of potential impacts on coral communities at the Gunn Reef Blue Holes because of water-quality impacts are discussed in Section 4.1.6. Discussion of potential impacts to barramundi at the mouth of the Howard River attributable to water-quality issues are discussed in Section 4.1.7.2.

As stated earlier, dry-season thresholds were used as they represent the most conservative value. It is also worth noting that for Phase 6 and Phase 4 modelling, wet-season conditions were assumed. This again represents a worst-case scenario given that assuming dry-season conditions in modelling would typically result in a smaller 90th and 95th percentile contour for a given SSC value.

4.1.3.10 Zones of impact and influence—area calculations

Zone of High Impact (Direct Impacts): Table 4-9 presents the areas of benthic communities that fall within the Zone of High Impact. To address impacts on infauna as a result of habitat removal (within dredging, spoil disposal and pipeline footprints), Table 4-9 also presents areas of sediment by type that may be impacted as well as the proportion of Darwin Harbour (for dredging and pipeline footprints) and Shoal Bay (for the spoil ground) that these areas represent.

Zone of Moderate Impact (Indirect Impacts): Table 4-10 presents areas of benthic communities predicted to be potentially impacted by suspended sediments and sedimentation generated by dredging activities in East Arm. Note that suspended-sediment concentrations and sedimentation levels from pipeline trenching (including shore-crossing works) are below threshold levels under all conditions; there are therefore no significant impacts expected from these activities. Note also that based on benthic habitat mapping and a conservative zone of impact development, there are no areas of mapped benthic communities predicted to be impacted by spoil disposal.

Zone of Influence: Table 4-11 presents areas of benthic communities predicted to fall within the area of influence. As stated in Section 4.1.3.9 the area of influence represents the area in which water quality may be affected by dredging activities but no significant biological impact is expected.

It is important to note that the areas presented in each table exclude the areas from the other tables; for example, the area of filter-feeders within the Zone of Moderate Impact are in addition to those within the Zone of High Impact (not inclusive of).

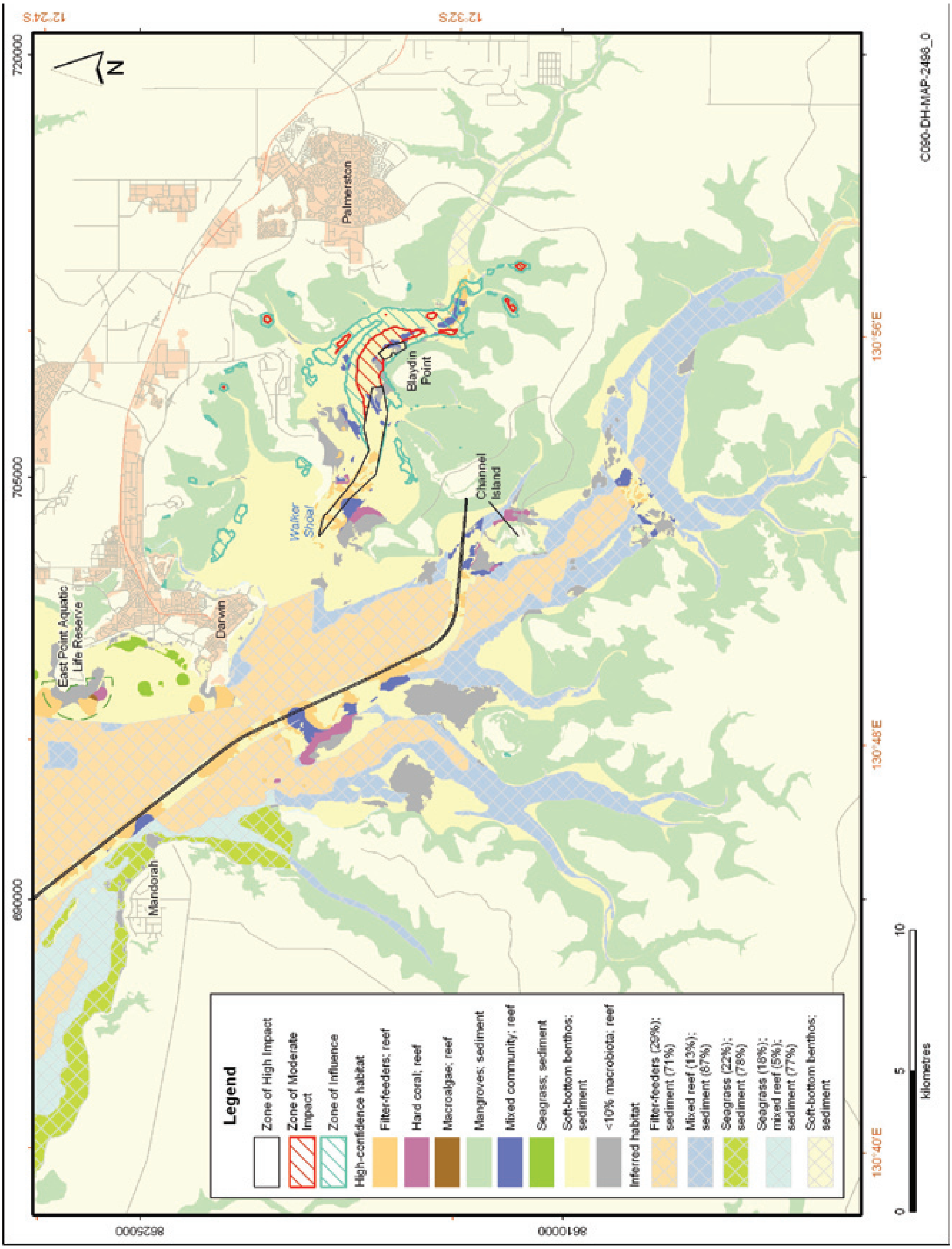


Figure 4-9: Zones of impact and influence from dredging-generated suspended sediment for Phase 4

Note that these zones of impact and influence from dredging-generated suspended sediment for Phase 4 are based on dry-season thresholds and wet-season modelling conditions. The zones apply to hard coral, macroalgal, seagrass and filter-feeder communities.

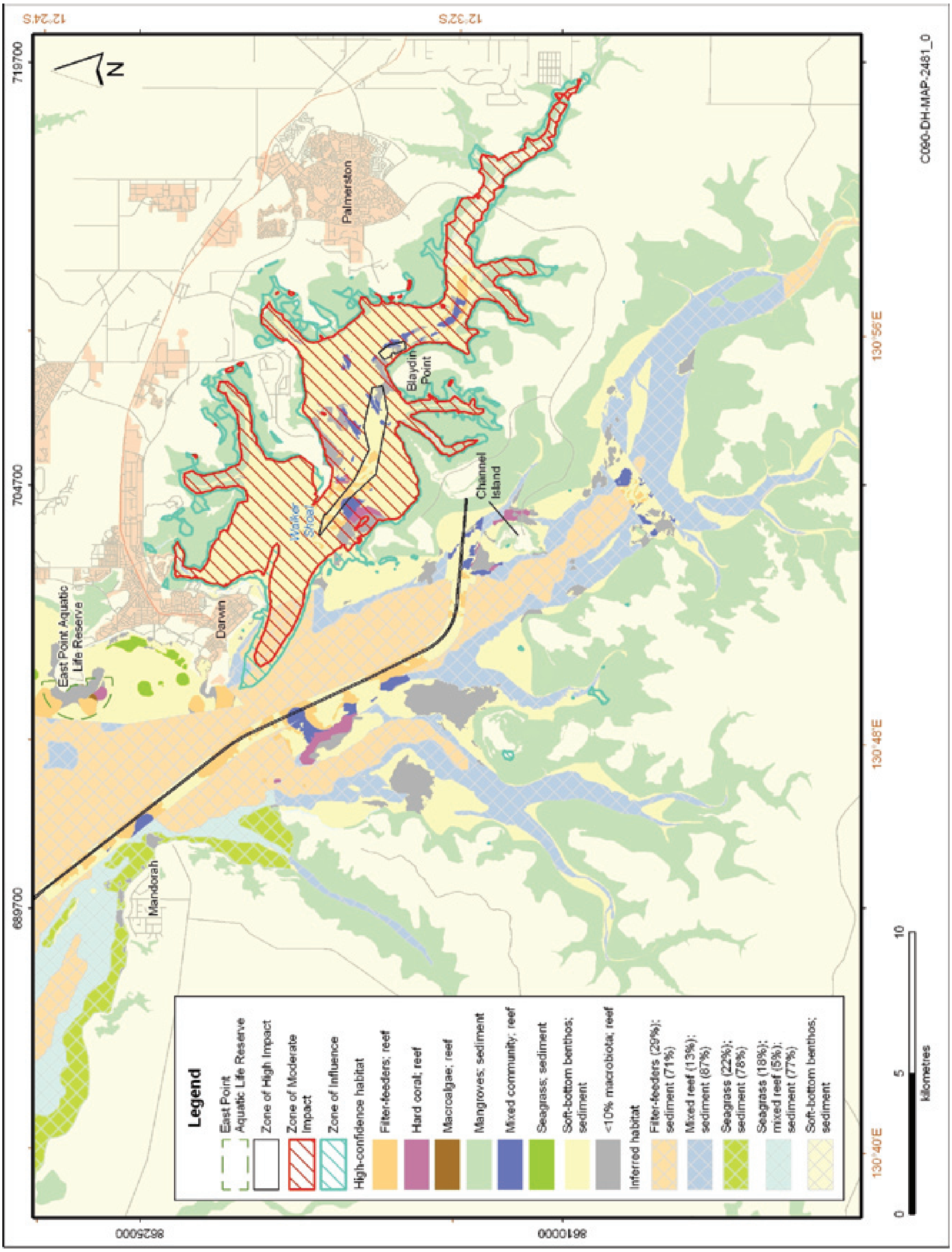


Figure 4-10: Zones of impact and influence from dredging-generated suspended sediment for Phase 6 (with cutter-suction dredger)

Note that these zones of impact and influence from dredging-generated suspended sediment for Phase 6 (with cutter-suction dredger) are based on dry-season thresholds and wet-season modelling conditions. The zones apply to hard coral, macroalgal, seagrass and filter-feeder communities.

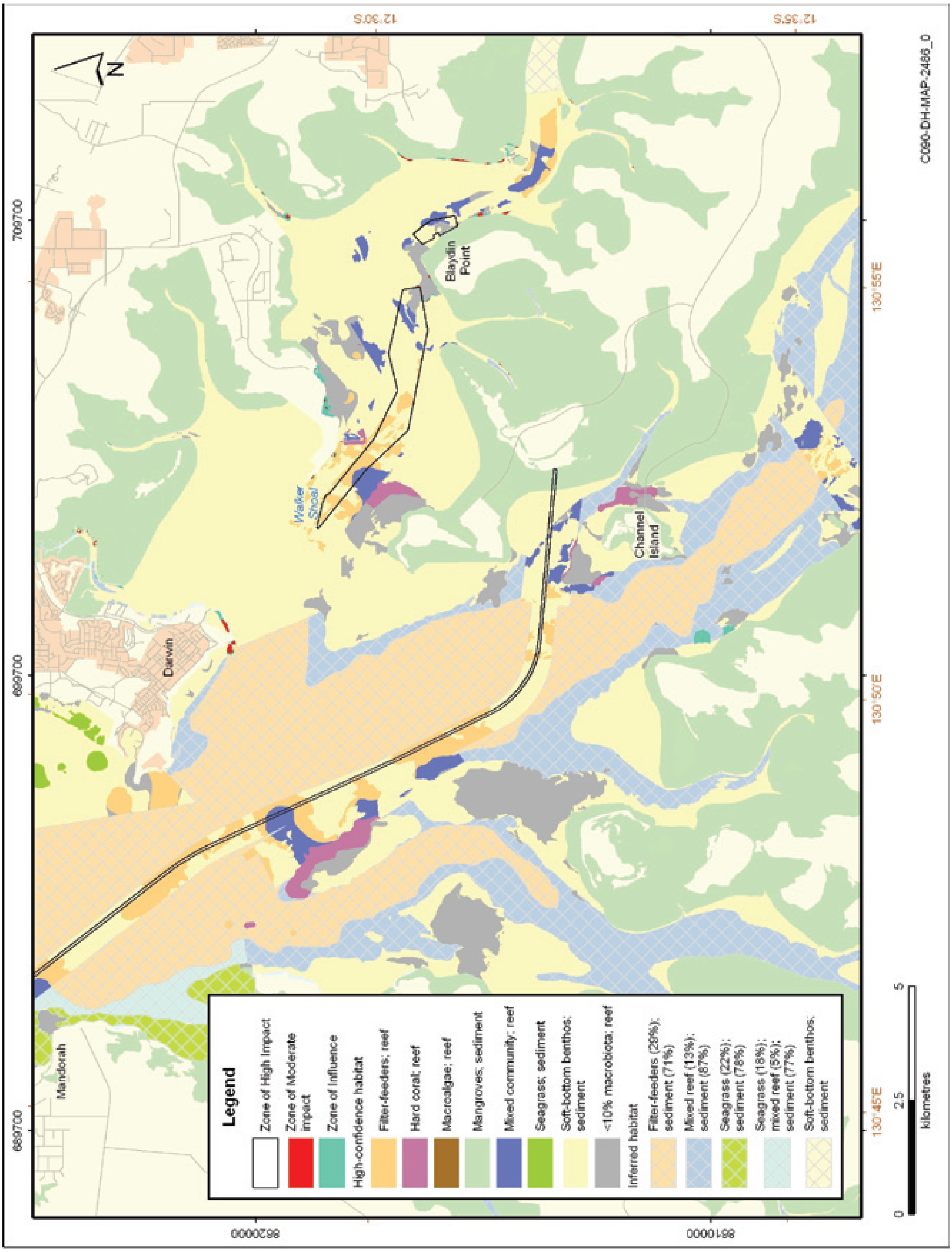


Figure 4-11: Zones of impact and influence from dredging-generated sedimentation for Phase 6 (with cutter-suction dredger)

Note that these zones of impact and influence from dredging-generated sedimentation for Phase 6 (with cutter-suction dredger) are based on dry-season thresholds and wet-season modelling conditions. The zones apply to seagrass communities.

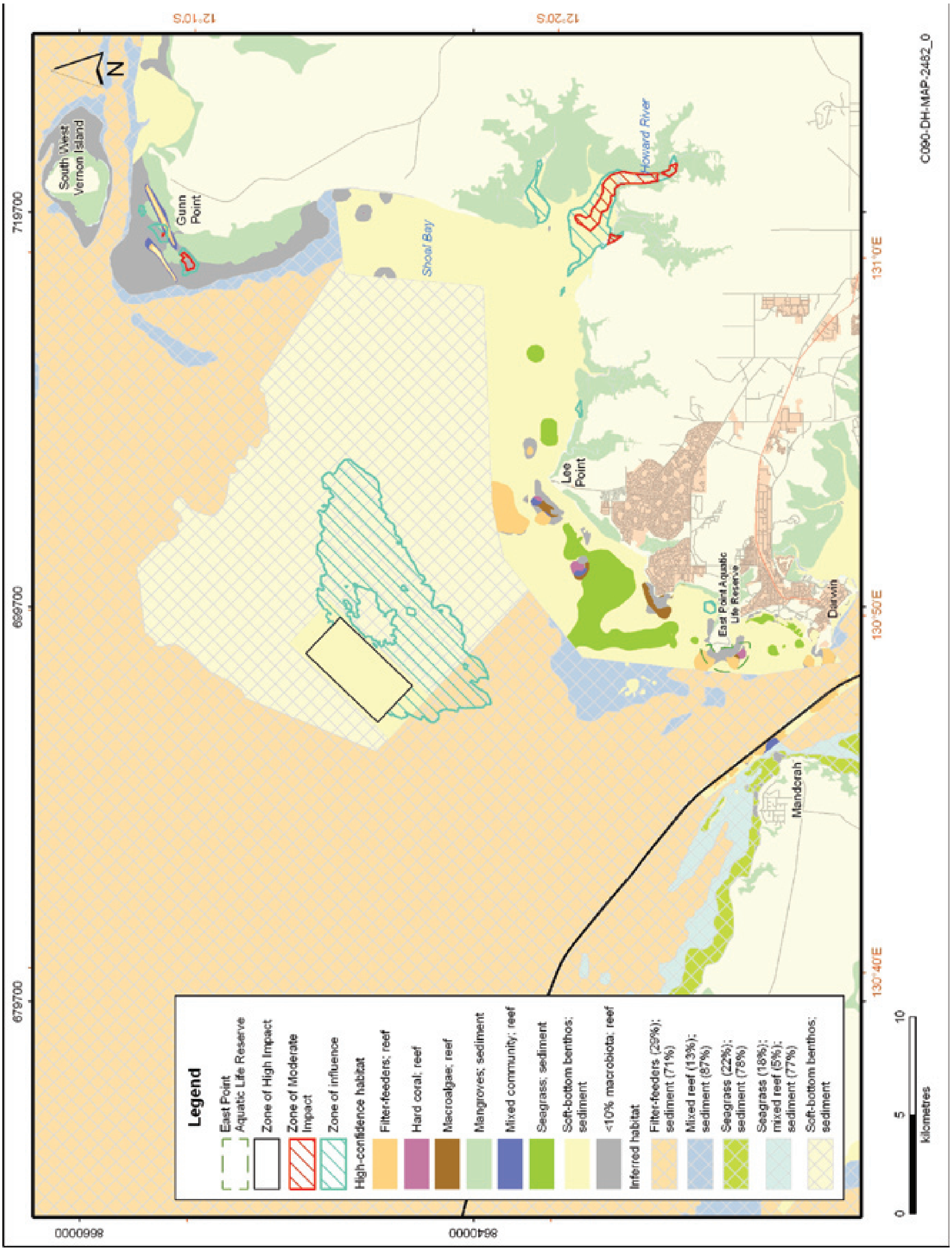


Figure 4-12: Zones of impact and influence from spoil-disposal-generated suspended sediment for Phase 5

Note that these zones of impact and influence from spoil-disposal-generated suspended sediment for Phase 5 are based on dry-season thresholds and wet-season modelling conditions. The zones apply to hard coral, macroalgal, seagrass and filter-feeder communities.

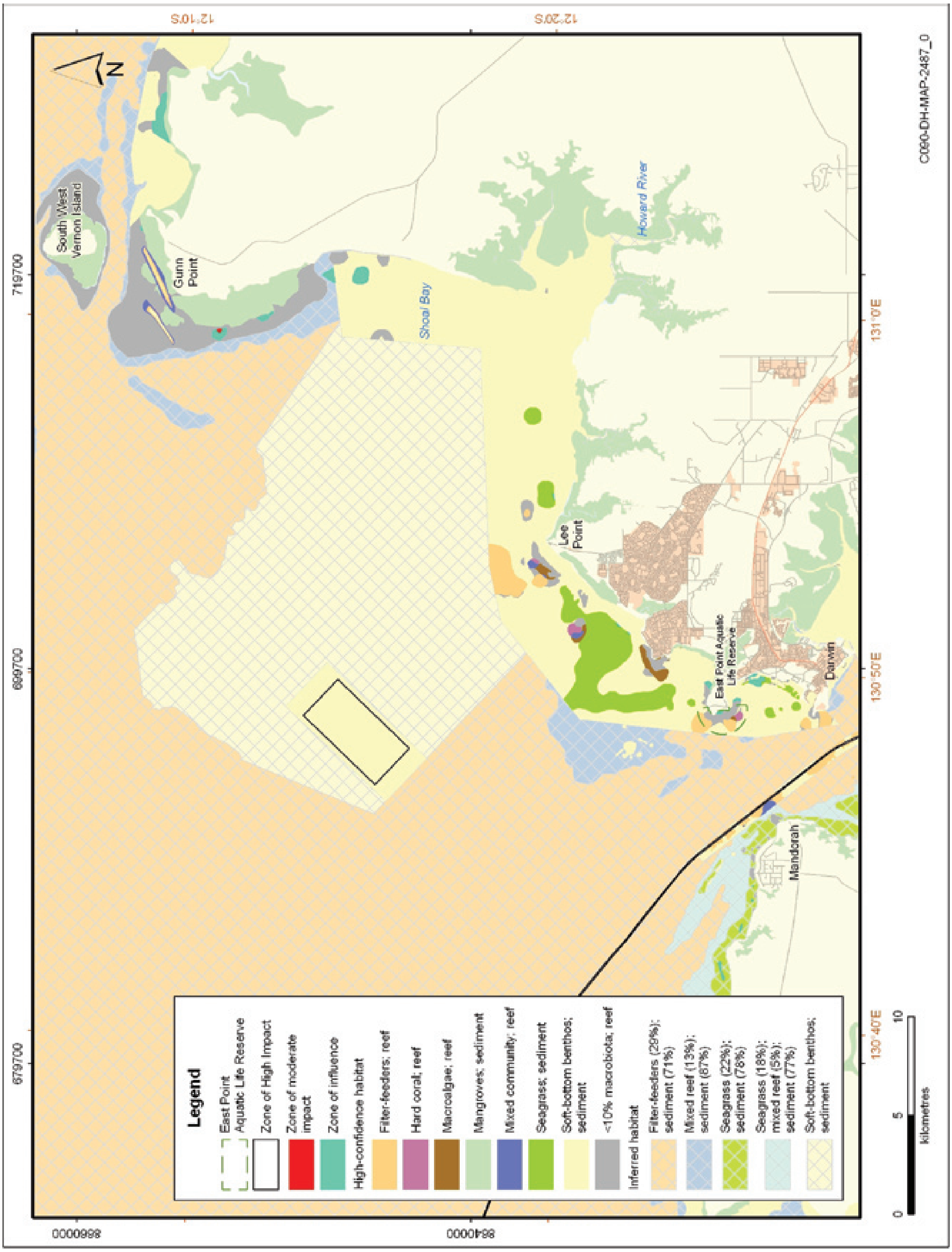


Figure 4-13: Zones of impact and influence from spoil-disposal-generated sedimentation for Phase 5

Note that these zones of impact and influence from spoil-disposal-generated sedimentation for Phase 5 are based on dry-season thresholds and wet-season modelling conditions sediment. The zones apply to seagrass communities.

Table 4-9: Zones of high impact—benthic community and sediment calculations

Aspect	Habitat type	Seagrass	Hard Coral	Filter-feeder	Macroalgae	Sand	Mud	Gravel
Direct/ high impact—spoil ground	Gravel							0.0
	Mud						0.0	
	Sand					1280.1		
Total inferred area impacted (ha)		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total high-confidence area impacted (ha)		0.0	0.0	0.0	0.0	1280.1	0.0	0.0
Total area (ha)		0.0	0.0	0.0	0.0	1280.1	0.0	0.0
Total as a percentage of surrounding sediment in Shoal Bay		**0.0**	**0.0**	**0.0**	**0.0**	**2.6**	**0.0**	**0.0**
Direct/ high impact—pipeline	Filter-feeders; reef			58.3				
	Mixed community; reef		0.6	1.3	0.3			
	No macrobiota (<10%); reef							
	Inferred; filter-feeders (29%); sediment (71%)			22.3				
	Inferred; mixed reef (13%); sediment (87%)		0.0	0.0	0.0			
	Gravel							54.3
	Mud						20.2	
	Sand					69.9		
Total inferred area impacted (ha)		0.0	0.0	22.3	0.0	0.0	0.0	0.0
Total high-confidence area impacted (ha)		0.0	0.7	59.6	0.4	69.9	20.2	54.3
Total impact area (ha)		0.0	0.7	81.9	0.4	69.9	20.2	54.3
Total as a percentage of community type in Darwin Harbour		**0.0**	**0.2**	**1.0**	**0.1**	**2.8**	**0.1**	**1.0**
Direct/ high impact—East Arm dredging	Filter-feeders; reef			66.0				
	Mixed community; reef		3.7	7.2	2.0			
	No macrobiota (<10%); reef							
	Inferred; filter-feeders (29%); sediment (71%)			0.0				
	Inferred; mixed reef (13%); sediment (87%)		0.0	0.0	0.0			
	Gravel							45.6
	Mud						42.9	
	Sand					86.7		
Total inferred area impacted (ha)		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total high-confidence area impacted (ha)		0.0	3.7	73.2	2.0	86.7	42.9	45.6
Total impact area (ha)		0.0	3.7	73.2	2.0	86.7	42.9	45.6
Total as a percentage of community type in Darwin Harbour		**0.0**	**0.9**	**0.9**	**0.8**	**3.4**	**0.1**	**0.8**

Mixed community; Reef = No macrobiota 47%:hard coral 15%: Filter-feeders 29%: Macroalgae 8%

Table 4-10: Zones of moderate impact—benthic community calculations

Aspect	Habitat type	Seagrass	Hard coral	Filter-feeder	Macroalgae
Sedimentation (>15 mm)					
East Arm dredging	Mixed community; reef; Subtidal		0.06	0.12	0.03
	No macrobiota (<10%); reef; Intertidal				
	Filter-feeders; reef			0.47	
	Sediment				
	Inferred; Filter-feeders (29%); sediment (71%)			0.42	
	Inferred; Mixed reef (13%); sediment (87%)		0.12	0.22	0.06
Spoil disposal	No macrobiota (<10%); reef				
Total inferred area impacted (ha)		0.00	0..12	0.64	.06
Total high-confidence area impacted (ha)		0.00	0.06	0.59	0.03
Total impact area from sedimentation (ha)		0.00	0.18	1.24	0.09
Total as a percentage of community type in Darwin Harbour		0.00	0.04	0.02	0.04
Suspended sediment					
East Arm dredging	Filter-feeders; reef			135.43	
	Hard coral; reef		38.32		
	Macroalgae; reef				
	Mixed community: reef		19.60	37.90	10.46
	No macrobiota (<10%); reef				
	Sediment				
	Inferred; Filter-feeders (29%); sediment (71%)			57.92	
	Inferred; Mixed reef (13%); sediment (87%)		0.62	1.21	0.33
Spoil Disposal	No macrobiota (<10%); reef				
Total inferred area impacted (ha)		0.00	0.62	59.13	0.33
Total high-confidence area impacted (ha)		0.00	57.92	173.33	10.46
Total impact area from suspended sediment (ha)		0.00	58.54	232.46	10.79
Total as a percentage of community type in Darwin Harbour		**0.00**	**13.61**	**2.94**	**4.37**

Mixed community; reef = no macrobiota 47%:hard coral 15%: filter-feeders 29%: macroalgae 8%.

*There are no benthic habitats expected to receive impacts associated with suspended or accreted sediment from spoil disposal with the exception of small areas of reef (4.5 ha) with low (<10%) macrobiota reef; no significant benthic biota cover has been recorded for this habitat type and therefore no areas of biota appear in the table or are included in impact calculations.

Table 4-11: Zones of influence—benthic community calculations

Aspect	Habitat type	Seagrass	Hard coral	Filter-feeder	Macroalgae
Sedimentation (3–14 mm)					
East Arm dredging	Mixed community; reef		0.04	0.09	0.02
	No macrobiota (<10%); reef				
	Seagrass	8.63			
	Filter-feeders			0.42	
	Inferred: filter-feeders (29%); sediment (71%)			0.23	
	Inferred: mixed reef (13%); sediment (87%)		0.35	0.68	0.19
Spoil Disposal	Seagrass	32.39			
	No macrobiota (<10%); reef				
	Macroalgae				0.00
	Hard coral		0.38		
	Inferred: seagrass (22%); sediment (78%)	4.49			
	Inferred: mixed reef (13%); sediment (87%)		0.54	1.04	0.29
Total inferred area influenced (ha)		4.49	0.89	1.95	0.48
Total high-confidence area influenced (ha)		41.02	0.42	0.50	0.02
Total area influenced by sedimentation (ha)		45.51	1.31	2.45	0.50
Total as a percentage of community type in Darwin Harbour		**1.81**	**0.30**	**0.03**	**0.20**
Suspended sediment					
East Arm dredging	No macrobiota (<10%); reef				
	Inferred; Seagrass (22%); sediment (78%)			40.01	
	Inferred; Mixed reef (13%); sediment (87%)		0.31	0.59	0.16
Spoil ground	Filter-feeders; reef			3.42	
	Mixed community: reef		0.98	1.90	0.52
	No macrobiota (<10%); reef				
	Inferred; filter feeders (29%); sediment (71%)			179.38	
Total inferred area influenced (ha)		0.00	0.31	219.99	0.16
Total high-confidence area influenced (ha)		0.00	0.98	5.32	0.52
Total area influenced by suspended sediment (ha)		0.00	1.29	225.31	0.69
Total as a percentage of community type in Darwin Harbour		**0.00**	**0.30**	**2.85**	**0.28**

Mixed community; reef = no macrobiota 47%:hard coral 15%: filter-feeders 29%: macroalgae 8%.

4.1.3.11 Benthic habitat risk assessment

Sections 7.3.2 and 7.3.3 in Chapter 7 *Marine impacts and management* of the Draft EIS present impact assessments and residual risk to benthic communities from dredging and spoil disposal activities respectively. The inclusion of substantially more data from benthic habitat surveys into habitat mapping presented in the above section has allowed for the following revised benthic community impact and risk assessment. Additional information on potential wider impacts to Darwin Harbour such as impacts to trophic structures and endemic benthic species, as well as potential for recruitment of soft-sediment fauna is also discussed in this section.

- *Hard coral*: The tables of impact areas in Section 4.1.3.10 include areas where zones of high and moderate impact overlie hard-coral communities. Around 4.4 ha of coral communities (high confidence and inferred) is predicted to lie within the zone of high impact. A total of around 59 ha of hard coral (high-confidence and inferred) is predicted to lie within the zone of moderate impact; this represents a total of around 14% of the hard-coral areas (high confidence and inferred) in Darwin Harbour. The total area of coral predicted to fall within high and moderate zones of impact represent around 15% of the total coral community area in Darwin Harbour. This percentage, which has been based on the conservative development of zones of impact (Section 4.1.3.6), for the most part represents those coral communities at South Shell Island and North East Wickham Point which will be the focus of a coral monitoring program to examine the response of these corals to sediment related impacts. As stated earlier, the greater part of the 15% is made up of the Zone of Moderate Impact and therefore represents areas in which the habitat and substrate is not permanently modified or removed, therefore providing opportunity for recovery. It should also be noted that calculations based on Phase 4 (which represents typical conditions throughout the dredging program) indicate that only around 2% of coral communities may be impacted; the 15% is therefore considered a highly conservative estimate. A long-term impact on Darwin Harbour coral communities or associated ecological function in the Harbour is considered unlikely; see the discussion below regarding biodiversity, trophic structure and recovery.
- *Filter-feeders*: The tables of impact areas in Section 4.1.3.10 include areas where zones of high and moderate impact overlie filter-feeder communities. Around 2% of filter-feeder communities (high-confidence and inferred) in Darwin Harbour are expected to be impacted by dredging, spoil ground and pipeline footprints (i.e. zones of high impact). Potential impacts to filter-feeders from suspended sediment within the zone of moderate impact may affect around 3% of the filter-feeder communities in the Harbour. As discussed earlier, effects from sedimentation are unlikely; at sedimentation levels as low as 3 mm (over 4 years), only around 0.03% of the filter-feeder communities in Darwin Harbour would experience sedimentation. Combining zones of moderate and high impact for filter-feeders yields an approximate 5% of the Harbour filter-feeder communities at risk. Given this small percentage, the low risk to Harbour-wide trophic systems and the opportunity for recovery in areas of moderate impact, the risk to these communities (or to the systems that these communities belong to) is considered low.
- *Seagrass*: The tables of impact areas in Section 4.1.3.10 include areas where zones of high and moderate impact overlay seagrass communities. No areas of seagrass fall within zones of high impact (i.e. within the development footprint or in immediately adjacent areas) and similarly no areas are predicted to experience sedimentation or SSC elevations above the seagrass thresholds.

  Under the seagrass sedimentation threshold (i.e. from 3 to 14 mm), approximately 1.8% of (high-confidence and inferred) seagrass areas are predicted to experience sedimentation; however, as mentioned in Section 4.1.3.8 these areas do not fall within areas of impact or influence for suspended sediment and so there are no impacts predicted to result from the cumulative effects of elevated sedimentation and suspended solids associated with dredging and spoil disposal. There are therefore no significant impacts to seagrass from dredging or spoil disposal activities predicted.
- *Macroalgae*: The tables of impact areas in Section 4.1.3.10 include areas where zones of high and moderate impact overlie macroalgal communities. Only small areas of macroalgae may be impacted by dredging and spoil disposal; this represents less than 1% of the Harbour's macroalgal communities within the zone of high impact, and less than 5% in the zone of moderate impact. Given the small percentages, the low risk to Harbour-wide trophic systems, and the opportunity for recovery in areas of moderate impact, the risk to these communities (or to the systems that these communities belong to) is considered low.

- *Infauna and epifauna*: Infaunal and epifaunal communities and habitat will be directly impacted within areas of the dredging footprint, pipeline and spoil disposal ground. Table 4-9 shows that very limited proportions of available sediment areas in Darwin Harbour and Shoal Bay will be impacted. It is assumed that infaunal and epifaunal communities are likely to be correlated closely with grain size and, therefore, given that relatively small areas of sediment (of each grain-size class) will be impacted and the likelihood of recovery (discussed below), the risk to infauna and epifauna is considered low.

Potential for impact to localised or endemic benthic species

Darwin Harbour is colonised by a diverse range of marine invertebrates, potentially numbering more than 3000 species. It is estimated that approximately 80% of the seafloor of Darwin Harbour is made up of soft sediments. Generally, foraminiferans, polychaete worms, crustaceans and molluscs were found to be the dominant taxa throughout the soft-bottom habitats. Sediment grain size, water depth, seabed exposure and sediment mobility were all factors identified to influence the invertebrate fauna community composition. The particle size distribution map (see Figure 4-5) shows how Darwin Harbour exhibits a patchy distribution of grain sizes and hence a mosaic pattern colonised by a range of soft-sediment invertebrate fauna communities.

High invertebrate fauna species diversity was identified in mangrove sediments and their adjacent intertidal mudflats and subtidal hard substrates colonised by epifaunal filter-feeding communities. The lowest invertebrate fauna is likely to exist in the frequently reworked coarse sediments of the scour zones of the channels of Darwin Harbour.

Deeper hard substrates (below the photic zone) support filter-feeding communities such as sponges and soft corals. The diversity of sponge species in Darwin Harbour has currently been listed as 56 species and the number of soft-coral species is estimated as 20 to 25 (Smit 2003). Fromont, Vanderklift and Kendrick (2006) reviewed existing studies on sponges in tropical Australia and highlight high species diversity in these waters with over 600 species recorded.

It has been noted that the species described from Darwin Harbour exhibit biogeographical affinities representative of the Dampierian Province of the Indo-West Pacific, and also considerable species overlap with the Dampier Archipelago in Western Australia. Combined with the fact that many benthic species have dispersive planktonic larval stages, the data available indicate that localised distributions or endemism of species/populations in Darwin Harbour are unlikely.

Recolonisation and recovery

In relation to the recovery or recolonisation of disturbed areas or new habitats (such as the pipeline route rock-armour), the benthic invertebrate fauna literature review identified a number of key factors which indicate high rates of recolonisation or recovery from disturbance or altered habitat should occur in Darwin Harbour.

Invertebrate fauna of tropical ecosystems, when compared with temperate invertebrate fauna, are generally more adapted to extreme environmental conditions and rapidly changing conditions. Such factors include high temperatures in intertidal regions, seasonal monsoonal freshwater inflow, low and patchy food supply, fluctuations in salinity and sediment load spikes. Cyclones also cause significant disturbance through severe wave action causing scouring and large-scale sedimentation, storm surges and significant freshwater inflow. Faunal communities exposed to these extreme environmental variations commonly experience seasonal mortality and changes in community structure (Alongi 1989). These environmental conditions often lead to a suite of species dominated by opportunistic species with adaptive strategies to respond quickly to erratic environmental changes and provide a level of resilience to the ecosystem. Assemblages made up of species that exhibit such resilience and are able to colonise changing and unstable habitats are considered the least vulnerable in the ecosystem (Alongi 1989).

Other studies from around the world that have demonstrated the re-establishment of soft-bottom benthic communities within disturbed soft-sediment areas include Bolam et al. (2010), Dernie et al. (2003), Evans et al. (1998), Newell, Seiderer and Hitchcock (1998), Ray (2000), Ray et al. (1994) and Somerfield et al. (2006).

Owing to the patchy nature of habitats in Darwin Harbour (see Figure 4-5 and Figure 4-6) and extensive areas that will remain undisturbed (see Table 4-9, Table 4-10 and Table 4-11), there will remain a large repository of organisms for recolonisation. Also, the planktonic larval stages of many invertebrate fauna species enable a high rate of dispersal. Wilson (1998) monitored soft-substrate fauna recolonisation in Botany Bay throughout a dredging program. The results of this monitoring found that dredging had altered some habitats, resulting in different faunal compositions. However, it was noted that functional relationships in an ecosystem can be preserved even if the species composition changes. This is also consistent with the findings of Metcalfe (2007), who found that invertebrate diversity and abundance in the mangrove communities in Darwin Harbour did not decline in response to moderate levels of anthropogenic disturbance.

Studies documenting recovery of filter-feeder communities after impact are generally scarce. However, information on selected sponge species indicates that they have a high capacity to adapt to changing and stressful conditions and recover quickly (Carballo 2006; Rützler; Duran & Piantoni 2007). This high recovery capacity is partly attributable to their primitive level of organisation that gives them more plasticity and adaptation potential. Some species of sponges have also been reported to adapt to a sedimentation regime by changing their morphology to prevent sediment settlement (Carballo 2006).

During the Pluto LNG Project in Western Australia, sponge coverage was documented along a transect using photography. Transects were recorded in 2006 before dredging commenced and after an intensive dredging campaign in 2008 and then in 2009. Declines in sponge cover were noted after the initial intense dredging phase but considerable recovery of sponge density was evident in the later surveys. Recovery was predominantly a result of sponges clearing sediment loads which had obscured them in the August 2008 survey with some regrowth or at least spatial extension of sponges to near their original size (DSD 2010).

As previously discussed, the particle size distribution map and the benthic habitat map of Darwin Harbour (see Figure 4-5 and Figure 4-6) shows distinct patches of hard – and soft-substrate and grain-size distributions throughout the Harbour. This means that soft and hard substrates and their associated invertebrate fauna also exhibit patchiness and their interconnectivity is potentially subject to interruption by disturbances.

The loss of areas of habitat or populations can affect the interconnectivity of the whole ecosystem. The major factors determining the severity of the effect are the number of patches lost in relation to their total number and the distance between the remaining patches.

The most severe impact on soft-substrate habitats may not be loss of habitat but the loss of its colonising fauna. Generally the severity of this impact must be judged in the context of the total available habitat colonised by such communities. An assessment of this situation based on superimposing impact footprints and pressure fields over a habitat map shows that there will be losses in the Harbour. The extent of soft substrates throughout the Harbour can be judged as substantially larger than affected areas (see Table 4-9) thus providing a repository of organisms for recolonisation. Such a repository helps maintain connectivity and facilitates recovery. It is therefore likely that the functions these communities fulfil are being preserved.

A three-year study investigating the effects of dredge material deposition in the Pearl River Estuary, Hong Kong challenges the view that tropical and subtropical faunal communities recover more rapidly than temperate ones. In this study three sites of different disturbance levels were monitored with the result that recovery at three sites varied between one and four years. Recovery at the most stable, undisturbed site was slower than at the more disturbed locations. The authors conclude that it seems likely that the frequency of disturbance, instead of latitude, is the major determinant for benthic recovery time. Moreover, the high concentration of suspended solids at the study site (100 mg/L at low tides), thought to have adverse effects on colonisation, could also have contributed to the slow recovery in the study area (Qian et al. 2003). A comparison of recovery periods for spoil disposal grounds at different locations and under different conditions, with recovery time spans varying between three months and over 2½ years, supports the finding that shallow disturbed sites recover faster than stable, deep sites.

Filter-feeder communities are an important element in the local ecosystem and are present in impact areas but there is insufficient information to establish thresholds that apply to them. However, the information presented indicates that significant potential for recovery from disturbance exists and has been documented in other similar cases of dredging programs.

Some areas of the Ichthys Project, such as the turning basin and berthing pockets will continue to experience some levels of disturbance, through propeller wash and maintenance dredging. Some recolonisation of these areas is anticipated, however with ongoing disturbances, the species diversity and abundance would be anticipated to be lower than other recolonised areas. However, as this area represents only a small percentage of available habitat (see Table 4-9), this is not anticipated to result in any significant impacts to trophic systems or interconnectedness of habitats in Darwin Harbour.

One of the impact areas of the Project development area that is likely to suffer loss of fauna is the offshore spoil disposal ground. It is a likely scenario that material released at the offshore spoil disposal ground will accumulate in mounds, creating a hummock-like topography. Benthic fauna smothered in that way are unlikely to survive. Studies investigating the recovery of spoil disposal ground fauna indicate that recolonisation from adjacent areas begins soon after the impact occurs (Birklund & Wijsman 2005; Bolam & Rees 2003; Cruz-Motta & Collins 2004). An uneven distribution of dredge material appears to enhance this process by preserving unaffected patches within the spoil disposal ground from which recruits can be sourced. In addition, a faunal community that is characterised by small opportunistic deposit-feeders, like those that are often dominant in infauna communities of tropical soft sediments (Alongi 1989), is pre-adapted to rapid recolonisation. A study of the recovery of the faunal community at a spoil disposal ground in Cleveland Bay (North Queensland) documents initial reduction in abundance and diversity followed by an unexpectedly rapid recovery within three months of the cessation of the disturbance (Cruz-Motta & Collins 2004). Generally, recovery in disturbed, shallow environments is thought to be faster than in stable, deep environments. This is mainly attributable to the pre-adaptation of the resident fauna to disturbances and its adaptive response (Bemvenuti, Angonesi & Gandra 2005).

Potential impacts to biodiversity and trophic structure

Links between biodiversity and ecosystem function are difficult to demonstrate and quantify, yet the notion that higher levels of diversity safeguard the loss or damage of ecosystem functionality is well accepted (Barrio Froján et al. 2009). As discussed earlier the potential for endemic fauna is low reducing the potential for species extinction. In addition environmental stress is generally greater in the tropics resulting in greater recovery and recolonisation ability.

In terms of biodiversity-enhancing functions, complex habitats such as filter-feeder communities that provide a three-dimensional structure and harbour many small cryptic invertebrates are of particular significance in maintaining biodiversity levels. Other species-rich habitats are mangroves that sustain diverse groups of detritivores and their predators, and intertidal flats that provide nutrient-rich food resources. A reduction of these habitats may contribute disproportionately to the loss of biodiversity.

Although it is not likely that anticipated disturbances will cause local extinctions and the complete loss of certain habitat types in the development area because the assessment suggests that there is a sufficient remaining habitat area that will not be severely impacted, species that occur in low numbers in a rare patchy distribution pattern may be vulnerable and changes to abundances and faunal compositions may be observable at least in the intermediate time frame after impact. A post-dredge monitoring study at Botany Bay for example, reported that dredging had changed the benthic fauna composition in the order of 20% (Wilson 1998).

The trophic structure is one of the most important elements of the marine ecosystem because many of the known massive changes or phase shifts in ecosystems have been caused by changes in the trophic structure. Well known are those caused by overfishing where top predators are removed. The effect then cascades down the food chain and the outcome is not necessarily easy to predict because food webs can be quite complex and their interactions poorly understood.

When discussing a benthic system it is appropriate to choose a bottom-up approach, with benthic organisms on the bottom, and higher order consumers and predators above. A large body of correlative evidence indicates a positive relationship between infaunal biomass and total fish catch on subtropical and tropical shelves (Alongi 1989) supporting a bottom-up approach.

An example of a trophic relationship from Darwin Harbour is the trophic connection between dolphins as upper level predators and invertebrate fauna. Three species of dolphins, snubfin, Indo-Pacific humpback, and the Indo-Pacific bottlenose dolphin live in Darwin Harbour and forage there. An analysis of the diets of snubfin and Indo-Pacific humpback dolphins revealed that their diet consisted of four major taxonomic groups: fish, cephalopods, decapods and bivalves with snubfin dolphins including more benthic invertebrates in their diet than Indo-Pacific humpback dolphins (Parra & Jedensjö 2009). Consequently snubfin dolphins have a more direct dependence on benthic invertebrates but other species with a preference for pelagic species of fish and cephalopods also depend on the productivity that benthic invertebrates provide, albeit indirectly.

This trophic relationship also illustrates the role that biodiversity plays in the trophic structure. Snubfin dolphins had consumed a variety of 24 different fish taxa, in addition to several cephalopods and decapods that had not been identified. Sixteen different fish taxa and few unidentified cephalopods and bivalves were found in Indo-Pacific humpback dolphin stomachs (Parra & Jedensjö 2009). The diverse array of invertebrates that convert detritus into biomass clearly sustains a far reaching trophic relationship. Substantial changes on such invertebrate communities can therefore have an effect on upper trophic levels.

Because of the patchy habitat distributions and interconnectedness, reproductive strategies, naturally highly variable environments and related presence of opportunistic species and predicted levels of disturbance, it is anticipated that the benthic invertebrate communities including infauna, epifauna and filter-feeding communities would not be impacted to an extent which would result in a loss of biodiversity, ecosystem function or impacts on other trophic levels in Darwin Harbour.

The benthic invertebrate fauna literature review (Technical Appendix S1 in this EIS Supplement) supports the conclusion that tropical benthic ecosystems exhibit a greater resilience and recovery potential than comparable temperate ecosystems. The benthic fauna appears to be characterised by many forms that are adapted to stressful environments. Some groups such as sponges and soft corals, for example, have multiple reproductive modes that allow them to re-establish themselves and multiply quickly after disturbance. Soft substrates are colonised by opportunistic deposit feeders, the same functional group that is characteristic for pioneering communities. This situation facilitates fast recolonisation after disturbances. Sessile assemblages may also be naturally adapted to seasonal stress, such as the impact of wet season run-off and increased sediment suspension and deposition. Such communities often have a dynamic structure that can react to erratic stressful events with a "growth and retract" response. The presence of species and communities with such resilience and recovery potential buffers the ecosystem against impacts and helps maintain a functional trophic structure.

Based on this and other information presented in the benthic invertebrate fauna literature review (Technical Appendix S1) INPEX contends that the residual-risk level of "medium" ascribed to dredging and dredge spoil disposal is appropriate as it is considered that none of the aspects assessed has the potential to cause impacts of greater consequence than "minor" (as defined in Row E of Table 6-3 of Chapter 6 *Risk assessment methodology* of the Draft EIS).

4.1.4 Nearshore benthic community and habitat monitoring

In Table 11-5 of Chapter 11 *Environmental management program* of the Draft EIS, INPEX committed to a monitoring program to document the effect of increased sedimentation on soft-bottom benthos communities in zones potentially impacted by dredging. INPEX notes that the purpose of this monitoring program was not clearly stated in the Draft EIS. The program is not intended to be reactive (i.e. with monitoring results potentially triggering management actions); rather, the purpose is to determine whether the abundance and diversity of benthic species at the completion of dredging are measurably different from those at the sites prior to dredging.

As discussed in the benthic invertebrate fauna literature review prepared for INPEX by AECOM Australia (see Technical Appendix S1), there is a large volume of published literature that demonstrates infauna and epifauna should recolonise soft-bottom substrates that have received additional sedimentation above background levels, particularly given the low rates of sediment accumulation anticipated from INPEX's dredging program. Therefore, it is considered unwarranted to attempt to conduct a monitoring program to determine "the maximum amount of sedimentation that infauna can tolerate before adverse effects are seen". This would require separate studies to be undertaken on each of the components of the benthic infauna community to establish their tolerances.

The actual monitoring methodologies will be refined and presented in greater detail during the preparation of the final dredging and dredge spoil disposal monitoring plan (see the provisional plan included as Annexe 6 to Chapter 11 of the Draft EIS), which will occur in consultation with the regulatory authorities and will require regulatory approval prior to the commencement of dredging.

4.1.5 Walker Shoal

4.1.5.1 Studies undertaken

In response to comments received on the Draft EIS, INPEX conducted more detailed investigations of the benthic communities present on Walker Shoal. The survey report is included as Technical Appendix S6 in this EIS Supplement.

The top of Walker Shoal is at a depth of approximately 5 m below LAT and slopes gradually down to a depth of around 11 m below LAT, where the rock slopes meet the surrounding soft sediments. The rock slopes of the shoal are quite broken and no steep changes in topography were noted during the survey.

Biota cover at the bases of the slopes was quite low (<10%), gradually increasing with decreasing depth to approximately 25% at about 7 m below LAT. Between this depth and the top of the shoal, biota cover was very patchy and diverse. Sponges of various growth forms, and soft corals (including gorgonian fans and whips), were visually dominant. Crinoids (feather stars) were common, typically occurring on the fronds of sea fans, and scattered bryozoans (lace corals), hydroids and ascidians (sea squirts) were also present.

4.1.5.2 Impact assessment

To place filter-feeder communities at Walker Shoal into context with those occurring elsewhere in the Harbour, investigations were undertaken at three other locations on the western side of the Harbour—Stevens Rock, Plater Rock and Kurumba Shoal. The investigations concluded that filter-feeder communities of Walker Shoal were represented at similar densities and diversities at these locations which are beyond the predicted zones of influence from dredging and spoil disposal.

Samples of the most commonly occurring biota on each of the transects at each of the locations were collected for taxonomic identification. The sponge taxa were distributed as follows:

- 17 taxa (nominal species) at Walker Shoal, seven of which were also collected at the western locations (where a further 26 taxa of sponges were collected).
- 21 taxa at Stevens Rock, five of which were also collected at Walker Shoal and 13 of which were also collected at the other western locations.
- 15 taxa at Plater Rock, four of which were also collected at Walker Shoal and 13 of which were also collected at the other western locations.
- 20 taxa at Kurumba Shoal, four of which were also collected at Walker Shoal and 16 of which were also collected at the other western locations.

For the soft corals:

- Six taxa of sea whips were collected at Walker Shoal, all except one of which were also collected from the western locations. Three or four taxa of sea whips were collected at each of the western locations.
- One taxon of sea fan was collected at Walker Shoal. This was also collected at two of the western locations (where a further six taxa of sea fans were collected). Five sea fan taxa were collected at Kurumba Shoal; two taxa were collected at each of Stevens Rock and Plater Rock.
- Three taxa of *Dendronephthya* soft corals were collected at Walker Shoal. One of the three was also collected at two of the western locations (where a further seven taxa were collected). Four taxa of *Dendronephthya* were collected at each of Plater Rock and Kurumba Shoal. None were collected at Stevens Rock, indicating that they were not a dominant part of the community on any of the transects.

From the foregoing analysis, it is apparent that while 13 taxa (10 sponges, one sea whip and two *Dendronephthya* soft corals) were collected at Walker Shoal but not at the western locations, the number of taxa collected at Walker Shoal was similar to those at the western locations. It must be noted that the composition of the communities were extremely variable between transects at each location and the absence of a taxon from the specimens collected at any location does not indicate its absence from that location. Rather, it indicates that it was insufficiently common on the transects for it to be collected. It should also be recognised that while different species may occur at different locations, if diversity and abundance are similar then the ecological function of the communities would be expected also to be similar.

Further information on the communities present at the four locations will be available once analysis of the video records from the survey, and identification of the samples collected, are complete. This will be available well in advance of the commencement of construction.

Removal of Walker Shoal will represent the loss of only 0.07% of the hard substrate (within the equivalent depth range) that is known or inferred to be present in Darwin Harbour (see Section 4.1.3.10). From the survey described above, it is considered that the ecological function of the Walker Shoal benthic community is likely to be similar to that of at least three other shoals and rocks on the western side of the Harbour (beyond the predicted influence of plumes from the dredging and spoil disposal operations). Hence it is considered that, in accordance with Table 6-3 in Chapter 6 of the

Draft EIS, the appropriate "consequence" ranking for the removal of Walker Shoal is "minor" ("loss of ecological diversity on a local scale … community, habitats and species well represented regionally"). This is consistent with the impact assessment presented in Table 7-29 of Chapter 7 *Marine impacts and management* of the Draft EIS.

4.1.6 Gunn Reef Blue Holes

4.1.6.1 Studies undertaken

In November 2010, Gunn Reef was included in the flight path for an aerial survey of intertidal habitats between Darwin Harbour and Adam Bay (see Technical Appendix S6 in this EIS Supplement).

The following investigations were subsequently undertaken in the Northern Blue Hole (NBH) of Gunn Reef:

- Water physico-chemical profiles, coral communities and seafloor characteristics (including collection of sediment samples), in December 2010 (see Technical Appendix S4 in this EIS Supplement).
- Water currents and turbidity, between December 2010 and January 2011 (see Technical Appendix S4).
- Bathymetry of the seafloor, in December 2010 (see Technical Appendix S6).

Water physico-chemical profiles and investigations of coral community characteristics were also undertaken in the Southern Blue Hole (SBH), in December 2010 (see Technical Appendix S4).

Water physico-chemistry and oceanography

Profiles were measured through the water column in both the NBH and SBH during a spring tide period in December 2010 (see Technical Appendix S4). Turbidity was typically very low (<2 NTU), with a few higher values recorded (up to 7.8 NTU in the NBH and 17.8 NTU in the SBH), generally at the bottom of the depth profile where seafloor sediments would have been suspended by tidal currents. Some elevations of turbidity in the surface water layers were measured when wind-generated wavelets were observed to be suspending fine sediments from intertidal depositional areas around the margins of the holes.

Turbidity levels in the SBH would be expected to be typically higher than in the NBH as the SBH is flanked by intertidal mudflats, supporting an almost continuous mangrove community around the perimeter. In contrast, the NBH is incised into a rock platform with only isolated areas of sediment deposition.

In the SBH, an eastward flow of water was observed throughout the low-water period. This was fed by clear water flowing off the reef flat to the west of the hole. The strong flow of this water out through the eastern entrance to the SBH prevented the inflow of the highly turbid water that moved through South Channel on the flood tide. Only when clearer waters were at the entrance to the SBH did the flood tide force its way into the SBH.

A turbidity logger was placed in the midst of a coral community on the southern margin of the NBH and an ADCP current profiler was positioned in the middle of the main channel of the NBH between 4 December 2010 and 25 January 2011.

The results from the ADCP and turbidity logger deployments are discussed below.

As shown in Figure 4-14, the dominant current direction is towards the ENE. These ENE flows are also the highest velocity flows. The tidal processes (tidal heights, current speeds and current directions) and associated effects on turbidity are displayed in Figure 4-15, Figure 4-16, Figure 4-17 and Figure 4-18.

Analysis of Figure 4-15 and Figure 4-17 shows that as the tide drops from the peak of the high tide the direction of flow through the NBH is towards the east-north-east. As the tide continues to drop, the current speed towards the east-north-east begins to slow. When the tidal height drops to +0.5 m mean sea level (MSL) the reef sill at the eastern end of the NBH cuts off water flowing eastwards, resulting in a reversal of current direction as the NBH begins to drain to the west-south-west (the sill at the western end of the NBH is slightly lower than the sill at the eastern end). As the tide continues to fall below the +0.5 m MSL, and again as it rises from the low-tide point, the NBH continues to drain at a slow rate (generally <0.25 m/s) towards the west-south-west.

When the NBH is slowly draining towards the west-south-west, the decreasing turbidity readings indicate that suspended sediments are settling out of the water column. NTU readings were generally as low as only 1 or 2 NTU for much of the period that the NBH was draining to the west-south-west. It is this factor that resulted in the name "Blue Holes", with the water turning a rich blue colour as the water clarity increases (as a result of the drop in turbidity).

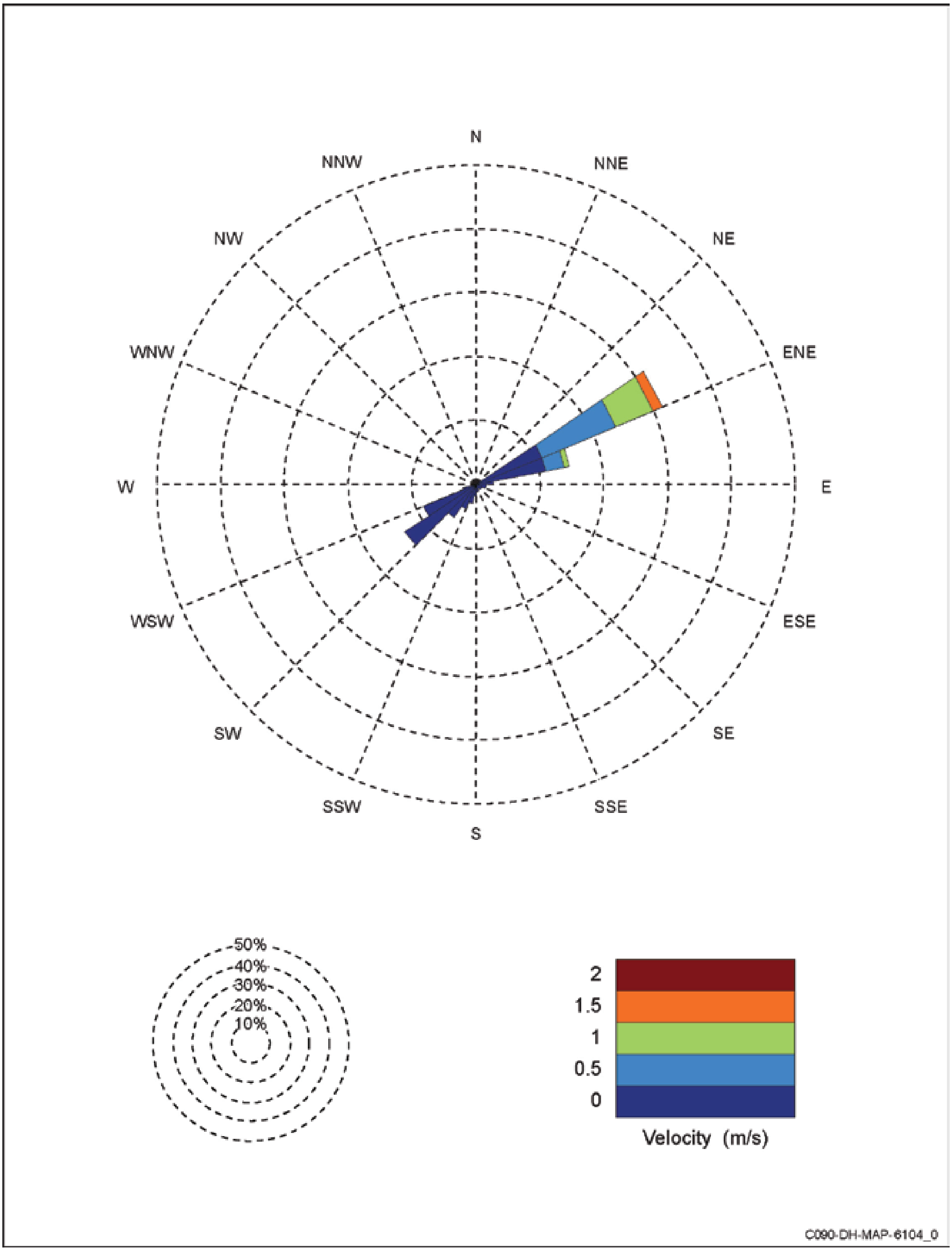


Figure 4-14: Northern Blue Hole current rose

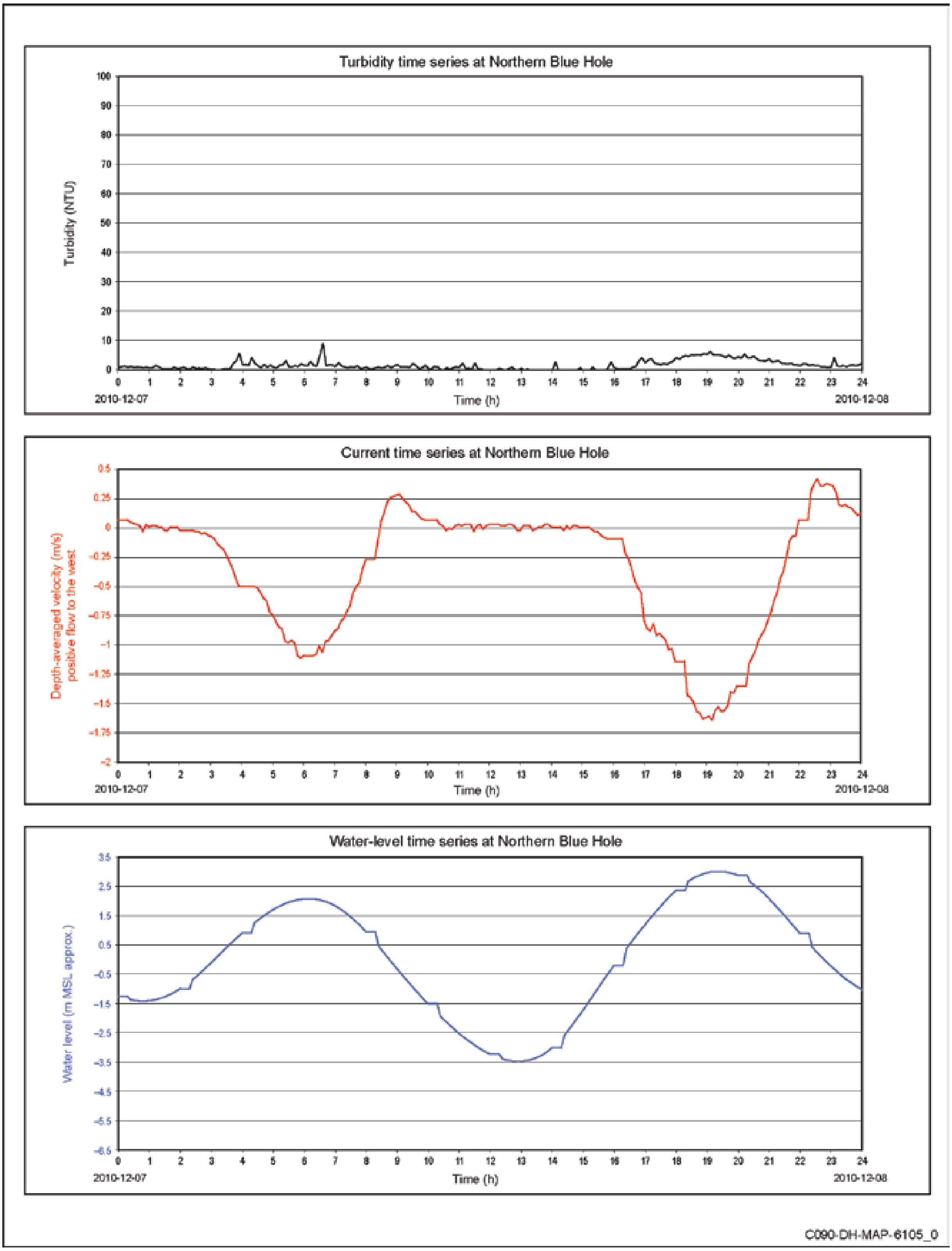


Figure 4-15: Turbidity, current and tide at the Northern Blue Hole—December spring tide

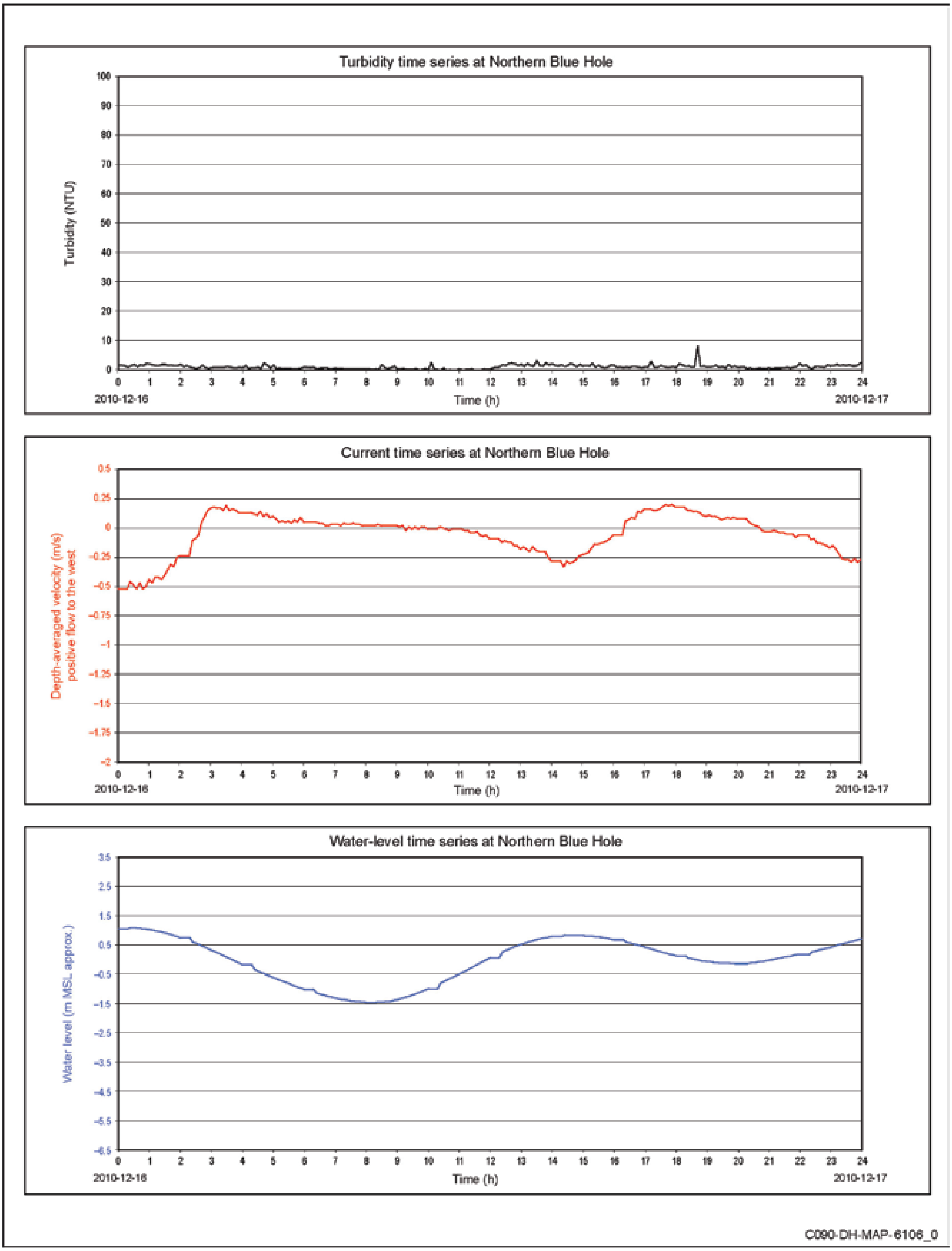


Figure 4-16: Turbidity, current and tide at the Northern Blue Hole—December neap tide

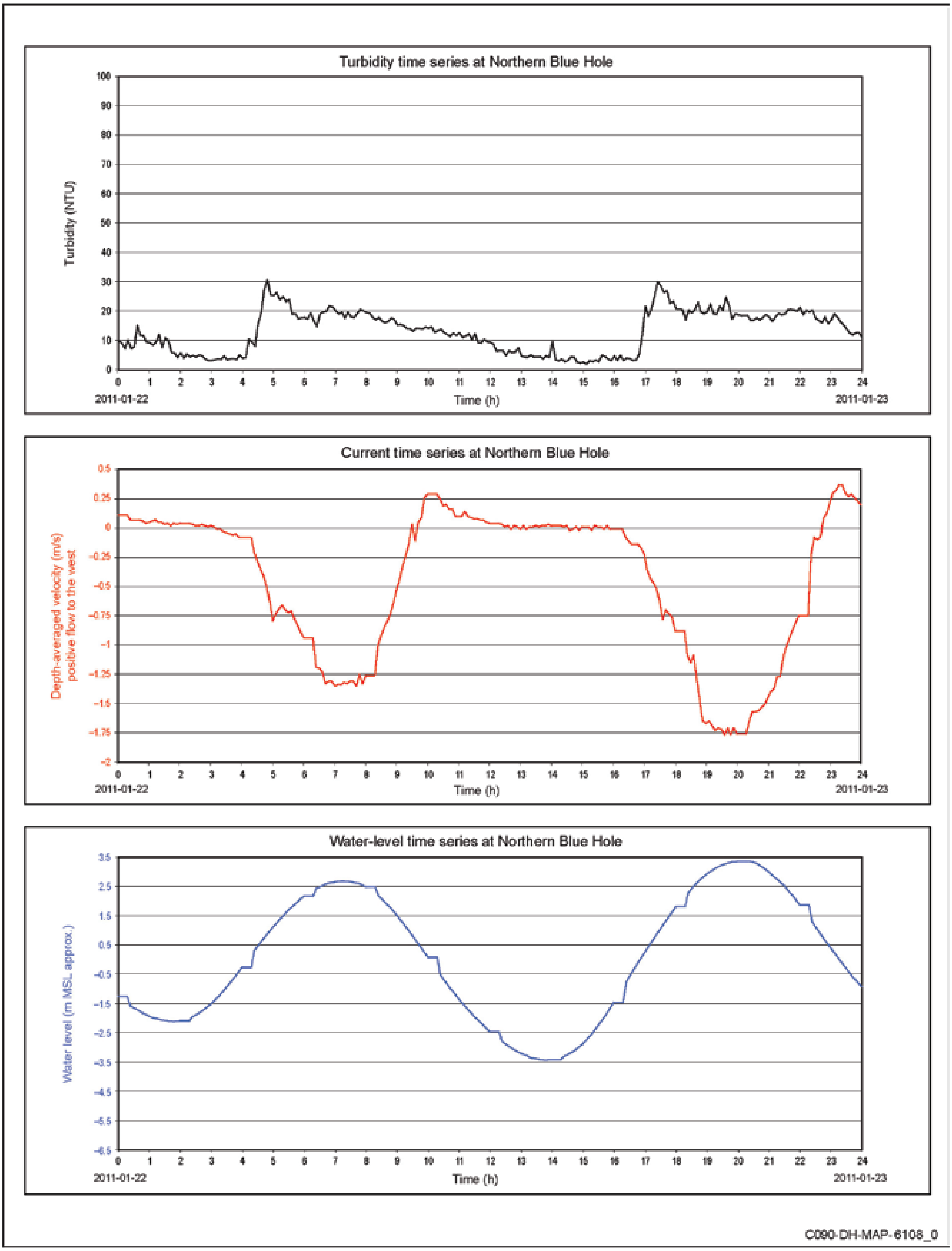


Figure 4-17: Turbidity, current and tide at the Northern Blue Hole—January spring tide

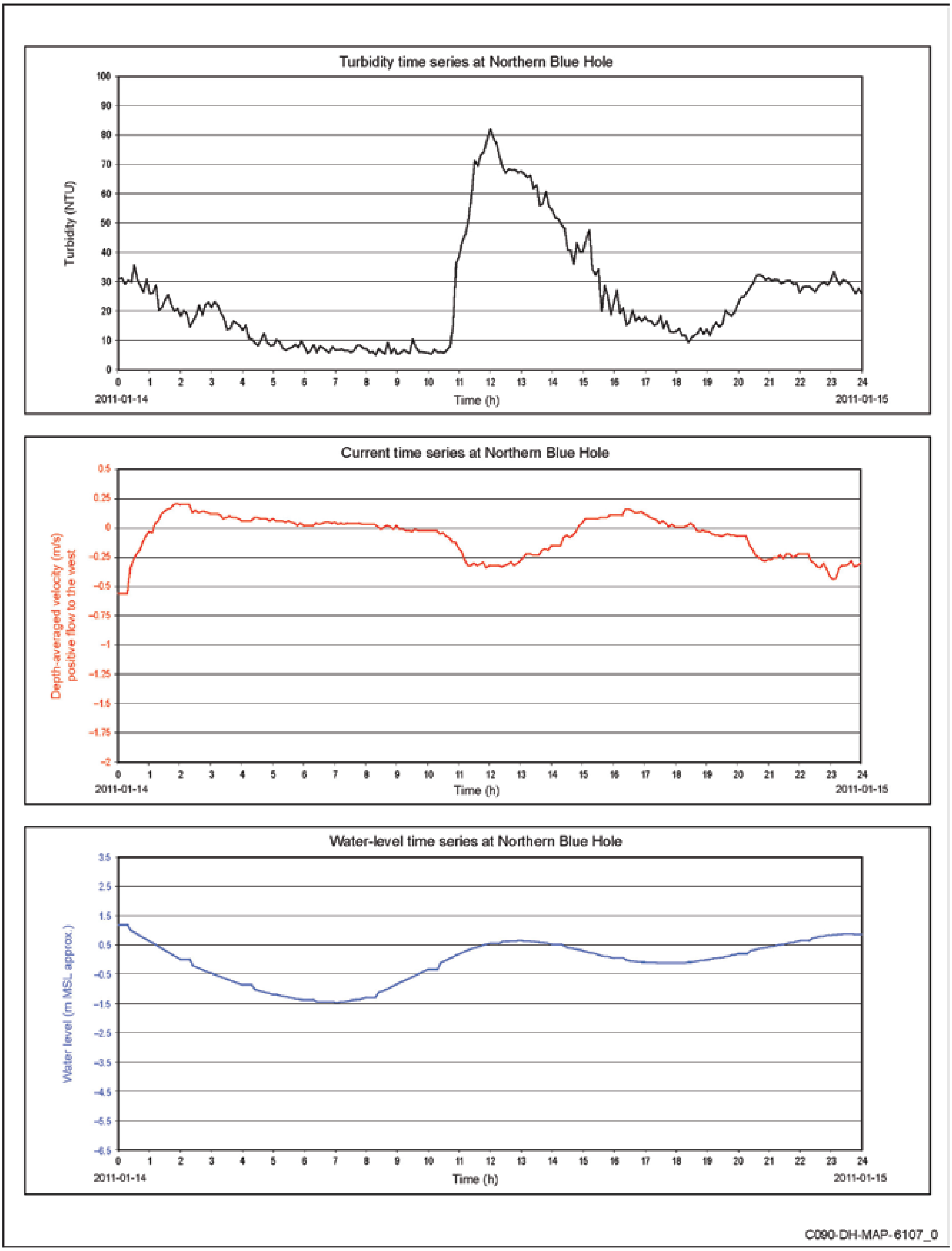


Figure 4-18: Turbidity, current and tide at the Northern Blue Hole—January neap tide

Outside the NBH, the body of high-turbidity water that flows westward through South Channel (between Gunn Reef and South Vernon Island) on the ebb tide is pushed back through South Channel in the early stages of the flood tide. By the time the rising tide reverses the flow through the western entrance to the NBH, the flood-tide waters are less turbid.

Figure 4-15 and Figure 4-17 show marked slack water periods within the main body of the NBH (when there is no specific current direction) which commence approximately five hours after high water, when the ebb tide water flow out over the western sill is reduced and the NBH is effectively isolated from the surrounding waters. They continue until some three hours after low water, when the rising tide overtops the eastern sill, forcing a change in current direction to the east-north-east and a rapid increase in current speed.

Figure 4-15 and Figure 4-17 show that peak flow rates to the east-north-east in December 2010 varied from only 0.25 m/s to 0.5 m/s on rising neap tides, up to 1.75 m/s on rising spring tides. During the rising spring tides, turbidity increased over the period of elevated current speeds, suggesting that the bed shear-stress level had been reached. This would have resuspended, from the seabed, the soft sediments that had settled there during the preceding slack water period. Turbidity peaks were less than 10 NTU during both spring and neap tides in December 2010 (Figure 4-15 and Figure 4-17).

A substantial overall increase in NTU in the NBH was observed from 8 January to 23 January 2011, with representative data presented in Figure 4-17 and Figure 4-18. This coincided with a period of consistent south-west to north-west winds of 15 to 30 knots and large increases in seas and swell in Shoal Bay. This period was a window of sustained monsoonal trough activity which preceded the development of Tropical Cyclone Bianca in the Joseph Bonaparte Gulf and Timor Sea. During this period of elevated sea states similar turbidity cycles were observed, with rises in NTU on the incoming tides and drops in NTU on the lower tides. However, peaks were often 30-50 NTU and reached as high as 80 NTU (Figure 4-18). Rather than resuspension of seabed sediments within the NBH, the elevated turbidity levels were probably indicative of the influx of turbid water from Shoal Bay on the flood tide.

These periods of extended peaks in NTU (values in January 2011 were generally above 10 NTU) would be common during every monsoon season. For example, similar if not higher NTU readings to those recorded in January 2011 would have been expected in the NBH for most of the week around 16 February 2011 that Tropical Cyclone Carlos was located in the Darwin region.

During the dry season, the typical tidal and associated NTU patterns that prevailed between 4 December 2010 and 7 January 2011 (represented by data presented in Figure 4-15 and Figure 4-16) would be expected unless significant sea states occur.

Coral communities

The hard-coral community in the NBH was considerably more highly developed than that in the SBH. Around the perimeter of the NBH, a high cover (60–90%) of tabular and corymbose (short-branching) *Acropora* colonies extended from the edge of the hole as a band some 10–50 m wide on to the reef flat. On the near-vertical walls of the NBH, the *Acropora* cover declined markedly within 2–3 m depth, where foliose and encrusting *Montipora* colonies became dominant, interspersed with sponges and ascidians. As the steepness of the wall decreased (at variable depths around the perimeter of the hole), the slope was made up of coral rubble, upon which was a diverse range of scattered sponges, soft corals (including gorgonian sea whips and fans) and ascidians.

In the SBH, continuous coral cover over distances of more than 10–20 m was mainly limited to the entrance channel at the eastern end of the hole. At the crest of the hole there were scattered massive faviid colonies (mainly *Goniastrea* spp.), some of which were partially bleached. On the upper sections of the near-vertical walls on either side of the entrance channel was a high cover (50–75%) of tabular *Acropora* colonies. Slightly deeper were colonies of foliose and encrusting corals such as *Montipora*, *Oxypora* and *Echinophyllia* at a cover of around 25-50%. Below this zone, the slope became more gradual and rubbly, with scattered sponges, soft corals and ascidians. Within the main body of the SBH, there were limited areas of hard substrate on both edges which supported a low cover (typically 10–25%) of hard coral, predominantly faviid genera (e.g. *Goniastrea*, *Favia*, *Montastrea* and *Caulastrea*). There were also scattered massive (diameters of 1–2 m) *Lobophyllia* colonies, which were observed during the November 2010 aerial survey but not located during the vessel survey when water levels were slightly higher.

The zonation in the coral communities of both the NBH and SBH reflects changes in light levels with depth:

- *Acropora* is one of the faster growing hard-coral genera and typically has a requirement for higher light levels. However, the faster growth rates result in less dense coral skeletons, hence they are susceptible to physical damage and *Acropora* skeletons are a major component of the rubble on the lower slopes and bottom of the NBH.
- At slightly greater depths are corals which adopt more spreading growth habits to enhance light capture (e.g. foliose and encrusting colonies).

Seafloor characteristics

The tow-camera survey undertaken in December 2010 showed the central part of the NBH to be the deepest (approximately 19 m below LAT), with the seafloor progressively shallowing towards both ends. The seafloor was predominantly composed of coral rubble with pockets of sediment.

Three samples of seafloor sediment were collected during the December 2010 water-quality survey. These showed a trend of decreasing proportions of fine sediments (<75 µm diameter) from west to east within the NBH. This suggests that fine particles entering the NBH from the west are carried to the eastern end of the hole before being deposited. It is also possible that the turbulent flood tide flow of water through the western entrance lifts the finer sediment fractions into the water column and carries them towards the eastern end of the hole. The weaker ebb-tide flows (see Figure 4-15 to Figure 4-18) may not be of sufficient strength to remobilise sediments back towards the western end of the hole, hence sediments could be progressively shunted towards the eastern end of the hole on each successive flood tide.

4.1.6.2 Impact assessment

Modelling of the dispersion of sediments from the spoil disposal ground, as presented in Figure 7-29 of Chapter 7 of the Draft EIS, predicted that suspended-sediment concentrations in the order of 5–10 mg/L could occur in the NBH as a result of dredge spoil disposal during Phase 5 of the dredging program. As shown in Figure 4-12 of the EIS Supplement, these levels are insufficiently high for the NBH to be considered to fall within the Zones of Impact or Influence from suspended sediments during the dredging program. That is, it is predicted that there is no potential for measurable impacts upon the receiving environment.

Figure 7-30 of Chapter 7 shows that no sediment deposition of more than 5 mm is predicted to occur in the NBH as a result of dredge spoil disposal at the end of Phase 6 of the dredging program. Figure 4-13 of the EIS Supplement shows that the NBH is considered to fall outside the Zones of Impact or Influence from sedimentation during the dredging program.

As shown in Figure 4-15 to Figure 4-18, strong tidal flows from west to east through the NBH occur for only a limited time in each tidal cycle. This is when the sea level is sufficiently high to reverse the flow of water through the western entrance to the hole, potentially bringing some sediments arising from the spoil ground into the hole. These would be transported rapidly across the coral communities on the walls of the narrow western channel, through the broader expanse of the central sector of the hole and towards the eastern end of the hole. In the latter areas there would be the potential for sediments to settle upon coral colonies around high water, though the bulk would be expected to settle to the deeper floor of the hole. Figure 4-15 to Figure 4-18 show that this will rapidly reduce suspended-sediment concentrations in the water column, increasing light availability for the coral communities fringing the hole and reducing the potential for impact.

4.1.7 Howard River

4.1.7.1 Studies undertaken

In December 2010, water-quality characteristics were investigated at the mouth of the Howard River and in the adjoining Hope Inlet, Hope River and Hope creeks system. Details of the survey are included in Technical Appendix S4 in this EIS Supplement.

At the beginning of December a logger was deployed at the mouth of the Howard River, in a channel to the north of the popular fishing location known as The Rock. The logger collected data over a 10-day period from the middle of a neap-tide phase through the subsequent spring-tide phase. After this time, heavy fouling of the sensors compromised the quality of the data and they were discarded from analysis.

The parameter of chief interest was turbidity, which fluctuated markedly on a diurnal basis. Turbidity tended to increase on ebb tides, reaching brief peaks at low water on each day, when the water depth around the logger was very low. This reflected the movement of turbid water out of the Howard and Hope River systems on ebb tides. On flood tides, the turbid water was displaced by clearer waters from Shoal Bay and turbidity levels dropped to minima around the high-water periods.

Turbidity also varied considerably with the phase of the tidal cycle. Peak turbidity in the mid-neap tidal phase was around 5 NTU; this rose steadily to reach a maximum of almost 160 NTU during the mid-spring phase. Peak turbidities declined again with decreasing tidal range as the next neap-tide phase approached.

On 1 December, a hand-held multiparameter probe was deployed at multiple sites between the logger location and the upper reaches of the Hope River creek system. Variations in turbidity with depth through the water column were only evident at sites in the creeks, where higher levels (up to almost 190 NTU) were recorded close to the seabed. Turbidity levels increased from the Howard River mouth (typically <2 NTU), into Hope Inlet (<5 NTU), and into Hope River (5 to 70 NTU, increasing upstream). Further upstream, in No Hope Creek, turbidity decreased (120 to 35 NTU) as the survey moved into the fresher, slightly cooler waters in the upper reaches of the creek. Filtered water samples for the analysis of suspended-sediment concentration were also collected over a flooding neap tide and ranged from 6 mg/L to 23 mg/L; they indicated suspended-sediment concentrations of the same order as those recorded in Darwin Harbour for the same tidal phase.

4.1.7.2 Impact assessment—effects of sediment on barramundi

The supralittoral wetlands on the floodplains of rivers draining into Shoal Bay have been identified as critical habitat for juvenile barramundi. High turbidity is a defining characteristic of tide dominated estuary systems. Based on the turbidity fluctuations and suspended sediment measurements discussed above, the Howard River estuary suspended-sediment regime approximates that of the tidally influenced turbidity regime in Darwin Harbour, where a mean of about 15 mg/L with a peak maximum of about 80 mg/L is observed.

Based on the modelling of suspended sediments presented in Chapter 7 of the Draft EIS the fish at Howard River would likely be exposed to elevated concentrations of up to about 15 mg/L above background concentration for relatively short periods of less than a few hours at a time as illustrated by Figure 4-19. This illustrates the influence of tides on the propagation of the suspended-sediment plume during Phase 6 spoil disposal. Under most circumstances, because of their limited swimming ability, larval and juvenile fish would be unable to move away from the suspended-sediment plume.

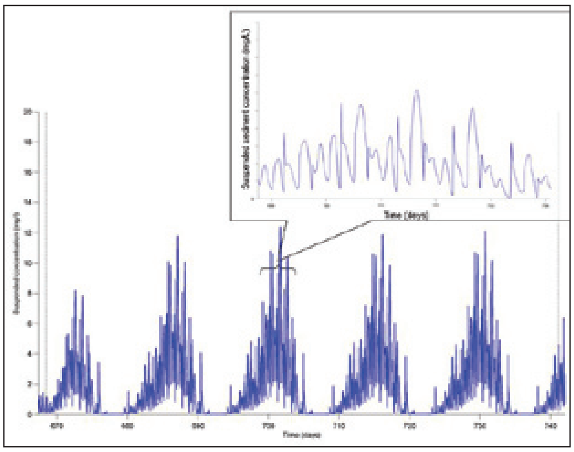


Figure 4-19: Predicted variation in total suspended solids concentrations (above background) at Howard River

A substantial volume of work has been carried out on the effect of suspended sediments on riverine and estuarine fishes. A summary graph has been produced to illustrate the study findings; this is presented as Figure 4-20; data have been drawn from a review by Berry et al. (2003) and plotted following the method of Wilber and Clarke (2001). The general trend indicated is that low concentrations can be tolerated for long periods of time with little or no observable effect. However increasing the concentration of suspended solids reduces the amount of time needed for effects to occur. The range of suspended-sediment concentrations and exposure durations predicted to occur as a result of dredge spoil disposal are substantially less than those required to cause impact to fish eggs.

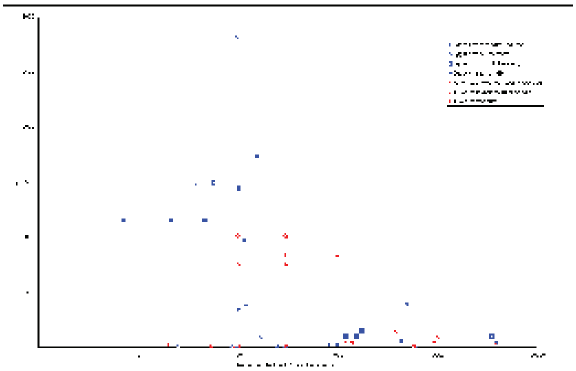


Figure 4-20: Response of fish to suspended-sediment concentrations

For larvae and juvenile fish the range of physiological responses varies greatly between species. Marine fish larvae appear to be most sensitive to SSC, for example Partridge and Michael (2010) in their study of snapper larvae found a rapid onset of mortality with increasing SSC with the threshold being about 10–40 mg/L and a 12-hour LC_{50} of 142–500 mg/L. In contrast riverine fish larvae tend to be more tolerant to SSC and do not begin to exhibit effects unless exposed to concentrations of about 500 mg/L or greater (Auld & Schubel 1978; Boehlert & Morgan 1985). Barramundi larvae and juveniles that live in the Howard River estuary may be expected to have a tolerance to SSC more similar to riverine fish than marine fish by virtue of acclimatisation to the existing habitat.

Relatively few studies have looked at potential effects on eggs and larvae. An experimental study was conducted to provide data on the direct and indirect effects of dredge spoil material on eggs and larvae of barramundi (*Lates calcarifer*). A copy of the study report is provided as Technical Appendix S5 in this EIS Supplement.

Sediment material from the seabed underlying the proposed shipping channel was retrieved from core samples. The material was then ground in the laboratory to simulate the effect of dredging and the fines portion of the resulting slurry (i.e. those particles with diameter less than 75 μm) was separated for use in the experiments. Hence the sediment material used in experiments was considered to be representative of dredge spoil that may be transported to the Howard River area.

Three experiments were conducted to determine the direct effect of dredge spoil exposure on eggs and larvae of barramundi. The results of this work are summarised in Table 4-12 and indicate that the concentrations of suspended solids to which fish in Howard River may be exposed are not likely to cause any detectable effect on barramundi eggs or larvae.

4.1.8 Mud crabs

4.1.8.1 Studies undertaken

Some concerns were raised from stakeholders over potential impacts, as a consequence of elevated suspended sediment and sedimentation associated with dredging, to the two species of mud crabs (*Scylla serrata* and *S. olivacea*) that are known to occur in Darwin Harbour and Shoal Bay. Potential impacts to mud crabs as a consequence of elevated suspended sediment and sedimentation were not specifically addressed in the Draft EIS.

INPEX acknowledges the importance of the two mud crab species found in the Harbour and Shoal Bay and their significant contribution to recreational fishery catch and has therefore undertaken a literature review and risk assessment to examine the potential for dredging-related impacts (see the full report in Technical Appendix S8 in this EIS Supplement).

An understanding of mud-crab biology is important for identifying and assessing potential impacts to mud crabs in Darwin Harbour as a result of proposed dredging and dredge spoil disposal activities. The aforementioned literature review was therefore undertaken to compile relevant information on key aspects of mud crab biology and ecology at various life-history stages, including habitat, migration, feeding, growth, reproduction, settlement and recruitment.

4.1.8.2 Impact assessment

Technical Appendix S8 in this EIS Supplement identifies and describes the potential direct and indirect impacts that the Project dredging and spoil disposal activities may have on aspects of key life history stages, identifies and describes mitigating factors for each of these potential impacts to mud crab populations in Darwin Harbour and Shoal Bay and assesses the level of impact associated with each

Table 4-12: Results of exposure of barramundi eggs and larvae to dredge spoil sediments

Experiment	Description	Summary of Results
Egg exposure	Newly spawned barramundi eggs were exposed to eight concentrations of dredge spoil material ranging from 0 to 2000 mg/L for either 4.5 or 11.5 hours.	It was found that sediment did not adhere to eggs regardless of concentration of sediment or exposure time nor was there any effect on egg viability or hatch rate
Exposure of newly hatched (mouth closed) larvae	Newly hatched larvae were exposed to eight concentrations of dredge spoil material ranging from 0 to 2000 mg/L for 12 hours prior to mouth opening.	There was no significant difference in larval mortality at sediment concentrations between 0 and 500 mg/L.
Exposure of larvae (mouth open)	At 36 hours post hatch, when the mouths (and opercula) had just opened, the larvae were exposed to eight concentrations of dredge spoil material ranging from 0 to 2000 mg/L for either 6, 12 or 18 hours.	Larval mortality was similar after exposure times of 6 and 12 hours, but higher after 18 hours. Within each exposure time, there were no significant differences in mortality at sediment concentrations between 0 and 100 mg/L.

of the identified potential impacts. A range of aspects of mud crab activity/ biology with potential to be impacted were examined including:

- habitat
- migration (local)
- feeding
- growth
- mating
- larval dispersion, settlement and recruitment.

With the exception of risk to local migration of juveniles and adults, which were ranked a medium risk, risk to all other biological aspects for all life phases were considered low. The study concluded there was an unlikely probability of a minor and temporary disruption to the mud crab population through a potential impact to Darwin Harbour and Shoal Bay mud crab migration and this equated to a medium risk.

The following is a synopsis of Technical Appendix S8 regarding the ranking of potential impact to local migration of mud crabs as a medium risk:

The local migration patterns of juvenile and adult mud crabs within, into and out of Darwin Harbour are not well known. However, the daily migration patterns of *S. serrata* and *S. olivacea* are characterised by relatively small scale movements around permanent and semi-permanent burrows in intertidal and subtidal mangrove habitats possibly linked to tidal regimes (Demopoulos et al. 2008; Hyland, Hill and Lee 1984; Moser et al. 2005). Mud crabs may also migrate larger distances within their available habitats as a result of seasonal regimes, interspecific and intraspecific habitat competition, foraging, mating and spawning activities (Hyland, Hill and Lee 1984; Koolkalya et al. 2006; Moser et al. 2005). During the wet season for example, mud crabs may move to the lower reaches of creeks in response to reductions in salinity caused by freshwater runoff. Females are also known to move large distances for spawning which is also believed to be linked to changes in salinity during the wet season (Hill 1994, Moser et al. 2005).

Elevated concentrations of TSS and sedimentation are predicted to occur in areas of mud crab habitat in East Arm and Shoal Bay and this may potentially affect the natural migration patterns of mud crabs within these areas. However, based on typical natural turbidity and sedimentation regimes in Darwin Harbour it is reasonable to assume that mud crabs are adapted to live in and migrate within highly turbid environments experienced in Darwin Harbour.

In the unlikely event that turbidity and sedimentation events exceeded the tolerances of mud crabs, adult and juvenile mud crabs may potentially exhibit avoidance behaviour and temporarily move away from the impact zones in East Arm and Shoal Bay. There are no data which could be used to infer whether there are limits to the levels of turbidity and sedimentation that can be tolerated by adult or juvenile mud crabs. However, given the scale of impact relative to the area of available habitat in Darwin Harbour and Shoal Bay and the temporary nature of the impact, any potential effect on migration patterns is likely to be both minimal and temporary.

Given risks to mud crabs are not considered likely to impact significantly on mud crab populations in the Harbour and Shoal Bay, no impact on the recreational mud crab fishery in these areas is expected.

4.1.9 Coastal dolphins

4.1.9.1 Studies undertaken

A comprehensive review has been conducted of the scientific and non-confidential "grey literature"[6] to further inform and supplement the information on coastal dolphins contained in the Draft EIS to:

- elaborate profiles on their ecology and behaviours
- review evidence for impact from marine construction activities
- review management measures to avoid or minimise potential impacts from marine construction activities.

Taxonomy

The family Delphinidae is the largest family of cetaceans, comprising approximately 36 species of dolphins and small toothed whales (Möller et al. 2008).

Three species of coastal dolphin occur in Darwin Harbour: the Indo-Pacific humpback dolphin (*Sousa chinensis*), the Indo-Pacific bottlenose dolphin (*Tursiops aduncus*), and the Australian snubfin dolphin (*Orcaella heinsohni*).

Indo-Pacific humpback dolphins

Indo-Pacific humpback dolphins are widespread and relatively common throughout Australian tropical waters, from Shark Bay in Western Australia across the Northern Territory and Queensland to northern New South Wales.

6 "Grey literature" is the term used for written materials that cannot be found easily through conventional channels such as publishers, but which are frequently original and usually recent. Examples include technical reports from government agencies or scientific research groups, working papers from research groups or committees, and also ephemera such as PowerPoint presentations.

Genetic studies by Frere et al. (2008) have indicated that all Australian humpback dolphins are genetically similar and can be grouped together in a single clade.

Indo-Pacific bottlenose dolphins

The Indo-Pacific bottlenose dolphin is the most widely distributed and abundant of the three coastal dolphin species in Darwin Harbour, and occurs all around the Australian coastline. As presently understood, the genus *Tursiops* has two species, the common bottlenose dolphin (*T. truncatus*) and the Indo-Pacific bottlenose dolphin (*T. aduncus*). Both occur in Australian waters although *T. truncatus* appears not to occur in coastal waters in the Northern Territory.

Bottlenose dolphins (*T. aduncus*) have been identified in Australian waters based on the following:

- morphological and genetic data from northern and eastern Australia (Hale, Barreto & Ross 2000; Kemper 2004)
- genetic data from New South Wales (Möller & Beheregaray 2004)
- osteological data from South Australia (Kemper 2004)
- genetic data from Western Australia (Krützen et al. 2004).

Recent mitochondrial DNA (mtDNA) studies by Möller et al. (2008) on specimens of bottlenose dolphins from New South Wales, Victoria, Tasmania and South Australia have indicated the possibility of the species *T. aduncus* being separated into a northern form and a southern form, thereby defining a third *Tursiops* species tentatively referred to as the southern bottlenose dolphin. Tissue samples have been taken from *T. aduncus* in Darwin Harbour for DNA genetic analysis by the Northern Territory Government (Palmer 2010a) but no information on the results of this work is available as yet.

Australian snubfin dolphins

As noted in Section 3.3.8 of Chapter 3 *Existing natural, social and economic environment* of the Draft EIS the snubfin dolphin is a recently described species, having previously been considered to be a population of the Irrawaddy dolphin (*Orcaella brevirostris*). Recent morphological and genetic studies on specimens of the genus *Orcaella* showed that populations in north-eastern Australia are distinct at species level from the South-East Asian populations; this means that the snubfin dolphin is endemic to Australia and is Australia's only endemic cetacean (Beasley, Robertson & Arnold 2005). The taxonomic revision was based on a range of features and included genetic sampling from South-East Asian and northern Queensland populations, as well as one sample from the Northern Territory. Preliminary genetic studies on mtDNA in snubfin dolphins from Western Australia, the Northern Territory and Queensland indicate that the overall population is genetically similar and is not divisible into subspecies. Further and more detailed genetic studies are under way to better characterise the extent of gene flow between local dolphin populations (Palmer 2010a).

Distribution

Australian snubfin dolphins

Orcaella heinsohni occurs across the subtropical and tropical parts of Australia from Broome in Western Australia (around 17°57′S) across the Northern Territory (Chatto & Warneke 2000) and south to the Brisbane River in Queensland (around 27°32′S) (Bannister, Kemper & Warneke 1996).

There is currently no overall population estimate for snubfin dolphins in Australian waters. Considering the length of coastline and area of suitable shallow habitat, and the apparent tendency of snubfin dolphins to occur in small localised groups, it is likely that mature Australian snubfin dolphins do not number more than 10 000 individuals (DSEWPaC 2010a). The most wide-ranging survey of Australian snubfin dolphins in the Northern Territory was that of Freeland and Bayliss (1989) who found the highest density of "Irrawaddy dolphins" (now known to have been Australian snubfin dolphins) along the western shoreline of the Gulf of Carpentaria. The population of snubfin dolphins observed on the surface was estimated to be approximately 1000. Although the accuracy of aerial surveys may be questioned, analysis by Bayliss (1986) and Marsh and Sinclair (1989) indicates that species identification is generally acceptable but that the count may be substantially depressed by altitude and sun angle. The number of snubfin dolphins observed along the western shoreline of the Gulf of Carpentaria was remarkable in size and showed seasonal variation. It is likely that the population has been reduced since 1989, primarily because of continued incidental capture in gill nets, including shark nets, and continued habitat degradation (DSEWPaC 2010a).

The survey by Freeland and Bayliss (1989) found low numbers of Australian snubfin dolphins (a total of 13) across the eastern zone of the Northern Territory, from the Daly River to Milingimbi, suggesting that this zone has relatively few snubfin dolphins. The Northern Territory Government has funded several surveys in Darwin Harbour (including Shoal Bay) and further north in the Alligator Rivers area and around the Cobourg Peninsula to assess the populations of coastal dolphin species. In Darwin Harbour, surveys conducted monthly over a two-year period recorded 31 sightings of snubfin dolphins (Palmer 2010a, 2010b). In the Alligator Rivers region of Kakadu National Park, 13 two-day surveys conducted between April 2007 and December 2008 resulted in 75 observations of Australian snubfin dolphins (Palmer 2009), while at the Cobourg Peninsula 126 observations of snubfin dolphins were recorded from five surveys (totalling 30 days) in 2008 (Palmer et al. 2009). These results indicate that the abundance of Australian snubfin dolphins at each of the surveyed areas is relatively low and, while data from different locations are not directly comparable, the results also suggest that there are significantly fewer Australian snubfin dolphins utilising Darwin Harbour than there are in the Alligator Rivers or Cobourg Peninsula regions.

Indo-Pacific humpback dolphins

Indo-Pacific humpback dolphins are distributed more or less continuously as local residents along the coast from False Bay, South Africa, to the South China Sea, including the Red Sea, the Arabian Gulf, the Indian subcontinent, the Gulf of Thailand, the Malacca Straits and northern Borneo, and the coast of China to the Changjiang River (31°50′N). Interestingly, at least one animal has reached the Mediterranean via the Suez Canal, the first known case of anthropogenic range extension for a marine mammal through habitat modification (Kerem, Goffman & Spanier 2001).

The distribution of the humpback dolphin in Australian waters extends from around 25°S on the west coast around the Northern Territory to 34°S on the east coast (Bannister, Kemper & Warneke 1996; Corkeron et al. 1997). Off the east Australian coast their distribution appears to be continuous. Although there are few records between the Gulf of Carpentaria in the north and Exmouth Gulf in the west, this is probably attributable to a lack of research effort and the remoteness of the area (Bannister, Kemper & Warneke 1996; Parra, Corkeron & Marsh 2006). Tin Can Inlet, the southernmost portion of the Great Sandy Strait in Queensland has a group estimated to number approximately 150 individuals (Cagnazzi, Harrison & Ross 2009). Several groups appear to be resident at Ningaloo Reef near Exmouth in Western Australia (Bannister, Kemper & Warneke 1996).

In Darwin Harbour surveys carried out monthly over a two-year period recorded 354 sightings of Indo-Pacific humpback dolphins in Darwin Harbour (Palmer 2010a). In the Alligator Rivers region of Kakadu National Park, 13 two-day surveys conducted between April 2007 and December 2008 resulted in 114 observations of Indo-Pacific humpback dolphins (Palmer 2009), while at the Cobourg Peninsula 118 observations of Indo-Pacific humpback dolphins were recorded from five surveys totalling 30 days in 2008 (Palmer et al. 2009). These results indicate that the abundance of Indo-Pacific humpback dolphins at each of the surveyed areas is low and while data from different locations are not directly comparable owing to differences in transect lengths and the frequency of the surveys, it does indicate that that Darwin Harbour, Alligator Rivers and the Cobourg Peninsula have populations of Indo-Pacific humpback dolphins of approximately similar size.

Indo-Pacific bottlenose dolphins

As noted in Section 3.3.8 of Chapter 3 of the Draft EIS, the Indo-Pacific bottlenose dolphin occurs from South Africa to the Red Sea and eastwards to the Arabian Gulf, India, China and Japan, southwards to Indonesia and New Guinea, and to New Caledonia. The species occurs around the whole Australian coast and frequents a large number of bays and inshore waters in considerable numbers, including parts of the northern coast of Tasmania. It is a coastal species and generally occurs in waters less than 20 m deep. Studies on South African populations of Indo-Pacific bottlenose dolphins suggested that the species rarely migrates and that females stay close to their birthplace throughout their lives (Ross 2006). The ecology of the population in Northern Territory waters has not been researched in detail.

Note, however, the comments under *Taxonomy* above that genetic studies may prove that the species *T. aduncus* should be separated into a northern form and a southern form, thereby defining a third *Tursiops* species in southern Australian coastal waters.

Microhabitat

The known distribution and habitat preferences of the three coastal dolphin species occurring in Australian waters were described in Section 3.3.8 of Chapter 3 of the Draft EIS. In this section it was noted that they generally occur in waters less than 20 m deep (DSEWPaC 2010b). It is recognised that fine-scale variations in distribution will occur between the species owing to habitat preferences and resource (food) partitioning. Indeed, research on the coastal dolphin species by the Northern Territory Government in Darwin Harbour and Shoal Bay (Palmer 2010a) as well as separate repeat transect studies at Cobourg Peninsula (Palmer et al. 2009) and Kakadu (Palmer 2009) do indicate that there are differences in habitat preferences between the species.

Ten transects (ranging in length from 4 to 10 km—around 2347 km in all over a two-year period) were surveyed in Darwin Harbour and Shoal Bay (Palmer 2010a). The transect routes were selected to represent a range of habitats and consequently only a portion of the Harbour was surveyed. When records of sightings are normalised to a "per unit effort" basis (i.e. sightings per kilometre for each transect) the following conclusions can be drawn:

- The Indo-Pacific humpback dolphin was the most commonly sighted species, was the only one of the three species to be observed on all ten transects, and occurred in its highest density in Shoal Bay (0.28, 0.32 and 0.34 sightings per kilometre on transects 8, 9 and 10 respectively). It is also the most common of the three species to occur near East Arm and Blaydin Point (0.15 and 0.12 sightings per kilometre for transects 3 and 4 respectively).
- The Indo-Pacific bottlenose dolphin was commonly observed along the north-eastern shorelines of Darwin Harbour, but not at all along transects near the north-western shorelines or in the shallower parts of Shoal Bay.
- The Australian snubfin dolphin was found to be the rarest of the three species. It was most often found along transects adjacent to the western shoreline of the Harbour. It was observed infrequently near Blaydin Point, only being observed once on each of the two transects (3 and 4) over the two-year period with 0.004 and 0.003 sightings per kilometre.

The vessel-based transects by the Northern Territory Government to collect coastal dolphin data focused mainly on the East Arm area of Darwin Harbour. To complement this work INPEX commissioned a pilot program to undertake a survey of large marine animals in the Middle Arm and West Arm of the Harbour.

The key objectives of the pilot program were as follows:

1. Determine presence, or otherwise, of coastal dolphins in Middle Arm and West Arm
2. Compare distance-sampling and capture–recapture survey techniques to investigate which methodology would provide the most robust estimates of coastal dolphin abundance for long-term population studies
3. Obtain photographic identifications of individual animals for comparison with existing catalogues and for use in future surveys
4. Collect appropriate environmental data to determine coastal dolphin habitat preferences
5. Collect other incidental data on large marine animals.

The survey program involved the use of a team of three observers, positioned on the fly-bridge of the survey vessel, conducting observations of dolphin and other large marine animals along transects in Middle Arm and West Arm. The survey program was undertaken as three survey events of four, three and three days in January, February and March 2011 respectively.

Throughout the pilot program, various survey techniques and survey transect designs were trialled and amended as the survey program progressed. This structured pilot study has led to a final study design that is robust and which, over the long term, will be capable of detecting significant changes in marine mammal abundance and distribution.

Based on the limited number of surveys conducted to date (see Technical Appendix S12 to this EIS Supplement) the following conclusions can be drawn:

- The density of Indo-Pacific humpback dolphins observed in the western parts of the Harbour is comparable to that observed near East Arm and Blaydin Point over the two-year period from 2008 to 2010 (Palmer 2010a, 2010b).
- The density of Indo-Pacific bottlenose dolphins observed in the western parts of the Harbour is comparable to that observed in the eastern parts of the Harbour but less than that observed in the northern parts of the Harbour.
- The density of snubfin dolphins observed in the western parts of Darwin Harbour is substantially higher than that observed near East Arm and Blaydin Point over the two-year period 2008 to 2010 (Palmer 2010a, 2010b). This is consistent with observations reported by Palmer (2010a) indicated that the highest abundance was in the north-western parts of the Harbour.

The causes of differences in habitat preference between the three coastal dolphin species in Darwin Harbour and Shoal Bay are unclear and may reflect physical habitat preferences related to hunting strategies, resource partitioning or possibly differing levels of avoidance of areas with higher levels of disturbance, as has been observed for Indo-Pacific bottlenose dolphins (Bejder et al. 2006; Lusseau 2005).

Residency and site fidelity

Residency of dolphin species is typically defined based on their observed presence in an area for a period of time. The protocol used does vary, but based on recent literature (e.g. Fury & Harrison (2008) and Zolman (2002)), can be generally defined as follows:

- If an individual's presence is observed repeatedly over a full season's range, then that individual can be considered to be resident in the area.
- If an individual's presence is observed in the same season over consecutive years then that individual can be considered to be a seasonal resident.

Site fidelity and residence time in an area are important components in assessing the potential risk from man's activities. Studies from other locations have indicated a range of residency patterns. In Cleveland Bay at Townsville in north-eastern Queensland, snubfin dolphins and Indo-Pacific humpback dolphins were not considered to be permanent residents; both used the area regularly from year to year following a pattern of emigration and remigration. Individuals of both species spent periods of days to a month or more in the coastal waters of Cleveland Bay before leaving, and periods of over a month outside the study area before entering the bay again (Parra, Corkeron & Marsh 2006). At Tin Can Inlet, Cagnazzi, Harrison and Ross (2009) found two separate groups of Indo-Pacific humpback dolphins: a northern group that did appear to be permanent residents within a relatively small geographical area and a southern group that ranged over a much wider area, the full extent of which was not determined but considered to be about 20 km wide.

Preliminary results of the monitoring sponsored by the Northern Territory Government in Darwin Harbour (Palmer 2010b) indicate that a large proportion of the identified individual dolphins have been observed only once over two years (56% of the Indo-Pacific humpback, 47% of the Indo-Pacific bottlenose and 75% of the snubfin dolphins). Such a high proportion of individuals sighted only once suggests that a possibly large proportion of the individuals of each population spend most of their time outside the study area. Parra, Corkeron and Marsh (2006), for example, considered that the fact that 41% of surveyed individuals were observed only once in the study area indicated either that a high number of individuals were dying or that they were spending most of their time outside the study area. Hence there are, at present, insufficient data to reliably classify the residency or otherwise of the coastal dolphin species in Darwin Harbour.

It is relevant to note that residency, should it be found to occur, does not necessarily equate to a permanent population presence. There are numerous documented examples of changes in home range of a variety of terrestrial species. Large-scale studies on an adequate temporal scale are rare for marine mammals. One such study, however, was of *Tursiops truncatus* in the Moray Firth of Scotland (Wilson et al. 2004), where an expansion of the population home range into neighbouring areas was accompanied by a decline in the number of individuals found in the original home range.

To help answer questions relevant to the conservation of coastal dolphin species in Darwin Harbour a comprehensive long-term marine mammal monitoring project has been initiated by INPEX. The pilot phase of this work, which has already commenced, will build upon previous similar studies and provide the basis for integrating available data from those surveys with ongoing work.

4.1.10 Other protected species (turtles and dugong)

4.1.10.1 Studies undertaken

The spatial extent of foraging habitat for turtles and dugong has been estimated based on distribution of seabed communities suitable for foraging. The methods used to determine seabed community distribution have been previously described in Section 4.1.2. Figure 4-22, Figure 4-23 and Figure 4-24 illustrate the spatial extent of potential foraging habitat for green, hawksbill and flatback turtles in Darwin Harbour. Figure 4-24 illustrates the spatial extent of potential foraging habitat for dugong in the Harbour.

4.1.10.2 Impact assessment

The potential for significant disturbance to foraging habitat for turtle and dugong has been assessed by determining the total area of foraging habitat for each species within a defined study area and then comparing this with the area of potential impact from dredge-related activities.

For the purposes of impact assessment a Darwin Harbour study area was delineated, the boundary of which is shown on Figure 4-21, Figure 4-22, Figure 4-23 and Figure 4-24. It is recognised that this study area does not encompass the full geographic range over which these species would be expected to roam. However, the approach is considered to be appropriate and conservative for two main reasons: Firstly, data on seabed habitat beyond Darwin Harbour are scant and, secondly, if the area was expanded to the full range for each species then the additional habitat included would "dilute" the proportion of foraging habitat affected.

Table 4-13 provides the calculated area of suitable foraging habitat in Darwin Harbour for the dugong and each of the turtle species. This is compared with areas that are predicted to receive "high" and "moderate" impact for either suspended solids or sedimentation (see sections 4.1.3.9 and 4.1.3.10 for further information on methods applied in mapping areas of impact).

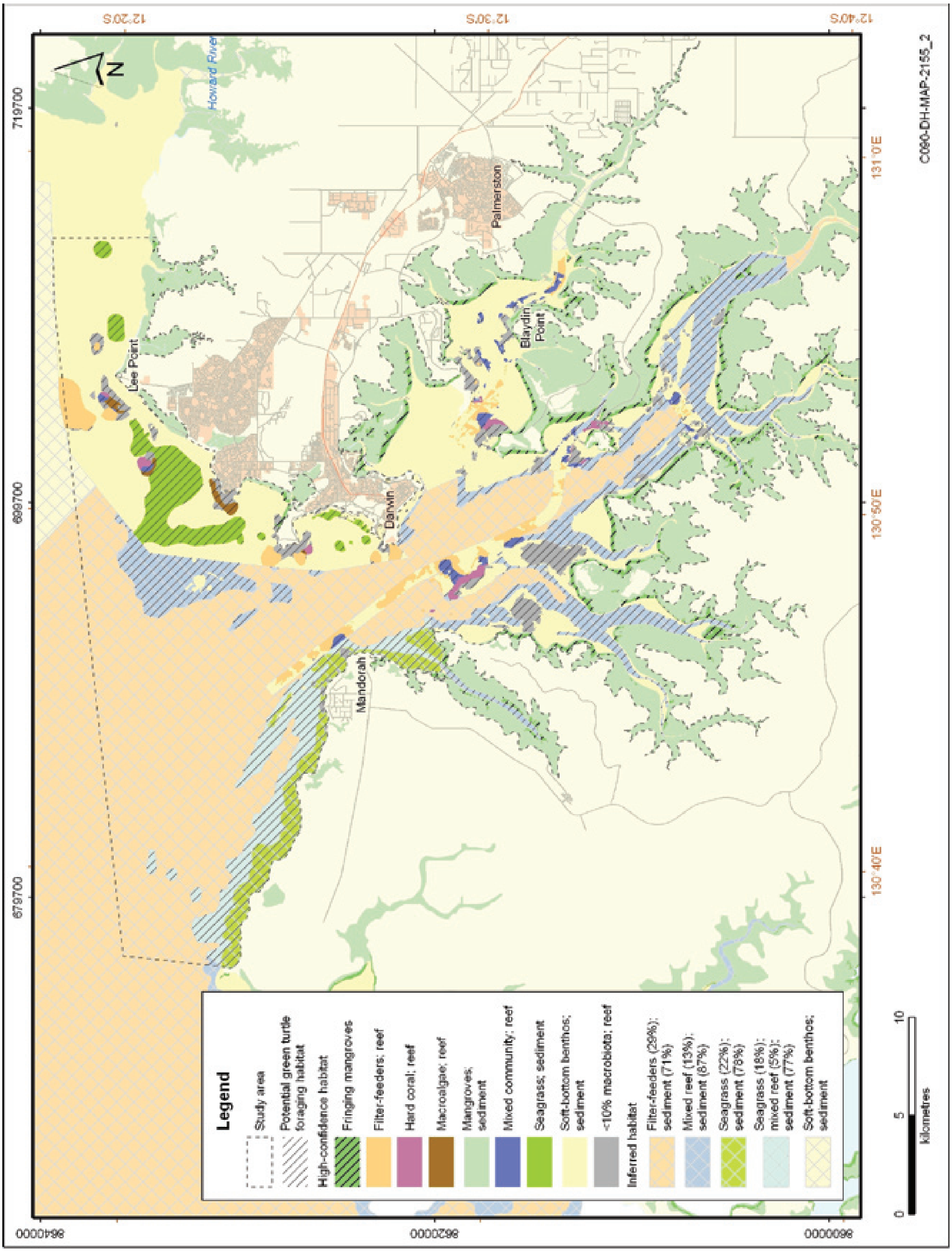


Figure 4-21: Potential green turtle foraging habitat in Darwin Harbour

Note that the potential foraging habitat represents areas of benthic communities known to contain food items stated in the scientific literature to be favoured by green turtles.

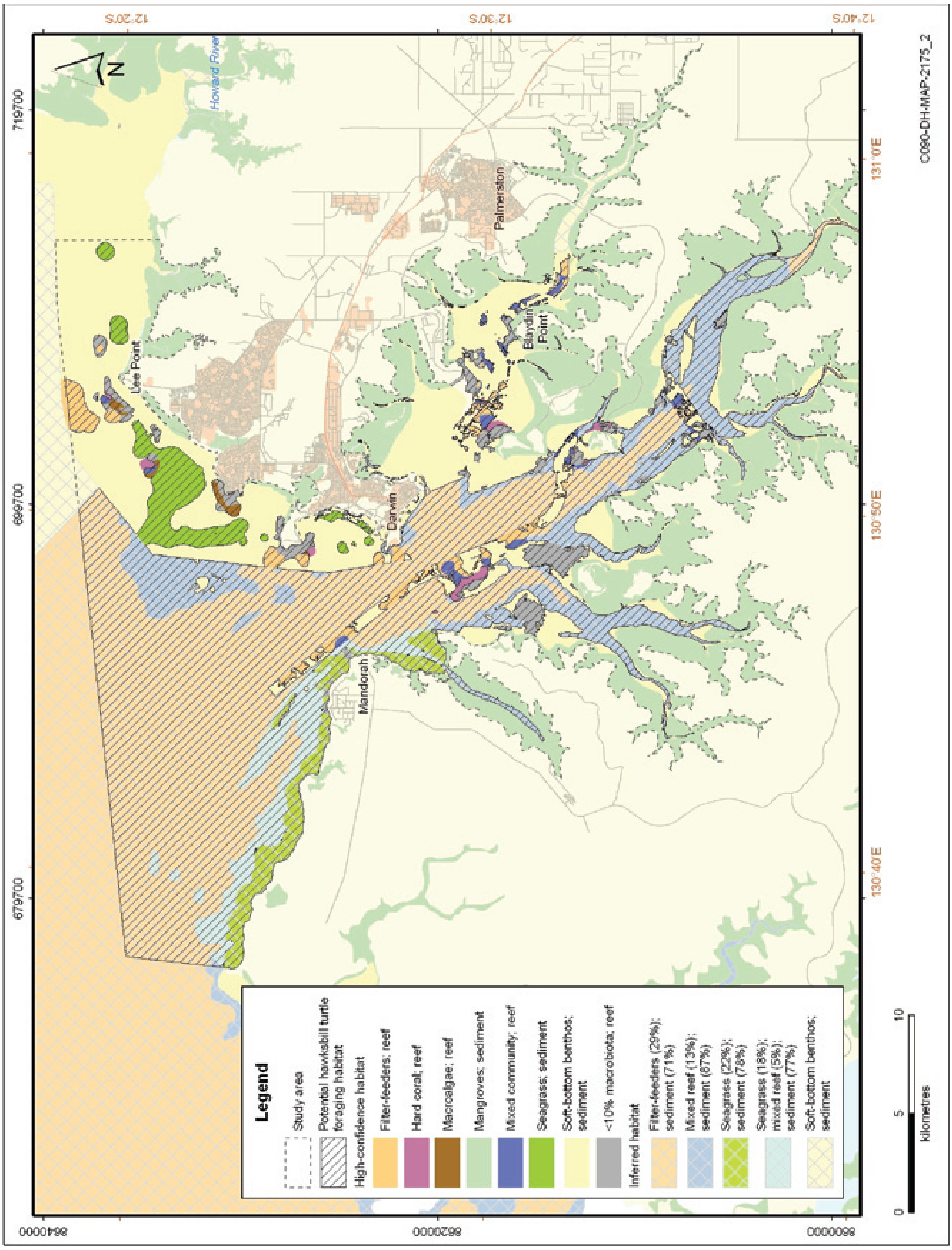


Figure 4-22: Potential hawksbill turtle foraging habitat in Darwin Harbour

Note that the potential foraging habitat represents areas of benthic communities known to contain food items stated in the scientific literature to be favoured by hawksbill turtles.

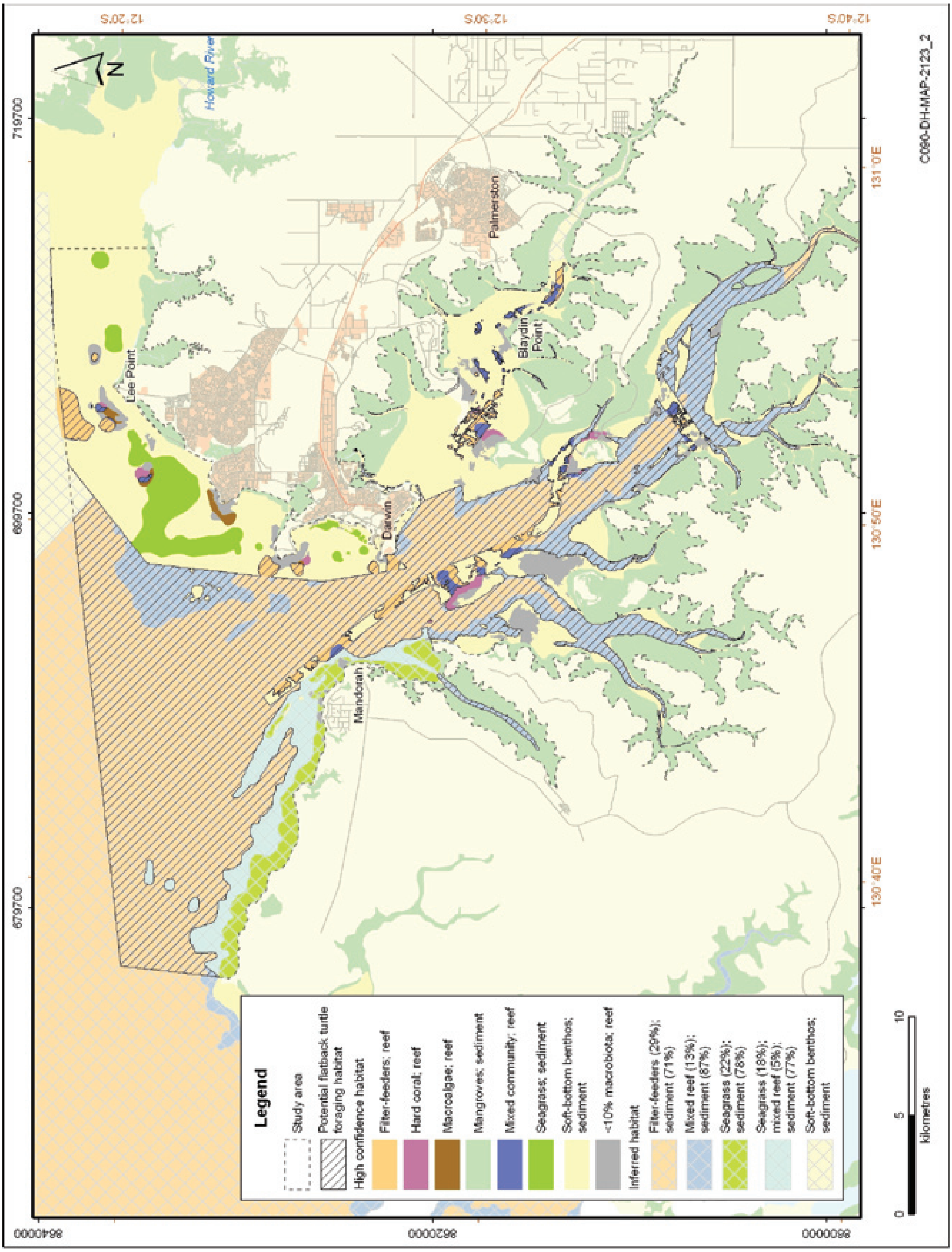


Figure 4-23: Potential flatback turtle foraging habitat in Darwin Harbour

Note that the potential foraging habitat represents areas of benthic communities known to contain food items stated in the scientific literature to be favoured by flatback turtles.

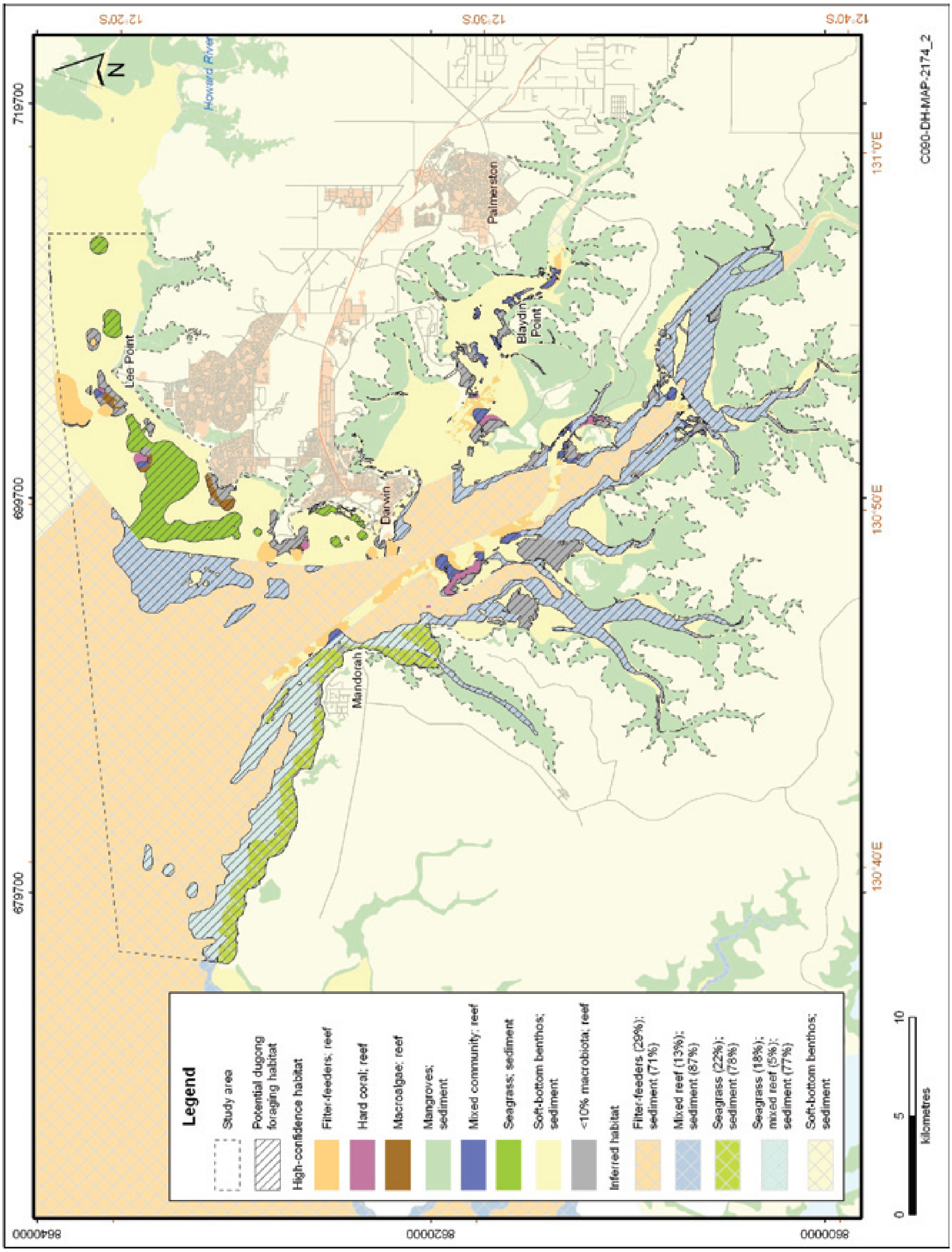


Figure 4-24: Potential dugong foraging habitat in Darwin Harbour

Note that the potential foraging habitat represents areas of benthic communities known to contain food items stated in the scientific literature to be favoured by dugongs.

Table 4-13: Area (in hectares) of potential foraging habitat for turtles and dugong in Darwin Harbour

Species	Habitat type				Total foraging habitat	Total foraging area potentially impacted	Percentage of total foraging habitat potentially impacted
	Seagrass	Filter-feeder	Macroalgae	Fringing mangrove			
Green turtle	2520	–	247	1743	4511	16	0.4
Hawksbill turtle	2520	7912	247	–	10 679	402	3.8
Flatback turtle	–	7912	–	–	7912	389	4.9
Dugong	2520	–	247	–	2768	13	0.5

Turtles

The flatback turtle is predicted to be the most affected of the species considered, with potential disturbance to around 5% of its foraging habitat in Darwin Harbour. The relatively high percentage of disturbance is attributable to the co-occurrence of its foraging habitat (filter-feeder communities), which occur in deeper waters of the Harbour, with areas predicted to receive suspended-sediment loads greater than the tolerance threshold for 10% or more of the time.

Like the flatback, the hawksbill turtle forages in the deeper filter-feeder communities but unlike the flatback it also forages amongst seagrass and macroalgal communities. Consequently, the total foraging area available to hawksbill turtles in Darwin Harbour (calculated to be 10 679 ha) is greater than that available to the flatback turtle and the percentage of foraging area available to the hawksbill turtle that may be disturbed is therefore less, at 3.8%.

The green turtle forages amongst seagrass, macroalgal and fringing-mangrove communities. Dredging operations are not predicted to cause substantial exceedance of sediment and suspended-sediment thresholds of these community types and consequently the area of green turtle foraging habitat likely to be affected is relatively small, representing 0.4% of the total available foraging habitat.

Dugong

The dugong forages amongst seagrass and to a lesser extent in macroalgae meadows. Dredging operations are not predicted to cause substantial exceedance of sediment and suspended-sediment thresholds of these community types and consequently the area of dugong foraging habitat affected is relatively small, representing 0.5% of the total available foraging habitat.

4.1.11 Underwater noise and vibration

Darwin Harbour contains an operational port, East Arm Wharf, that already generates underwater noise from a variety of sources and activities. Many of its existing facilities were constructed and currently operate in a manner similar to INPEX's proposed development of its nearshore Project area. The key Ichthys Project activities that are likely to produce noise emissions significantly different from or louder than current East Arm Wharf activities are piledriving and drill-and-blast operations.

A supplementary review of marine noise is provided as Technical Appendix S7 in this EIS Supplement. The review presents a synopsis of the latest available research, policies and field experiences and presents guidance concerning the evaluation and management of blast and in-water noise and its implications for potentially sensitive marine animals, in the context of the INPEX's proposed marine construction works in the Harbour.

In parallel with this literature review, the potential impacts of noise from key Project activities in the nearshore development area were subjected to underwater acoustic modelling. For each modelling scenario, the received root mean square (rms) sound pressure levels (SPLs), the corresponding peak pressure levels (SPL peaks) and the corresponding sound exposure levels (SELs) for different ranges from the receiver to the noise sources were modelled (see Section 3.2 of Technical Appendix 15 for a detailed description of underwater noise measurement methods). Three frequency weightings, namely, mid-frequency cetacean weighting (150 Hz to 160 kHz (Southall et al. 2007)), 100 Hz to 1 kHz flat-frequency weighting, and 100 to 2 kHz flat-frequency weighting, were applied to the SEL estimates, along with various exposure durations.

Noise and blast exposure criteria

No definitive models are available to predict the precise nature of, and potential for, injury. A broad range of variables relating to bathymetric and environmental conditions affect the propagation of underwater noise and the characteristic of the organisms influence the impact. As a result, “safe” distances cannot be predicted with certainty; however the most recent literature has presented considered conservative estimates of the geographic extent of the “area of damage” for a range of animals. These are based upon current research and analysis, accumulated experience, and contemporary policy and regulatory objectives and practices.

For marine mammals the assessment adopted the exposure criteria developed by a panel of international experts in acoustics and marine mammal science (Southall et al. 2007). These criteria were developed for cetaceans and pinnipeds and were based primarily on the levels at which “permanent threshold shift” (PTS) and “temporary threshold shift” (TTS) have been found to occur. Induced PTS represents tissue injury, but TTS does not. Although TTS involves reduced hearing sensitivity following exposure, it results primarily from the fatigue (as opposed to loss) of cochlear hair cells and supporting structures and is, by definition, reversible (Nordmann, Bohne & Harding 2000).

The conservative criteria arrived at by Southall et al. (2007) for injury from exposure to a single pulse are as follows:

- In terms of sound pressure level (SPL) peak pressure: TTS onset levels (unweighted peak levels of 224 dB re 1 μPa) plus 6 dB of additional exposure. That is, 230 dB re 1 μPa.
- In terms of sound exposure level (SEL): TTS onset levels (mid-frequency-weighted SEL exposure of 183 dB re 1 $\mu Pa^2 \cdot s$) plus 15 dB of additional exposure. That is, 198 dB re 1 $\mu Pa^2 \cdot s$.

It is noted that the EPBC Act Policy Statement 2.1 (DEWHA 2008a) applies criteria based on TTS onset, limiting exposure to an SEL of 183 dB re 1 $\mu Pa^2 \cdot s$ for the protection of whales. This is included here for completeness; however it is not considered to be an appropriate measure for blasts separated by several hours. For multiple exposures the policy statement assumes an exposure time of 33 minutes. This criterion, an SEL of 183 dB re 1 $\mu Pa^2 \cdot s$ over a 33-minute exposure, is presented for piledriving noises.

There are no established criteria for sound exposure for turtles. Therefore the exposure criteria were obtained from Broner and Huber (2010), as used in the environmental assessment, under the EPBC Act, of the proposed expansion of the BHP Billiton Mitsubishi Alliance’s Hay Point Coal Terminal in Queensland (BMA 2010).

Key variables that appear to control the physical interaction of sound with fishes include the size of the fish relative to the wavelength of sound, mass of the fish, anatomical variation, and location of the fish in the water column relative to the sound source. Most studies on fish kills have been related to explosive blast pressure waves consisting of an extremely high peak pressure with very rapid rise times (<1 ms).

Yelverton et al. (1975) exposed eight different species of fish to blasts having high peak pressures with varying impulse lengths. It was found that there was a correlation between body mass and the magnitude of the impulse[7] that caused mortality. Further studies using explosives suggest that fishes with swim bladders are more susceptible to blast effects than species that do not have such air chambers (e.g. Baxter et al. 1982; Hastings & Popper 2005) although it should be noted that the effects of blasts vary by species, even when all test fish have a swim bladder (Govoni Settle & West 2003).

For blast effects, the correlation between impulse and mortality derived by Yelverton et al. (1975) has been used to determine the maximum impulse pressure that correlates to “no injury”, 1% mortality and 50% mortality for fish of differing sizes. The distance from a confined blast of 50 kg at which these critical impulse levels would be received are given in Table 4-14. It can be seen that for a 1 kg fish there is a risk of 50% mortality within about 125 m of a 50-kg confined blast and the risk of injury decreases to “no injury” beyond a range of approximately 400 m. For smaller fish the range is increased and conversely for larger fish the range is reduced. It should be noted that these distances (safety ranges) differ from those given in the Draft EIS primarily due to a difference in the assumed size of explosive charge.

Table 4-14: Calculated distance from a confined blast of 50 kg for no injury, 1% mortality and 50% mortality to fish of differing body mass

Fish mass (kg)	Distance from 50 kg blast (m)		
	No injury	1% Mortality	50% Mortality
0.1	689	459	207
1	402	230	126
10	287	138	98

7 Impulse was characterised by Yelverton et al. (1975) as the product of peak overpressure and the time it takes for the overpressure to rise and fall back to zero, expressed as psi. msec.

Assumptions made in the calculation of impact to fish from blasting are as follows:

- A confined 50-kg explosive blast was used. This is the maximum explosive size expected. It should be noted that because micro-delays would be used between detonations each successive 50 kg blast is treated separately not cumulatively.
- The impulse of detonation from a confined blast is assumed to be 40% of that from an equivalent unconfined blast. This is a conservative assumption as studies (for example Nedwell 1989) indicate that the impulse from confined blast is typically reduced to 30% for an equivalent unconfined blast.
- Depth of detonation was assumed to be 16 m below LAT, this being 10 m below LAT to the top of the hard rock requiring blasting and a worst-case assumption of high tide (6 m) on top of that.
- Depth of receptor fish was assumed to be middle of the water column (i.e. 8 m below LAT).

For piledriving the application of a "critical impulse level" is not appropriate because of the significantly longer rise time of the pressure wave. Hastings and Popper (2005) reasoned that if transient sounds, such as those produced by piledriving, could be characterised using a waveform similar to the impulse, then effects of piledriving on fish could be extrapolated from data based on effects observed from exposure to blasts. Based on this and extrapolating from Yelverton et al. (1975), they derived preliminary guidance SEL for protection of fish from underwater noise caused by piledriving. The "no injury" SEL values for a single piledriving pulse derived by Hastings and Popper (2005) are given in Table 4-15 for different sizes of fish. For all piledriving scenarios considered, the distance from the piledriving rig wherein the potential for serious physical injury exists was less than 50 m.

Table 4-15: Threshold sound exposure level for protection of fish from a single piledriving pulse

Fish mass (kg)	"No injury" sound exposure level (dB re 1 $Pa^2 \cdot s$)
0.1	199
1	200

Blasting

INPEX has committed to using methods other than drilling and blasting for the removal of Walker Shoal (the reader is referred to Section 3.3.8 for a full description of alternative methods for fragmenting and removal of hard rock). It is proposed instead that a specialised cutter-suction dredger will be employed and that it will have sufficient power to remove the greater part, if not all, of the hard material. If necessary, however, other mechanical methods such as a hydraulic hammer or drop chisel will also be used. As INPEX cannot be completely certain that these methods will be fully effective, it is considered appropriate that a contingent drill and blast option for approximately 4 weeks is maintained during the environmental assessment process and the subsequent approval for the Project. In the unlikely event that drilling and blasting will be required, INPEX will have best-practice procedures and a monitoring plan in place to reduce the risks to marine animals to as low as reasonably practicable. An update on marine animal detection methods is provided in Section 4.1.12. If blasting should be required for the removal of Walker Shoal, it will be undertaken using the "confined" blasting (drill-and-blast) method, which involves drilling small holes in the rock with charges placed and connected in the holes for subsequent surface-firing.

In comparison with surface blasting methods, confined blasting generates reduced effects upon the marine environment. Nedwell (1989) showed that the in-water peak pressure for an embedded charge is reduced substantially, to approximately 5%, and that the impulse is reduced to approximately 30% of that for the equivalent unconfined charge; the rise time of the impulse wave is also greatly extended. It should be noted that it is the fast rise time of impulse waves that is the cause of most physiological damage.

The impact of a set of underwater blasts can also be reduced by inserting small timing delays ("micro-delays") between explosions. The detonation event therefore consists of a chain of individual subordinate detonations. These produce irregular and less pronounced peak pressure levels than would occur if all the explosives were detonated simultaneously or if a single aggregate charge of the same net explosive content was detonated.

Three scenarios were considered for blasting:

- 24 holes, each with a 50-kg charge
- 12 holes, each with a 25-kg charge
- 6 holes, each with a 50-kg charge

The assumptions made were as follows:

- Each hole would be such that charges are laid 4 m below the seabed and "stemmed" (i.e. covered).
- A micro-delay interval of 25 ms between individual charges would be used.
- The tide height (of 6 m) and water and seabed characteristics would be as defined in Technical Appendix S7 in this EIS Supplement.

The results of modelled scenarios are provided in Technical Appendix S7. Figure 4-25 illustrates the propagation of noise for a scenario of 6 holes each with a 50-kg charge.

The outcomes of the modelling of blast noise exposure have been compared with the exposure criteria referred to above, and the predicted safe ranges for marine mammals, turtles and fish are given in Table 4-16.

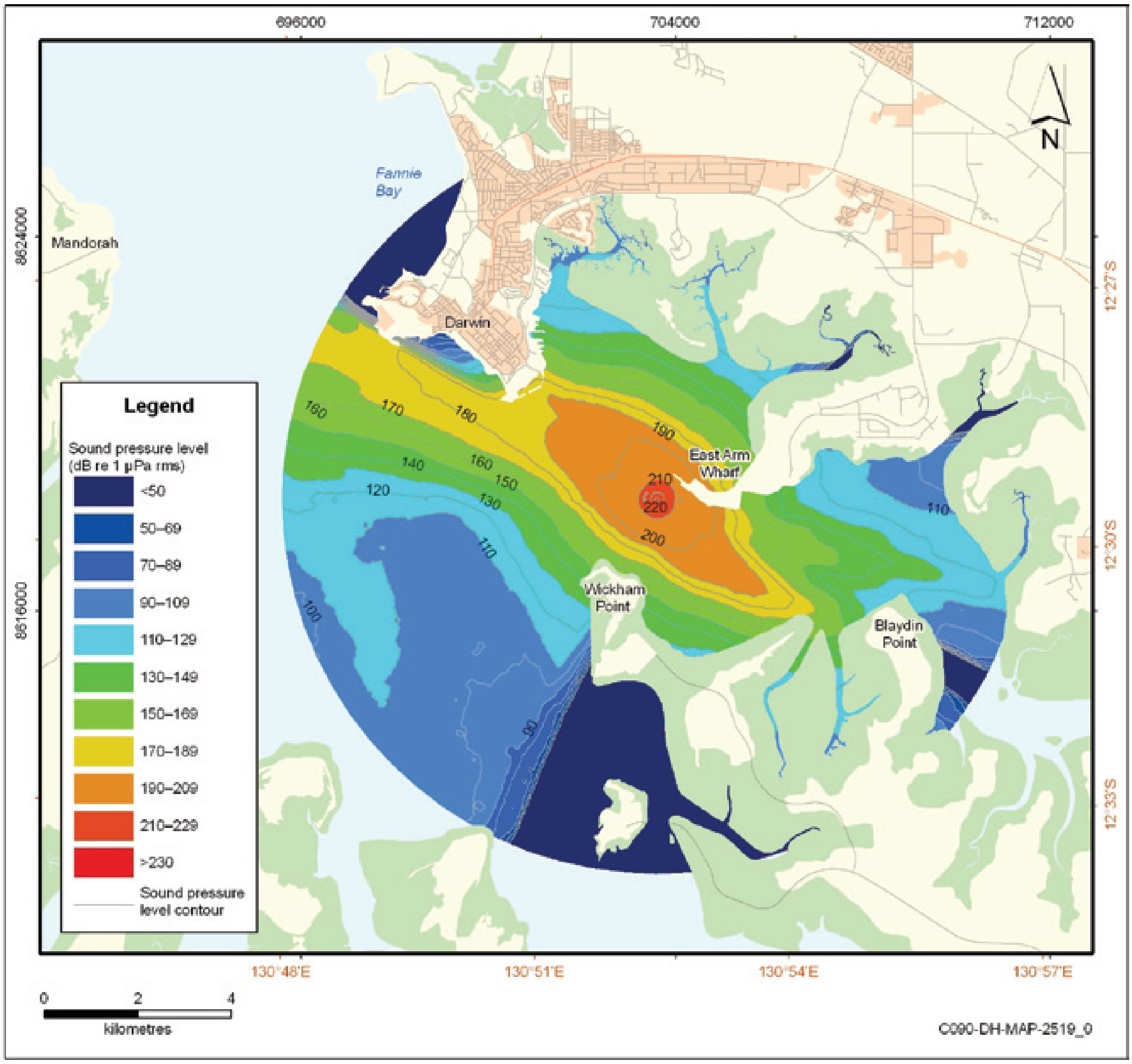


Figure 4-25: The modelled received root mean square sound pressure level contour for the scenario of a blasting operation at Walker Shoal

Note that each blasting operation has 6 holes with a 50-kg charge in each hole.

Table 4-16: Proposed INPEX blast noise exposure criteria for marine animals and the predicted safe ranges for 50 kg confined charge

Criterion	Metric	Type of impact		Reference	Safe range
Marine mammals					
230 dB re 1 μPa peak	SPL (peak unweighted)	Blast injury (PTS)		Southall et al. (2007) p. 443	1000 m
Turtles					
224 dB re 1 μPa peak	SPL	Blast (possible TTS)		Broner and Huber (2010) p. 2	1000 m
Fish					
37 kPa.ms	Critical impulse level	Blast injury	0.1 kg fish	Yelverton et al. 1975	700 m
77 kPa.ms	Critical impulse level	Blast injury	1.0 kg fish	Yelverton et al. 1975	400 m
160 kPa.ms	Critical impulse level	Blast injury	10 kg fish	Yelverton et al. 1975	300 m

All values are expressed as received levels, not as source levels.

The 1000 m mitigation range derived from the (conservative) modelling and the exposure criteria of Southall et al. (2007) compare favourably with the predictions from first principles drawn from Yelverton et al. (1973) of a low incidence of "trivial" injuries at a range of 854 m from the blast source, and a "safe" range of 1248 m that was presented in the Ichthys Project's Draft EIS. This suggests that the work of Yelverton et al. is robust and provides a useful foundation for the development of pragmatic risk assessments and mitigation measures on the basis of the principles of physics and vertebrate anatomy.

Piledriving

Piledriving for the construction of the module offloading facility (MOF) and the product loading jetty (PLJ) will be undertaken by contractors. INPEX has prepared a scope of works detailing the physical dimensions and standards to which the MOF and PLJ are to be constructed. The final design, however, will be completed by the contractor and the exact number, configuration and type of piles that will be used can only be finalised at that time. INPEX has identified potential scenarios for piledriving operations, described in Section 3.3.9, and has carried out the assessment of potential environmental impacts based on these scenarios.

Piledriving for the MOF and the PLJ is expected to take approximately 18 months and 8 months respectively if a single piledriving rig is used. In reality, however, it is likely that several rigs would be used. For piledriving at the PLJ three scenarios were considered: using one, two or three rigs simultaneously. For piledriving at the MOF two scenarios were considered: one piledriving rig operating alone or two operating simultaneously.

The assumptions made were as follows:

- 1.5 m diameter steel piles would be used
- Hydraulic impact hammers would be used
- Blows will occur approximately 1 second apart (i.e. 60 blows per minute)
- The duration of each blow is 90 ms
- The tide height (of 6 m) and water and seabed characteristics would be as defined in the Technical Appendix S7 in this EIS Supplement.

The results are provided in Technical Appendix S7. Figure 4-26 and Figure 4-27 illustrate the propagation of noise for piledriving rigs at the MOF and the PLJ.

The outcomes of the modelling of piledriving noise exposure have been compared with the exposure criteria referred to above, and the predicted safe ranges for marine mammals, turtles and fish are given in Table 4-17. It should be noted that the contours linking areas of equal sound pressure are irregular in shape, tending to increased propagation in of greater depth and attenuated in shallower waters (see Figure 4-25, Figure 4-26 and Figure 4-27). The stated "safe range" is the maximum distance at which the threshold noise level would occur. It is not correct to assume that this is a radius of effect.

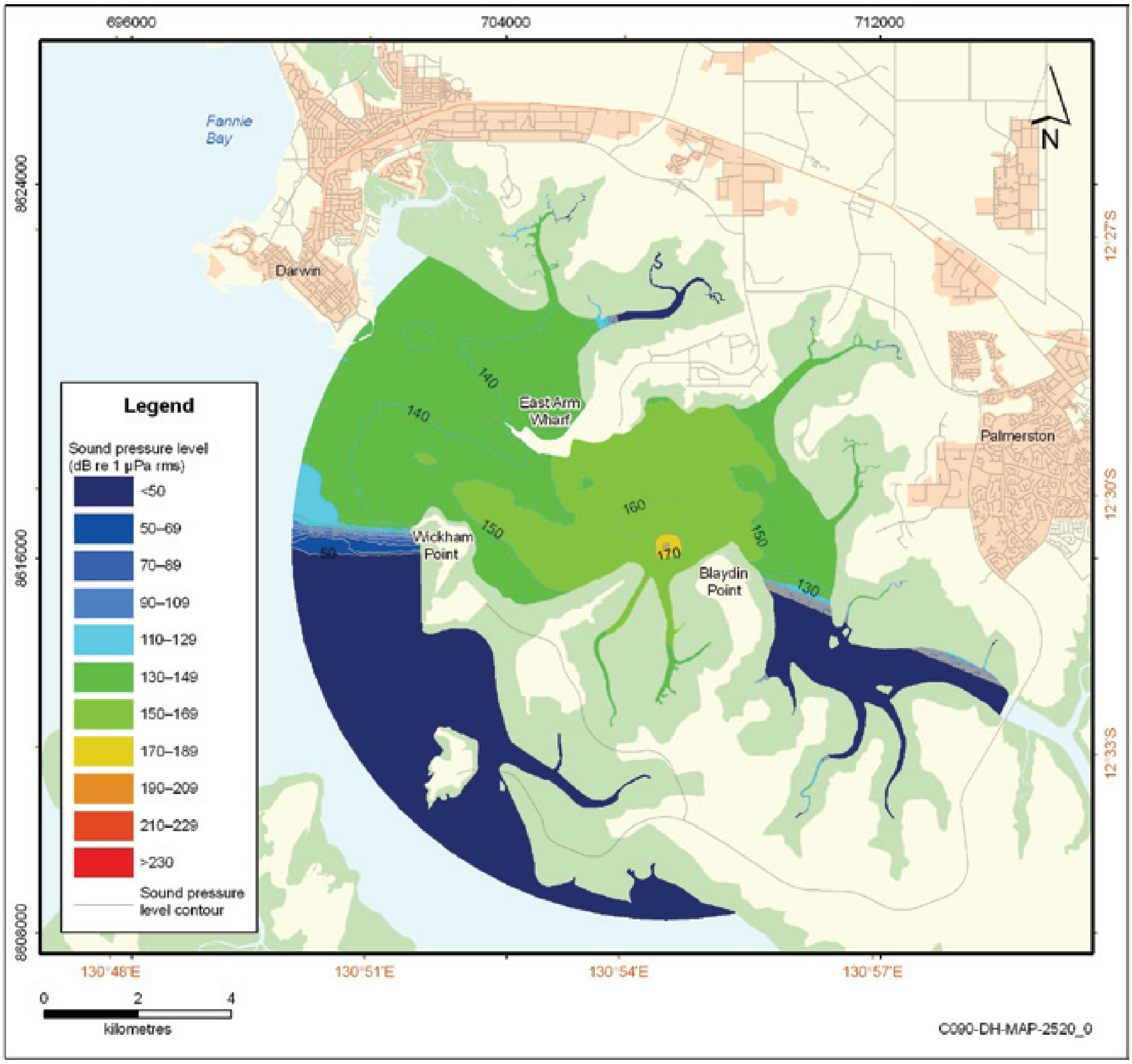


Figure 4-26: The modelled received root mean square sound pressure level contour for the piledriving operation at the product loading jetty

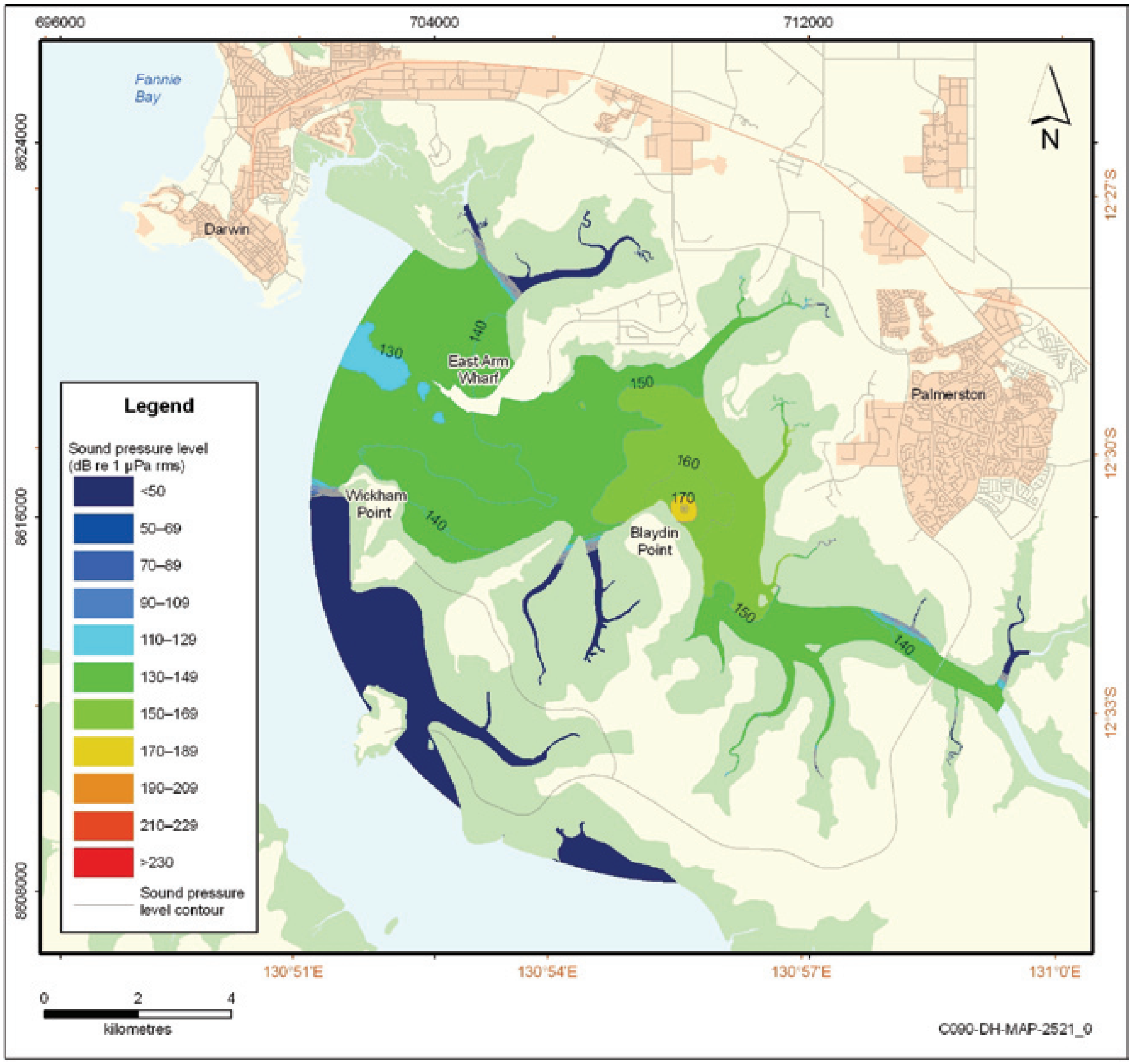


Figure 4-27: The modelled received root mean square sound pressure level contour for the piledriving operation at the module offloading facility

Table 4-17: Proposed INPEX piledriving noise exposure criteria for marine animals and the predicted maximum distance to safe range

Criterion	Metric	Type of impact		Reference	Safe range
Marine mammals					
198 dB (re 1 µPa²-s)	SEL (mid-frequency weighted)	Injury (PTS) from single or multiple blows		Southall et al. (2007) p. 443	500 – 1000 m
183 dB (re 1 µPa)	SEL (mid-frequency weighted)	TTS onset from 30-minute exposure time		DEWHA Seismic Guidelines background paper	2000 m
170 dB (re 1 µPa) rms	SPL (rms mid-frequency weighted)	Adverse behavioural response		Southall et al. (2007) p. 456	500 m
Turtles					
198 dB (re 1 µPa²-s)	SEL (100 to 1 kHz flat weighting)	Injury from single or multiple blows		Broner & Huber (2010) p. 2	500–1000 m
183 dB (re 1 µPa²-s)	SEL (100 to 1 kHz flat weighting)	Behavioural response		Broner & Huber (2010) p. 2	2000–5000 m
Fish					
199 dB (re 1 µPa²-s)	SEL (100 to 2 kHz flat weighting)	No injury from single blow	0.1 kg fish	Hastings & Popper 2005	<50 m
200 dB (re 1 µPa²-s)	SEL (100 to 2 kHz flat weighting)	No injury from single blow	1.0 kg fish	Hastings & Popper 2005	<50 m

All values are expressed as received levels, not as source levels.

* Variation in range is due to differences in the scenarios considered.

A sensitivity study of the predicted received noise levels from piledriving as a result of tidal fluctuation was undertaken. For this study one piledriving operation at the product loading jetty was used. Three different tidal heights, namely 2 m, 4 m and 6 m above LAT were considered. Medium-grained sand was used as the seabed type.

The change in predicted received levels as a result of tidal fluctuations is illustrated in Figure 4-28, which shows that tidal height fluctuation in shallow water does affect the predicted received levels, particularly in the far-field where acoustic propagation has more interaction with the seafloor under the lower tidal height. The data presented on piledriving noise exposure criteria for marine animals in Table 4-17 were calculated assuming a constant tidal height of 6 m above LAT.

For a single pulse noise (such as blasting) the use of maximum tide height can be considered to be a worst-case scenario. However, for multiple exposures over an extended period the use of a constant maximum tide height overstates the actual SEL that would be received because the tide height falls and rises twice over a daily cycle and, as illustrated by Figure 4-28, the received sound level at any given location would rise and fall in unison.

However because the computational power required to calculate the variation in SEL in dB re 1 µPa²·s over time for the area affected is so great, it is not possible to model SEL with natural tidal fluctuations. Hence it can only be noted that there is an overstatement in the model that is additional to the worst-case assumptions made.

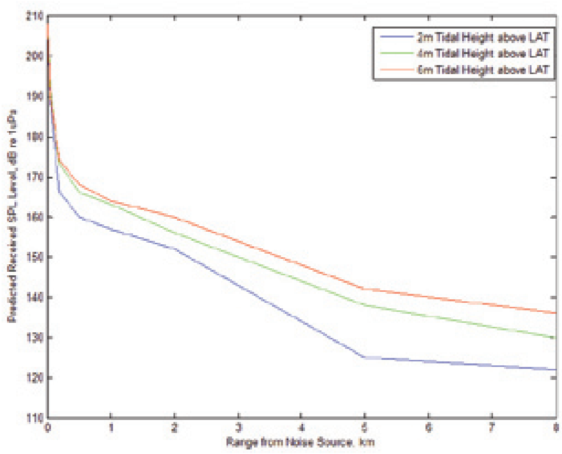


Figure 4-28: The predicted received sound pressure level against range from a piledriving operation at the product loading jetty (with a medium-grained sand seabed type)

4 Supplementary Information to the Draft EIS

Hydraulic hammer

A hydraulic hammer is a hydraulically operated ram enclosed in a hammer housing with an appearance similar to an oversized jackhammer. A hydraulic hammer is suitable for underwater rock-breaking.

Signals generated from a hydraulic hammering operation are regarded as pulses. It is assumed that the blow rate of the hammer is roughly equal to that of the piledriving, that is, 60 blows per minute, with the duration of each hammering impulsive signal taken as approximately 90 ms. This duration was used to calculate the SEL of the hammer. Outcomes of noise exposure modelling for hydraulic hammer operations at Walker Shoal (presented in Technical Appendix S7 to this EIS Supplement) have been compared with the exposure criteria referred to above and the predicted safe ranges for marine mammals, turtles and fish. At no point is it predicted that noise from hydraulic hammer operations would exceed the underwater noise criteria.

Cutter-suction dredger

The noise from dredging activities is mainly generated by the operating motors and engines of dredging vessels and has non-pulse characteristics. It is expected that cutter-suction dredgers will be used to undertake some of the dredging operation in Darwin Harbour. A cutter-suction dredger is a ship that employs a suction pipe with a cutterhead at the suction inlet, which is used to loosen the seafloor substrate and transport it to the suction mouth. The cutter can also be used for hard surface materials like gravel or rock. The dredged soil is usually sucked up by a wear-resistant centrifugal pump and discharged through a pipeline or to a barge.

Specialised cutter-suction dredgers will be used in the first instance as an alternative to the drill-and-blast operation at Walker Shoal described in the Draft EIS. As the source spectrum data for a specialised cutter-suction dredger are not available, its spectrum curve was assumed to be the same as that of normal cutter-suction dredger (see Figure 4-29) with a 6-dB higher spectrum level than that of normal cutter-suction dredging.

Modelling of noise exposure from cutter-suction dredge operations were carried out for three dredge locations: the north end of Walker Shoal, the south end of Walker Shoal, and midway of the shipping channel. Outcomes of noise exposure modelling have been compared with the exposure criteria referred to above and the predicted safe ranges for marine mammals, turtles and fish. At no point is it predicted that noise from cutter-suction dredge operations would exceed the underwater noise criteria.

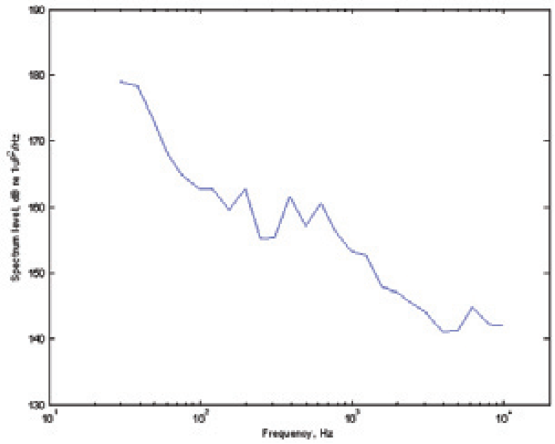


Figure 4-29: Source spectrum level of a normal cutter-suction dredger

4.1.12 Evaluation of acoustic monitoring techniques

Studies undertaken

INPEX has commissioned a detailed study involving desktop modelling and recommendations for field trials to test the effectiveness of passive acoustic monitoring (PAM) and active acoustic monitoring (AAM) techniques.

Passive acoustic monitoring techniques are based on establishing listening posts to detect marine mammal sounds. Active acoustic monitoring uses one or more sonar systems that actively emit sound and measure the returning noise signal to locate objects.

Passive acoustic monitoring

Passive acoustic monitoring relies on the ability of the monitoring system firstly to detect animal vocalisations and secondly to recognise the vocalisations. In order to estimate the capacity of PAM to detect large marine animals, sound propagation was modelled in three dimensions for an animal located near Walker Shoal emitting tonal calls at 500 Hz and at 1, 2, 5 and 10 kHz. In the absence of source level information for any of the Darwin Harbour populations of large animals, a source spectrum level of 140 dB re 1 μPa^2/Hz at 1 m was used (this represents the louder end of reported source levels). It was concluded that detection of vocalising large animals by PAM would be feasible at all tides. The next step investigated the ability of PAM to detect a number of species-specific vocalisations along two perpendicular transects; again the animal was located at Walker Shoal.

The vocalisations considered were as follows:

- communication calls: modelled at 400 Hz and at 1 and 10 kHz with a source level of 140 dB re 1 μPa^2/Hz at 1 m
- false killer whale clicks: modelled at 40 kHz with a reported source level of 154 dB re 1 μPa^2/Hz at 1 m
- dolphin echolocation clicks: modelled at 100 kHz with a reported source level of 180 dB re 1 μPa^2/Hz at 1 m.

For the vocalisations considered, 400 Hz signals were deemed detectable with a 50% probability over a 16 km range; 1 kHz signals over 8.5 km; 10 kHz signals over 1.8 km; 40 kHz signals over 3.0 km; and 100 kHz signals over 1.8 km.

Detection of echolocation clicks between 40 kHz and 100 kHz will depend on where the animal is pointing. The echolocation signals are highly directional (10° width) and the direct path for an animal aiming at the hydrophone was modelled. Across the shipping channel, all signals modelled were detectable all the way to Wickham Point and East Arm Wharf.

No information was found in the literature that would be suitable for identifying populations of large animals in Darwin Harbour from their call characteristics. Although it is not necessary for active management purposes to know the species' identity, during monitoring operations it is necessary to ensure that systems are capable of detecting the particular call characteristics from species that may occur in the area. Data for other populations of the same species elsewhere have showed the following:

- Dugongs produce a variety of calls between 500 Hz and 18 kHz (Anderson & Barclay 1995).
- False killer whales produce whistles between 4 and 10 kHz (Murray, Mercado & Roitblat 1998), and clicks between 30 and 100 kHz with source levels of 201–225 dB re 1 μPa at 1 m (Madsen, Kerr & Payne 2004).
- Indo-Pacific bottlenose dolphins whistle between 2 and 22 kHz (Hawkins 2010). No record of their echolocation clicks was found in the literature.
- Indo-Pacific humpback dolphins whistle between 1 and >22 kHz (Schultz & Corkeron 1994; Van Parijs & Corkeron 2001a), click between 2 and 200 kHz (Goold & Jefferson 2004), and emit burst-pulse sounds between 0.6 and >22 kHz (Van Parijs & Corkeron, 2001b).
- Snubfin dolphins whistle at 3-4 kHz; clicks exceed 22 kHz (Van Parijs, Parra & Corkeron 2000).

No information was found on the characteristics of underwater calls of turtles and crocodiles.

Populations belonging to the same species but living in different environments can exhibit quite different vocalisation characteristics. Given that no recordings or descriptions have been published on the call characteristics, source levels and calling rates of large marine animals in Darwin Harbour, it will be necessary to obtain field recordings in the Harbour prior to setting up a passive acoustic monitoring system. This will ensure that monitoring systems are able to recognise the full suite of species that may occur in the area.

Mid-frequency active acoustic monitoring

Active acoustic monitoring has the potential to detect non-vocalising animals. Mid-frequency sonars emit sound in the range from 20 to100 kHz and are able to detect animals of lengths 0.5 m and larger to distances of almost 1 km. This capability allows the tracking of animals, which helps with the identification if typical kinetic behaviours are known. The strength of the acoustic signal returned from an animal at mid-frequencies depends on the size, shape and orientation of its gas-filled organs (lungs, swim bladders) relative to the acoustic source.

Several types of mid-frequency AAM equipment are available "off the shelf" although none of these are specifically designed for the detection of marine mammals. The beam pattern of commercial fisheries sonars would be unsuitable for the detection of large animals in the shallow-water environment of East Arm. Forward-looking navigational sonars have a narrow beam-width, but are not easily networkable to achieve 360° coverage. Diver detection systems appear most promising and some manufacturers have the capacity to modify their systems for marine mammal detection.

All of the mid-frequency AAM systems modelled were found to be reverberation-limited in the shallow-water environment of East Arm. Existing proprietary diver detection sonars are expected to overcome reverberation, but as hardware and software specifications are not available this could not be confirmed.

High-frequency active acoustic monitoring

High-frequency AAM sonars operate at 100 kHz to 1 MHz, provide fine range and bearing resolution, and are capable of high-resolution imagery over a few tens or hundreds of metres in range, allowing target identification. Commercially available systems are portable and could be mounted on a small boat to provide a roving investigation capacity. Search systems operating at less than 200 kHz are promising for short-range imagery. The very-high-frequency classification systems would only be useful if species identification was desired, which it is not. Their performance ranges are so short, that they would only be of value if used as part of an integrated monitoring system.

Selection of best-practice monitoring methods

Visual observations, PAM and AAM can all be considered as potential management practices that can be used in to monitoring marine mammals. It should not be assumed that applying all possible management practices will lead to the best possible protection of marine mammals. Instead it is necessary to evaluate the costs and environmental benefits of each practice both in isolation and in combination to determine which is the best.

Visual marine mammal monitoring is commonly utilised in mitigation protocols. However, animals may be missed because of time spent underwater or because of poor conditions, such as rough seas, poor light, or rain. Underwater acoustic monitoring is not affected by these conditions. The limitations of passive acoustic methods are attributable to the fact that animals do not vocalise all the time, that little is known about typical calling rates, that school size is hard to determine, that some species are difficult to tell apart, and that concurrent anthropogenic noise interferes with acoustic detection.

In Darwin, PAM is expected to have the longest detection ranges and could potentially be used to inform marine mammal observers (MMOs) of probable animal locations. Mid-frequency sonar will equally inform MMOs and high-frequency sonar operators of probable targets, both of which can then focus on the detection area for target confirmation.

Studies are continuing to assess the best-practice method for the monitoring of marine mammals.

4.1.13 Comparison of proposed management measures for protection of marine mammals to Australian and international practices

Studies undertaken

Potential impacts from marine construction activities are primarily associated with underwater noise. This was discussed in the Draft EIS's Technical Appendix 15 *Review of literature on sound in the ocean and on the effects of noise on marine fauna*. The main construction activities having the potential to cause disturbance to marine mammals are as follows:

- vessel movements
- dredging operations
- percussive piledriving
- blasting.

A review of Australian and international environmental assessments has been conducted, firstly to determine what constitutes current best practice and secondly to provide a comparison between current best practice and the proposed INPEX management practices. It should be noted that it is wrong to assume that the application of all possible management measures will lead to the best practice. Best practice is the combination of management practices, that is determined after impact assessment, examination of alternative practices and appropriate stakeholder participation to be the most effective practical and sustainable means of achieving an environmental performance objective.

The comparison of proposed management measures for protection of marine mammals has included a review of the environmental impact assessments of the following projects:

- Australia
  - Hay Point Coal Terminal Expansion 2010
  - Port of Hay
  - QCLNG
  - Port Phillip Bay Channel Deepening
  - Pluto LNG
  - Gorgon LNG
  - Gladstone LNG
  - Cape Lambert Port B Development
  - Western Australian Water Corporation Southern Seawater Desalination Project
  - Western Australian Water Corporation Alkimos Wastewater Treatment
  - Department of Defence, mine warfare training, Shoalwater Bay, Queensland

- Hong Kong
  - Sokos Island LNG
  - Hong Kong 2020 Port Study
  - Hong Kong Zhuhai and Macau Bridge Boundary Crossing Facility
- United States
  - Port Dolphin
  - North East Gateway Deepwater Port and Pipeline Development
  - Knik Arm Crossing EIS, Cook Inlet Alaska
  - Removal of Bridge Support Structures, Duval County
  - Port of Miami-Dade Channel Dredging, Miami, Florida
  - Pier removal, Sarastoa Bay, Florida
- United Kingdom
  - Greater Gabbard Windfarm
  - Gunfleet Sands Offshore Windfarm

Vessel movements and dredging

It is apparent that underwater noise and vessel movements can affect marine mammal behaviour adversely. But evidence from other areas suggests that these impacts are more likely to occur from recreational power-boat traffic than from larger slow-moving construction vessels as a consequence of their noise characteristics and speed of travel.

From a review of Australian environmental impact assessments it was found that there were few recommended measures to mitigate the impacts of vessel noise on marine mammals other than restrictions on vessel speed, vessel course management, vessel design criteria, and restrictions on aircraft. Recent large-scale dredging projects in Australia, required for port and oil & gas developments, are managed according to a number of precautionary and mitigation measures and conditions, including the following:

- marine mammal exclusion zones, applicable to dredge spoil disposal
  - animals to be absent from 300 m for 10 minutes prior to works commencement
  - cease operations if marine mammals are within 300 m, and recommence works when absent within 300 m for 20 minutes
- observations of work area prior to works commencement to avoid startle response to marine mammals
- slow starts to dredge equipment and vessel movements to allow marine mammals to move away
- follow defined procedures during vessel manoeuvring (applicable to all vessels) in the event of encounters with cetaceans within 300 m including speed restrictions (<5 knots and avoid change in direction) (i.e. not applicable to stationary dredging vessels)
- inductions to vessel crews regarding operations in marine mammal habitat
- continual watch for marine mammals and notification of their presence to other Project vessels
- marine mammal sightings daily logging and routine reporting
- immediate reporting of interactions resulting in marine mammal injury/mortality
- immediate reporting of marine mammal strandings
- documentation of risks, measures and monitoring in environmental management plans and dredging and spoil management plans.

In Hong Kong, a number of measures are typically recommended for projects to reduce potential dredging and vessel impacts to marine mammals. These include:

- briefings to vessel operators alerting them to the possible presence of marine mammals, and guidelines for safe vessel operations
- if high-speed vessels are used, they are required to slow to less than 10 knots through areas of high dolphin density.
- vessels to use predefined and regular routes as these will become known to marine mammals.
- monitoring for marine mammals within 250 m for at least 30 minutes prior to dredging works commencement. if present, works are delayed until marine mammals have left this area.
- cessation of dredging operations are not required during dredging, if marine mammals enter closer than 300 m as they are assumed to have acclimatised themselves to the works
- scheduling constraints to avoid dredging during peak calving season.

In the US, measures to control impacts to marine mammals from dredging operations and vessel noise are summarised as follows:

- during dredging operations, maintain a continual lookout for marine mammals
- cease operations if marine mammals enter within 92 m (100 yards), and recommence works when they have left this area
- speed restrictions, dredging vessels (and all other vessels) to operate at idle or no-wake speeds in construction area and in areas where the draught of the vessel has less than 4-foot clearance from the seabed

- slow starts or “ramp up” for dredge equipment
- during transit, vessels to follow marked channels wherever possible
- maintain separation distance between vessel and marine mammals during transit
- inductions to vessel crews regarding operations in marine mammal habitat , and emergency procedures in unlikely event of vessel strike.

In the United Kingdom, specific mitigation measures for dredging related to marine mammals are generally not proposed.

Annexe 4 *Provisional cetacean management plan* to Chapter 11 *Environmental management program* of the Draft EIS includes the following management measures, which are considered to be consistent with best-practice operations:

- All members of the marine workforce will be required to complete an HSE induction which will include information on cetacean management requirements.
- Vessel masters will be trained in cetacean interaction procedures.
- INPEX vessels will operate at "no wash" speed when within 50 to 150 m of a dolphin and will not intentionally approach within 50 m of a dolphin

The final cetacean management plan will expand the scope of the management plan to include dugongs.

Piledriving

Reviews of recent Australian oil & gas sector projects requiring piledriving works have shown that, to date, few specific measures to control impacts from piledriving have been required, at least as reported in environmental impact statements and “ministerial conditions” documentation. It also appeared there have been no requirements for stringent monitoring of marine mammal exclusion zones around piledriving works. A summary of measures that have been taken is as follows:

- Scheduling constraints, minimise overlap of construction schedules in nearshore areas with key breeding periods
- Marine mammal sightings daily logging and routine reporting;
- Documentation of risks and measures in environmental management plans
- Work area checks:
  - Observations to be made in the works area (water greater than 3 m depth) before commencement of works each day or if there is an extended break during the day
  - If marine mammals are present in the works area, commencement of piledriving will be delayed until they have left the area, or a "soft-start procedure" will be considered.

A number of recent coastal development projects in Hong Kong have required percussive piledriving works in marine-mammal habitat. Measures to manage associated impacts are summarised as follows:

- Equipment and operations:
  - Use of quieter hydraulic hammers instead of diesel hammers
  - Acoustic decoupling (i.e. repositioning or use of rubber fittings) of noisy equipment
  - Use of bubble jackets and curtains
  - Soft start/ramping-up of operations
  - Activities will be continuous without short breaks and avoiding sudden random loud sound emissions
- Scheduling constraints, piledriving works are not permitted in the peak calving season for marine mammals
- Marine mammal exclusion zone:
  - Visual monitoring of 500 m exclusion zone for at least 30 minutes prior to piledriving. Visual monitoring will continue during piledriving works.
  - Commencement of works will be delayed until after marine mammals have left this area
  - Works will cease if marine mammals enter within the 500 m exclusion zone, and will not recommence until 30 minutes after they have left.

Best-practice procedures in the United Kingdom for percussive piledriving are contained in the protocol produced by the Joint Nature Conservation Committee (JNCC 2009a). A summary of key management controls outlined in these guidelines are as follows:

- Equipment and operations
  - Adopt best available techniques
  - Use soft-start for 20 minutes
- Scheduling constraints:
  - Seasonal restrictions may be required
  - Restricted to daylight hours and good visibility and sea state conditions conducive to visual monitoring
- Marine mammal exclusion zone:
  - Minimum exclusion zone radius of 500 m.
  - Use marine mammal observers (visual monitoring) and, if required, passive acoustic monitoring

- – Conduct marine mammal monitoring in the exclusion zone for at least 30 minutes prior to start of piledriving.
  - – Piledriving may not commence within 20 minutes of a marine mammal leaving the exclusion zone.
  - – If a marine mammal enters exclusion zone during piledriving there is no requirement to stop works.

Based on several recent US project examples, typical controls to manage impacts to marine mammals associated with percussive piledriving are summarised as follows:

- Scheduling constraints, no piledriving during period of peak marine mammal abundance
- Equipment and operations:
  - – Soft start-up
  - – Additional measures are to be considered where practicable
- Marine mammal exclusion zone:
  - – Distance of exclusion zone determined by modelling findings
  - – Conduct visual monitoring of exclusion zone and surrounding areas for 30 minutes before, during and 30 minutes after piledriving.
  - – Piledriving will temporarily cease if marine mammals enter the exclusion zone.

Annexe 12 *Provisional piledriving and blasting management plan* to Chapter 11 of the Draft EIS includes the following management measures:

- It is intended that piledriving activities will be undertaken only during daylight hours. Night-time piledriving will only be resorted to if Project construction activities fall significantly behind schedule.
- A watch will be maintained for cetaceans, dugongs, turtles and crocodiles for a duration of 10 minutes prior to the “soft start” of piledriving activities. If any animal is observed within the “fauna observation zone”, that is, within a radius of 100 m of the piledriving location, the “soft start” will not proceed until the animal has been observed to have moved outside the zone or is not sighted for 10 minutes.
- Piledriving will commence with the “soft-start” procedure, where activities are gradually scaled up over a 5-minute period. This will provide an opportunity for any sensitive marine animals to leave the area before being exposed to the full intensity of underwater noise.

Note that soft starts are not possible during pile testing, which occurs after completion of driving and involves dynamically testing and measuring the pile by striking it at maximum force.

Modifications and additional measures to be included in the final piledriving management plan to ensure consistency with best-practice methods include the following:

- Visual monitoring of 500 m is to be undertaken in the "observation zone" for at least 30 minutes prior to piledriving. The observation zone has been expanded to 500 m based on the numerical modelling presented in Technical Appendix S7 in this EIS Supplement. The duration has been extended to allow for the cryptic behaviour of coastal dolphin species.
- If any animal is observed within the observation zone, that is, within a radius of 500 m of the piledriving location, the “soft start” will not proceed until the animal has been observed to have moved outside the zone or is not sighted for 30 minutes.
- Visual monitoring will continue during piledriving works and for 10 minutes after stoppage.
- Piledriving will temporarily cease if marine mammals approach within 100 m of the piledriving operation and will not recommence until the animals have been observed to have moved outside the observation zone (500 m) or is not sighted in the observation zone for 30 minutes. A distance of 100 m has been selected for shutdown based on numerical modelling which indicates potential onset of permanent threshold shift at <50 m from the piledriving operation.

For marine mammals there are no known periods of special sensitivity; hence seasonal restrictions are not considered to be appropriate.

The proposed management measures, including the proposed modifications and additions, are considered to be consistent with best-practice piledriving operations.

Blasting

Management measures to control blasting impacts to marine mammals from Australian operations have included the following:

- Select blast techniques that reduce the zone of impact
- Scheduling constraints:
  - – schedule blasting outside sensitive periods (e.g. breeding season), where practicable
  - – daylight blasting only (avoiding dawn and dusk); this is also a legal requirement)
  - – only to be conducted when sea and daylight conditions permit marine mammal exclusion zone monitoring

- Marine mammal exclusion zone:
  - exclusion zone (distance to safe zone) determined from blast modelling
  - boundary of exclusion zone (i.e. safe zone) to be marked with buoys
  - visual monitoring of exclusion zone and surrounding waters (e.g. a further 1 km) for at least 60 minutes prior to each blast
  - implement stop-work measures if marine mammals enter the designated exclusion zone
  - track and monitor any marine mammals observed in the surrounding waters
  - use warning charges or repetitious warning shots (air guns) prior to blasting
- Collect any dead marine animals (e.g. fish) after blasts to avoid attracting marine mammals
- Report any animal in distress
- Record and report marine mammal sightings
- Document blasting details, modelling findings, measures and monitoring in the relevant plan or program (e.g. marine blasting management plan; dredging and spoil management plans; best-practice dredge program; marine facilities construction environmental management plan).

The review identified no project examples of management practices for marine blasting from Hong Kong.

Best-practice procedures in the United Kingdom for marine blasting to minimise injury are contained in guidelines published by the Joint Nature Conservation Committee (JNCC 2009b). A summary of the key management controls outlined in these guidelines is as follows:

- Scheduling constraints:
  - Blasting in daylight hours only
  - Restricted to times of good visibility and sea state
  - Avoid times when encounters with marine mammals are more likely.
- Marine mammal exclusion zone (mitigation zone):
  - Default exclusion zone is 1 km (but requires consultation with regulator – may be larger or smaller)
  - Use marine mammal observers (visual monitoring) and, if required, passive acoustic monitoring
  - Conduct a pre-detonation search in the exclusion zone for at least 1 hour prior to blast.
  - Blasting may not commence within 20 minutes of a marine mammal leaving the exclusion zone

Based on a recent US project example, typical controls to manage impacts to marine mammals of blasting are summarised as follows:

- Select blast techniques that reduce the zone of impact
- Scheduling constraints:
  - Blasting restricted to daylight hours (not within 2 hours after sunrise and 1 hour before sunset)
  - Blasting scheduled for periods when low marine mammal abundance was expected
- Marine mammal exclusion zone:
  - Exclusion zone (distance to safe zone) determined from blast modelling
  - Visual monitoring of exclusion (from vessels and helicopters) for at least 60 minutes before and 30 minutes after each detonation
  - No blasts if animals are sighted in the exclusion zone

Annexe 12 *Provisional piledriving and blasting management plan* to Chapter 11 of the Draft EIS includes the following management measures:

- Blasting operations will only be undertaken during daylight hours
- Only the minimum required charge will be used for onshore and nearshore blasting operations.
- Confined blasting methods will be used, with micro-delays between charges to reduce peak pressure levels of each blast in the surrounding waters.
- Fauna protection zones will be developed for nearshore blasting. The extent of these zones will be determined once detailed geotechnical investigations have been completed and further information from drill and blast contractors has become available.
- Trained marine fauna observers will survey the fauna protection zones prior to the commencement of blasting. If large marine animals such as cetaceans, dugongs, turtles and crocodiles are observed to enter the fauna protection zone, blasting activities will be suspended. Detonations will only be permitted if the fauna protection zone is observed to be free of large marine animals for a period of at least 20 minutes.
- For effective surveillance, blasting will only be conducted during the hours of daylight and in benign sea conditions so that observers will be better able to sight any large marine animals within the fauna protection zone.

- The potential to use passive or active acoustic monitoring to identify submerged marine animals within the fauna protection zone will be evaluated by field testing. If shown to be practicable, these methods are likely to be used to complement vessel-based surveys prior to the commencement of blasting activities.
- Explosive casings will be selected to minimise the risk of floating debris which, if ingested, could be harmful to marine mammals, birds, turtles and fish.
- Should fish be killed as a result of blasting activities and float to the surface of the water, they will be retrieved in order to minimise the possibility of scavenging seabirds and other predators being injured by subsequent blasts.

Modifications and additional measures to be included in the final blasting management plan to ensure consistency with best-practice methods include the following:

- The marine mammal (and other large marine animal) protection zone is defined as 1000 m based on numerical modelling.
- Detonations will only be permitted if the fauna protection zone is observed to be free of marine mammals (and other large marine animals) for a duration of 30 minutes (increased from the 20 minutes given in the Draft EIS) to allow for cryptic behaviour of coastal dolphin species.
- If a marine mammal (or other large marine animal) is observed within the fauna protection zone during the 30-minute observation period, blasting will not commence until after the fauna protection zone has been observed to be clear of large marine animals for 20 minutes.

In addition, the drill-and-blast contractor (should drilling and blasting be required) will be required to identify and evaluate if there are further management controls which could be practicably implemented to mitigate risks to marine animals. Such considerations could include use of active deterrent devices and the use of blast impulse bubble curtains.

The proposed management measures, including the proposed modifications and additions, are considered to be consistent with best-practice blasting operations.

4.1.14 Nutrients in wastewater

Some submissions on the Draft EIS concerned nutrients from sewage discharges into Darwin Harbour during the Project construction and operations.

The potential contribution from the Ichthys Project to the nutrient load in East Arm as well as existing contributions into East Arm are provided in Table 4-18.

INPEX's total nitrogen (TN) and total phosphorus (TP) inputs into East Arm from sewage discharges were calculated using the predicted average annual sewage discharge volumes from the construction and operations phases and the maximum discharge concentration limits for TN and TP of 40 mg/L and 10 mg/L respectively committed to in Section 5.6.3 of the Draft EIS. For this assessment these concentration values were used.

Table 4-18: Existing nutrient pollutant annual loads into East Arm and percentage of Project contribution for construction and operations phases

Source		Unit	TN	TP
Existing Annual Pollutant Loads into East Arm*	Diffuse	t/a	129.3	8.4
	Sewage treatment plants	t/a	73.0	19.4
	Total	t/a	202.3	27.8
Project Construction Phase	Average flow	m^3/d	25.0	25.0
	Concentration	mg/L	40.0	10.0
	Annual load	t/a	8.8	2.2
	Percentage of existing pollutant load	%	4.3	7.9
Project Operations Phase	Average flow	m^3/d	3.0	3.0
	Concentration	mg/L	40.0	10.0
	Annual load	t/a	1.1	0.3
	Percentage of existing pollutant load	%	0.5	0.9

* Pollutant loads are based on Skinner, Townsend and Fortune (2009) and consist of subcatchment runoff and sewage treatment plant discharges into Darwin Harbour's East Arm.

4 Supplementary Information to the Draft EIS

As can be seen from Table 4-18, INPEX's projected annual TN and TP contributions during the Project's construction phase (based on an average of 2500 workers) are 4.3% and 7.9% respectively in comparison with the current annual loads into East Arm.

During operations, when the numbers of personnel are significantly lower (an average of 300), the annual nutrient load contribution from the Project will be significantly lower at 0.5% and 0.9% for TN and TP respectively, when compared with existing East Arm annual loads.

NRETAS has identified current TN and TP point source annual loads and also point source annual load targets and for the Darwin Harbour region (Fortune & Maly 2009). These values and also INPEX's calculated annual construction and operations TN and TP loads are presented in Table 4-19. The percentage of INPEX's TN and TP annual loads compared with current point source loads are also presented.

As can be seen from Table 4-19, INPEX will only contribute and additional 2% to 3% of TN and TP average annual load during construction and 0.3% average annual load during operations.

Existing diffuse runoff and point-source sewage discharges are relatively minor compared with the overall nutrient status of the Harbour (Fortune & Maly 2009). INPEX's small incremental additions of TN and TP to the average annual loads are not expected to affect water quality in the Harbour and these additional loads do not result in a substantial increase towards the upper trigger for point source annual loads in Darwin Harbour.

4.2 Oil-spill contingency planning

4.2.1 Spill-trajectory modelling

INPEX has conducted additional spill-trajectory modelling of three new spill scenarios that were not presented in the Draft EIS. These are as follows:

- a 50-m^3 pipeline rupture in Darwin Harbour, adjacent to the pipeline shore crossing
- a 50-m^3 pipeline rupture in Beagle Gulf, at locations identified as the worst-case scenario for each season in relation to Bare Sand Island (a known turtle nesting location)
- an 11-week seabed well blow-out, with a flow of 4000 barrels per day, representing an average subsea blow-out rate for a typical well over an extended production period.

A stochastic modelling approach was used to estimate risks to surrounding waters and shorelines from each defined spill scenario. This involved repeated simulations of the same scenario, defined by the oil type, spill volume, spill duration, and location of the release point. For each simulation, different samples of metocean conditions (currents and winds) were used. The metocean conditions for each simulation were selected randomly from a database of historic current and wind data for the study area. The random selection ensures that environmental conditions are selected objectively and proportional to their occurrence over the study area and also for the relevant season of the start of the simulation.

Each model output (provided below) displays the combined results of all the simulations, to provide a probability map for the various condensate spill scenarios within the relevant season. The model outputs are not a representation of how the condensate would behave from a single simulation.

The methods and full results of these modelling scenarios are provided in Technical Appendix S2 in this EIS Supplement.

All scenarios were conducted in wet, dry and transitional seasons, using the same condensate specifications as were used in the Draft EIS.

Section 7.2.4 (page 268) of Chapter 7 *Marine impacts and management* of the Draft EIS contains the relevant condensate weathering data, and the Draft EIS's Technical Appendix 7 *Marine hydrocarbon spill modelling* describes how these condensate weathering data were incorporated into the spill trajectory modelling; hence all spill model outputs in both the Draft EIS and this EIS Supplement includes the fate of the non-volatile residue remaining after condensate weathering.

Table 4-19: Darwin Harbour TN and TP current condition, INPEX inputs and annual load targets

	Darwin Harbour current point source load (tonnes)*	INPEX construction annual load (t)	INPEX Construction percentage of existing point source	INPEX operations annual load (t)	INPEX operations percentage of existing point source	Darwin Harbour point source annual load upper trigger (t)
TN	321	8.8	2.7	1.1	0.3	402
TP	102	2.2	2.2	0.3	0.3	128

Note: The data in columns 2 and 7 are extracted from Fortune and Maly 2009.

4.2.1.1 Risks to Darwin Harbour, the Browse Basin and the Kimberley coastline

Darwin Harbour

The full suite of model outputs of the two additional gas export pipeline rupture scenarios are provided in sections 3.1 and 3.2 of Technical Appendix S2 to this EIS Supplement. The model outputs displaying the predicted probability of oil exposure to the water surface of more than 1 g·m^{-2} (with a film of thickness 1 μm) under summer, autumn, winter and spring conditions are presented in figures 4-30 to 4-33.

Results of the gas export pipeline rupture within 1 km of the Wickham Point shore crossing indicate that surfaced condensate is most likely to affect waters between Wickham Point and Channel Island, with most of the surfaced condensate evaporating over one or two tidal cycles, but it is predicted that adjacent shorelines will be affected by condensate that spreads as a result of dispersion and wind-induced drift. As there is only a short distance to the shore (1 km), shoreline contact by condensate was predicted to occur in all model simulation cases in all seasons. However, the highest volume predicted to reach shoreline in any scenario was 0.6 m^3, or 1.2% of the total release volume.

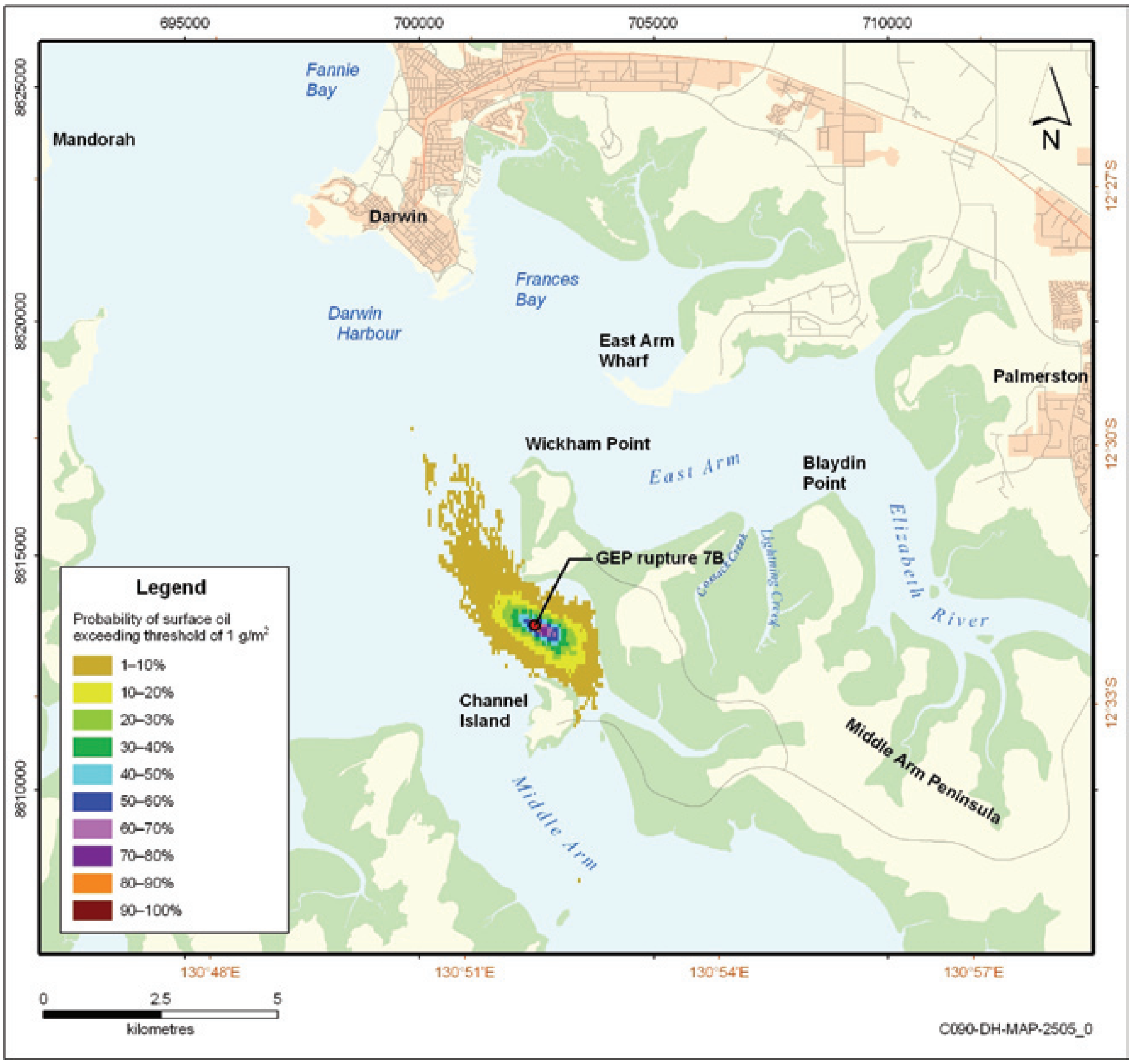


Figure 4-30: Gas export pipeline rupture (50 m^3) near Wickham Point—summer

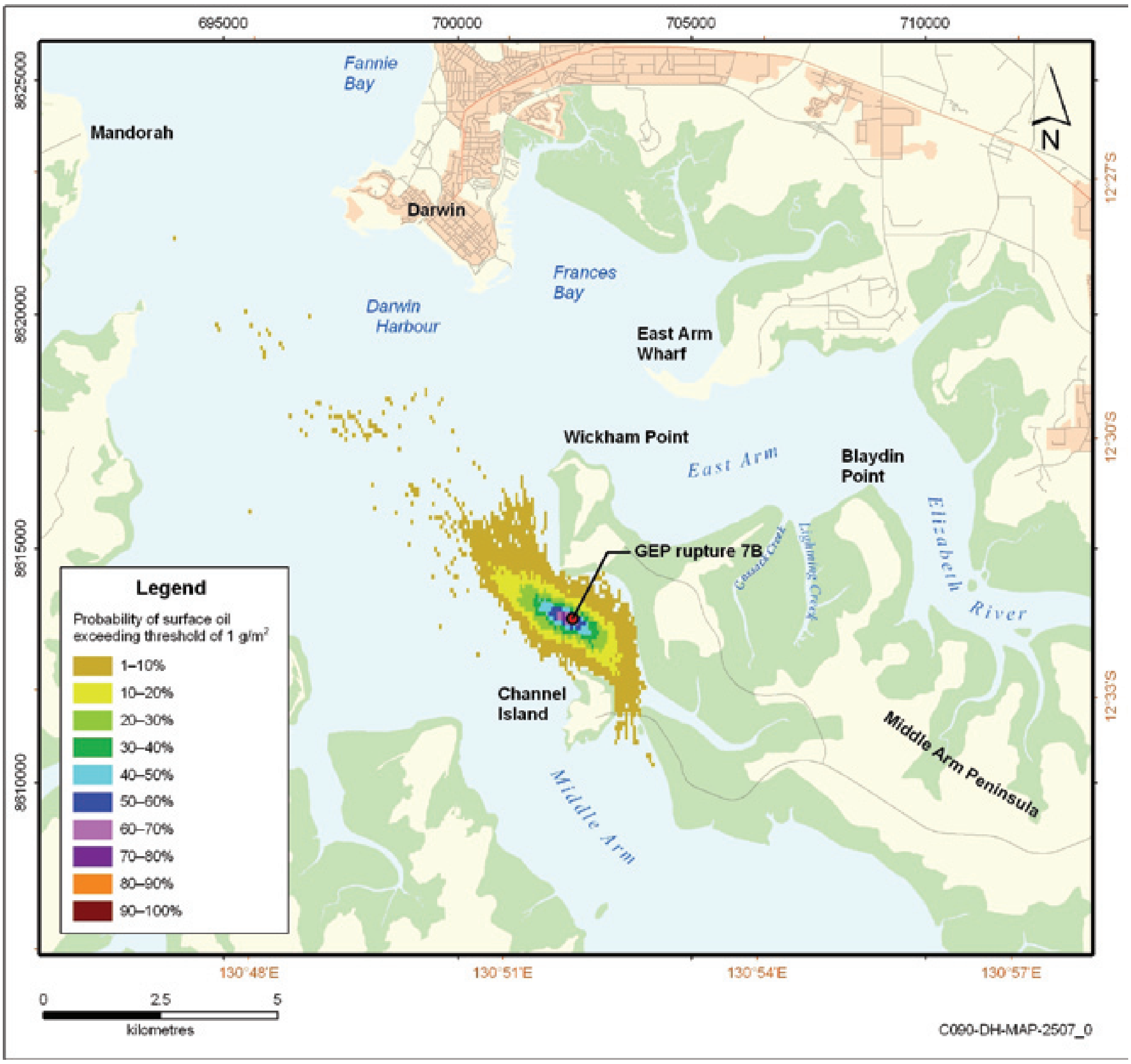


Figure 4-31: Gas export pipeline rupture (50 m³) near Wickham Point—autumn

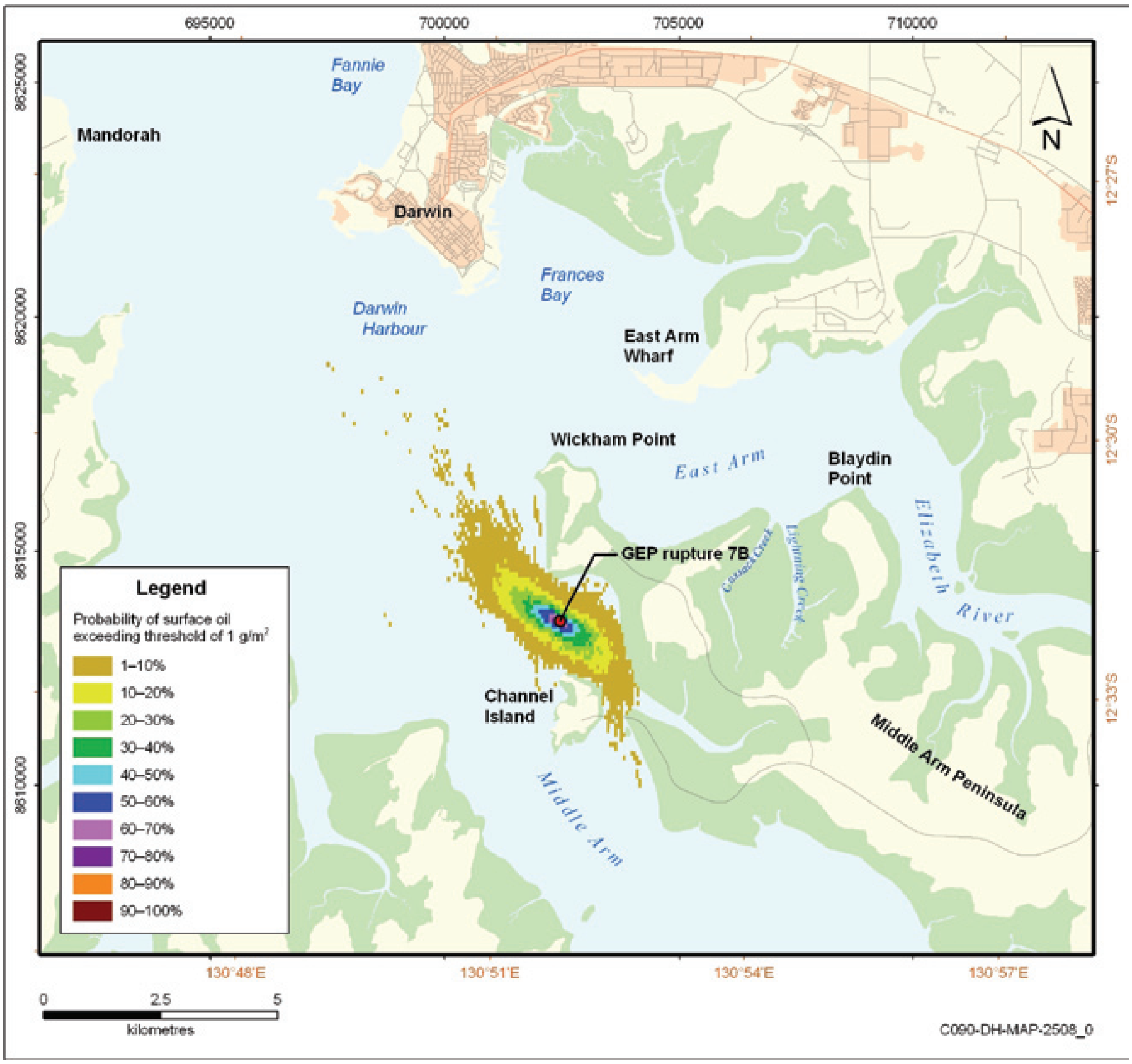


Figure 4-32: Gas export pipeline rupture (50 m³) near Wickham Point—winter

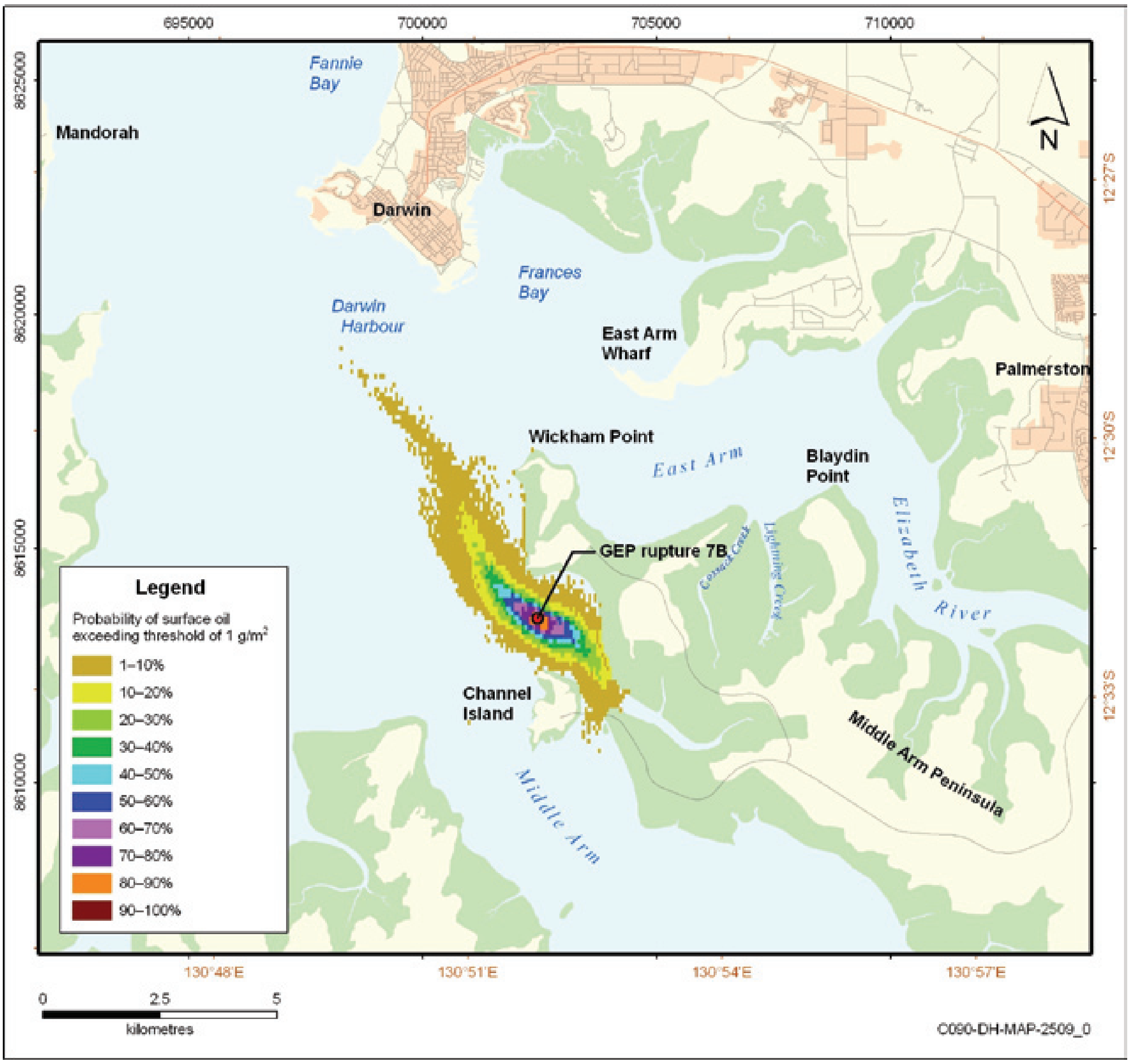


Figure 4-33: Gas export pipeline rupture (50 m³) near Wickham Point—spring

Locations for the gas export pipeline rupture scenarios for the area north-west of Darwin Harbour were chosen using reverse stochastic modelling from Bare Sand Island, a known sensitive turtle nesting location adjacent to Cox Peninsula. Model outputs of the summer, transitional and winter conditions are provided in Figure 4-34, Figure 4-35 and Figure 4-36. Under all simulations there is a very low risk of any oil reaching Bare Sand Island. Under the summer and transitional conditions, the model outputs indicate a very low risk of any shoreline contact. Results of the winter simulation indicate a low probability (<10%) of shoreline contact for the eastern and western headlands of Darwin Harbour, including the coastline east of Charles Point, coastline south of Lee Point and the rock platform south of Gunn Point (see Figure 3-16 of Technical Appendix S2 to this EIS Supplement).

The potential impacts of condensate spills on various environmental receptors around Darwin Harbour are discussed on pages 347 and 352–354 in Section 7.3.5 in Chapter 7 *Marine impacts and management* of the Draft EIS.

Browse Basin and the Kimberley coastline

Model outputs of the 11-week blow-out scenario are contained in Section 3.3 of Technical Appendix S2 to this EIS Supplement. The model outputs displaying the predicted probability of oil exposure to the water surface of more than 1 $g{\cdot}m^{-2}$ (with a film of thickness 1 μm) under summer, transitional and winter conditions are presented in figures 4-37 to 4-39.

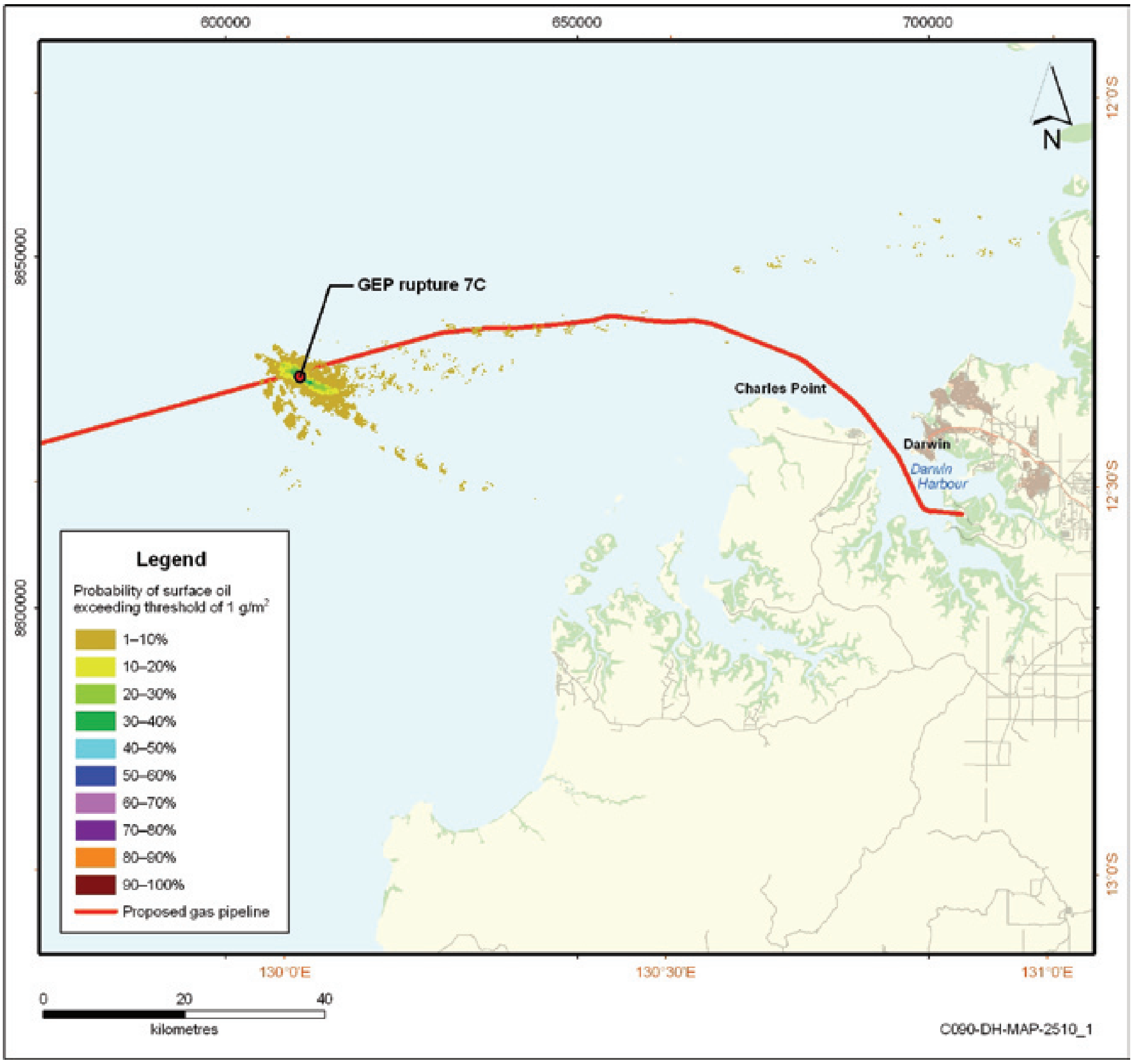


Figure 4-34: Gas export pipeline rupture (50 m^3) in outer Darwin Harbour—summer

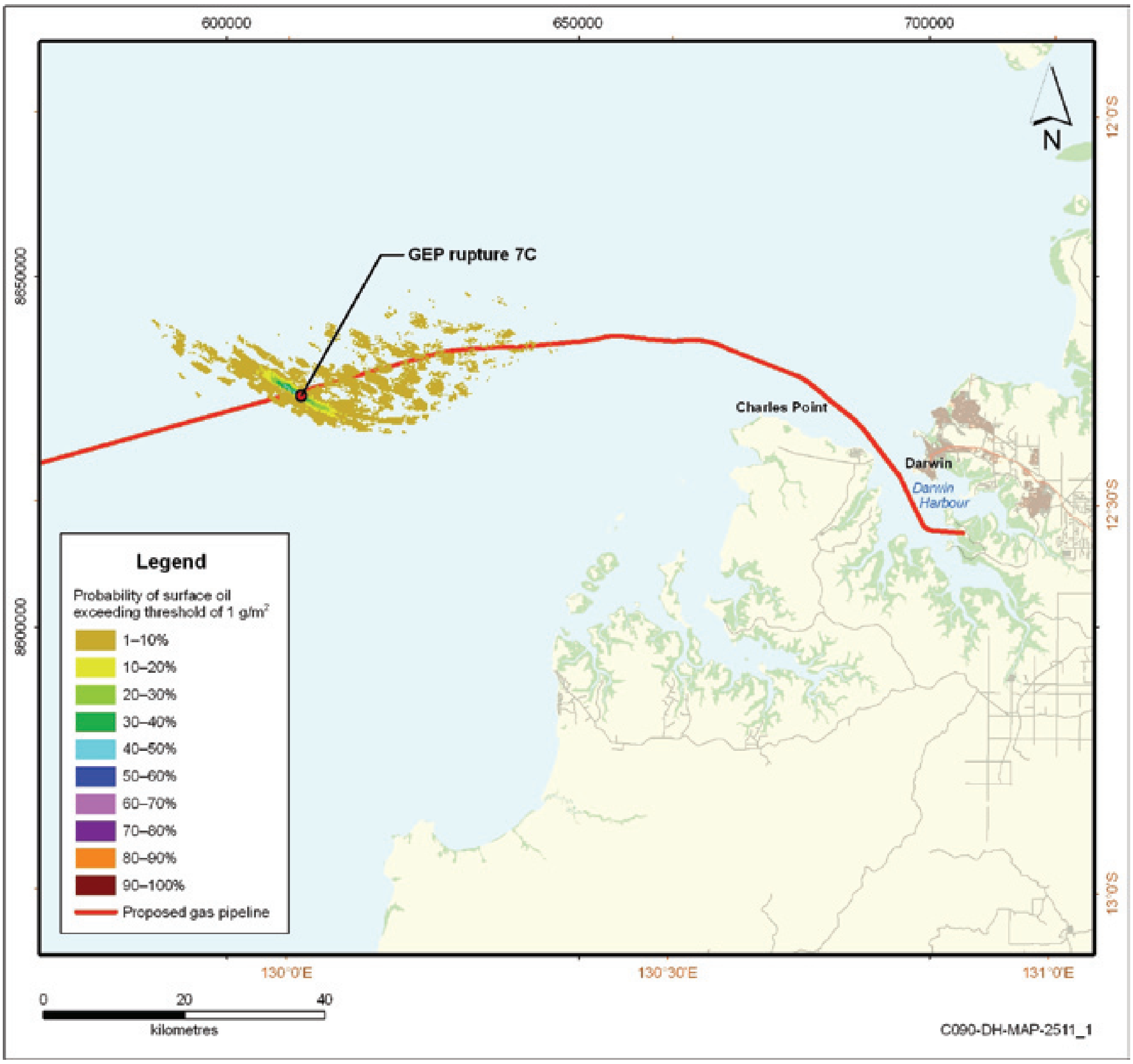


Figure 4-35: Gas export pipeline rupture (50 m³) in outer Darwin Harbour—transition

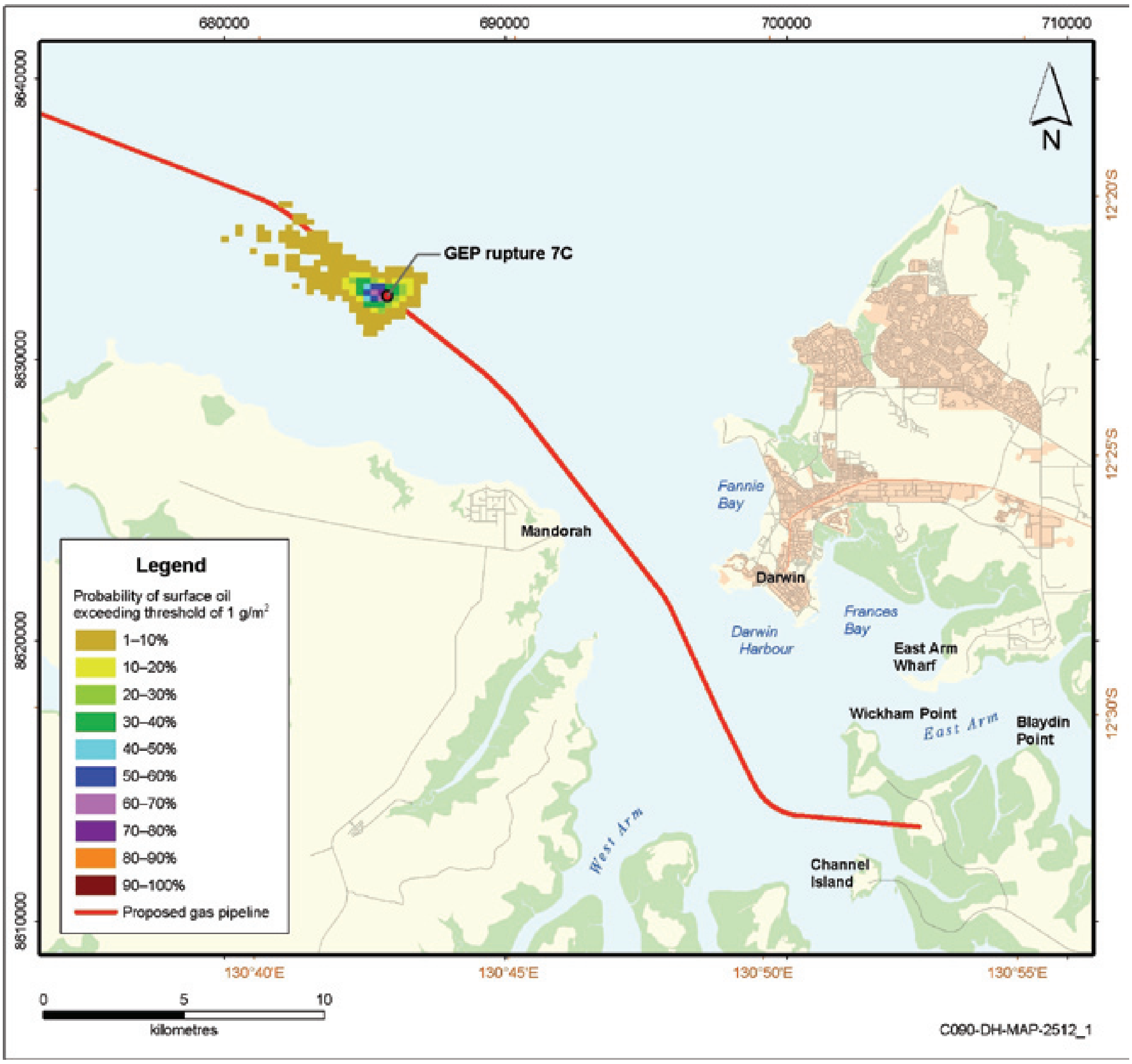


Figure 4-36: Gas export pipeline rupture (50 m³) in outer Darwin Harbour—winter

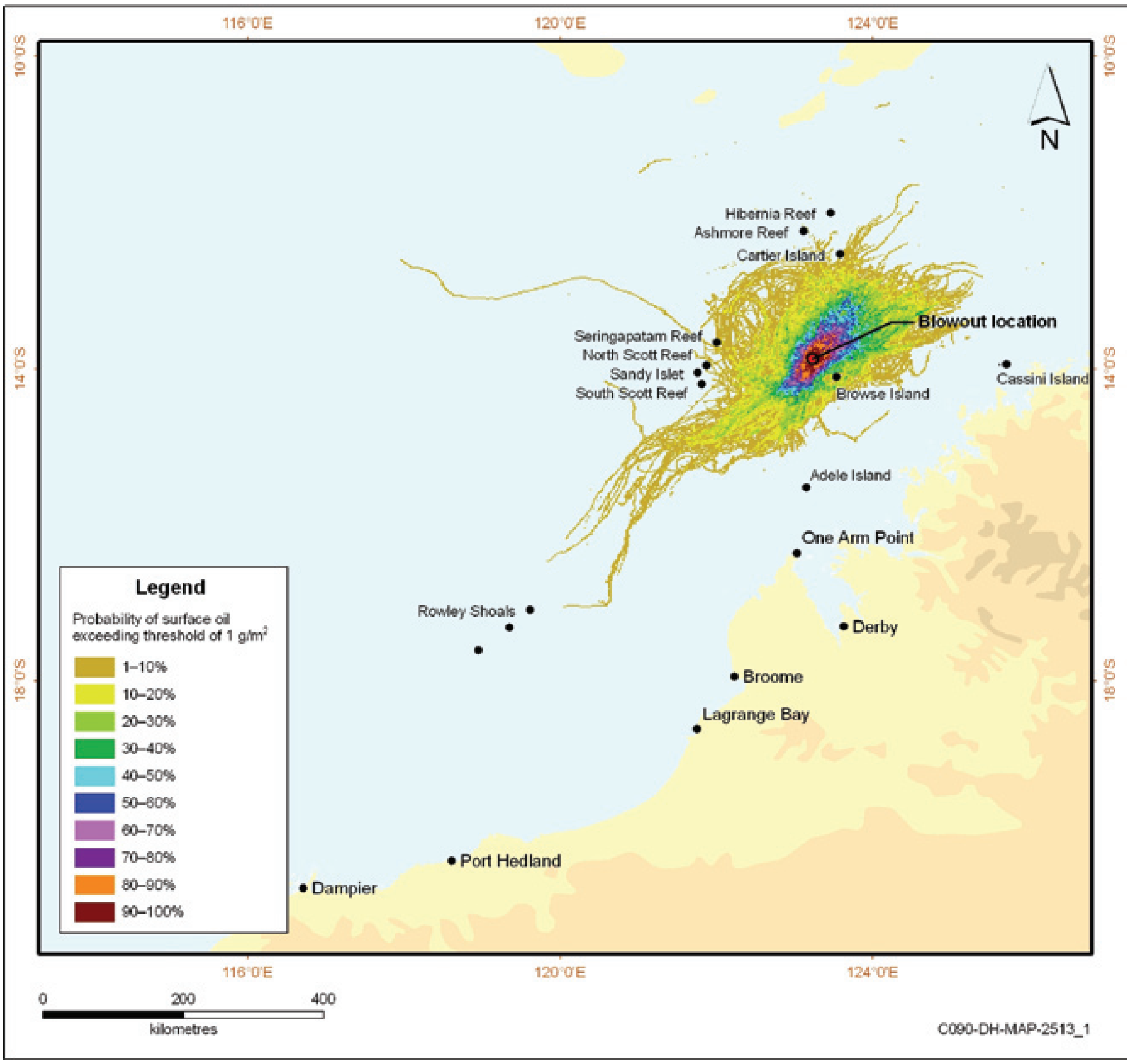


Figure 4-37: Eleven-week well blow-out at the Ichthys Field—summer

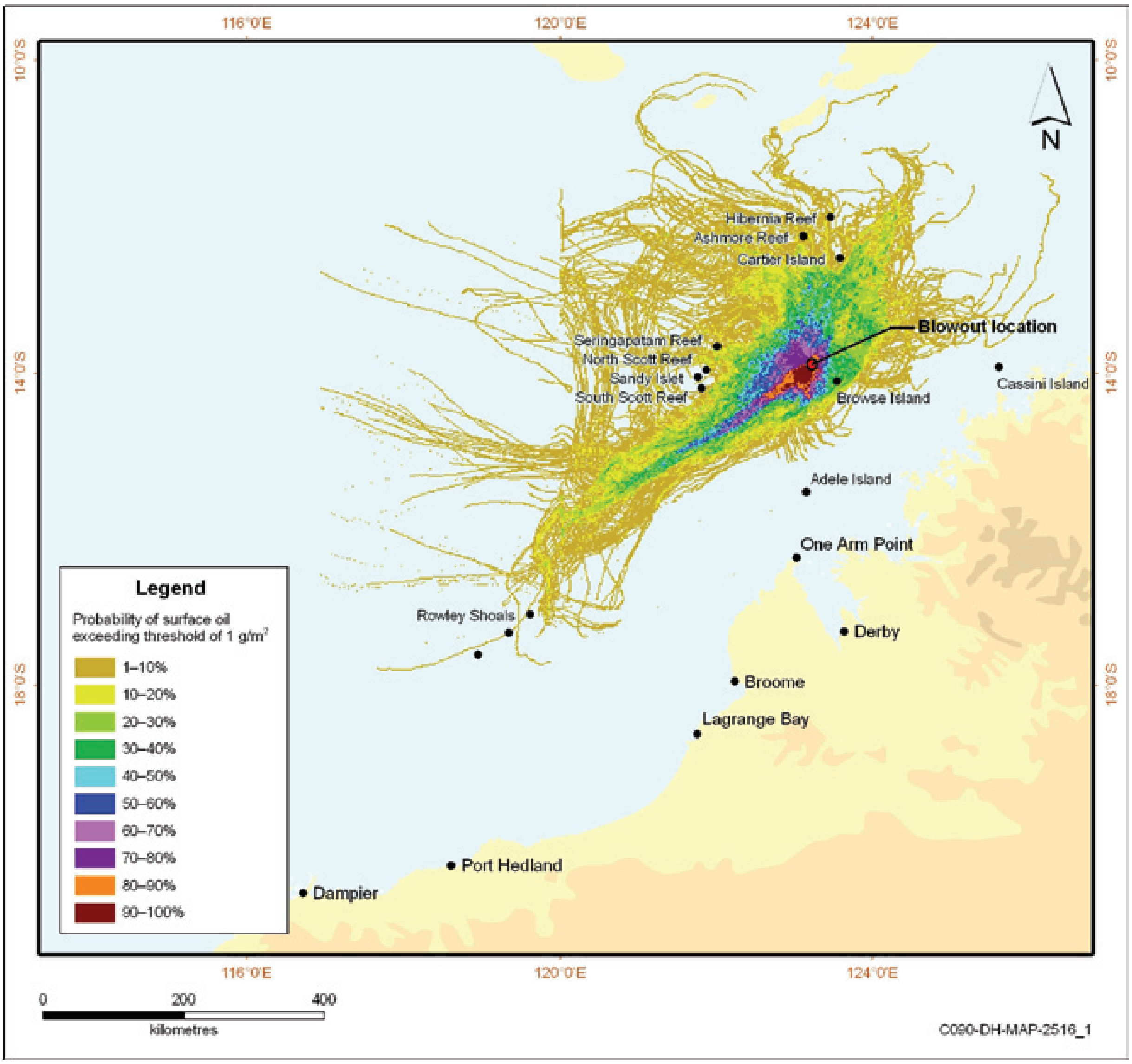


Figure 4-38: Eleven-week well blow-out at the Ichthys Field—transitional

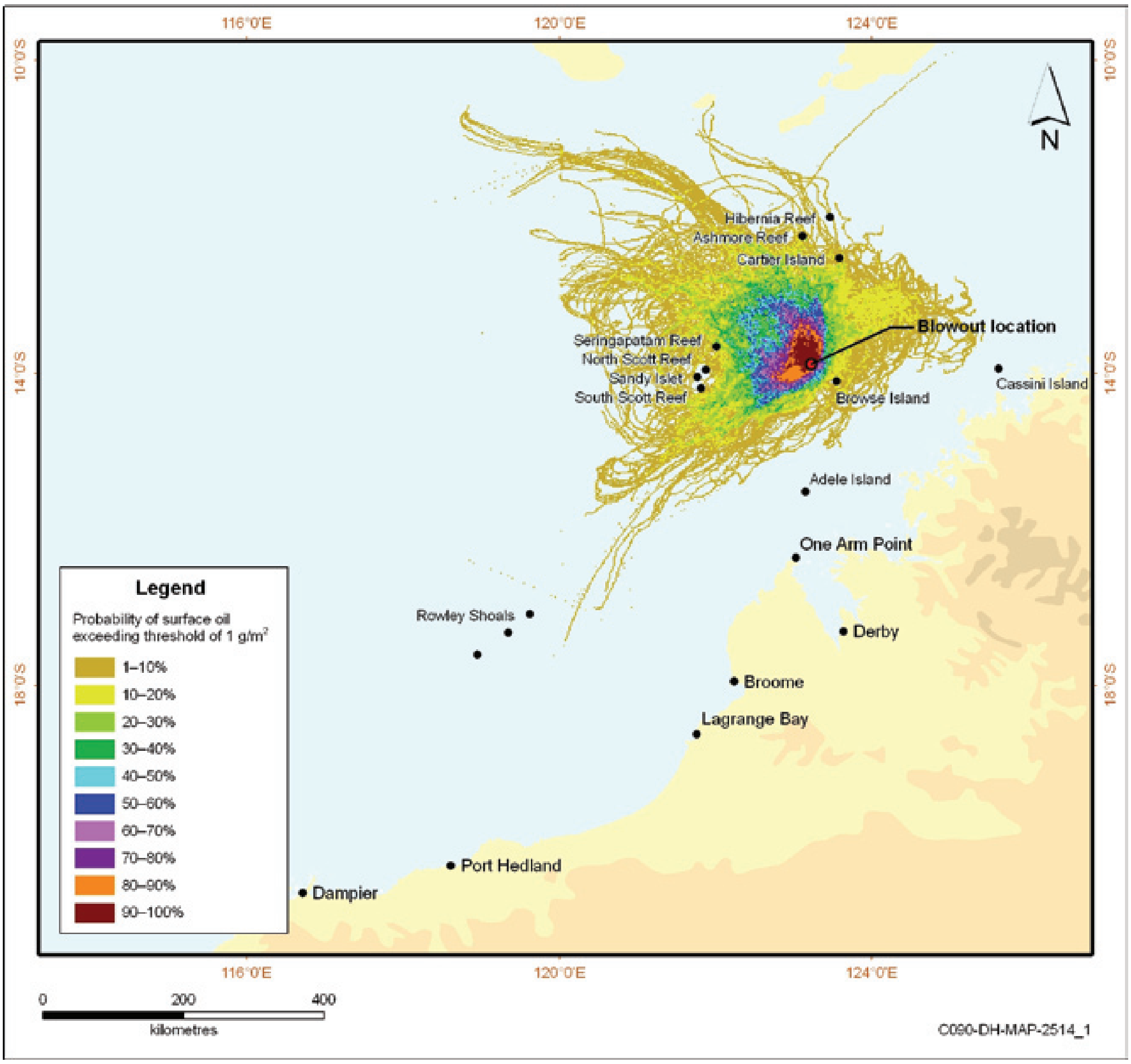


Figure 4-39: Eleven-week well blow-out at the Ichthys Field—winter

As expected from a large well blow-out scenario, the model outputs indicate that released condensate has the potential to affect emergent reefs such as Browse Island, Ashmore Reef, Cartier Reef and the Scott Reef systems. The risk of shoreline contact to individual islands and reefs calculated from the blow-out trajectory modelling is presented in Table 4-20.

Table 4-20: Risk of shoreline contact of more than 1g·m^{-2} for a blow-out in each season

Season	Browse Island	North and South Scott Reef and Sandy Islet	Seringapatam Reef	Ashmore Reef	Cartier Island	Hibernia Reef	Adele Island	Rowley Shoals	Kimberley coastline
Summer	30%	10%	20%	1%	1%	1%	<1%	<1%	<1%
Transitional	45%	45%	15%	3%	10%	2%	<1%	1%	<1%
Winter	10%	85%	85%	<1%	10%	1%	<1%	1%	<1%

Interestingly, as discussed in Section 3.3 of the APASA spill-modelling addendum (see Technical Appendix S2 in this EIS Supplement), the results of the blow-out scenarios indicate that the Kimberley coastline is unlikely to be impacted in such a well blow-out regardless of the season. This is contrary to the model outputs shown in Figure 7-9 in Section 7.2.4 of the Draft EIS for a 1000-m^3 surface condensate spill from the FPSO in the wet season which indicates a potential for impacts on the Kimberley coastline.

Factors that have resulted in a lower modelled risk to the Kimberley coastline are discussed in detail Section 3.3 of the APASA spill-modelling addendum and include the spill release from seabed rather than the surface, resulting in days to weeks of condensate entrainment in the water column, affected only by currents and tides, rather than shallow surface wind-driven currents and inclusion of longer-term south-west drift currents in the wet season.

The well blow-out model outputs including more sophisticated drift currents indicate that the model outputs in the Draft EIS may have potentially overestimated the risk of a Kimberley coastline impact from other spill scenarios. However, regardless of the model outputs, INPEX recognises the high biodiversity and conservation values of the Kimberley coastline and the requirement to minimise risks of impacts to this coastline.

Operators in the Browse Basin are investigating the option of cooperatively developing an environmental sensitivities map for the Browse Basin, including the Kimberley region. This map will draw on information held by operators and government and from the published literature and will guide the development of response priorities under various spill scenarios.

It is acknowledged that there are also potential risks to offshore wildlife not associated with the Kimberley coastline and emergent reefs. The WWF wildlife assessment from the Montara spill (Mustoe 2009) found that while some species appeared to avoid the spill, others were found in and around the slick. In the Draft EIS, INPEX acknowledges that while some species of cetaceans have been observed avoiding oil spills, it is not known if all species would exhibit this same behaviour (see Section 7.2.4 (pages 282–283) in Chapter 7 *Marine impacts and management* of the Draft EIS). The Draft EIS also clearly acknowledges that other species of marine reptiles, fish and birds would be at risk from a large oil spill.

4.2.2 The Montara and Macondo (Deepwater Horizon) incidents

At the time of preparation of this EIS Supplement, the Report of the Montara Commission of Inquiry (Borthwick 2010), the Draft Government response to the report of the Montara Commission of Inquiry (Australian Government 2010) and the report of the inquiry into the Deepwater Horizon disaster at the Macondo well in the Gulf of Mexico (NCBPDH 2011) had only recently been released. INPEX, from an individual company perspective, and the Australian Petroleum Production & Exploration Association (APPEA), from a whole-of-industry perspective, are currently reviewing and evaluating the various Montara and Macondo reports and their associated recommendations.

APPEA has formed the APPEA Montara Taskforce which includes a range of working groups to review and develop consistent industry-wide responses and amendments to procedures in light of the Montara and Macondo inquiries and associated reports.

Key tasks being undertaken by the APPEA Montara Taskforce include:

- development of a well-operations audit tool to ensure that good oil-field practice and appropriate well control procedures are followed at all times
- investigation of global developments in "cap and containment" technology for recovery from a well blow-out
- development of a mutual aid agreement for operator companies to provide mutual aid in the form of rigs, vessels, equipment and personnel for use in emergency situations including large oil spills
- review oil-spill preparedness and response capability to identify improvement opportunities in oil spill planning and response.

INPEX is participating in the APPEA Montara Taskforce working groups and will continue to work through the Montara and Macondo findings to ensure that the lessons are learned and incorporated into the relevant plans developed for the Ichthys Project.

4.2.3 Operational and scientific monitoring program

INPEX, in collaboration with other petroleum operating companies in the Browse Basin, is examining the feasibility of developing a joint operational and scientific monitoring program (OSMP), specific to large-scale oil spills in the Browse Basin. It is intended that the OSMP will include the following:

- details of the baseline, operational and ongoing post-spill scientific monitoring studies to be undertaken to determine and evaluate the success of the operational response, the extent of any impacts and ecosystem consequences, and the potential environmental reparations required
- an implementation strategy for the OSMP
- triggers for the initiation and termination of the OSMP
- an audit and review strategy for the OSMP.

An environmental sensitivities map for the entire Browse Basin, including offshore reefs and the Kimberley coastline is also proposed to be developed jointly by the operating companies. This map would draw on information held by operators and government and contained in the published literature and will guide the development of response priorities under various spill scenarios.

The development of the joint OSMP is currently under way. However, in the event that the participating operating companies in the Browse Basin are unable to develop the OSMP cooperatively, INPEX will independently develop its own OSMP.

4.2.4 Oil spill response plan development and approvals

As discussed in Section 7.2.4 (page 284) of Chapter 7 *Marine impacts and management* the Draft EIS, INPEX has previously developed and received approval for numerous oil spill contingency plans (OSCPs) to support exploration and appraisal drilling in the Browse Basin. The OSCPs will be revised and resubmitted for approval by the relevant government agencies prior to the commencement of construction, commissioning and operations activities.

In the Northern Territory, OSCPs will be approved under the relevant Territory petroleum legislation while for offshore activities the OSCP will be approved under the *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (Cwlth).

The OSCP will include the following information:

- Environmental sensitivities information/maps
- Environmental response priorities
- Identification of credible spill scenarios
- Response Action Plans to credible scenarios to protect priorities identified
- Roles and responsibilities of personnel in a spill event
- Equipment lists and inventories to enable rapid activation of the response action plans
- Oil-spill training and drills/exercises
- emergency contact details
- Spill-response activation procedures including internal response and regulator notification and reporting requirements
- Protocols for activation of external spill-response support (e.g. the Australian Marine Oil Spill Centre)
- 24 hour on-call spill trajectory modelling capability
- interface with relevant port, state and national plans
- waste-management requirements
- environmental monitoring requirements (OSMP).

During the construction phase, oil-spill contingency plans will be prepared by the relevant contractor organisations. These plans will be reviewed by INPEX and will interface with the overarching INPEX OSCP.

Findings from the Montara and Macondo inquiries will be incorporated into INPEX's production well drilling planning processes and all other OSCPs where relevant.

INPEX's OSCPs for production drilling and the commissioning and operations phases (the Project phases in which INPEX's activities will be directly in contact with the gas and condensate reservoir at the Ichthys Field) will be peer-reviewed by appropriate agencies or organisations.

4.2.5 Oil-spill response equipment and personnel

The Port of Darwin and the Broome Port Authority maintain oil-spill-response equipment stockpiles at East Arm Wharf and the Port of Broome respectively. East Arm Wharf is less than 5 km from Blaydin Point. Equipment and resources from this stockpile are able to be activated in the event of a significant oil spill through the Darwin Port Corporation, with an estimated response period of within 2 hours. The oil-spill-response equipment at Broome will take up to 18 hours to transport from Broome to the Ichthys Field using a standard rig tender. In addition the industry-funded Australian Marine Oil Spill Centre (AMOSC) maintains an extensive equipment stockpile in Geelong which is designed for rapid deployment within 24 hours to anywhere in Australia (AMOSC 2009).

As shown in Table 5 of Technical Appendix S2 *Marine Hydrocarbon Spill Modelling Addendum Report – Supplemental Spill Risk Modelling*, the mimimum time for a blow out spill to reach landfall (Browse Island or Scott Reef) is 65 hours. Therefore, adequate time is available to mobilise first-strike equipment from Broome.

Additional oil-spill-response equipment is also available through National Plan[8] stockpiles at locations other than Darwin and Broome and from international oil-spill-response agencies in Singapore and the United Kingdom. As previously mentioned, industry operators are also developing a mutual-aid agreement to facilitate the sharing of equipment and personnel in the event of a large oil spill.

INPEX will purchase and maintain appropriate oil-spill-response equipment to enable a rapid response to both inshore and offshore spills. The selection of equipment will be determined in consultation with industry and government experts and itemised within the relevant OSCPs.

INPEX will maintain an in-house team of trained oil-spill-response personnel for overall spill response coordination. In addition, through the AMOSPlan, the mutual-aid arrangement administered by AMOSC, INPEX has access to the AMOSC "Core Group", a group of petroleum industry personnel highly trained in oil-spill response available to be called upon in the event of a significant oil spill.

4.2.6 Financial penalties and performance bonds

In relation to financial penalties and performance bonds, the legislative process for regulatory approval of exploration and production wells is undergoing government review, in light of the Montara incident in the Timor Sea in August 2009 (Australian Government 2010). This review will affect all oil and gas production companies. INPEX will comply with the relevant legislated contingencies specified by the government in relation to production well blow-out and other oil-spill risks, including any compensation requirements if deemed appropriate by the regulatory agencies.

8 *The national plan to combat pollution of the sea by oil and other hazardous and noxious substances* is managed by the Australian Maritime Safety Authority on behalf of the Commonwealth, state and Northern Territory authorities and the oil and shipping industries (AMSA 2011a).

4.3 Seabird distribution and abundance

In 2010 INPEX commissioned a literature review of seabird distribution and abundance in the vicinity of Ichthys Field infrastructure in the Browse Basin (Surman & Nicholson 2011). The review includes an evaluation of INPEX's seabird survey data collected in the Browse Basin between June and November 2008 (see Section 3.2.8 in Chapter 3 *Existing natural, social and economic environment* of the Draft EIS).

The full literature review is provided in Technical Appendix S3 to this EIS Supplement and a summary of its key findings is presented below.

The Browse Basin is species-rich in terms of seabird diversity at sea, with 39 species having been recorded over numerous surveys. This is comparable to the 39 species recorded during surveys of the eastern Indian Ocean (Dunlop, Surman & Wooller 1995). On a smaller scale within the Browse Basin, Jenner, Jenner and Pirzl (2009) recorded 16 species during their June–July surveys and 16 species during the October–November surveys. Eight of these species were observed during both periods, so that 24 seabird species in all were recorded for the survey area. A similar number of species (range 15–21) were recorded during several surveys undertaken between Broome and Ashmore Reef. From the available literature and survey results, within the proposed sphere of operations of the Ichthys Project it would be expected that approximately 28 seabird species would be encountered regularly.

Table 4-21 lists the seabird species likely to occur in the Browse Basin and in particular in the area of the Ichthys Field and provides information on their status (breeding, migratory, regular visitor or vagrant) and the distance to the nearest breeding colony.

Table 4-21: Seabird species likely to occur in the Browse Basin and in the area of the Ichthys Field

Species	Status in the area of the Ichthys Field	Distance to nearest colony (rounded) (km)
Bulwer's petrel	Regular visitor	n.a.
Tahiti petrel	Vagrant	n.a.
Hutton's shearwater	Regular visitor	n.a.
Streaked shearwater	Regular visitor	n.a.
Wedge-tailed shearwater	Regular visitor	200
Short-tailed shearwater	Vagrant	n.a.
Wilson's storm-petrel	Regular visitor	n.a.
White-faced storm-petrel	Regular visitor	n.a.
Matsudaira's storm-petrel	Regular visitor	n.a.
Leach's storm-petrel	Vagrant	n.a.
Swinhoe's storm-petrel	Vagrant	n.a.
Red-tailed tropicbird	Occasional visitor	200
White-tailed tropicbird	Occasional visitor	1900
Brown booby	Breeds in region; regular visitor	160
Masked booby	Breeds in region/occasional visitor	160
Red-footed booby	Breeds in region; occasional visitor	200
Lesser frigatebird	Breeds in region; regular visitor	160
Great frigatebird	Breeds in region; regular visitor	160
Christmas Island frigatebird	Vagrant	1900
Arctic jaeger	Occasional visitor	n.a.
Silver gull	Breeds in region; regular visitor	160
Bridled tern	Breeds in region; regular visitor	200
Sooty tern	Breeds in region; regular visitor	200
Crested tern	Breeds in region; regular visitor	30
Lesser crested tern	Breeds in region; regular visitor	30* (?)
Common tern	Regular visitor	n.a.
Common noddy	Breeds in region; regular visitor	167
Black noddy	Breeds in region	200

Sources: AES 2004, 2008; Birding-Aus 2010; CCWA 2010; DEC undated; Johnstone and Storr 1998; Jenner, Jenner and Pirzl 2009.

* In the North-west Marine Region lesser crested terns invariably breed amongst the larger colonies of the crested tern (Nicholson 1998).

n.a. = not applicable.

Within the North-west Marine Region* similar numbers of seabird species have been recorded at other sites. For example, Dunlop, Surman and Wooller (1995) predicted that 18 seabird species could be expected to be observed in areas around the FPSO *Jabiru Venture*, which is situated further north in the region, while 23 seabird species have been recorded at the Lowendal Group, further south in the region (Surman and Nicholson 2010).

The number of breeding seabird species found on islands within 345 km of the Ichthys Field are comparable to the numbers on breeding islands elsewhere in the North-west Marine Region.

Ten seabird species have been recorded nesting on Adele Island (160 km from the Ichthys Field), 13 species on Ashmore Reef (200 km from the Ichthys Field) and 14 species at the Lacepede Group (CCWA 2010; DEC undated; Table 3 in Surman & Nicholson 2011). These numbers compare well with the Lowendal and Montebello groups, where 13 species of seabirds have been recorded breeding (Burbidge et al. 2000; Surman & Nicholson 2010). Two islands in the Browse Basin which have fewer seabird species recorded breeding are Browse Island (approximately 30 km from the Ichthys Field) with one species (crested tern), and Scott Reef (167 km) with two species (common noddy and brown booby), which may reflect a lack

* Which is geographically defined in the North-West Marine Bioregional Plan (DSEWPaC 2010c)

of frequency of researcher access to record other possible breeding species, and/or lack of suitable habitat in the case of Scott Reef.

Breeding seabirds are dependent upon sources of marine food within their foraging range from the breeding colony and this range differs between species. Browse Island and Scott Reef, two of the closest islands to the Ichthys offshore development area, maintain few breeding species. However the numbers of foraging seabirds in this area would not come from these colonies alone: some of the species that nest on Adele Island, 160 km away, would also forage across these waters.

From data collected from seas adjacent to Christmas Island, Dunlop, Surman and Wooller (2001) found that common noddies and brown boobies foraged within 200–250 km of their breeding colony, while the red-footed booby foraged up to 900 km away. Similarly, lesser frigatebirds and great frigatebirds foraged at least 700 km from their breeding colonies on Christmas Island. Crested terns were observed foraging several hundred kilometres from land, over the continental shelf in the North-west Marine Region (Nicholson 2002). Frigatebirds, boobies and crested terns are all known to have long-distance foraging ranges (Dunlop, Surman & Wooller 2001; Nicholson 2002). The observation of an Abbott's booby during the survey by the Centre for Whale Research (Jenner, Jenner & Pirzl 2009) was not unique—there have been at least six other sightings in the Scott Reef and Browse area—and demonstrates the potential importance of the Browse Basin to the Christmas Island endemic seabird species as well as to seabirds nesting on the Lacepede Group (330 km to the south of the Ichthys offshore development area) and on Adele Island (160 km south) and Ashmore Reef (197 km to the north).

A key risk to populations of seabirds in the Browse Basin would be a significant oil-spill event affecting significant seabird foraging areas or nesting beaches.

As noted in Table 6 of Technical Appendix S3 in this EIS Supplement, seabird breeding occurs in the Browse Basin for two-thirds of the year, the non-breeding period being the months of November to February inclusive. The main seabird breeding colonies in the Browse Basin are located on Ashmore Island and Adele Island. The risk of oil reaching Ashmore Island from a seabed blow-out (in the absence of mitigation measures) is 3% during transitional conditions and 1% or less during summer or winter (see Table 4-20). The risk of shoreline contact to Adele Island from a blow-out scenario is <1% in all seasons. Given the very low primary risk of a blow-out actually occurring (5.0×10^{-6}), the maximum secondary risk (per year) for a spill reaching Ashmore and Adele Island is 1.5×10^{-7}.

Other islands of the Browse Basin, such as Browse Island and Scott Reef, have higher risks of shoreline contact. However these islands support breeding and roosting for far fewer species and in lower densities than Ashmore and Adele islands.

Although weathered condensate may reach intertidal shorelines of islands utilised by seabirds, this does not necessarily result in any direct impact. Breeding and roosting seabirds typically utilise areas above HAT (highest astronomical tide) level. However waders and other birds that utilise the intertidal zone would be susceptible to impacts such as hydrocarbon ingestion, as discussed in Section 7.2.4 in Chapter 7 *Marine impacts and management* of the Draft EIS.

INPEX's oil-spill response plans will identify all known seabird roosting and breeding habitats as priority areas for protection and clean-up in relation to oil-spill response. It should be noted that in some instances natural weathering is more appropriate than human intervention for cleaning an oiled shoreline. However, the decision on appropriate shoreline clean-up techniques would be discussed and agreed with relevant regulatory authorities and wildlife experts, taking into consideration all relevant factors prevailing at that time of any such incident.

Impacts could also occur to seabirds foraging in oil-affected waters of the Browse Basin in the event of an oil spill, with the potential impacts discussed in Section 7.2.4 of Chapter 7 of the Draft EIS.

4.4 Vegetation-clearing and changes to the terrestrial footprint

This section describes changes to the vegetation-clearing and terrestrial footprint estimates since publication of the Draft EIS.

4.4.1 Corrected vegetation-clearing estimates

This section serves to first correct spatial vegetation data presented in Table 8.5 of the Draft EIS, and to provide revisions to vegetation clearing estimates as a result of amendments to the onshore plant layout.

Figure 4-40 shows the reproduced vegetation map presented in the Draft EIS. This map reflected the changes from the initial vegetation maps produced in the flora and fauna studies carried out by GHD Pty Ltd for INPEX and included in the Draft EIS as Technical Appendix 16. Subsequent to the publication of the Draft EIS, INPEX discovered that the supporting data table (Table 8.5 of the Draft EIS) did not reflect the changes made by INPEX to the underlying vegetation maps. This discrepancy is addressed in data provided in this EIS Supplement. Table 4-22 shows Draft EIS-published and subsequently corrected vegetation-clearing areas which account for revised Blaydin Point vegetation community data.

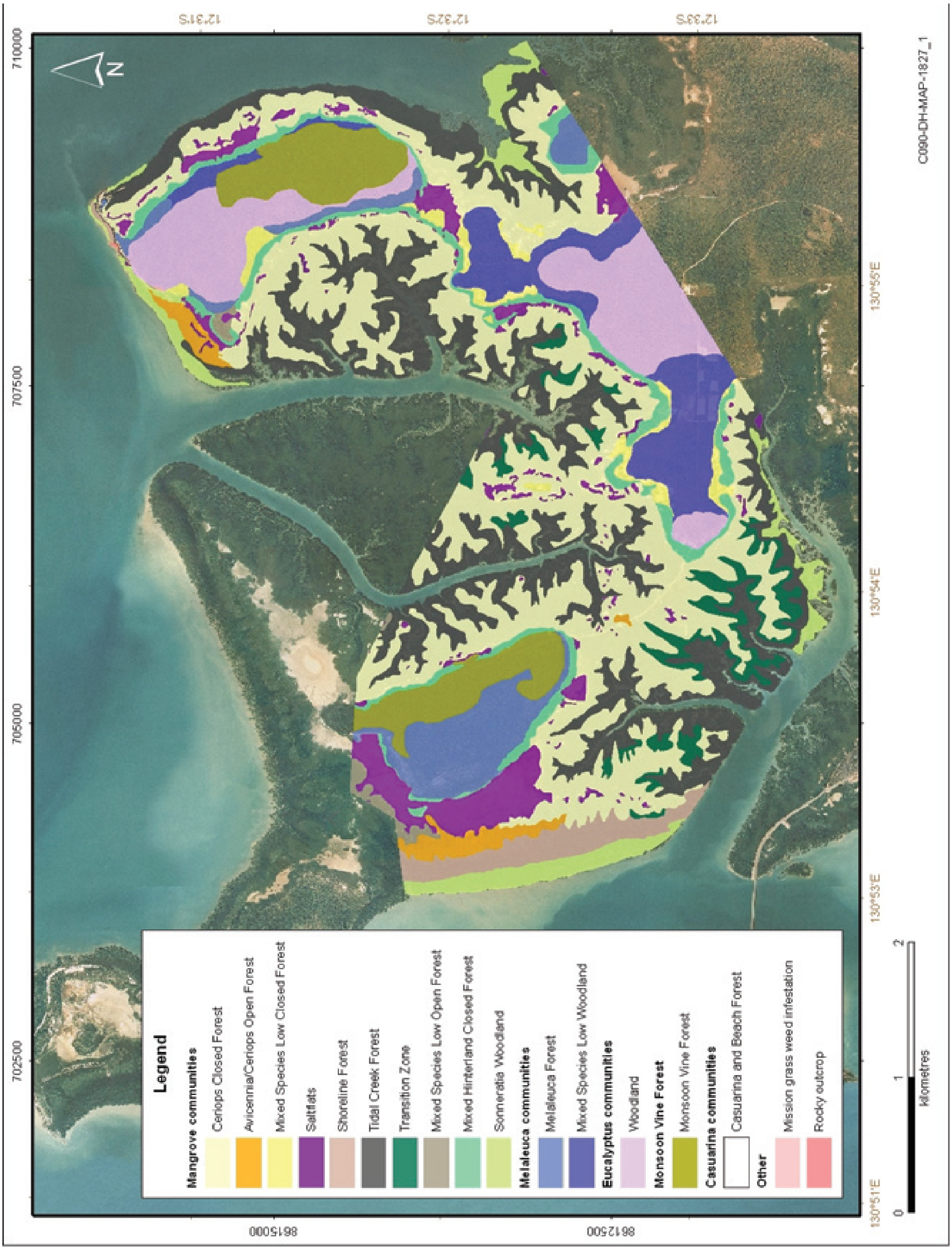


Figure 4-40: Vegetation communities of the onshore development area at Blaydin Point

(Reproduced Figure 3-38 of the Draft EIS)

Table 4-22: Corrected vegetation-clearing estimates

Vegetation community	Original Draft EIS calculations from Table 8.5 Area proposed to be cleared (ha)	Revised Draft EIS calculations (revision necessitated by vegetation-mapping correction) Area proposed to be cleared (ha)
Casuarina and beach forest	**1**	**1**
Eucalyptus woodland	**161**	**133**
Monsoon vine forest	**66**	**59**
Mangrove communities		
Avicennia–Ceriops open forest	5	5
Ceriops closed forest	25	31
Mixed hinterland closed forest	16	19
Mixed species low closed forest	8	10
Shoreline forest	2	2
Sonneratia woodland	4	5
Tidal creek forests	3	4
Salt flats *	20	13
Transition zone *	0	0
Subtotal – mangrove communities	**83*** **(63 excluding salt flats and transition zone)**	**89*** **(76 excluding salt flats and transition zone)**
Melaleuca communities		
Melaleuca forest	8	23
Mixed species low woodland	33	42
Subtotal – melaleuca communities	**41**	**65**
Total*	**352 †**	**347 †**

* Table note: for the purposes of comparison, the “saltflats” and the “transition zones” are included within the “mangrove communities” in the table. In the vegetation-clearing estimates provided in Table4-23 of this EIS Supplement these communities have been listed seperately. This reflects the difference in primary vegetation and coverage between the salt flats and the mangrove communities.

† Table note: the reduction in total vegetation clearance area from 352 ha to 347 ha can be explained by changes in flare pad and WWTP areas made after the publication of the Draft EIS. These areas have again been redesigned as described in sections 3.3. Table 4-23 reflects the current design and layout for the facilities and infrastructure for the onshore development area and shows a total area for vegetation clearance of approximately 362 ha.

Table 4-22 shows the corrected vegetation clearing estimate of 347 ha which is 5 ha less than originally proposed. This is made up of the following changes within the vegetation communities of:

- a reduction in clearing estimates for eucalyptus woodlands of approximately 28 ha (most of which is attributable to the reassignment of some of this community to the melaleuca communities) and monsoon vine forest approximately 7 ha
- an increase in clearing estimates for melaleuca communities of approximately 24 ha (mostly due to the reassignment of some areas previously identified as eucalypt communities) and mangrove communities of approximately 6 ha, (there are both reductions and increases across the different subtypes of mangrove community due to amendments to plant layout).

4.4.4.1 Revised vegetation-clearing estimates: relocation of manned facilities and GEP realignment

This section describes changes to vegetation-clearing associated with the relocation of the manned facilities to the combined operations complex. It relates to information presented in Section 3.3.2 of this EIS Supplement. This also includes the realignment of the gas export pipeline which includes a buffer between it and the building complex, and to avoid the heritage sites identified in this area.

As some of the land in the nearshore area at the site of the proposed combined operations complex is in the intertidal zone, there is insufficient supratidal land for the construction of the complex. Therefore vegetation will have to be cleared and intertidal land will be infilled to provide a suitable substrate on which to construct the access road, the gas export pipeline and ancillary umbilical lines, and the combined operations complex.

Figure 4-41 provides a visual comparison between the vegetation communities showing the original location and the new location for the manned facilities and the realignment of the gas export pipeline. It also shows the comparison between the area to be cleared for the original and revised layouts.

This relocation will require a net increase in clearing and disturbance of approximately 5 ha. The total area of vegetation-clearing associated with the manned facilities is almost 79 ha, compared with the 74 ha of the original design. Most of this is within the mangrove communities group. The total area of mangrove communities to be cleared is almost 14 ha.

While the relocation results in an increase of clearing around the mangrove and salt-flat areas, the changes have been made in such a way that identified heritage sites, previously likely to be disturbed or destroyed, will not be affected. The changes are incorporated into the overall vegetation-clearing estimates for the onshore development area presented in this EIS Supplement (see Table 4-23).

4.4.2 Revised vegetation-clearing estimates – plant layout amendments

Following the publication of the Draft EIS, a number of changes were made to the onshore processing plant layout at Blaydin Point described in Section 3.3.2. These changes included amendments to the layout of the ground flares compound, former WWTP area and the relocation of the operations and maintenance complexes from the processing-plant ("hot") areas to a new site outside the plant boundary where they will be co-located with the administration complex to form a combined operations complex. This has resulted in revisions to the estimates for vegetation-clearing which are provided in Table 4-23. The cleared area attributable to the above layout changes is approximately 5 ha.

During the review of the vegetation data and clearing estimates it was noted that there are areas of sparse vegetation and/or transition zones, which include samphire grass and salt flats that had been included as mangrove communities in the Draft EIS. However these areas are sparsely vegetated and do not actually contain mangrove communities. Therefore they have been separated from the mangrove community group in this EIS Supplement to provide a more accurate representation of the vegetation communities to be impacted by the Project

4.4.3 Revised total vegetation-clearing estimates

Table 4-23 shows derivation of the estimated total vegetation-clearing area of 362 ha for the Project. The total footprint for the onshore development area is 413 ha. The difference of 51 ha relates to existing areas of cleared or modified land such as patches of weeds (mission grass primarily), access tracks and roads and the borrow and fill pits area.

The main changes to vegetation-clearing estimates because of building relocations (and incorporating corrections to the Draft EIS vegetation-mapping data) are an overall increase of 14.4 ha (approximately 15 ha for the purpose of this exercise) in total vegetation clearance area (EIS Supplement total area= 362 ha and Draft EIS total area = 347 ha) which includes:

- an overall increase of about 6 ha to be cleared within the mangrove communities
- an overall increase of 8.4 ha to be cleared in the melaleuca communities

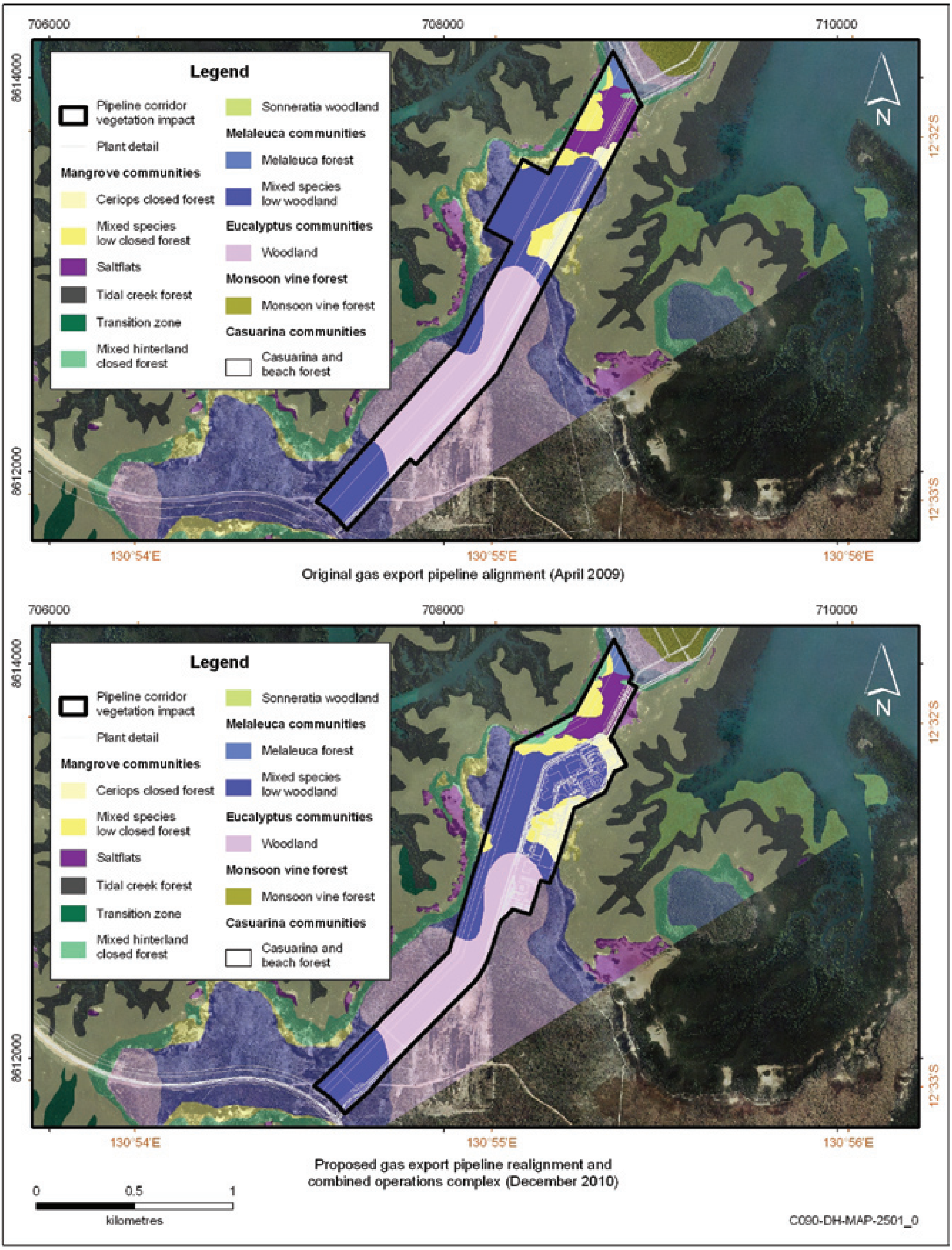


Figure 4-41: Vegetation communities impacted by the relocation of the manned facilities and the realignment of the gas export pipeline

Table 4-23: Revised Vegetation-clearing estimates

Vegetation community	Area proposed to be cleared (ha)
Casuarina and beach forest	**0.1**
Eucalyptus woodland	**132.4**
Monsoon vine forest	**60.7**
Mangrove communities	
Avicennia–Ceriops open forest	3.3
Ceriops closed forest	39.2
Mixed hinterland closed forest	16.8
Mixed species low closed forest	12.6
Shoreline forest	1.9
Sonneratia woodland	4.0
Tidal creek forests	4.3
Subtotal – mangrove communities	**82.1**
Transitional, sparsely vegetated, samphire-grass and salt-flat communities	
Salt flats	12.3
Transition zone	0.7
Subtotal salt flats	**13**
Melaleuca communities	
Melaleuca forest	23.8
Mixed species low woodland	49.6
Subtotal – melaleuca communities	**73.4**
TOTAL – vegetation clearance	**361.7 (362) ha**

Note: The vegetation-clearing estimates take into account changes in the design of the plant since publication of the Draft EIS in July 2010 as well as corrections to the areas of the vegetation communities.

4.5 Public safety

4.5.1 General

INPEX has further evaluated and assessed the risks of its operations since publishing the Draft EIS, and stands by the presentations provided in Section 10.3.14 of Chapter 10 *Socio-economic impacts and management* of the Draft EIS. One area of update, however, concerns shipping in Darwin Harbour, for which additional information is provided in the following subsection. Numerous submissions were received on public safety, and responses to these submissions can be found in Section 5.2.2.16 of this EIS Supplement.

4.5.2 LNG Shipping in Darwin Harbour

This section of the EIS Supplement has been provided to assist in clarifying the safety risks associated with LNG ship movements in Darwin Harbour.

Since the first LNG shipments began in the late 1950s there have been over 80 000 LNG ship transits in ports worldwide. To date there have been no significant safety incidents that have threatened cargo tank containment. There have been two significant grounding incidents. Both occurred outside port areas and neither resulted in a loss of cargo tank containment.

This excellent safety record is attributed to the stringent design and operating standards implemented in the LNG shipping industry. Each LNG tanker has been specifically designed to protect its cargo with multiple barriers in place to prevent any leak from the internal tank to the external environment. Figure 4-42 shows the layers of protection provided on a typical membrane carrier.

Strict design and operating standards govern the LNG shipping industry and reduce the risks associated with shipping activities to low levels. LNG shipping operations have therefore been accepted at relatively congested ports located in close proximity to densely populated areas, such as Osaka, Tokyo Bay and Boston.

A good example of an LNG shipping location with very similar surrounding land use characteristics to the Blaydin Point site currently operates on the Isle of Grain in the United Kingdom.

INPEX has carried out a detailed risk assessment of export product shipping operations in Darwin Harbour as part of the front-end engineering design phase for the Blaydin Point site. This study has concluded that the safety risks associated with transporting LNG and LPG in Darwin Harbour are low.

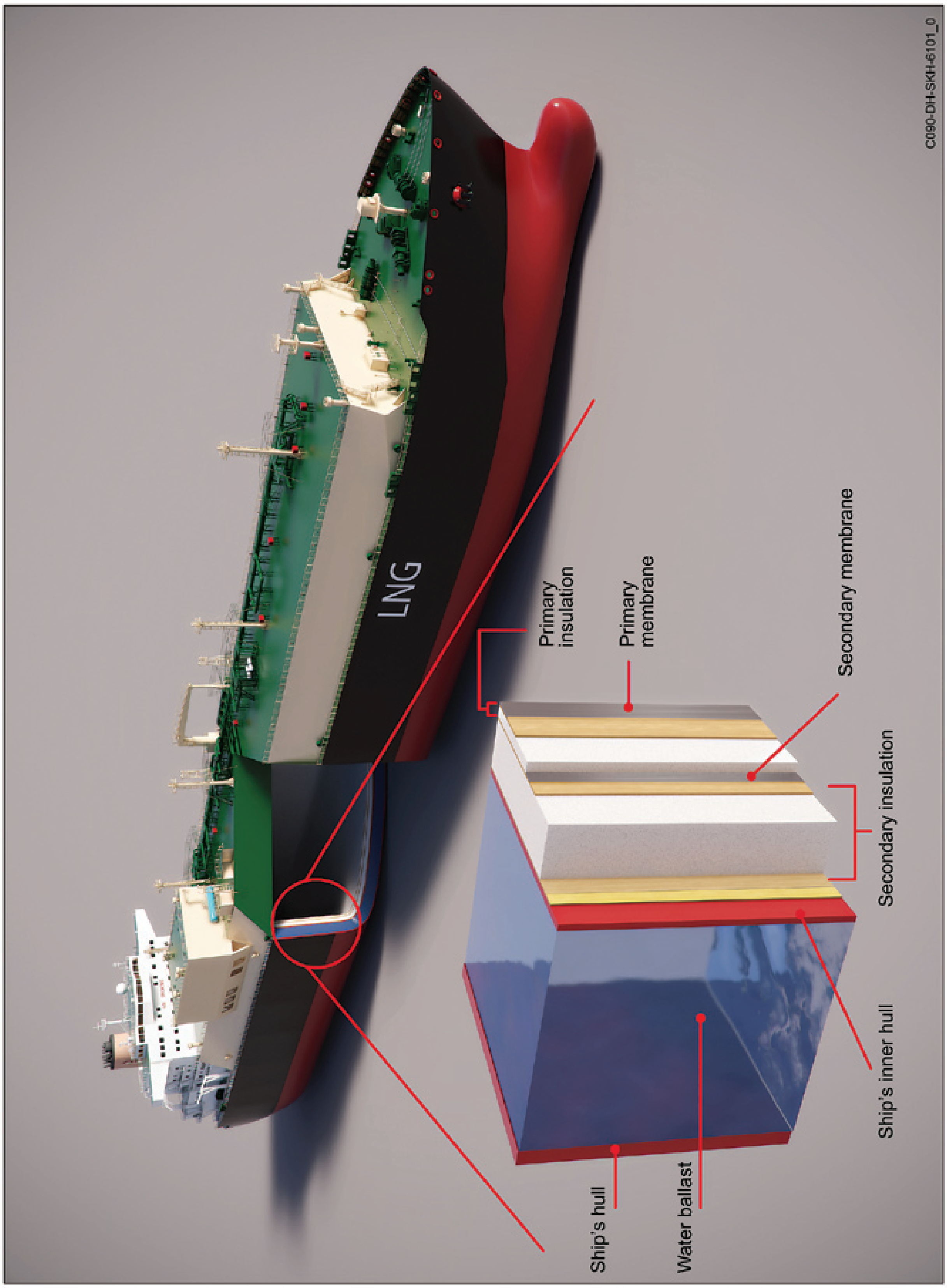


Figure 4-42: LNG Tanker Containment

When the estimated risk levels are compared with Australian and international risk-assessment criteria (for individual and societal risk) they are considered to be acceptable as long as they are maintained at "as low as reasonably practicable" (ALARP) levels.

Other key study findings concluded that:

- The removal of Walker Shoal reduces the risk of a grounding event resulting in the loss of containment of LNG or LPG to negligible levels. This is because of the relatively soft seabed within the Harbour.
- The protection inherent in the design of LNG carriers means there is negligible risk of loss of containment from collisions with small ships or as a result of passing or head-on collisions.
- The risk of collisions with large vessels (e.g. loaded container ships or Panamax carriers) may threaten the integrity of the LNG shipping and close interaction between these types of vessels at crossing points in the Harbour will be mitigated through the implementation of vessel traffic management systems and strict port operating procedures.

INPEX continues to work with Darwin Port Corporation to ensure that the appropriate traffic-management systems and controls will be developed and in place in Darwin Harbour prior to the commencement of operations, to ensure the safe passage of LNG, LPG and condensate tankers.

To this end, the movement of vessels within Darwin Harbour will conform to all established international standards for the safe navigation of vessels. To accomplish this, the following policies and actions have either been implemented already or are planned to be in place prior to the commencement of operations:

- Extensive investigations, including numerous simulation evaluations, have been undertaken to confirm the safe operational envelopes and the types and sizes of towage support required for servicing the Ichthys facilities.
- These parameters will be formalised as operational procedures that will provide clear guidance to personnel.
- All manoeuvres within the Harbour will be under the direction of suitably qualified pilots and towage professionals.
- All pilots, tug masters and towage professionals will receive extensive training prior to the commencement of operations at the Ichthys facilities to ensure that they have the highest levels of familiarity with the manoeuvring requirements.
- This initial training will be supplemented with an ongoing training program to ensure that all personnel maintain the highest levels of expertise.
- A fleet of tugs with adequate power reserves will be sourced to service the Ichthys facilities.
- All manoeuvres, both inward and outward, will be supported by escort tugs.
- Prior to the commitment to navigate through the INPEX shipping channel, all the required tugs will be secured and in position to provide the necessary support.
- While a tanker is alongside the loading facilities, a standby tug and pilot will be available to ensure that there is an immediate response to any weather event or emergency.
- All manoeuvres within Darwin Harbour will be under the management of the Darwin Port Corporation's vessel traffic management system. This will ensure that no manoeuvre commences until weather and traffic conditions permit, and that adequate management of shipping will be maintained throughout the manoeuvre.

4.5.3 Update on access to Lightning and Cossack creeks

Preliminary quantitative risk analysis (QRA) indicates that public access to recreational fishing areas in Lightning and Cossack creeks ("Catalina Creeks 1 & 2") can be maintained. However, exclusion zones are likely to apply to the eastern "fingers" of Lightning Creek. Access to Lightning and Cossack creeks will, however, be subject to the results of the final QRA to be completed in the detailed-design phase and the demonstration to, and acceptance by, the Northern Territory safety regulator NT WorkSafe that safety risks to the public engaged in recreational activities in this area are as low as reasonably practicable.

4.6 Socio-economic issues

4.6.1 Aboriginal and Torres Strait Islander participation in the Ichthys Project

INPEX's Aboriginal and Torres Strait Islander (ATSI) Engagement Policy, adopted in July 2010, commits the company to the goal of working with ATSI peoples and communities wherever its activities occur in Australia, with the aim of building sustainable mutually beneficial relationships.

In November 2009, INPEX entered into a memorandum of understanding (MOU) with the Larrakia Development Corporation in order to guide a meaningful working relationship between the Ichthys Joint Venture and the traditional owners of the Darwin region.

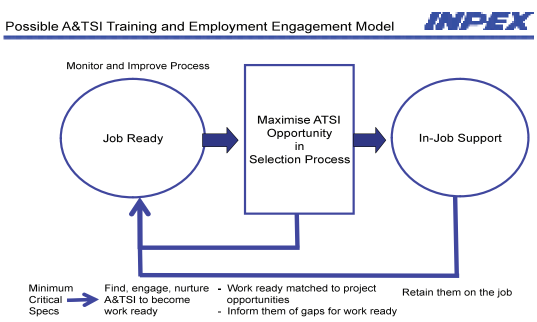
The MOU recognises the Larrakia people as the traditional owners of the Darwin area. The objective of the MOU is to facilitate INPEX's working together with the Larrakia people to ensure the establishment of a mutually beneficial relationship for the development of the Project. This includes creating employment, training and business opportunities for Larrakia and other ATSI peoples and to ensure that heritage and environmental values important to these groups are managed appropriately. Employment opportunities for Larrakia people have already begun to be realised on early environmental and geotechnical surveys.

INPEX also has an agreement with the Djarindjin people on the Dampier Peninsula to facilitate access to an emergency airstrip at their community. This agreement delivers five years' funding for the Djarindjin–Lombadina Airport Corporation, which has created employment opportunities for the local community in the airport's operations.

INPEX has consulted extensively with stakeholders including community and government representatives in the Darwin region, to understand expectations and previous models in regard to ATSI business and employment participation.

In December 2009, INPEX agreed on an "industry participation plan" (IPP) with the Northern Territory Government. The plan commits to identification of sustainable opportunities for ATSI business participation in the Project through the construction phase and in the long-term operations phase. INPEX will pass on its ATSI obligations to its contractors.

The IPP also commits the Project to an ATSI employment and training plan. The plan commits the Project to develop and implement mentoring initiatives to assist ATSI peoples to achieve sustained success, identify appropriate employment opportunities for ATSI peoples, identify barriers to success and potential programs to mitigate their effects and align contractor and Operator ATSI objectives.



In March 2010, INPEX provided a one-off capital contribution of $3 million to the Larrakia Development Corporation to establish a Larrakia Trade Training Centre in Darwin. The centre will train Larrakia, other Aboriginal and non-Aboriginal young people in basic trade skills that may assist them to find work in the broader community.

4.7 Heritage

4.7.1 Terrestrial Aboriginal cultural heritage

The Larrakia are the Aboriginal traditional owners of Larrakia country which traditionally has been taken to include Darwin Harbour, Cox Peninsula (to the north-west of Darwin Harbour), most of Gunn Point and much of rural Darwin. The Larrakia people are known as "saltwater people", with their country extending up to 50 km inland. They had trading routes with South-East Asia, and imported goods from as far afield as South Australia and Western Australia. Established "songlines" penetrated throughout the country, allowing stories and histories to be told and retold along the routes.

The Larrakia lodged the Kenbi land claim in 1979. The native title claim was finally settled in 2000 by Land Commissioner Justice Gray, who determined that native title existed for the 600 square kilometre Cox Peninsula but not for the Darwin area. However the Court did acknowledge the traditional ownership of this land by the Larrakia people. Later attempts by Larrakia people to establish native title covering Darwin were unsuccessful.

Larrakia organisations include the Larrakia Nation Aboriginal Corporation (LNAC) which was established in 1997 (through the *Native Title Act 1993* (Cwlth)) by the Northern Land Council and Larrakia Development Corporation. In February 2002 the Larrakia Development Corporation Pty Ltd was officially incorporated under the *Corporations Act 2001* (Cwlth). The Larrakia Development Corporation is a shareholder company established and owned by the Northern Land Council. Its primary role is to assist all Larrakia in developing businesses and gaining meaningful employment.

4.7.1.1 *Aboriginal heritage site management*

All matters relating to actual and/or potential Aboriginal heritage sites have been discussed with the LDC. Representatives from the LDC were involved in the Blaydin point archaeological/heritage surveys and were integral to the development of the Project's Heritage Management Plan. The Heritage Management Plan covers INPEX's area of interest at Blaydin Point and defines the process that will be used to manage Aboriginal sites.

The plan identifies where direct involvement of Larrakia representatives is required during the construction phase for the purpose of managing any other potential heritage or archaeological sites that may be identified during site preparation. Detailed strategies to be undertaken in the event a site is identified have been outlined in the plan.

Annexe 9 *Provisional heritage management plan* to Chapter 11 *Environmental management program* of the Draft EIS outlines the framework and high-level management strategies from the detailed heritage management plan which will be finalised in consultation with representatives of the Larrakia people and submitted to government for approval prior to issuing for use.

The Draft EIS also states that "three sites will be required to be disturbed during construction of the onshore facility: one isolated artefact located close to the pipeline corridor, a shell and stone artefact scatter and a subsurface midden/shell scatter located within the access road corridor". These sites were identified as of low significance and disturbance to the sites was discussed with Larrakia representatives.

However, since the Draft EIS was published, optimisation of the onshore design has occurred and alternative approaches assessed with consideration of heritage sites, safety, land availability, vegetation impact, operational impact, and cost. Through this process, INPEX decided to pursue options that avoided disturbance to the three identified Aboriginal heritage sites within the operations complex area. Disturbance to the three sites mentioned above is therefore no longer necessary.

A Larrakia Heritage Management Committee (LHMC) made up of representatives of the Larrakia people and INPEX will be established well in advance of any works being undertaken on site at Blaydin Point and will coordinate the compilation of materials to be included in site training and inductions.

The aim of the Ichthys Project employee and contractor inductions will be as follows:

- to ensure that all employees, contractors, subcontractors, and consultants are aware of their obligations under the *Northern Territory Aboriginal Sacred Sites Act* (NT), the *Heritage Conservation Act* (NT) and other applicable legislation
- to endeavour to ensure that sites are protected and that further impact is minimised
- to make all employees, contractors, subcontractors, and consultants aware of Larrakia traditions and culture as they relate to the Project area
- to instil in inductees an understanding of the Project's Heritage Management Plan, including specific guidelines on issues that may arise from time to time
- to promote a knowledge and understanding of, and respect for, Larrakia and other Aboriginal and Torres Strait Islander tradition and culture
- to foster good relationships between the Larrakia people, other Aboriginal and Torres Strait Islander and non-Aboriginal people in accordance with the heritage management plan.

It should be noted that information specific to comments concerning Aboriginal cultural heritage matters submitted during the public review period for the Draft EIS is included in the responses to individual comments in Section 5 of this EIS Supplement.

4.7.2 Maritime heritage: assessment of adequacy of marine heritage survey methods

Representatives of the Environment and Heritage Division of the Department of Natural Resources, the Arts and Sport (NRETAS) requested that INPEX engage an independent specialist marine archaeologist in order to determine whether the methods employed by INPEX to identify the presence of marine heritage artefacts within the nearshore Project development area were adequate.

INPEX developed a detailed work scope with input from NRETAS and engaged two separate consultancies to undertake the task which included the following:

- assessing the suitability and limitations of the survey methods employed within the nearshore infrastructure development footprint and offshore spoil disposal ground to detect maritime objects of heritage significance

- reviewing data collected to determine whether there were any potential maritime "contacts" identified through surveys, which have not been adequately assessed to determine whether they have heritage significance
- reviewing historic shipwreck databases and assess the likelihood of any unknown wrecks being present within the Harbour and based on available data such as vessel dimensions, age, materials, etc., indicate where possible the likelihood of detection based on the survey methods employed.

To facilitate the work, INPEX provided the consultants with extensive data sets collected within the Harbour and from the offshore spoil disposal ground. These data sets included reports addressing:

- sidescan sonar surveys
- multibeam echo-sounder surveys
- sub-bottom profiler surveys
- magnetometer surveys
- refraction surveys
- diver inspection surveys.

The reports from the two consultancies are provided in Technical Appendices S10 and S11 in this EIS Supplement.

The conclusion from the report prepared by URS Corporation marine archaeology specialists is summarised below:

> The remote-sensing techniques employed for the Ichthys Gas Field Development Project were adequate to identify any maritime cultural heritage places or objects, given the local setting, cultural history, and geological conditions. There were six classes of remote-sensing data that were reviewed for this project which included sidescan sonar, phased differentiated bathymetric sidescan and multibeam, single-beam echo sounder, sub-bottom profiler, gradiometric, and high-resolution continuous seismic profiling (CHiSP). These geophysical methods recorded 78 acoustic anomalies and 25 gradiometric anomalies within the INPEX project areas. Re-analysis of the geophysical data only added an additional acoustic anomaly URSAA1, which measures 14 m by 8 m in the proximity of five reported shipwrecks in the Australian National Shipwreck Database. Analysis of the gradiometric data did not record any potential new targets, but two anomalies, FA185 and FA186, may represent portions of the World War II anti-submarine nets that crossed Darwin Harbour and should be buffered and avoided in lieu of further archaeological surveys.
>
> There are no known or reported shipwrecks in Darwin Harbour that have not been located with precision to date. The techniques used for the geophysical surveys were adequate to have identified these potential shipwrecks. None of these wrecks were recognised during the current re-analysis of remote-sensing data for the project and therefore are not likely to be in the project area.

The conclusion of the report prepared by Cosmos Archaeology is summarised below:

> It is concluded that the remote-sensing data obtained for the development of the nearshore facilities in Darwin Harbour were of a high quality for the detection of the identified submerged cultural heritage. The surveys undertaken for the proposed pipeline route and dredging disposal ground were the optimum given the seabed topography and composition. A magnetometer survey within the remainder of the proposed dredge envelope would be an important measure for the detection of shipwrecks.
>
> In most cases the data collected were not interrogated adequately for the presence of timber hulled sailing vessels, which would present as low relief debris clusters on the seabed. Reviewing most of the data collected to date has mitigated this. This has resulted in some additional anomalies of potential cultural significance being identified. Sidescan sonar data however from the eastern portion of the proposed primary and secondary dredge envelopes within Area A were not available for review. It is possible that one or more wrecks associated with the 1987 cyclone may be present within these locations.

The author has recommended that INPEX undertake, with the assistance of a maritime archaeologist, a review of the remaining sidescan sonar data that have been collected, undertake additional magnetometer surveys in selected areas of the dredging footprint and undertake diving inspections on a number of anomalies identified through his review, which may contain cultural-heritage material.

INPEX will need to discuss the contents of both reports with representatives of NRETAS's Environment and Heritage Division before confirming follow-up actions.

4.8 Greenhouse gas

4.8.1 Reservoir CO_2 reinjection

As described in Chapter 9 *Greenhouse gas management* of the Draft EIS, reinjection of reservoir CO_2 (also referred to as geosequestration or carbon (dioxide) capture and storage (CCS)) is a potential means by which INPEX could significantly reduce its GHG footprint. Before the implementation of this option could be contemplated, however, further progress is needed in each of the following areas:

a. Technical risk—an injection site has to be identified which is confidently assessed to have the storage capacity and geological integrity required to safely store CO_2 indefinitely.

b. Commercial viability—the investment and operating costs for the reinjection facility have to be reduced to a level which is competitive with the cost of venting the CO_2, however that cost is determined (emission trading, carbon tax etc).

c. Legislative certainty—the current inconsistent and incomplete set of climate change legislation, regulation and incentive programs does not provide the certainty required to make large investments associated with CO_2 reinjection.

The team established by INPEX to investigate the reinjection option for the Ichthys Project is active in all three of these dimensions. A screening study has been carried out to identify the potential injection sites within range of Darwin. This exercise has produced a short list of options. Further, detailed modelling work is under way to determine whether or not there are any locations which satisfy the conditions above and, if so, which is the optimal location. Meanwhile, a number of engineering studies have been carried out to optimise the design of the onshore plant required to dehydrate and compress the CO_2. In the plans for the Blaydin Point LNG plant, plot space has been reserved to accommodate a potential future reinjection facility, as otherwise the option to implement reinjection of reservoir CO_2 would not be practical after the LNG plant has been designed, built, and started up.

In pursuit of legislative and regulatory-authority certainty, INPEX has been active, both directly and indirectly (through industry bodies such as APPEA (the Australian Petroleum Production & Exploration Association), in promoting harmonisation of the disparate legislation governing geological storage of CO_2.

Should the technical studies described above produce a concept which promises to meet the test of commercial viability, the next step would be to invest in appraisal of the selected storage site, involving possible seismic surveys and/or the drilling of one or more appraisal wells. The time frame for appraisal, development and implementation of a CCS project could take approximately 10 years.

It is essential for the Ichthys Joint Venture that a decision on reservoir CO_2 injection is made in a commercial context. This requires a consistent, national GHG legislative framework that facilitates a robust comparative analysis of the various offset and abatement options and allows project proponents to select the lowest cost of carbon abatement consistent with their project objectives. Such investment decisions are based on sound economic considerations, while giving due regard to the environmental and socio-economic benefits. Furthermore, it is important to realise that the current studies into reservoir reinjection and potential appraisal of an injection location are no indication or guarantee that this option will ultimately be implemented.

4.8.2 Biosequestration assessment project

INPEX continues to investigate reforestation options in Australia, including the Northern Territory. The two reforestation pilot projects INPEX has set up in the south of Western Australia (at Kirkwood and Goldings) continue to perform to expectation and generate valuable insights into this form of carbon offset.

Figure 4-43: The Kirkwood plantation two years after planting

4.8.3 Combined-cycle power plant

The Ichthys Project's onshore facilities will require between 260 and 370 MW of electrical power. INPEX has now included in its base-case design a combined-cycle power plant (CCPP) for this function. The principle of a CCPP is that it generates its power through a combination of conventional gas turbines and steam turbines. The "combined-cycle" aspect of the design is that the heat required to generate the steam for driving the steam turbines is recovered from the gas turbine exhaust stream. This is achieved by installing heat-exchanger coils in the gas turbine exhaust stacks; water passed through the coils is converted to steam as it travels through. The heat-exchanger coils constitute a waste-heat recovery unit.

The steam system is a "closed loop" (see Figure 4-44) and requires very little in the way of water make-up into the steam system. If a CCPP is employed at Blaydin Point, the small water make-up required would be sourced from the Power and Water Corporation (PWC). To ensure that there would be no build-up of minerals in the steam system, a small quantity of water would be drained ("blown down") from the steam circuit and this water could potentially be reused in the steam circuit after treatment, or would be combined with other plant wastewater streams, treated and discharged through the plant's water-treatment systems to site irrigation or to Darwin Harbour.

The recovery of the gas turbine exhaust heat improves the efficiency of the power plant compared with a plant employing only conventional gas turbines. At this stage of design, the benefit of a CCPP over a conventional plant using only gas turbines is estimated in the range of 0.3 – 0.35 Mt/a of CO_2 emission reduction when the plant is at peak production.

From time to time, owing to large "transients" in power demand, such as during the shutdown of an LNG train, the steam system may need to vent excess steam; on such occasions a white cloud of water vapour, which could be mistaken for smoke, may be visible from the Darwin area.

4.8.4 Offshore power cable

INPEX has now included in its base case design an offshore subsea electrical power-sharing cable between the CPF and the FPSO.

This design feature eliminates the need to run one 25-MW turbine for the life of the Project by avoiding the necessity for both facilities each to run one extra turbine at all times—the "n+1" operating philosophy[9]—in the event that one of the turbines at either facility might experience sudden failure. For most of the time, power would be sent from the FPSO to the CPF.

9 The "n+1" operating philosophy means that if the electrical load can be supplied by n modules, the installation will contain n+1 modules. In this way, failure of one module will not impact upon the operation of the system.

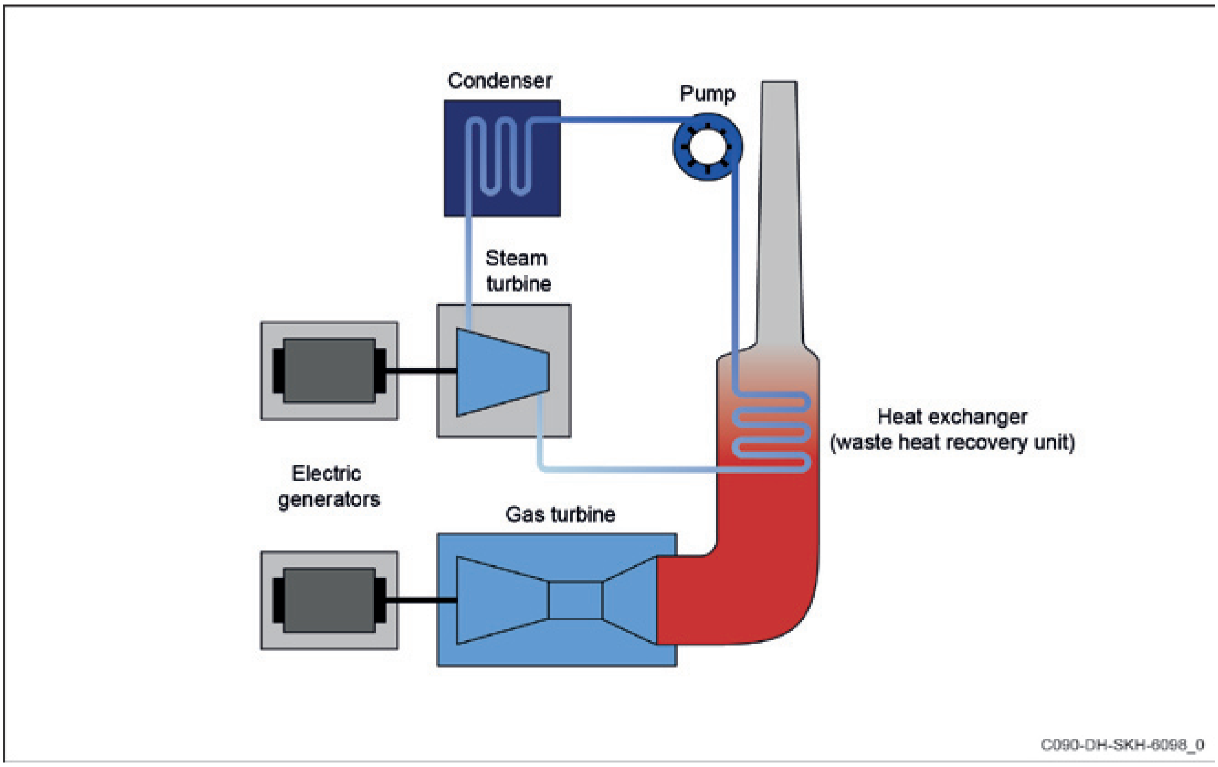


Figure 4-44: Schematic of a combined-cycle power plant

Essentially, the power-sharing cable would allow both facilities, taken together, to operate on an n+1 power generation basis as opposed to each facility, the CPF on the one hand and the FPSO on the other, having to separately operate on an n+1 basis.

Another benefit would be that more waste heat will be generated on the FPSO instead of on the CPF. The FPSO will need large amounts of waste heat to stabilise condensate and regenerate MEG (monoethylene glycol). Supplemental fired heaters would sometimes be needed when waste heat from power generation turbine exhausts might not be sufficient. On the other hand, the CPF will require large amounts of electric power without significant need for waste heat. Elimination of one turbine from the CPF instead of the FPSO will therefore also not cause loss of waste heat on the FPSO, and will minimise the need for supplemental firing for condensate stabilisation and MEG regeneration.

The GHG emission reduction of the power-sharing cable is estimated at between 0.1 and 0.2 Mt/a.

4.8.5 Fire-management projects in the Northern Territory

Savannah-burning accounts for 33–50% of the Northern Territory's GHG emissions and has therefore been identified by the Northern Territory Government as a unique and material opportunity for GHG emission reductions and biodiversity protection in the Territory. By working with traditional owners, fire management also offers a significant opportunity for Aboriginal economic development. This has been demonstrated in the West Arnhem Land Fire Abatement (WALFA) Project, a pioneer fire-management project initiated in Arnhem Land in 1998 and, with support from the Darwin LNG project, implemented at full scale from 2006. This project is widely celebrated for its success in reducing emissions from wildfires and in achieving positive biodiversity and socio-economic outcomes for the Aboriginal community through the employment of Aboriginal rangers on country in culturally appropriate work.

INPEX has indicated to the Northern Territory Government that it would like to commit to two savannah fire-management projects, in the Daly River area and in the Delissaville–Wagait–Larrakia Aboriginal Land Trust area, to expand the success of fire-management regimes in the Territory. The Daly River area was identified by the Northern Territory Government in a draft discussion paper on potential offset projects in the Territory in February 2010. INPEX has also committed to consider the Delissaville–Wagait–Larrakia Aboriginal Land Trust area and would like to finalise the appropriate arrangements for these two projects with the Northern Territory Government and with the land councils, landowners and other stakeholders as soon as possible. As areas of monsoon vine thicket occur within the areas proposed for fire management, it is anticipated that the program could be designed to assist in the protection of these vegetation communities from fire—one of the key threats to their continued existence.

4.8.6 Additional information on life-cycle emissions

A number of submissions have challenged the statements in the Draft EIS with regard to reduction of global emissions as a result of the use of Ichthys LNG. While most respondents acknowledge that Ichthys LNG will result in a reduction in global GHG emissions if it displaces more carbon-intensive fuels such as coal or oil, how much displacement will occur in practice has been questioned. This is a complex issue and touches on fundamental choices by sovereign nations on their energy security and climate change policies. INPEX offers the following observations in this regard.

The countries that purchase Ichthys LNG have energy demands that are a result of their current and future economic development. National emissions resulting from energy consumption are mainly determined by two factors: the level of energy use and the method of generation. Reduction of emissions should therefore consider these two factors.

Reduction of energy use is challenging for many nations as it directly impacts on their abilities to grow and develop. Energy efficiency and conservation programs have significant potential to impact the level of energy use but it is widely accepted that a country's desire to grow its economy will result in continued growth of energy use. Therefore a key focus for emission reduction is on the method of power generation and in particular the mix of energy sources deployed to meet demand.

How a country decides which energy sources to use to meet its energy demand involves many factors, such as availability, energy security, cost and risk, to which must be added climate change. Energy supply is invariably a combination of sources in order to spread risk and mitigate against sudden shortfalls. For example, Japanese primary energy demand and power generation for 2008 was made up as follows (IEA 2011):

	Primary energy demand (%)	Power generation (%)
Oil	43	12
Gas	17	24
Coal	23	27
Nuclear	14	31
Hydro	1	3
Renewables	2	3
Total	**100**	**100**

The share of nuclear energy has been growing in Japan because of the lower GHG emissions from nuclear power production. However, nuclear energy can only increase to a modest level because of waste, earthquake and tsunami concerns and costs. Damage and associated risks caused to conventional hydrocarbon power plants (e.g. by earthquakes and tsunamis) may also be easier to manage with fewer human health risks than damage caused to nuclear power plants.

The availability of hydroelectric power is naturally limited and in some cases the creation of new reservoirs to feed hydroelectric power stations can have adverse environmental and social consequences. Other forms of renewable energy will play a more important role in the future but will be insufficient to provide the capacity to replace other fuel sources. The International Energy Agency's world energy outlook report for 2010 estimates that global renewable power generation would need to triple by 2035 to reach the Copenhagen Accord greenhouse gas target of 450 ppm of CO_2 in the atmosphere, but this would require the enormous sum of US$3 trillion of government support to achieve (IEA 2011).

In the coming decades, Asian economies will continue to rely on fossil fuels to complement nuclear, hydroelectric, and renewable energy supplies to meet their total energy demands. INPEX's view is that every tonne of LNG used for power generation or manufacturing in Asia will result in either a reduction in emissions if directly displacing the use of oil and coal, or reduce the increase in emissions if chosen in preference to oil and coal.

The actual extent to which Ichthys LNG will displace oil or coal requires detailed information on energy end-use which will be unknown until the LNG is consumed. However, there is clear evidence that fuel-switching is happening in Japan. The *Australian Financial Review* of 20 December 2010, for example, notes under the headline "Japan's producers to step on the gas infrastructure" that "Japan's major gas suppliers are raising their output and distribution capacities to meet demand from manufacturers, which are switching from crude oil to gas to lighten their carbon footprints" (AFR 2010).

Some sources argue that Ichthys LNG will simply be used in addition to coal and oil and therefore increase global GHG emissions. INPEX acknowledges this potential if countries have an increasing energy demand to satisfy. INPEX believes it is not its role to challenge countries' increased energy use and their choices in terms of economic development. Instead, INPEX aims to provide a cleaner fuel alternative to oil and coal, which would otherwise be used to meet demand to an extent that nuclear and renewable sources such as hydroelectric and wind power cannot meet. It is widely acknowledged that gas is an important transition fuel that can help countries to make the required short-term emissions reductions before sufficient renewable sources are available to meet longer-term demand. The International Energy Agency (IEA) notes that "during this radical transformation, the flexible operational nature of gas-fired generation and its lower CO_2 content makes it an attractive "bridging" fuel".

INPEX acknowledges concerns about increased GHG emissions, but notes that climate change and GHG emissions are global issues that do not recognise borders. INPEX supports the Commonwealth Government's efforts to establish a global climate change framework that will recognise the emissions benefits that LNG offers compared with more carbon-intensive fuels.

4.9 Environmental offsets

INPEX has commenced dialogue with the Commonwealth's Department of Sustainability, Environment, Water, Population and Communities and with the Northern Territory Government to outline a process for the development of an environmental offsets package for any significant residual environmental impacts arising from the Project.

Significant residual environmental impact can only be determined by government after the submission of the Final EIS, that is, the Draft EIS and this EIS Supplement taken together.

In the interim, INPEX has made a number of voluntary environmental offset commitments which are outlined below.

Improving understanding of coastal dolphin abundance, distribution and critical resource needs

INPEX will establish a long-term boat-based survey of coastal dolphins within Darwin Harbour to improve the understanding of the abundance, distribution and critical resource needs. A three-month pilot program commenced in January 2011 in Middle Arm and West Arm using boat-based transect methods.

In total 40 km of transects have been established based on 20 x 2-km transect lines. A detailed methodology for the survey was developed by INPEX and marine mammal experts from GHD, with review and input from NRETAS. Information collected includes species, group size, group composition, behavioural categories, photographs of dolphin fins and environmental data such as water temperature, sighting depth, etc. Representatives from the Larrakia community were provided with training to enable them to participate in the surveys under the supervision of expert whale observers. Preliminary results from the pilot program are outlined in Section 4.1.9 of this EIS Supplement. The pilot program will be expanded to cover a larger area of Darwin Harbour and is expected to last for a number of years. It is anticipated that this program will complement and expand upon the previous dolphin research undertaken in Darwin Harbour by the Northern Territory Government.

Integrated marine monitoring and research program

As indicated in Chapter 11 *Environmental management program* of the Draft EIS, INPEX is committed to participating in the proposed integrated marine monitoring and research program for Darwin Harbour. This program offers the potential for the identification, funding and implementation of priority research and monitoring needs for the Harbour.

Australian Research Council Linkage Projects

The Australian Research Council (ARC) is a statutory authority within the Commonwealth Government's Innovation, Industry, Science and Research Portfolio. The ARC advises government on research matters and manages a significant component of Australia's investment in research and development.

The Linkage Projects scheme supports research and development projects which are collaborative between higher-education researchers and industry partners ("partner organisations") who must make a significant contribution in cash or in kind that is equal to, or greater than, the ARC funding.

The objectives of the Linkage Projects scheme are as follows:

- to encourage and develop long-term strategic research alliances between higher-education organisations and other organisations, including industry and other end-users, in order to apply advanced knowledge to problems and/or to provide opportunities to obtain national economic, social or cultural benefits
- to enhance the scale and focus of research in national research priorities
- to foster opportunities for postdoctoral researchers to pursue internationally competitive research in collaboration with organisations outside the higher-education sector, targeting those who have demonstrated a clear commitment to high-quality research
- to provide outcome-oriented research training to prepare high-calibre postgraduate research students
- to produce a national pool of world-class researchers to meet the needs of the broader Australian innovation system.

INPEX has committed to support two ARC Linkage research proposals within Darwin Harbour.

The first project, which has been successfully approved by the ARC, is titled *Understanding and predicting sediment distribution and net transport in estuaries and coastal oceans with an emphasis on muddy bottom layers*. It is a collaborative research project over three years between the University of New South Wales, the Australian Institute of Marine Science and the State Key Laboratory of Satellite Ocean Environment Dynamics of the People's Republic of China.

The aims of the project are to improve understanding of mud transport and siltation problems in muddy ports and coastal estuaries and to collect data which will allow the development of high-resolution hydrodynamic and sediment-transport models that are capable of reproducing fluid mud layer dynamics in estuaries.

The completion of the project will deliver a state-of-the art sediment-transport model for estuaries. It will also advance scientists' understanding of the behaviour of fluid mud layers and sediment–water interfaces in muddy coastal environments. The proposed research has many applications to Australia and China where a more accurate prediction of fluid mud layer dynamics and its impact on the water quality and dispersion of chemical species from the sediments to the water column is important for the improvement of the management of port and engineered structures and of the health of the ecosystem of muddy coasts. Muddy ports in Australia where such knowledge is expected to be applicable include Brisbane, Townsville, Cairns and Darwin.

The second project, titled *The Darwin Harbour water quality and sentinel habitats: the microbiology of tidal creeks receiving treated sewage effluent* is a collaborative three-year project by Charles Darwin University and the Australian Institute of Marine Science. NRETAS and the Power and Water Corporation are also partner organisations.

The project aims to develop a microbial assessment tool and establish a microbial baseline within Darwin Harbour. The outcome of the application is expected to be known in March 2011.

If successful, the program will result in the development of new tools to undertake rapid assessment of microbial populations and establish a qualitative baseline from which to assess anthropogenic impacts on microbial species. It has the potential to deliver a fast and accurate method for determining environmental impact and provide early warning for potential impacts on higher-level species within the Harbour.

Publication of Kimberley research

As indicated in Section 11.5 of Chapter 11 *Environmental management program* of the Draft EIS, INPEX has undertaken extensive studies along the Western Australian Kimberley coastline. These studies include the following:

- regional-scale aerial surveys to identify marine turtle nesting locations on the mainland and on coastal islands from Broome to Cape Bougainville
- detailed surveys of marine turtle nesting activity and abundance on several islands off the Kimberley coast
- surveys to identify potential foraging areas, inter-nesting areas and migratory routes for green and flatback turtles by means of satellite-tagging and -tracking
- genetic analyses of green and flatback turtles nesting on the islands of the Kimberley region
- extensive aerial and boat-based surveys to identify the distribution ranges of the humpback whale, pygmy blue whale, and other species of large marine animal off the Kimberley coast
- offshore sea-noise logger surveys to gather data to identify pygmy blue whale distribution and abundance
- detailed coral habitat mapping and species identification surveys on a number of Kimberley islands
- fish, algae and mollusc surveys of a number of Kimberley islands
- benthic infauna surveys in the Ichthys offshore development area and at the Maret Islands.

To facilitate the transfer of this information into the general scientific, regulatory-authority and general community, INPEX has committed to publishing this valuable research, which has cost more than $15 million to collect.

4.10 Alternatives

4.10.1 Alternative shipping channels

Background and proposal

The ability to efficiently and safely move, berth and load product tankers at the product loading jetty is critical to the Project. Jetty and shipping channel design is based on a series of complex loading and navigation studies, geotechnical and environmental surveys, and safety quantitative risk assessments (QRAs).

Key technical criteria influencing jetty and shipping channel design include the following:

- The water depth and channel width in the approaches to the jetty must be sufficient for safe navigation
- The turning basin width must be sufficient to allow tugs to safely turn and manoeuvre product tankers to the jetty head
- The jetty alignment must take into account prevailing winds and tidal currents to facilitate safe manoeuvring for product tanker turning, berthing and departing
- The separation distances for berthing vessels at East Arm Wharf and the product loading jetty at Blaydin Point need to be maximised for safety reasons
- The shipping channel must avoid maritime heritage objects or sites.

Figure 4-45 shows the shipping channel alignment with respect to the location of maritime heritage objects within East Arm. These include the wrecks of six World War II Catalina flying boats, the coal barge *Kelat*, which is listed on the Northern Territory Heritage Register and a steel barge which remains unlisted and is not currently subject to a recommendation for listing. Five of the six flying boats are currently under heritage assessment: Catalina 6 is protected under an interim conservation order issued by the Minister for Natural Resources, Environment and Heritage, while Catalinas 2, 3, 4 and 5 have been proposed for listing on the Northern Territory Heritage Register.

Early discussions between INPEX and the Heritage Branch of the Department of Natural Resources, Environment, the Arts and Sport (NRETAS) made it clear that the protection of these maritime heritage sites was a priority. As a consequence, INPEX unilaterally established protection zones around the sites to ensure that the design of the product loading jetty and the shipping navigation channel would not impact upon them.

INPEX was also encouraged during early discussions with representatives of the Darwin Port Corporation to remove Walker Shoal, which was considered to be a navigational safety hazard and an impediment to future expansion of the East Arm Wharf facility. A cross-section profile of Walker Shoal is provided in Figure 4-46 to illustrate how close it is to the sea surface. At 4.2 m below LAT, Walker Shoal in its natural state will not allow safe transit for the Project's product tankers, regardless of tidal height. Groundings on the shoal would also be possible for the majority of larger vessels transiting to and from East Arm Wharf should they accidentally pass over this hazard. One possible consequence of a vessel grounding on Walker Shoal could be loss of containment of fuel oil or product, which would have a significant adverse environmental impact on the Darwin Harbour environment.

During the public review period for the Project's Draft EIS, a number of submissions were received suggesting that INPEX should consider alternative shipping routes which could potentially avoid the need for drill-and-blast activities at Walker Shoal.

This section of the EIS Supplement provides information on a number of alternative shipping channel routes which have been considered by INPEX and provides INPEX's rationale for maintaining the current alignment.

Walker Shoal local geology

Figure 4-47 shows a "sun-illuminated" image of Walker Shoal and the surrounding area of the proposed shipping channel. This image has been formed using the data obtained from a detailed multibeam echo-sounder bathymetric survey of the seabed. The figure suggests that the rock which forms Walker Shoal is not solely limited to the feature marked on marine charts as Walker Shoal, which rises close to the surface, but continues both to the north and south of "Walker Shoal" at greater depths.

To improve its understanding of the nature of the seabed and the underlying geology within the proposed shipping channel and in particular around Walker Shoal, INPEX has carried out a number of geophysical and geotechnical investigations. Refraction and reflection surveys were undertaken to provide a broad overview of the subsurface soil strengths and their spatial distributions, and a geotechnical drilling program was undertaken in two phases to provide core samples of Walker Shoal for analysis. The results from the surveys were used to refine site selections for the second-phase geotechnical boreholes, allowing areas of high-strength material to be targeted to confirm the presence of rock.

It is possible to obtain only low-resolution data from reflection and refraction surveys and this tends to exaggerate the spatial distribution of high-strength material; this is further exacerbated when high-strength material overlies weaker material (as is the case at Walker Shoal). For these reasons, INPEX's first estimate of the volume of high-strength material at Walker Shoal (and at two other sites within the dredging footprint) was excessively conservative. Information from the second phase of the nearshore geological investigation was necessary to refine the figures for the amount of high-strength material. However, owing to the highly confused and complex nature of the geology at Walker Shoal, the interpretation of the data took longer than expected.

An extensive borehole pattern was drilled over Walker Shoal in an attempt to better understand the nature of its geology and structure. In all, 68 boreholes were drilled on an approximate grid of 30 m over the entire area of the shoal. The drill cores were then subjected to a number of geotechnical tests to assist in the interpretation of, among other things, the potential dredgeability of the shoal. An additional 30 strength tests were carried out in October 2010 to gain a better understanding of the dredgeability of the material. It is this greatly increased knowledge of Walker Shoal that has allowed INPEX to substantially reduce its original estimate of the likely volume of hard rock to be removed.

Figure 4-48 shows the locations where cores were obtained within the Walker Shoal geological feature.

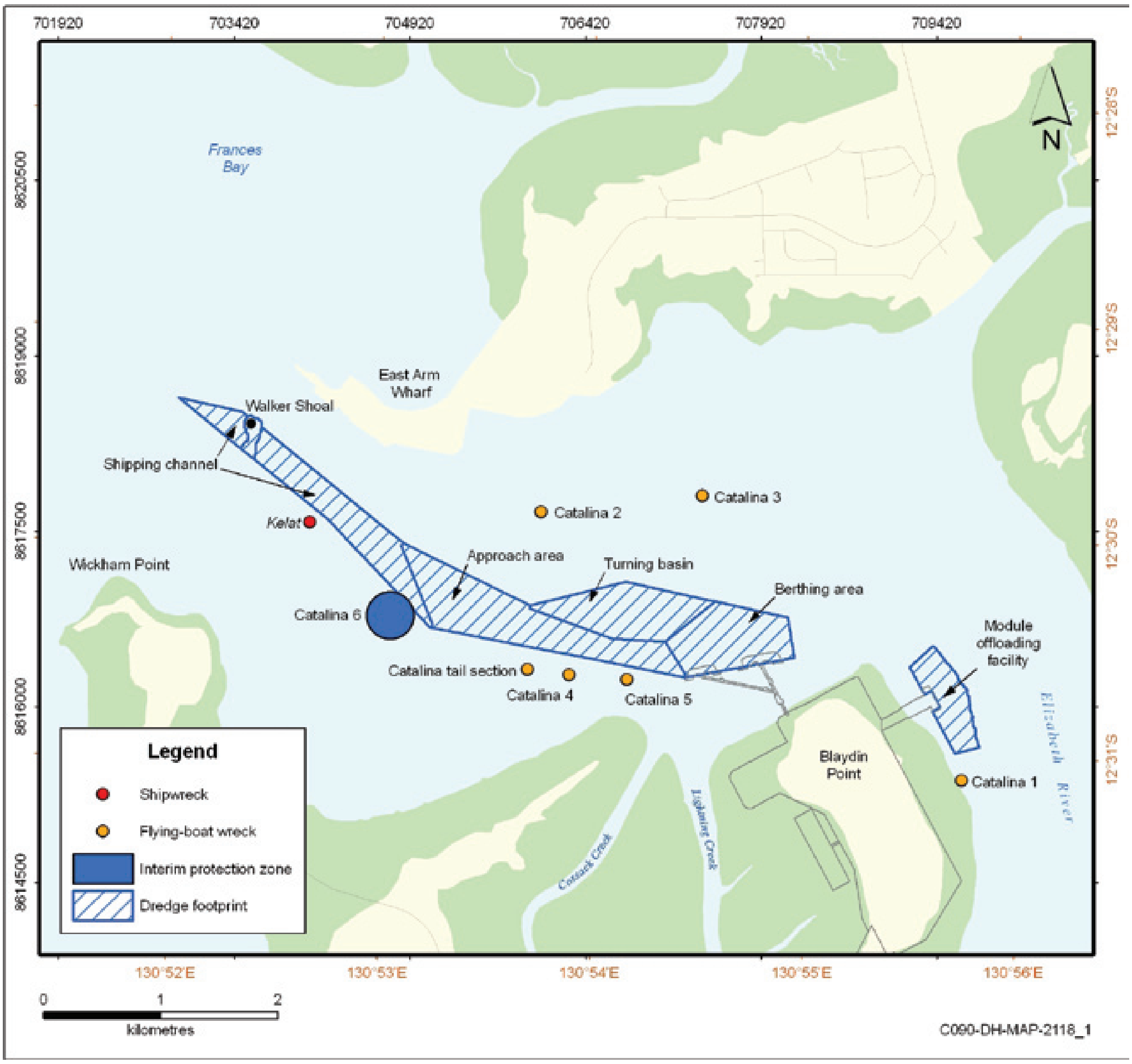


Figure 4-45: Indicative dredging footprint for the shipping channel

Note that this figure includes shipwrecks, flying-boat wrecks and a flying-boat interim protection zone.

While the survey area did not extend all the way into the shallower waters south of the proposed shipping channel, a number of observations provide supporting information to indicate that the hard-rock intrusion continues beyond the surveyed area. This includes the presence of hard-rock outcrops in the vicinity of north-east Wickham Point and the fact that hard rock was encountered by ConocoPhillips during the piledriving operations for the product loading jetty for its Darwin LNG plant.

Figure 4-49 shows the known and inferred location of rock within the Walker Shoal area. It is interesting to note from this figure that the hardest rock in this area actually occurs to the south of the feature popularly called “Walker Shoal”.

The data collected from these surveys confirm that Walker Shoal consists mainly of high-strength conglomerate from the Burrell Creek Formation, and forms an S-shape generally striking north–south across the proposed shipping channel. This is because of the near-vertical dip of the strata and the tight folding associated with the Burrell Creek Formation. Walker Shoal is the only area within the dredging footprint where this conglomerate was found.

The greater part of the rock found at Walker Shoal is steeply bedded (around 80 degrees), has undergone significant folding and some metamorphism, possibly contains a number of faults, and exhibits considerable variability in physical characteristics and weathering state. As Walker Shoal is formed from this conglomerate, it indicates that it is potentially more durable than the other materials adjacent to it and has been eroded at a far slower rate.

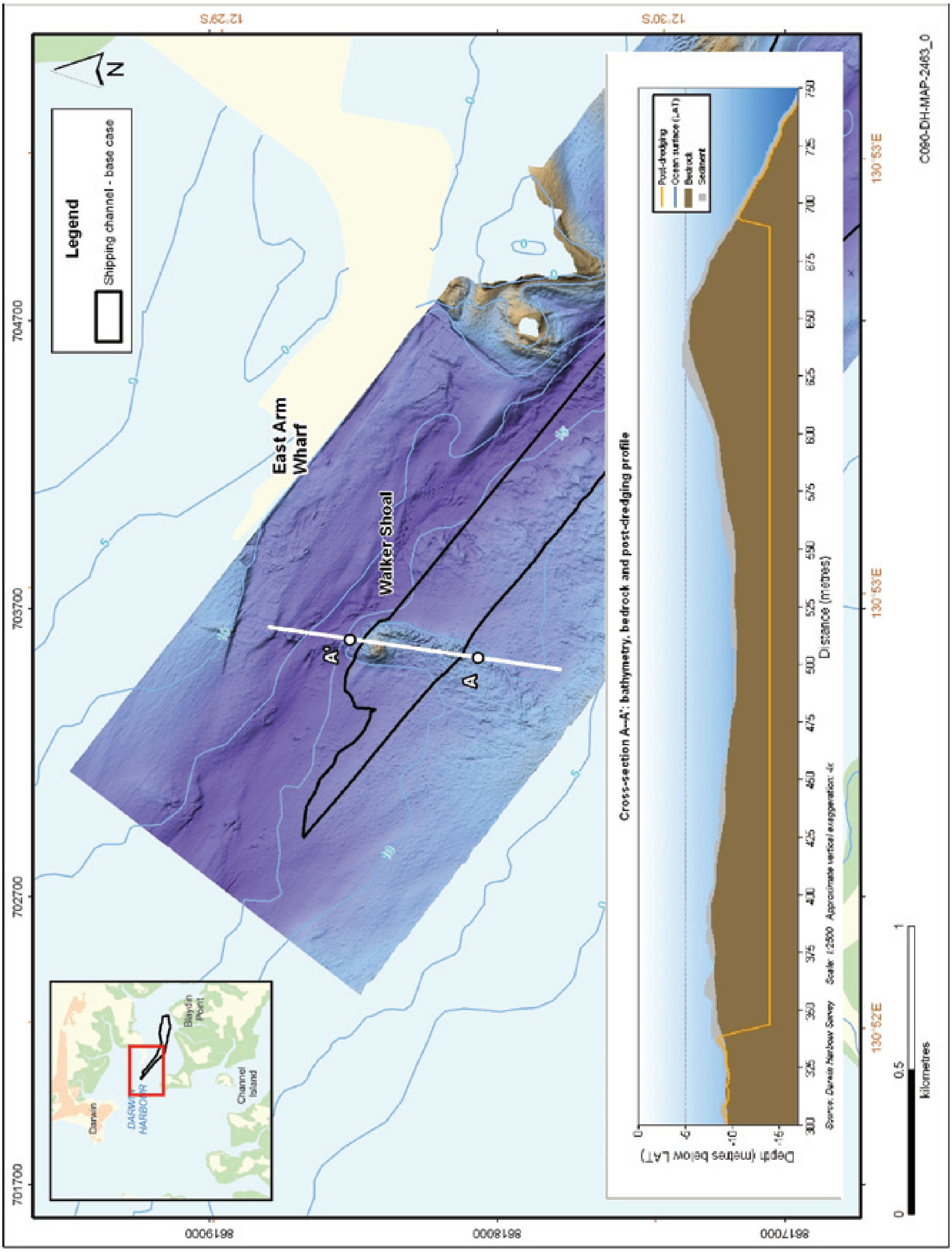


Figure 4-46: Cross-section profile of Walker Shoal

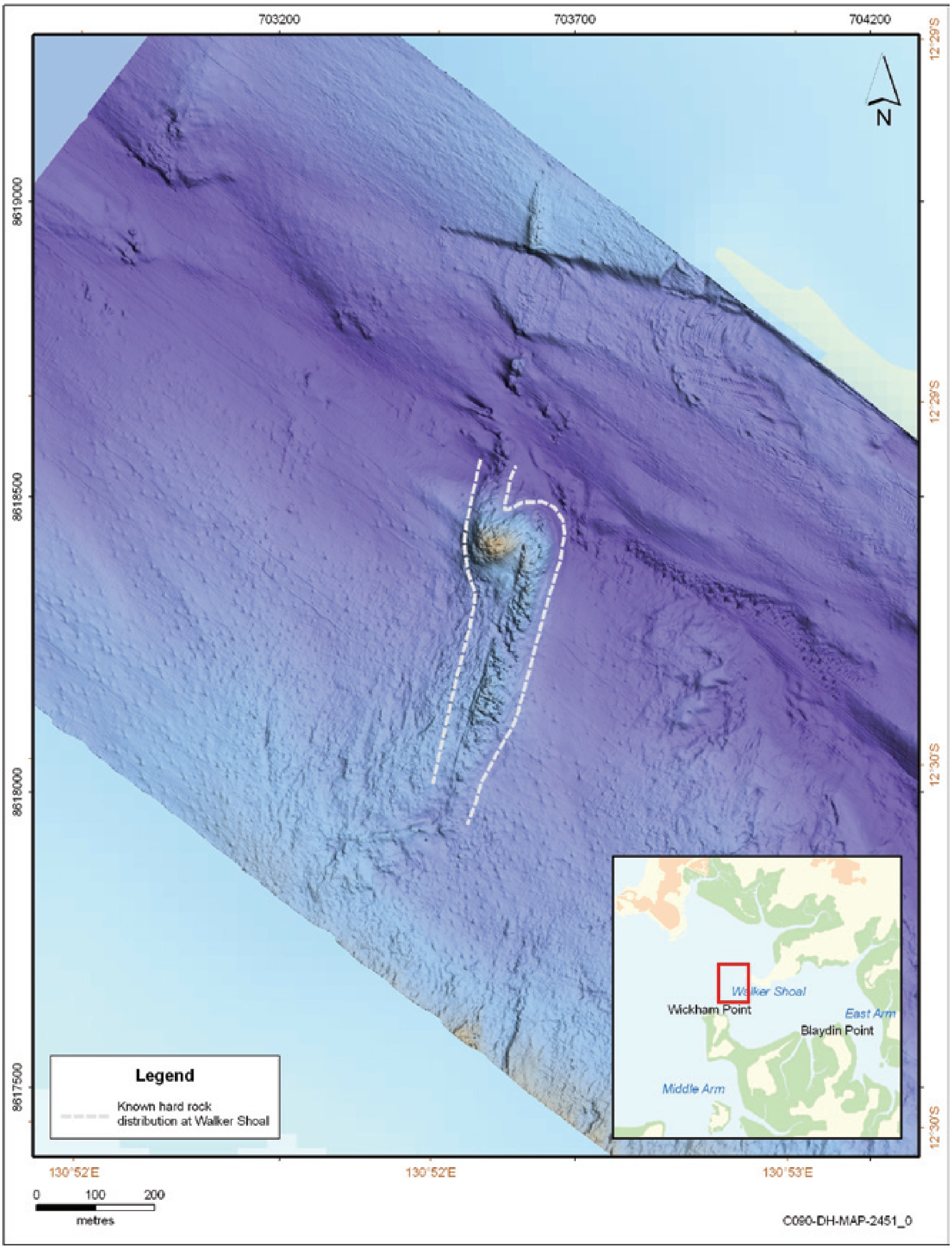


Figure 4-47: Surface geological features of Walker Shoal showing area of rock outcropping

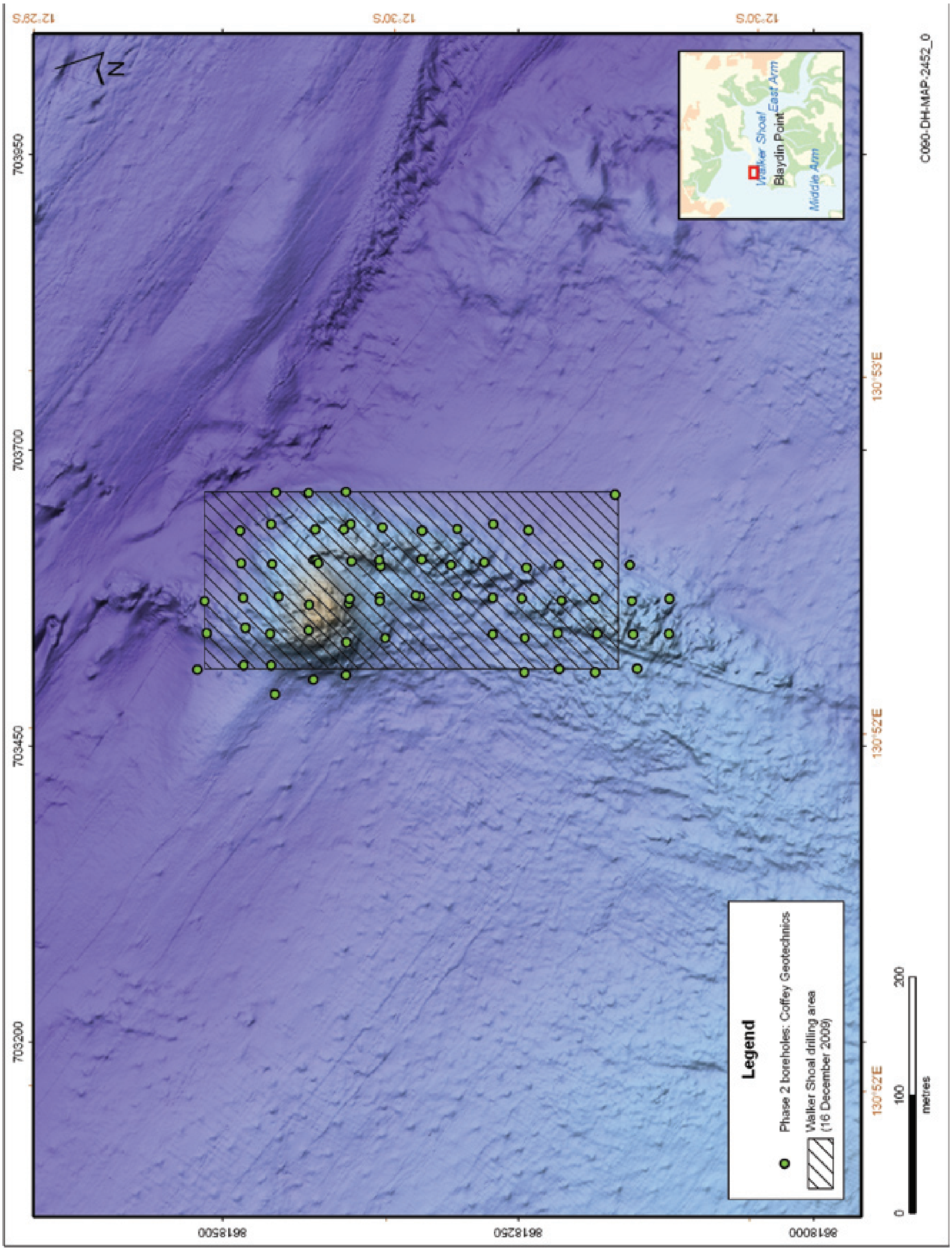


Figure 4-48: Location of boreholes over the Walker Shoal geological feature

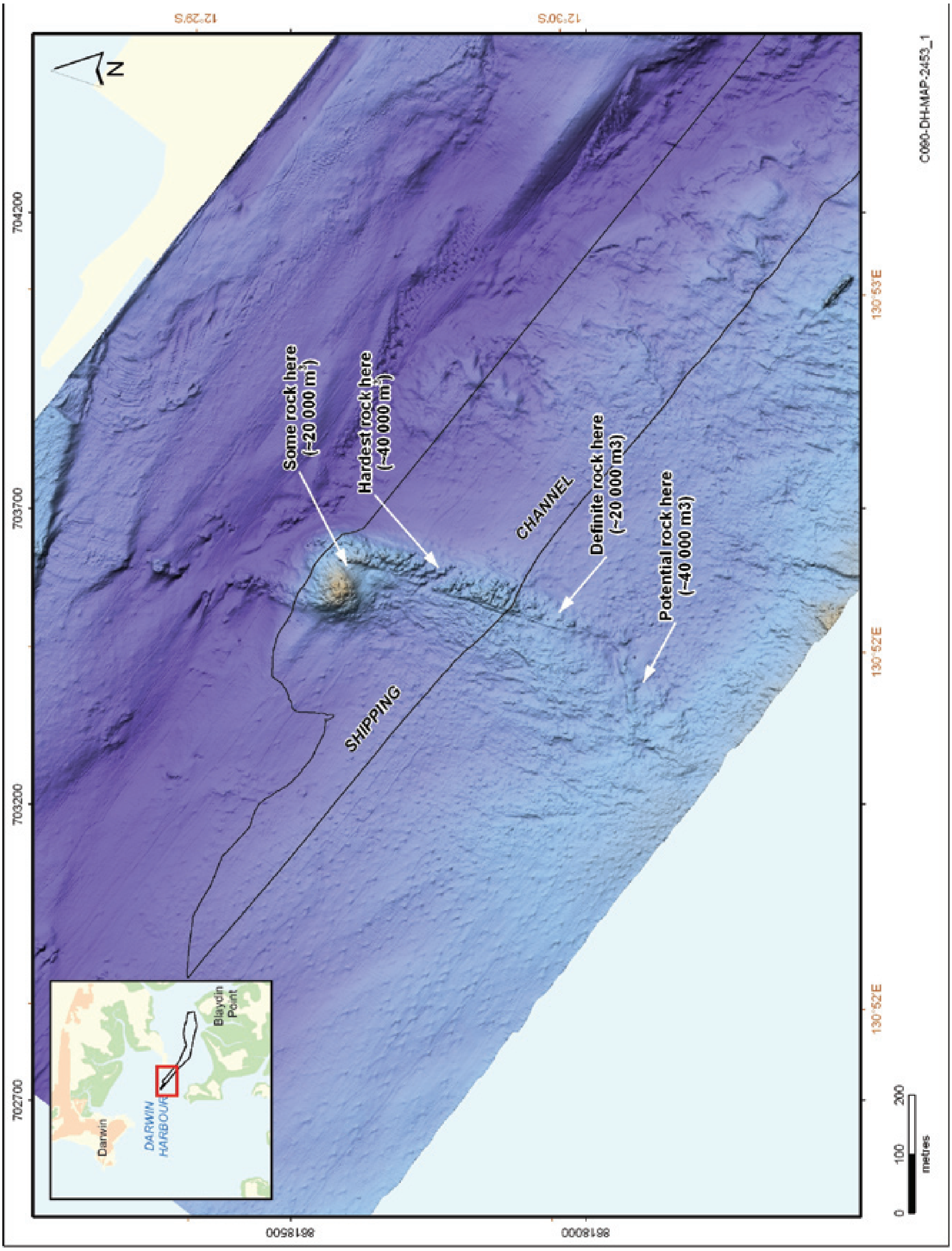


Figure 4-49: Inferred rock strength within the Walker Shoal geological feature

4 Supplementary Information to the Draft EIS

Options for alternative shipping channel alignments

INPEX has considered four alternative shipping channel alignments. One option, which included moving the shipping channel to the north of Walker Shoal, was quickly eliminated as it would take the Project's product tankers too close to East Arm Wharf. In Darwin Harbour there is a safety requirement for a 500-m exclusion zone around all LNG tankers. This means that the accepted minimum safe distance for any vessel from an LNG tanker is 500 m. If the proposed shipping channel were placed north of Walker Shoal, it would not be possible to maintain this distance from vessels which are moored at East Arm Wharf.

The remaining three options are represented in Figure 4-50, Figure 4-51 and Figure 4-52.

- Option 1: This option involves swinging the shipping channel 200 m to the south to avoid Walker Shoal. No change to the approach channel is required. The *Kelat* wreck is not disturbed and nor are other areas of maritime heritage.
- Option 2: This option involves moving the shipping channel 400 m to the south and requires some adjustments to the approach channel to suit. The *Kelat* wreck is not disturbed and nor are other areas of maritime heritage.
- Option 3: This option involves moving the shipping channel 650 m to the south and the approach channel is adjusted to suit. The *Kelat* wreck is not disturbed and nor are other areas of maritime heritage.

All three options result in the shipping channel being relocated into progressively shallower water to the south of Walker Shoal.

Table 4-24 provides an estimate of the increased dredge volumes and an estimate of the volume of hard rock which would require removal for each option. For comparative purposes the "base case" for the shipping channel as published in the Draft EIS is also included in the table.

The following may be noted from Table 4-24:

- Option 1 does not result in any reduction of hard-rock material over the base case. There would also be a corresponding increase in dredge volumes of between 0.5 and 1 Mm^3 and the main section of Walker Shoal would remain in situ and present a long-term navigation hazard to Ichthys Project product tankers. Option 1 is not therefore seen to offer any environmental or social improvements over the base-case shipping-channel route.
- Option 2 provides for a reduction in hard-rock volume of approximately 33%. However, as Option 2 is located in shallower water (refer to Figure 4-51), there would be a significant increase in the dredging volume required, of between 3 and 4 Mm^3. INPEX does not believe that the reduced rock volume provides an adequate environmental benefit to offset the increases in environmental and social impacts associated with these significantly larger dredge volumes.
- INPEX does not have supporting geotechnical information to confirm whether hard rock occurs within the shipping channel alignment for Option 3. Anecdotal evidence (refer to Walker Shoal local geology above) suggests that hard rock is likely to be present. Regardless of whether hard rock is present or absent within the Option 3 shipping channel alignment, it is INPEX's view that the additional environmental and social impacts associated with the increased dredge volume for this option (between 5 and 6 Mm^3) do not adequately compensate for any potential reduction in hard-rock volumes.

Summary

INPEX has evaluated four alternative options for the shipping channel alignment described in the Draft EIS. One of the options—relocation north of Walker Shoal—was rejected because it would create unacceptable shipping safety risks for both Ichthys Project and East Arm Wharf operations.

Table 4-24: Indicative dredge and hard-rock volumes for the alternative shipping channel options

	Base case	Option 1	Option 2	Option 3
Additional dredge volume	0	0.5-1 Mm^3	3-4 Mm^3	5-6 Mm^3
Volume of hard rock	60 000 m^3	60 000 m^3	40 000 m^3	Unknown, but hard rock assumed to be present

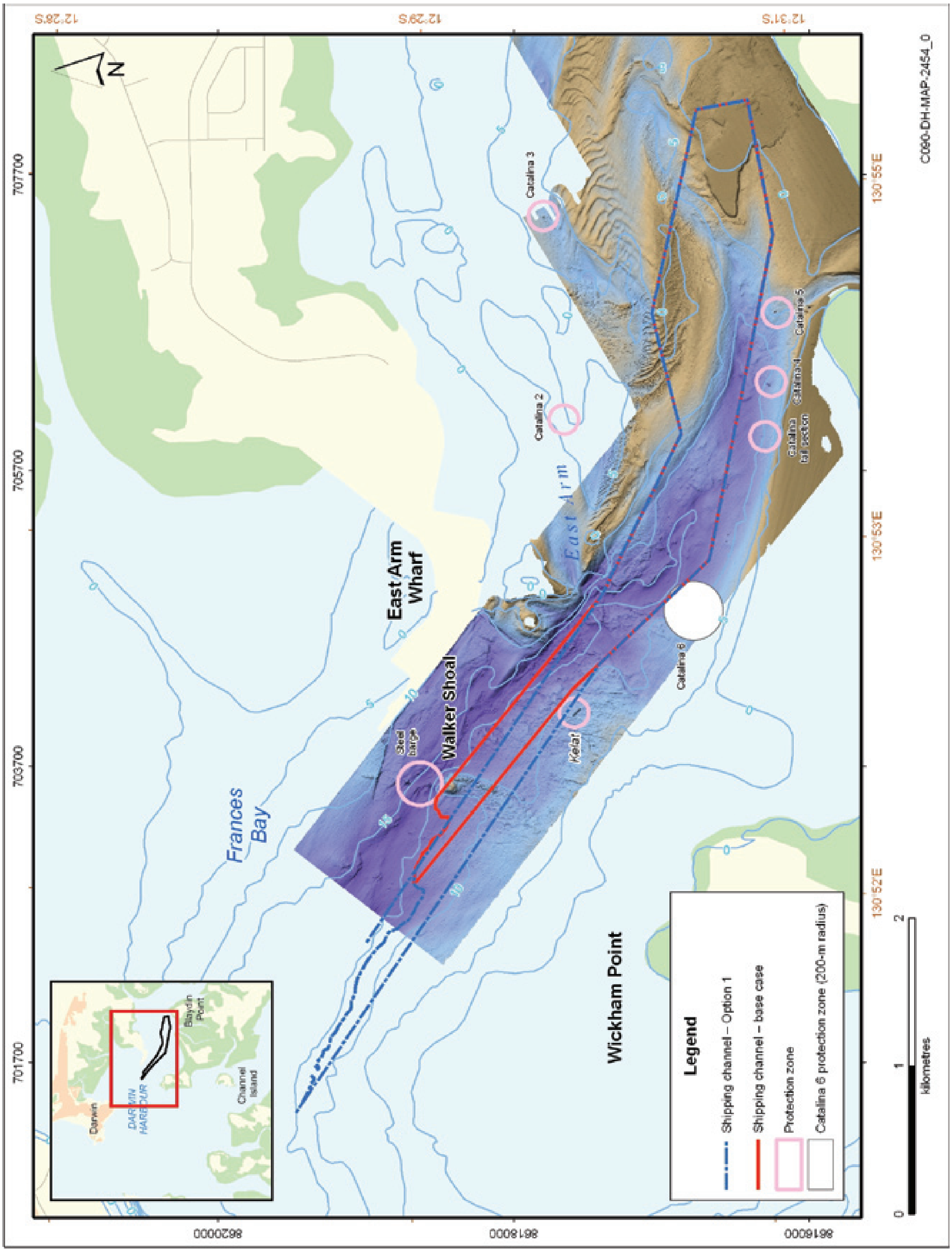


Figure 4-50: Alternative shipping channel Option 1

4 Supplementary Information to the Draft EIS

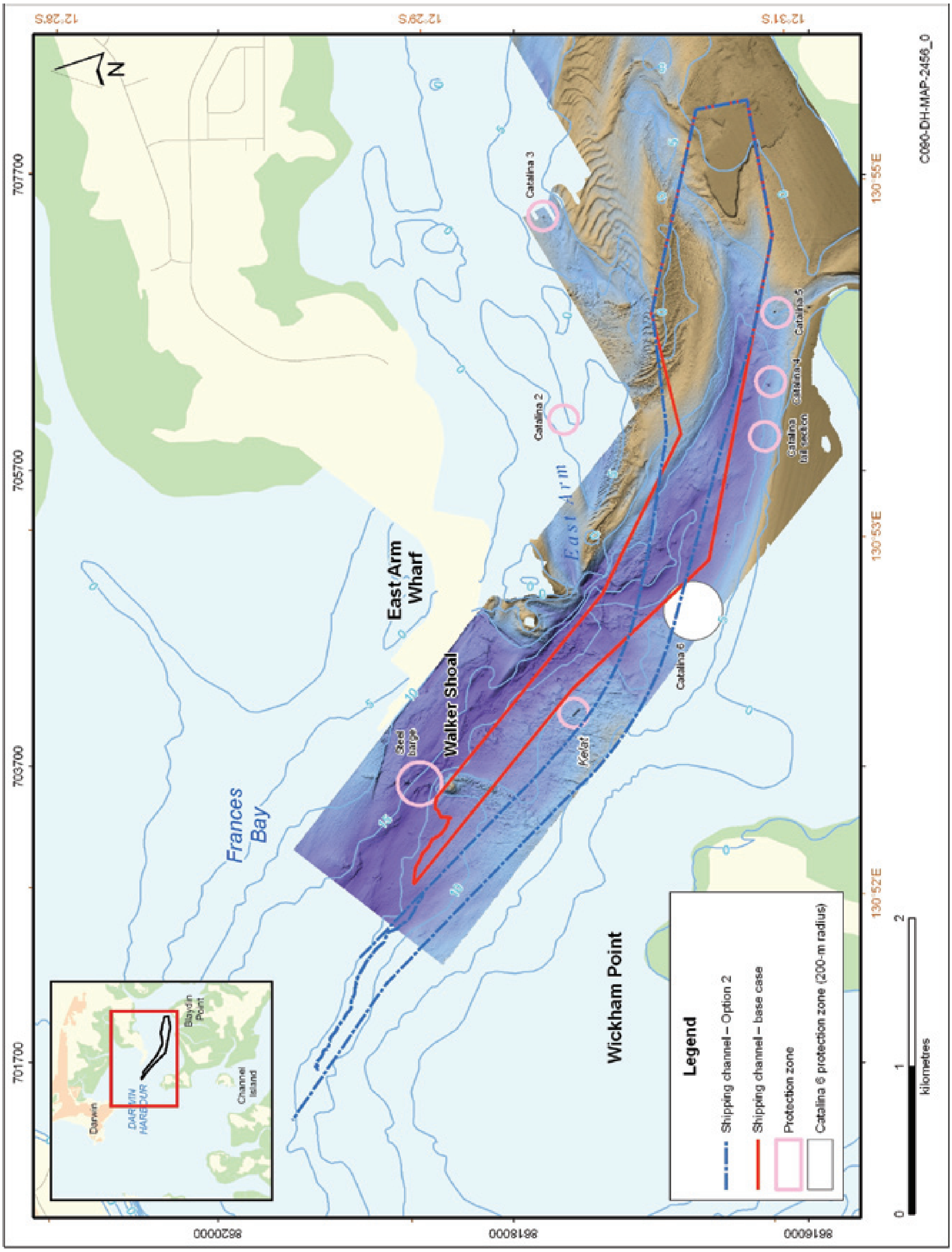


Figure 4-51: Alternative shipping channel Option 2

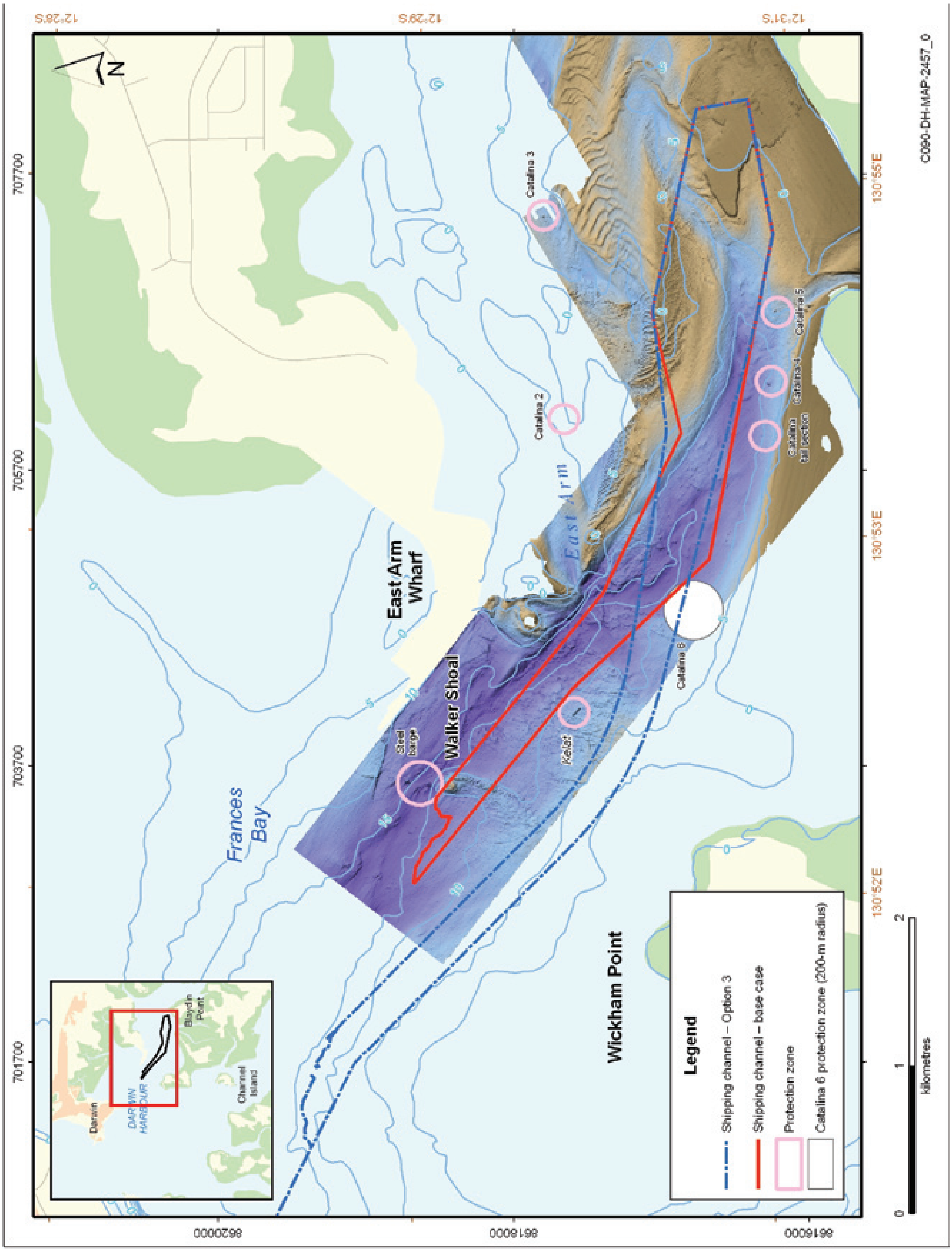


Figure 4-52: Alternative shipping channel Option 3

The remaining three options are all to the south of the shipping channel as proposed in the Draft EIS, and require relocation into progressively shallower water. This results in increased dredge volumes of up to 6 Mm^3 for Option 3. Hard-rock intrusions associated with Walker Shoal set to the south and consequently the alternative shipping channels do not avoid the presence of hard rock. No reduction in hard-rock volume is anticipated for alternative shipping channel Option 1, and a 33% reduction in hard-rock volume for Option 2 is not considered to provide an adequate offset in environmental and social impact given it is accompanied by a 3 to 4 Mm^3 increase in dredge volume. Any potential reduction in hard-rock volume for Option 3 is likewise not considered to offer an environmental and social benefit over the base case, given it will be accompanied by an additional dredging volume of between 5 and 6 Mm^3.

INPEX therefore proposes to maintain the current shipping route alignment as proposed in the Draft EIS.

4.10.2 Additional information on the selection of the product loading jetty option

During the public review period for the Project's Draft EIS, a number of submissions requested further information from INPEX on the selection process for the product loading jetty.

As indicated in Section 4.1.1 of Chapter 4 *Project description* of the Draft EIS, selection of the jetty option for the Project was undertaken with consideration of a range of complex and competing environmental, social, safety and technical issues.

Since Darwin Harbour supports a large population centre with intensive recreational use of the Harbour and extensive commercial port operations, it is appropriate to consider social, environmental, safety and technical aspects in the design of the product loading jetty (and its attending navigation channel). Environmental impacts therefore need to be balanced against the Project's safety and technical requirements and the broader societal risks and values.

Early consultation with key stakeholders in Darwin identified a range of pertinent issues to be considered in the jetty design. These included:

- maintaining access to Catalina creeks, (also known as Lightning and Cossack creeks), for recreational fishing
- ensuring the protection of World War II Catalina flying boat wrecks located north west of Blaydin Point; one of which has an Interim Heritage Protection Order in effect
- minimising the visual amenity impact of the jetty
- minimising the environmental impact of the jetty
- minimising congestion and shipping risks at East Arm Wharf.

Two jetty concepts were considered by INPEX during the early FEED phase:

- a short jetty—a short jetty length, with a position and orientation as shown in Figure 4-53
- a long jetty—a jetty approximately 3 km long with a westerly orientation directly across the entrance to Lightning and Cossack creeks as shown in Figure 4-54.

To assist in determining which of the concepts should be selected as the preferred jetty option for continuation through FEED (front-end engineering design), INPEX developed a decision-support method which integrated principles of sustainable development into the decision process and clarified the objectives, drivers and priority considerations for selecting the most appropriate jetty design. The method aligns with the objects of the EPBC Act for ecologically sustainable development which states, among other things, "that decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations".

A description of the decision-support method and the process used to evaluate the concepts is provided below. The impacts associated with the preferred option, the "short jetty", are described in Chapter 7 *Marine impacts and management* and Chapter 10 *Social-economic impacts and management*.

Detailed assessment process

The decision support method incorporated a number of sustainability criteria under the broad categories of environment, social and economic.

The decision support method subdivided the social criterion into health, safety and security and socio-political subcriteria and the economic criterion was further divided to include Project risk and technical viability. The criteria were developed (as presented in Table 4-25) by a cross-section of engineers, health and safety, external affairs, economic and environmental specialists within INPEX. The categories were considered to represent the key criteria which needed to be taken into account in the selection process.

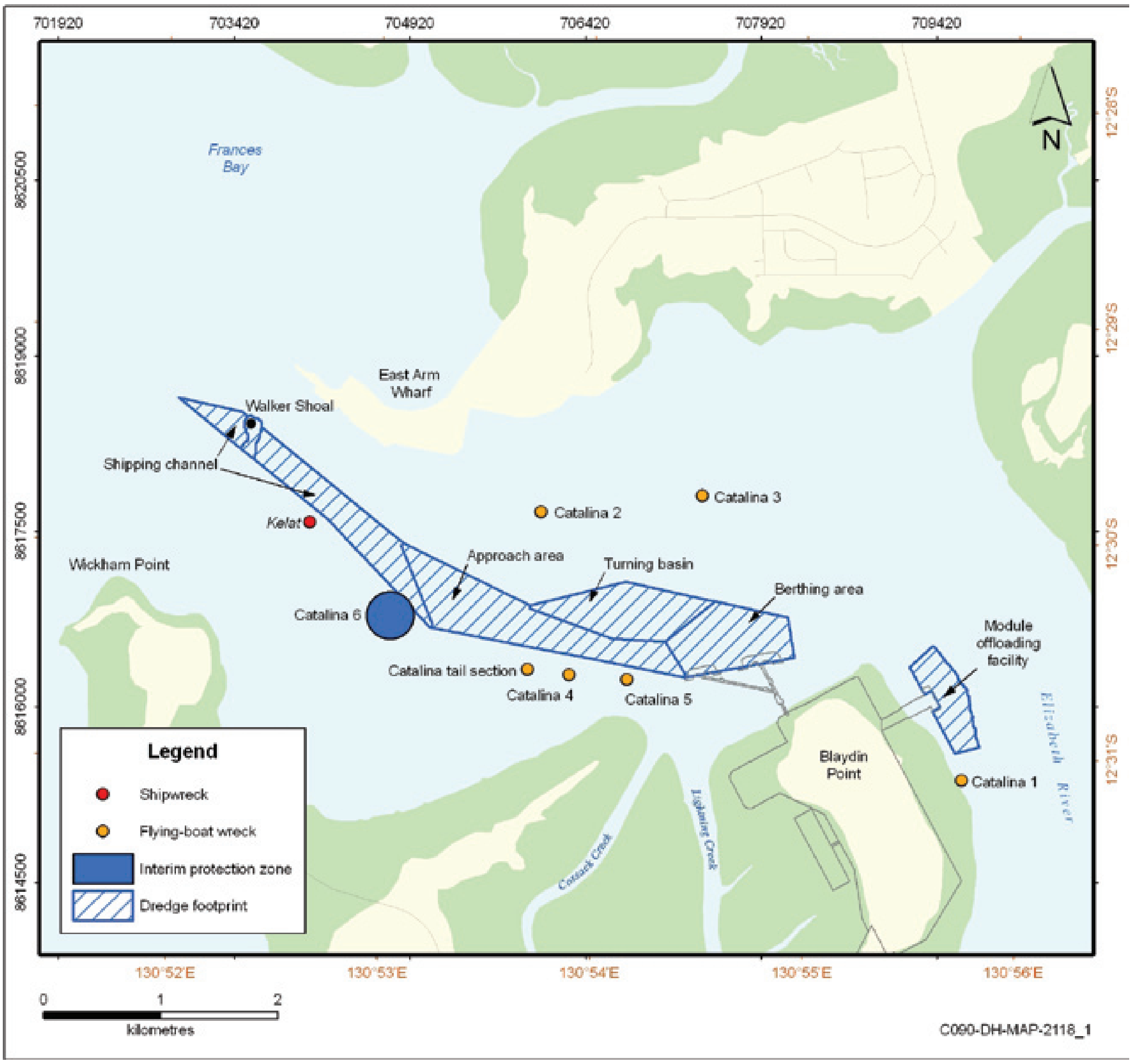


Figure 4-53: Short jetty concept

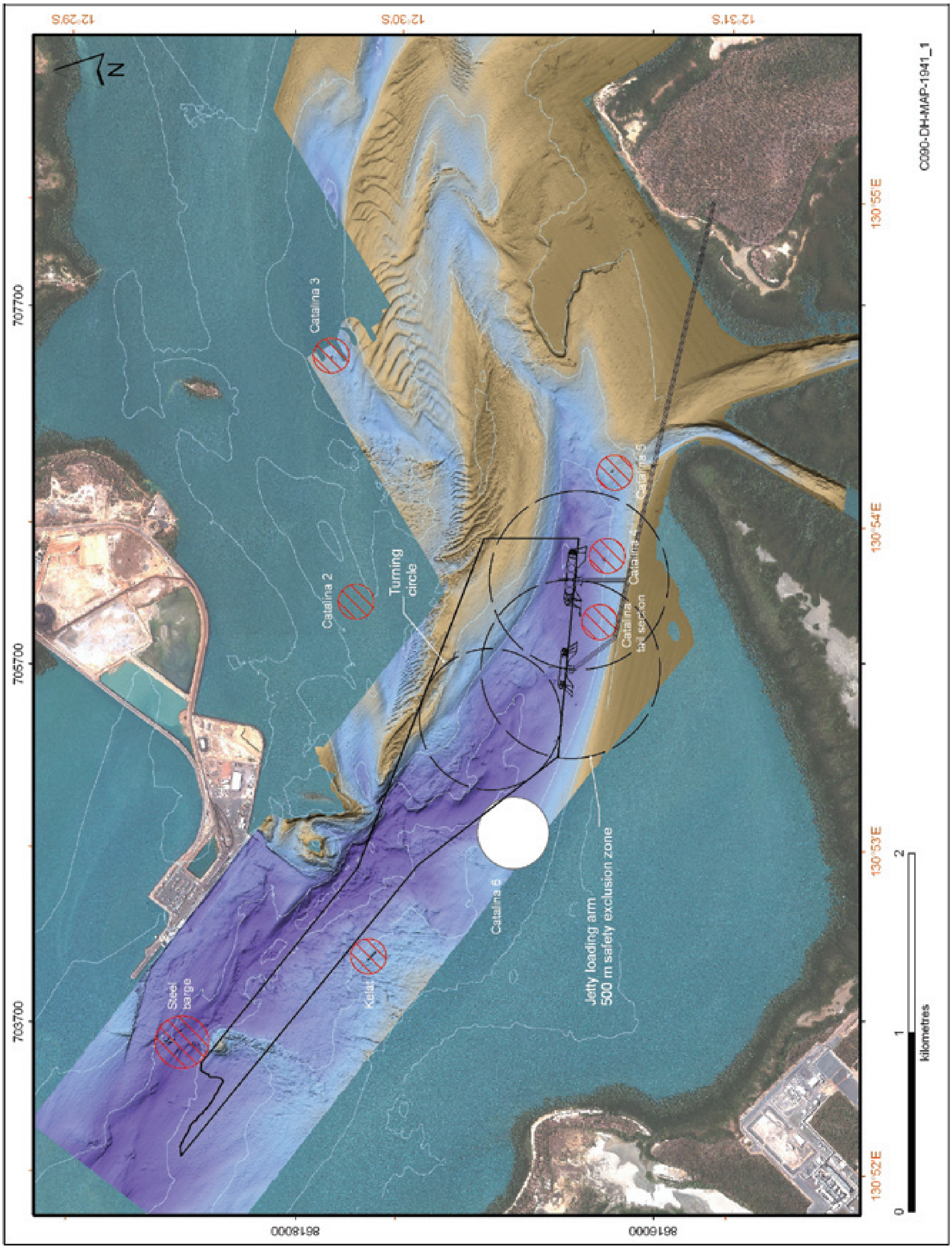


Figure 4-54: Long jetty concept

Table 4-25: Detailed sustainability criteria for jetty selection process

	Environmental	Clarifier
Environmental	Impacts on habitat (hard coral)	Impacts on hard-coral communities
	Impacts on habitat (soft sediments)	Impacts on soft-sediment communities
	Impacts on habitat (sponges, soft corals)	Impacts on sponge and soft-coral communities
	Productivity (mangroves)	Impacts on mangroves
	Protected species	Displacement or mortality of listed and migratory species
	Water quality	Duration of period of reduced water quality
	Oceanographic processes	Changed habitat attributable to changes in hydrodynamics
	Air emissions and resource use	Use of fuel and release of greenhouse gases and air toxics
	Introduced marine pests	Risk of introducing marine pests
Social	**Health, safety and security**	
	Potential loss of life (PLL) (construction)	Workforce safety during construction
	Potential loss of life (PLL) (operations)	Workforce risks during the operations phase
	Potential loss of life (PLL) (general public)	Risk to general public
	Collision risk	Which option minimises collision risk
	Risk of ship grounding	Which option minimises grounding risk
	Risk to/from third party vessels	Which option is safer for existing shipping
	Risk of impact with jetty during berthing	Longer pipe run equates to increased risk
	Socio-political	
	Visual amenity (dredging)	Which options result in longer dredging
	Visual amenity (operations)	Which options are less visible from tourist vantage points
	Heritage protection	Potential for damage to Catalina flying-boat wrecks from construction and operations activities
	Public access (to Lightning and Cossack creeks)	Long-term exclusion of recreational fishers from Lightning and Cossack creeks
	Public access (dredging)	Impacts on recreational fishing, tourism operations and diving
	Commercial	Loss of access to cyclone moorings in Lightning Creek
	Schedule delay from recreational fishing sector	Concern over access constraints
	Schedule delay from environmental non-governmental organisation (NGO) groups	Concern over dredge volume
	Secondary community benefits	Potential for fill to be provided to Darwin Port Corporation
Economic	**Economic**	
	Economics	Includes jetty and dredging construction costs, LNG production rates (LNG boil off) and ongoing jetty maintenance costs
	Project risk and technical	
	Constructibility	Uncertainty in constructibility
	Schedule	Schedule risk delay
	Navigation and manoeuvring	Which option is most favourable for berthing and departures
	Operability of jetty	Maintainability and accessibility
	Loss of access (maintenance dredging)	Loss of sales as a result of maintenance dredging
	Expandability	Which option provides the best expansion potential

Scores and weighting for each criterion were developed by specialists within INPEX and, in some cases, by INPEX's lead consultancies. Relevant reports from studies and investigations informed the scoring process. For example, preliminary quantitative risk assessment studies were used to inform the public safety risk and marine habitat maps of the development area and preliminary dredge spoil modelling outputs were used to assist in assessing the relative environmental impacts of the jetty concepts. Sensitivity tests were undertaken to allow consideration of different weighting factors for the categories.

The jetty concept which scored the highest represented the best option on a sustainability basis. Note that for the evaluation economic weightings were set to zero, so that the decision support process was not influenced by costs associated with the alternative jetty concepts.

Table 4-26 below summarises the outputs from the decision support tool. While acknowledging that better short-term environmental outcomes could be achieved by adopting a long-jetty concept, the process identified that the health, safety and security, socio-political and Project risk and technical viability categories all scored better for the short-jetty concept.

The key advantages of the short jetty concept include the following:

- a reduction in the risk of recreational vessels travelling into the jetty safety exclusion zones and taking potentially unsafe short cuts under the jetty trestle
- a reduction in safety risks from the Project's product loading jetty because of the increased separation distances for vessels berthing at East Arm Wharf
- a reduction in the long-term impact on visual amenity from Darwin's central business district and other vantage points around Darwin Harbour
- the elimination of the need for jetty piledriving and jetty construction works in close proximity to the World War II Catalina flying boat wrecks and its associated risks
- a reduction in leak paths for products (LNG, LPGs and condensate) from the jetty loading lines
- Potential for access to Lighting and Cossack Creeks maintained
- Significantly reduced piledriving operations and therefore noise impacts on marine fauna lessened.

Table 4-26: Summary outputs from the jetty selection process

Categories	Long jetty	Short jetty	Comments
Environmental	Lower risk to East Arm mangroves from dredging-derived sedimentation	Increased risk to East Arm mangroves from dredging-derived sedimentation	Environmental impacts acceptable for short jetty (see Chapter 7 *Marine impacts and management* of the Draft EIS and Section 4.1.3 of this EIS Supplement)
Health, safety and security	Increased risks owing to longer load-out lines and leak paths	Better heath, safety and security outcomes	Short jetty is safer and more secure
Socio-political	Larger exclusion area for recreational vessels—a social negative	Better socio-political outcomes in the long term	
Economic			Weighting set to zero – economics does not influence selection process
Project risk and technical	Technical constraints for potential future jetty expansion	Better Project risk and technical outcomes	

The disadvantage of the short jetty concept is that larger dredge volumes are required to be removed in the shallower water closer to Blaydin Point. Overall, however, the short-term environmental and social disadvantages caused by an increased dredge volume are mitigated by improved safety outcomes, a reduction in long-term visual amenity impact, and a reduction in the extent of the area excluded by safety requirements for recreational users in East Arm.

Preliminary quantitative risk assessment (QRA) shows that public access to recreational fishing areas in Lightning and Cossack creeks can be maintained. However, safety exclusion zones will apply to the eastern "fingers" of Lightning Creek. This, however, will be subject to safety demonstration through final QRA.

INPEX has presented a comprehensive assessment of the potential marine impacts associated with the short jetty concept in Chapter 7 *Marine impacts and management* of the Draft EIS, while the potential social impacts are presented in Chapter 10. Additional information is provided in Section 4.1 of this EIS Supplement.

4.11 Planning legislation

Local planning context

The key instruments for land-use planning in the Northern Territory are the *Planning Act* (NT) and the Northern Territory Planning Scheme. The Department of Lands and Planning administers the Northern Territory Planning Scheme (DLP 2007).

Land-use planning in the Northern Territory is governed by the *Planning Act*, which provides for appropriate and orderly planning and control of the use and development of land.

The Act:

- establishes the Northern Territory Planning Scheme and provides for a development approval process
- provides for interim development control
- provides for an appeals regime and enforcement
- establishes the Development Consent Authority.

The Planning Scheme contains, among other things, the following:

- statements of policy with respect to the use or development of land
- provisions that permit, prohibit or impose conditions on a use or development of land
- provisions that provide instructions, guidelines or assessment criteria to assist the consent authority in assessing development applications
- other provisions in connection with planning for, or control of, the use or development of land
- maps, plans, designs and diagrams.

The Planning Scheme establishes land-use zones which guide the type of land developments and land use that are considered consistent with the planning values of a specific area to ensure the orderly and logical development of Northern Territory lands. The Minister for Lands and Planning is responsible for the Planning Scheme.

INPEX's proposed onshore processing plant for the Ichthys Project is located at Blaydin Point on Middle Arm Peninsula. This area is covered by the Planning Scheme and was identified as a "development area" in 2007 in a presentation by the then Department of Planning and Infrastructure (now the Department of Lands and Planning) in May 2007 (DPI 2007).

The Planning Scheme was amended on 12 December 2007 with the stated intent of allowing for the development of further gas-based industry on Middle Arm Peninsula (NT Planning Scheme – Amendment No. 37). Amendment 37 omitted Clause 9.1.2 which limited the development of gas-based industry on Middle Arm Peninsula.

Subsequent to this, a project development agreement (PDA) between the joint venturers INPEX Browse, Ltd. and Total E&P Australia on the one hand and the Northern Territory Government on the other was signed on 18 July 2008.

The area constituting the mangrove fringe around Middle Arm Peninsula is zoned for conservation. The Ichthys Project will create disturbance in parts of the mangrove community, however, and certain areas will require rezoning for the Project to proceed. Development within the mangrove community will be undertaken consistent with the outcomes of the environmental impact assessment process.

Land for industrial development at Middle Arm will be administered by the Land Development Corporation (LDC), which is the Northern Territory Government's leading land development agency.

The LDC provides companies with access to a range of strategically located industrial and commercial land areas ready for development. It assists key industry sectors to take advantage of major industrial projects in the region and facilitates strategic industrial land development to further stimulate economic growth (LDC undated).

The area set aside for development on Middle Arm has been designated as the Wickham Industrial Estate. The Blaydin Point area is currently undeveloped land that has been set aside for industrial development. Previous land use has included borrow pit extraction.

The development of the Ichthys onshore processing plant will entail a range of land tenure acquisitions at Blaydin Point. These are as follows:

- option to lease
  - for the initial development site prior to the final investment decision (FID)
  - for any optional development site required following FID (note that any optional development will require a separate environmental impact assessment process)
- lease
  - for the initial development site following FID
  - for the beach valve inland of the pipeline shore crossing on the western side of Middle Arm Peninsula
  - for any temporary storage or laydown areas as may be required
- easement
  - for the gas export pipeline corridor to Blaydin Point on Middle Arm Peninsula
- estate in fee simple
  - for the initial development site (when the relevant conditions specified in the PDA are met).

The required land tenure will be sought under the *Crown Lands Act* (NT). The PDA establishes the processes and conditions precedent in respect of the acquisition of land tenure for the Project. At the time of the granting of the required tenures, INPEX and the Northern Territory Government will negotiate appropriate payment terms.

Development consent under the *Planning Act* (NT) is required prior to the commencement of development activities. It is likely that this will be undertaken in stages depending on the actual timing of works and discussions with the Department of Lands and Planning.

The indicative development consent staging is as follows:

1. for land preparation (clearing and earthworks)
2. for the establishment of temporary facilities (construction offices and related facilities)
3. for the establishment of the permanent facilities.

4.12 Ecologically sustainable development

The National Strategy for Ecologically Sustainable Development (NSESD), endorsed by all Australian jurisdictions in 1992, defines the goal of ESD as "development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends" (DSEWPaC 2010d).

Today the guiding principles of ESD have been incorporated into most national state and territory legislation. Section 3A of the EPBC Act defines these principles as follows:

- Decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equitable considerations (the "integration principle").
- If there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation (the "precautionary principle").
- The present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations (the "intergenerational principle").
- The conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making (the "biodiversity principle").
- Improved valuation, pricing and incentive mechanisms should be promoted (the "valuation principle").

Section 136 of the EPBC Act has a mandatory requirement for the minister to consider economic and social matters and in considering these matters must take into account the principles of ecologically sustainable development. Again in Section 391 the minister is required to consider the precautionary principle in making decisions.

INPEX recognises that it has a responsibility to support these principles of ESD and that it has a duty of care both to the natural environment and to the communities in which it operates. This concept is set as a core objective of the INPEX environmental policy for operations within Australia and related Project locations (Figure 11-2 in Chapter 11 *Environmental management program* of the Draft EIS).

This section describes how the development and operation of the Ichthys Project is consistent with the goals and guiding principles of ESD.

4.12.1 Economic and social benefits

Both direct and indirect economic benefits will contribute to a better quality of life in the Northern Territory as well as Australia-wide. Economic modelling, detailed in Chapter 10 *Socio-economic impacts and management* of the Draft EIS, indicates that the Project will benefit the Northern Territory economy, contributing an increase of almost 18% in GSP during each year of the 40-year operating period. The Project will also benefit the Australian economy, with predicted annual contributions of A$3.5 billion to Australia's GDP.

In addition, the Darwin community will benefit directly from the construction of infrastructure, the provision of education and training, and the creation of business and employment opportunities. For example, opportunities for training and long-term career paths will be generated through the construction of a Trade Training Centre whose objective is to "to deliver … a dedicated community-based trade training school for the provision of nationally accredited trade apprenticeships and training for the benefit of the Larrakia, other local Aboriginal people and the wider Darwin community".

Through such direct and indirect benefits, the Ichthys Project has the potential to offer an enduring benefit to a broad range of stakeholders over the long term.

4.12.2 Maintaining ecological processes

A key objective of the Project is to design, construct and operate the Ichthys gas field development so that negative impacts on the environment are avoided or kept at levels that are "as low as reasonably practicable" (ALARP). The Draft EIS details the extent of Project impacts on ecological processes and the management measures to address these impacts in the following chapters:

- Chapter 7 *Marine impacts and management*
- Chapter 8 *Terrestrial impacts and management*.

Additional work has been undertaken in Section 4.1 to map habitats and communities over the entire extent of Darwin Harbour and to quantify actual and potential areas of impact arising from dredging activities. The section shows that only a small percentage of key communities in the Harbour (macroalgae, seagrass, filter feeders coral and mangroves) are affected or at risk and that soft sediment communities (the most broad spread within the harbour) are unlikely to be significantly impacted by indirect impacts. As such the potential for any significant changes to productivity and trophic structure in the Harbour is considered very low and ecological processes are not considered to be at risk.

Ecologically sustainable practices that have been used as a basis of Project design include:

- minimising impacts on ecologically valuable areas, for example the mangrove communities and "matters of national environmental significance" (such as threatened and migratory species)
- maximising energy efficiency and minimising fuel consumption
- minimising emissions and discharges
- minimising waste production through the waste hierarchy (i.e. eliminate, reduce, reuse, recycle)
- avoiding or minimising the use of harmful chemicals
- minimising the risk of accidental spills.

INPEX is also committed to working closely with government to identify and explore potential environmental offset opportunities in the Darwin region in order to contribute to positive conservation outcomes. INPEX has already committed to some voluntary offsets, described in Section 4.9 above. These include the following:

- participating in the proposed integrated marine monitoring and research program for Darwin Harbour
- establishing a long-term coastal dolphin research program
- supporting Australian Research Council Linkage Projects
- publishing the results of INPEX-funded biological research studies along the Kimberley coast.

Through its commitment to implementing these projects and programs and to those detailed mitigation measures recorded in the Draft EIS and in the EIS Supplement, INPEX is demonstrating the importance it places on protecting biological diversity and maintaining essential processes and life-support systems consistent with "the biodiversity principle". In doing so, the cost of such measures is incorporated into the total cost of the Project, enabling the value and price of environmental resources and their protection to be more accurately reflected in line with "the valuation principle".

An example of where INPEX has committed to best-practice methods in support of biodiversity conservation is in its planning of dredging activities. Annexe 6 *Provisional dredging and dredge spoil disposal management plan* to Chapter 11 *Environmental management program* of the Draft EIS provides an overview of the monitoring of environmentally important parameters for the protection of the Channel Island coral communities and Darwin Harbour mangroves. Monitoring will gauge whether effects from sediments generated by dredging are being maintained within conservative and acceptable thresholds. Exceedance of thresholds will trigger further monitoring and management responses.

INPEX has also committed to further management controls to reduce the environmental impacts which will result from dredging and from the removal of Walker Shoal near East Arm Wharf. INPEX has committed to using alternatives to the traditional drill and blast methods to remove hard-rock material at Walker Shoal. This approach removes a key risk factor for marine mammals and turtles. INPEX has also been able to reduce dredge spoil volumes by approximately 1 m^3 by reducing the shipping-channel depth by 0.5 m, without imposing any operability constraints or safety risks.

INPEX has also committed to employing best-practice dredging methods, to minimise risks to the Darwin Harbour mangrove communities to as low as reasonably practicable. The costs of this approach to dredging which will result in additional costs to the Project of more than A$200 million.

Other decisions made by the INPEX design team demonstrate how emissions and discharges will be minimised and how energy efficiency has been integrated into the design, such as the commitment to install an acid gas incinerator, selection of combined-cycle gas turbines, as well as recovery of waste heat both onshore and offshore. These are described in Chapter 4, *Project description* and Chapter 9 *Greenhouse gas management* of the Draft EIS and in Section 4.8 of this EIS Supplement.

4.12.3 ESD in decision-making

Chapter 6 *Risk assessment methodology* of the Draft EIS describes how risk assessment has been used systematically and from the early planning stages of the Project to address environmental, social and economic considerations, thereby demonstrating how "the integration principle" has been applied. The assessment of environmental risk is an essential component of INPEX's approach to the environmental impact assessment process. It also forms the basis for ongoing management and review of significant environmental and societal risks throughout the life of the Project. The outcomes from the risk assessment have and will continue to be used in the design, construction, commissioning, operations and decommissioning phases to ensure that all risks identified will be managed appropriately, with suitable additional controls being incorporated as the Project progresses.

Consultation and communication with a broad range of government, industry and community stakeholders is also a critical part of the decision-making process as outlined in Chapter 2 *Stakeholder consultation* of the Draft EIS.

A key example of where INPEX has addressed environmental, social and economic considerations in reaching a Project design decision is in the assessment of alternative jetty options as discussed in Section 4.4.2 of Chapter 4 *Project description* of the Draft EIS and Section 4.10.1 in this EIS Supplement. INPEX recognised at the early scoping stage of risk assessment that there were complex and competing environmental, social and technical issues associated with the selection of a short or a long jetty. In consultation with community stakeholders, a particular concern raised was that recreational fishing access should be maintained to Lightning and Cossack creeks adjacent to the west side of Blaydin Point. As a result, INPEX committed to investigation of jetty design concepts which could maintain safe public access to these creeks.

A detailed evaluation was undertaken with key advantages identified for the short-jetty option such as a reduction in risk to and from recreational vessels travelling into the jetty exclusion zone, a reduction in technical risk by increasing the separation between East Arm Wharf and vessel-berthing, a reduction in long-term visual impacts, and the elimination of the need for construction activities in close proximity to the World War II Catalina flying-boat wrecks. The disadvantage of the short-jetty concept is that larger dredge volumes are required to be removed in the shallower water closer to Blaydin Point. INPEX's assessment was that the temporary environmental disadvantages would be mitigated by the improved safety outcomes, protection of World War II heritage sites and decreased long-term visual impacts.

4.12.4 The precautionary principle

The precautionary principle, as defined in the EPBC Act (s.391(2)), is "… lack of full scientific certainty should not be used as a reason for postponing a measure to prevent degradation of the environment where there are threats of serious or irreversible damage". This section sets out how the precautionary principle has been included by INPEX in the assessment of potential environmental risks associated with Project activities.

As with all environmental assessments of this size and complexity it is not possible to state with full scientific certainty the exact nature of the impact that will occur. Early in the risk-assessment process, a high-level risk assessment and analysis is undertaken to identify and categorise significant activities during successive phases of the Project that would have environmental and social consequences. One of the key objectives of this early scoping phase is to identify uncertainties and any gaps in knowledge in order to direct the development of environmental studies and surveys and to influence Project design from an early stage.

These studies were performed by a range of environmental specialists engaged by INPEX and the scope of the studies was discussed and agreed with NRETAS through a two-day workshop in April 2008.

The outcome of the studies and surveys is presented in the Draft EIS and in the EIS Supplement demonstrating a sound understanding of the interaction between the various components of the Project and the receiving environment.

Wherever significant uncertainty, impact or risk has been identified, measures have been identified to minimise these uncertainties and risks. Uncertainties, for example in the sensitivity to disturbance of receiving ecological communities, have been addressed by adopting conservative assumptions and/or by undertaking detailed studies as to the nature and scope of the potential impact and by committing to additional reactive monitoring. Examples include:

Coral monitoring (Annexe 6 *Provisional dredging and dredge spoil disposal management plan* to Chapter 11 of the Draft EIS and Section 5 in this EIS Supplement). Sublethal assessment methods to assess health of corals at Channel Island will include water-quality monitoring and visual assessment by divers. This will allow for pre-mortality indicators to trigger further investigation and/or mitigation measures.

Mangrove sedimentation monitoring (Annexe 6 *Provisional dredging and dredge spoil disposal management plan* to Chapter 11 of the Draft EIS). Monitoring of both mangrove health and sedimentation levels will be undertaken throughout the dredging program. Real-time sedimentation levels will be compared with those levels predicted through modelling. Should monitoring indicate sedimentation levels accumulating at faster rates than predicted, INPEX will be able to consider appropriate strategies to ensure mangrove protection. Conservative sedimentation threshold levels have been set based largely on sudden deposition events rather than the slow accumulation that will occur during dredging activities.

Marine mammals (Section 4.1.13 of this EIS Supplement).

The key areas of uncertainty with potential to affect assessment of impact to marine mammals are considered to be:

- *Distribution and abundance*: The long-term distribution and abundance of marine mammal species in the area affected by the Project is uncertain. INPEX has responded to this uncertainty by; firstly, assuming that the marine mammal species identified by the Northern Territory Government surveys are present in Darwin Harbour on a year-round basis, and secondly initiating long-term studies to better define distribution and abundance.
- *Effect of blasting*: The effect of blasting on marine mammals is not precisely known. The best available data are drawn from of extrapolations of effect on terrestrial species and opportunistic samplings post marine blasting operations. This uncertainty has been addressed by, firstly, adopting conservative physiological tolerance levels derived from peer-reviewed literature, secondly, by including conservative assumptions in the preparation of the numerical model used to predict propagation of blast effects, and, thirdly by developing a management plan to avoid impacts from blasting that is consistent with national and international best practice.
- *Effect of underwater noise*: The effect of underwater noise on marine animals is drawn from a very limited number of direct studies and extrapolations from terrestrial mammalian physiology. As for blasting this uncertainty has been addressed by; firstly, adopting conservative physiological and behavioural tolerance levels derived from peer-reviewed literature and, secondly, by including conservative assumptions in preparation of the numerical model that was used to predict propagation of underwater noise. For piledriving, which has been assessed to be the most substantial noise source, a management plan to avoid impacts has been developed that is consistent with national and international best practice.
- *Secondary effect caused by reduction in prey or food availability*: The assessment of construction and operational activities has not indicated a risk of material reduction in abundance of species that would be preyed on, or foraged, by marine mammals. Therefore it is not considered likely that the potential reduction in prey or food availability would impact the marine mammal species in Darwin Harbour.

Where areas of uncertainty exist in the prediction of potential impacts to marine mammals, these uncertainties have been addressed by applying several levels of conservativeness in the assessment process. In addition, management measures put forward by INPEX for the avoidance and mitigation of risk are consistent with national and international best practice. The conclusion of the environmental assessment is that the risk of the proposed activities leading to a serious or irreversible impact to marine mammals of Darwin Harbour is slight.

In taking such conservative approaches given above, the likelihood of serious or irreversible damage would be remote, as early indications of potential impacts will be monitored and actions taken prior to any observable impact on biota. It therefore follows that the precautionary principle has been adequately addressed.

4.13 Cumulative impacts

4.13.1 Introduction

"Cumulative effects" include the impacts from existing projects and conditions, those of a proposed project or projects, and those of other developments that are realistically defined at the time of environmental impact assessment preparation and that would impact directly on a project's area of influence.

Expectations from the regulatory authorities, the community and other stakeholders for assessment of cumulative effects has increased in recent years and a number of proposed LNG projects have responded by including such assessments in their environmental impact assessment documentation.

This review describes how INPEX has incorporated the assessment of cumulative effects into the Ichthys Project's Draft EIS and provides reference to where further information is provided elsewhere in the EIS Supplement. It also assesses whether there are other projects that could have realistically been included in a cumulative impact assessment for the Project at the time of environmental assessment.

4.13.2 Legislation and industry practice

4.13.2.1 Environmental approval processes

The Project requires environmental assessment jointly under the Commonwealth's EPBC Act and the Northern Territory's EA Act. Both Acts assess impacts from actions on a project-by-project basis and approval solely relates to that individual action.

The EA Act does not explicitly provide for assessment of cumulative impacts. Rather, its purpose is to "ensure, to the greatest extent practicable, that each matter affecting the environment which is, in the opinion of the minister, a matter which could reasonably be considered to be capable of having a significant effect on the environment, is fully examined and taken into account".

Also, the EPBC Act does not use the potential for cumulative impacts on "matters of national environmental significance" as part of the determination of whether a Project is a controlled action or not:

"An action carried out by an individual which is not likely to have a significant impact on a [protected matter] will not require approval, even if the overall impact of a large number of individuals independently carrying out actions of the same kind may have a significant impact on the [protected matter]. The cumulative impacts of independent actions by different persons, all of which are below the significant impact threshold, are primarily to be addressed through State planning and land management legislation, and recovery plans"[10]

Although there is no specific requirement to address cumulative impacts within these Acts, decision-makers may consider the cumulative nature of the action being assessed to determine whether it is acceptable to approve the action, and what conditions may be appropriate. This has been reflected in the guidelines for development of the Ichthys Project's Draft EIS (see the Draft EIS's Technical Appendix 1) which state that cumulative effects should be discussed with specific reference to air dispersion modelling of current and future point sources and diffuse sources such as bushfires.

No guidance is provided by the Commonwealth or Northern Territory governments on how to conduct such an assessment.

4.13.2.2 Industry methods of cumulative impact assessment

Recently published environmental impact statements that have included a separate assessment on cumulative impacts include Prelude FLNG (Gas field northwest Western Australia), Wheatstone LNG (Onslow, Western Australia) and Australia Pacific LNG (Gladstone, Queensland). Below is a summary of the methods and level of detail within these other draft EISs.

Prelude FLNG

Prelude FLNG, a proposal for a 3.6-Mt/a floating LNG facility within the northern Browse Basin, is the closest currently proposed development to the Ichthys offshore facilities. The Draft EIS for the project was released for public comment in October 2009.

Prelude interprets cumulative impacts as the result of effects of an action associated with one project or activity combining with those of another. Prelude was required within its EIS guidelines to include cumulative effects within its draft EIS. Based on the following list of criteria, activities were identified for inclusion in an assessment of cumulative effects:

- Activities that already exist, or have a high degree of certainty of proceeding in the future, such as those under construction or for which approvals and budget have been obtained
- Conceptual activities, those with insufficient information and non-oil and gas related activities were excluded.

Since the Browse Basin is largely undeveloped, there was only a limited list of projects that fulfilled these criteria, one of which is the Ichthys Project. The Prelude EIS made a qualitative statement on the likelihood and type of cumulative impacts on a local and regional scale.

10 Explanatory Memorandum, Environmental Protection and Biodiversity Conservation Bill 1999 (Cth), paras [51], [61] and [79].

Wheatstone LNG

Wheatstone gas, a proposal for a 25-Mt/a LNG facility on the Pilbara coast, Western Australia, released its draft EIS for public comment in July 2010. Within the Commonwealth "Guidelines for the Content of a Draft Environmental Review and Management Programme/ Environmental Impact Statement" for the project, they were required to determine "how the action relates to any other actions (of which the proponent should be reasonable aware) that have been, or are being, taken or that have been approved in the region affected by the action".

From this, the Wheatstone EIS interpreted cumulative effects as those that will result from the proposed project when added to those of other past, present and reasonably foreseeable future actions.

Cumulative effects from project activities on environmental and social factors were included in the overall environmental impact assessment. Based on the following list of criteria, a series of projects for inclusion in the cumulative assessment were generated:

- It must be pre-existing, under construction or proceeding in the reasonably foreseeable future
- It must have aspects that may cause impacts on the same factor as those of the Project
- It must have sufficient information available to undertake a qualitative assessment.

Impacts from the list of identified projects were then discussed in a qualitative review of environmental and social factors except for air emissions and terrestrial footprint which were quantified. Each factor was discussed in turn with regard to the nature of the activities, the controls that will be in place and the predicted impact from the combined activities.

Australia Pacific LNG

Australia Pacific LNG is a proposed 18 Mt/a LNG plant to be constructed on Curtis Island in Gladstone, Queensland. It is one of four coal-seam-gas to LNG projects proposed for the area. The Draft EIS for the project was released for public comment in March 2010.

The terms of reference for the Australia Pacific LNG Project required that cumulative impacts be addressed from known, existing or proposed projects where details had been provided by the Department of Infrastructure and Planning (QLD). Particular focus was to be given to the cumulative impacts arising from LNG projects co-located on Curtis Island and the introduction of a large construction workforce.

Impacts from existing projects and conditions were incorporated into the overall impact assessment while cumulative impacts from potential future projects were included in a separate chapter within the draft EIS (Volume 1. Chapter 5. Cumulative impact assessment) and for each of the major components of the project: gas fields, pipelines and LNG plant.

Criteria for selection of projects for the cumulative assessment included:

- The project is within the Australia Pacific LNG project's area of potential influence
- The coordinator-general has declared the project significant, for which an EIS is required under the *State Development and Public Works Organisation Act 1971* and the *Environmental Protection Act 1994* or *Sustainable Planning Act 2009*.

The list of 30 projects which fulfilled these criteria were from resources, power generation, infrastructure and oil and gas sectors.

Each relevant environmental factor was assessed quantitatively where data availability allowed and qualitatively where not. Quantitative assessments included the following:

- total vegetation-clearing calculations
- greenhouse gas calculations
- brine discharge modelling
- air-quality modelling
- total greenhouse gas
- airborne noise modelling
- road-traffic modelling.

All other factors were assessed qualitatively including economic impacts and impacts from introduction of the construction workforce.

The dredging component of the Gladstone projects is currently being assessed separately through the Western Basin Dredging and Disposal Project EIS.

Summary of industry practice

From these three examples, the following general approach to cumulative assessment emerges:

- Assessment of cumulative impacts from project activities within impact assessment process while considering existing conditions
- Develop criteria for selection of future projects for inclusion in assessment
- Identify projects for inclusion in assessment
- Assess data availability for quantitative or qualitative assessment
- Undertaken cumulative impact assessment.

At the time of publishing the Draft EIS, INPEX assessed that there were no other significant proposed industrial development projects that were defined sufficiently to include within a cumulative assessment.

In order to review this position, an outline of the initial stages of such an assessment following the sequence as suggested above is provided here.

4.13.3 Review of cumulative effects addressed within the Ichthys Project's Draft EIS

This section provides a high-level overview of where the Draft EIS and this EIS Supplement have specifically addressed cumulative impacts.

Marine impacts and management

Offshore underwater noise impacts—Draft EIS Section 7.2.6 *Underwater noise emissions*

Underwater noise will be emitted from the offshore development area during the construction and operations phases of the Project. During the early stages of the Project, there is a potential for multiple sources (e.g. condensate tankers, support vessels and drilling vessels) to be operating simultaneously. The potential impact from these sources has been modelled for the prediction of potential noise impacts on marine animals.

Nearshore dredging activities—Draft EIS Section 7.3.2 *Dredging*

The preliminary dredging program in East Arm was divided into 10 phases, including a final 6-month post-dredging period. The nearshore pipeline dredging was also modelled as a discrete activity. Each phase was modelled separately and then added to the others to simulate the combined effect of the full dredging program.

Nearshore underwater noise impacts—Draft EIS Section 7.3.7 *Underwater noise and blast emissions, Subsection Cumulative impacts*

Noise generated by the Project will add to the existing periodic and transitory sounds contributing to ambient underwater noise in Darwin Harbour. The percentage contribution that the Ichthys Project will make during the operations phase to overall vessel movements within Darwin Harbour has been calculated along with a qualitative assessment of the Ichthys Project's contribution against existing conditions in order to predict impacts on marine animals.

(Chapter 7) Conclusion—Draft EIS Section 7.4.1. *Outcome of risk assessment*

In the conclusion to the offshore section, a brief statement is made that because of the remote location of the Ichthys Field, emissions and discharges are very unlikely to combine with those from other facilities and contribute to cumulative impacts. No equivalent summary of likelihood of cumulative impacts in the nearshore environment is provided.

Benthic habitat impact assessment—EIS Supplement Section 4.1.3 *Benthic habitat impact assessment*

Risk to benthic habitats and communities from a range of direct and indirect impacts associated with dredging and spoil disposal has been considered. Total areas of benthic marine communities and habitats to be potentially impacted from relevant construction activities and Project infrastructure, and the percentage these areas represent of individual habitats/communities in Darwin Harbour, provide a basis for assessment of potential impact to the trophic component of the Darwin Harbour ecosystem.

Water quality—EIS Supplement Section 4.1.14 *Nutrients in wastewater*

The potential contribution from the Ichthys Project to the net nutrient load in Darwin Harbour has been provided in this EIS Supplement. This measure provides an indication of the extent of any cumulative effect the Project may have on water quality when combined with diffuse and point source discharges.

Terrestrial impacts and management

Air-quality impacts—Draft EIS Section 8.4 *Air emissions*, Subsection 8.4.3 *Operations phase*

An assessment of the existing ambient air quality in the Darwin airshed was undertaken prior to consideration of the additional emissions from the Ichthys Project. Existing emissions sources incorporated into the model include Darwin LNG (up to approved case of 10Mt/a), the Channel Island Power Station, Weddell Power Station and existing shipping emissions, and biogenic emissions from vegetation and soil. Accounting for these various sources in the air-quality model therefore provides a cumulative assessment of the Project's impacts on the Darwin airshed. The technical report produced for this study (SKM 2009) was provided in Technical Appendix 19 to the Draft EIS.

Vegetation-clearing assessment—Draft EIS Section 8.3.1 *Vegetation-clearing*

The vegetation-clearing calculations given in the Draft EIS were based on the total land take for the onshore development area. Vegetation-clearing is set within a regional context by comparing total remaining hectares of each vegetation type within the Darwin Coastal Bioregion with the number of hectares to be cleared by the Project. In doing so, the Draft EIS assessed the cumulative impacts from Project related clearing and previous clearing activities.

(Chapter 8) Conclusion—Draft EIS Section 8.7.1 *Outcome of risk assessment*

The conclusion to Chapter 8 describes how cumulative impacts of the onshore component of the Project are associated with the potential for air-quality impacts during the operation of the onshore facility.

Socio-economic impacts and management

Road traffic impacts—Draft EIS Section 10.3.4 *Road traffic*

The Project's impact on existing traffic was assessed using an intersection evaluation software tool. Inputs into the tool included traffic from all Project activities, including supporting facilities such as the accommodation village, movements to and from a nominal quarry and landfill facility. Population growth predictions supplied by the Australian Bureau of Statistics were also used as a guide to predict future volumes of traffic on local roads, outside those generated by the Project.

Maritime traffic and navigation impacts—Draft EIS Section 10.3.5 *Maritime traffic and navigation*

Construction and operational marine traffic has again been set in the context of the existing traffic within Darwin Harbour. Percentage contributions to existing vessel numbers are given with a qualitative statement on the likelihood of impact. Also provided is a prediction that the Project's relative contribution to overall shipping activities will decrease over time as the Port expands its operations.

Airborne noise impacts—Draft EIS Section 10.3.10 *Airborne noise*

In order to assess the potential impacts of these noise sources upon the community, noise-propagation modelling was undertaken for the Draft EIS by SVT Engineering Consultants (SVT 2009). The modelling results were compared against the ambient noise measurements conducted for residential areas in Bayview Haven and Palmerston (presented in Chapter 3) as a "baseline" for noise levels experienced prior to development of the Project. This allowed an assessment of cumulative noise impacts from the Project in combination with existing noise from other sources.

(Chapter 10) Conclusion—Draft EIS Section 10.5.1 *Outcome of risk assessment*

The chapter conclusion gives a brief qualitative statement that potential factors that could impact cumulatively could be noise emissions from the onshore gas-processing plant, light and visual amenity. It then sets the potential impacts from these factors in the context of "several other industrial facilities" also operating in Darwin Harbour so as to limit the relative contribution of the Ichthys Project.

Cumulative impacts from supporting facilities

Cumulative impacts from supporting facilities for the Project were not included in the Draft EIS except for the cumulative impacts of road traffic from these facilities when combined with overall Project activities.

The approval for construction of the proposed Howard Springs accommodation village site has been dissociated from the rest of the Project. The reason for not including the construction of the accommodation village in the Draft EIS is that, at the time, the facility was expected to be required to be completed and available prior to commencement of works on Blaydin Point, and hence in advance of overall environmental approval. The assessment of the environmental and social impacts of the accommodation village is therefore being undertaken separately through an "exceptional development application" submitted to the Northern Territory Government under the requirements of the *Planning Act*.

The remaining facilities listed below are likely to be supplied by third parties, either through development of new facilities or by the use of existing sites. In each case, the facilities are not within the Project's area of influence for environmental assessment:

- quarries for supply of fill, rock and aggregate
- rock load-out and stockpiling area
- marine supply base
- tug harbour
- waste-disposal resources
- utilities corridors (outside the onshore development area footprint).

4.13.4 Identification of other projects

4.13.4.1 Criteria for selection of projects

Based on recently published environmental impact assessments undertaken for similar projects (APLNG, Wheatstone LNG, Prelude LNG) criteria applied to the identification of applicable projects for a cumulative impact assessment could include the following:

- Within the project's area of influence
- Referral made to the Commonwealth Government and Notice of Intent to Northern Territory Governments

- Activities that already exist or have a high degree of certainty of proceeding such as those under construction
- Sufficient information to reasonably and practically assess environmental and social impacts.

4.13.4.2 Identification of projects

Based on the criteria above, the following projects could be identified within the offshore and onshore environments.

Other projects in proximity of offshore field

The Ichthys Field is located within the northern Browse Basin about 200 km off Western Australia's Kimberley coast, at the western edge of the Timor Sea. It lies within the petroleum exploration permit area WA-285-P which is one of many title areas within the basin. A series of project development activities are occurring in the area.

The most advanced of these is the Prelude FLNG project which lies approximately 25–30 km to the north-east of the Ichthys Field. Further projects may be anticipated in the greater Browse Basin but no other projects fulfil the criteria above as being sufficiently defined at the time of publishing.

Other projects within Darwin Harbour

The Project's onshore processing plant is to be located on Blaydin Point in Darwin Harbour. A search for relevant projects within Darwin Harbour on the EPBC referral database and for "current projects" on the NRETAS web site gave the following results:

- EPBC referral 2010/5304. East Arm Wharf Expansion works (January 2010), Department of Planning and Infrastructure. A Notice of Intent has also been submitted to the Northern Territory Government (December 2009).
- EPBC referral 2010/5431. Shipping Channel Enhancement (April 2010). Darwin Port Corporation. Further documentation not currently available.
- EPBC referral 2005/2270. Expansion of the Olympic Dam copper, uranium, gold and silver mine, processing plant and associated infrastructure (August 2005). Draft EIS was released for public comment (July 2009).

4.13.4.3 Assessment of available information and likelihood of cumulative impacts

Prelude FLNG represents the only offshore project with documentation available at the time of publishing the Ichthys Project's Draft EIS. Impacts from Prelude FLNG were considered for potential cumulative effects in the Draft EIS but it was determined that they would be very unlikely because of the distances involved (25–30 km).

Activities described in the Olympic Dam draft EIS that could potentially combine with impacts from the Ichthys Project are limited to a potential increase in the number of road and vessel movements to and from East Arm Wharf. Road-traffic movements would be restricted to construction traffic associated with the minor expansion of the wharf facilities that would involve an additional 25–27 ship movements per year. This would average approximately one extra ship movement every two weeks. Cumulative impacts are therefore very unlikely from the combination of activities of the Ichthys and Olympic Dam Expansion projects.

Both the East Arm Wharf expansion and shipping-channel enhancement projects have initial documentation which gives an overview of proposed activities. Those activities that would have the potential to combine with impacts from the Ichthys Project involve the dredging of the shipping channel and the disposal of the dredge spoil. Options and ranges of activities have been given for the following:

- Extent of reclamation area: four areas have been identified for reclamation, volumes of dredge material required not defined.
- Volume of dredge spoil to be generated: from 0.5 to 13 Mt of dredge material.
- Type of dredge vessel: final option not determined.
- Option to use drill-and-blast techniques: not determined.
- Disposal method: not determined.
- Potential impacts on water quality: not determined.

Without greater definition on the above, the extent and impact of a cumulative impact when combined with Ichthys dredging cannot be assessed qualitatively or quantitatively.

4.13.5 Conclusion

The assessment of cumulative effects within the environmental impact assessment process is encouraged by the Northern Territory and Commonwealth governments. However, no direct guidance on how to conduct such an assessment is prescribed. This review has identified that although the Ichthys Project's Draft EIS does not have a separate section dedicated to "cumulative impact assessment", cumulative effects have been addressed where relevant through integration into assessment of individual environmental and social factors.

Discussion on cumulative effects from Project activities has been included in the Draft EIS and the EIS Supplement on the following topics: offshore and nearshore noise impacts, dredging impacts, nearshore water quality, air quality, marine navigation and road traffic. These topics were considered to represent a high enough risk to merit inclusion in the assessment.

Further, this review confirms the original INPEX position that, beyond the impacts already integrated into the Draft EIS, there were no other significant activities or projects proposed with a reasonable enough definition for INPEX to assess against at the time of publishing. For example, while the expansion or enhancement of East Arm Wharf and associated shipping channels is foreseeable, the extent and impact from the activities is not.

If additional projects were to be developed within the Project area of influence, each would be subject to their own separate environmental impact assessment process to determine their acceptability, or otherwise. As and when such projects become more defined, INPEX may need to work with proponents on review of combined impacts and management practices as appropriate.

4.14 Summary of design-change impacts

A summary of key Project design changes presented in this EIS Supplement, and the predicted positive or negative changes to environmental impact, is presented in Table 4-27:

Table 4-27: Summary of Project design changes and potential environmental impact

Project aspect	Design change	Environmental impact of change
Dredging	Reduced dredge depth, with reduction in under-keel clearance of 0.5 m.	Positive – less dredging volume of approximately 1 Mm^3; less volume of spoil for disposal; reduced period of dredging.
Marine blasting	Commitment to use alternative methods to marine blasting for the removal of Walker Shoal. A contingency of approximately 4 weeks for marine blasting is maintained should alternative methods be unable to completely remove all hard-rock material.	Positive – avoidance of blast impacts or substantially reduced blast duration.
Changes to onshore infrastructure	Relocation of key plant infrastructure (e.g. reorientation of LNG trains, change to flare pad footprint and wastewater treatment plant).	Negative – net additional plant footprint and vegetation impact of ~ 5 ha to accommodate enclosed elevated ground flares. Positive – improved noise and light mitigation from flaring during commissioning.
Relocation of manned facilities	Relocation of operations centre and the maintenance and warehouse facilities from the processing plant area to a location outside the plant boundaries; slight realignment of the gas export pipeline.	Negative – minor increase in area of mangrove impact (around 5 ha). Positive – protection of Aboriginal heritage sites which previously would have been disturbed.
Project traffic and rock transport requirements	Increase in rock and fill requirements.	Negative – increase in road traffic.
Operational noise	Noise levels may exceed 45 dB(A) in Palmerston during process upset flaring events a few times a year for a few minutes on each occasion.	Negative – short duration elevated noise above 45 dB(A) from operations.
Condensate export (onshore)	Increase in condensate export rate up to 20 000 barrels per day at Blaydin Point.	Negative – additional hydrocarbon liquids processed onshore (up from 15 000 barrels per day in the Draft EIS). This translates into a slight increase in potential spill risk.
Piledriving	More detailed scenarios for piledriving operations provided.	Negative – coincident multiple piledriving plant likely, with commensurate increase in noise impacts. Positive – reduced duration of piledriving operations.

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4 Supplementary Information to the Draft EIS

5 Draft EIS Public Review and Comment

5 DRAFT EIS PUBLIC REVIEW AND COMMENT

5.1 Summary of submissions received

The Draft EIS was released on 15 July 2010 for an 8-week public review and comment period. The official public review period concluded on Friday, 10 September 2010; INPEX, however, continued to accept submissions beyond this date.

A total of 1488 submissions were received, however the overwhelming majority (n = 1353 or 91%) of these were template submissions generated from the Australian Marine Conservation Society (AMCS) web site. These are considered a “petition submission” which warrant a single response to the common issues raised.

Of the 135 remaining submissions, 5 were categorised as invalid in that they did not provide relevant context or reference to the Draft EIS.

A record of submissions received and the relevant sections of this EIS Supplement in which issues raised are addressed is provided in Technical Appendix S1 in this EIS Supplement.

All submissions are cross-referenced to relevant sections of this EIS Supplement and an index for sourcing relevant responses is provided in Annexure 1.

Original copies of all submissions received by INPEX are available for viewing on the INPEX web site at <http://www.inpex.com.au/ichthys-draft-environmental-impact-statement/welcome.aspx> or on the enclosed CD.

5.2 Response to submissions

As the designated Operator of the Ichthys Gas Field Development Project, INPEX has prepared and responded to public comments on behalf of the joint venture partners in the Ichthys Gas Field Development Project.

Submissions received on the Draft EIS for the proposed Project identified a range of issues in relation to potential environmental, social and economic impacts of the Project.

A large number of comments were similar in nature or raised similar issues. To address these comments in an efficient manner, this EIS Supplement presents responses to comments in two forms:

- summary responses—which provide a brief response to comments similar in nature
- individual responses—which address individual comments that warranted a specific response because of the unique or detailed nature of the comment.

Issues raised within each submission have been coded according to submission number (see Technical Appendix S1) and the sequential number of the issue within the submission. For example, the sixth issue raised within the NRETAS submission (123) is coded as 123.06.

In responding to each comment INPEX has provided the most recent and accurate information available at this stage of the Project’s development. Summary responses to common issues raised are provided in section 5.2.1 and response to individual responses are provided in section 5.2.2.

5.2.1 Summary responses

The majority of the issues raised in submissions related to the following key areas:

- marine blasting
- dredging
- protected marine species
- underwater noise
- greenhouse gas emissions
- vegetation-clearing
- public safety
- environmental management plans
- environmental offsets
- oil-spill modelling.

INPEX has responded to these issues in summary form in Table 5-1. Additional detail in relation to these issues may be found in the relevant sections of the Draft EIS or are referenced in column 3 of Table 5-1 below.

Table 5-1: Summary responses to key issues

Summary issue	INPEX response	Reference for further information E = Draft EIS S= EIS Supplement
1. Marine blasting Many submissions referred to the potential negative impact of a 57-week-long underwater drill-and-blast program to remove Walker Shoal in Darwin Harbour.	INPEX has committed to using methods other than drilling and blasting for the removal of Walker Shoal. The methods proposed are to use a specialised cutter-suction dredger with sufficient power to remove the greater part, if not all, of the hard material and, if necessary, to employ a hydraulic hammer or drop chisel. As INPEX cannot be completely certain that these methods will be fully effective, it is considered appropriate that a fall-back option is maintained within the environmental assessment and subsequent approval for the Project for drill-and-blast methods to be employed for approximately 4 weeks. Should it become necessary to use drill-and-blast methods, INPEX will have best-practice procedures and a monitoring plan in place to reduce risks to marine animals to a level that is as low as reasonably practicable.	S3.3.8 S4.1.11
2. Dredging Some submissions expressed concern about the scale of dredging and the impacts dredging may have on marine environment aspects not discussed in the Draft EIS. Some respondents also queried the reliability of the dredge modelling presented in the Draft EIS.	INPEX has optimised the design of the shipping channel which has produced a lower dredge volume and decrease in associated residual environmental impacts. The original shipping channel design presented in the Draft EIS incorporated a dredge depth of 14 m below Lowest Astronomical Tide (LAT) to allow for safe navigation of the largest fully laden tanker. Further engineering and navigation studies (including navigation simulations) explored opportunities to reduce the dredge footprint and dredge spoil volumes and indicate that a reduction of 0.5 m in underkeel clearance will provide for sufficient vessel clearance. This 0.5 m reduction in overall dredge depth will result in a reduction in overall dredge volumes of approximately 1 Mm^3. This approximate 6% reduction in dredge volume represents a reduction in the volume of fine material entering the water column and is considered to further reduce the current residual risks of damage to benthic marine habitats in Darwin Harbour. Work has also been undertaken to map the benthic habitats and communities of Darwin Harbour and areas of Shoal Bay, Gunn Point and Adam Bay in considerably greater detail to quantify areas of dredge and dredge spoil impact and to provide further confidence in INPEX's assessment of residual risks to benthic communities and marine animals. To create a greater degree of confidence in INPEX's dredge modelling, additional information has been provided to explain INPEX's conservative approach to modelling and to the assumptions that underpin the models. The cumulative effect of these conservative assumptions means that dredge model outputs are highly likely to overestimate the predicted environmental impacts as presented in the Draft EIS.	S3.3.6 S4.1.1 S4.1.2 S4.1.3 S4.1.4 S4.1.5 S4.1.6 S4.1.7 Technical appendix S1 Technical appendix S4 Technical appendix S6
3. Protected Marine Species Some submissions pointed out areas in which INPEX could provide additional detail with regard to protected species known to inhabit Darwin Harbour.	INPEX has undertaken additional desktop research to provide further detail on the taxonomy, abundance, distribution and critical habitat for marine mammals in Darwin Harbour. Furthermore, INPEX has undertaken field surveys to improve the level of knowledge with regard to presence, absence, and distribution in broader areas of the Harbour.	S4.1.9 S4.1.10
4. Underwater noise The noise impact on marine animals from construction activities, particularly the drill-and-blast operations at Walker Shoal, is a matter of concern to some submitters.	The levels and characteristics of underwater noise that will occur during the construction phase of the Project have been the subject of detailed numerical modelling. The modelling completed has covered several different construction operations including dredging, piledriving and blasting. The results of this modelling are presented in this document along with a discussion of the potential risks to marine animals and the proposed management measures which will be required to reduce the risk to as low as reasonably practicable. Also refer to summary issue 1 above regarding marine blasting.	S4.1.11 E7.3.7 Technical Appendix 15 of Draft EIS

Summary issue	INPEX response	Reference for further information E = Draft EIS S= EIS Supplement
5. Greenhouse gas A number of submissions have suggested that INPEX do more to reduce greenhouse gas (GHG) emissions and offset some or all of the greenhouse gas emissions that remain.	INPEX has considered and included numerous best-practice energy-saving measures in its designs which will reduce GHG emissions. For example, INPEX has gone beyond normal industry practice and now considers combined-cycle power generation as the base case for electricity production at Blaydin Point. The Draft EIS assumed open-cycle power generation as the base case. Combined-cycle power generation uses less fuel and creates less GHG to generate the same amount of electricity as open-cycle power generation. INPEX has also designed a subsea power-sharing cable to optimise energy use between the central processing facility and floating production, storage and offtake facility. This also goes beyond normal industry practice for GHG reduction. INPEX has indicated to the Northern Territory Government that it would like to commit to two savannah fire-management projects; one in the Daly River and one in the Wagait areas in the Northern Territory, south-west of Darwin. Besides a range of environmental and socio-economic benefits, these projects will result in a reduction of GHG emissions from these areas. INPEX will also continue to evaluate large-scale abatement and offset options such as biosequestration and reinjection of reservoir CO_2. However, these options involve large capital investments that impact the cost of the Ichthys Project. Therefore these options can only be considered if a well-designed and nationally consistent regulatory framework for GHG emission reduction is implemented and the options can be demonstrated to be commercially viable.	E Chapter 9 S4.8
6. Vegetation-clearing A number of submissions expressed concern at the area of mangroves and monsoon vine forest to be cleared at Blaydin Point.	The onshore processing plant footprint and the areas of vegetation to be cleared have been revised since the publication of the Draft EIS to reflect design changes to the plant layout and the acquiring of additional information in regard to the distribution of the different vegetation communities. During detailed design of the onshore plant, opportunities to minimise the final vegetation-clearing footprint will be investigated. However construction and engineering constraints will prevent any significant reductions in the size of the onshore development area, owing to the requirements for laydown areas and the design need to maintain safe distances between hazardous and non-hazardous areas. The protection of areas of monsoon vine forest could also be incorporated in fire management programs within the Daly River and Wagait areas.	E 8.3 S4.4
7. Public safety A number of submissions questioned the impacts of the new facilities on public safety.	INPEX has already carried out extensive safety studies and risk reviews, and will continue to evaluate safety and risk as the Project design matures. The studies have considered and will continue to consider all Project infrastructure including the gas export pipeline, facilities at Blaydin Point, and Project-associated ship traffic. The objectives are to ensure the safety of the public and the Project's workforce, and to safeguard all Project facilities. Safety aspects of the design, construction and operation of LNG plant will be assessed by NT WorkSafe based on the provision of the facility's safety report. Acceptance of the facility's safety report is a statutory requirement that must be in place prior to commencement of operations at the site. Section 4.5.2 of this document contains additional safety information on shipping in Darwin Harbour.	E 10.3.14 S4.5

Summary issue	INPEX response	Reference for further information E = Draft EIS S= EIS Supplement
8. Environmental management plans A number of submissions questioned the level of detail provided in the (provisional) environmental management plans (EMPs) provided in the Draft EIS.	The Draft EIS stated clearly that the EMPs provided are provisional only, and that they will form the basis and framework for the development of the detailed EMPs that will be prepared as design, engineering and the award of contracts progresses. This is because many of the details to be included will be developed in conjunction with the contractors engaged to manage or implement particular activities. The provisional EMPs were produced to provide an outline of the core information required to develop the detailed EMPS, including management measures and controls along with specific objectives, targets and indicators. They are based on the potential impacts documented in the Draft EIS's Chapter 7 *Marine impacts and management*, Chapter 8 *Terrestrial impacts and management*, and Chapter 10 *Socio-economic impacts and management*. The final (statutorily compliant) EMPs will be developed with regulatory-authority approval prior to the commencement of Project activities. These finalised plans will be publicly available at the appropriate time prior to execution.	E 11.3
9. Environmental (biodiversity) offsets A number of submissions suggested the application of environmental offsets to the Project.	INPEX has commenced dialogue with the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) and with the Northern Territory Government to outline a process for the development of an environmental offsets package for any significant residual environmental impacts arising from the Project. Significant residual environmental impact can only be determined by government after the submission of the Final EIS, that is, the Draft EIS and this EIS Supplement taken together. In the interim, INPEX has made a number of voluntary environmental offset commitments which are outlined in Section 4.9. These include: • a commitment to funding and participation on the proposed integrated marine monitoring and research program for Darwin Harbour • funding Australian Research Council Linkage projects involving Darwin based scientists and institutions to (1) deliver a state-of-the art sediment transport model for Darwin Harbour estuaries; and (2) to develop rapid and sensitive impact assessment tools and a Darwin Harbour baseline using microbes • conducting research to improve understanding of coastal dolphin distribution, abundance and critical resource needs in Darwin Harbour • publishing extensive scientific data sets from studies on turtles, corals, cetaceans and terrestrial flora and fauna in the Kimberley region.	S4.9
10. Oil spill modelling Many submissions raise concerns regarding INPEX's oil spill modelling scenarios, oil spill contingency plans and the Montara and Macondo incidents. Scientific monitoring and equipment stockpiles were also areas where further clarification was sought.	INPEX has conducted additional oil-spill modelling for critical emergency situations including well blow-outs in the Ichthys Field and gas export pipeline ruptures in and around Darwin Harbour. With this additional modelling data as well as the findings of the Montara and Macondo inquiries available (Australian Government 2010; NCBPDH 2011), INPEX, in consultation with the rest of the upstream petroleum industry including the Australian Petroleum Production & Exploration Association Limited (APPEA) and the Australian Marine Oil Spill Centre (AMOSC), is making significant amendments to oil-spill preparedness and response arrangements.	S4.2

5.2.2 Responses to individual comments

5.2.2.1 Air quality and air-quality modelling

Submission 3-1: The proposed Inpex LNG plant would result in increased atmospheric nitrogen oxides, VOC's and ozone (Section 5.3) and lead to increased smog.

The ozone formed with smog is reported to exacerbate breathing problems for asthmatics.

Predicted ground-level concentrations of atmospheric pollutants and their associated potential effects (and significance) are discussed in Section 8.4 of Chapter 8 *Terrestrial impacts and management* of the Draft EIS. In Section 8.7 of the Draft EIS, INPEX concludes that the impacts of nitrogen oxide (NO_x) and VOC emissions and any ozone formed will be minimal. Predictive air-quality modelling conducted for the Project shows that after the addition of the emissions from the INPEX facilities, ground-level air quality in the Darwin region will remain well within the criteria prescribed in the National Environment Protection (Ambient Air Quality) Measure (NEPC 2003) at all times for NO_x, photochemical oxidants (as ozone (O_3)), and sulfur dioxide (SO_2).

Submission 123-158: Comments relevant to air emissions for the onshore phase are detailed in the Appendices section of this submission (Appendix 19).

See INPEX's responses to comments 123-233 through to 123-241 in this section and section 5.2.2.5. These responses answer the questions raised related to the Draft EIS's Technical Appendix 19 *Onshore air quality study*.

Submission 123-233: Information on the meteorological environment would have been enhanced by the inclusion of a discussion on dispersion meteorology. The reasons for specifically selecting meteorological data for 2005 should be explained. Is this year representative of average or worse-case meteorological conditions?

INPEX and its consultant Sinclair Knight Merz Limited (SKM) undertook a review of meteorological parameters for the Darwin region in 2007. Data available for the Bureau of Meteorology's Darwin International Airport site for the period 1997–2007 were analysed. This analysis determined that the data from 2005 were representative of the period 1997–2007 and that the year 2005 could be taken as representative of average meteorological conditions. As there are 365 × 24 = 8760 hourly data sets in a modelling year, a representative year is believed to capture many "worse than average" hourly periods.

Submission 123-234: (1) The approach taken for background air quality assessment was to model all existing sources of emissions for the airshed. This is considered a valid approach in the absence of extensive ambient air quality monitoring data (which could otherwise be used to characterise existing air quality). It would be appropriate, however, for INPEX to implement an ambient monitoring program to verify the modelling predictions. (2) NO2 emissions from soil relies on Darwin rainfall data. As the modeling domain is fairly large and tropical rainfall displays extreme spatial variability, additional rainfall station data should have been used.

INPEX intends to carry out ambient air-quality monitoring and plans to discuss details with the Northern Territory's Department of Natural Resources, Environment, the Arts and Sport (NRETAS) in the period leading up to the finalising of the conditions of an environment protection licence for the operation of the onshore processing plant at Blaydin Point.

INPEX agrees that the levels of natural nitrogen dioxide (NO_2) emissions from soil in the Darwin region and elsewhere (and which contribute to ground-level ozone production) depend on the amount of rainfall. INPEX also agrees that the modelling domain used is relatively large and that the tropical rainfall in the Darwin region does display considerable spatial variability. To accommodate this variability, a conservative estimate approach was used in the modelling assumptions.

Submission 123-235: The emission estimates from shipping are not clearly outlined or explained:

- Section 6.4.2 describes how the commercial shipping emission estimates were derived and provides emission factors for all pollutants and emissions summary for NO2, SO2 and VOCs (Table 6-18).
- Section 8.3.2 discusses shipping emissions for SO2 only; and
- Table 8-2 provides emission estimates from existing shipping for NO2 and SO2. Clarification is sought on what exactly was modelled. Clarify whether shipping was included in both the area-based emissions files and also as point sources for berthing in the harbour. The emission rates for berthing (Table 8-2) seem low and further information is requested on how these were derived.

In the Draft EIS's Technical Appendix 19 *Onshore air quality study* of the Draft EIS, the estimates of emissions from shipping are based on the following assumptions:

- The modelling incorporates only ship emissions at berths as point sources.
- The estimates take into account the current shipping movements in Darwin Harbour as well as an estimate of future shipping movements when the Ichthys Project becomes operational.
- The emission rate estimates take into account the nature, size and duration of each vessel's stay at its berth.

It should be noted that vessels use marine diesel and not bunker fuel during berthing and at berth. As there is some variability in the allowable sulfur content of marine diesel from country to country, and as vessels docking in Darwin may have taken on fuel in any one of several countries, an average sulfur content for marine diesel was used in the modelling.

Submission 123-236: Generally, the TAPM model used by INPEX is considered appropriate in the context of Darwin regional conditions and for a screening level assessment of photochemical smog formation (i.e. impacts from ground level ozone (O3)). However, the EIS should provide justification for the choice of TAPM V3 rather than the more recent version TAPM V4. Previous versions of the model over-predict winds in the lighter range and hence under-predict the resultant adverse air quality impacts. The potential impacts would be better simulated with V4.

INPEX's preliminary air quality modelling and assessment commenced during 2007 through the agency of Sinclair Knight Merz Pty Limited (SKM). The air-quality modelling used Version 3 of the three-dimensional modelling program TAPM as this was the newest available version of the program at the time the study commenced. An iterative process of scenario development and modelling was used during the engineering design process. Comparisons were made between various scenarios to assess the potential implications of various design changes. To ensure that the comparisons could continue to be made retrospectively as the Project progressed, SKM and INPEX decided not to employ Version 4 of TAPM when it became available in 2008.

Submission 123-237: The model setup as reported appears to be mostly adequate; however, (1) the pollution grid selected is probably too coarse to resolve local-scale impacts and (2) building downwash was not modelled, which has implications for near-field effects. The EIS needs to discuss these setup issues.

(3) The values in the list file attached as an appendix in SKMs report do not correspond to the values cited in the main body of the report (e.g pollution grid size, background RSMOG and FPM).

(4) It is not clear if observational data from the Darwin Bureau of Meteorology (BoM) site was incorporated into the modelling. The output list file provided in the report is for a pollution run with meteorological input from previously saved *.M3D files. It is generally considered that observational data can be included in TAPM meteorological modelling to improve model performance. Clarification is sought on whether this was done in this case.

(5) The EIS should describe how the buoyancy enhancement factors, presented in the output list file, were derived.

(6) The fraction of All Particulate Matter (APM) emitted as Fine Particulate Matter (FPM) of 0.5 is quite low for natural gas consumption and should be supported with some discussion or data to justify.

Random checks between the sources/source parameters in the list file and the report confirm that the correct sources/parameters were modelled (subject to the earlier concerns raised about the list file). However, the EIS should explain why the point source emission characteristics in the output *.lst file for source numbers 75 and 76 in the output file do not appear to match any source listed in the tables in the body of the report.

Limited model validation was performed in order to test the RSMOG value. (7) Explain why annual 2005 values were compared against measured values for Jan/Feb 2009 and May/June 2009. A better approach would have been to model for 2009 and compare appropriate modelled months against measurements, which would also have provided validation of the model.

1. The coarseness of the pollution grid is considered appropriate for assessing the potential contribution of the Ichthys Project's emissions to the ambient air quality of the Darwin region. Based on INPEX's assessment that the cumulative emission estimates beyond the boundary of the onshore processing plant at Blaydin Point are within acceptable limits, there is no demonstrated need to determine impacts at a finer scale.
2. Taking into account the proposed design and layout of the Ichthys Project's infrastructure in the vicinity of the significant discharge points, building downwash was not accommodated in the model in order to ensure that a conservative estimate of emissions was obtained beyond the processing-plant boundary.
3. An incorrect *.lis file was incorporated in Chapter 8 *Terrestrial impacts and management* of the Draft EIS. The correct *.lis file was used for modelling and was listed in the Draft EIS's Technical Appendix 19 *Onshore air quality study*, which was prepared by SKM.
4. Observational data from the Bureau of Meteorology (BOM) were not used in the modelling. The inclusion of observed data along with the generated data would have had the potential to introduce errors at the observed–predicted boundary, introducing a degree of uncertainty with the results.
5. Buoyancy enhancement factors for INPEX were not incorporated into the model in order to retain a conservative model and emission estimate. Based on the design and layout of the Project infrastructure in the near vicinity of the significant discharge points, retaining the default values of the buoyancy enhancement factors ensures that the modelled off-site estimates are a conservative overestimate.
6. All particulate matter (PM) in the modelling has been taken as being PM_{10} (particles smaller than 10 µm in diameter), and hence the modelling provides a conservative estimate.
7. Modelled 2005 values were not compared with 2009 measured values. INPEX's consultant SKM had concerns with the applicability of the biogenic emission calculations and the reactivity coefficient. To address these concerns, a passive sampling program was undertaken over the period January–June 2009. The monitored results were compared with the modelled results for this period. Based on the comparison, the reactivity coefficient was amended to reflect the findings.

Submission 123-239: The emission rates for the Channel Island Power Station differ from what was presented in the report for the Darwin LNG plant (Bechtel, 2001). The emission rates in Bechtel 2001 were taken from the EIS for the Channel Island Power Station whereas the draft EIS derived emissions using NPI emission factors and emission parameters obtained from the Northern Territory Power and Water Corporation. Explain why the emission rates in Bechtel 2001 are higher than those presented in this report (assuming the emissions are presented as NOx and not NO2).

INPEX's assessment was based on actual operational data for the Channel Island Power Station. The results presented in the Bechtel report (Bechtel Corporation 2001) are assumed or estimated figures determined prior to operations for the purpose of environmental assessment and hence are not actual operating values.

Submission 123-241: The contribution from bushfires has not been included in the assessment of background conditions. These can be significant sources of pollutant levels in the NT. During bushfire season, background concentrations, particularly particulates, can be very much higher than the criteria, often for several days at a time. This should be discussed further in the EIS.

Bushfire particulates are discussed in the Draft EIS in Section 8.4.3 of Chapter 8 *Terrestrial impacts and management*. While it is recognised that bushfires do have an impact on regional air quality, the complexity of modelling bushfires into the regional context would not be justifiable or meaningful.

Submission 128-10: Particulates: What are the effects of particulate matter generated from operations in the wet season or during extended periods of heavy cloud cover?

What is the extent and make up of pollution which occurs when processes and emissions vent through gas turbines when the incinerators are not operating?

Most of the emissions from the onshore processing plant will stem from combustion of gas in gas turbines and gas incinerators. Minimal particulate emissions are expected compared with facilities that might burn liquid fuels or coal. To the extent that particulates are emitted from the Blaydin Point site during the wet season, it is expected that rain and humidity will bring such particulates to ground more quickly than during the dry season.

The incinerators will be installed to combust the small amounts of hydrocarbons and hydrogen sulfide that will be co-exhausted with carbon dioxide and water from the acid gas removal units. When it is necessary to bypass one of the two incinerators (one on each LNG train) for maintenance purposes, then the small amounts of hydrocarbon and hydrogen sulfide will instead be vented to atmosphere. This will be done through 65-m-tall turbine exhaust stacks at high temperature to ensure that there is good dispersion of the small amounts of hydrocarbon and hydrogen sulfide.

Submission 128-24: Air Emissions. The National Environment Protection Measures Ambient Air Quality (NEPM) does not take into account the cumulative impacts on air quality in a particular air shed. Therefore it would not address additional point and diffuse sources of air pollution, particularly in the dry when air quality is mostly compromised by smoke from bush fires.

It is also noted that NEPM will be exceeded in some instances.

The impacts of these larger amounts and the cumulative effects on the air quality over Darwin, particularly in the dry season and during extended periods of overcast days in the wet, need to be thoroughly monitored.

The air-modelling work carried out for the Draft EIS included emissions from existing operations such as the Channel Island Power Station and the ConocoPhillips Darwin Liquid Natural Gas plant, assuming production at 10 Mt/a. The Blaydin Point plant will emit very low levels of particulates, hence will not contribute significantly to background particulate levels during the bushfire season.

INPEX will undertake ambient air quality monitoring during the operations phase. This monitoring may include sampling for particulates during the wet season and/or the dry season.

Submission 128-37: Annex 2 – Provisional Air Emissions Management Plan

Diffuse air quality monitoring should go beyond the NT Government's proposed Darwin Airport monitoring station. This location would only provide relevant air quality data during the dry season. Yet in the wet season the prevailing winds tend to blow from west to east.

Stack emissions should be monitored continually in order to identify potential issues before they become a problem. Periodic monitoring would not instil a sense of confidence with the community.

INPEX will undertake ambient air quality monitoring during the operations phase. This monitoring may include sampling for particulates during the wet season and/or the dry season, at the most meaningful locations to the east and west, depending on seasonal wind directions.

INPEX does not agree that stacks should be sampled continuously. The turbines and incinerators will burn essentially the same fuel sources for the projected 40-year operating life of the plant. Stack sampling on a frequency basis that will be decided in negotiations with the Department of Natural Resources, Environment, the Arts and Sport (NRETAS) for the environment protection licence will provide consistent emission data.

5.2.2.2 Alternatives

Submission 1-84: PART III Question 8 Has INPEX considered an alternative LNG Platform location off-shore for loading of LNG once liquefied by an Onshore train at Cox Peninsula or Tiwi Islands (ex Matilda Minerals port operations could be utilised and provide revenue and employment for Islanders?

INPEX did not consider placing its onshore processing plant on Cox Peninsula or the Tiwi Islands, nor having an offshore LNG loading platform. The Northern Territory Government proposed the Blaydin Point site, zoned for industrial development, as the preferred site for the development of the onshore components of the Ichthys Gas Field Development Project. The location is on Middle Arm Peninsula, where there is an existing LNG facility—ConocoPhillips' Darwin LNG plant.

Submissions 8-6, 13-3: Develop an alternative shipping channel in Darwin Harbour that avoids blasting Walker Shoal.

Submission 16-21, 20-6, 36-5, 89-21, 101-22, 102-20: Move the shipping channel either south or north of Walker Shoal to avoid the need for blasting (noting that moving the channel south will require relocation of the Kelat shipwreck.)

Submission 26-1, 27-1, 28-1, 30-1, 38-1, 39-1, 41-3, 44-1, 45-1, 46-1, 47-2, 49-1, 50-1, 52-2, 55-5, 56-1, 57-1, 58-4, 60-1, 62-1, 64-2, 64-6, 70-1, 75-2, 76-1, 79-1, 80-2, 88-2, 90-1, 91-1, 92-5, 114-1, 115-1: Change the course of its shipping channel to avoid blasting Darwin's dolphins, build a longer jetty to cut the volume of dredging

Submission 54-1: It seems to me that the proposal to blast the rock bar in Darwin Harbor is completely unnecessary and needlessly endangers marine life, specifically dolphins and dugongs. Is there another path that the shipping channel could be created on so that less blasting, and therefore lessen potential damage.

Submission 67-2: I am a Darwin resident and I am horiffied at the proposed distruction the of my local marine environment. There is an alternative route for the shipping channel and I expect that to be developed as opposed to destroying our marine ecosystem.

Submission 84-3: The Environment Centre NT has also identified alternative routes for ships (should the plant really need to be established in the current proposed site) which would require less (if any) blasting and therefore have a lot less impact. Could Inpex please provide reasons why the most destructive route should be chosen?

Submission 86-2: Walker Shoal Removal – on page183 of the EIS the proponent advises that it is examining alternatives but is yet to determine whether there is a viable option to blasting. The NTG encourages the proponent to finalise this analysis as early as possible so that the least impact process can be adopted.

Submission 92-1: INPEX should take off the table the option of blasting water shoal and find an alternative channel route either south or north of the shoal that avoids blasting. This is the only way they can ensure the dolphins, turtles and fish in the Darwin Harbour are protected.

Submission 92-2: A long jetty option and a shipping channel south or north of Walker shoal will protect marine wildlife and reduce dredging.

Submission 93-9: 1. The destruction/removal of Walkers Shoal and the explosive requirement to undertake this activity. There is a belief that an alternative solution must exist and that the impact of the removal of this shoal will cause considerable negative impact on wildlife.

Submission 111-1: I wish to register my concern about the proposed Inpex Development. Specifically my concern relates to the blasting and dredging that is proposed both for the broader Darwin Harbour and specifically for Walker Shoal (Inpex proposal Ref: 7.3.7). Whilst I am not totally opposed to the development and up understand the need for further industry and opportunity for Darwin I do wish to register my concern about protecting the integrity of Darwin Harbour, its marine life and the local environment. In relation to Walker Shoal it is requested that the alternate proposal to move the site further south is considered. Alternately to extend the wharf further into the harbour may project the integrity of the harbour.

Submission 117-5: 1. Agreeing to change the course of it's shipping channel

Submission 124-2: Blasting of Walker Shoal. Recommendations: Move the shipping channel to either north or south of Walker Shoal to avoid (or significantly reduce) blasting.

Submission 124-36: A less acceptable alternative option, but better than that proposed in the Draft EIS, is to construct the shipping channel from Blaydin Point to either north or south of Walker Shoal to avoid (or significantly reduce) blasting. Moving the shipping channel northwards would enable LNG tankers to access the existing shipping channel past Darwin CBD and into East Arm Wharf. Alternatively, dredging the shipping channel south of Walker Shoal is feasible, and would provide a more direct path from Blaydin Point to connect to the existing shipping channel from Darwin CBD to East Arm Wharf. Such an option, particularly if coupled with building a much longer jetty (see dredging section) would require the relocation, in part or full, of the heritage listed shipwreck the Kelat. We understand relocating the shipwreck is possible whilst it remains a heritage listed object. Engineering assessments are required as to the feasibility of relocating the Kelat. Additional dredge volumes from digging the shipping channel through shallower sediments on the southern and western side of Walker Shoal would be offset by extending the jetty into deeper water (see below).

INPEX has assessed alternative shipping channel options within Darwin Harbour. Section 4.10 of this EIS Supplement provides detailed analyses for each of these options. In summary, the alternative options would require increased dredge volumes and do not eliminate the need for hard-rock removal as a seam of hard rock extends southward from Walker Shoal. Improved understanding of the geological characteristics of these hard-rock areas (derived from geotechnical investigations) and new information on alternative rock-removal techniques, have however provided INPEX with confidence that most, if not all, of the hard-rock areas within the shipping channel can be removed without the need for a drilling and blasting program. Further details on the options for the removal of hard rock are provided in Section 3.3.9 of this EIS Supplement.

Submission 8-7, 13-4: Drop the short wharf proposal and investigate alternatives to cut dredge volumes and minimize risks to sensitive habitats.

Submission 16-22, 20-7, 36-6, 89-22, 96-21, 101-23, 102-21: Re-examine the long jetty option.

Submission 74-1: 1. Explore all options to minimise the amount of disturbance required to achieve a shipping channel, specifically to avoid a route through Walker shoals.

Submission 110-11: Failing that, I urge Inpex to adopt the 'long Jetty' option ahead of the higher impact 'short jetty' option.

Submission 117-6: 2. Building a longer jetty to cut the volume of dredging

Submission 26-1, 27-1, 28-1, 30-1, 38-1, 39-1, 41-3, 44-1, 45-1, 46-1, 47-2, 49-1, 50-1, 52-2, 55-5, 56-1, 57-1, 58-4, 60-1, 62-1, 64-2, 64-6, 70-1, 75-2, 76-1, 79-1, 80-2, 88-2, 90-1, 91-1, 92-5, 114-1, 115-1: Change the course of its shipping channel to avoid blasting Darwin's dolphins, build a longer jetty to cut the volume of dredging.

Submission 124-36: A less acceptable alternative option, but better than that proposed in the Draft EIS, is to construct the shipping channel from Blaydin Point to either north or south of Walker Shoal to avoid (or significantly reduce) blasting. Moving the shipping channel northwards would enable LNG tankers to access the existing shipping channel past Darwin CBD and into East Arm Wharf. Alternatively, dredging the shipping channel south of Walker Shoal is feasible, and would provide a more direct path from Blaydin Point to connect to the existing shipping channel from Darwin CBD to East Arm Wharf. Such an option, particularly if coupled with building a much longer jetty (see dredging section) would require the relocation, in part or full, of the heritage listed shipwreck the Kelat. We understand relocating the shipwreck is possible whilst it remains a heritage listed object. Engineering assessments are required as to the feasibility of relocating the Kelat. Additional dredge volumes from digging the shipping channel through shallower sediments on the southern and western side of Walker Shoal would be offset by extending the jetty into deeper water (see below).

INPEX undertook a detailed evaluation of the short-jetty and long-jetty concepts before selecting the short jetty as the better option for the Ichthys Project. The evaluation included environmental, social and technical considerations. The advantages and disadvantages of the short jetty and long-jetty concepts are provided in Section 4.4.2 in Chapter 4 *Project Description* of the Draft EIS. Additional information on the jetty selection process is provided in Section 4.10 of this EIS Supplement. The primary consideration in the design of the preliminary dredging program has been the need to ensure that the environmental impact of the dredging operations in Darwin Harbour will be kept as low as reasonably practicable.

INPEX has assessed alternative shipping channel options within Darwin Harbour. Section 4.10 of this EIS Supplement provides detailed analyses for each of these options. In summary, the alternative options would require increased dredge volumes and do not eliminate the need for hard-rock removal as a seam of hard rock extends southward from Walker Shoal. Improved understanding of the geological characteristics of these hard-rock areas (derived from geotechnical investigations) and new information on alternative rock-removal techniques, have however provided INPEX with confidence that most, if not all, of the hard-rock areas within the shipping channel can be removed without the need for a drilling and blasting program. Further details on the options for the removal of hard rock are provided in Section 3.3.9 of this EIS Supplement.

Submission 20-1: I am particularly concerned with the proposed blasting of Walker Shoal. It appears that a high impact option is being considered when other less damaging options may exist.

Submission 126-1: There are alternative sites I gather that would negate the need tor thi s time consuming, dangerous and environmentally damaging option, so I would urge IMPEX to abandon this extremely controversial part of the development. There is talk oflegal action if this option is pursued and I'm sure the company would want to avoid such an outcome if possible and maintain good community relations with the people of Darwin .

INPEX advised in Section 4.4.4 in Chapter 4 *Project description* of the Draft EIS that alternative techniques to drilling and blasting were to be investigated for removing hard-rock material within the shipping channel. At the time of publication of the Draft EIS it was not possible to confirm whether there were any viable alternatives to drilling and blasting. Improved understanding of the geological characteristics of these hard-rock areas (derived from geotechnical investigations) and new information on alternative rock-removal techniques, have however provided INPEX with confidence that most, if not all, of the hard-rock areas within the shipping channel can be removed without the need for a drilling and blasting program. Further details on the options for the removal of hard rock are provided in Section 3.3.9 of this EIS Supplement.

Submission 20-8: Blasting should be graded near the highest level of risk to the natural heritage of Darwin Harbour. All other options should be considered first and serious consideration be given to moving shipwrecks of limited heritage value or losing access to Catalina Creeks. As a local amateur fisherman I believe this would be a preferred option to blasting.

The design of the product loading jetty and the shipping channel required to take into account a number of competing environmental, social and technical considerations. Section 4.10 of this EIS Supplement provides detailed consideration on each of the alternative shipping-channel options considered. In summary, the alternative options would require increased dredge volumes and do not remove the need for rock removal as a hard-rock seam extends southward from Walker Shoal. Improved understanding of the geological characteristics of these hard-rock areas (derived from geotechnical investigations) and new information on alternative rock-removal techniques, have however provided INPEX with confidence that most, if not all, of the hard-rock areas within the shipping channel can be removed without the need for a drilling and blasting program. Further details on the options for the removal of hard rock are provided in Section 3.3.9 of this EIS Supplement.

Submission 83-2: There are other ways of dealing with the situation there, like using smaller ships and using the right tides to go out and into the harbour.

Dredging depths are determined by allowing safe under keel clearance (based on Project-specific navigation studies and internationally recognised navigations standards) at all stages of the tide for all types of tankers. The largest tankers will have a fully laden draught of approximately 12 m.

Submission 86-1: Jetty Options – the guidelines require the proponent to provide detailed reasons for the selection/rejection of particular options. More detailed information on the relative advantages and disadvantages of the short/long jetty options would assist in evaluating the preferred option choice.

Additional information on the jetty concept selection process is provided in Section 4.10 of this EIS Supplement.

Submission 98-4: Short-jetty Vs Long-jetty. Chapter 4 Project Description, 4.4.2 pg 179. Of the two options the Long-jetty has some long-term advantages:

- Less dredge material needs to be removed in the development stage and during maintenance dredging,
- Less material needs to be removed for wharf upgrades to accommodate larger tankers in the future.
- Multiple loading facilities may be incorporate in the future.
- Because recreational fishers will be excluded from Lightning and Cossack creeks, these mangroves become Marine Protected Areas, Conservation Reserves and nurseries for the fish and crabs of Darwin Harbour.

These benefits and others were not presented in the Draft EIS.

INPEX undertook a detailed evaluation of the short-jetty and long-jetty concepts before selecting the short jetty as the better option for the Project. The evaluation included environmental, social, safety and technical considerations. The advantages and disadvantages of the short-jetty and long-jetty concepts are provided in Section 4.4.2 of Chapter 4: Project Description within the Draft EIS. Additional information on the jetty selection process is provided in Section 4.10 of this EIS Supplement. The primary consideration in the design of the preliminary dredging program has been the need to ensure that the environmental impact of the dredging operations in Darwin Harbour will be kept as low as reasonably practicable. In order to reduce the environmental impacts associated with dredging, INPEX has committed to a best practice dredging methodology at significantly greater costs.

The likely frequency of maintenance dredging and the potential volumes required to be removed are described in Section 4.4.5 of Chapter 4: Project Description of the Draft EIS. As maintenance dredging is only anticipated to be required once per decade and volumes are comparatively low, INPEX does not see that this would be a significant discriminating factor for jetty-concepts.

INPEX has no plans for additional channel deepening to accommodate larger tankers.

INPEX has no current plans for expanding the number of jetty berths. Any future expansion of the Ichthys Gas Development Project would be subject to further environmental approval.

The creation of marine protected areas and conservation reserves within Darwin Harbour is the responsibility of the Northern Territory Government. Neither a long-jetty or short-jetty option precludes the establishment of marine protected areas in Cossack Creek or Lightning Creek should this be determined as a desirable option in the future.

Submission 100-14: WWF recommends that the EIS be required to be revised to include a full consideration of alternate shipping channel locations, routes and jetty configurations that would substantially reduce the amount of dredging or blasting required, as well as the proponents be required to substantially revise and produce more accurate, up to date and more accurately referenced assessment of marine impacts and management, including on primary data on the distribution of coastal dolphin species in Darwin Harbour to more accurately inform development options and management and impact assessment planning.

See the INPEX responses under comment 8-6 to address the first part of this comment.

Additional information on potential marine impacts is addressed in Section 4.1 of this EIS Supplement.

Preliminary data on the distribution and abundance of coastal dolphin species in Darwin Harbour have been sourced from the Northern Territory Government which in collaboration with WWF-Australia and other funding partners have undertaken a 2-year survey for coastal dolphins over selected areas within the Harbour. INPEX has recently initiated a coastal dolphin survey in Middle Arm and West Arm of the Harbour to acquire data on distribution and abundance. This is a significant area of the Harbour which has not yet been surveyed and it has the potential to be utilised by coastal dolphins for foraging activities. Preliminary findings from this study are included in Section 4.1.9 of this EIS Supplement. INPEX has also indicated that the provision of funding to government or carrying out direct complementary research to improve the understanding of coastal dolphin abundance, distribution and critical resource needs in Darwin Harbour, may be a suitable offset.

Submission 100-20: 3. Inadequate and incomplete assessment of the direct and indirect impacts of blasting Walker Shoal for the shipping channel (Chapter 7 and Chapter 11 Annex) and inadequate exploration of alternative channel and jetty options.

The EIS recognizes that the blasting of Walker Shoal at the entrance to the shipping channel 'has the potential to disturb, injure or even kill dolphins'. This confined blasting is predicted to continue up to 57 weeks, 3 times daily and around six 50Kg charges and yet it is still ranked low–medium risk. A population viability assessment of snubfin dolphins in Cleveland Bay, Queensland, suggests that the removal of just three dolphins per annum from the population could lead to their localised extinction (Parra et al., 2006). Given that only 33 Snubfin dolphins have been observed in Darwin Harbour to date, the loss of just one or two dolphins could pose an even greater impact/ significant risk to the survival of the local population of this EPBC listed species.

On page 35 EIS states that 'Alternative techniques to drilling and blasting are being investigated for the removal of the hard rock material within the shipping channel. At this stage, it is not possible to confirm whether there are any viable alternatives.' WWF-Australia believes that the EIS needs to be revised to include full assessment and provision of alternative options.

WWF recommends all alternatives to blasting Walker Shoal need to be fully explored, for particular consideration to be given to moving the shipping channel either south or north of Walker Shoal to avoid the need for blasting and to re-examine the long jetty option. WWF considers the description and assessment of a full range of alternatives to one of the most important elements of EIA practise, and where some of the most useful and meaningful mitigation decisions can be taken. We urge the proponent and government to revise this EIS so that it provides the full range of alternatives, and relevant risk assessments.

Additional information on the potential impacts of blasting at Walker Shoal is provided in Section 4.1.11 of this EIS Supplement.

INPEX's responses to comment 8-6 address alternative shipping channel and jetty options.

INPEX has committed to implementing visual observation procedures within the fauna protection zones around blasting areas (should blasting be required) to minimise the potential for impacts on coastal dolphins and other large marine fauna. INPEX has also initiated studies to investigate additional protection methods including passive acoustic monitoring, active acoustic monitoring and active acoustic disturbance measures. The most effective methods for protecting coastal dolphins and other large marine animals will be implemented, ensuring that any blasting activities in Darwin Harbour will constitute demonstrably best practice. A summary of the findings to date on the investigations of complementary detection methods is provided in Section 4.1.9 of this EIS Supplement.

INPEX also indicated in the Draft EIS that it was exploring alternatives to a drilling and blasting program. See Section 3.3.8 of this EIS Supplement for an account of progress on this issue.

The risk ranking for the potential impacts on the snubfin dolphins shows that only a small portion of the broader population which extends from Broome in north-west Western Australia to Brisbane in southern Queensland is potentially exposed to the risk and that INPEX's proposed management controls will be effective in further reducing the risk. In addition, information collected by the Northern Territory Government (Palmer 2010a) indicates that snubfin dolphins are infrequently seen in the Walker Shoal area.

Submission 101-1: Blasting, dredging and the long jetty option. I find it offensive that the small but noisy fishing lobby has been able to influence the design of the project by demanding that access to particular fishing spots – the Catalina Creeks – be maintained at all costs.

Source: http://fishingterritory.com/afant-f10267/afant-s-submission-on-inpex-eis-t23430.html, viewed 10 September 2010

According to figures quoted by the Amateur Fishermans Association of the Northern Territory (AFANT) at the above address, 68% of the non-Indigenous population do not fish and 2 in 3 households do not own boats. It is therefore clear that there are twice as many people who are not interested in fishing than those who are. It is also clear that the AFANT membership will be happy to reap the economic benefits of this project, provided it does not inconvenience them in any way. This is a totally unacceptable position. It is likely that we will all receive some economic benefit from this project whether we support it or not, so we must all accept the consequences. For those of us who are concerned about the environment, the cost of this project will be having to watch the destruction of 66 ha of regionally-significant monsoon vine forest and 83 ha of mangrove communities, as well as the increased pollution of Darwin Harbour. If the AFANT have to give up some of their fishing spots, so be it. The key driver for the design of the INPEX project should be to minimize harm to the environment. If the environment is protected, we will all benefit. The long jetty option should therefore be re considered.

While it is appropriate for social considerations to be taken into account in determining impact mitigation options for a development project, the key considerations in determining the design of the Ichthys Project's product loading jetty are outlined in Section 4.4.2 of Chapter 4 *Project description* of the Draft EIS and are updated in Section 4.10 of this EIS Supplement.

Submission 120-14: We would prefer to see some serious consideration of uses of as much of the dredge spoil as possible rather than simply dumping it. We understand that much of the fine sediment in Darwin Harbour is unsuitable for use but any sand, gravel and rock should be utilised if at all possible.

Submission 122-4: Alternative dredging options may reduce this impact, together with further consideration for a longer jetty. DHAC notes that INPEX has engaged Dr Kristin Metcalfe to provide advice on mangrove rehabilitation and general mangrove health which is very encouraging.

Submission 122-5: Dredging in Darwin Harbour: Further, DHAC would like to see land-based disposal of dredge spoil seriously considered as a viable option to sea disposal. It is acknowledged that there would be issues with site selection, acid sulfate sediments, salt content and drainage, but believes it is worth exploring.

Submission 130-29: Despite the many alternative locations examined, there remain significant environmental problems associated with the proposed offshore spoil disposal – particularly because the entire spoil dump can be mobilized by effects from an intense TC tracking in (not necessarily very close) proximity to the spoil site. For this reason, AMSTECI consider that the proponent should use established engineering techniques to construct and manage onshore spoil disposal sites.

The bulk of the dredged material will be made up of fines and plasticky clayey soil. As a result, it will be unsuitable as fill. There are limited areas of sandy substrate throughout the proposed shipping channel and it is expected that these sands would be thoroughly mixed with the predominantly clayey material to form a predominantly clayey dredged spoil. It is not practical to separate the small quantities of sands from other soils in the dredge discharge as an area in the order of 100 ha would have to be set aside to store the fines which would separate from the sands. There are no sites of this size available on the Ichthys Project site. Furthermore, there are few adequate long-term disposal or treatment methods for these fines once they have been separated out from the suitable fill material.

Submission 120-20: We note that "consideration will be given to relocating rock removed from Walker Shoal within the Harbour" (Draft EIS p. 306) but our view is that as much of this rock as possible should be put to meaningful use and this should be an integral part of the rock removal program. Any rock that might provide suitable underwater structure useful for fish aggregation and artificial reef habitat should be deployed to suitable locations within Darwin Harbour and in nearby waters. A number of such sites currently exist including the Song Saigon/John Holland Barge/ Medkhanun reef complex inside the harbour, the area of artificial reefs near Lee Point and the area of artificial reefs at Fenton Patches.

INPEX and its contractors will work with community and government stakeholders to identify options for rock emplacement to create fish aggregation areas and artificial reef habitats. Material recovered from Walker Shoal will, however, first need to be assessed for its suitability for in-Harbour placement.

Submission 122-2: Drill and Blasting (p 357 +): DHAC strongly recommends that alternative options to reduce the length of time proposed for blasting be explored and adopted, or ideally alternatives to blasting are explored including moving the Kelat and/or the Catalinas.

INPEX has committed to using methods other than drilling and blasting for the removal of Walker Shoal. The methods proposed are use of a specialised cutter-suction dredger with sufficient power to remove the greater part, if not all, of the hard material and if necessary, the employment of a hydraulic hammer or drop chisel. As INPEX cannot be completely certain that these methods will be fully effective, it is considered appropriate that a fallback option is maintained within the environmental assessment and subsequent approval for the Project for drill-and-blast methods to be employed for approximately 4 weeks. Should it become necessary to use drill-and-blast methods, INPEX will have best-practice procedures and a monitoring plan in place to reduce risks to marine animals to a level that is as low as reasonably practicable. A progress update on marine mammal detection methods is provided in Section 4.1.12 of this EIS Supplement. Further details on the drill and blast alternatives are provided in Section 3.3.8 of this EIS Supplement.

Submission 123-11: Discussion of alternatives and reason for discounting not apparent.

The Executive Summary contains only an abbreviated version of information contained within the main volumes of the Draft EIS. Further information on alternatives is included in Chapter 4 *Project description* of the Draft EIS. Additional information on shipping channel alternatives is included within Section 4.10 of this EIS Supplement.

Submission 123-80: The EIS Guidelines (p12 section 5 alternatives) state: "Alternative proposals must be discussed, including detailed reasons for the selection and rejection of particular options…" Further discussion of and reasons for discounting of alternatives should be addressed in the EIS for: • Long jetty vs short jetty; • Not removing Walker shoal; • Non-blasting methods to remove Walker shoal; • Alternative dredge spoil locations; • Construction of causeway to Middle Arm Point; • Alternative shipping channels; and • Onshore reuse of dredge spoil. Statements should be backed up with documented evidence.

Further information on the selection process for the Project's jetty selection is provided in Section 4.10.2 in this EIS Supplement and details on the alternative shipping channels are provided in Section 4.10.1. The assessment of alternative, non-blasting methods for removing Walker Shoal is provided in Section 3.3.8 and as indicated in Section 3.3.8, INPEX has committed to removing Walker Shoal using non-explosive methods. INPEX does not believe that leaving Walker Shoal in place is a realistic alternative, due to the navigational safety risks it poses to shipping. Alternative spoil disposal grounds were considered in the Draft EIS (Chapter 4, Section 4.4.6 and in Technical Appendix 4) and the process for site selection, including the consultation which took place with key stakeholders is summarised within this section. Onshore reuse of dredge spoil is addressed in Section 4.4 of the Draft EIS. No alternatives are posed for the construction of the short section of road between Middle Arm and Blaydin Point. The Draft EIS commits to constructing this road with sufficient culverts to ensure that water flows across the salt flat during high spring tides are uninterrupted. This form of design is common place in road construction in such areas. The road constructed across the Middle Arm – Blaydin Point salt flat by INPEX in April 2008, to facilitate access for geotechnical surveys, incorporated culverts and these have functioned effectively with no negative impacts observed on the mangrove community adjoining the road.

Submission 124-19: Another general concern is that the Draft EIS addresses Project alternatives in limited detail. We believe that matters such as pipeline routes, onshore site-selection, infrastructure layout, blasting of Walker Shoal, short jetty versus long jetty options, and dredge spoil disposal, need to be considered in more detail in order for the proponent to adequately demonstrate that their proposed and preferred course of development is in agreement with the definition and principles of ecologically sustainable development (ESD), as defined by the Environment Protection Authority (EPA) of the Northern Territory3. It is unacceptable for the proponent to rely on statements like: "The Northern Territory Government identified Blaydin Point industrial site as its preferred location for the onshore component of the Project and proposed it to INPEX" (Chapter 2, Annexe A, p. 29), for justifying significant Project decisions such as site selection.

Submission 124-35: The preferred option is relocating the INPEX LNG plant and positioning it adjacent to Darwin LNG on Wickham Point to eliminate the need for blasting (and significantly reduce the need for dredging), share existing infrastructure, and avoid land clearing on the relatively intact Blaydin Point.

INPEX believes it is appropriate for the Northern Territory Government to indicate its preferred location for industrial development in the Darwin region. It should be noted, too, that Middle Arm is the site of an existing LNG facility, the Darwin LNG plant operated by ConocoPhillips. INPEX does not have the option to co-locate its onshore processing facilities at Wickham Point as this area has been reserved for future expansion of the existing Darwin LNG facilities.

Chapter 4 *Project description* of the Draft EIS describes the Project which is being submitted for formal assessment, the relevant alternatives which have been considered, and INPEX's rationale for the selection of the preferred design.

Additional information on Project alternatives for shipping channels, the product loading jetty and the removal of Walker Shoal is provided in sections 4.10 and 3.3.8 of this EIS Supplement. Alternative dredge spoil disposal locations were addressed in Section 7.3.3 of the Draft EIS. An alternative onshore pipeline route across Cox Peninsula was considered by INPEX early in the FEED (front-end engineering design) phase but was ruled out on the basis that it would have caused more environmental and social impacts than the marine pipeline option.

INPEX also considered a number of other plant locations along Western Australia's Kimberley coastline, including the Maret Islands, before announcing in September 2008 that it had selected the Blaydin Point site in Darwin for its onshore facilities.

Submission 130-25: Technical Appendix 1 of the Draft EIS gives the guidelines required of INPEX for their Draft EIS as jointly determined by both NT and the Australian Governments. Section 5 of Appendix 1 lists the requirements for "Alternatives" as follows:

"Alternative proposals must be discussed, including detailed reasons for the selection and rejection of particular options. The selection criteria must be discussed, and the advantages and disadvantages of preferred options and alternatives detailed. The short, medium and long-term potential beneficial and adverse impacts of each of the options should be considered and associated risks detailed and analysed.

Alternatives to be discussed must include:

- Not proceeding with the proposal;
- Site selection within the Darwin region;
- Alternative locations for various components of the proposal;
- Alternative gas and condensate processing scenarios, onshore and offshore;
- Alternative scenarios for development of port facilities;
- Alternatives to foreshore reclamation;
- Alternative dredge methods considered and dredge spoil disposal locations;
- Alternative sources of raw materials for the project, including water supply and fill/borrow materials; and
- Alternative environmental management techniques for moderate or higher risk impacts."

The Draft EIS has:

- a short but interesting section "4.1.2 Site Selection" on page 160 which gives the history of how the first option of having the processing plant on the Maret Islands off the Kimberley coast of WA failed to gain the necessary approvals and how the NT Government then offered the Blaydin Point site for the processing plant;

- a section ‘4.1.3 Design alternatives’ which occupies one quarter of page 161 which states in general terms that alternatives were examined for subsea pipeline routes, locations for off-loading the modules for the processing plant, for the product loading jetty and navigation channels, for the dredge spoil disposal ground and for the processing plant layouts;
- one paragraph on page 189 devoted to “Alternative dredging methodology” ;
- one paragraph of the section “4.4.6 Dredge spoil disposal ground” on page 190 dealing with the alternative to offshore disposal of “onshore disposal to settlement ponds either on Blaydin Point or on land managed by the Darwin Port Corporation.”
- one sentence on page 200 saying that the alternative to using the Darwin water supply of incorporating efficiency measures into the design of the processing plant is being investigated;
- one sentence on page 201saying that alternative geometry for the flare pad layout will be investigated;
- one sentence on page 204 that an alternative borrow pit site is being investigated in Middle Arm Peninsula;
- one sentence on page 205 that alternatives to using fill for the flare pit are being investigated;
- several paragraphs on pages 209 and 210 relating to options for the decommissioning of the facilities.

From the above, it is concluded that Draft EIS mentions most of the bullet points listed in the government guidelines but, except in one or two instances, not in the detail required by the opening three sentences in the guideline paragraph quoted above.

Chapter 4 *Project description* of the Draft EIS describes the Project which is being submitted for formal assessment, the relevant alternatives which have been considered and INPEX’s rationale for selection of the preferred design option. Additional information on the shipping channel and alternatives to drilling and blasting is provided in sections 4.10.1 and 3.3.8 of this EIS Supplement. Additional information on the jetty concept selection is also provided in Section 4.10.2 of this EIS Supplement.

Submission 130-27: Many of these problems could be overcome by an alternative, 23 km long, GEP route across the Cox Peninsula leading to a 10 km sub-sea section across West Arm and Middle Arm to a point on Middle Arm Peninsula just south of the ConocoPhillips plant at Wickham Point.

This alternative would presumably require NT Government assistance in the purchase or lease of the GEP corridor across Cox Peninsula. But there should be no technical difficulties – for instance, there are no large waterways to cross and at this stage, there is only one road crossing. Obviously, such a corridor would be used for future pipelines as well.

Submission 130-28: It would seem that a much better location for the processing plant would be on the land south-east of the ConocoPhillips facility and west of the access road to that facility.

The area available is slightly more than the Blaydin Point site although it is at lower elevation. Among the disadvantages would be that there is more fill required and there would need to be cooperative shipping arrangements between ConocoPhillips and the proponent. On the other hand, advantages would include:

- probably much less dredging required and with any luck, no hard rock intrusions similar to the Walker Shoal;
- the western shore of East Arm (which is highly visible from the CBD and Palmerston) can be retained in its present pristine condition. (The eastern shore of Middle Arm already contains the ConocoPhillips LNG plant and the Channel Point power station, so to that extent, the eastern shore of Middle Arm is no longer ‘pristine’.);
- close proximity of LNG/LPG/condensate carriers to the East Arm Port shipping is avoided;
- most importantly, the site would provide a wider separation of the processing plant from populated areas and less chance of LNG spills being blown over water in the event of the TC disaster scenarios discussed in Sections 2.3 and 2.4, page 4, above.

INPEX’s conceptual engineering and subsequent front end engineering and design has been conducted on the Blaydin Point site at Middle Arm Peninsula as this was the site identified by the Northern Territory Government.

Submission 130-30: In the section "4.4.6 Dredge spoil disposal ground" on page 190 of the Draft EIS there is the following statement on the alternative for onshore disposal:

"An appropriate disposal location for the spoil generated by the dredging program is required. Options considered include offshore disposal of acceptable material to a subsea spoil ground, and onshore disposal to settlement ponds either on Blaydin Point or on land managed by the Darwin Port Corporation (DPC) for land reclamation. It was initially considered that the existing settlement pond capacity at East Arm Wharf and the area for its proposed future expansion might provide opportunities for onshore disposal. INPEX's geotechnical and geophysical investigations have, however, demonstrated that the dredge source material is very fine and therefore unsuitable for infill and construction purposes. The results of the INPEX investigations have been made available to the Northern Territory Government. The use of dredge material for fill purposes on Blaydin Point had been previously ruled out because there is insufficient space to accommodate the necessary settlement ponds.

Therefore, for the purposes of the Draft EIS, it is assumed that all dredge spoil material will be disposed of offshore. Should the opportunity for some onshore disposal arise closer to the start of the dredging program, INPEX would explore the option in conjunction with the DPC."

COMMENTS:

5.3.1 Judging from the particle size distributions given in the Draft EIS, the dredge source material is not so fine that it should present major problems in converting it into suitable filled ground. (The process of converting the pumped slurry from the dredging into solid fill is known as consolidation and simply entails the removal of water from between the soil particles. That process takes time but it can be speeded up by using well established techniques such as using vertical sand drains, horizontal filter layers and applying extra, temporary, top weight by surcharging with additional fill.

INPEX acknowledges that there are civil-engineering techniques to accelerate consolidation of fine material. Presently, however, no options exist for the supply of dredged material to East Arm Wharf. While disposing of the spoil onshore is an option, there are a number of constraints which, when considered together, make onshore disposal unviable:

- A large reclamation area would be required to accommodate the entire amount of fill which may be available. It is estimated that there may be several million cubic metres of sandy material which, with engineering treatment, may provide suitable fill material. However, it is further estimated that an area of up to 100 ha would be required to accommodate it. While the expansion of the backup area to East Arm Wharf might provide enough area, there is no area large enough on the Ichthys Project site that could be used to accommodate this volume of fill.
- Dredged material will be made up of a content of fines and plasticky clayey soil. Limited sandy zones throughout the proposed shipping channel mean that these sands would be thoroughly mixed with the predominantly clayey material to form a clayey dredged spoil. It is not practicable to separate the limited sands from other soils in the dredge discharge as an area in the order of 100 ha would have to be dedicated to store the fines which will separate from the sands. There are no sites of this size available on the Project site. Furthermore, there are few adequate long-term disposal or treatment methods for these fines once separated out from the suitable fill material.
- If a suitably sized reclamation area should become available to the Project in an acceptable time frame, it will be possible to engineer the landfill by mixing fines with suitable fill material (such as sand) and providing vertical wick drains to aid dewatering of the fill, and surcharge material to preload the fill area for consolidation. The success or otherwise of this approach is dependent on a number of constraints:
  - All investigations, designs and approvals for enabling works at the reclamation site would need to be in place before the Project dredging contract is finalised.
  - There would be potential risks of interference with other port users resulting from the many kilometres of dredge piping and the movements of support vessels within the Harbour area over a period of several months.
  - A number of months would be needed for consolidation before the fill would be suitable for further construction of roads, services, buildings and other structures.
  - There would be potential risks associated with future settlement, the possible presence of hazardous substances, and dust.

Submission 130-31: AMSTECI requested to see the results of "INPEX's geotechnical and geophysical investigations" in order to understand what the problem could be with the dredge source material but the request was denied with the following explanation:

"The geotechnical and geophysical information provided to government is preliminary information only; however this information was sufficient to support the case for the disposal of the dredge spoil. It is important to note that the geotechnical and geophysical investigations have not been provided to government, and will not be provided until an appropriate stage in the design and development process. As such the investigations you refer to have a commercial value and will not be released by INPEX at this point in time."

AMSTECTI submits that under the terms of the government guidelines, the information should be made available to the public. The writer has some experience with consolidation projects, including the consolidation of the very deep layer of estuarine mud underlying Perth's Narrows Interchange. Consequently, we dispute the inference that the dredged material will not be suitable for onshore disposal and, at some time, make suitable land fill. The fill may not be suitable to the DPC for fill at the East Arm Wharf due to time or access constraints, but there are numerous alternative locations – including the alternative site for the processing plant discussed above.

INPEX cannot provide copies of Ichthys Project geotechnical reports to AMSTECI as this would compromise the Ichthys Project's tendering process. The information will be made available to the Northern Territory Government at the appropriate time.

Submission 130-32: Recommendation: 8. That the NT Government make available suitable sites for the disposal of non-PASS dredge spoil so that it may be subsequently utilized as land-fill.

This is a question for the Northern Territory Government.

Submission 130-33: 5.3.2 It is noted that the dredging proposal for BHP Billiton Iron Ore's expansion at Nelson Point, Port Hedland involves the disposal of 2.7 Mm3 of potential acid sulphate soil (PASS) material to an offshore disposal ground and 4.0 Mm3 of the remaining dredged material involves disposal by pumping onshore to a 'dredge material management area' adjacent to the harbour. However, AMSTECI consider that all dredged material from the Darwin harbour, including the PASS material should be disposed of onshore. The PASS material would also be pumped but requires special treatment to preventing it from drying out at any stage, and it must be disposed in areas that will be permanently inundated by either fresh or salt water. Such disposal areas could eventually become lakes for recreation or for aquaculture; the cut material obtained from excavating the sites could be used for forming the bunds for the remaining pumped spoil or for other fill purposes. Recommendation: 9. That the NT Government make available suitable sites for the disposal of PASS dredge spoil which will in the future become lakes for recreational, aquaculture or other uses.

If the Northern Territory Government makes available suitable sites for the disposal of potential acid sulfate soil (PASS) dredge spoil in time to meet the Ichthys Project's schedule, then INPEX will consider disposing of some or all of the Ichthys PASS dredge spoil in these sites. However, for the purposes of the Ichthys EIS, INPEX needs to assume that such sites may not be available in time, if at all. For this reason, INPEX needs to count on the ability to dispose of all the Ichthys PASS dredge spoil at the location discussed in the Draft EIS. INPEX's responses to comments 120-14 and 130-30 should be noted.

5.2.2.3 Drilling

Submission 18-1: It is reasonable to take into consideration the importance of cumulative impacts, in particular of all drilling fluids acting in conjunction. The toxicity tests completed do not show the toxicity results of ALL drilling fluids acting in conjunction on a particular area. Moreover, a result yielding LD50% is enough to consider any of these drilling fluids harmful to marine organisms and most components of these fluids will persist in the environment. To consider that these toxic fluids will "disperse" and cause no harm is an arrogant statement.

The water-based mud additives listed in Table 7.3 of Chapter 7 *Marine impacts and management* of the Draft EIS represent the range of common additives that may be used in the Ichthys Project's drilling program. As some of these are different chemicals that effectively serve the same purpose, only one will be chosen, while others will only be required in specific circumstances (e.g. shale-control chemicals). Hence the final mud mixtures used would contain only a subset of the additives listed in the table.

Determining the combined toxicity of a mixture in water is not a precise science. The “dose addition” method, which is the more generally applied, conservatively assumes that each individual component acts additively and behaves as though it was a dilution of the other(s) (Kortenkamp, Backhaus & Faust 2009). Using this method the combined toxicity of the water-based mud mixture can be estimated by applying the following formula:

The LC_{50} of the mixture = (sum of ((all) $C_i / LC_{50\,i}$))$^{-1}$

where C_i is the concentration of the individual component

and $LC_{50\,i}$ is the reported LC_{50} concentration for the individual component.

In calculating the combined toxicity the following conservative assumptions have been made:

- All of the additives in Table 7.3 are used in the water-based mud mixture discharged.
- All of the additives are used at the highest concentration in the quoted concentration range.
- Where a range of LC_{50} concentrations is given the more toxic (i.e lower) concentration has been used.

Using the method and assumptions noted above, the LC_{50} of the water-based mud mixture to the mysid shrimp *Americamysis bahia* (the standard organism used in such toxicity tests) is estimated to be around 324 000 ppm. This means that the mixture can be considered “non-toxic” under the toxicity rating classification system used by Western Australia’s Department of Mines and Petroleum (DoIR 2006). Furthermore, dilution of the mixture on discharge to sea would reduce the potential for toxicity, and hence (as noted in the Draft EIS) it is predicted that the mixture would disperse and cause no environmental harm.

Submission 123-87: This chapter [Section 7.2.2] contains inadequate description of risks associated with the impacts of drilling muds. There is no mention of literature from Europe where their findings have led to the objective of zero discharge of SBMs to environment by the end 2000. The EIS needs to provide a genuine discussion on the use of WBMs and SBMs. Further it needs to provide an estimate how much will be discharged into the marine environment and model to what degree these contaminants will be biodegraded (if at all) or accumulated over time. It also needs to (1) place this into the context of environmental effects and risk; (2) provide indicators of exposure and effect; and (3) discuss if and how monitoring will take place.

Submission 123-88: This statement [SBMs are relatively non-toxic and readily biodegradable, and are considered to be an environmentally effective solution compared to traditional mud systems based on diesel and mineral oil. Using the toxicity ratings outlined by Cobby and Craddock (1999), most formulations range from “almost non toxic” to “non-toxic”] is inaccurate and infers that the discharge of SBMs into the environment has limited impact. However, the Department of Trade and Industry (UK) and OSPAR working group (2000) respectively state that: “Since the biodegradation of most synthetic drilling fluids was found to be unacceptably low…” or “ recently developed synthetic drilling fluids are likely to persist when discharged into the marine environment at high concentration on drill cuttings where anaerobic conditions develop” . References published prior to 2000 are typically based on inadequate testing methods, with the EU revising their assessment, resulting in the acceptance of zero discharge of SBMs.

Submission 123-89: The concentration of SBMs on drill cuttings discharged to sea will be restricted to 10% by dry weight or less in accordance with Western Australian Government guidelines (DoIR 2006). An internal target of 5% or less of SBM on drill cuttings released to sea will be set. This statement is inaccurate and infers that the discharge of SBMs into the environment has limited impact. However, the Department of Trade and Industry (UK) and OSPAR working group (2000) respectively state that: “Since the biodegradation of most synthetic drilling fluids was found to be unacceptably low…” or “ recently developed synthetic drilling fluids are likely to persist when discharged into the marine environment at high concentration on drill cuttings where anaerobic conditions develop”. References published prior to 2000 are typically based on inadequate testing methods, with the EU revising their assessment, resulting in the acceptance of zero discharge of SBMs.

Regulation of discharge

The Convention for the Protection of the Marine Environment of the North-East Atlantic ("the OSPAR Convention") (OSPAR Commission 1998) is the mechanism by which 15 governments of the western coasts and catchments of Europe, together with the European Commission, cooperate to protect the marine environment of the North-East Atlantic. The OSPAR Convention, in particular Annex III and decisions 1992/2 and 2000/3, has been the main driver for reduction in the discharge to sea of synthetic-based mud (SBM) on drill cuttings. It allows the discharge to sea of cuttings contaminated with organic-phase fluids provided that the concentration on cuttings does not exceed 1% by weight.

INPEX is committed to recovering and recycling neat SBM by returning it to shore for reconditioning or disposal. There will however be a small proportion of SBM that will not be able to be recovered and that will be discharged adhered to the drill cuttings. It is estimated that the final concentration of SBM on drill cuttings (for the hole sections drilled using SBM) will be in the order of 5–10% by weight. This volume is consistent with the guidelines published by Western Australia's Department of Mines and Petroleum (DoIR 2006), the regulatory authority responsible for the granting of licences for drilling in the offshore permit areas. The discharge of SBM to sea at the proposed concentration is also consistent with several other international regulatory guidelines, including for example those of the US Environmental Protection Agency (US EPA 2000a) and the Canada–Newfoundland and Labrador Offshore Petroleum Board (C–NLOPB 2010).

Effects

Several groups have independently prepared reviews of the effects of SBMs in the marine environment based on results obtained from field monitoring exercises. These include government agencies such as the Minerals Management Service of the US Department of the Interior (Neff, McKelvie & Ayers 2000) and the US EPA (Avanti Corporation 1997; US EPA 2000b); and mud companies such as Schlumberger (Friedheim & Patel 1999; Getliff et al. 1997). Reviews of the results of field monitoring indicate that there is a considerable degree of variability in the observed effects. The variability appears to be chiefly influenced by the characteristics of the receiving environment (such as ocean energy, seafloor dynamics and dissolved oxygen concentrations), ocean depth, and the volume of discharge. The following general conclusions can be drawn from the reported studies:

- Field studies suggest that the initial concentration of SBMs on the seabed is influenced more by the dispersability properties of the SBM than by the depth of water where drilling is occurring, except for shallow areas less than about 30 m deep.
- Measurements of the accumulation of SBM cuttings in sediments have consistently shown that the initial distribution is greatest nearest the discharge point and decreases with distance outwards to a maximum of approximately 2000 m.
- Where temporal changes in the concentration of SBM in the sediments have been measured, the results are variable. Studies from Australia show a rapid reduction in the concentration of SBM in the sediments; much of this loss is attributed to dispersal by storm-generated currents. By contrast, studies from the North Sea show that the mean concentration of SBM in the sediments within 100 m of the discharge point is unlikely to change significantly within 12 months, except in very shallow areas (less than 30 m deep).
- Where changes in the composition and abundance of the benthic fauna in sediments have been observed, these were associated with the highest concentrations of SBMs. Reductions in concentrations over time were associated with a return to "normal" benthic community characteristics.
- When changes in benthic communities are observed, they usually include a decrease in biological diversity; however the total number of individual animals and the biomass of the benthic faunal community may increase in some cases.
- Benthic community responses are often associated with a decrease in oxygen concentration in the surficial layers of sediments.
- Organic enrichment appears to be the main mechanism of adverse impact of SBM cuttings on benthic communities.

These results are similar to the findings from the SEA SERPENT Project's research program conducted in the Ichthys Field in 2008, where the effects of drill mud and cuttings discharged from a completed well (including SBM use in the lower sections) were assessed (Pile 2010). Highly mobile scavengers (hermit crabs and gastropods) were identified in remotely operated vehicle (ROV) transects in all three zones of drill-spoil coverage in the Ichthys Field. No significant differences were observed in macrofaunal activity between the zones. The SEA SERPENT research results indicated that drilling and drill-cutting disposal on the seabed was not acutely affecting the epibenthic fauna. In addition, the area of direct burial where infauna had not immediately recovered was only within a 25–30 m radius of the blow-out preventer, indicating that there was a high degree of cuttings dispersion and a low overall impact from direct smothering.

In summary, minimal impact from production well-drilling programs is anticipated in the Ichthys Field from disposal to the seabed of cuttings and associated drilling fluids. This conclusion is based on the following considerations:

- There is and will be minimal overall percentage seabed disturbance in the Ichthys Field.
- Epibenthic faunal diversity and abundance in the Ichthys Field are at low levels.
- There are vast areas of similar (and undisturbed) habitat throughout the North West Shelf, the Browse Basin and the Timor Sea.
- The strong sea currents which occur in the Ichthys Field will rapidly disperse cuttings piles.
- Naturally high turbidity exists near the seabed in the Ichthys Field.
- The research listed above demonstrates that recovery from SBM disposal is likely to occur within 1 to 2 years of discharge.
- Observations from the SEA SERPENT Project (Pile 2010) during drilling with SBM showed that there was minimal impact to epibenthic fauna.

5.2.2.4 EIS content and management plans

Submission 86-9: (Table 1-3) The Department of Health and Families (DHF) should be included as an approving authority. Under the Public Health (General Sanitation, Mosquito Prevention, Rat Exclusion and Prevention) Regulation the Department approves alternative septic tanks.

INPEX acknowledges this point and the Department of Health and Families (DHF) is now recorded as an approving authority.

Submission 86-14: The proponent has not identified how the project footprint relates to the NT Planning Scheme as requested in clause 4.5 of the guidelines to the EIS.

See Section 4.11 of this EIS supplement.

Submission 86-15: The potential health risk is significant. The Medical Entomology Report 2009 states that midges will be present in all months of the year. Measures to prevent worker exposure to biting insects will need to be included in any relevant construction and operational management plan, and site induction. They are to include appropriate personal protection measures; as well as measures to reduce adult biting insect populations in the region;

Submission 128-50: Table 11-5 Summery of Monitoring Programs – Darwin Harbour water quality monitoring program – does not include Bacto sampling. This will need to be done, as it is proposed to discharge sewerage co-mingled with waste water.

Intertidal sediment monitoring is required. Invertebrate species which inhabit these zones should be monitored; sediments should also be sampled for heavy metals and nutrients. Monitoring for potential mozzie breeding sites resulting from siltation and ponding water is required. Shell fish in the intertidal zone should also be monitored in order to better understand the effects of increased sediment loads on this intertidal habitat. Mangrove community species richness and abundance should also be monitored.

This response to comment 128-50 relates specifically to mosquito breeding site monitoring only. For details of the proposed monitoring programs in Darwin Harbour see the marine sections of this EIS Supplement.

Section 8.3.3 in Chapter 8 Terrestrial Impacts and Management of the Draft EIS summarises the findings from a biting-insects survey commissioned by INPEX for the Blaydin Point area. In addition to the identification of mosquito species and associated management actions to be incorporated into health, safety and environment site planning, biting midges were also identified as a human health impact factor.

Two species of midges of the genus *Culicoides* can be considered significant human pests in mangrove areas across the Top End of the Northern Territory. The species responsible for most of the bites in the mangrove regions is *Culicoides ornatus* (sometimes referred to as the "mangrove biting midge").

While the management actions described in the Draft EIS focused on mosquito reduction and other management options such as removing breeding sites and suitable habitat, these measures also apply to the biting midges. The hazards and potential health risk from biting insects is well recognised by INPEX, and previous experience at the proposed site during field surveys has been and will continue to be incorporated into health, safety and environment management plans.

INPEX proposes to run a comprehensive campaign during construction which will include biting insect awareness sessions for personnel and provision of PPE (clothing, insect repellent etc) to minimise the potential for open and exposed areas of skin. INPEX may also include regular fogging areas where midges and mosquito larvae will breed.

For personnel involved with field surveys and/or geotechnical investigations at Blaydin Point, INPEX has already implemented a number of measures to afford protection to personnel, including biting insect awareness initiatives, long sleeved shirts and long pants, industrial strength DEET, suggestions to secure clothing (e.g. insect entry points) such as taping around the button line of shirts, sleeves and gloves, and minimising the pooling of water around the work/site office areas.

Submission 106-13: The EIS referred to a Provisional Liquid Discharges, Surface Water Runoff and Drainage Management Plan, Annexe 10 Chapter 11. Yet, there was little detail in this plan and The Wilderness Society was unable to assess important environmental management of the project. The plan listed further more specific management plans INPEX would undertake. It is imperative that the INPEX develops and writes these plans that would go out for public comment before the project is granted approval. Much more detail in environmental management is required from INPEX.

Provisional environmental management plans (EMPs) provided in the Draft EIS are intended to provide core information that will form the basis of construction EMPs (CEMPs) and operations EMPs (OEMPs) required under the *Waste Management and Pollution Control Act* (NT) and the *Water Act* (NT). This EMP structure was developed with input from the Northern Territory's Department of Natural Resources, Environment, the Arts and Sport (NRETAS) and the Commonwealth's Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC). Both the CEMPs and the OEMPs will require approval by the Northern Territory Government. Neither the Northern Territory nor Commonwealth environmental assessment processes requires or allows for an additional public review phase for this secondary approval phase. The purpose of developing the provisional EMPs at this earlier stage of the Project is to demonstrate INPEX's capacity to manage the environmental risks to an acceptable level. These provisional EMPs will be finalised once contracts have been awarded and detailed planning for the construction and operations phases develops.

Submission 107-1: We are aware that the risk posed by residues that might emanate from condensate, water and gas flows might be considered to be low, but are concerned that a risk nevertheless exists. This has the potential in some circumstances, to result in the application of standards lower than might be expected during design, construction and commissioning phase. In particular, we are concerned about the apparent lack of substantive ecological research or measurement of eco-toxicology of some of the chemicals involved. Instead, there is a reliance on industry-based standards and an inherent assumption that the ocean provides infinite dilution for toxicants, creating the impression that the likely impacts on various ecosystems affected by the project remain largely unquantified.

The condensates that INPEX will produce offshore and onshore will all be biodegradable. In high concentrations in sea water they would be ecotoxic, but when discharged in wastewater at low concentrations and then mixed with surrounding water the discharges will not pose a risk to the environment. The hydrocarbons in condensate are biodegradable, especially when in warm sea water at low concentrations. For this reason, dilute hydrocarbon discharges in water will not continue to dilute infinitely in concentric contours around the discharges, but will instead drop to zero after complete biodegradation has occurred.

Offshore, INPEX proposes to treat produced water and other aqueous streams (stormwater runoff, bilge water, etc.) to a specification of less than 30 mg/L hydrocarbon before discharge. Tables 6 and 7 of the Draft EIS's Technical Appendix 6 *Produced water discharge modelling* of the Draft EIS show that the produced-water discharge will dilute by a factor of around 100 within a horizontal distance of 4 to 5 m from the discharge for a discharge rate of 2000 m^3/d. Figure 5-1 in Chapter 5 *Emissions, discharges and wastes* of the Draft EIS shows that INPEX expects produced water rates to range between 1000 and 3000 m^3/d over the life of the Project, below the range of rates modelled.

Onshore, INPEX proposes to treat all wastewater to a specification of less than 10 mg/L of hydrocarbon. The 10-mg/L number is a limit INPEX expects to stay well below most of the time. INPEX expects the flow rate from the Blaydin Point plant to range from around 18 m^3/h during dry weather to a maximum of approximately 160 m^3/h during heavy rains. Table 7 of the Draft EIS's Technical Appendix 10 *Wastewater discharge modelling* shows that, on average (50th percentile), a concentration of 10 mg/L in the discharge will dilute to below the ecotoxic threshold levels of 0.015 mg/L within 27 m and to 0.007 mg/L within 87 m.

Submission 107-2: MSDS documents for the chemicals to be used in bulk appear to be missing from the EIS and Appendices. The addition of these documents would have been useful as they assist in understanding specific risks associated with these chemicals to people accessing the nearby environment, if not the impacts on marine organisms.

At this early stage of the design of the Ichthys Project, and until engineering and construction contractors are engaged, it is not practical to provide detailed information such as material safety data sheets (MSDSs).

INPEX is required to seek various environmental protection licences and permits prior to construction and operation of the Project, should the Project be approved under the current environmental assessment process. Such licences and permits will address hazardous chemical transport and storage through various Northern Territory statutes, which will require MSDS documentation.

INPEX is therefore committed to providing such information in accordance with the necessary licensing processes at an appropriate time in the development of the Project.

Further information on waste storage and management can be found in Annexe 16 *Provisional waste management plan* to Chapter 11 *Environmental management program* of the Draft EIS.

Submission 107-7: This chapter considers the major infrastructure components of the submarine offshore and onshore facilities but is bereft of technical detail. Descriptions of how the individual components of the systems operate are not provided, making it difficult to assess fully many of the potential problems that might occur at each stage of the process, as described below.

The Draft EIS is not intended to be a detailed engineering document that describes the level of detail requested here. The document provides an adequate description of the Project and its major components. Regulation of the operational issues that is suggested in this comment is captured under alternative legislation listed in tables 1-2 and 1-3 in Chapter 1 *Introduction* of the Draft EIS and INPEX will comply with all the requirements contained in these instruments.

Submission 107-8: As only the "base case" infrastructure has been proposed in the EIS it is not possible for us as a third party to consider the full extent of the impacts associated with the project. The proponent indicates that the final design of the infrastructure will be refined as the front-end engineering design phase progresses but no mechanisms by which these changes will be assessed in line with the environmental impact assessment process are offered.

Any ministerial decision to approve the Ichthys Project will refer to the proposed Project design described within the Draft EIS and this EIS Supplement. INPEX is committed to managing the impact of the Project to remain within the limits described within the environmental assessment documentation. To that end, INPEX has allowed for ongoing development and refinement of Project design and this is acknowledged in the Draft EIS.

Should any Project design changes be proposed following the ministerial decisions associated with this environmental assessment process, INPEX will consult with the relevant regulatory agencies to determine the significance of such changes and whether they might also have a significant environmental impact. Mechanisms exist within the environmental legislation instruments of both the Commonwealth and Northern Territory governments for variations to approvals to be considered by the relevant minister; INPEX would adhere to this process should it be required.

Submission 107-11: A number of other facilities (accommodation, tug harbor, waste disposal resources and utility corridors that constitute a part of the project are identified but not included as a part of the EIS. The reason why they are not included and an indication of how these are to be assessed is unclear and should be provided. Ideally, each of these components should also be made available to the public for comment so that assessment for the whole of the project is complete.

All aspects and components of the Ichthys Project will be assessed in accordance with the relevant legislation. Secondary facilities or infrastructure which provides support to the Project such as those mentioned in this comment will be assessed at the appropriate time in the development of the Project.

Submission 107-15: Table 4-1 indicates that polymer gels and "synthetic-based muds" will be used as drilling fluids. Rather than providing a generic description, the exact nature and volumes of these drilling fluids should be provided so that their potential environmental impacts can be assessed.

As the drilling fluid contractor has not yet been selected it is not possible for INPEX to specify the exact polymer gels and synthetic based drilling fluids. However, significant detail on the low toxicity of these products is provided in Section 7.2.2 in Chapter 7 *Marine impacts and management* of the Draft EIS, which enables the potential environmental impacts to be assessed.

INPEX will meet or exceed all regulatory standards for its selected drilling fluid and will supply specific details of the drilling fluid properties in the environment plan, to be submitted for approval by the appropriate authorities, once the drilling fluids contractor has been selected.

Submission 107-22: The proponent indicates that further environmental information will be provided to the Northern Territory Government after the final dredging program has been designed. This will include a detailed dredging environmental management plan, which should have been included in the EIS or provided for public consideration prior to its acceptance by the NT Government.

Submission 107-28: INPEX states that an environmental management plan will be developed under the OPGGS Regulations and that this is to act as a risk control. The major components of this plan, required to explain how INPEX will deal with the toxic impacts on marine life, are not provided, nor is it explained how these will be implemented and monitored. This plan should be completed and offered for public review before the project is permitted to proceed.

Many of the EMPs prepared by INPEX for Project activities are statutory documents under a specific piece of legislation (Act or Regulations) and form part of the secondary approvals process. Many of the proposed EMPs or MPs identified in the Draft EIS form part of the core information required to develop the Construction and Operations EMPs which are required under the *Water Act* (NT) and the *Waste Management and Pollution Control Act* (NT).

The structure developed for the Project's EMPs was developed in consultation with NRETAS and DSEWPaC, and where applicable the actual plans will be developed in consultation with these departments, and ultimately the relevant regulatory authority will be required to approve each plan.

Offshore drilling environmental management plan

Documentation for offshore activities, including emissions, discharges and wastes are coordinated under appropriate Commonwealth and state (as a designated authority) legislation. An environmental plan will be prepared and submitted to the Department of Mines and Petroleum in Western Australia (the "designated authority") for the required activities. The environmental plan is not a document required under legislation to be issued for public consultation, although the regulatory authority will publish summary environmental plan on its web site.

Management controls for drilling discharges and potential toxicity effects have been discussed in the Draft EIS.

It is not within the remit of INPEX to comment on the appropriateness or content of the existing legislative structures.

Dredging management plans

For activities in Northern Territory waters, such as the dredging and dredge spoil disposal program, plans will be submitted to the Northern Territory Government when applying for applicable licences under the requirements of the *Fisheries Act* (NT), the *Waste Management and Pollution Control Act* (NT) and the *Water Act* (NT). It is also possible that the Commonwealth environment minister will seek to approve the final dredging and dredge spoil disposal management plan prior to the commencement of dredging activities.

Provisional environmental management plans have been prepared (see Chapter 11 *Environmental management program* of the Draft EIS), but it is recognised that some details cannot be confirmed until the dredging contractor is appointed.

The normal procedure is for environmental impact assessment to be conducted on a conceptual dredge program and a provisional environmental management plan. The description of activities, given in Section 4.4.4 in Chapter 4 *Project description*, Section 7.3 of Chapter 7 *Marine impacts and management* and technical appendices 5, 11, 12, 13, 14 and 15 of the Draft EIS, has been structured to include conservative assumptions in such a way that it represents a "worst-case" full range of environmental impacts. Secondary approvals (i.e. the final dredging management plan or the final dredging and dredge spoil disposal management plan) are then obtained after the finalisation of design. This approach is consistent with best-practice management as described in PIANC (2009), and all project environmental impact assessments including those for the Port of Melbourne, Gladstone Western Basin, Pluto and Gorgon. It should be noted that the selection of best practice will be project-specific; the selection of management practices and tools during the design, planning and construction phases should be based on appropriate baseline data and understanding of the ecosystem or environment in which the dredging will be undertaken.

While changes in dredging design may occur once the dredging contractor has been engaged, the final dredging design will be remodelled to ensure that predicted environment impacts do not exceed those presented in the Draft EIS.

Submission 107-25: Chapter 7 of the EIS describes potential impacts on the marine environment that will be associated with offshore and nearshore developments. Additional, related information is found in Chapter 3, which describes the existing natural, social and economic environment. The lack of detail provided in Chapter 3 has led to a subsequent inability to describe fully the potential impacts of this project.

INPEX has complied with the requirements of the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act) and the *Environmental Assessment Act* (NT) (EA Act) to prepare and publish the Draft EIS.

The Commonwealth and Northern Territory regulators issued their approval to publish the Draft EIS in May 2010. Their approval was provided on the basis that the Draft EIS adequately described the existing environment and the Ichthys Project's potential impacts in accordance with the EIS guidelines published specifically for the Project by the Commonwealth's Department of the Environment, Water, Heritage and the Arts (renamed in 2010 as the Department of Sustainability, Environment, Water, Population and Communities) and the Northern Territory's Department of Natural Resources, Environment, the Arts and Sport in September 2008 (and which were published in the Draft EIS as Technical Appendix 1 *Guidelines for preparation of a draft environmental impact statement: Ichthys Gas Field Development Project*. Additional information relevant to assessing the impacts of the Project, in particular, improved habitat maps and quantification of potential impacts, are provided in Section 4.1 of this document.

Submission 107-30: The Hydrotest Management Plan is unavailable for public comment as it does not constitute a part of the EIS, will be published later and is subject to acceptance by the Western Australian Department of Mines and Petroleum — and not by the Northern Territory Government. As a result, the EIS does not appear to provide information related to the types, concentrations, quantities disposal and fate of the chemicals involved in hydrotesting.

Submission 128-12: Darwin harbour discharges. The chemicals which may be used in hydro test water have not been identified so the impacts of discharges into the harbour can not be adequately assessed or commented on.

Hydrotesting, and the management of hydrotest water, is covered in the Draft EIS in Section 7.2.3 Liquid Discharges in Ch. 7 Marine Impacts and Management, and in Annexe 10 *Provisional liquid discharges, surface water runoff and drainage management plan* in Chapter 11 *Environmental Management Program*.

The main hydrotesting programs for the Project (in terms of water volume) are associated with testing of the gas export pipeline and the storage tanks (LNG, LPG and condensate) at the onshore plant. It is proposed to fill the offshore portion of the gas export pipeline from the harbour end using filtered sea water and discharge this water underneath the CPF. The onshore gas export pipeline section and the onshore tanks will either be hydrotested with PWC potable water or filtered seawater, and then discharged into Darwin Harbour. Where possible, this onshore hydrotest water will be reused to hydrotest other onshore facilities.

The hydrotesting programs have not yet been finalised. Water requirements, including sources of water will be decided as detailed design progresses. Therefore the requirements for chemical dosing cannot be identified at this time and will depend on the type and quality of the water to be used. The use of filtered seawater, while reducing the requirement to source large volumes of potable water, would require additional chemical dosing.

Chemical dosing usually includes a dye (offshore only, to trace or identify potential leaks), oxygen scavenger, biocide, scale inhibitor and corrosion inhibitor. INPEX and its EPC contractor will undertake a chemical selection process, based on water quality, ecotoxicity and efficacy of the chemical agents.

The offshore hydrotesting management plans will be prepared by INPEX and submitted to Western Australia's Department of Mines and Petroleum which is the "designated authority" for facilities in Commonwealth waters.

For the onshore facilities, an onshore hydrotesting management plan will be prepared and submitted to the Northern Territory Government for approval.

Submission 107-33: The EIS does not appear to define the actual distance between the FPSO and Browse Island, or whether there are any coral reef systems with the maximum chronic toxicity mixing zones. This should be specified within the EIS, and where any reef systems are present, the chronic impacts must be defined.

The distance between the two adjacent Ichthys Project offshore floating facilities (the central processing facility (CPF) and the floating production, storage and offtake (FPSO) facility) and Browse Island will be approximately 30 km.

As discussed on page 261 of the Draft EIS, the dilution rate for acute toxicity effects from produced water discharges is reached within a 60-m radius from the discharge point and dilution rate for chronic effects reached within a 1.1-km radius from the discharge point. This is also displayed in Figure 7-3 of the Draft EIS.

Therefore, Browse Island and all other more distant coral-reef systems (e.g. Scott Reef and the Kimberley coastline) are well beyond the outer boundary of the chronic-toxicity mixing zone.

Submission 107-39: INPEX states that the rate by which the Rowley Shoals are replenished by Scott Reef is not well known. This matter should be investigated, and appropriate contingencies for dealing with damage to either or both of these coral areas developed, in light of the findings of that study.

The coral connectivity between these two reef systems, and other reef systems of the NW Shelf will not be affected by routine discharges or other general operations from the Ichthys Project.

The only potential impacts to Scott Reef and Rowley Shoals from the Ichthys Project are from very low probability oil-spill events.

As discussed in the oil-spill section of this EIS Supplement, INPEX in conjunction with other petroleum operator companies with production interested in the Browse Basin are collaboratively developing a scientific monitoring program to address coral reefs and other significant ecosystems in the event of a significant oil spill (see Section 4.2.3).

Submission 107-44: It is recognised that As levels in the tropical marine environment are generally high. However, with the disturbance of fine grained material, it is also reasonable to assume that the amount of As mobilised in the environment will increase. The amount by which As levels are expected to increase in the marine waters and in pelagic and benthic organisms via trophic transfer should be defined. This should be supplemented with a description of the potential risk to human beings through transfer via the food chain.

As noted in Section 7.3.3 of Chapter 7 *Marine impacts and management* of the Draft EIS, laboratory testing using acid digests showed that arsenic in dredged material is unlikely to be toxic in the marine environment, as only very small proportions are dissolved into a bioavailable form. Uptake of arsenic by marine organisms is therefore not expected to increase as a result of dredging. INPEX has committed to the monitoring of metals in invertebrate bio-indicators (see Table 11-5 in Chapter 11 *Environmental management program* of the Draft EIS).

Submission 107-50: INPEX states that the removal or alteration of habitat will not affect the overall survival of species of significance as these animals are found throughout the Darwin Harbour region. This statement needs to be supported by a summary or description of regional populations of each species placed at risk.

Based on the results of plant and animal field surveys on Blaydin Point none of the terrestrial species identified at Blaydin Point are listed under the EPBC Act or the *Territory Parks and Wildlife Conservation Act* (NT) as "critically endangered" or "endangered". Therefore no species will be placed at risk or threatened in terms of its conservation status because of the clearing and/or Project activities, i.e. there is no habitat or plant or animal species found during the field studies that is not represented elsewhere within the Darwin Coastal Bioregion or the Northern Territory.

Submission 107-61: The EIS indicates the INPEX HSE Management process is modeled on the international standard AS/NZS 14001:2004. A technical project of this size and complexity should have a fully and independently auditable HSE Management system that ensures compliance and offers maximum environmental protection. In this regard, INPEX should be encouraged and be willing to undergo full accreditation to the AS/NZS 14001 as a condition of approval.

Submission 107-62: It is indicated that internal and external audits will be used to ensure compliance with regulatory requirements, project approvals and licences. The regulatory parties should be identified and the scope of external auditing extended to include the operations of the HSE Management process (see above).

INPEX's Health, Safety and Environmental Management Process (HSE Management Process) incorporates steps to ensure that the system is functioning effectively in delivering environmental outcomes. Such steps include establishing objectives, targets and key performance indicators for review by INPEX management; engaging in annual monitoring programs; implementing audit and inspection programs; and carrying out an annual review to determine the effectiveness of the system. These steps will occur regardless of whether the management system is certified by an accredited certification body under *AS/NZS 14001:2004, Environmental management systems—Requirements with guidance for use*.

INPEX does require its major contractors for the construction and execution phases of the Ichthys Project at Blaydin Point to have a documented and fully implemented HSE management system that shall, among other things, address the minimum requirements of:

- *AS/NZS 4801:2001, Occupational health and safety management systems—Specification with guidance for use*
- *OHSAS 18001:2007, Occupational health and safety management systems requirements*
- *AS/NZS 14001:2004, Environmental management systems—Requirements with guidance for use*
- *HB 167:2006, Security risk management.*

Submission 107-64: The proponent proposes environmental targets and indicators which will trigger actions but does not appear to provide in the EIS specific values for water quality or other wastes that might trigger a response. Acceptable trigger values should include various response levels, from commencing a watching brief through to full intervention, to ensure that the potential for impact can: first, be maintained at the lowest possible level; and second, be rectified should an incident occur.

Submission 107-67: There appears to be little discussion of specific surface and groundwater quality criteria, against which impacts can be measured, or trigger values derived. Presumably there are groundwater criteria in use for the facility at nearby Wickham Point that could have been utilized in conjunction with accepted industry standards to develop water quality criteria and associated triggers; and to provide assurance that a consistent approach to environmental management has been considered across Darwin Harbour.

Submission 107-68: A list of impacts, which are stated more-or-less as a fail accompli, is presented; but there is no detailed characterisation of the hazards. It is reasonable to assume that under the stated conditions limiting release, a range of impacts will occur (HCOs at 10mg/1, BOD 20mg/1 plus nutrients), however no specific site related information is presented to suggest that a detailed management plan would not be possible. If this information is presented elsewhere in the EIS, reference should be made; if not, this information should be provided prior to approval of the EIS.

See the summary response on environmental management plans in Table 5-1 of this EIS Supplement.

INPEX installed groundwater monitoring wells during the geotechnical investigation programs at Blaydin Point. The results from groundwater sampling provided INPEX with existing groundwater data, in particular on water elevations, hydrogeology and water quality, and a summary of this information is provided in Section 3.4.7 in Chapter 3 *Existing natural, social and economic environment* of the Draft EIS. INPEX will implement an ongoing groundwater monitoring program. It should be noted that ConocoPhillips' Darwin LNG plant at Wickham Point is not required to undertake groundwater monitoring as part of its licence conditions.

INPEX will apply for an environment protection licence. The conditions associated with the licence will be incorporated in the groundwater and surface-water monitoring programs and will consequently be included in the relevant environmental management plans.

INPEX recognises that specific criteria, limits and/or thresholds associated with impacts and discharges and emissions have not been provided in the provisional environmental management plans. The detailed criteria and thresholds will be determined in conjunction with the appropriate regulatory authorities and incorporated into the final environmental management plans to be submitted as part of the secondary approvals process.

The environmental management plans associated with the overarching construction environmental management plan will be submitted and approved prior to construction works commencing on site. Operations environmental management plans will be submitted for approval to the regulatory authorities prior to the commencement of the operations phase.

Submission 107-66: Management strategies for acid sulphate soils should be adequate provided that sufficient characterisation of the material is done. The metals and metalloids listed (with the possible exception of Cu) are incorrectly characterized as heavy metals; which undermines confidence in INPEX's assessment of geochemistry of these soils in particular and more generally across the wider region.

There is no widely accepted definition of the term "heavy metal". The International Union of Pure and Applied Chemistry (IUPAC), has produced a technical report on "Heavy metals"—a meaningless term?", which was published in the journal *Pure and Applied Chemistry* 74: 793–807 in 2002 (IUPAC 2002). The paper notes the following:

> The term "heavy metal" has never been defined by any authoritative body such as IUPAC. Over the 60 years or so in which it has been used in chemistry, it has been given such a wide range of meanings by different authors that it is effectively meaningless. No relationship can be found between density (specific gravity) and any of the various physicochemical concepts that have been used to define "heavy metals" and the toxicity or ecotoxicity attributed to "heavy metals".

That IUPAC's conclusion is correct is supported by much of the literature on the management of acid sulfate soils in Australia and elsewhere, where the term "heavy metals" is standardly used without a clear definition. Refer to the following, for example:

- The Victorian coastal acid sulfate soils strategy (DSE 2009) published by Victoria's Department of Sustainability and Environment: "Other heavy metals and metalloids (such as arsenic) can also be mobilised … Sulfuric acid has the potential to mobilise heavy metals such as arsenic and aluminium which may be dissolved in the soil …"
- Queensland's guidelines for sampling and analysis of lowland acid sulfate soils (Ahern, Ahern & Powell 1998) published by Queensland's Department of Natural Resources: "… to remove toxic forms of aluminium and other heavy metals …"
- Queensland's acid sulfate soil management guidelines (Dear et al. 2002) published by Queensland's Department of Natural Resources and Mines: "… contain sulfides and high levels of arsenic (and other heavy metals) … Furthermore, aluminium, iron and other heavy metals that are more soluble in acidic waters … "

* A study of the mobility of radium and heavy metals from uranium mine tailings in acid sulfate soils (Willett, I.R., Noller, B.N. and Beech 1994): "Four soils were studied: two samples were acid sulfate … materials and two were acidic materials overlying acid sulfate horizons. Copper, iron, manganese, lead, uranium and zinc fractions were determined".

So, from these it can be seen that all five metals and metalloids mentioned in Chapter 8 and Annexe 1 of Chapter 11 of the Draft EIS, namely iron, aluminium, manganese, copper and arsenic, are named as heavy metals in an acid sulfate context.

On the one hand, the world's peak chemistry body IUPAC says that the term "heavy metal" cannot be defined and is therefore "meaningless". On the other hand the term is nearly always used by scientists and biologists studying acid sulfate soils because it is a handy and convenient term, which is rarely defined and which most users know is imprecise and loose.

Submission 107-72: It is difficult to regulate the impact of major industrial projects without a suitable and statistically sound baseline ecological database; and although there has been a move away from biological monitoring as a regulatory tool in recent years, its absolute value and necessity as a tool for impact assessment cannot be understated. Consequently, INPEX should be required to use all available opportunities until project start-up to gather a statistically sound baseline ecology data-set, and to measure project impacts against this.

The information collected, both specifically for this environmental assessment and indirectly through previous surveys and studies, has been collated to provide the most thorough and comprehensive environmental baseline available for the areas potentially affected by the proposed Project.

INPEX has been guided by ongoing discussions with both Northern Territory and Commonwealth regulators in the design and execution of studies and collation of these data sets, and has complied with the requirements of the environmental assessment scope.

The Draft EIS lists a range of environmental monitoring plans (see Table 11-5 in Chapter 11 *Environmental management program*), which will be implemented to measure the impacts of construction and operational activities. Detailed baselines will be established prior to the commencement of activities to enable this assessment to occur. The results of monitoring will assist with ongoing management and mitigation of impacts.

INPEX therefore believes sufficient information has been presented in the Draft EIS and this EIS Supplement for the purpose of making a determination under the EA Act and the EPBC Act.

Submission 107-73: At the very least, a commitment from INPEX should be sought, that INPEX will undertake wider ongoing continuous monitoring and studies of the unaffected natural environment around Darwin Harbour, to provide a better assessment of the background ecology, and more points of comparison against which the impacts of their process can be measured.

INPEX has committed to various programs that contribute to improving the knowledge and management of Darwin Harbour, for example the Darwin Harbour Integrated Monitoring and Research Program.

In addition, as noted in Section 11.4 of Chapter 11 *Environmental management program*, appropriate and detailed environmental monitoring programs for the receiving environment will be developed in consultation with the regulatory authorities prior to the commencement of construction activities. Amongst other aims, INPEX's monitoring programs will be designed to complement other monitoring being carried out in Darwin Harbour by government agencies and/or other Harbour users. Each program will be conducted by appropriately qualified personnel in a systematic and scientifically defensible manner.

A preliminary outline of INPEX's proposed receiving environmental monitoring programs was provided in the Draft EIS in Table 11-5 of Chapter 11.

Refer to Section 4.9 regarding environmental offsets.

Submission 107-74: Regionally, arsenic is associated with PAF shales and perhaps is worthy of a separate management plan if present in the area in significant amounts.

INPEX has conducted extensive acid sulfate soil testing programs at Blaydin Point. Details are included in Technical Appendix 17 of the Draft EIS. No PAF shales have been encountered in any of the investigations conducted to date.

Additional research was undertaken specifically into the Burrell Creek Formation (the main geological formation of the Blaydin Point site) and no references were found to it being classified as PAF.

Shales that classify as PAF are known to be present in the Northern Territory. These shales tend to be black, anoxic/reducing, and hence sulfide containing. INPEX's research has indicated that such shales are known to exist in the Northern Territory at the following locations:

- Browns and Area 55 Oxide Projects, 65 km south of Darwin
- McArthur River Mine, McArthur, Northern Territory
- Princess Louise and North Point mine sites, Burnside Operations Pty Ltd, Brooks Creek, Northern Territory (170km SE of Darwin)

All of these occurrences relate to mining projects. PAF materials oxidise when subjected to the atmosphere and hence stockpiling of such materials, and other sulfides containing waste, is of the most concern.

Some of the Phase 1 and 2 geotechnical investigation boreholes went to a depth of 30m however site preparation and foundation works will only reach 5m below current surface levels. Therefore, based on the soil investigations conducted to date, additional research into PAF shales and the proposed depths of excavation, PAF shales are not considered to be an issue.

INPEX is proposing to undertake a contaminated land survey (which will cover the Blaydin Point site and also Borrow Pit area) to confirm the presence/absence of particular contaminants/hazardous materials. Should through these investigations PAF Shales be identified, appropriate management strategies will be implemented in consultation with relevant regulatory agencies.

Submission 109-18: Recommendation: A harbour wide mangrove monitoring program building on past work should be established immediately to monitor sedimentation effects on the mangroves from dredging and other works.

Submission 120-12: There will be a requirement for an ongoing mangrove monitoring program.

INPEX has committed to monitoring mangrove communities (throughout construction and operations) and intertidal sedimentation depths (throughout construction); refer to Table 11-5 of the Draft EIS. Consideration to past mangrove work done in the Harbour will certainly be a key aspect of the design of this monitoring plan.

Submission 123-242: The following references cited in the draft EIS should be provided to NRETAS to facilitate the assessment: JKC Dredging Strategy report, 2009. Ichthys Onshore LNG Facilities (Feed), June 2009. Coffey Geotechnical, 2009. Laboratory Testing report, Ichthys Gas Field Development Nearshore Geotechnical Investigation, Volume 1. HR Wallingford, Ichthys LNG, Laboratory disaggregation and abrasion testing, Darwin harbour, Report EX6226, revision 2.0. Fugro Seismic Refraction report Vol1, 2009 Ichthys Gas Field Development – Darwin Harbour, January 2009.

The reports contain valuable commercial data which cannot be provided at this time. This is because INPEX is in the process of an ITT (invitation to tender) which renders these documents sensitive to this process.

In due course, should these documents still be required INPEX will make them available.

Submission 123-244: Section 4.2 of the guidelines for preparation of the EIS requested an explanation of the objectives. benefits and justification for the project. The overall objectives for the project are not clear in the draft EIS and should be clearly stated in the context of social and economic aspects and ecologically sustainable development in the Darwin region.

The Draft EIS describes the rationale and benefits of the proposed development in Chapter 1 *Introduction*, Chapter 3 *Existing natural, social and economic environment*, Chapter 4 *Project description* and, in particular, Chapter 10 *Socio-economic impacts and management*.

The economic model and other potential positive impacts are assessed in detail in Chapter 10.

Submission 124-17: No reference to highly relevant government processes, such as Commonwealth Marine Bioregional Planning.

INPEX has engaged with relevant Commonwealth agencies since the inception of the Project. The issue of Commonwealth Marine Bioregional Planning has been discussed, but was not sufficiently mature in its development in potential Project impact areas for INPEX to address at the time of preparation of the Draft EIS.

It should be noted however, that INPEX has provided extensive raw data and information relevant to the Kimberley coast and Browse Basin to Commonwealth authorities. This has contributed to recent development of marine planning concepts for the Kimberley coast.

Submission 124-26: Environmental Management Program The various management plans that comprise INPEX's Environmental Management Program are limited in detail. Regular mention is made of INPEX's Incident Reporting, Recording and Investigating Procedure (IRRIP) in the proposed Environmental Management Program. However, there is no indication of who might be responsible for compiling the IRRIP, what the IRRIP actually involves, who has access to it, or who will be responsible for taking action on the basis of what is reported and recorded. All of the provisional management plans developed as part of the proposed Environmental Management Program fail to clearly outline who INPEX or its contractors will report to, (internal and external to the Project), and whether or not independent auditing and monitoring will be undertaken to "ensure that all significant potential environmental effects...are minimised or avoided" (Chapter 8, Section 8.1, p. 380). Following lax regulation and compliance enforcement of Montara and port ship loaders by the Northern Territory Department of Resources, we are not confident there are adequate measures in place to deal with spills, ships running aground, fires etc. This underscores the importance of INPEX conducting a thorough risk assessment for all aspects of its Project, and on the basis of this assessment, putting in place a comprehensive, detailed Environmental Management Program. Recommendation: INPEX to provide further information about its intended Environmental Management Program to allow for an assessment of whether the company will have the technical knowledge and capacity to adequately and appropriately deal with environmental incidents. In particular, we request further details about planned monitoring and reporting of impacts on marine and terrestrial environments.

The Incident Reporting, Recording and Investigating Procedure (IRRIP) is an internal procedure developed by INPEX in accordance with its Business Management System. The IRRIP has been prepared by INPEX's Health, Safety and Environment team, reviewed by various company personnel, and approved by company management. It stipulates the types of incident that may occur and procedures to be undertaken for initiating an incident response including notifications, reporting and investigation processes. The intention of the IRRIP procedure is to ensure that all incidents, including near misses, no matter how minor, are reported, recorded and investigated so that the following objectives can be achieved:

- deficiencies in workplace conditions are identified
- improvements to methods and equipment are identified
- failures in management systems and controls are identified
- lessons can be learned
- regulatory authority and industry reporting obligations are fulfilled
- management systems are continuously improved
- "at risk" behaviours are identified.

Actions arising from incident investigations are tracked by INPEX management to ensure that there is timely close-out and that lessons learned are communicated within INPEX and, where appropriate, to industry colleagues.

Roles and responsibilities for personnel who may be involved with an incident, investigating the incident and/or forming part of the response team are outlined in the IRRIP.

Prior to the commencement of construction at Blaydin Point a detailed Construction Environmental Management Plan (CEMP) will be prepared and submitted to NRETAS for review and approval in accordance with the *Waste Management and Pollution Control Act* (NT).

The CEMP will include a detailed description of the management system and procedures to apply to the construction site and will include finalised activity based environmental management plans.

The EPC contractor in charge of construction activities will be accountable to INPEX to ensure all environmental management commitments and conditions of environmental approvals are adhered to; and that the HSE management system is used to systematically identify, assess and manage any additional environmental impacts.

INPEX will conduct regular inspections and audits of work undertaken by the onshore EPC contractor, and it is anticipated that NRETAS will also undertake inspections and audits throughout the construction and operational phases of the Project.

INPEX is also developing a detailed environmental monitoring program. This program acts independently to the IRRIP and will allow INPEX to incorporate timely changes to its activities if the actual impacts are more significant than predicted.

Information provided in response to marine impacts and monitoring should be read for additional information about INPEX's activities in the marine and nearshore (Harbour) environments.

Submission 124-34: The Draft EIS further states that it is not known whether breeding and foraging areas for many species are located in Darwin Harbour (Chapter 7, Section 7.3.7, p. 361, Table 7-41), and that no significant breeding or feeding grounds have been identified in or near the nearshore development area (Chapter 7, Section 7.4.1, p. 367), to support the assumption that the habitats in Darwin Harbour are not critical to species life histories and therefore not important to protect. This ignores the results of studies conducted by Palmer (2010)14 which show: ??There are primary habitat areas for all three dolphin species found in the Harbour; ??Foraging was the most common behaviour observed for all three species, as it was for false killer whales, and although there was some overlap in habitat use among the dolphin species, the predominant foraging habitat for each was different; ??Individually identified Indo-Pacific humpback dolphins show minimal movement away from the Elizabeth River, East Arm area (i.e. very high site fidelity). Foraging has been recorded as the predominant behaviour observed in this area and mother calf pairs have been observed. (Note, East Arm and the Elizabeth River estuary are adjacent to Blaydin Point.) The Draft EIS also states that other known key habitats outside Darwin Harbour exist and therefore species could move to these areas if disturbed by the proposed development. This is not supported by the peer reviewed literature. Dyck and Baydack (2004)15 found that in areas of critical habitat animals may not have the choice of moving to other areas during periods of disturbance. Recent work by Wintle (2007)16 recommends an adaptive management approach to assess the impacts of noise on cetaceans and a number of related articles discuss the complexity of decision making under disturbance scenarios for cetaceans and marine mammals (e.g. Bateson 2007, Beale 200717). The Draft EIS does not consider any of these matters when assessing likely impacts. Recommendation: On the basis of the above critique, we do not believe INPEX can blast Walker Shoal in a manner that will not seriously jeopardise Darwin Harbour's marine wildlife. Instead, INPEX should work with the Northern Territory and Australian Governments to find an alternative shipping channel route.

Additional information in relation to breeding and foraging areas for Darwin Harbour species has been expanded in this EIS Supplement and is presented in sections 4.1.9 and 4.1.10.

INPEX does not intend to infer that foraging or breeding does not occur for coastal dolphins within Darwin Harbour, only that it is not recognised as critical habitat for the maintenance of the species in a broader Australian context.

Section 4.1.9.1 of this document contains additional information on coastal dolphins obtained from a comprehensive review of the scientific and non-confidential "grey literature"[8] which specifically addresses ecology and behaviour, impacts from construction activities, and management measures to avoid or minimise potential impacts. An updated impacts assessment on the potential effects of noise on coastal dolphins is contained in Section 4.1.10.2.

As stated in the Draft EIS INPEX has continued to explore alternatives to the drilling and blasting of Walker Shoal. INPEX has now committed to employ alternative methods that preclude the need for drill and blast, thereby removing the key risk to these species during the construction period. Further details in regard to proposed alternative rock-removal methods is provided in Section 3.3.8.

8 "Grey literature" is the term used for written materials that cannot be found easily through conventional channels such as publishers, but which are frequently original and usually recent. Examples include technical reports from government agencies or scientific research groups, working papers from research groups or committees, and also ephemera such as PowerPoint presentations.

Submission 124-47: The Draft EIS claims that no significant seagrass habitat exists in the nearshore area (Chapter 7, Section 7.3.2, Table 7-31, p. 327), however, as noted previously, habitat mapping is incomplete (Chapter 3, Section 3.3.6, Fig. 3-16, p. 70) and Figure 3-23 (Chapter 3, Section 3.3.8, p. 84) shows potential dugong foraging habitat in nearshore areas expected to be impacted by Project activities.

Supplementary mapping of seagrass habitat is provided in Section 4.1.2 of this document and confirms that seagrasses do no occur within the inner and middle sections of Darwin Harbour.

Submission 124-59: It is difficult to fully appreciate the extent of biodiversity loss that will result from the onshore aspect of the Ichthys Project. Reference has been made to relatively old data (c. 1997) for vegetation community coverage in the Darwin Coastal Bioregion (Volume 1, Section 3.4.8, p. 102). With significant land use change (for urban, industrial and horticultural development) having occurred over the last decade, these data are likely to over-represent native vegetation coverage. Additionally, pre-development terrestrial ecology survey efforts undertaken by INPEX have been limited, encompassing one-off wet and dry season surveys. These surveys may present a limited picture of the site's full range of biodiversity values, particularly given bushfires occurred 12 to 18 months before the surveys on Blaydin Point (Volume 2, Section 8.3.5, p. 396).

Vegetation community data for the Darwin Coastal Bioregion used by INPEX represented the best available data at the time of publication. INPEX acknowledges the limitations of this data set, given the land-use changes since its publication. Nevertheless, the Draft EIS and Section 4.4 of this EIS Supplement provide an adequate indication of the relative impacts of vegetation-clearing in a regional context. INPEX has also undertaken surveys at Blaydin Point in accordance with the EIS Guidelines and following guidance from relevant regulatory authorities. The information presented in the Draft EIS and this EIS Supplement is therefore considered adequate for the purpose of assessing the environmental impacts of the Project.

Submission 124-77: species biology description

Adequacy of information

This Draft EIS, (despite its volume), provides brief information on the species and habitats found in the region, yet most high quality EIS documents incorporate in-depth reviews for each species (including biology, foraging habits, habitat use and behaviour etc.). If these are not known for the area in question, then special effort is usually made to provide important life history information from what is known of the species in other areas (see LGL Ltd 200733 for a good example). This comprehensive style of EIS allows the reader/stakeholder to interpret likely impacts and risks and assess management plans much more effectively.

The Draft EIS contains adequate information regarding the specific aspects of the biology of critical species to enable the reader and government assessors to evaluate the potential impacts. This approach is consistent with the vast majority of large petroleum EIS documents including those for Gorgon, Prelude, Wheatstone and Pluto.

Critical marine species biology is provided in sections 3.2.7, 3.2.8 and 3.2.9 for the offshore environment and in sections 3.3.7, 3.3.8 and 3.3.9 for Darwin Harbour. More detailed information is contained in the relevant technical appendices. Additional information has been included in this document on marine habitats in Darwin Harbour, the distribution of coastal dolphins within the Harbour, and for seabirds in the offshore development area. Life-history information has also been produced for the two species of mud crabs and potential habitats for turtles and dugongs are also provided.

5.2.2.5 Emissions, discharges and wastes

Submission 1-35: PART I Question 34. How has the plant been designed to take account of best practice for Energy Conservation and emissions? My prior knowledge relates to BP Wytch Farm as outlined below

Chapter 9 *Greenhouse gas management* of the Draft EIS (in particular Section 9.8) and Section 4.8 of this EIS Supplement discuss various features which have been included in the plant and offshore facility design to improve energy efficiency and to reduce greenhouse gas (GHG) emissions. These include using waste heat, using more efficient gas turbines (such as aeroderivative gas turbines offshore), selecting activated methyldiethanolamine (aMDEA) to remove carbon dioxide (CO_2) onshore, and using an incinerator to destroy hydrocarbons in the CO_2 stream rather then venting them to atmosphere. Dry low-NO_x turbines (turbines designed to reduce combustion emissions of the two mononitrogen oxides (NO_x)) have been specified for the onshore processing plant at Blaydin Point. High-quality valves with low emissions have been specified to reduce losses to the flare and atmosphere. Flare-gas recovery systems have been specified for both the central processing facility (CPF) and the floating production, storage and offtake (FPSO) facility at the Ichthys Field to reduce the amount of flaring. The Project has also specified a power-sharing cable between the CPF and the FPSO and a combined-cycle power generation plant for the onshore processing plant. INPEX considers that these and other technologies being employed constitute best practice or standard practice in the offshore and onshore oil & gas industry.

Further details on GHG reduction aspects are provided in Annexe 8 *Provisional greenhouse gas management plan* to Chapter 11 of the Draft EIS and in Section 4.8 of this EIS Supplement.

Submission 1-36: PART I Question 35 What are the specific maximum daily volumes for Direct and Indirect Emissions when the Plant is at Maximum capacity for: Hydrocarbons, Carbon Dioxide, Methane (CH4), Volatile Organic Compounds (VOCs) Hydrochlorofluorocarbons (HCFCs)

Emissions of gases are not normally estimated on the basis of daily volumes, but on the basis of mass per unit of time, as the volume occupied by the mass of any given gaseous emission will vary greatly according to the temperature and pressure.

Figure 9-3 in Chapter 9 *Greenhouse gas management* of the Draft EIS provides predicted annual carbon dioxide (CO_2) emissions for the expected life of the Project, both offshore and onshore, in megatonnes per annum. This includes an allowance for equipment downtime for maintenance. A breakdown of the sources of these CO_2 emissions is provided in Table 9-2 of the Draft EIS.

Other gaseous emissions, including methane (CH_4) and volatile organic compounds (VOCs) (which together make up the hydrocarbons directly and indirectly emitted by the plant), are considered in Chapter 5 *Emissions, discharges and wastes*, for example in Section 5.3.6 and Table 5-1 of the Draft EIS (which provides estimates of combustion emissions in tonnes per annum).

INPEX does not plan to use hydrochlorofluorocarbons (HCFCs) in its Project operations.

Submission 1-38: PART I Question 37 How will Total emissions of oxides of nitrogen (NOx) be managed by ensuring limitations of flaring during and after the operational phase? Will emissions remain within authorised IPC limit (125mg/m3) from the gas turbines?

Reduction technologies for mononitrogen oxides (NO_x) are discussed in Section 4.5.2 of Chapter 4 *Project description* of the Draft EIS as well as in Section 5.3.1 of Chapter 5 *Emissions, discharges and wastes*. The total predicted emissions of NO_x (and other primary atmospheric pollutants) are shown in Table 5-1 of the Draft EIS. The primary sources of NO_x will be the refrigeration train and the power-plant gas turbines. The NO_x emissions associated with flaring will represent a relatively small contribution to the onshore plant total. During the operations phase the Ichthys Project's emissions will exceed the minimum reporting thresholds stipulated for NO_x, sulfur oxides (SO_x) and volatile organic compounds (VOCs) under the National Pollutant Inventory (NPI) (DEWHA 2010a). Annual emissions of atmospheric (and other) pollutants will therefore be reported under the NPI reporting framework once the Project becomes operational.

The NO_x emissions from the gas turbines will be less than 125 mg/m^3 during normal operations.

Submission 1-39: PART I Question 38 In the development phase how much Sulphur dioxide emissions will result from the amount of diesel used for drilling?

A typical drilling rig of the size required for the Ichthys Project would be expected to use a maximum of 50 t of diesel per day. This figure includes the diesel used by the rig's support vessels.

The diesel used will meet the requirements of the *Fuel Quality Standards Act 2000* (Cwlth), that is, it will contain a maximum of 10 g/t (mg/kg) of sulfur (see, for example, Shell Australia 2009).

Consuming 50t of diesel per day equates to the emission of approximately 0.5 kg of sulfur per day or 1 kg of sulfur dioxide (SO_2) per day—around 365 kg of SO_2 per annum. Such an emission rate may be regarded as insignificant when compared with the statistics contained within the National Pollutant Inventory (NPI) database for SO_2 emissions Australia-wide (DSEWPaC 2010e). This is particularly the case given the remote location of the Ichthys Field and its considerable distance from any sensitive receptors on the mainland—it is around 220 km from the nearest point on the Kimberley coast.

Submission 1-41: PART I Question 40 Are Palmerston's and Howard Spring's current Waste Management facilities adequate to cater for the potential new waste created by the site development and new INPEX employees and resulting population increase?

Submission 1-42: PART I Question 41 Waste levels from INPEC Plant will be related to the amount of activity on the development site.

Submission 1-44: PART I Question 43 Waste Management – The generation of waste impacts the environment; firstly as natural resources will have been used to create the material which after use is then a waste and secondly in the treatment and disposal of the waste which may lead to emissions, land take and pollution. How does INPEX aim to reduce the waste generated, recycle the waste that is generated and only dispose of the waste that cannot be reused or recycled? Will fluorescent tubes and lamps, toner cartridges, empty drums and most waste oils be recycled?

During the identification and selection of waste-management options, the waste-management hierarchy will be applied and will also include the separation of recyclable waste streams. Many of the waste streams identified in the Draft EIS have the potential to be recycled either on site, or off site by the waste-management contractor or by other third parties. All of these will be assessed.

The final waste management plan to be finalised prior to start of construction and after the appointment of waste-management contractors will provide a framework for the identification of potential waste stream and management controls.

Selection of appropriate waste-management contractors for the construction phase will occur during the detailed design phase. Tendering for the waste-management services for the operations phase will take place during the construction phase.

In addition to this, waste-management contractors who have experience in the management and/or development of new facilities will be considered in tender evaluations. Once suitable contractors have been identified for the construction phase the relevant regulatory and management bodies associated with waste management in the Northern Territory will be approached and appropriate disposal locations and controls for all construction waste streams identified.

Submission 1-43: PART I Question 42 How will Waste fluids and gases, Carbon sequestration Injection (excludes fluids reinjected for reservoir pressure support) be managed long term?

As recorded in Section 9.11 of Chapter 9 *Greenhouse gas management* of the Draft EIS, INPEX is currently investigating the various options for offsetting greenhouse gas (GHG) emissions. An update on planning for greenhouse gas offsets, including possible carbon sequestration is contained in Section 4.8 of this EIS Supplement.

Waste fluids will be managed in accordance with the prescriptions of facility waste, liquid discharges, surface water runoff and drainage management plans. Provisional versions of these plans were provided in the Draft EIS as annexes to Chapter 11 *Environmental management program*.

Submission 1-100: How will the increase in landfill material be managed during the development and eventual decommissioning of the site.

Submission 128-38: Annex 5 – Provisional Decommissioning Management Plans

Consideration should be given to determine the volume and type of waste generated from the decommissioning phase and its disposal location.

Final plans and options for decommissioning of the offshore and onshore facilities will be determined with the relevant regulatory bodies. The details of the decommissioning will be driven by the final use of the site and/or infrastructure. Prior to the commencement of any decommissioning activities a final environmental management plan will be prepared for approval by the appropriate regulatory authorities. This plan or an accompanying waste management plan will detail the management of wastes generated during decommissioning.

The EPC contractor for onshore construction activities will develop detailed waste-management planning once waste quantities can be better quantified. The plan will identify appropriate disposal locations and controls for all construction waste streams.

Submission 1-101: Will increased drilling activity, which generates cuttings be offset by the reinjection of some of the cuttings on site?

Submission 106-6: Waste from drilling well heads

Drill cuttings from 50 wells will create 35 000 cubic metres of sediment will be spread across 800 square kms.

INPEX does not propose to drill or utilise waste injection wells. INPEX plans to treat and discharge separated cuttings to the marine environment for each well, which is standard Australian practice.

Reinjection of cuttings to subsea wells from a mobile offshore drilling unit has not been proved to be technically feasible. INPEX will apply cuttings-drier technology to reduce the percentage of residual synthetic-based drilling fluid adhering to cuttings.

Cuttings settling to the seafloor will cause localised but recoverable impacts. The area of soft-sediment seabed that will be affected by drilling discharges in the offshore development area represent a very small proportion of the available and similar habitat in the broader Browse Basin region.

The Draft EIS states:

> Dispersion of cuttings across the seafloor will be influenced by the prevailing currents and vertical settling forces, and a small proportion of cuttings (particularly fine material) could travel several kilometres from the drilling point.
>
> At the Ichthys Field, the "South-East Asia Scientific and Environmental ROV Partnership using Existing iNdustrial Technology" (SEA SERPENT) project recorded the changes in benthic habitat caused by drill spoil cover, using remotely operated vehicle (ROV) transects around an exploration drilling centre (SERPENT 2008). These surveys recorded:
>
> - "High" drill spoil coverage within 20–35 m of the drilling point, causing complete coverage of the benthos with no evidence of bioturbation by benthic infauna.
> - "Moderate" drill spoil cover extended out to 50–70 m from the drilling centre, with benthic infauna having re-established burrows in the drill spoil material.
> - "Low" drill spoil coverage, where burrows made by benthic infauna were maintained under a light dusting of material, extended to the 80 m radius, which was the limit of the ROV survey area."

The drill spoil area recorded in ROV surveys was elongated along the north-west – south-east axis because of tidal currents. Overall, the extent of moderate to high coverage by drill cuttings at the single drilling centre was estimated at 0.7 ha (SERPENT 2008). Extrapolated across the entire 50-well drilling program, this would represent a total disturbance area at the Ichthys Field of 35 ha—equivalent to 0.0004% of the field area.

Submission 7-17: Water quality and seabed reports were used from old surveys and not current to reflect the current effects of the current Darwin LNG Gas Plant and East Arm Port.

A substantial body of work has been completed by INPEX to describe the water quality and seabed conditions of the nearshore marine environment. These are described in the Draft EIS and supporting technical appendices. Further information is provided in Section 4.1 of this EIS Supplement and in Technical Appendices S1 and S6 of this EIS Supplement.

Submission 7-20: Waste water treatment plant & sewerage disposal information was incomplete. The water treatment plant is planned in the small inlet in the entrance of the creek!

The operations phase wastewater treatment plant, including the sewage treatment plant, will treat all wastewater sources to a high standard. An environment protection licence (similar to the licences provided for the ConocoPhillips Darwin LNG plant at Wickham Point in 2005 (NRETA 2005) and 2010 (NRETAS 2010)) will be agreed with the Department of Natural Resources, Environment, the Arts and Sport (NRETAS) prior to start-up of the plant.

The operations-phase wastewater treatment facilities will be located on high ground on Blaydin Point, adjacent to where Lightning and Cossack creeks meet the East Arm of Darwin Harbour. However, as indicated in the Draft EIS, the wastewater outfall will be at the base of the product loading jetty. The outfall will be around 300 m offshore from Blaydin Point and several hundred metres from the entrances to the creeks.

Submission 7-21: There was mention of sewerage but still no plan for disposal.

Details of sewage discharge and treatment during the construction and operations phases of the Ichthys Project are provided in Section 5.6 of Chapter 5 *Emissions, discharges and wastes* of the Draft EIS. The sewage treatment requirements are likely to be met by packaged sewage treatment plants, self-contained septic-tank systems and/or ablution blocks. All wastewater discharges from the onshore processing plant will be subject to approval from NRETAS through an environment protection licence (similar to the licences provided for the ConocoPhillips Darwin LNG plant at Wickham Point in 2005 (NRETA 2005) and 2010 (NRETAS 2010)) under the *Waste Management and Pollution Control Act* (NT).

Submission 7-23: The Darwin Harbour does not flush on each tide. Water exchange in the harbour is very slow with minimal flush on the extreme high (neap) tides. Models show that water within the harbour just move around, thus the turbidity moves silt from one side of the harbour to the other with some points being a continual 'dumping' site (East Arm).

The oceanography and hydrodynamic characteristics of Darwin Harbour have been described in Section 3.3.2 in Chapter 3 *Existing natural, social and economic environment* of the Draft EIS. The residence and flushing times have been modelled and the results were provided in the Draft EIS's Technical Appendix 11 *Nearshore geomorphological modelling* and Technical Appendix 12 *Description and validation of hydrodynamic and wave models for dredging and spoil disposal*. The settlement pattern of sediments released during dredging operations are described in Section 7.3 of Chapter 7 *Marine impacts and management* of the Draft EIS and the modelling results were provided in Technical Appendix 13 *Dredging and spoil disposal modelling*.

Submission 18-6: Unfortunately, turbidity affects marine organisms and ... Not to mention that an increase in the number of vessels will also contribute to water pollution through fuel leaks.

The potential effects of turbidity on marine organisms are recognised, and are discussed in Chapter 7 *Marine impacts and mananagement* of the Draft EIS and in Section 4.1 of this EIS Supplement.

It is considered that any increase in vessel numbers within the Harbour (from small recreational boats up to large LNG tankers) inevitably adds to the *risk* of a contribution to water pollution through fuel leaks. Whether or not this risk is realised as an actual leak depends upon the vessel management procedures in place. INPEX contends that the vessels engaged during construction and operation of the Project will have more strict procedures in place to prevent fuel leaks than do the many recreational boats using the Harbour. Modelling of a refuelling spill at East Arm Wharf is included in Technical Appendix 7 of the Draft EIS and management measures to minimise the risk of a spill are described in Section 7.3.5 of Chapter 7 *Marine impacts and management* of the Draft EIS.

Submission 84-8: It seems from the proposal that waste water from the project site will be poured directly in the harbour. There again, I would like to see an independent study analysing potential effects on the marine life. I believe that part of Inpex's submission should include a closed circuit water system with zero discharge. In turn Inpex could be working hand in hand with Power and Water to generally ameliorate the quality of the harbour's waters. Inpex's response to the public submissions should include a detailed description of proposed water use, and treatment of waste water.

Submission 104-4: It is astounding and totally unnecessary that waste water be discharged directly into the Harbour. Darwin is already feeling the effects of pollutants in our waterways and on our beaches. We certainly don't need another source of contaminants when the technology exists to close the wastewater loop.

Submission 128-9: Discharges and waste: There are many sources of discharge that will come into the harbour from this project which could be of concern. INPEX will further add to these. Inpex is encouraged to manage their discharge and waste 'on site' through new technologies.

Submission 128-40: Annex 10 – Provisional Liquid Discharge Surface Water Run off and Drainage Management Plan.

There should be no discharge of polluted water into Darwin Harbour. Waste water should be treated on site.

Only water with a minimum water quality of the receiving water should be discharged into the harbour. The technology is available and should be utilised.

In order to ensure the near pristine values of the harbour are maintained for future generations it should not be subjected to any spills and discharges. Clarity around emergency arrangements needs to be much tighter and these arrangements should be communicated with the public. Assurance of updated safety measures being put in place should be written into an agreed timeframe.

All wastewater streams will be treated to remove contaminants down to low levels before discharge to the Harbour. No wastewater streams will be poured directly into the Harbour without significant treatment. Before start-up of the plant, INPEX will negotiate an environment protection licence (similar to the licences provided for the ConocoPhillips Darwin LNG plant at Wickham Point in 2005 (NRETA 2005) and 2010 (NRETAS 2010)) with NRETAS. The new INPEX licence will state quantitative limits on relevant (potential or expected) contaminants for all wastewater streams. Wastewater discharge will be measured and monitored, and results will be shared with the government and the community.

Table 5-6 in the Draft EIS (page 226) shows that the largest discharge source will be potentially contaminated storm runoff when it is raining. Runoff from potentially contaminated plant areas and roads will pass through de-oiling equipment such as a corrugated plate interceptor (CPI), dissolved air floatation unit (DAF), and filters in case it has come in contact with hydrocarbons.

All sewage will pass through an extensive biological treatment system prior to discharge. The effluent will be treated well enough to allow a choice of either on site irrigation or safe discharge to the Harbour.

Demineralisation brine and steam loop water will contain low levels of salts but no significant levels of other contaminants. Both these streams will be created from PWC potable water that has been treated to remove salts. Steam loops and other plant equipment need extremely low salinity water to protect equipment. The salinity of the brine and steam loop discharge streams will be between that of fresh water and sea water; within the range always found in Darwin Harbour water.

Wastewater streams will be used wherever possible for irrigation. However, there will be limits to the amount of irrigation water that can effectively be used on site.

Submission 86-12: (Table 5-5) The proponent shall confirm that the following liquid discharges do not contain faecal coliforms:

- Hydrotest water;
- Demineralised reject water;
- Process water;
- Drainage and stormwater run-off;
- Ballast Water

INPEX confirms that the following sources of liquid discharges will not contain faecal coliform bacteria:

- hydrotest water
- demineralised reject water
- process water
- ballast water.

Drainage and stormwater runoff are not expected to contain significant numbers of faecal coliform bacteria, but since there is likely to be some animal excrement within the Blaydin Point stormwater catchment, concentrations of faecal coliforms in drainage and stormwater runoff may not be zero. (Note however that this is the case today, before development has been approved.)

However, the five sources of liquid discharges in question will all be commingled with treated sewage prior to discharge, and because the treated sewage will have low levels of faecal coliforms, the commingled stream will also contain faecal coliforms.

Submission 36-10: Reduce demand on Power and Water Corporation's scheme water via waste water reuse and zero discharge from the development site; or a combination of waste water reuse and tertiary treatment of waste water before discharge, and on-site stormwater harvesting and reuse.

Submission 89-26: Reduce demand on Power and Water Corporation's scheme water via waste water reuse and zero discharge from the development site; or a combination of waste water reuse and tertiary treatment of waste water before discharge, and on-site stormwater harvesting and reuse.

Submission 7-19: Water use and where this was going to be resourced was not discussed.

Submission 7-22: There was mention of water usage but not estimated based on like size plants.

Submission 109-2: In addition to the issues raised below, the gas plant is going to use significant amounts of water in its production, this will put an additional burden on a resource which is already stretched in the dry season. Potentially this will necessitate additional water infrastructure such as dams in the region, which will in turn impact on native vegetation.

Submission 118-4: 3. Workers' Accommodation. The workers' accommodation at Howard Springs will certainly have an impact on the surrounding residential and retail area. Some of these affects are mentioned in the Socio-Economic Impacts section of the EIS but I believe there needs to be a more fulsome study done. Will there be sufficient water storage in the Whitewood Road water tank to supply the accommodation village without effecting local supplies and pressure? Whilst I realise that matters relating to the accommodation village may be dealt with at the planning application stage later on, the issue is mentioned in the EIS and deserves some comment.

Submission 124-66: INPEX is proposing to use mains water (Darwin water supply scheme) during its construction and operation phases (p. 441, Volume 2) at a time when local water supplies are under increasing pressure.

Submission 124-69: Recommendations: Reduce demand on Power and Water Corporation's scheme water via waste water reuse and zero discharge from the development site; or a combination of waste water reuse and tertiary treatment of waste water before discharge, and on-site stormwater harvesting and reuse.

Submission 124-71: Develop a water management plan for the whole of Middle Arm Peninsula, covering both surface water and groundwater (as per Terms of Reference for Preparation of an Environmental Assessment to Support the Proposed Development of Industry on Middle Arm Peninsula, March 200827). This plan should be developed in conjunction with the Water Quality Protection Plan for Darwin Harbour, as outlined in Darwin Harbour Region Report Cards28. Broader-landscape, rather than single site or single project management is critical, given the degree of development proposed for Middle Arm and the critical importance of protecting its water resources in order to ensure the health of marine and terrestrial ecosystems.

Submission 128-8: Utilities. What are the predicted effects of increased demands on Darwin's potable water supply, and in the context of sustainability? How will the increased demand for water in both the construction and operating phase effect Darwin's potable water supply? What plans are being developed to assess and manage the impacts of the borrow pits which are currently being investigated in Middle Arm. Council requests that this information is made available for public comment.

INPEX has been in contact with the Northern Territory's Power and Water Corporation (PWC) and is continuing to assess opportunities for reducing water consumption. In Section 4.5.2 of Chapter 4 *Project description* of the Draft EIS INPEX stated that recent advice from the PWC indicated that there will be sufficient capacity to accommodate the water demands of the Project. However it was also noted that alternatives to using PWC water and incorporating water-efficiency measures into the design of the onshore gas-processing facility are being investigated.

In the Draft EIS, INPEX identified the following estimates for water use (and therefore supply requirements) for the three main Project development phases. (Note that these represent estimates based on peak requirements while in fact daily demands will vary and will often be less than the volumes indicated.)

- Construction phase: estimate 1200 m^3/d. This may vary depending on the season; for example there will be a reduced water demand for dust suppression purposes during the wet season.
- Commissioning phase: estimate 7800 m^3/d. Where technically feasible, water demand will be minimised through the reuse of tank hydrotest water.
- Operations phase: estimate 2000 m^3/d.

As mentioned, PWC has indicated to INPEX that it can supply water to the Project, including the accommodation village, without detrimentally affecting local population supplies. The PWC has conducted its own assessment which identified any additional infrastructure requirements to provide water supply but also confirmed availability of water to both village and onshore plant construction and operations.

The accommodation village will also store sufficient levels of water on site for firefighting requirements. The village development will be assessed separately from the LNG development project through the planning application process where further details of the village development will be provided.

Where additional infrastructure is required to support the provision of water services to its sites, INPEX will negotiate the process with the PWC to have these in place in time for the Project schedule and without negatively impacting community water planning and provisions. In many instances, INPEX and its subcontractors may install water pipework and structures during site preparation works in accordance with the PWC's requirements and standards. For instance, INPEX will develop the infrastructure to take water for the accommodation village from the mains supply rather than from aboveground tanks, such as the Whitewood Road tank.

Alternatives to using PWC water and incorporating water-efficiency measures into the design of the onshore gas processing facility are being investigated, and a water conservation management plan will be prepared that will form the framework for the identification and capture of water-efficiency, conservation and management initiatives.

Submission 103-1: A MEG regeneration system has been included in the design, however there is no mention within the EIS of how the precipitated salts from the MEG regeneration process will be handled or disposed of. This should be detailed in the EIS.

The salt from the monoethylene glycol (MEG) unit will originate from the Brewster and Plover gas and condensate reservoirs which together make up the Ichthys Field. It will be blended back into the produced water and discharged to sea.

Submission 103-3: The produced water limit is specified as 30 mg/L – please state whether this is dispersed or total (dissolved and dispersed).

INPEX will treat to a specification of less than 30 mg/L petroleum (i.e. hydrocarbon) in produced water and plans to use an online analyser that will measure dispersed hydrocarbon for compliance purposes.

> Section 4.1.29(1) of the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 states that: "The operator of an activity must ensure that the concentration of petroleum in any produced water discharged to sea as the result of operations for the activity is not greater than an average of 30 mg/L over any period of 24 hours." Section 7, Definitions, of the same Regulations subsequently defines "petroleum" as "any naturally occurring hydrocarbon or mixture of hydrocarbons, whether in gaseous, liquid or solid state." Since all the hydrocarbons in Ichthys Project produced water will be naturally occurring and in liquid state, this EIS Supplement uses the terms "petroleum" and "hydrocarbon" interchangeably when referring to the less than 30-mg/L produced-water specification, even though Section 4.1.29(1) uses only the word "petroleum", not "hydrocarbon". The term "hydrocarbon", not "petroleum", is also more commonly used terminology in the oil & gas industry when referring to the less than 30-mg/L produced-water specification.

Submission 103-4: MEG will be present in the produced water stream, however no mention has been made of the cosolvent effect of MEG which significantly increases the dissolved oil concentrations (particularly BTEX and phenols) in the produced water stream. The impact of this and the treatment methodology proposed should be detailed in the EIS.

INPEX plans to use "macro porous polymer extraction" (MPPE) technology to reduce the hydrocarbon content of the produced water to <30 mg/L prior to discharge. See Oil and Gas Online (2010) for a brief description of this technology. Produced water will be discharged to deep, open waters at the Ichthys Field.

Submission 103-5: The cooling water will contain notionally 5 ppm of hypochlorite – however no assessment seems to have been carried out regarding the potential environmental impact of this discharge, or for example whether it exceeds the ANZECC trigger limits. This should be detailed in the EIS.

The Ichthys Project needs to treat cooling water to minimise (and ideally avoid) biofouling of the cooling-water lines. The use of low concentrations of hypochlorite for this purpose is standard and accepted industry practice and has been used in numerous locations without adverse environmental consequences. Even though the cooling water will be dosed with hypochlorite at a concentration of 5 ppm, it is expected that this will be consumed and degraded during transit through the cooling water system. Any residual concentration of hypochlorite will be rapidly diluted on discharge to sea. There are no ANZECC trigger levels for hypochlorite.

Submission 103-6: It is stated that biocide up to 200 ppm may be present in the discharge streams, however no assessment seems to have been carried out regarding the potential environmental impact of this discharge, or for example whether it exceeds the ANZECC trigger limits. This should be detailed in the EIS.

Section 5.6 of Chapter 5 *Emissions, discharges and wastes* of the Draft EIS, states that between 10 and 200 ppm of biocide will need to be applied in short doses to kill sulfate reducing bacteria. It is necessary to do this as sulfate-reducing bacteria produce hydrogen sulfide which is both corrosive and toxic in high concentrations. INPEX expects to dose no more often than once every few months, for approximately 30 minutes at a time. Dosing at 200 ppm is at the high end of the scale and represents a conservative or "worst-case" dose estimate. Biocide dosing is carried out by most, if not all, offshore oil & gas facilities, all of which generate produced water. INPEX regards it as critical to minimise corrosion risk and the Project does not expect any negative consequences from occasional dosing, as this has been the experience from other facilities. Biocides that will biodegrade quickly in the environment will be selected. The Draft EIS's Technical Appendix 6 *Produced water discharge modelling* shows that any biocide remaining in the produced water (after being partially consumed in the process of killing any sulfate reducing bacteria in the system) will be diluted by a factor of over 100 within around 5 m (horizontal) of the discharge point for a produced water discharge rate of 2000 m^3/d. Figure 5-1 in the Draft EIS shows that 2000 m^3/d is the expected average discharge rate from the offshore facilities over the 40-year operations phase.

Submission 103-7: The marine discharges in general do not appear to have been assessed against the ANZECC trigger limits for marine water quality. This should be detailed in the EIS.

In a Draft EIS the content of hypochlorite in cooling water and of biocide in produced water are not normally compared against the trigger levels laid down in the Australian and New Zealand guidelines for fresh and marine water quality (ANZECC & ARMCANZ 2000). After the start-up of the offshore facilities, ecotoxicity tests are typically carried out on the produced water and normally demonstrate an acceptably small mixing zone around their discharge point for substances listed or not listed in the guidelines.

Submission 103-9: The EIS states the produced sand will be discharged overboard, which does not represent best practice (onshore disposal). No assessment seems to have been carried out regarding the potential environmental impact of this discharge. This should be detailed in the EIS.

INPEX does not expect to produce much sand at its offshore facilities. In addition, INPEX has decided to ship sand removed from its offshore facilities to shore for processing and disposal.

Submission 106-7: Liquid discharges – hydraulic fluids, produced water.

After a well head is drilled hydraulic fluids containing additives toxic to the marine environment will be discharged volumes are 100 to 4500 cubic m/a in the first year to approx 300 cubic m/a for the rest of the project life. When every well head has been drilled this means up to 225 000 cubic m of water for first year or up to 825,000 cubic m in total. Hydraulic fluids include additives such as hydrate inhibitors, biocides, lubricants, corrosion inhibitors, and surfactants. It is very difficult to determine how much of these chemicals will be released into the environment throughout the life of the project.

Produced water is discharged from FPSO and contains hydrocarbons, minerals, production chemicals, dissolved salts and solids. Although there are standards set for to limit the concentration of oil discharged from FPSO, as it is a rate (less than or equal to 30 mg/L over any period of 24 hours – Clause 29 of the Offshore Petroleum and Green house Gas Storage (Environment Regulations) 2009 (Cwlth)) the amount discharged will vary depending on the quantity of produced water discharged.
As production water also contains added chemicals including MEG (monoethylene glycol), corrosion inhibitors (imidazoline derivative max conc. Range expected to be 7.5 – 30 ppm), scale inhibitors and biocides, that quantities are also given as a range it is also difficult to determine what levels of these chemicals will be released into the environment throughout the life of the project.

Given that Brewster has low concentrations of MEG ~ 100 mg/L and Plover has up to 150 times higher levels (up to 15 000 mg/L) it is difficult to determine how much MEG will be released into the environment.

The EIS should be stating the range of quantities released into the environment of each type of chemicals that is used in the project. A range of rates in a range of amounts does not clarify the environmental risk.

Submission 106-9: The impacts of the development on the Ichthys Field need to be properly quantified in the EIS – e.g. actual amounts of chemicals released over the life of the project.

The mass of various chemicals discharged to the sea over any time period can be estimated by multiplying the total discharged amount by the concentration in the discharge. For example, if offshore facilities discharge 1000 m^3/d of produced water this is equivalent to 1 ML/d. If the concentration of MEG in the 1000 m^3/d is 100 mg/L then the daily discharge weight will be 100 kg (100 000 000 mg, where 1 000 000 mg = 1 kg). If the MEG concentration is 15 000 mg/L the daily loss to sea will be 150 times as much—15 000 kg, which equals 15 t.

Discharges of hydrocarbon, MEG and other contaminants in water are normally quoted in concentration, not total mass, over long periods of time, for example over a 40-year Project life, because environmental impacts on marine species depend on concentration exposure levels, not on the mass discharged to the sea. The Draft EIS's Technical Appendix 6 *Produced water discharge modelling* shows that concentrations of hydrocarbon, MEG and other contaminants in produced-water discharge are expected to dilute by a factor of around 100 within a few metres of horizontal distance from the discharge point. In addition, pelagic marine species are not expected to spend any significant amount of time within a few metres of the discharge point. For this reason, though numbers such as 100 kg or 15 t of MEG discharge per day may *sound* large, the impact on marine species will not be, especially considering the relatively low toxicity of MEG. Hydraulic fluid is also MEG-based and hence also possesses low toxicity. Biocides and other potentially toxic components are normally present only at low levels, measured in parts per million.

Submission 106-15: It was very difficult to understand the environmental protocols in the EIS. "Response to adverse findings by an annual management review" on page 518 will be triggered by failure to meet identified objectives and targets. This suggested that adverse findings will only be dealt with once a year and this could be much too late to control environmental damage.

As the Brewster reservoir will be developed first and it has low concentrations of MEG ~ 100 mg/L when the project changes to Plover gas that has up to 150 times higher levels (up to 15 000 mg/L) extra and careful monitoring to the MEG levels discharged in waste waters.

Detailed management plans with clear objectives, outcomes and protocols, must be provided by the company for all environmental risks. These plans must be made public and must be a condition of project approval.

Section 4 of Annexe 2 *Provisional air emissions management plan* to Chapter 11 *Environmental management program* of the Draft EIS discusses air-quality monitoring and discusses responses associated with an annual management review (page 518). The paragraphs which immediately precede the text on the annual management review (pages 517–518) outline responses associated with exceedances of air-emission criteria set for the Ichthys Project and state that responses associated with such exceedances could include the following:

- an increase in the frequency of monitoring of relevant parameters at control and impact monitoring sites
- an investigation into the source or cause of the exceedance
- a review and update of existing management controls and procedures associated with air emissions.

The use of monoethylene glycol (MEG) is discussed as follows in Section 7.2.3 of Chapter 7 *Marine impacts and management* of the Draft EIS:

> The hydrate inhibitor MEG will be added in large volumes to the production process but will, in the main, be retained and recycled at the FPSO. Varying amounts of MEG will be discharged in the produced water directly to the marine environment. Worldwide, MEG is used as a chemical intermediate in the manufacture of polyesters or fibres, films and bottles, as well as for antifreeze in engine coolants or as a de-icer on airport runways and planes—runoff from these is the principal contributor of MEG to the environment (IPCS 2000).
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> MEG is miscible with water, does not volatilise nor undergo photodegradation, and is not adsorbed on to soil particles. Studies on a green alga (*Chlorella fusca*), a freshwater crayfish (*Procambarus* sp.) and a golden orfe carp (*Leuciscus idus melanotus*) revealed low potential for bioaccumulation of MEG in the marine environment (IPCS 2000).
>
> MEG biodegrades readily when released to the environment, in both aerobic and anaerobic conditions, and several strains of micro organisms capable of utilising ethylene glycol as a carbon source have been identified. Evans and David (1974) studied the biodegradation of ethylene glycol in four samples of river water under controlled laboratory conditions. The samples were dosed with 0, 2, or 10 mg of ethylene glycol per litre and incubated at either 20 °C or 8 °C. At 20 °C, primary biodegradation was complete within 3 days in all 4 samples, while at 8 °C, it was complete after 14 days and degradation rates were further reduced at 4 °C. Price, Waggy and Conway (1974) assessed the biodegradation of ethylene glycol in both fresh and salt water over a 20-day incubation period. Concentrations of up to 10 mg ethylene glycol per litre were used. In fresh water, 34% degradation was observed after 5 days, rising to 86% after 10 days and 100% after 20 days. Degradation was less in salt water—20% after 5 days and 77% after 20 days (IPCS 2000).
>
> It is considered that MEG poses a negligible risk of ecotoxicity, as lethal effects on exposed organisms can only be caused by very high concentrations in sea water. Ecotoxicity values for the effect of MEG on a number of aquatic organisms are provided in Table 7-8 [of the Draft EIS]; the high LC_{50} values indicate low toxicity.
>
> In summary, given that produced water is rapidly dispersed by ambient currents, MEG would not be expected to have toxic effects on the marine environment.

The provisional management plans provided as annexes to Chapter 11 *Environmental management program* in the Draft EIS will be further developed to detailed operational management plans and will include clear objectives, outcomes and protocols. The provisional EMPs have been structured so that they provide the core information required to develop the construction EMPs (CEMPs) and operations EMPs (OEMPs) required under the *Waste Management and Pollution Control Act* (NT) and the *Water Act* (NT).

Submission 107-10: The concentrations and hazards associated with the use of monoethylene glycol (MEG) do not appear to have been provided in the document. Consequently, the risk to the environment has not been fully described.

Monoethylene glycol (MEG) has a very low toxicity. MEG use is discussed at some length in Section 7.2.3 of Chapter 7 *Marine impacts and management* of the Draft EIS. Refer to response to Comment 105-15. Subsection *Production chemicals* notes that "MEG will be added in large volumes to the production process but will, in the main, be retained and recycled at the FPSO [floating production, storage and offtake (facility)]. Varying amounts of MEG will be discharged in the produced water directly to the marine environment … Studies on a green alga (*Chlorella fusca*), a freshwater crayfish (*Procambarus* sp.) and a golden orfe carp (*Leuciscus idus melanotus*) revealed low potential for bioaccumulation of MEG in the marine environment (IPCS 2000) … MEG biodegrades readily when released to the environment, in both aerobic and anaerobic conditions … It is considered that MEG poses a negligible risk of ecotoxicity, as lethal effects on exposed organisms can only be caused by very high concentrations in sea water."

It is considered that MEG poses a negligible risk of ecotoxicity, as lethal effects on exposed organisms can only be caused by very high concentrations in sea water. Ecotoxicity values for the effect of MEG on a number of aquatic organisms are provided in Table 7-8 of the Draft EIS; the high LC_{50} values indicate low toxicity.

Submission 107-13: Details of the expected concentrations of H2S and Hg that might potentially be released, and the expected environmental impacts associated with these impurities at those concentrations are not apparent and should be provided.

Details of the types, concentrations and anticipated environmental impacts of the "heavier hydrocarbons" identified in figures 4-5 and 4-6 are not apparent and should be provided.

In addition, a measure of the eco-toxicity of H2S, Hg and the "heavier hydrocarbons" to a variety of biota collected from the area and consumed should be provided. Without this level of information, a full assessment of potential effects on health of people who harvest from the area cannot be done.

The hydrocarbons that will arrive at Blaydin Point through the gas export pipeline will not be very heavy. Those heavier than butane (C_4H_{10} in figures 4-5 and 4-6 of the Draft EIS) will be mostly pentanes (C_5H_{12}), hexanes (C_6H_{14}) and slightly longer-chain hydrocarbons. Most of the long-chain hydrocarbons referred to in Figure 4-5 and Figure 4-6 will be removed offshore and will not be sent to Blaydin Point through the gas export pipeline. Detailed molecular breakdowns have not been provided for hydrocarbons in the C_5–C_{12+} range in Figures 4-5 and 4-6 because these hydrocarbons make up only in the range of 1–4.5% of the reservoir gas.

INPEX will be installing H_2S and Hg removal equipment offshore and onshore to remove these trace components. INPEX expects there to be almost no concentrations of heavy hydrocarbons, H_2S and Hg in wastewater discharges from Blaydin Point, and no impact on people who harvest in waters around Blaydin Point.

Submission 107-16: The proponent indicates that an open-loop system is likely to be used. If used, this will release "a small amount" of hydraulic fluid to the sea each time a valve is opened. If these fluids are different to the drilling fluids described above, the hazards associated with this hydraulic fluid should be identified and the total volume expected to be released on a weekly, monthly or annual basis provided. This will allow greater detail of any potential impacts over the term of the project and associated with the fluid to be more fully assessed.

It is common practice for the subsea natural gas developments currently operating off the north western Australian coast to use a system of open loop control valves at the wellheads, risers and manifolds. The hydraulic fluids used are specifically formulated to be water soluble and to have low toxicity (see Section 7.2.3 and Table 7-6 in Chapter 7 *Marine impacts and management* of the Draft EIS). These control-system fluids are different from drilling fluids. In Section 7.2.3 INPEX states that approximately 20 L may be discharged from each main valve at the bases of risers and manifolds about twice a year when they are operated and approximately 4 L may be discharged from the smaller valves at the wellheads about five times a year.

The Ichthys Field will be developed through the phased installation of subsea production equipment. Initial operations will be started with three drill centres (12 wells); an additional 12 to 15 drill centres (approximately 38 additional wells) will be installed over the subsequent 22 years. Considering this phased installation and operation of subsea equipment, INPEX expects the release of control system fluids to be less than 10 t in the first year of operation, then increase to around 200 t/a after Year 22 of the Project when all drill centres and wells are operational. From the first year of operation, routine subsea inspection programs, together with daily system monitoring, will help to ensure that any significant subsea control fluid leaks will be identified and repaired, in order to limit releases to sea to intended levels.

See also commitments 23.8 and 23.9 in Chapter 12 *Commitments register* of the Draft EIS.

Submission 107-17: The proponent indicates that triethylene glycol (TEG) will be used to dehydrate the gas. The volumes of TEG to be used and the hazards associated with TEG and the byproducts of the dehydration reaction should be provided.

Triethylene glycol (TEG) is used in a closed loop system to dehydrate natural gas before transmission through a pipeline, as is common practice on many offshore oil & gas facilities in north-western Australia. The "lean" TEG absorbs water from the gas and the resultant "rich" TEG is then heated to drive the water off and allow the TEG to be reused. No "by-products" are normally produced.

Submission 107-20: The FPSO will also be required for the removal of Hg from condensate. The proponent should describe the method by which this will be removed. This should also include an estimate of the volume of Hg anticipated, details of how and where it will be contained and the method for its disposal.

Offshore mercury removal methods are currently under review. Cartridge filters or solid adsorbent material may be used to reduce the mercury content of the condensate prior to shipment. However, other options are also under consideration. Disposal details will be identified in the Project's final waste management plan.

Submission 107-21: Details of the ballast including its source and the likely place of disposal should be provided. Legislation and standards relevant to disposal of ballast in Darwin Harbour and in international waters should be provided and used as a base against which INPEX's assessment of environmental risk associated with ballast is referenced.

Ballast water will be managed in accordance with legislative requirements as described in Section 7.2.8 of Chapter 7 *Marine impacts and management* and in Annexe 13 Provisional quarantine management plan to Chapter 11 *Environmental management program* of the Draft EIS. Sections 7 and 8 of Annexe 13 list the applicable legislative instruments and guidelines which deal with ballast water treatment and these include both Australian (e.g. AQIS 2008a, 2008b) and international (e.g. IMO 1978, 1998) requirements. Normally, potentially contaminated ballast water from a ship's port of origin will be exchanged for uncontaminated ocean water outside the Australian territorial sea to ensure that there will be no risk of contaminating Darwin or any other Australian coastal waters when the ship reaches Darwin Harbour or any other Australian port that may serve the Ichthys Project.

Submission 107-23: Volatile organic compounds (benzene, toluene, ethylbenzene and xylenes — BTEX) are expected to be produced. In §8.4.3 (page 400) INPEX indicates that the majority of BTEX compounds will be incinerated, but does not indicate what the concentration, toxicity, type or fate of these by-products of incineration are. These should be specified and also included in calculations of Greenhouse gas emissions if they are a significant contributor.

The purpose of the incinerators (see Section 8.4.3 of Chapter 8 Terrestrial impacts and management of the Draft EIS) is to combust hydrogen sulfide, methane and other hydrocarbons, including the BTEX compounds (benzene, toluene, ethylbenzene and xylenes), to carbon dioxide (CO_2) and water (H_2O). The contribution of the CO_2 from the combustion of hydrocarbons to the Ichthys Project's overall greenhouse gas (GHG) emissions will not be significant, but is included in the GHG totals. See also Table 9-2 in Chapter 9 Greenhouse gas management where, in the row dealing with the acid gas removal unit (AGRU) incineration, the figure of 0.1 Mt/a of CO_2 includes CO_2 from both the combusted BTEX and the fuel gas needed to fire the incinerator.

As noted in Section 9.8 of Chapter 9, activated methyldiethanolamine (aMDEA) has been selected as the solvent for CO_2 removal because it co-absorbs a smaller quantity of hydrocarbons than the other solvents that might be used. This means that the vent streams sent to the incinerators will contain smaller quantities of hydrocarbons and hence the CO_2 emissions after combustion will be reduced.

The BTEX burned in the incinerator is expected to break down almost completely to CO_2 and H_2O, with minimal by-product generation.

Submission 107-29: INPEX states that up to 1000t of subsea control fluids can be released each year from a single facility without prior notification to the Government. However, INPEX does not indicate what volume it actually expects will be released each year from this project, nor how much is allowed to be released if notification is given to government bodies. The systems to be put in place to notify, to control and to contain in the case of a larger-than allowed release, and the worst case scenario with respect to anticipated impacts, do not appear to have been identified.

In Section 7.2.3 of Chapter 7 *Marine impacts and management* of the Draft EIS, INPEX notes that subsea control fluids have been tested under the OSPAR Commission's Harmonised Offshore Chemical Notification Format (HOCNF). The testing includes an assessment of the potential of each component of a product to bioaccumulate and biodegrade in the environment, as well as the performance of three out of four possible toxicity tests that are chosen in accordance with the expected fate of the materials. Based on the results of these tests, the UK HOCNF classification for various water-based subsea control fluids is "Group E", representing the group of least environmental concern. Under this classification, up to 1000 t (approximately 1 000 000 L) of a substance may be released per annum from a single facility without prior notification to government bodies.

INPEX expects considerably less than 1000 t/a of subsea control fluid to be released from the combined offshore facilities at the Ichthys Field. The 1000 t/a figure is a conservative maximum, not a level that INPEX ever expects to exceed.

Section 7.2.3 of Chapter 7 *Marine impacts and management* of the Draft EIS states that approximately 20 L of control fluid may be discharged from each main valve at the bases of risers and manifolds about twice a year when they are operated, while approximately 4 L may be discharged from the smaller valves at the wellheads about five times a year.

See also INPEX's response to comment 107-16 of Section 5.2.2.5.

Submission 107-41: INPEX states that there may be some minor concentration of NORM in the pipeline scale. While the quantity of this material is likely to be very small and the radiation levels very low; the prospect of radioactive wastes is nevertheless a highly emotive issue. The APPEA guidelines are mentioned but not provided, so matters specific to the handling of NORM should be raised in the Supplement. It appears that the development of procedure for dealing with NORM is considered to be another future act that will not be covered through the normal environmental impact assessment process.

Submission 86-17: • Scale removed from gas pipelines may contain Naturally Occurring Radioactive Material (NORM). If the radiation level associated with the 20t of scale removed each 6 – 12 years at the plant is above the threshold outlined in the NT Radiation Protection Regulation 7, it must be treated as a radiation source and the Radiation Protection Act applies. An application for handling and disposal of NORM under the Radiation Protection Act must be made;

Submission 1-99: PART I Question 43 Waste Management – Will fluids arising from drilling activities be re-injected into the reservoir and include NORM (Naturally Occurring Radioactive Material) wastes.

INPEX acknowledges the comment in Submission 86-17. Any attempt to remove and dispose of naturally occurring radioactive materials (NORMs) will be performed according to the legislation and policies associated with such potentially hazardous materials.

This response provides additional information on the potential for the occurrence of NORMs during Ichthys Project operations, strategies for their management, and relevant Northern Territory legislative requirements and industry guidelines.

Draft EIS references to NORMs

- Section 7.2.5 in Chapter 7 *Marine impacts and management* discusses the potential for formation of scale that may contain NORMs within the processing systems.

- Section 5.7.2 in Chapter 5 *Emissions, discharges and wastes* also states that pipeline pigging wastes and wastes accumulated in the slug catcher will consist of a slurry of removed scale, sand, rust, and possibly small quantities of NORMS.
- Table 5-6 in Chapter 5 indicates that 20 t of scale may be collected during maintenance shutdown periods, which will occur every 6–12 years. This does not mean that there will be 20 t of NORMS, but that the scale has the potential to have small quantities of NORMs entrained within the scale deposit as a whole.

During the development planning for the Ichthys Field, INPEX identified and assessed the potential for scale formation, both across the field and from individual wells. These early results indicated that there is the possibility for scale deposition downhole and in the processing system. Scale inhibitor is likely to be used to dose wells and downhole infrastructure and throughout the processing systems to reduce scale formation.

The early field development and reservoir analysis results will be further substantiated by data collected once the field development wells are drilled, tested and in production. This will provide more information on the reservoir formations and individual well stream composition, both of which may change over the life of the development. The data collected from the well and field production will inform associated works programs, such as maintenance shutdowns, and allow for more accuracy in production-waste management (including actually and potentially hazardous wastes streams).

Explanation of scale and NORMS

Scale is a term used to refer to a deposit or coating formed on the surface of metal, rock or other material. Scale is caused by a precipitation due to a chemical reaction with the surface, precipitation caused by chemical reactions, a change in pressure or temperature, or a change in the composition of a solution. Typical scales are calcium carbonate, calcium sulfate, barium sulfate, strontium sulfate, iron sulfide, iron oxides, iron carbonate, the various silicates and phosphates and oxides, or any of a number of compounds insoluble or slightly soluble in water.

Produced water, having been in contact with various rock strata at elevated pressure and temperature, contains many soluble components including barium and the radioactive intermediates of the uranium and thorium decay series. As the water is produced the temperature and pressure decrease, creating conditions in which the barium and radionuclides can co-precipitate inside separators, valves and pipework, forming an insoluble NORM scale.

Some of the soluble radionuclides and particles of NORM scale will pass through the processing and separation systems and be discharged with the produced water at the FPSO. Similarly, some particulate scale and soluble radionuclides will be entrained with the exported gas by pipeline. This means that pipeline pigging and maintenance/cleaning activities associated with the onshore gas export pipeline receiving facilities (such as the slug catcher, pig receivers and associated waste sludges) may have wastes, including collected scale, that may have low levels of NORMs present.

Although certain parts of the produced water process system may be cleaned periodically, there is the potential for a quantity of NORM scale to remain within the system; this must be dealt with at the time of decommissioning of the installation. Whether the NORM scale is cleaned and discharged offshore or at an onshore location will be installation-specific and determined during the development of the decommissioning plan.

Reinjection of scale that may contain NORMs is not considered a viable option by INPEX.

Management strategies and controls

Further details are provided below on management of NORMs to support information provided in Annexe 16 *Provisional waste management plan* of Chapter 11 *Environmental management program* of the Draft EIS.

The Northern Territory Government regulatory environment relating to radiation sources and materials are covered under the *Radiation Protection Act* (NT) and the Radiation Protection Regulations (NT). Should waste scale produced during shutdown programs exceed (or be anticipated to exceed) the threshold limits for NORMs outlined in the Radiation Protection Regulations, relevant legislative application and approvals including a detailed management plan for handling and disposal will be made as per the strategies outlined above.

Suitable disposal options will be identified (e.g. discharge to the marine environment for dilution and dispersion) that are in accordance with industry practice as outlined in the APPEA "Guidelines for naturally occurring radioactive materials" (APPEA 2002) and in the Northern Territory Government's "Guidelines for application for approval to dispose of petroleum related naturally occurring radioactive materials (NORM)" (DRDPIFR 2008).

Submission 107-48: Aluminium is a light metal and should not be referred to as a 'heavy metal'. Its impacts are different to true heavy metals but should nevertheless be considered and described.

There is no widely accepted definition of the term "heavy metal". The International Union of Pure and Applied Chemistry (IUPAC), has produced a technical report on "Heavy metals"—a meaningless term?", which was published in the journal *Pure and Applied Chemistry* 74: 793–807 in 2002 (IUPAC 2002). The paper notes the following:

> The term "heavy metal" has never been defined by any authoritative body such as IUPAC. Over the 60 years or so in which it has been used in chemistry, it has been given such a wide range of meanings by different authors that it is effectively meaningless. No relationship can be found between density (specific gravity) and any of the various physicochemical concepts that have been used to define "heavy metals" and the toxicity or ecotoxicity attributed to "heavy metals".

That IUPAC's conclusion is correct is supported by much of the literature on the management of acid sulfate soils in Australia and elsewhere, where the term "heavy metals" is standardly used without a clear definition. Refer to the following, for example:

- The Victorian coastal acid sulfate soils strategy (DSE 2009) published by Victoria's Department of Sustainability and Environment: "Other heavy metals and metalloids (such as arsenic) can also be mobilised … Sulfuric acid has the potential to mobilise heavy metals such as arsenic and aluminium which may be dissolved in the soil …"
- Queensland's guidelines for sampling and analysis of lowland acid sulfate soils (Ahern, Ahern & Powell 1998) published by Queensland's Department of Natural Resources: "… to remove toxic forms of aluminium and other heavy metals …"
- Queensland's acid sulfate soil management guidelines (Dear et al. 2002) published by Queensland's Department of Natural Resources and Mines: "… contain sulfides and high levels of arsenic (and other heavy metals) … Furthermore, aluminium, iron and other heavy metals that are more soluble in acidic waters … "
- A study of the mobility of radium and heavy metals from uranium mine tailings in acid sulfate soils (Willett, I.R., Noller, B.N. and Beech 1994): "Four soils were studied: two samples were acid sulfate … materials and two were acidic materials overlying acid sulfate horizons. Copper, iron, manganese, lead, uranium and zinc fractions were determined".

So, from these it can be seen that all five metals and metalloids mentioned in Chapter 8 and Annexe 1 of Chapter 11 of the Draft EIS, namely iron, aluminium, manganese, copper and arsenic, are named as heavy metals in an acid sulfate context.

On the one hand, the world's peak chemistry body IUPAC says that the term "heavy metal" cannot be defined and is therefore "meaningless". On the other hand the term is nearly always used by scientists and biologists studying acid sulfate soils because it is a handy and convenient term, which is rarely defined and which most users know is imprecise and loose.

Submission 107-52: Oils and petroleum products often contain high levels of heavy metals, such as V, Cd and Pb. The potential risk associated with burning of oily wastes and other by products (including BTEX) from this process should be described in terms of potential concentrations of heavy metals, their volatility and toxicity to the terrestrial environment.

Submission 107-53: Plans for the mitigation and management of heavy metal emissions from the process should be devised and described within the EIS.

Some crude oils and semi-refined petroleum products contain high levels of heavy metals. However, the primary turbine fuel used at the LNG plant will be natural gas which will be extremely low in heavy metals, and so the associated risk to the terrestrial environment will be very low. Gas flares and the waste-gas incinerators, all of which will have very low heavy metal emissions. Diesel fuel will be used as an alternative fuel for backup power generation and also in emergency equipment such as firewater diesel generators. The quantity of diesel consumed per annum will be small compared with the amount of gas consumed as fuel. The diesel used will meet the requirements of the *Fuel Quality Standards Act 2000* (Cwlth) and will contain virtually no heavy metals.

Submission 107-69: Of interest is the oily water management system, where a disposal criterion of a certain quality as the output is only provided. The basis for the provided criterion (<10mg/L) should be explained; and greater detail on how this system operates discussed.

Prior to commencing operations at its onshore processing facilities at Blaydin Point, INPEX will require an environment protection licence from the Department of Natural Resources, Environment, the Arts and Sport (NRETAS). INPEX found the <10-mg/L TPH criterion in the environment protection licences for other facilities discharging into Darwin Harbour just before the Draft EIS was published.

In addition, Chapter 7 *Marine impacts and management* of the Draft EIS Section 7.3.4 *Toxicity of wastewater* discusses how INPEX decided on a conservative threshold of 0.007 mg/L (7 parts per billion) of TPH in Harbour water outside the onshore processing plant's discharge point. The 0.007-mg/L TPH concentration in Harbour water will be achieved outside the small mixing zones shown in Figure 7-31 in Chapter 7 for the maximum discharge rate at 10 mg/L of TPH.

The oily-water treatment system described in Section 5.6.3 in Chapter 5 *Emissions, discharges and wastes* of the Draft EIS and shown in the schematic diagram in Figure 5-2 of that chapter will consist of storage tanks, a corrugated plate interceptor (CPI) for initial gravity separation of the oil from water, followed by a dissolved air flotation (DAF) unit for further de-oiling of the wastewater. Potentially oily wastewater will also be passed through sand or other filters downstream of the DAF unit to make sure that the TPH specification is met.

Submission 107-70: In summary, the draft EIS places various and often unidentified toxic agents against a receiving system ecology that does not appear to have been fully described. The resulting perception is that receiving system ecology is complex and largely unknown, and therefore that the full extent of the hazards and risks posed by the project has not been fully detailed. Given the volume and nature of hazardous chemicals that may be released, and the longevity of the project, significant additional effort will be required to achieve and to maintain best practice environmental management during the life of this project.

All chemicals used by the Ichthys Project will be assessed based on INPEX's chemical selection process, to ensure that the most environmentally acceptable chemicals are used and provided that they also meet technical and safety standards.

INPEX will carry out a wide range of environmental monitoring programs (as discussed in Section 11.4 of the Draft EIS) to ensure that chemicals selected and used on the Project meet the Project's environmental objectives.

Submission 120-31: It appears that there will be a considerable amount of wastewater, hydrotest water, treated sewage and other liquids that will be discharged into Darwin Harbour during the construction and operational phases of the Ichthys Project. A temporary wastewater outfall is proposed for the construction phase and a permanent outfall at the end of the loading jetty will be used once construction is complete (Draft EIS p. 200 and 203).

AFANT takes the view that the Ichthys Project will be just one of a number of developments that will be located in this area or further upstream in Darwin Harbour (the new city of Weddell for example). This means that we should be considering the possibility of cumulative impacts. While the liquid discharges proposed by Inpex may not in themselves have a significant impact on water quality in the harbour, they could well contribute to adverse impacts if there are more discharges of similar waste from other developments. With this in mind we are suggesting that Inpex should set the standard for others to follow.

Treatment processes proposed for sewage and grey water in the operational phase are intended to produce "high-quality treated wastewater suitable for discharge and for irrigation." (Draft EIS p. 224) Depending on the treatment system in place for the construction phase of the project, processed sewage and grey water will either be taken to existing sewage treatment facilities, discharged into the harbour or applied to ground infiltration (Draft EIS p. 223-224). AFANT's view is that, with modern technology, it should not be necessary to discharge any treated sewage or grey water into Darwin Harbour and that it should be used for irrigation or other purposes. This issue should be clarified between Inpex and the NT Government regulators to ensure treatment quality is acceptable for irrigation use.

INPEX intends to treat all its sewage to a high enough standard to allow all sewage treatment plant wastewater to be used for irrigation purposes. However, the requirement for irrigation water on Blaydin Point will be limited. Discussion on cumulative impacts is provided in Section 4.13 of this EIS Supplement.

Submission 120-32: Plans for wastewater management (Draft EIS p 343 and 576-585) appear to be generally satisfactory but should include consideration of methods to reduce the overall amount of wastewater (other than pre-plant levels of surface run-off) that will be required to be discharged through the outfall into the harbour.

Table 5-6 in the Draft EIS estimates that the dry-weather continuous wastewater flow rate to the Harbour will average approximately 18 m^3/h. This will be made up as follows:

- 3 m^3/h of treated sewage
- 7 m^3/h of demineralisation brine
- 8 m^3/h of steam loop bleed.

Flow rates above these levels will be either due to either:

- short-term variations in year-round sources, e.g. that the rate of sewage treatment plant effluent will vary throughout the day/night around shift timings, or
- rainfall, which would occur independently of the existence of the plant.

None of the three primary dry weather streams listed above will contain hydrocarbons or other contaminants that would preclude their use for irrigation purposes, should there be need for irrigation water anywhere on Blaydin Point.

INPEX has already undertaken and adopted the recommendations of a number of water minimisation and water reuse studies to both minimise the need for potable water import and minimise wastewater discharge. Further efforts between now and plant construction and commissioning may allow further reduction of wastewater discharge.

Submission 120-33: It appears that the proposed discharge of large amounts of hydrotest water during the commissioning phase of the project is relatively high risk (Draft EIS p 341) and hydrotest water management plans have not yet been developed (draft EIS p. 581). Every effort should be made to avoid the need to discharge this water into the harbour and, if discharge is unavoidable, we would want to see clear evidence that it can be treated to produce water quality levels that will not adversely impact the harbour environment including the area close to the outfall. Also, it is not clear to us if the temporary or permanent outfall would be available for any such discharge.

INPEX will endeavour to minimise the amount of hydrotest water needed, e.g. through possible reuse of water used to hydrotest one tank as hydrotest water for a second tank. However, some amount of hydrotest water will need to be discharged to the Harbour since there is no immediate use for (or storage capacity for) large volumes of such water.

The types and amounts of treatment chemicals that may need to be added to hydrotest waters will be minimised to the extent possible. Chemicals will be assessed to understand the environmental risks. Appropriate controls to mitigate risks will be included in a hydrotest management plan, which will be prepared and approved by government before hydrotesting.

Most likely the permanent outfall will be available in time for some but not necessarily all of the hydrotest water discharges.

Submission 120-34: Other types of waste proposed for discharge through the jetty outfall during the operational phase include "process water" and "demineralization reject water" (Draft EIS p. 339 and 577). These discharges will be continuous but we have not been able to identify the quantities of the proposed discharges and what, if any, environmental risks they may pose. This should be more clearly detailed in the Supplementary EIS. (We note the assumptions and modeling described in Technical Appendix 10 but it does not make this issue much clearer for the lay person.)

Submission 122-7: DHAC is of the opinion that INPEX should be adopting best available technology and practice. As such, DHAC seeks that further consideration be given to waste water and sewerage management. DHAC's preference is for zero or at least an absolute minimum of discharge to the marine environment, even following appropriate treatment. Indeed, further development of recycling options for all water is recommended.

Process water, as mentioned in Section 7.3.4 in Chapter 7 *Marine impacts and management* of the Draft EIS, will be made up almost exclusively of water drained from the bottom of condensate tanks. It will contain traces of condensate and will need to be treated to remove condensate. A few cubic metres of such water will need to be removed from the condensate tanks every few days or weeks, depending on the build-up rate. As shown in Table 5-6 in Chapter 5 *Emissions, discharges and wastes* of the Draft EIS, INPEX expects that there will normally be no flow of process wastewater through the wastewater treatment system. When process wastewater is being treated, it will be at a processing rate of approximately 1 m^3/h. The intention is to treat oily process water through a gravity separator, an air flotation unit, and then a filter, to ensure that there is less than 10 mg/L of total petroleum hydrocarbon (TPH) in the treated water. INPEX does not expect any residual risk to the Harbour from such a small and intermittent stream, processed as planned prior to discharge. See also the response to comment 107-69 in Section 5.2.2.5.

In contrast to process water, demineralisation reject water will be a continuous discharge. Table 5-6 of the Draft EIS shows an expected rate of around 7 m^3/h on average. The LNG plant will require several cubic metres per hour of high-purity water with almost no mineral content. Such water will be needed in the amine CO_2 removal unit and, potentially, in the steam loop in the combined-cycle power plant. These facilities will evaporate water and hence will need make-up of mineral-free water to avoid rapid scale and sediment build-up. Demineralisation water will be created by further processing potable water purchased from the Northern Territory's Power and Water Corporation (PWC). The reject from this process, called "demineralisation reject water" will essentially be slightly more saline potable water, but still far less saline than sea or Harbour water and will contain few if any treatment chemicals. This stream (as with treated sewage effluent and steam loop water, the other two continuous discharges) can be used for irrigation, but for the purposes of the Draft EIS, INPEX has stated that they may be discharged to Darwin Harbour since it is expected that there will be only a limited need for irrigation or dust suppression water on Blaydin Point after plant start-up.

Submission 123-238: It is acknowledged that Volatile Organic Compounds (VOCs) including air toxics are generally present in low concentrations in ambient environments, however, characteristics such as toxicity or persistence for some of these substances means they can be hazardous to human, plant or animal life and as such air quality goals for these compounds are usually very stringent. A comparison of the Ichthys proposal with other industry sources in the NT through the National Pollutant Inventory (NPI) indicates INPEX will be the single largest producer. According to table 5.1, INPEX will produce 500 tonnes/annum and the only comparable NT emitters are offshore gas platforms. The biggest Darwin-based emitter is ConocoPhillips with 120 tonnes/annum. The Air-NEPM are becoming concerned about research indicating that there are no safe minimum levels reported for some of the more serious VOCs such as Benzene and PAHs. Further discussion of potential impacts from air toxics such as benzene and formaldehyde should be included in the EIS.

INPEX plans to incinerate the emissions from the acid gas removal units at the onshore processing plant at Blaydin Point as these emissions will contain volatile organic compounds (VOCs), including the BTEX compounds (benzene, toluene, ethylbenzene and xylenes), as well as small amounts of hydrogen sulfide (H_2S). The incinerators (one for each of the two LNG trains) will convert almost all of the VOCs to CO_2 and water. The Blaydin Point onshore facilities will also emit VOCs, including small amounts of BTEX, from the loading of condensate ships. When it is necessary to bypass one of the two incinerators (one on each LNG train) for maintenance purposes, then the small amounts of hydrocarbon and hydrogen sulfide will instead be vented to atmosphere. This will be done through 65-m-tall turbine exhaust stacks at high temperature to ensure that there is good dispersion of the small amounts of hydrocarbon and hydrogen sulfide.

The Ichthys Project, including the Blaydin Point facilities, will not process or otherwise use polycyclic aromatic hydrocarbons (PAHs) or formaldehyde. As noted in the Draft EIS in Annexe 2 *Provisional air emissions management plan* to Chapter 11 *Environmental management program*, emissions of benzene and other air pollutants will be reported annually under the National Pollutant Inventory (NPI) reporting requirements (NEPC 2008). INPEX will conduct air quality monitoring during the operations phase to confirm that any air toxics remain within the National Environmental Protection (Air Toxic) Measure's monitoring investigation levels. INPEX will also continue to monitor the progress towards development of air toxics standards through the Environmental and Heritage Council.

Submission 123-240: It is not clear from this section how the emission estimates for normal and also upset conditions were derived, whether by using emission factors or manufacturers emission guarantees. There are insufficient data provided to allow a review of emission estimates, i.e, emission concentrations, flow rates, emission factors, fuel consumption.

This information should be provided to facilitate further assessment of the modelling.

The following general observations have been made in the absence of the above information and require clarification in the EIS:

- Confirm that stack heights for compressor turbines and power generation turbines are 65 m and 40 m respectively. These seem high.
- Emissions rates in Table 8-2, 8-3 and 8-4 are provided as N02 however the emissions are modelled as NOx with a NOx/NO ratio of 0.9. Clarify whether the emission rates in Table 8-2, 8-3 and 8-4 are provided as NOx or N02. It is assumed the emissions are presented as NOx, as this is mentioned in the text , but the tables" headings have a typographical error. The emission rates provided in Bechtel 2001 for the Darwin LNG plant are provided as NOx and these are the same as in the SKM report, but reported as N02 in the table heading.

Gaseous emission estimates for the onshore processing plant at Blaydin Point have been derived by considering both emission factors and vendor guarantees. In most cases emission factors and operating experience from similar equipment in other locations give more accurate emission predictions as vendor guarantees are conservative and often tend to overestimate average, long-term emissions.

The emission-rate modelling assumptions used for nitrogen dioxide (NO_2) are high and conservative. Lower NO_2 emissions are expected during operations than have been assumed for Draft EIS modelling purposes.

The stack heights planned are 65 m and 40 m for the Frame 7 and Frame 6 gas turbines respectively. Higher stacks will allow better dispersion of turbine exhaust gases. INPEX agrees that stacks in the 35–40 m range are often provided at other similar facilities.

The NO_x emissions from any combustion source are always a mixture of nitric oxide (NO) and NO_2. Normally the emissions of nitrogen oxides (NO_x) (see Glossary) are assumed to be 100% NO_2 in order to be conservative. NO_2 molecules weigh more than NO molecules because of the extra oxygen atom; for this reason, an emission rate of a given number of NO_2 molecules will always weigh more than an emission rate of the same number of NO or NO_x molecules (e.g. on either a gram/second or tonne/annum basis). Assuming that the NO_x consists entirely of NO_2 molecules therefore maximises the emission rate of NO_x on a weight basis. Since NO_2 molecules weigh more than NO molecules, it is also more conservative to carry out air modelling assuming NO_2 emissions; NO_2 molecules are heavier than air whereas NO molecules are approximately the same weight as air (a 79%:21% mixture of N_2:O_2). For this reason, assuming 100% NO_2 increases the concentration of "NO_x" in ground-level contours makes the model results conservative.

Submission 128-13: (Table 5.7) The contaminates associated with the liquid discharges from the onshore facilities do not indicate the presence of biocides, anti fowling agents contained in the hydro test water or any other potential contaminates and physiochemical parameters which have the potential to occur in the waste water. It is questioned that detail contained in the table is somewhat understated.

Questions which arise are:

What is the expected impact of discharging contaminated hydro test water into the harbour in the case of emergency?

A similar question arises for reject water and waste water from de-scaling and cleaning of filters. What other options are available managing this water.

What volumes of co-mingled waste water are expected to be discharged into the harbour?

What arrangements will be put in place for INPEX to fully attend to the treatment and discharge of sewage into the Harbour? The Draft EIS indicates that INPEX will not manage their sewerage through any new 'best practice' technologies that could be put in place with 'on site' arrangements and which would provide themselves and Darwin with a contemporary response to the water quality of Darwin Harbour.

Treated waste water will be discharged into Darwin Harbour via a combined outfall on the loading jetty. This is also cause for concern as the deposit may be after the macerator point at the loading jetty. Clarification is sought as to the way of disposal and at what point it will be made to the outfall site.

It is unclear as to how sediment runoff from the site will be managed and what the expected quantities of sediment and silt are that will be carried off site particularly during construction.

INPEX should be required to provide a full treatment plant for their sewage.

Submission 128-14: Nearshore discharge characteristics. Concern over the effects of discharging unknown quantities of contaminates into the harbour. Further information and clarification is required.

Table 5-7 in Chapter 5 *Emissions, discharges and wastes* of the Draft EIS addresses the contaminants expected in discharges during the operations phase of the plant. Table 5-7 does not include hydrotest water which will be generated during initial plant commissioning.

INPEX will endeavour to minimise the amount of hydrotest water needed, for example through possible reuse of water used to hydrotest one tank as hydrotest water for a second tank. See INPEX's response to comment 120-33 in Section 5.2.2.5. Any treatment chemicals that may need to be added to hydrotest waters will be minimised to the extent possible, and a hydrotest management plan will be prepared and agreed with government before hydrotesting commences.

No emergency discharge to Darwin Harbour of hydrotest water will be necessary from the plant (e.g. from tanks and lines). The Draft EIS, on page 223, Hydrotest Water paragraph 3, stated that up to 10 000 m^3 of hydrotest water might need to be discharged on an emergency basis from the gas export pipeline during a cyclone. After further assessment, INPEX can now state that emergency release of hydrotest water from the gas export pipeline will not be necessary.

At this time INPEX expects to evaporate water from de-scaling operations. If any water from this source is sent to the Harbour it will meet all the criteria listed in the environment protection licence to be issued to INPEX by NRETAS.

INPEX plans to treat all its sewage during both the construction and operations phases. No sewage will be discharged to the Harbour without bio-treatment and achieving an agreed discharge specification. Some sewage may be relocated from site to an authorised sewage treatment plant for treatment during the early construction period before INPEX or its contractors have had time to install permanent or temporary biological treatment facilities.

Submission 128-15: Waste generated onshore

1. What locations are being considered for the disposal of offshore waste?
2. Reference is made to the Shoal Bay Waste Management Facility as being a Northern Territory facility which conveys a sense of it being a Northern Territory Government landfill.

Given Shoal Bay is a facility provided by Darwin City Council a strong indication of this should be sought in documentation so that the matter is clear to Governments, Industry and the public.

Shoal Bay Waste Management Facility does not accept waste generated from outside the greater Darwin area. Darwin City Council does not accept heavy industry waste therefore Inpex will need to enter into further discussions with Darwin City Council on the matters of waste management.

Submission 128-22: Waste. The draft EIS reports that waste generated from off shore will be brought onshore for disposal. Shoal Bay Waste Management Facility is a municipal landfill and Council does not accept large quantities of industrial waste.

Has INPEX considered alternative locations for waste disposal?

Submission 128-25: Waste. There are no details provided on volumes of waste expected to be disposed of except for what has been identified in Table 4-7 page 207 Assumed Average Peak Daily Road Traffic Generated by Construction.
The reported estimated vehicle movements to Shoal Bay suggest large quantities of waste are expect to be disposed of at Shoal Bay during construction.

Origin	Round Trips/Day (estimation)	Cargo
Blaydin Point	30	Waste
Blaydin Point	80	ASS
Accommodation Village	2	Waste

* Information obtained from the Shoal Bay Weighbridge Office, suggests that approximately 300 vehicles a day currently pass over the weighbridge. Therefore further discussions are required to be held with Darwin City Council to address a potentially significant increase in traffic.

Submission 128-26: Listed Waste. Darwin City Council landfill is referred to as ‘Northern Territories Shoal Bay Waste Disposal Site’;

This landfill is owned and operated by Darwin City Council and is a municipal landfill servicing the Darwin municipality and near neighbours.

It is not a regional/Territory facility and clarification in this regard needs to be made to both INPEX and the Northern Territory Government for further discussion.

The classification of non hazardous waste includes liquids and sewerage, both of which are not accepted currently at Shoal Bay Waste Management facility.

Submission 128-27: 7 Applicable Legislation, Standards and Guidelines

Whilst Northern Territory Government legislation, standards and guidelines are mentioned there is no reference to Darwin City Council requirements for disposing of waste at Shoal Bay.

As noted in these comments, the Draft EIS refers in a number of places to the Northern Territory’s Shoal Bay Waste Disposal Site. It was not the intention to suggest that this is a Territory government-owned facility. INPEX recognises that this facility is a landfill with restrictions on the types of wastes able to be disposed of and that the facility is owned by Darwin City Council. It is further recognised that Shoal Bay may not be used as the primary disposal site.

The submitter also refers to the EIS statements on hazardous waste and Shoal Bay. However the EIS does not state or make assumptions that Shoal Bay does accept commercial hazardous waste sewerage or liquid waste.

The Draft EIS states in Section 10.3.3 of Chapter 10 *Socio-economic impacts and management*, “Local waste-disposal capabilities catering for wastes generated during the construction and operations phases will be addressed during the detailed design phase of the Project. This will be done in consultation with the relevant local-government authorities.” INPEX’s reference to “local-government authorities” here was to local governments or councils as opposed to territory or state governments.

See also Section 3.3.3.2 in this EIS Supplement.

Submission 128-28: Hazardous Waste. Shoal Bay Waste Management does not accept commercial hazardous waste or liquid waste.

INPEX needs to makes alternate arrangements to dispose of these materials?

Submission 86-13: (Table 5-9) Information is to be provided as to how the proponent proposes to dispose of an estimated 5 tonnes per annum medical waste.

There is currently no facility for controlled-waste handling or disposal in the Northern Territory and most controlled wastes are transported interstate for disposal (e.g. to South Australia or Western Australia).

Appendix A to Annexe 16 *Provisional waste management plan* to Chapter 11 *Environmental management program* of the Draft EIS contains the “listed wastes” prescribed under Schedule 2 of the Waste Management and Pollution Control (Administration) Regulations (NT).

Section 1.2 of Annexe 16 notes that only listed wastes that have been determined under the New South Wales Environment Protection Authority Waste Guidelines (DECC 2008; DECCW 2009) as acceptable for disposal by burial may be disposed of at the Shoal Bay Waste Disposal Site (DIPE 2005). INPEX has the information relating to which wastes may be accepted at Shoal Bay and this will be included in tender packages during the prequalification of suitable waste-management contractors. It is recognised that existing disposal options (i.e. landfill or incineration) are limited and that additional options may need to be assessed.

Annexe 16 *Provisional waste management plan* to Chapter 11 *Environmental management program* of the Draft EIS will guide the development of a series of more detailed plans during the construction and operations phases of the Project. In addition to the management controls outlined for non-hazardous wastes, key inclusions for hazardous wastes are as follows:

- Chemicals and hazardous substances used during all phases of the Project will be selected and managed to minimise the potential adverse environmental impact associated with their disposal.
- All hazardous liquid wastes will be stored over a bund in leakproof sealed containers.

Any requirements to dispose of hazardous wastes will be identified and appropriate management options will be selected that are in accordance with industry best practice and legislative requirements.

5.2.2.6 General and miscellaneous issues

Submission 1-5: Can INPEX and the NT Government supply to the EIS the list of the individuals, along with their qualification, experience and positions of responsibility in the oil and gas industry?

INPEX has complied with the requirements of the EIS Guidelines as published and provided a list of contributors to the preparation of the Draft EIS. This level of information is considered adequate.

Submission 1-6: Why have INPEX mislead the EIS stating that there is little opposition to this project?

Submission 1-7: PART I Question 6 Why is INPEX EIS ignoring educated opposition and argument to the location of the plant at Blaydin Point?

INPEX has conducted surveys during the public review period of the Draft EIS which showed approximately 74% of Darwin residents support the Project.

The Project also received the bipartisan support of the Northern Territory Parliament in passing the Project Development Agreement in 2009.

Submission 1-8: What are INPEX’s and NT government timeline constraints and pressures from Japan that wish them to rush the legal planning process in the NT?

INPEX commenced the assessment process for the Project in May 2008, which was preceded by the initiation of various environmental surveys. Since that time, INPEX has invested millions of dollars and substantial hours of effort to address all issues raised through not only the environmental approval process, but all other legal prerequisites for the Project to proceed.

INPEX intends to be fully compliant with all relevant Northern Territory and Commonwealth government regulatory requirements and planning processes for the Ichthys Project.

Submission 1-47: Land Management and Biodiversity – Does INPEX recognise the importance of biodiversity issues at Blaydin Point and seek to address these issues as an integral PART of the way they do business? INPEX biodiversity action plans should set objectives and measurable targets to ensure positive results for biodiversity through its operations, education, and conservation projects. INPEX must undertake surveys of vegetation and wildlife within the operational areas. This includes monitoring Marine life, reptiles and bird life within Darwin Harbour.

Submission 7-1: Surveys. In general I found that the EIS guidelines have not been fully responded to and therefore there is insufficient information to enable the clearing of any portion of the site or blasting of the Darwin Harbour due to a defined impact the construction will have on flora, fauna, water and air quality of that in existance, now and in the future. The comments in the draft proposal that the Australian continent is simply a small part of the wider range of most species continues in the EIS and remains objectionable and gives no cause to destroy a habitat. General species that are separated by distance increase the gene potential to retain existance and maintain the surviveal of the species should an area be destroyed – which we are increasingly doing. It is also recorded in history that numerous species are recognised as subspecies as their separation from other species has resulted in a genetical modification with often slight differences. Appeasement to fisheries and heritage to retain the Catalin Reef in its existing place is flawed as abutted mangroves (30ha) where fidlings rear will be destroyed and the Wishart Industrial area between East Arm and the proposed INPEX site will add further stress to that area. It is also noted that there is a proposal by Darwin Clean Fuel for an alternative extension site behind the INPEX site and to have a pipeline across the harbour to East Arm which will further turbid the waters. A proposal to build a chemical and phosphate plant (no location given) is likely to be in this area too.

These comments raise a broad range of issues which are addressed in their entirety through the scope of the environmental approval process.

INPEX as the Operator of the Ichthys Gas Field Development Project is committed to undertaking a thorough and transparent environmental assessment of the Project under both the Northern Territory's *Environmental Assessment Act* and the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999*. This joint process of environmental impact assessment is designed to deliver informed decisions by both the responsible minister in the Northern Territory and the Commonwealth Environment Minister in regard to the environmental acceptability of the Project. This process is described in greater detail in the Section 1.2 of Chapter 1 *Introduction* of the Draft EIS and at the relevant government web sites (NRETAS and DSEWPaC: <http://www.nt.gov.au/nreta/environment/assessment/index.html> and <http://www.environment.gov.au/epbc/assessments/index.html>.

The Draft EIS and this EIS Supplement provide information which give due consideration to the environmental, social and economic impacts and benefits of the Project to facilitate informed decision-making by the ministers. For example, and relevant to these particular comments, INPEX has already "undertaken surveys of vegetation and wildlife within the operational areas" which are sufficient in detail to enable an informed determination of the environmental impacts of the Project, and ultimately lead to an decision of the Project's environmental acceptability by the relevant government environment ministers. INPEX has committed to a detailed environmental monitoring program as outlined in Chapter 11 of the Draft EIS.

Submission 7-2: There is still a notable exclusion in the list of Acts & Legislation that are to be followed, namely the WorkSafe NT Act.

1. INPEX Browse Ltd, Ichthys Gas Field Development NOTICE OF INTENT—BLAYDIN POINT, DARWIN Doc No: DEV-EXT-RP-005 Revision 2 Date: 5 May 2008 Page 42 of 52 Point 7.1 states

- To assist in meeting this commitment, a Health, Safety and Environment (HSE) Management Process has been developed. Ownership of the HSE Management Process resides with INPEX's management team who will ensure that adequate resources are provided to guarantee the successful implementation and sustainability of the Process.

2. There are many ‘management plans’ for individual concerns – Chapter 8 11.2.8 Element 8 page 497: Emergency and crisis management presumably will cover a Disaster and/or Recovery Plan particularly in the event of War, Terrorism or Natural Disaster for the period after the Project implementation and maintenance of the plant thereafter. “All emergency and crisis management plans will contain the identification of resources (personnel and equipment), key roles and responsibilities, and the procedures to be followed if the plans are activated. Relevant personnel will receive sufficient training to ensure that they have the skills and competence to respond to an emergency”. This management plan should be produced, audited independently and publicised prior to final approval to proceed. The plan should incorporate both off shore and on shore and show that emergency communications are reliably interactive between both sites.
3. A further dumping of waste water and sewerage into the Darwin Harbour is not acceptable given that the Harbour does not ‘flush’ with tidal flow but merely moves around the harbour.
4. There was no mention of who would be responsible and fund a Disaster Recovery ~ resources and the timeframe those resources would be on site.
5. The APPEA award inserted into the proposal covers ‘drilling’ not gas plant construction, maintenance and safe storage achievements.
6. The Plant will have its own emergency response team however it will still heavily rely on current Darwin emergency response teams – who will be funding the increase of infrastructure and man power to cover the Risks of an additional plant in the Harbor particularly during the Dry Season when resources are fully stretched with fire management. (Ref Point 1 above)
7. There was no mention of whom or how the increase of shipping in the harbor is to be managed. (Quarantine, CSIRO and Berrimah Farm have reduced budgets and in fact are now replaced with BioSecurity based in Canberra. No mention of how these services are going to manage an increase of shipping in the harbor). It is noted that there is a Proposed NTG Tender to Review the Darwin Port Authority & another for provision of additional equipment.
8. No mention of certification requirement of shipping into the Harbor. Will the Darwin Port Authority have addition resources to cover monitoring of ships into the harbour particularly in relation to Tributyl tin compounds. UNEP/FAO/RC/CRC.1/27.rev.1 & checking of shipping for pests attached to below water points?
9. Ballast or waste dumping restrictions from shipping in the Harbor or at what distance it must be from the coastline. Will the Darwin Harbour Port Authority have additional resources to monitor?
10. No mention of shipping priority into the Harbor or designated waiting anchorage area.
11. At the end of the life span there is the understanding that the site and surrounds will not be fully rehabilitated or returned for other use due to the fact that some infrastructure may not be able to be removed as too great a risk! There is no mention of an amount being paid into a monetary trust fund for this rehabilitation.
12. No mention of responsibility for road infrastructure & maintenance of existing roads that will be impacted during and after the project implementation. Traffic models have been completed showing that one or more areas do exceed the safety expectation. There have already been a number of fatal road train related accidents within the proposed traffic route in recent months.
13. Still no Risk assessment or results of explosion that may be caused by natural causes or acts of war or terrorism. What is the known devastation zone for an explosion; are current residential areas within that zone? http://www.austlii.edu.au/cgibin/sinodisp/au/cases/vic/VSC/2001/263.html?stem=0&synonyms=0&query=longford
14. A pipeline through or within close proximity to an active Military zone is not acceptable ~ there is a Risk of accidental damage to the pipeline which will impact at both the commencement and destination points even though Defence has approved no risk.
15. No performance indicators by which all anticipated and potential impacts can be measured.

This submission refers to a number of issues, which are addressed, where possible in sequence below. (The numbers refer to the numbered items in the submission comment).

1. With reference to the “Worksafe NT Act” quoted in the submission, it is not clear as to what specific legislation the submitter is referring to as there is no legislative instrument of this name. In regard to health and safety regulation, INPEX’s Health and Safety Policy is provided as Figure 11-3 in Chapter 11 *Environmental management program* of the Draft EIS. This policy states clearly that “INPEX will … comply with all applicable laws and regulations and apply INPEX standards where laws and regulations do not exist or are considered insufficient”.

2. Management plans provided in the Draft EIS are provisional. All management plans will be finalised at the appropriate time in the design and development of the Project and will be fully assessed by the appropriate regulating authority.
3. Details of wastewater discharge into the Harbour and the specifications of the discharge are provided in the Draft EIS, and further updated in this EIS Supplement. Impacts to the Harbour from such discharges are deemed to be of low to medium risk (Table 7-34).
4. INPEX is responsible for insurance and direct costs with emergency planning and response which covers all credible emergency scenarios.
5. The APPEA awards refer to environmental practice; and highlights INPEX's commitment to sound environmental practice in general.
6. INPEX will provide the necessary resources to respond to incidents that may potentially occur at the Blaydin Point site.

7 – 10. Management of Darwin Harbour is the responsibility of Darwin Port Corporation. Management of quarantine and biosecurity in Darwin Harbour is the responsibility of the Australian Quarantine and Inspection Service (AQIS). INPEX will however have its own quarantine procedures (refer to Chapter 11 of the Draft EIS) and will work with all relevant authorities to ensure compliance.

11. INPEX has prepared a provisional decommissioning management plan (Chapter 11 of the Draft EIS). This will be developed with the appropriate authorities at a future time when land use needs are understood in the context then government and community expectations.
12. INPEX is working with the Northern Territory Government (Department of Lands and Planning – Transport Group) to determine potential traffic impacts associated with the Project (refer to Section 3.3.3 of this EIS Supplement). This work is ongoing as final traffic volumes and routes are determined. Traffic modelling presented in the Draft EIS projects traffic volumes and flows indicative of known traffic routes and volumes at the time of publication. There is no indication of any breach of traffic safety standards on the basis of this traffic modelling.

    INPEX will repeat its traffic-modelling work undertaken for the Draft EIS on the basis of revised traffic estimates. The transport impact assessment studies will also investigate potential infrastructure development that may be required to ensure Project traffic/transport requirements do not saturate or overburden existing systems.
13. Natural occurrences such as seismic events are included in the risk-assessment work completed for the site. Acts of terrorism are a consideration in the design of security facilities and in setting up a coordinated approach to prevention and response between INPEX and government. Terrorism has not been estimated within the overall plant quantitative risk assessment because there is no way of estimating the likelihood of these scenarios. The high-energy nature of a wartime or terrorist-style attack scenario such as a bomb that causes damage to the plant would result in any release of hydrocarbons igniting immediately. Therefore any consequent fire would have a limited consequence zone which would be likely to remain local to the site and not significantly affect the general public.

    The extent of an impact zone for an explosion is dependent on numerous factors relating to an accident including the following:

    - the material released
    - the quantities of the material involved
    - the meteorological conditions at the time of an explosion
    - the local topography.

    Hence there is no one explosion scenario that is representative of the whole site. This is why INPEX use a risk-based approach in line with Australian standards and guidance which examines a large number of potential scenarios based on their likelihood and consequences. These scenarios are well understood and robust controls have been implemented to ensure that the associated risks are very low and fall within Australian risk acceptance criteria, these scenarios and the associated controls will be reviewed extensively with the safety regulator as part of meeting the safety reporting requirements.
14. INPEX has considerable and ongoing discussions with the Australian Department of Defence (Defence) regarding the coordination, deconfliction and safety of both organisations operations in the Northern Australia Exercise Area (NAXA). This includes completing a detailed risk assessment supported by technical input from Defence. The risk assessment demonstrated that Defence activities in the NAXA pose a low level of risk to the pipeline. Further reduction in risk is being achieved through a Deed of Cooperation and an Access Protocol between Defence and INPEX that establishes procedures and safeguards to assure the integrity of the pipeline through the NAXA. Defence is placing the pipeline location and protective zones on nautical charts and on materials used

in support of Defence operations and exercises. The existence of the pipeline and the procedures to safeguard are being embedded into Defence procedures. Both parties are pleased with the high level of cooperation, understanding and ongoing communication between them and are confident in the safety and security of the gas export pipeline as a result.

15. Performance measures are listed through the various "objectives, targets and indicators" provided in each of the provisional environmental management plans listed in Chapter 11 *Environmental management program* of the Draft EIS.

Submission 1-80: Why is Darwin not apparently observing high level opposition from this second massive plant in our harbour ?

Submission 1-57: How will the financial security and risks relating to the Japanese economy be managed after commencement of building at Blaydin Point?

Submission 1-59: What risks are posed during the longevity of this plant if Japanese – Australian relationships are soured for any reason. Which country has operational control of the potential LNG hazard in the event of a breakdown in international relation between Australia and Japan?

Submission 1-74: Can Territorians be certain that INPEX and the energy industry has our best interests at heart?

Submission 1-81: Why is Darwin not apparently observing scientific and environmental opposition from this second massive plant in our harbour ?

Submission 7-32: Retail shops will benefit in sales but will they be happy with turnover at best prices or increase their prices to monopolize on a short term period ~ thus the local suffers.

Submission 7-33: What will be the impact on fuel prices to the local – particularly diesel?

Submission 7-34: There are no long term benefits for the local ~ the project finishes in 40 years and it will leave a residue of infrastructure too risky to move.

Submission 7-41: The models are based on gas product sales projections. If the gas production declines due to over-supply or reduction in demand (as it currently stands) then the projection will be flawed. The construction is a 5 year period before production so it is hard to predict. http://www.forecasts.org/natural-gas.htm; http://www.eia.gov/pub/oil_gas/natural_gas/feature_articles/2010/ngyir2009/ngyir2009.html

INPEX welcomes all comments concerning the proposed Ichthys Project, and these views are noted and published accordingly.

However, these comments also raise issues that INPEX is not in a position to respond to or does not have the authority to answer, or that are outside the scope of the environmental assessment process.

Submission 7-24: GEOLOGY AND LANDFILL

1. Mt Bundy has been defined as the area that rocks and soil for landfill is planned to come from.
2. The largest exposed unconformity, reportedly in the world, is along Tiger Brennan Drive (pers. com. George Heys) and earth tremors are not uncommon.
3. The proposed shipping route requires extensive blasting will need to occur to remove the Walker Shoal which will require ongoing dredging – something that Darwin LNG was advised to avoid and did so.

INPEX welcomes all comments concerning the proposed Ichthys Project, and these views are noted and published accordingly.

Submission 7-42: The FID for the off shore component is yet to be finalised http://fwix.com/perth/share/70cb7d4aff/inpex_mulling_ichthys_stake_sale Dow Jones Newswires reported that Inpex 'is mulling over the possible sale of stake in the $20 billion processing plant for the Ichthys project off the coast of WA....Inpex is the majority holder, and operator, of the project with a 76% interest while France's Total holds the balance". If Inpex loses the majority stake hold what becomes of Inpex's EIS requirements?

INPEX is committed to the development and operation of the Ichthys Gas Field Development Project, and has no plans to transfer the role of Operator to another party. Nevertheless, environmental approval and any conditions that may be attached to such an approval, would transfer with any change in ownership of the Project.

Submission 7-43: ECONOMICS

None of the Gas from INPEX proposed Gas Plant is destined for the Australian market – so it will not increase industry to Darwin ~ only further un-environmentally friendly petrochemical industry. The current Darwin LNG now supplies a minimal amount of gas to the Weddell Station due to the required assistance needed by Power and Water during the large outages incurred in Darwin in 2008-9.

The Project is short term ~has a life span of 40 years – including the proposed expansion of 4 trans in the future (6 in total).

It is a well known fact that specialist workers are required that in most cases will be fly in fly out and likely not to be existing NT or Australian residents.

The maintenance of roads will suffer with increased heavy loads being transported.

There will be a life time legacy of infrastructure to be maintained and monitored because it is too risky to be moved at the end of the life span.

Consider the accommodation proposal be included to kick start Weddell ~ a proposed eco friendly city ~ this would be more beneficial to the NT population.

Consider Solar power so as to put back into the NT grid.

Submission 7-44: EXPENDITURE INCREASES WITH NO RETURN TO THE LOCAL

Housing & Rental ~ short term: demand increase that will increase costs and further extend the reach of locals. Long Term: cheap cluster accommodation with social instability.

Fuel costs ~ Supply and Demand increases fuel costs

Electricity costs ~ Supply and Demand increases costs to the local due to infrastructure upgrade and fuel required to maintain additional demands. Power failures due to increase demand in additional housing for air conditioning etc

Road Maintenance ~ Heavy vehicles damage roads and the local tax payer pays

Water Supply ~ Infrastructure upgrades to reduce the risk of water restrictions due to additional demand and possible failure of a Wet to fill the water tables and dams.

Sewerage ~ Upgrade of infrastructure to cope with the increase of sewerage and subsequent outflow into the Harbor and surrounds.

Council rates ~ new infrastructure increases council resources and workload which is passed onto the local.

See Alternative Options Page 15

INPEX welcomes all comments concerning the proposed Ichthys Project, and these views are noted and published accordingly.

However, these comments represent personal opinions on matters that are addressed in the body of the Draft EIS and this EIS Supplement.

Submission 7-45: February 2007 amendments to the EPBC Act 1999:

- Monetary penalties will not deter breaches of contract.
- Breaches of Environmental and Heritage statements should hold penalties of stand-down during investigation with the possibility of make good and vacate ~ loss of contract.
- The breach should be listed with a relevant International body.
- How will this project be reported in the 2011 State of the Environment? 'State of the Environment and section 516A
- The EPBC Act requires that a report on Australia's environment be prepared every five years. The third State of the Environment report was published in December 2006.
- Section 516A of the EPBC Act requires Australian Government organisations to include in their annual reports a section detailing their environmental performance and the organisation's contribution to ecologically sustainable development.
- The department's report under section 516A is in the first volume of this set of annual reports.'

This comment refers to administrative matters associated with the EPBC Act. As INPEX is a project proponent, it is not in a position to respond to this question. That is a matter for the Commonwealth's Department of Sustainability, Environment, Water, Population and Communities.

Submission 10-1: Just to say I am not at all happy with this proposed development as a potential tourist to the area

Submission 12-4: I do not think there is any benefit that outweighs the costs of allowing this ecologically unsustainable development to proceed. Thinking human beings must now act to protect our planet from further large scale unsustainable development. It concerns me that the human species is living far beyond its ecological footprint and this will prevent our grandchildren from living in a healthy world. It concerns me even more that our selfish and greedy species wants to take other more environmentally-sensible species with us when we destroy our world. I value the Top End environment for its health and well-being and for how it sustains our health and well-being. This is an essential part of the world as an ecologically-sustainable powerhouse. I would like to know that you value it as essential to the healthy future of human and other species across the world. You are mistaking short-term economic gain as ecologically sustainable development. I would like you to reconsider this in light of how we as a species are mistreating our world. Please put yourself into our place and use commonsense to save our world – by thinking locally as well as globally. We (humankind as well as other life on Earth) really don't NEED this massive dislocation of our precious environment.

Submission 15-1: Please don't destroy a beautiful natural place for gas development. You will be murdering the animals that live there and destroying ecosystems that took hundreds of years to become the wonderful places that they are today. You will be doing the world a great disservice if you continue with your plans.

Submission 19-5: # (5) The current government is a minority government, it went to an election stating that Inpex was the main reason for it going to an election, 25% of the people refused to vote and now it is Gerry Woods who holds this government together. What should be seen is the people spoke, refusing to accept this project and so it should not proceed! Go to W.A.

Submission 21-1: I support the development of the Ichthys Gas Field Development Project and associated construction activity in Darwin. Australia needs this development.

Submission 22-1: I am shocked to read of the imminent dangers to the vegetation and wildlife of the northern territory – from construction of a new harbour in Darwin – and the Kimberley coastline – from potential hazardous spills from shipping. Please observe the recent international tragedy of oil spillage in the US/Mexico region and beyond. Please respect the natural wonderland of our Australian fauna and flora and find a way for commercial progress to occur in harmony.

Submission 25-1: I regret that I seem to discern a correspondence to Japan's behaviour with cetaceans in general, and hope that I'm wrong.

Submission 30-3: The Commonwealth Government needs to listen to the Australian public and understand that the turn away from them has so much to do with their lack of leadership in environmental protection.

Submission 31-1: Japan is working hard to develop a renewable industry.Why does Japan think that is fine to come to Australia and contribute hugely our loss of marine life and increased carbon emissions. Please think carefully as many of us here are starting to think carefully about not purchasing Japanese goods,as that seems to be the area in which Japan is most sensitive.

Submission 32-2: It is difficult to believe that the Northern Territory Government is considering allowing a LNG gas field development project that would see underwater blasting, dredging and landclearing of sensitive coastal forests in one of the healthiest harbours in Australia.

Submission 33-1: Every life is a priceless treasure, dolphin and man alike! Continuing your blasting project at Darwin Harbour can never be justified, it is downright murder!

Submission 34-1: I read with considerable dismay that your government is supporting INPEX in its plans to create a shipping channel in Darwin Harbour. Even INPEX admits this will cause the killing of dolphins, dugong and turtles as well as injuring others and causing such stress to these wild creatures that the survivors may well never return. If this Japanese company can actually acknowledge such environmental damage, with the appalling marine history Japan already has, how can your government even contemplate supporting such damaging practices? Surely it is time to acknowledge that profit is not the only factor to consider, particularly profit going to an overseas concern. There must be a way to ensure that, in this day and age, economics and the environment can work together and not be automatically exclusive.

Submission 35-1: The proposed blasting in Darwin Harbour is a death sentence for the marine like there. The Japanese have no regard for sea mammals as they have shown over the years. There is too much of the environment being spoilt for ever by greedy companies.With no environment, there is no life for all, including humans.

Submission 37-2, 38-3, 41-2, 55-4, 58-3: The gas plant will also increase Australia's carbon emissions by 1.2%, clear hundreds of hectares of rainforest, mangroves and woodland on the harbour's edge, and smother coral reefs and mangroves by dredging 17 million cubic metres of mud.

Submission 37-3: I am concerned to learn about the proposed Japanese oil & gas INPEX project planned for Darwin Harbour. I understand that there are plans to blast within the harbour which would fatally damage dolphins and other marine wildlife which are protected by law. Furthermore there would be an irreversible impact on the rainforest and mangroves around the harbour and the coral reef. I am also concerned about the economic impact on the tourism industry because Darwin Harbour would not be so attractive. Visitors come from other parts of Australia but also from abroad to see the animals and marine life. Please don't destroy the heritage of Darwin.

Submission 42-2: Before you and the gung-ho Northern Territory government destroy our much prized harbour for short-term gain and greed STOP – and think! What is this sort of ecologically unsustainable development doing to our world? What kind of environmental and social uncertainty will you leave for future generations? Leave some natural beauty and resources for them to treasure. I'm sick of your lies and misinformation. I'm sick of your greed. LEAVE OUR HARBOUR ALONE!

Submission 43-1: Please protect Darwin Harbour from Japanese gas drilling. The Japanese must change the course of the shipping channel. We need to protect the dolphins, turtles, dugongs and sea-horses and other marine life.

Submission 48-1: NO BLASTING DOLPHINS, DUGONGS OR ANY OTHER KIND OF MARINE WILDLIFE IN AUSTRALIAN WATERS, GO AND DO IT IN JAPANESE WATERS !

Submission 51-1: The history of Japan's total indifference to the health of marine populations is well known. Their willingness to make a profit and ignore or walk over any entity that tries to minimize their impact is also well known. Please don't let Japan bully your ministry into allowing this disastrous project. Require Japan to take the steps suggested by the Wilderness Society. It would protect the marine life in the area while still allowing Japan to ship the oil and gas. The oceans and its marine creatures are still under attack by interests which have a short term goal and no concern for the long term impacts. Blue fin tuna are close to extinction, and yet the international community failed to protect them. I am terribly disappointed in my country for failing to sign that protection agreement. Please be more far sighted, and a leader in protecting the valuable resources in your keeping.

Submission 55-1: Darwin Harbour is home to amazing marine wildlife that other Australian capital cities can only dream about. Where else can you spot three species of coastal dolphins as you cycle around the foreshore, kayak quietly behind a mother dugong with calf, or spot four species of threatened marine turtles from the ferry on your way to work? No where! Now these attributes are under threat from a massive gas plant planned for the middle of the harbour – and the Northern Territory Government is doing everything it can to make sure it gets built.

Submission 59-1: It is beyond belief that your company is considering damaging this fragile marine environment in such a way. Please ensure that a proper environmental impact study is commissioned, to ensure damage mitigation. You have a responsibility to future generations, so please do not vandalise this unique marine area.

Submission 61-1: While it doesn't seem to be of any significant or major consequence that marine life could suffer under the proposal of blasting rock in Darwin Harbour, I would just ask for a few moments of contemplation over the decision that could not only kill marine life within the harbour confines but do irreparable damage to the marine environment in the whole area around Darwin for a great number of years to come.

The commercial bottom line has to be refocused to take in to consideration of what is not only good and acceptable for humans but what is also good for Our Planet's Wildlife, who incidentally don't have a voice to express an opinion.

I appreciate that "Japan as a Nation" has a different way of not only doing things but looking at the marine environment, but even so we all have a life to live on "THIS PLANET EARTH".

Surely the executives of your company can see further than the ends of their collective noses that it is time enough to think of others species rather than just humans species and any profit they will become beneficiary of.

I would like to remind you that the human species is the one and only species threatening the very existence of "All Species" with the continual destruction of the only place in our universe that any living species as we know it can really call home.

It is obvious when one looks at the advances in modern science that there are ongoing attempts to find another place in the universe for the human species to live other than earth, but even if that eventuates, it will be a very long time before colonisation could ever take place.

Meantime we have to look after our overall environment and consider all species on this Planet Earth.

Just recently the massive oil spill in the Gulf Of Mexico has been on a scale unseen before and that in itself should be ringing alarm bells that despite our best efforts to minimize risk of such occurrences, nothing is ever guaranteed safe.

As a senior citizen my time on this planet is coming to an end but our children and grandchildren are facing a threat that is even greater than this isolated incident.

Global Warming is a fact of life despite the sceptics appraisal of what they consider is not happening, the weather is changing at an alarming rate, we constantly see floods, landslides and all manner of tragedy's striking at the human race and all of this is as consequence of our collective mismanagement of this planet and be actually be called "Man Made".

This is an accumulation of bad decisions made throughout human history but mostly during the last one hundred years and many people are now facing the consequences of this ongoing destruction and unless one has been living under a rock in some out of the way place, one could not miss the daily reports of such problems.

What more can I add.............................?

Submission 63-1: I am horrified at the proximity of the project to Palmerston and its likely future impact on Darwin and the harbour as a whole – as a long term resident of Howard Springs and having been involved in keeping the area's rural identity I am also opposed to the proposed workers village development there. Submission 64-4: I am horrified at the proximity of the project to Palmerston and its likely future impact on Darwin and the harbour as a whole – as a long term resident of Howard Springs and having been involved in keeping the area's rural identity I am also opposed to the proposed workers village development there.

Submission 64-5: Darwin Harbour is a significant natural asset. I submit that trashing it to install a gas plant would be a poor decision, and urge the Commonwealth Environment Minister and Northern Territory Government to insist on measures to mitigate its major problems, until a sane cost-benefit analysis comes out most clearly in the long-term interests of the Australian people.

Submission 68-1: Please, NO! Japan's reputation as a killer of whales is not good. Australia's reputation for hypocrisy will grow, should we allow this proposal to go ahead.

Submission 69-1: I am deeply concerned about the current methods Inpex is proposing to use to develop a shipping channel in Darwin Harbour. Your corporation is rich and powerful, but strength is not about refusing to work with nature. Intelligent people work with nature and intelligent people work with those who understand the impacts this development will have on nature. Your business is oil and there are people who's business is the health of the environment. Your business is money and your concerns are less to do with the effects you will have on nature. The best and most respectable solution for everyone is if you work with those who are deeply concerned about the impact your company's actions will have in order to plan the best method of action which will have least impact on the environment.

Buddhism is still strong in Japan, but I see none of it here in your proposals. Many people on this planet have a contempt for nature and see themselves above all other life forms on this planet. The thing is that we rely on the planet to be health in order to enjoy the resources it gives us and our behaviour has a huge impact on health of the planet. You may be just one company and think that the results of your actions will be insignificant, but there are thousands more like you who have the same attitude and over time this will lead to a great loss for everyone. It already is and it already has. and it will continue to do so until people change their approach.

Working with others to provide a healthy solution is does not mean showing weakness, it means bravery and strength. Strength that comes from doing what is right. This is the only way forward for the human race, we have brains that allow us to learn quickly and to make educated choices. Please be brave enough to tread a new path, this has to become the way of the future.

I understand that The Environment Centre of the Northern Territory, Australia, has proposals for alternative methods of achieving your goal, so please do talk with them. Being a man does not mean being unbending, flexibility is the key to our survival and success as a race.

Submission 73-1: PLEASE DONT GO AHEAD WITH THIS PROJECT JUST THINK OF THE BEAUTIFUL WILD LIFE THE DOLPHINS THIS IS THEIR TERROTORY.

Submission 75-4: Please consider our environment. Why should a international company be allowed to come into Australia and cause all this distruction and pollution here? I am very worried about what is happening, particularly with climate change and its effects.

Submission 77-1: What the bloody hell do you people think you are doing??? I can just see what the japanese people would have to say about this kind of environmental vandalism being perpetrated in the middle of Tokyo Bay. What makes you think that it's in any way acceptable to slaughter all marine life in a radius of 500 metres, that's a kilometre across all up, in case you've forgotten your basic math, with an injury zone that will cover 2.5 kilometres, plus letting off three explosions a day? Marine life like whales and dolphins will hear that from thousands of kilometres. does anyone know what effect this will have on their navigational systems?? If this is not criminal, it should be, and morally, ethically, and as an example to our children of the way to treat the planet, it stinks like a pound of prawns two days in a Darwin wheelie bin. You bastards are bloody unbelievable!

Submission 82-1: Hello I am writing to add my concern as many others are doing in regards to the dredging of the Darwin Habour for Japan to make money of Australias natural resources. Please think hard about this decision as quite frankly I don't beleive that us humans have any right to manipulate the Earth's natural design in order to gain riches when in reality natural gas is not renewable. The habitat for many species including us humans will be destroyed and is not renewable. There are many other ways to make money and to believe this will help our economy is very narrow minded as when the Earth starts to let us know that we are messing with it's structure you will be accountable and money can not buy guilt. At least think about putting a longer jetty or something like that.

Thankyou for reading my plea, it is extremely important for us to be careful as this is everyones home.

Submission 83-1: I feel that your efforts to change the topography of Darwin Harbour with so much distain for the local inhabitants of the harbour do not give me the impression that you value life on the planet with very much integrity. Maybe you feel that marine animals are not important in the in the ecology of the planet – – it is now acknowledged that every species has there part to play on planet earth even though we as human kind may not realise what it is. Dolphins and similar species are rated as the highest inteligence to human kind – -you would not consider killing off human beings because there are so many of them in the way of your project. Death is death, when an animal is killed the person or company still has the responsibility of carrying the weight of it – -are you sure that all of the people working for you are willing to take on that resposibility?

Submission 83-3: As a ex resident of Darwin I feel that as a multi national company more respect for a place other than your homeland is needed not less.

I hope that you will accept that my concerns for the ecology stem from animals who have as much right here as humans but do not have the ability to understand or communicated what we as humans decide their fate will be

Submission 84-1: As it stands the INPEX Ichthys Gas Field Development Project will forever change the nature of Darwin Harbour – a unique environment of international conservation significance. Inped will derive great financial benefits from the operation and at the present moment the people of Darwin cannot see anything in the project that would benefit them even though they are asked to sacrifice their lifestyle and environment to it. The onus should not be on the people of Darwin to provide scientific explanations or expert advice on the EIS. I believe instead that the onus is on Inpex to genuinely address people's concerns and to provide intangible proofs that there will be no impact on the environment from the proposed plant, or details on how they are planning to minimise them, before putting the a submission to the people of Darwin asking them to consider whether they would accept the project.

Submission 84-9: Drawn from these studies I ask Inpex to provide guarantees to fishermen, sailors and all other users of Darwin Harbour that their quality of life will not be affected by the project. This concerns all marine life in the harbour, fish stocks, the quality of the water, the physical landscape as one looks out from Darwin's shores, as well as the exclusion zones around the ships which, if their frequency increases, will effectively prevent sailing clubs from conducting any regattas on the harbour.

Submission 87-2: 2. The proposed development at Middle arm and the resulting land clearing and inevitable pollution that accompanies such development.

Submission 87-6: A thorough Environmental Assessment undertaken using the most up to date scientific processes and reports. Most of all, we would like to see the creation of Darwin Harbour National Parks in the West Arm, Middle Arm and Ludmilla Bay.

Submission 92-3: Clearing hectares of monsoon rainforest and mangroves in Darwin harbour will bring weed infestation and sewage pollution from the wastewater plant should be a zero discharge operation.

Submission 99-1: I am deeply disturbed by this development proposal. Darwin Harbour is a special place that contributes hugely to Darwin being a special city. The Harbour supports 4 species of dolphin, dugong, marine turtles and crocodiles to name just a few of the larger and more obvious animals. The fringing mangrove forests are exceptionally diverse and support a considerable number of mangrove endemic birds and reptiles. Water quality is, at the moment, exceptional. We don't live here to have it degraded and turned into an industrial estate as has happened in so many other Australian cities and cities around the world. The scale of disturbance you are proposing – a major dredging operation, reef destruction and clearing of a substantial area of mangroves and coastal vine-thicket – is far from minor. I question whether any adequate assessment of these is available – it certainly isn't in the public discussion.

Submission 112-1: I totally oppose the project in its entirety. Among other issues, I find that the proposal should be disqualified on the grounds of unacceptable climate impacts; unacceptable loss and detriment of coastal ecological communities; the insane plan to endanger marine macrofauna by blasting Walker Shoal; and for simply posing too huge a dredging burden for our living harbour. But I realise that our Chief Minister has staked his career on insisting that Inpex can enjoy certainty in Darwin. I realise that this makes it next to impossible for Mr Henderson's environment minister to reach any conclusion other than to recommend the project can proceed, and so, while I'd rather dismiss this proposal outright, I will endeavour to offer some recommendations for lightening the severity of this project's local environmental impacts.

Submission 112-3: It's not just our economic, but also our policy environment that is ill-prepared for such a massive jolt. Despite years of to-ing and fro-ing in the Darwin Harbour Advisory Committee (which was set up in response to community dissent and dissatisfaction with the decision to sacrifce Wickham Pt on Middle Arm for the Connocco Philips LNG plant), the NT Government still has no policy for managing dredging. As the EIS glaringly exposes, neither the NT or federal governments have come up with a workable framework or pathway for managing industrial greenhouse gas emissions, and the level of formal protection and conservation management of our high conservation value coastal communities remains too poor for the task.

Submission 113-1: I am opposed the location of the Gas Tank in Darwin Harbour. I am opposed to further industrial development in the Harbour including this Gas Project because of grave concerns regarding polution of the harbour environment and visual polution.

Submission 121-1: This project will have substantial long term detrimental effects and considerably lower the biodiversity in the Darwin Harbour. Protected species will be killed – how can this be allowed. Critical breeding habitats in the mangroves for fish will be impacted. This will impact on fishing in the harbour.

Submission 121-2: Tourism will also be impacted with mass marine deaths fouling the beaches, loss of clear water due to sedimentation creating anoxic environments, foul smells from all the rotting animals. Loss of land amenity through clearing of precious rainforests. Years of construction resulting in considerable noise and pollutants entering and contaminating the pristine marine and land environments that affects the behaviour and make up of all Darwin Harbour's living organisms, people included.

Submission 126-2: There are alternative sites I gather that would negate the need tor thi s time consuming, dangerous and environmentally damaging option, so I would urge IMPEX to abandon this extremely controversial part of the development. There is talk oflegal action if this option is pursued and I'm sure the company would want to avoid such an outcome if possible and maintain good community relations with the people ofDarwin .

INPEX welcomes all comment relating to the proposed Ichthys Gas Field Development Project. These comments are personal opinions that are not relevant to the scope of this environmental impact assessment process; however, the views expressed by the submitters are noted and published accordingly.

Some of the public comments above may also be addressed through consideration of the broader environmental impact assessment process. This process requires the respective environmental ministers to take into consideration relevant environmental, social and economic issues prior to making a final determination on the Project. This process, of which this EIS Supplement to the Draft EIS forms an integral component, is described in greater detail in Section 1.2 of the Draft EIS.

Various issues are also referred in the above comments. Specific information in regard to these issues are presented in this EIS Supplement as indicated in the table below:

Issue	EIS Supplement reference
Marine blasting	S3.3.8
Dredging	S3.3.6, S4.1.3, S4.1.6.2
Land-clearing	S4.4
Accommodation village	This is not within the scope of the assessment process.
Environmental assessment process	S0
Alternative jetty	S4.10.2
Shared facilities	S4.10.2, response to comment 84-2
Exclusion zones and Darwin Harbour access	Response to comment 9-14
National parks (offsets)	S4.9
Wastewater	Response to comment 7-20 and 84-8
Weeds	Response to comment 109-24

Submission 16-8, 24-8, 29-7, 89-8, 96-7, 101-9, 102-7: There is no NT Government dredging policy for Darwin Harbour so there are no formal guidelines or standards in place that INPEX can be held accountable to.

As the Project is undergoing a formal, open and public approval process under both Northern Territory and Commonwealth environmental legislation, the lack of a Northern Territory Government dredging policy or of Northern Territory Government dredging guidelines or standards does not result in a lack of accountability for the dredging component of the Project. Note that INPEX must also seek approval for the Project's dredging component under the *Water Act* (NT), the *Waste Management and Pollution Control Act* (NT) and the *Fisheries Act* (NT).

Submission 18-9: In conclusion, the fact is that through cumulative effects and dispersal, more than 74 ha will be affected by this proposal.

INPEX is commited to the facts and statements presented in the Draft EIS and in this EIS Supplement, and will limit the footprint and impacts of the Ichthys Project to those stated in these documents.

Submission 81-1: 1 General comment

No dates for the commencement of the construction or the completion of construction or the commencement of operations is provided.

NRETAS and DEWHA should refuse to evaluate what is, therefore, a hypothetical development with an uncertain commencement date (if any). Approval under current law, policy and circumstances giving a "blank cheque" for development at any time in the future is not good public policy. The Project should be evaluated at the relevant time.

At the time Inpex decided to move the Project from WA to the NT, it cited "schedule delay" as the issue. Since then the schedule has slipped on multiple occasions and by several years and the Project now appears to have no schedule. As there are no LNG sales agreements and never has been, there was no schedule as there is no one to buy the product. It follows the move was not supported by the stated foundation and appears to have some other basis.

The Project is being assessed in accordance with the time-frame provisions of the EPBC Act (Cwlth) and the EA Act (NT).

INPEX is expecting to start construction of the Ichthys Project on Blaydin Point in the first quarter of 2012, conditional upon achieving environmental approval. Once construction commences, the development schedule as provided in Section 4.1.5 of Chapter 4 *Project description* of the Draft EIS gives an indication of the scheduling for separate components of the Project and major milestones.

Submission 81-2: The move from WA to NT:

(a) Involves the Project burning an additional 1.5 to 2 Trillion cubic feet (Tcf) of fuel gas (more than 10% of the gas in the field) to pipe the natural gas to the NT. This fuel gas cannot be converted into LNG thereby impacting revenue and rendering the Project near sub economic. To put the amount of fuel gas wasted into perspective, this is half the amount of gas WA has consumed in its whole history.

(b) Involves the Project emitting additional Greenhouse Gas associated with burning of above mentioned wasted fuel gas. Given this is a dirty Project with the reservoir CO2 as high as 17%, there should be a requirement for Reservoir CO2 to be captured and injected as part of a Carbon Capture and Storage project. Further, Inpex should be required to offset the wasted fuel gas and to pay compensation for revenue foregone.

(c) Removes the liability to compensate Native Title claimants and offer indigenous employment and contracting opportunities in the Kimberley, an area bereft of such opportunities.

(d) Deprives Australia of the benefits from a Kimberley Gas Hub for no good reason.

(e) Relieves the Project of any obligation to supply any hydrocarbon product, including domestic gas, into Australia thereby depriving other Australian businesses of the opportunity to burn gas rather than dirtier fuels. This leads to increased Greenhouse Gases being emitted.

(f) Renders the Project close to sub economic and therefore paying little (probably zero) Petroleum Resource Rent Tax and vastly reduced corporate tax. This is an amazing feat of incompetence given this is the largest liquids discovery in Australia since the Bass Straight containing half a billion barrels of condensate and an equivalent amount of LPG.

The upshot of the above is a Project which pays no royalty, wastes valuable resources, creates extreme and unnecessary amounts of Greenhouse Gas, sells no hydrocarbon product into Australia, and, given most engineering work and modular construction is done overseas, provides few jobs for Australia. This wanton waste and exploitation of Australia and its valuable resources should be clearly stated in the EIS.

The EIS does not deal with a Supply Base. It is impossible to build the Project without a Supply Base which would need to be located in WA for safety reasons. Therefore, a WA ERMP assessment should have been carried out.

The Draft EIS includes the assessment of environmental, social and economic impacts for the referred action only with the following components:

- offshore infrastructure and activities at the Ichthys Field
- the gas export pipeline from the Ichthys Field to Darwin Harbour
- nearshore infrastructure, including the pipeline shore crossing and associated activities within Darwin Harbour and at the proposed offshore spoil disposal ground north of the Harbour
- onshore infrastructure on Blaydin Point, and Middle Arm Peninsula and associated activities that could cause off-site impacts, such as air emissions and traffic.

The scope of the Draft EIS is not required to provide comparative analysis against other redundant projects that are no longer under consideration.

A marine supply base is not within the scope of the Draft EIS.

Submission 81-4: 2.2 Introduction – Paragraph 1.2 – Project Proponent

Whilst Inpex's parent company has "been involved" in the development of oil and gas resources, no Inpex company has ever developed and operated any oil and gas project anywhere in the world.

The EIS should state this and detail what measures Inpex is taking to overcome its complete lack of competence in this regard.

This Project has several "World Firsts". In oil and gas Projects, it is generally considered that more than one World First is almost certain to mean failure of the Project – even when carried out by experienced operators.

Background information on INPEX and Total, its joint venture partner, are provided in the Draft EIS in Section 1.1 of Chapter 1 *Introduction*.

Submission 84-2: I do not believe that any blasting should take place in Darwin harbour and would like Inpex to reconsider their approach to the whole project. The existing gas plant and facilities could be shared by Inpex rather than building a whole new one. Cost sharing would certainly be beneficial to the company, would reduce the impact on our environment, and not add another feature to mar our landscape. Sharing facilities would also minimise land clearing impact from the project and would generate less pollution than two separate sites. Could Inpex clarify the exact reasons why the existing site can't be shared?

INPEX advised in Section 4.4.4 in Chapter 4 *Project description* of the Draft EIS that alternative techniques to drilling and blasting were to be investigated for removing hard-rock material within the shipping channel. At the time of publication of the Draft EIS it was not possible to confirm whether there were any viable alternatives to drill and blasting. Improved understanding of the geological characteristics of these hard-rock areas (derived from geotechnical investigations) and new information on alternative rock-removal techniques, have however provided INPEX with confidence that most, if not all, of the hard-rock areas within the shipping channel can be removed without the need for a drilling and blasting program. Further details on the options for the removal of hard rock are provided in Section 3.3.9 of this EIS Supplement.

Significant commercial, technical, safety and spatial constraints preclude the co-location of production facilities with the existing LNG plant in Darwin Harbour.

Submission 86-11: (Table 1-3) The plant may also require assessment as a recycled water system in accord with DHF guidelines for the Management of Recycled Water systems please refer to the following web address for additional information: http://www.health.nt.gov.au/Environmental HealthlWastewater Management/index.aspx#RecyciesWaterSystems

INPEX acknowledges this advice and, should it be required, will seek assessment at the appropriate time.

Submission 94-4: Clear incentives need to be established for the operator INPEX to minimize the risks. We would argue that a system of financial penalties and a performance bond be established for the operator – that is commensurate with the potential damages. This would require a valuation of the potential damages from an accidental hydrocarbons release scenario. Finally, there needs to be an acknowledgement by the operator INPEX of the need for financial recompense, consistent with the value of the impacts, should any adverse event occur. Again, this would be informed by the potential damages estimates.

INPEX has assessed the risk of an offshore oil spill in the Draft EIS and provided updated information in this EIS Supplement. It is in the interests of INPEX and all operators in the Browse Basin region to manage such risks to levels that are as low as reasonably practicable (ALARP). To that end, INPEX together with other operators, is investigating an environmental management program specific to the Browse Basin that will reduce these risks further (see Section 4.2.3 in this EIS Supplement). A description of the most recent oil-spill risks and associated programs may be found in Section 4.2 of this EIS Supplement.

The matter of financial penalties or performance bonds are matters for consideration by relevant government regulatory bodies.

Submission 104-5: The costs of the Ichthys Gas Field Development Project as have been outlined in the Draft Environmental Impact Statement will be borne by Territorians for generations to come. If Inpex is a responsible corporate citizen we would expect it to invest in technology that achieves positive social and environmental outcomes.

INPEX welcomes all comment relating to the proposed Ichthys Gas Field Development Project. This comment is a personal opinion that is not relevant to the scope of this environmental impact assessment process; however, the views expressed by the submitter are noted and published accordingly.

Submission 106-3: 3. The lack of important details in the EIS

The EIS lacks adequate information on enough issues to be rejected at this stage. Much work needs to be done in the Supplementary EIS to enable the NT and Federal Governments to make an informed decision on whether the Ichthys Gas Field Project should be approved.

E.g. The amount of Hydraulic liquid to be discharged is [presented in a range of values and the concentrations of chemicals in the liquid is a range of values per amount of water. The EIS needs to calculate the upper and lower amounts (of hydraulic liquid and chemical concentrations) to provide the actual quantities of toxic chemicals predicted to be released into the environment over the life of the project.

E.g. The EIS discounts any impacts of pipe laying due to the small proportion of non – featureless benthos occurring along the total route of the pipe. To quantify the impact of laying the pipe be the EIS must address what will occur in the 17 km of varied seabed (the 2% of non-featureless area). Is this seabed likely to require the more destructive forms of pipe laying – trenching and rock armouring? If so how much of the 17 km is expected to be impacted?

Much more detail in the EIS is required before the development can be approved. The Wilderness Society is very concerned that INPEX believes its environmental impacts to the region will be minor because it is operating in a remote location. The cumulative impacts of the oil and gas industry, both current and proposed gas operations, in this region must not be ignored.

This submission does not make it precisely clear on what grounds the Draft EIS is considered inadequate. The two examples are provided above do not provide sufficient evidence to substantiate such a claim.

INPEX is committed to undertaking a thorough and transparent environmental assessment of the Project under both the *Environmental Assessment Act* (NT) and the *Environment Protection and Biodiversity Conservation Act* 1999 (Cwlth). This joint process of environmental impact assessment is designed to deliver informed decisions by both the responsible minister in the Northern Territory and the Commonwealth's environment minister in regard to the environmental acceptability of the Project. This process is described in greater detail in Section 1.2 in the Draft EIS and at the relevant NRETAS and DSEWPaC government web sites.

INPEX believes the information provided in the Draft EIS, together with additional information provided in this EIS Supplement, particularly in response to public comment, meets the requirements of an informed impact assessment and complies with the scope as defined in the published Draft EIS Guidelines (see the Draft EIS's Technical Appendix 1 *Guidelines for preparation of a draft environmental impact statement: Ichthys Gas Field Development Project*).

With regard to the specific examples cited above:

- Liquid discharges—these issues are addressed in the response to comment 106-7 in Section 5.2.2.5.
- Impacts of pipelay—the entire gas export pipeline has a concrete weight coating which varies in thickness from 40 to 80 mm, it is applied to the pipe joints at the coating yard for the purpose of increasing the submerged weight.

Eighteen sites were identified along the offshore pipeline route as potential hard-bottom areas, as discussed in Technical Appendix 4 *Studies of the offshore marine environment* of the Draft EIS. Of these 18 sites, only 1 site, at KP 848.1 will either be trenched prior to installation of the pipeline, or the gas export pipeline will be post-lay trenched by ploughing.

In all other areas of the offshore pipeline route, including the remainder of all the 17 km of hard areas, the gas export pipeline will be laid directly on to the seabed with no additional weight-coating, trenching or rock-armouring. Impacts on hard substrate or pockmarks will be localised and minimal in the context of regional benthic habitat.

Submission 106-14: Risk management in the EIS is stated as a "continual process of identification, refinement and assessment of risk." Such a statement lacks substance of the protocols and methodology on how this is will be done within the company.

The risk assessment process is defined in detail in Chapter 6 *Risk assessment methodology* of the Draft EIS. This describes the methodology applied to derive the residual environmental impacts which are presented in the Draft EIS. This process will continue to be applied as the Project develops and new information comes to light.

The risk-assessment process described here is aligned with the joint Australian, New Zealand and ISO Standard *AS/NZS ISO 31000:2009, Risk management—Principles and guidelines*.

Submission 107-4: There is no real consideration of INPEX's contribution to the cumulative impacts on the environment resulting from increasing industrialization of Darwin Harbour. In addition, other parts of the overall project (e.g. the accommodation village and product loading jetty for LNG, LPG and condensate export) do not appear to be subject to environmental impact assessment.

Submission 107-12: The area near Blaydin Point is becoming heavily industrialized. Continued development of the area will lead to a range of cumulative impacts that have not been considered in this EIS. It is therefore recommended that a Cumulative Impact Assessment is undertaken to ensure that the wider environment of this region is not compromised by future and on going industrial development. The NLC recognises that this may be a responsibility of the NT Government, rather than INPEX, but recommends that INPEX should undertake at the least to contribute to this assessment if a consideration of the combined effects of their project with other local industries is not done here.

Submission 107-24: Chapter 6 describes the risk assessment methodology applied to the EIS. It is a standard approach that is significantly diminished because it does not assess to what extent the construction and operation of the INPEX project will result in a cumulative environmental impact. A description of the methodology required and a measurement of the extent of additional cumulative impacts resulting from INPEX should be included.

Submission 124-14: Cumulative impacts of multiple construction activities on marine flora and fauna are not considered in any depth;

Submission 124-20: The residual risk to marine communities and species from dredging and related impacts is assessed as low to medium (Chapter 7, Section 7.3.2, p. 326), apparently due to the mitigation and management measures outlined above. Disappointingly, cumulative impacts from other Project activities are not taken into account in INPEX's risk assessment and management determinations.

Submission 124-40: The residual risk to marine communities and species from dredging and related impacts is assessed as low to medium (Chapter 7, Section 7.3.2, p. 326), apparently due to the mitigation and management measures outlined above. Disappointingly, cumulative impacts from other Project activities are not taken into account in INPEX's risk assessment and management determinations.

Submission 124-84: Cumulative impacts including impacts not due to the Project (e.g. reductions in critical habitat such as seagrass from other sources).

Submission 128-41: Annex 10 – Provisional Liquid Discharge Surface Water Run off and Drainage Management Plan. The cumulative effects of waste water discharge from the gas plant as well as the associated industries that will develop as a result of the gas plant over the life of the project have the potential to severely impact on the water quality in Darwin Harbour.

The cumulative effect of different elements of the Ichthys Project on environmental values has been assessed within the Draft EIS. See also Section 4.13 in this EIS Supplement.

All future projects with the potential to effect the environmental values of Darwin Harbour would be subject to the environmental impact assessment process of the day to determine their acceptability, or otherwise. Each such project would have a range of environmental management options available to its designers. Assessment of the cumulative effect of Ichthys Project activities, when combined with other commercial or industrial operations that may occur at some point in the future is discussed in Section 4.13.

Submission 107-9: We note that the project is expected to last for up to 40 years. During this period there may be technological advances that might lead to improved systems for environmental management. There is no indication whether the project will be subjected to further periodical assessment, or whether implementation of advanced or improved technologies will trigger a new assessment of environmental impacts related to those technologies.

INPEX will be bound by any conditions associated with the ministerial determinations under Northern Territory and Commonwealth legislation. Furthermore, the Ichthys Project will be subject to various licensing conditions and addittional approvals as outlined in Chapter 1 *Introduction* and Chapter 11 *Environmental management program* of the Draft EIS. INPEX is committed to complying with all such requirements over the life of the Project, and is proactively identifying and assessing opportunities to improve environmental management of the Project.

Submission 110-13: I would ask that the appendices be amended so that we can understand them, plainly, so that we can educate ourselves to what is likely to happen with some degree of confidence and accuracy.

It is not clear from this comment, what particular technical appendices are in question, nor what specific aspects of the technical appendices require clarification.

However, each technical appendix represents the work of highly specialised and professional consultants, prepared expressly for INPEX in the preparation of the Draft EIS. The information presented within each is of a professional standard accepted within that particular scientific discipline, and a standard therefore accepted by INPEX.

The information presented in each technical appendix is, by its very nature, highly specialised and technical. The role of the main body of the Draft EIS is to synthesise relevant information from the technical appendices to support or present a particular position or statement. Therefore, the key information contained within the technical appendices is presented in the Draft EIS in a manner that is intended to be understood by a wider and less technical audience. It is within the Draft EIS that a simplified interpretation of the technical appendices may be found.

Submission 116-3: Why is the response period so short

The public review and comment period (the "response period") of 8 weeks is double the minimum period required under the relevant Commonwealth and Northern Territory leglisation. The period was set and agreed by both the Department of Natural Resources, Environment, the Arts and Sport (NRETAS) and the Commonwealth's Department of Sustainability, Environment, Water, Population and Communities prior to the publication of the Draft EIS. Notwithstanding this, it should be noted that INPEX continued to accept public submissions after the official response period closed, including the response of NRETAS itself.

Submission 120-8: Dredging Program for Darwin Harbour

There is little doubt that this, along with rock removal on Walker Shoal, is the most significant part of this project in terms of the concerns of recreational fishers and many others for its potential impacts on Darwin Harbour. Although it has been urged to do so by Darwin Harbour Advisory Committee, the NT Government has still not developed a dredging policy for the harbour. Also, there is no strategic environmental assessment for the area in question so we can only consider the current project in isolation. This is less than satisfactory given that there are already other major projects such as proposed developments and expansion at the East Arm Port, BHP Billiton's Olympic Dam copper concentrate loading/shipping proposal and the NT Government's recent call for expressions of interest to develop and operate a marine supply base in the East Arm area. This is not intended as a criticism of Inpex but it is something that the NT Government should have already addressed.

INPEX acknowledges this comment, and the concerns of the Amateur Fishermen's Association of the Northern Territory.

However, these comments raise issues that INPEX is not a position to respond, does not have the authority to answer, or are outside the scope of the environmental assessment process.

Submission 120-30: An adaptive management approach should be implemented so that spoil dumping practices and even locations can be adjusted if monitoring indicates a risk of adverse impacts on barramundi breeding in the Howard River, mud crabs in Shoal Bay and corals, fish and other marine life in the Gunn Point Vernon Islands area.

In this EIS Supplement INPEX has assessed the potential for impacts from spoil disposal on the following:

- barramundi in the Howard River estuary area (Section 4.1.7)
- mud crabs in Shoal Bay (Section 4.1.8)
- benthic habitats (including the potential for impacts on the wider ecosystem) within the areas of influence and impact including the Gunn Point and Vernon Islands areas (Section 4.1.3).

In all circumstances, the risk of adverse impact is not significant.

Notwithstanding these projected outcomes, INPEX will work with regulatory agencies and other stakeholders to manage actual impacts during construction through adaptive and proactive practices.

Submission 123-1: Assumptions. The guidelines for preparation of an EIS state “Any and all unknown variables or assumptions made in the assessment must be clearly stated and discussed. The extent to which the limitation, if any, of available information may influence the conclusions of the environmental assessment must also be discussed and assessed in relation to risk and international best-practice.” The draft EIS draws conclusions on a range of issues. These conclusions often appear to be based on assumptions that are implicit rather than clearly expressed. The uncertainties that are associated with some of the concluding remarks in the text should have been explicitly documented throughout the draft EIS so that readers were able to ascertain the strength of conclusions drawn. For some of the key issues, this identification of uncertainties and assumptions could help to inform further studies or research that might need to be undertaken to reduce uncertainty. The Supplement, henceforth called the EIS (the draft EIS together with the Supplement form the EIS), should provide a comprehensive list of the assumptions made against the conclusions they inform.

The following response is provided in the context of risk-assessment conventions. It intends to provide clarity and relevance for the risk-assessment methodology described in the Draft EIS. To assist in ascertaining the intent of the comment above, it has therefore been broken down into its relevant components which are addressed below.

The *Guidelines for preparation of a draft environmental impact statement* prepared for INPEX by the Commonwealth and Northern Territory governments in 2008 (see the Draft EIS’s Technical Appendix 1) state that “Any and all unknown variables or assumptions made in the assessment must be clearly stated and discussed. The extent to which the limitation, if any, of available information may influence the conclusions of the environmental assessment must also be discussed and assessed in relation to risk and international best-practice.”

In the first instance, the requirement “Any and all unknown variables or assumptions … must be clearly stated and discussed” is erroneous. This statement appears to require that an impossible, and therefore implausible, statement and discussion appear in the Draft EIS as it requires a discussion on “*unknown* variables or assumptions”. The Draft EIS provides sufficient detail concerning all known variables and assumptions.

The Draft EIS acknowledges an “inherent degree of uncertainty” in environmental risk assessment (see Section 6.2 in Chapter 6 *Risk assessment methodology* of the Draft EIS). Where data were not available, “a qualitative evaluation [of risk] was made which relied on the knowledge and experience of team members and specialists” (see Section 6.2.2 of the Draft EIS).

Limitations of available information were acknowledged and used to develop the program of technical studies and surveys to inform the risk-assessment process. The scope of these technical studies and surveys was discussed in a workshop with Northern Territory Government departments in April 2008 (see Section 6.2.1 of the Draft EIS), and are ongoing in respect of further development of the provisional environmental management plans.

Uncertainty in risk estimates errs on the side of caution and will be improved as the results of technical studies and surveys are made available. Improvements to planned risk-control measures will be identified and implemented as necessary. These improvements are captured in the risk register for the Project.

The submission states that “The draft EIS draws conclusions on a range of issues. These conclusions often appear to be based on assumptions that are implicit rather than clearly expressed.”

Detailed discussion of the environmental aspects and potential impacts is presented in each of the chapters of the Draft EIS (e.g. in Chapter 7 *Marine impacts and management*).

INPEX contends that any inaccuracies in the assumptions made in the application of the risk-assessment methodology would be insufficiently large to elevate the level of consequence to the extent that it would result in a higher residual-risk ranking. Therefore conclusions drawn are based upon a traceable lineage through tables 6-1, 6-2, and 6-3 in Chapter 6 of the Draft EIS.

The submission states that "The uncertainties that are associated with some of the concluding remarks in the text should have been explicitly documented throughout the draft EIS so that readers were able to ascertain the strength of conclusions drawn."

The concluding remarks in the text of Chapter 6 *Risk assessment methodology* and the chapters of the Draft EIS refer to the risk management controls contained in Chapter 11 *Environmental management program*. The environmental management program provides a robust mechanism for implementing the selected environmental management measures in a manner which allows for continuous improvement.

The submission states that "For some of the key issues, this identification of uncertainties and assumptions could help to inform further studies or research that might need to be undertaken to reduce uncertainty".

This point has been explicitly addressed and explained in Section 6.2.2 of the Draft EIS. This EIS Supplement also provides additional information arising from studies which have been undertaken to provide greater understanding of the potential risks to the environment. For example, studies have been undertaken by INPEX to determine the tolerance of barramundi eggs and larvae to suspended sediment while detailed literature reviews and impact assessments have been undertaken to assess the potential risks of sedimentation and suspended sediment on mud crabs and on invertebrate fauna communities.

The submission states that "The Supplement, henceforth called the EIS (the draft EIS together with the Supplement from the EIS), should provide a comprehensive list of the assumptions made against the conclusions they inform."

The environmental risk assessment was necessarily qualitative and based on expert judgment. The uncertainty in the risk assessment was addressed by selecting experienced and highly qualified experts and relying on their professional knowledge and judgment to estimate and rank risk in workshops where their assessments could be tested and validated among their peers. Expert judgment routinely errs on the side of caution to ensure that management controls and mitigating factors are carefully and appropriately considered when ranking risk, so that the level of risk is not understated in a precautionary manner. INPEX believes that the outcomes of the risk assessments presented in the Draft EIS are therefore, by design, conservative in nature.

Submission 123-2: Risk assessment. In general the risk assessment is qualitative given that INPEX has not accumulated sufficient information to conduct a more robust risk assessment. In the main part, INPEX has relied on unsubstantiated assumptions to inform risk. Robust baseline surveys may be required as indicated throughout this submission. It is difficult to determine the extent to which information requirements outlined in Section 6 of the draft EIS guidelines relating to Risk Assessment were addressed. Chapter 6 of the draft EIS contains very little detail and only briefly and very generally acknowledges the inherent levels of uncertainty. It does not discuss the issue of risk associated with realising benefits. The risk assessment components of subsequent draft EIS chapters contain little to no discussion of the residual risk that would be expected to be borne by the community.

This response is presented in a similar manner to the response to 123-01, that is, in the context of risk-assessment conventions, It intends to provide clarity and relevance for the risk-assessment methodology described in the Draft EIS. To assist in ascertaining the intent of the comment above, it has therefore been broken down into its relevant components which are addressed below.

The submission states that "In general the risk assessment is qualitative given that INPEX has not accumulated sufficient information to conduct a more robust risk assessment."

This is explicitly acknowledged in the risk-assessment methodology (see Section 6.2.2 in Chapter 6 *Risk assessment methodology* of the Draft EIS). Qualitative assessments are an accepted and appropriate method of ranking risk when data are unavailable to perform a quantitative assessment. Furthermore, the *Guidelines for preparation of a draft environmental impact statement* (see the Draft EIS's Technical Appendix 1) state that the EIS "Quantify (where possible) and rank risks". In accordance with these guidelines, where quantification of risks was not possible, qualitative assessments were made.

Quantitative methods, however, have been used to inform the risk-assessment process wherever possible. For example, air-quality modelling outputs have been compared against Australian air-quality standards; the potential impacts from residual oil in wastewater discharges from the onshore processing plant have been determined by comparison against very conservative levels derived from a literature review of laboratory studies; oil-spill risks have been quantitatively determined; and the effects of dredging-derived sediment deposition in mangrove communities has been determined from field observations reported in the literature. In addition, this EIS Supplement includes additional quantitative information on literature-derived dose-response thresholds of seagrass and soft-sediment invertebrate communities to sediment deposition and of experiment-based dose-response thresholds for barramundi eggs and larvae to suspended sediments. INPEX has also developed water-quality thresholds based on site-specific, long-term, water-quality data for hard corals, macroalgae and filter-feeders. Section 4.1.3 in Chapter 4 *Project description* of this EIS Supplement discusses the derivation of these thresholds for suspended sediments in Darwin Harbour.

The submission states that "In the main part, INPEX has relied on unsubstantiated assumptions to inform risk."

Expert judgment, integral to the qualitative risk assessment, is highly substantiated and precautionary, based on the experience and knowledge of the persons undertaking the assessment. This approach is fundamentally sound and accepted in risk-assessment convention.

INPEX contends that any inaccuracies in the assumptions made in the application of the risk-assessment methodology would be insufficiently large to elevate the level of consequence to the extent that it would result in a higher residual-risk ranking.

The submission states that "Robust baseline surveys may be required as indicated throughout this submission."

INPEX acknowledged in the Draft EIS that ongoing detailed baseline studies and surveys would be necessary prior to the commencement of construction and operations of the Project as these will form the basis for validating impact predictions and quantifying environmental change due to Project activities. A preliminary outline of the proposed monitoring programs is provided in Section 11.4 in Chapter 11 *Environmental management program* of the Draft EIS. INPEX will further develop these monitoring programs in consultation with the Departrment of Natural Resources, Environment, the Arts and Sport and other relevant stakeholders.

The submission states that "It is difficult to determine the extent to which information requirements outlined in Section 6 of the draft EIS guidelines relating to Risk Assessment were addressed."

All of the guidelines were addressed in Chapter 6 *Risk assessment methodology* of the Draft EIS, to an extent that is considered appropriate for the purposes of environmental risk assessment.

The submission states that "Chapter 6 of the draft EIS contains very little detail and only briefly and very generally acknowledges the inherent levels of uncertainty."

Chapter 6 *Risk assessment methodology* of the Draft EIS presents the methodology for environmental risk assessment and addresses all of the EIS guidelines. The methodology is applied in each of the relevant chapters of the Draft EIS, where environmental aspects and uncertainty are addressed in detail, and the results of the precautionary assessments are presented.

The submission states that "It does not discuss the issue of risk associated with realising benefits."

The issue of risk associated with realising benefits is addressed in the commitment to maintain and update the aspect register for the Project (see Section 6.2.4 in Chapter 6 *Risk assessment methodology* of the Draft EIS). The benefits of the Project are discussed in Chapter 1 *Introduction* and more particularly in Chapter 10 *Socio-economic impacts and management* of the Draft EIS, which describes the socio-economic aspects of realised benefits through improved opportunities and greater prosperity for the people of the Northern Territory and Australia.

The submission states that "The risk assessment components of subsequent draft EIS chapters contain little to no discussion of the residual risk that would be expected to be borne by the community."

Residual risk is clearly identified in all of the assessments presented in the Draft EIS for each environmental aspect of the Project that may be impacted by specific activities. The potential consequences of derived residual risk is clearly articulated in tables 6.1 to 6.3 of Chapter 6 of the Draft EIS.

Submission 123-3: Confidential resources. Where confidential or commercially sensitive reports or information have been requested, INPEX may lodge an objection to the making of part of the report available to the public. Please refer to Section 10 of the Environmental Assessment Administrative Procedures. Previously requested references are listed in the 'Appendices' component of the table below.

It is understood that references previously requested in the "Appendices" component of the table referred to in this submission have been provided by INPEX.

Submission 123-7: Scenario Planning. Sometimes models may not accurately simulate observed conditions. Planning for scenarios that could eventuate, where observed conditions during dredging operations depart significantly from conditions simulated by the sediment transport modelling, should be discussed in the EIS. Currently, NRETAS assumes there is a high degree of uncertainty associated with the modelling predictions as the draft EIS gives little insight into the conservatism or otherwise of the many assumptions used to build the model.

The EIS should address this by clearly stating the assumptions that were used to build the sediment transport model where empirical data was unavailable, with an explanation supported by evidence of the basis for each assumption. Further sensitivity analysis should be applied to some of the modelling parameters to clarify to what extent changing the input values might affect the model results. The likelihood that input values for more sensitive parameters will change once the dredging contractor is nominated, and the environmental implications of such changes, should also be discussed.

Management contingencies will need to be developed to protect significant habitats in the event that observed sediment parameters arising from dredging activities stray outside of the predicted values. The processes for developing contingencies and establishing triggers for implementing contingency action should be discussed in the EIS.

INPEX acknowledges that the outcomes of numerical models have limitations in confidence levels. This inherent aspect of modelling has been addressed by INPEX through the application of conservative assumptions within models presented within the Draft EIS. That is, where there is some uncertainty as to what particular parameter to apply, or in the absence of any meaningful or reliable field data, INPEX has applied conservative assumptions. The consequence of this approach is that model outcomes are very conservative and therefore the potential for environmental impacts to exceed those predicted is very low.

Further details in relation to assumptions incorporated into the dredge and dredge spoil modelling are provided in Section 4.1.3 of this EIS Supplement. Prior to the commencement of dredging, INPEX will remodel to ensure that acceptable environmental outcomes are maintained.

Monitoring of mangrove health and sediment deposition within Darwin Harbour will be designed such that actual sedimentation can be compared with predicted sedimentation rates. It is proposed that such monitoring will be conducted at 3-monthly intervals. In the unlikely event that sedimentation rates in mangroves exceed those predicted, or mangrove health is impacted at lower levels of sedimentation than assumed in the Draft EIS, the monitoring program will detect such changes early and adaptive management practices can be identified and discussed with NRETAS to facilitate protection of mangrove communities.

Submission 123-30: These statements are based on data provided by unpublished reports (eg RPS 2007a, RPS 2008b). These data/reports need to be provided with the EIS so it can be independently reviewed for accuracy and appropriateness.

The reports cited in this comment were not referenced in the Draft EIS, but in a technical appendix. These reports have been made available to the Department of Natural Resources, Environment, ther Arts and Sport (NRETAS).

Submission 123-86: Add a summary table of all Medium risks (inshore and offshore separate) including a column with proposed mitigation and whether it is included within a separate management plan.

The Draft EIS documents all residual risks in summary tables within the relevant chapters and sections of the document. These summary tables list the management controls and mitigating factors and the text within the tables refers to the provisional environmental management plans (EMPs) that are applicable. See also Table 11-3 in Chapter 11 *Environmental management program* for a list of all provisional EMPs included in the Draft EIS.

Submission 123-167: It is acknowledged that the provisional plan will contain details as it is developed further. Monthly reporting of any incident to relevant authorities is expected.

Submission 123-198: Reporting, auditing and review need to be undertaken at least quarterly. Monthly reporting of any incident to relevant authorities is preferred. This may enable methodological changes to occur if incident levels are unacceptable.

All environmental management plans (EMPs) will be provided to the relevant regulatory authorities for approval prior to execution. Reporting conditions are expected to be an integral part of any approval process.

Submission 124-11: Inadequate habitat mapping used as a basis for assessing impacts and likelihood of recovery of marine communities;

INPEX has worked with both Commonwealth and Northern Territory regulators since early 2008 to establish and execute surveys and studies to provide sufficient data to inform the environmental assessment process.

Public comment, and further input from NRETAS since the publication of the Draft EIS has guided additional work on behalf of INPEX to further develop habitat maps in key areas that are likely to be impacted by the Project. This EIS Supplement presents this additional information in Section 14.1.2.

INPEX believes the information provided is now adequate to facilitate an informed determination by respective environment ministers in accordance with the requirements of the EA Act and the EPBC Act.

Submission 124-12: Literature reviews missing key references, or lacking in up-to-date references important to determine impacts and risks to ecosystems and species;

Poor interpretation of cited literature and omission of important information from cited references resulting in inadequate assessments of threats, impacts, risks and likely outcomes;

A general under-rating of risks (due to above inadequacies);

INPEX has prepared the Draft EIS and EIS Supplement with the support of a range of highly professional local and international consultancies. The literature reviews presented in the Draft EIS and this EIS Supplement represent a professional standard adequate to address the needs of an environmental impact assessment.

The above comments appear to be subjective in nature and unsubstantiated.

Submission 124-73: Land and capital requirements, costs and risks

The Ichthys Project has been openly welcomed by the Northern Territory Government since it was first mooted, with the Government offering INPEX the Blaydin Point site for the onshore components of its Project (p. 160, Volume 1). Along with knowledge about the offering of Blaydin Point to INPEX, the public also has a right to know about any costs and risks incurred, or likely to be incurred, by Government as a result of additional infrastructure provision to support the Project. Information about potential costs is important for enabling an objective socio-economic assessment.

Recommendation: A detailing of any land and capital costs and risks to be borne by Government in support of the INPEX project. These may relate to land development at Middle Arm Peninsula, road and transport corridor upgrades, and provision of enhanced emergency service response capabilities for potential accidents.

INPEX has committed to bear the development costs of the Ichthys Project without seeking any subsidy or capital offset from government.

The future land transactions for the site of the onshore processing plant and related facilities on Middle Arm Peninsula will be undertaken on commercial terms with the Northern Territory Government and an appropriate value will be agreed by the parties and paid by the Ichthys Joint Venture to the government. Through its corporate service provider, the Power and Water Corporation (PWC), the government will invest in the provision of sewerage, water, power and gas supply services to the plant at Blaydin Point and to the site of the accommodation village for the Project workforce at Howard Springs. The cost of this capital outlay is not yet known and it is expected that government may recover these costs over time through fees and charges to INPEX for the services used. This process is normal practice and has been in effect for decades, servicing residential housing in the city and outlying developments and business developments around the Territory.

Requirements for upgrades to road corridors are still to be determined and INPEX will work with the Road Network Division of the Northern Territory's Department of Lands and Planning to determine what may be necessary. INPEX anticipates that the Ichthys Project will have to provide funds to upgrade or repair roads.

In relation to the comment about the provision of emergency services, INPEX will develop appropriate levels of in house expertise and resources for dealing with emergency response situations and will work with NT WorkSafe and the Northern Territory emergency service authorities to ensure that its capability meets the requirements of Australia's National Standard for the Control of Major Hazard Facilities (NOHSC 2002).

Submission 124-83: Reassess risks, taking into account the potential for serious impacts on marine habitat function and impacts on marine species conservation status such as (known or likely). Factors for consideration include: site fidelity, localised ranges, small populations.

As a relatively small portion of Darwin Harbour's marine habitats are subjected to environmental stressors from Project activities (see Section 4.1.3), the potential for serious impacts on marine habitat function is considered very low.

The key Project stressor to marine mammal species is the previously proposed drilling and blasting program. With the likely elimination of drilling and blasting (see to Section 3.3.8 of this EIS Supplement) risks to marine mammal species are significantly reduced.

Further information on marine mammal status and distribution in Darwin Harbour and on the Project's risks and management controls is provided in sections 4.1.9 to 4.1.13.

Submission 127-2: Minimising Ichthys project green house emissions. This section outlines options Inpex seeks to investigate for minimising green house gas emissions (GHG). The Council understands that transportation makes a significant contribution toward the total GHG's that the project will emit.

In this context, the Council suggests that the development of the Marine Supply Base has the potential to assist in reducing the amount of GHG produced over the life of the project. It is the understanding of the Council that servicing the offshore activities by sea during both the construction and operational phases is inefficient in terms of energy and time and therefore the creation of the Point Torment Supply base has the potential to reduce travel times and thus the amount of GHG emissions. Point Torment has the shortest straight line distance of any other supply base option. It is located near major road transportation routes that would facilitate the bulk movement of materials by road that would then significantly reduce the time that supply vessels take to deliver those materials to the offshore operations. It is contested that the efficiency that this option delivers would have significant benefits in reducing the total amount of GHG emissions produced by the project over its projected 40 year life.

INPEX is currently assessing several options for selection of a Marine Supply Base (MSB) to service the Project.

However, the construction and operation of a MSB is outside the scope of this environmental impact assessment and will be subject to a separate assessment process at a later date.

Submission 128-6: Onshore infrastructure. Dot Point 5 – Require definition of the term 'upset condition' in reference to the separation of processes areas.

"Upset conditions" refer to a departure from steady state operations in the onshore gas processing facility. The most common cause of an upset condition is a mechanical or process malfunction. Under such conditions, hydrocarbon product is usually purged to the flare in order to maintain safe operations.

The plant will be designed to safely accommodate upset conditions, including safe separation distances between plant components.

Submission 128-7: Onshore infrastructure. Dot Point 6 – Do the Future facilities mentioned in this paragraph form part of the Draft EIS?

If not, further details are required.

Council requires an understanding of how Mercury contained in the absorbent beds will be managed and disposed of. This and other hazardous materials will not be accepted at Shoal Bay Waste Disposal Site.

The Draft EIS mentions provision for future expansion of the proposed onshore plant at Blaydin Point, however there are no plans to expand the Project beyond that described in Chapter 4. Environmental approval is therefore limited only to that described in the Draft EIS.

INPEX acknowledges the position of the DCC in regard to management and disposal of hazardous wastes. The disposal of such wastes will be subject to the preparation of a final waste management plan which will demonstrate compliance with all necessary legislation and local by-laws. The Provisional Waste Management Plan provided as Annexe 16 of Chapter 11 *Environmental management program* in the Draft EIS lists the applicable legislation, standards and guidelines upon which the final plan will be structured.

5.2.2.7 Government approvals

Submission 86-10: (Table 1-3) Note Middle Arm area is within a Building Control Area. DHF involvement depends upon whether the package plant to be used is an approved type or not. If it an approved type authorisation/certification is provided under the Building Act. If the package plant is not an approved type approval must be sought from DHF for its use and installation.

INPEX's position is that an approved type would be the preferred option, but should this option not be available the need for approval by the Department of Health and Families (DHF) is acknowledged

5.2.2.8 Greenhouse gas

Submission 1-34: PART I Question 33. How will any future tax on carbon or an Emissions Trading Scheme effect the longevity and productivity of the Plant?

A future carbon tax or ETS would primarily increase the operating cost of the plant. Increased operating costs potentially accelerate the decommissioning date of the LNG facility. Towards the end of the Ichthys Field's production life, the LNG plant will be decommissioned when the product revenue is no longer sufficient to cover the plant operating costs. Higher operating costs would bring the decommissioning date forward (assuming the same production revenues).

INPEX may implement plant modification, in addition to the design modifications mentioned in the Draft EIS and in Section 4.8 of this EIS Supplement, to further reduce GHG emissions. These modifications are unlikely to affect the operation of the plant.

Submission 1-37: PART I Question 36 Will Ozone Depleting Substances such as Hydrochlorofluorocarbons (HCFCs) be used in the refrigeration system that forms PART of the gas processing plant at the Gathering Station and how will potential losses be monitored and prevented?

The two refrigerants selected for use in the onshore plant refrigeration loops will be propane and mixed refrigerant as explained in sections 4.5.1 and 4.5.2 of Chapter 4 *Project Description* of the Draft EIS. The propane refrigerant will be high-purity propane, while the mixed refrigerant will be a mixture of ethane, methane and nitrogen. Neither the propane nor the mixed refrigerants will contain any ozone depleting substances (ODSs) or hydrochlorofluorocarbons (HCFCs).

Potential losses of both process refrigerants will be monitored by means of pressure monitors within the refrigeration loops and by gas detectors outside the loops.

Submission 1-49: PART I Question 48 Energy Use and Air Emissions What are the plans for the long term management of Carbon Dioxide emissions – INPEX will generate carbon dioxide in massive quantities each year by the combustion of fossil fuels. Carbon Dioxide concentrations in the atmosphere have been rising due to the combustion of fossil fuels around the world and the majority of scientific evidence links this to global climate change. What is INPEX's position on Global warming and what strategies and aims do INPEX have to use energy efficiently to reduce the quantity of green house emissions; especially carbon dioxide, Methane (CH4), Volatile Organic Compounds (VOCs), Sulphur dioxide (SO2) and Oxides of Nitrogen (NOx) –Nitrogen oxide emissions are largely as a result of combustion of gas in electricity generating turbines and from combustion of gas in the flares. How will this be managed?

INPEX acknowledges the risk of climate change and is committed to developing and implementing measures to reduce global warming. INPEX's Environmental Policy (reproduced on page 492 of Chapter 11 *Environmental management program* of the Draft EIS) explicitly states the following in relation to greenhouse gas (GHG) emissions and energy efficiency:

INPEX will:

- endeavour to prevent pollution and seek continual improvement with respect to emissions, discharges, wastes, energy efficiency and resource consumption
- actively promote the reduction of greenhouse gas emissions across its operations in a safe and technically and commercially viable manner

Section 9.3 of Chapter 9 *Greenhouse gas management* of the Draft EIS provides a more detailed account of INPEX's greenhouse gas policy position and interim management strategy.

Section 9.8 of Chapter 9 of the Draft EIS outlines various technologies which have been incorporated into the Project's design to reduce GHG emissions. Figure 9-7 in particular shows the improvements that have been obtained as the design has progressed. INPEX will continue to explore other emission mitigation measures as the Project advances through the design phases into construction, commissioning and operations.

Figure 9-8 in Section 9.9 of Chapter 9 of the Draft EIS also demonstrates the relative proportions of LNG's carbon dioxide equivalent (CO_2-e) emissions from the extraction of the raw gas from the gas field, through the processing phases, and finally to transport to the market and combustion by the end-users. It may be noted that the end-user emissions represent by far the greatest proportion of the total emissions. Figure 9-9 compares LNG's life-cycle CO_2-e emissions with those produced by coal on an equivalent energy output basis, and demonstrates that LNG is the cleaner fuel of the two. Further discussion of the topic of life-cycle emissions can be found in Section 9.6 of Chapter 9.

As recorded in Section 9.11 of Chapter 9 of the Draft EIS, INPEX continues to examine the feasibility and cost effectiveness of GHG offsets.

It should be noted that volatile organic compounds (VOCs), sulfur dioxide (SO_2) and oxides of nitrogen (NO_x) are not greenhouse gases. See Table 9-1 of Chapter 9; the definition of "greenhouse gas(es)" in the Glossary to the Draft EIS; and the list of greenhouses gases in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC 2007).

Submission 1-50: PART I Question 49 How will Ozone Depleting Substances be managed – A layer of ozone gas in the upper atmosphere filters ultraviolet radiation from the sun, reducing the amount of harmful radiation reaching the earth's surface. Ozone depleting substances such as chlorofluorocarbons (CFC's) and Hydrochlorofluorocarbons (HCFC's) react with the ozone and break it down removing this protective layer from our upper atmosphere. How many tonnes of HCFC's will be utilised at the INPEX plant? How will this gas be managed and disposed of if necessary?

INPEX does not plan to use any hydrochlorofluorocarbons (HCFCs) in Ichthys Project activities. Should it be found necessary to use HCFCs for a specific purpose in the future, the amounts used would be small (measurable in kilograms rather than in tonnes) and would be contained within sealed systems. Any leaks would be rare and at very low levels. Greenhouse gas (GHG) and ozone-depletion impacts of HCFCs from the onshore processing plant at Blaydin Point will therefore be zero or close to zero.

Submission 9-15: The substantial increase in greenhouse gas emissions that this project will deliver exacerbates the already negative emissions profile of the Northern Territory, having the highest emissions per capita in Australia. The tourism industry has been the subject of criticism for the contribution of aviation to global greenhouse gas emissions and as a result long haul travel is being discouraged in some international markets, which threatens our international visitation.

As discussed in the Draft EIS in Section 9.10 of Chapter 9 *Greenhouse gas management*, and further in Section 4.8 of this EIS Supplement, the quantity of greenhouse gases (GHGs) emitted over the full life cycle of LNG production, processing, transportation, and combustion at end use is significantly less than the comparable life-cycle emissions from either coal or fuel oil as a means of delivering the same amount of energy. Figure 9-9 of Chapter 9 of the Draft EIS shows that Ichthys Project GHGs, generated in Australia at the Ichthys Field and in the Northern Territory, offer a net global benefit when compared with the alternative of using coal to provide a similar amount of energy in the consuming country.

It is true that the Northern Territory's per capita GHG emissions are higher than those of the rest of Australia. This, however, is in part attributable to the large contribution of transport sector emissions from cars, freight vehicles, and domestic air travel made necessary by the large area of the Territory (NRETAS 2007). Per capita statistics can be misleading, as the Territory has 17.5% of Australia's land area but only 1% of its population.

Submission 16-10, 24-10, 29-9, 89-10, 96-9, 101-11, 102-9: INPEX has stated: "In a global context, the use of Ichthys LNG to generate electricity in Asia will…likely result in a significant reduction in CO_2 emissions"1. However, there is no guarantee that INPEX gas will actually displace coal, it may simply be used in addition to coal. Thus, INPEX cannot provide any guarantee that global GHGE will fall due to its project. Without emissions trading schemes in Australia and gas purchasing countries, a price on carbon, or a global climate treaty stipulating significant cuts in GHGE, the reality is that INPEX's LNG will probably just increase global GHGE, and significantly increase GHGE in the Northern Territory.

Submission 65-5: 2. Gas is a non-renewable resource, which is currently likely to increase CO_2 outputs rather than replace more polluting sources. Therefore INPEX should create a carbon fund to offset 100% of the 7 million tonnes of greenhouse gas emissions it will produce.

Submission 84-6: Could Inpex provide a detailed account of how they will offset the greenhouse gas emissions generated by the project? (this consideration includes the loss of carbon catching environment through land clearing) There is no guarantee that the gas project will actually displace coal-related greenhouse gas emissions and Inpex's carbon offsets should not be linked to other industries or companies. It is up to the company producing the emissions to offset them in a tangible way, i.e. participation in Territory-based initiatives such as bush regeneration & revegetation, Indigenous fire management, supporting (including financial support) the creation of a network of national parks in Darwin Harbour in collaboration with the NT Government to ensure that our coastal areas are protected for future generations all worthwhile projects which would also create actual long term employment for Territorians. Additionally, Inpex's proposal should include signing and supporting the Darwin Harbour Integrated Monitoring and Research Plan Agreement as a prerequisite to the plant going ahead.

Submission 87-5: Gas emissions – this is a global issue and increasing Territory emissions is very serious

Submission 92-4: INPEX and NT and the Australian governments can give absolutely no guarantee that global emissions will fall due to LNG processed in Darwin. The goal should be a zero net emissions LNG plant, particularly until national and global regulatory frameworks are established and operating.

Submission 104-1: The Draft Environment Impact Statement for the Ichthys Gas Field Development Project Overseas notes that "In a global context, the use of Ichthys LNG to generate electricity in Asia will...likely result in a significant reduction in C02 emissions'", Our view is that there may be some reduction if industries choose gas rather than coal as a source of power, but locally there will be a significant increase in greenhouse gas emissions. These emissions will negate the best efforts of community, industry and government to achieve real reductions. The magnitude of the emissions will far outweigh the efforts of Territorians to do their part in protecting the environment.

Submission 106-17: 9. Greenhouse gas emissions

INPEX (and its backers in the NT and Federal Government) cannot provide any guarantee that global greenhouse gas emissions will fall due to its LNG displacing coal in Japan or other purchasing nations. INPEX's LNG will most likely increase global emissions because Australia lacks an ETS or price on carbon, there is no global climate treaty ensuring deep cuts by 2020, and ETS is not legislated in Japan and other purchasing nations. The INPEX project will add another 7M tonnes p.a. to the Australian account – more than a 1% increase.

INPEX must offset 100% of the 7 M tonnes p.a. of GHG emissions it will create in the Territory and in WA until the regulatory measures listed above are implemented. Offsets should be developed in conjunction with the local environment groups in NT and WA.

Submission 109-25: Section 9.6.1 page 418 states 'Over its 40 year lifetime, INPEX expects the Project to emit about 280 Mt of CO_2. This amounts to an average annual emission of about 7.0 Mt. This will be approximately 1.2% of Australian emissions, and 30% of Northern Territory emissions. INPEX should aim for 100% offsetting of carbon emissions created by the project. INPEX has indicated its interest in bio-sequestration as an option to offset large volumes of carbon. However no commitments have been made.

Submission 112-7: No Net Benefit

In the invitation to comment to the draft, Inpex inappropriately proscribe an overly rigorous set of requirements on community comments, including the declaration that:

"Supporting factual information and/or references should be provided for each point raised."

But Inpex themselves fail to meet this standard when it comes to describing the climate imapcts of the project.

Section 9.1 elliptically identifies advantages of LNG over coal or oil to fuel power plants. We are further given the unsupported assertion that:

"natural gas has a positive transitional role to play in the domestic and transport energy markets."

Without any description or justification of the relevance of this discussion, more is written on the greenhouse gas impacts of using LNG instead of coal for electricity generation. Then again, the provisional greenhouse gas management plan tells us that:

"Compared with coal and fuel oil, natural gas produces less GHG to produce the same amount of power."

The Draft Statement deliberately avoids mentioning the true carbon burden of downstream burning of the LNG product, and Inpex representatives were unable to provide this number to community consultations held upon release of the Draft. So it is doubly curious, that in this total information vacuum, the company repeatedly presents the empty assertions that:

a) gas is cleaner than coal; and
b) LNG is a transitional fuel on the path to a carbon-light economy.

That the proponent wants to claim a net benefit, without presenting the basic parameters, is one thing.

But even if we put aside Inpex's failure to front up to the full carbon burden of this project, these statements remain glaringly misleading. The lack of substance to these claims invites a cursory analysis which quickly leads to the obvious conclusion that there is in fact no net carbon benefit to this project.

Territorians have a right to be confused that Inpex are asking us to compare LNG to coal. We don't have any coal, and we sure don't use it. We are familiar with gas, but also truly renewable energy sources, such as the biomass power produced at Shoal Bay, and the solar concentrator PV technology that powers a number of NT communities. We don't have any coal resource, but we have a consistent wind resource in the Barkly, and an interesting proposal before us for a tidal power station in the Clarence Strait. We are very well aware of the range of cleaner alternatives to gas. So why is this monolithic energy company so ignorant? Inpex offers no rationale for why they are comparing LNG to coal instead of solar.

Inpex cannot demonstrate that this LNG product will in any way displace dirtier fuels. Certainly, there are no Australian or international mechanisms for leaving any coal in the ground. Australia (the producer) has not committed to export any less coal, and Japan (the consumer) have not committed to shutting down any coal fired power stations. Both countries have poorly defined and pathetically weak short term emission reductions targets, that appear to be independent of fossil fuel consumption. Inpex themselves are not contributing in any way to the development of effective strategies or policies for moving away from coal and oil. Indeed, given the failure of all parties to realise any agreement to reduce consumption of the dirties fossil fuels leads to an obvious conclusion : that the Ichthys resource will be used in addition to, rather than in place of, existing use of dirtier fossil fuels such as coal and oil, effectively guaranteeing a net detriment.

So what if gas is cleaner than coal : if the LNG cannot be shown to be strategically displacing the dirtier alternative, that absolute statement is hardly relevant. Maybe tobacco is safer than heroin, but that doesn't mean I want my kids to start smoking. Similarly, the claim that LNG "has a positive transitional role to play" is just as irrelevant if no-one can demonstrate that this resource is being strategically applied in such a role. And they can't – no parties to this project have come close to developing or even describing a strategic trajectory or pathway for managing the carbon burden of our economies.

This is all the more infuriating when we remember that LNG itself is a finite resource, and that the nonstrategic plunder and squander of that resource disqualifies future (smarter) generations from realising this capacity. Contrary to the misleading statements and implications presented by Inpex in the draft statement, it becomes clear that this project represents a net carbon burden, a net climate detriment, and a real barrier to effective action to manage the worst ravages of climate change.

Submission 124-5: Major greenhouse gas pollution with no guarantee of reduced coal use in Asia

Although the Project will cause major carbon pollution over 40 years, the draft EIS does not (and cannot) provide any guarantee that global carbon emissions will fall due to displacement of coal with gas for electricity generation in Asia. Emissions will contribute to climate change impacts, such as on World Heritage Sites that are afforded protection under the EPBC Act.

Recommendations: Ichthys LNG to be made a carbon neutral project by offsetting 100% of emissions through a Northern Territory Carbon Fund.

Submission 124-22: 2.1 Greenhouse Gas Emissions

Ichthys LNG is not clean

The Draft EIS clearly shows Ichthys LNG has very high CO_2 content compared to other gas fields (Chapter 9, Section 9.1, p. 427, Table 9.4). Ichthys LNG is not a clean fuel, as has often been claimed by INPEX staff and the Northern Territory Government, in comparison to most existing LNG projects. Reservoir CO_2 levels for the project are 8 mol% for the Brewster Member, and 17 mol % for the Plover Formation. These figures are at the very highest level for LNG projects reported globally in Table 9.4.

Moreover, Ichthys LNG is certainly not clean compared to sources of renewable energy. Sections 9.1 and 9.10 only compare greenhouse gas emissions from LNG with coal. This is designed to put Ichthys LNG in a positive light. In view of previous comments that INPEX can provide absolutely no guarantee that their natural gas will displace any coal globally, these sections, and Figure 9.9, therefore fail to provide a broad comparison with other energy sources, particularly sources of renewable energy such as solar and wind.

Recommendation:

Expand Sections 9.1, 9.10 and Figure 9.9 to compare greenhouse gas emissions produced per unit of electricity production between different types of fossil fuels and renewable energy sources.

Ichthys LNG is likely to increase – not decrease – global emissions

The estimated 280 Mt of greenhouse gas emissions to be released over the 40 year life of the Ichthys Project are likely to increase global atmospheric carbon dioxide levels and hence hasten climate change, rather than lead to a decrease. The most likely scenario, at least in the next one to two decades, is that nascent carbon markets and non-existent or weak abatement targets and legislative emissions trading schemes in purchasing countries will not significantly drive the use of Ichthys LNG to displace the use of coal for electricity generation. Instead, Ichthys LNG will most likely be used in addition to cheaper coal.

The Draft EIS for INPEX's proposed Ichthys Project comes at a time when there are no science-based legislated emissions reductions targets linked to carbon trading schemes in Australia, in Asian purchasing nations, or globally. Whilst we acknowledge the potential for displacement to occur, we consider this will be substantially contingent on major progress being made globally and by Asian purchasing nations to legislate rapid emissions abatement through cap-and-trade markets; commit to science-based cuts (absolute cuts of 25-50% on 1990 levels by 2020, based on advice in the IPCC's Fourth Assessment Report5); and impose strong prices on carbon. These scenarios do not appear at all likely in the next decade or two for many likely purchasing nations, e.g. China.

In a Draft EIS spanning 728 pages, plus the appendices, the strongest language INPEX uses to underpin its argument that Ichthys LNG will cut global greenhouse gas emissions occurs on p. 429 (Chapter 9, Section 9.10) in very equivocal and unambitious terms: "In a global context, the use of Ichthys LNG to generate electricity in Asia will therefore likely result in a significant reduction in CO_2 emissions" [italics added].

This unsupported statement provides no guarantee global greenhouse gas emissions will fall due to the Ichthys Project and we consider that it cannot be justified. The absence of established and effective regulatory frameworks and a strong price on carbon means that coal will likely remain much cheaper than Ichthys LNG as a source of fuel for electricity generation in purchasing nations.

For example, Japan will probably be a major purchaser of Ichthys LNG and does not yet have a legislated domestic emissions trading scheme that entrenches science-based emissions reductions targets, such as cuts of 25-50% below 1990 levels by 2020. In addition, media reports indicate draft legislation that is likely to be considered by the Japanese Parliament for commencement in 2013 provides insufficient detail regarding the size of emissions reductions and whether these will relate to cuts in absolute emissions or only emissions intensity.

There is a strong likelihood that should Japanese energy utilities and companies purchase Ichthys LNG from 2016 when production is likely to start, it will not be subject to a strong carbon price signal or binding caps on emissions that would drive the rapid displacement of coal.

Ichthys LNG will cause major carbon pollution in the Northern Territory and Australia

The Ichthys Project will increase Australia's greenhouse gas emissions by a massive 280 Mt over 40 years, equivalent to increasing Australia's national emissions by 1.2% p.a. on 2007 figures. It will cause the Northern Territory's greenhouse gas emissions to leap by 30% p.a., or 5 Mt p.a. over the next 40 years.

This will occur at a time when the Australian Government has committed to cutting emissions by between 5 and 25% on 2000 levels by 2020, and when climate scientists and the Australian community are warning that emissions from developed nations must fall significantly in the next decade.

In light of this, and given that INPEX cannot guarantee that Ichthys LNG will drive emissions reductions in Asia by displacing coal used in electricity generation, the very real likelihood is that the Ichthys Project will increase greenhouse gas emissions in the Northern Territory, Australia AND globally.

Australia's national interest is threatened by climate change, including the future of some of our most significant World Heritage Sites6. Rising sea levels and even larger storm surges will push saltwater into the extensive freshwater wetlands of Kakadu National Park. Warmer water will continue to bleach the world's largest coral reef in the Great Barrier Reef, and snow will melt in the Australian Alps. Changing rainfall and warmer weather in the mountains of the Wet Tropics are predicted to drive regional species extinctions and range contractions across many taxa.

It is important to note that World Heritage Sites in Australia are afforded a level of protection as a Matter of National Environmental Significance under the federal Environment Protection and Biodiversity Conservation Act 1999. This must be taken into account when assessing impacts from the Ichthys Project.

A common challenge in the public submissions relates to the statements in the Draft EIS about global emissions reductions as a result of the marketing of Ichthys LNG. While several respondents acknowledge that Ichthys LNG will result in a reduction in global GHG emissions if it displaces more carbon-intensive fuels such as coal or oil, how much displacement will occur in practice is questioned. This is a complex issue and touches on fundamental choices by sovereign nations on their energy security and climate change policies. INPEX offers the following observations in this regard (see also Section 4.8.6 in this EIS Supplement).

The countries that purchase Ichthys LNG have energy demands that are related to their current and future economic development. Emissions resulting from stationary energy consumption are mainly determined by two factors: the level of energy use and the method of generation. Reduction of emissions should therefore consider these two factors.

Reduction of energy use is challenging for many nations as it directly impacts it ability to grow and develop. Energy efficiency and conservation programs have significant potential to impact energy use but it is widely accepted that a country's desire to grow its economy will result in a continued increase in energy demand. Therefore a key focus for emission reduction is on the method of power generation and in particular the mix of energy sources deployed to meet demand.

The decision which energy sources to procure to meet domestic energy demand concerns many factors, such as availability, energy security, cost, risk, as well as climate change. Energy supply is invariably a combination of sources in order to spread risk and mitigate against sudden shortfalls. For example, Japanese primary energy demand and power generation for 2008 is shown in the table in Section 4.8.6.

The share of nuclear energy has been growing in Japan because of the lower GHG emissions from nuclear power production. However, nuclear energy can only increase to a modest level because of waste, earthquake and tsunami concerns and costs. Damage and associated risks caused to conventional hydrocarbon power plants (e.g. by earthquakes and tsunamis) may also be easier to manage with fewer human health risks than damage caused to nuclear power plants.

The availability of hydroelectric power is naturally limited and in some cases the creation of new reservoirs to feed hydroelectric power stations can have adverse environmental and social consequences. Other forms of renewable energy will play a more important role in the future but will be insufficient to provide the capacity to replace other fuel sources. The International Energy Agency's world energy outlook report for 2010 estimates that global renewable power generation will need to triple by 2035 to reach the Copenhagen Accord greenhouse gas target of 450 ppm of CO_2 in the atmosphere, but this will require the enormous sum of US$3 trillion of government support to achieve (IEA 2011).

In the coming decades, Asian economies will continue to rely on fossil fuels to complement nuclear, hydroelectric, and renewable energy supplies to meet their total energy demands. INPEX's view is that every tonne of LNG used for power generation or manufacturing in Asia will result in either a reduction in emissions if directly displacing the use of oil and coal, or a reduction in the increase in emissions if chosen in preference to oil and coal.

The actual extent to which Ichthys LNG will displace oil, gas and coal requires detailed information on energy end-use which will be unknown until the LNG is consumed. However, there is clear evidence that fuel-switching is happening in Japan. The *Australian Financial Review* of 20 December 2010, for example, notes under the headline "Japan's producers to step on the gas infrastructure" that "Japan's major gas suppliers are raising their output and distribution capacities to meet demand from manufacturers, which are switching from crude oil to gas to lighten their carbon footprints" (AFR 2010).

Some submissions argue that Ichthys LNG will simply be used in addition to coal and oil and therefore increase global GHG emissions. INPEX acknowledges this potential if countries have an increasing energy demand to satisfy. INPEX believes it is not its role to challenge countries' increased energy use and its choices in terms of economic development. Instead, Instead, INPEX aims to provide a cleaner fuel alternative to oil and coal, which would otherwise be used to meet demand to an extent that nuclear and renewable sources such as hydroelectric and wind power cannot meet. It is widely acknowledged that gas is an important transition fuel that can help countries to make the required short term emissions reductions before sufficient renewable sources are available to meet longer-term demand. The IEA notes that: "*During this radical transformation, the flexible operational nature of gas-fired generation and its lower CO_2 content makes it an attractive "bridging" fuel*". It estimates that global gas consumption continues to grow for decades while oil and particularly coal demand declines dramatically due to its unfavourable CO_2 footprint (Ref 2010 WEO figure 14.7).

INPEX acknowledges concerns about increased GHG emissions, but notes that climate change and GHG emissions constitute a global issue that does not recognise national or state borders. INPEX supports the Commonwealth's Government's efforts to establish a global climate change framework that will recognise the emissions benefits that LNG offers compared with more carbon-intensive fuels.

Submission 16-11, 24-11, 29-10, 89-11, 96-10, 101-12, 102-10: A significant increase in the Territory's GHGE will be taking place at a time when emissions must fall sharply – the IPCC recommends a 25-40% cut by 2020.

Submission 100-12: Without substantial sequestration, the Inpex Ichthys development will result in an unacceptably large CO_2 footprint. As stated on p 422 of Section 9.7, the relative contribution of the project's GHG emissions compared against 2007 levels is 1.2% of the Australian CO_2 emissions and 30% of the Northern Territory's CO_2 emissions. In particular the gas from the Plover formation has an extremely high reservoir CO_2 at 17 mol %. WWF-Australia's position is that the EIS as it currently stands, does not adequately describe detailed sequestration and mitigation pathways, and the contribution that these pathways would make to the overall CO_2 footprint of the Project. WWF recommends that the identification of these pathways be required as part of a revised EIS that is released for comment by the community.

Submission 112-6: climate change

carbon emissions

With respect to the project's massive carbon emissions, Inpex claim that:

"standard risk assessment processes (assessing consequence versus likelihood) is not an appropriate tool for evaluating global pollutants."

No justification for Inpex's decision to side step a risk analysis of the huge carbon burden of this dirty project is presented. No alternative analysis is described. Beyond acknowledging that this single project represents a carbon burden greater than 30% of the NT's last audit, all we get from Inpex on this topic is a terse, specious set of assertions that the project presents a net benefit.

Submission 112-8: Policy vacuum

The public are entitled to ask : how did such a grossly inaccurate and misleading account of the project's carbon burden make it to the draft? While this deliberate misrepresentation is inexcusable, we should try to understand how, despite the guidance of the environment departments of three jurisdictions, the company are, even at this late stage, maintaining such a fantastic fairy tale regarding their pollution plans.

The draft statement clearly describes the policy vacuum evident at both terrtiory and federal jurisdictions. When we are told :

"The Commonwealth and Northern Territory governments are developing a suite of policy, strategy and legislative documents related to GHG management."

we can read for 'governments are developing' instead : 'governments have so far failed to come up with ...'

Inpex tell us that : "As the policy and legislative landscape is still evolving, INPEX's approach has been to advance understanding of a range of practical alternatives to reduce and offset CO_2-e emissions in order to be well prepared to react positively once GHG management requirements and options become clearer."

This is a confused statement. The scientific requirements are quite clear. What is as yet not clear is the base level for pollution control and offsetting which governments may soon make mandatory. Just as the lack of government action is unacceptable, so too is the lack of corporate responsibility. Inpex are clearly hiding behind the inertia of our governments, postponing any action in the misguided hope that it will come late and come light. Inpex should instead commit to not wait around for governments to set an 'acceptable' level of pollution, and should instead aim to offset all their carbon emissions.

Inpex also describe the paucity of appropriate guidelines for addressing climate impacts in environmental assessment :

"The Northern Territory Government's objective for managing GHG emissions from new and expanding operations is to minimise GHG emissions to a level that is as low as practicable. This objective is contained in the NT Environmental impact assessment guide: greenhouse gas emissions and climate change (NRETAS 2009). This Draft EIS has been prepared in accordance with this guide" The fact that Inpex has conformed to the NT's guide, and yet totally avoided any commitment to action, or even a realistic appraisal of the projects massive carbon impacts, should sound alarm bells for the NT department and the responsible minister. This draft statement highlights the NT Governments utter failure to make any progress towards an effective policy framework for addressing dirty, carbon heavy development proposals such as this, in the age of catastrophic runaway climate change.

Submission 117-4: This project would also increase Australia's carbon emissions. This is not acceptable.

Submission 124-5: Major greenhouse gas pollution with no guarantee of reduced coal use in Asia

Although the Project will cause major carbon pollution over 40 years, the draft EIS does not (and cannot) provide any guarantee that global carbon emissions will fall due to displacement of coal with gas for electricity generation in Asia. Emissions will contribute to climate change impacts, such as on World Heritage Sites that are afforded protection under the EPBC Act.

Recommendations:

Ichthys LNG to be made a carbon neutral project by offsetting 100% of emissions through a Northern Territory Carbon Fund.

All other things being equal, INPEX's Ichthys Project will result in GHG emissions in Australia increasing. However, as shown in the Draft EIS in Figure 9-9 of Chapter 9 *Greenhouse gas management*, using LNG is a significantly less GHG intensive way to generate electrical power to meet projected demands in Asia than using alternatives such as coal. INPEX believes, therefore, that it is more important to consider the overall effect of the use of LNG on global emissions than to view the Northern Territory's or Australia's emissions in isolation. Atmospheric carbon dioxide (CO_2) and other GHGs do not respect national, state or territory boundaries.

See also INPEX's response to comment 16-11 and Section 4.8.6 of this EIS Supplement.

Submission 81-6: 3 Chapter 9 – Greenhouse Gas Management

The EIS should include, as do other LNG EIS, a bar chart showing the GHG emissions relative to other LNG Projects. Presumably this has been omitted to cover up the large emissions from the Project. As the EIS notes:

(a) High Reservoir CO2.
(b) Energy intensive offshore facilities because of the greater distance between the field and the LNG Plant. As stated above in comment on the Introduction, this is largely due to Inpex's decision to select a Darwin location and the additional amount of GHG created by burning 1.5 Tcf of fuel gas. The "Schedule" reason given for selecting Darwin now appears to have been either without foundation or a reflection of Inpex's utter lack of capability as the operator of an oil and gas project of this magnitude.
(c) The Ichthys Project will emit more CO2 per unit of LNG or total liquid hydrocarbon produced than other projects undertaken so far. This will be the most GHG intensive LNG project ever. In light of this, Inpex should be required to offset or geo-sequester CO2. In particular, Inpex should be required to geo-sequester reservoir CO2.

The Draft EIS provides evidence-based benchmarks (see Section 9.9.3 of the Draft EIS – Ichthys Project greenhouse gas emissions compared with other projects) that clearly show how the Ichthys Project compares against historical LNG projects on the basis of electricity generated per MW·h (Figure 9-8).

Details regarding the proposed GHG offset provisions at this stage of Project development are provided in Section 4.8 of this EIS Supplement.

Submission 103-10: 34% (96 Mt) of the project's greenhouse emissions are from the venting of the reservoir carbon dioxide (due to the reservoir carbon dioxide contents of 8% and 17% respectively). Why is geosequestration (as per Gorgon) not being considered, nor an appropriate offset strategy (as required for Pluto) developed should geosequestration be proven "infeasible"?

As described in Section 9.11 of Chapter 9 *Greenhouse gas management* of the Draft EIS, INPEX is currently investigating and evaluating reinjection of reservoir CO_2 (geosequestration) and other offset options. INPEX estimates that, to date, the Ichthys Joint Venture has spent more than A$5 million on investigating reservoir CO_2 reinjection options.

Submission 103-11: Why have emissions of methane (CH4) and nitrous oxide (N2O) and other greenhouse gases been excluded from the greenhouse assessment of the EIS? Methane emissions in particular will be significant, and all significant greenhouse emissions should be detailed in the EIS.

In the Draft EIS, Section 9.6 of Chapter 9 *Greenhouse gas management* discusses the quantities of methane (CH_4) and nitrous oxide (N_2O) likely to be emitted from the gas production process. Figure 9-1 shows that these two gases will contribute respectively around 1% and 3% of the overall Project carbon dioxide equivalent (CO_2-e) emissions. The emissions of CH_4 from a modern LNG plant and modern offshore gas extraction infrastructure will not be significant. High-quality equipment has been specified to avoid or reduce leaks and technology is available to the oil & gas industry and other industries to detect leaks should they occur.

This includes, for example, the use of infrared cameras to locate and quantify sources of fugitive hydrocarbon emissions. This technology (FLIR Systems Inc. 2009) has been used successfully by ConocoPhillips at the Darwin Liquefied Natural Gas (DLNG) plant at Wickham Point, some 6 km west of INPEX's proposed plant at Blaydin Point, as reported in that company's environmental performance report for 2007 (ConocoPhillips 2008). (INPEX has an 11.27% interest in the Darwin LNG plant.)

Schedule 1 Energy content factors and emission factors of the National Greenhouse and Energy Reporting (Measurement) Determination (Attorney-General's Department 2009) provides typical factors for natural gas combustion (such as would occur in the gas turbines) as follows:

- CO_2 = 51.2 kg of CO_2-e per GJ
- CH_4 = 0.1 kg CO_2-e per GJ
- N_2O = 0.03 kg CO_2-e per GJ.

These factors show that CH_4 and N_2O make a very small contribution to the total GHG emissions associated with combustion (0.2% and 0.06% respectively). Essentially, even though the 100-year global warming potentials (GWPs) in CO_2-e for CH_4 and N_2O are taken as 21 and 310 respectively (IPCC 2007), compared with the GWP value of 1 which is conventionally assigned to CO_2, the relative masses of CH_4 and N_2O emitted from combustion sources such as turbines burning fuel gas are so low that CH_4 and N_2O are not significant compared with CO_2.

Submission 103-12: Why have venting and fugitive emissions sources been excluded from the greenhouse assessment of the EIS? All sources should be detailed in the EIS.

As noted in the Draft EIS in Section 4.5 of Chapter 4 Project description, INPEX intends to incinerate the waste vapour emissions from the acid gas removal units on each LNG train.

Overall, INPEX expects to have very low levels of fugitive emissions.

See INPEX's response to comment 103.11.

Submission 103-14: The greenhouse emissions benchmarking of Ichthys against similar projects should be carried out on the established basis of t CO2-e/t LNG. This measure shows that Ichthys will be among the most carbon intensive LNG projects in the planet, and does not represent best practice – as such carbon abatement/mitigation/offset measures should be developed and put in place.

Using the established benchmarking methodology:

Snohvit LNG ~0.22 t CO2-e/t LNG (Ref Wheatstone EIS) – this is the benchmark for best practice globally.

Pluto LNG ~0.32 t CO2-e/t LNG (Ref Wheatstone EIS) – this is the current benchmark for best performance in the region.

Gorgon LNG ~0.35 t CO2-e/t LNG (Ref Wheatstone EIS) – this is an appropriate analogue to Ichthys based on the similar reservoir CO2 contents (Gorgon's reservoir CO2 contents exceed those of Ichthys).

Ichthys LNG ~0.8 t CO2-e/t LNG (average over 40 years)

~1.1 t CO2-e/t LNG (peak) (Ref Ichthys EIS, calculated based on nominal production and the reported peak and 40 year average greenhouse emissions).

This shows that Ichthys has a carbon intensity around 3 times higher than an analogous project (Gorgon).

In the Draft EIS, Figure 9-7 of Chapter 9 *Greenhouse gas management* shows the Ichthys Project's greenhouse gas (GHG) emissions, given as tonnes of carbon dioxide equivalents (CO_2-e) per tonne of LNG, in the context of the design improvements that have been made by INPEX to minimise its Ichthys Project GHG emissions.

Figure 9-4, Figure 9-6 and Table 9-2 in Chapter 9 of the Draft EIS break down Ichthys GHG emissions at different levels to demonstrate the relative contributions made by the different Project processes. Detailed analysis of the GHG emissions in terms of the technologies used, and taking into account Project-specific factors such as the CO_2 content of the Ichthys Field reservoirs, shows that there are no projects currently in operation which can be considered analogous to the Ichthys Project and that Ichthys GHG emissions are demonstrably as low as reasonably practicable (ALARP). For example, the high CO_2 content of the two Ichthys Field reservoirs collectively contribute approximately 34% of total Project emissions as shown in Figure 9-4 and Figure 9-6.

Emission benchmarking between LNG projects is notoriously difficult as each project has different geological characteristics and local conditions. For example, the quoted Snøhvit LNG facility has the lowest plant emission intensity in the world because it operates in arctic conditions and can use cold sea water for cooling purposes. Unlike the Ichthys Project, the Pluto and Gorgon projects do not require an extensive offshore processing facility to condition the gas to allow it to be transported to the onshore facility. This is a result of different geological features of the gas fields, such as location, depth, reservoir fluid composition, and so on. When the Gorgon and Pluto LNG facilities are benchmarked with the Ichthys LNG facility, the emission intensities are very similar.

The closest analogue to Ichthys is the Browse LNG Development which will be operated by Woodside. The Calliance, Brecknock and Torosa fields are on average similar in reservoir CO_2 content and geographic location to the Ichthys Field. The Browse LNG Development is planned to be located at the proposed Browse LNG Precinct at James Price Point in Western Australia. Table 9-3 in the recently released strategic assessment report on the LNG precinct by the Western Australian Government (DSD 2010) indicates emission intensities of 0.77–0.8 tonnes of CO_2-e per tonne of LNG. This is slightly above the Ichthys onshore emission intensity of 0.74 tonnes of CO_2-e per tonne of LNG (as derived from Table 9-2 in Chapter 9 Greenhouse gas management in the Draft EIS).

Submission 103-15: Substantial offshore greenhouse emissions are forecast for the facility arising from the extraordinarily long pipeline and corresponding compression requirements (stated in the EIS as 100 MW). These should be offset to bring the greenhouse emissions intensity of the facility in line with standard/current facilities.

Submission 110-18: I urge Inpex to do the right thing, not only as a corporate citizen, but as a prospective resident of Darwin and the Northern Territory. The actions you take will effect on not only us, but future generations as well. The CO2 emissions from the proposed plant need to be offset here in the Territory where they will be created. I urge you, as a prospective citizen, to respect your neighbours, no matter what life form they take, as you would expect us to respect you in your home environment. I would ask you to be a positive influence and a good neighbour to those of us that make this place our home now and in the future.

In the Draft EIS, Table 9-2 of Chapter 9 Greenhouse gas management provides a breakdown of the projected greenhouse gas (GHG) emissions associated with the Project. It should be noted from this table that all infrastructure items, apart from the export gas compression turbines at the central processing facility (CPF) at the Ichthys Field, are required for an LNG development of this size, regardless of whether the plant is located on the Kimberley coast line or Darwin. The CPF export gas compressors contribute approximately 0.5 Mt/a of carbon dioxide equivalents (CO_2-e) to the Project's annual average emissions of 7 Mt/a of CO_2-e, that is, approximately 7%.

It should be noted that the total GHG emissions associated with the current development scenario for the Project in Darwin are estimated to be only around 2% higher than if the Project was located at James Price Point just north of Broome in Western Australia. This is because most of the offshore processing will be the same and will still need to occur regardless of the choice between Darwin and James Price Point, and also because the emissions of CO_2 from the onshore processing plant (reservoir CO_2 and combustion emissions) will be the same regardless of onshore location. The difference in export compression CO_2-e between the Darwin and James Price Point options will be a fraction of the 0.5 Mt/a (7% of the total CO_2-e) described in the previous paragraph.

Submission 107-54: Chapter 9 describes the approach taken by INPEX to management of greenhouse gases. This approach is incomplete because other than the possible use of solar collectors, the EIS does not appear to consider the contribution to environmental impacts pursuant to the construction of the accommodation village (as this is subject to a separate assessment process). The additional volumes of greenhouse gases expected to emanate from the accommodation village should be quantified and reported in the EIS.

To avoid double counting of greenhouse gas (GHG) emissions and other environmental effects, the environmental impacts associated with INPEX's accommodation village will be assessed separately, as noted in the comment. It should however be noted that the GHG emissions associated with the construction of the accommodation village will primarily be attributable to diesel use by earthmoving equipment and to electricity consumption for various purposes.

Emissions associated with the operation of the accommodation village will primarily be associated with electricity consumption; the associated emissions will then most likely occur at the Channel Island Power Station.

Submission 123-159: The NT Government recognises that climate change is a serious environmental threat with significant social and economic impacts. The proposed INPEX Ichthys Gas Field Development Project will result in greenhouse gas emissions of a very high order. It is estimated by the proponent that the project will result in net greenhouse gas emissions of approximately 7 Mt of CO2 per annum over its 40 year life. Of this, 5.2 Mt of CO2 per annum will be emitted in the Territory (the remaining emissions will count against Commonwealth territory). These estimated emissions represent approximately 31.87% of the total annual greenhouse emissions from the Northern Territory1 in 2008. Although the price of emission permits under an Australian emissions trading scheme will be set by the market, the estimated annual emissions from this proposal could be valued at approximately $119,600,0002, based on the projected price for the Australian Government's proposed Carbon Pollution Reduction Scheme (Australian Government, 2008). This represents an indication of the potential economic cost of the proposal from a greenhouse emissions perspective. The proposal has very significant implications for the emission of greenhouse gases.

INPEX acknowledges that if the Australian government was to impose a carbon tax—on some or all of INPEX's proposed operations—that the annual cost would be substantial. INPEX has consistently supported the development of a carbon trading scheme in Australia, provided that it allows access to the lowest cost of abatement available globally and protects the international competitiveness of the Australian LNG industry. Project-specific regulations are to be avoided as this is inefficient and increases compliance costs.

Submission 124-24: We do not support the use of geosequestration to bury carbon emissions. Geosequestration remains an unproven methodology and is unlikely to ever be feasible for many emissions intensive projects due to engineering, risk and financial viability factors.

As stated in the Draft EIS in Section 9.11 of Chapter 9 Greenhouse gas management, INPEX is currently investigating the various options for offsetting its greenhouse gas (GHG) emissions; reservoir CO_2 reinjection (geosequestration) is among these options. INPEX does not consider geosequestration unproven:

- Statoil's Sleipner geosequestration project in the North Sea between Norway and Scotland has been operating successfully since 1996 (StatoilHydro 2009).
- The Snøhvit LNG project in Norway has injected its reservoir CO_2 since start-up in 2007.
- The In-Salah gas project in Algeria has reinjected reservoir CO_2 since its start in 2004.
- INPEX has been working with the Research Institute of Innovative Technology for the Earth (RITE) since 2003 to test CCS technology at its Iwanohara Site located in Nagaoka, Japan.
- Last year TOTAL started on of the world's first integrated CCS projects in Pau in the south of France.
- In Australia, the Chevron-operated Gorgon Project on Barrow Island is proceeding with reinjection of carbon dioxide (CO_2) from the Gorgon gas field.
- Both INPEX and Total E&P Australia are members of the CO2CRC, which has successfully completed a CO_2 injection pilot project in Victoria.
- CO_2 injection has been used for decades in the US oil industry to enhance recovery from depleted oil fields.

In Section 4.8.1 of this EIS Supplement an update is provided on INPEX's investigation into reinjection of reservoir CO_2.

Submission 128-29: GHG emissions objectives state that INPEX will comply with the recommendations contained in the Northern Territory Government EIA Guide which states the requirements for the proponent to minimise emissions to a level as low as practical.

This should be viewed as a minimum requirement not a target. The Northern Territory Government EIA Guidelines are only a guide and nothing short of current best practice to achieve the best possible emission reduction targets should be accepted.

The Ichthys Project will be designed with the new, energy-efficient technology in order to minimise fuel consumption and also minimise CO_2-e emissions. It is one of INPEX's key objectives to minimise generation of CO_2-e emissions through design optimisation of the facilities. The combined-cycle power plant and subsea power-sharing cable described in Section 4.8 of this EIS Supplement are examples of INPEX's application of best-practice technology in this area.

Submission 128-30: Project GHG Emissions Relative to Aust. and NT. Emissions Fig 9-3, page 420, reports the estimated emissions for the 40 year project life in the vicinity of 280 Mt CO2. The total project emissions are reported again on Page 422 in table 9-3 but they are expressed as CO2-e. Can this discrepancy be investigated and corrected or explained.

The Draft EIS has been written on the basis that Ichthys Project GHG emissions could average as much as 7 Mt CO_2-e per annum. Over the Project's estimated 40-year operating life this would mean its CO_2-e emissions would be around 280 Mt. To this extent, the caption to Table 9-3 in Chapter 9 Greenhouse gas management of the Draft EIS which says "CO_2-e" is correct, and the heading in Figure 9-3 should say "CO_2-e", not "CO_2".

Figure 9-1 in the Draft EIS shows that INPEX estimates that about 96% of the Project's CO_2-e emissions will come from CO_2, and the remaining 4% from other GHGs (primarily N_2O and CH_4). The 7 Mt/a of CO_2-e emissions are therefore expected to be made up of around 6.7 Mt of CO_2 and around 0.3 Mt of CO_2-e from other GHGs. The 280 Mt figure for 40 years of CO_2-e production is expected to be made up of around 270 Mt CO_2 and around 10 Mt CO_2-e from other GHGs.

INPEX considers the CO_2-e emission estimates of 7 Mt per annum and 280 Mt over 40 years as conservative upper limits. For the Ichthys Project, as with many other very large projects, EIS approval is being sought from government well before the detailed designs can be finalised and equipment purchased. Therefore, actual emissions can only be known when operations commence but INPEX is confident that actual emissions will not exceed the Draft EIS estimates.

Submission 128-31: NT emissions 17.2 Mt/a CO2-e Ichthys project 7 Mt/a CO2-e.

Emissions will be in excess of 8Mt/a for 9 years and will peak at 9Mt/a for the ongoing years.

Total emissions from the project will contribute to 40% of the total Green House Gases (GHG) for the Northern Territory in a year. INPEX calculations do not add up to this percentage, so the question of total emissions needs to be clarified.

Table 9-2 of the Draft EIS shows that offshore facility CO_2-e combustion emissions are expected to average around 1.8 Mt/a over the 40-year Project life. These emissions will be generated over Australian Commonwealth waters, not in the Northern Territory. Table 9-2 also shows that Northern Territory CO_2-e emissions are expected to average around 5.2 Mt/a over the 40-year Project life; the 5.2 will be made up of 2.4 Mt/a from reservoir CO_2 and 2.8 Mt/a from Blaydin Point combustion emissions.

Offshore emissions in Commonwealth waters of around 1.8 Mt/a together with onshore emissions in the Northern Territory of around 5.2 Mt/a gives a total of around 7 Mt/a Project-wide.

In Table 9-3, to get the percentage increases to Northern Territory CO_2-e emissions, INPEX divided 5.2 (the Project's expected Northern Territory, but not Project total) annual emissions by 17.2, the Northern Territory emissions. This amounts to an approximately 30% increase.

It is not correct to divide 7.0/17.2 to get a 40% increase since 1.8 of the 7.0 new emissions will originate in Commonwealth waters offshore Western Australia, not on land in the Northern Territory or in its waters. Note that the reservoir emissions have been included as Northern Territory emissions even though they originate from reservoirs under Commonwealth waters off Western Australia, because INPEX proposes to vent them to atmosphere in the Territory.

To calculate the percent increase to Australian CO_2-e emissions, INPEX divided 7.0/597.2 to get a 1.2% increase. For this calculation, using 7.0 is correct because both offshore and onshore GHG emissions will count towards Australia's total.

INPEX agrees that in some years, the percentage increase in GHG emissions over 2007 Australian and Northern Territory amounts will exceed the 1.2 and 30% figures in Table 9-3. However, in other years the increases will be commensurately lower. INPEX believes that the best measure is to use 40-year-average expected GHG emissions, not to select individual years within the Project life that would give percentage changes higher or lower than the long-term average.

5.2.2.9 Heritage in the marine environment

Submission 123-15: In the threat and control tables, underwater heritage issues have been addressed under the socio-economic impacts (pg 63). This is relevant but it also means that it has been excluded from other parts of the risk tables which highlight key potential threats such as sea bed disturbance, sand removal, trenching and rock dumping (41, 42, and 43). Page 63 has an entry for maritime heritage that does not consider the issue of unlocated sites and objects and with that the issues of dredging, rock dumping etc. If INPEX have undertaken sufficient remote surveying and diver verification work throughout the harbour then it should be listed as a separate aspect in the matrix and covered under management controls/mitigative measures. Another separate aspect should be the spoil dump and what remote sensing should be conducted there.

Underwater heritage is appropriately included within socio-economic impacts, management and residual-risks table. The "other parts of the risk" tables mentioned in the submission re late to impacts on the biological marine environment. The key point of the submission, however, is that the potential risks to marine heritage from physical disturbance may not have been addressed and that it does not appear to address the issue of un-located sites.

A number of management controls pertinent to the protection of the marine heritage, for example, anchor management plans, design to avoid disturbance to sites, implementation of controlled zones around heritage sites, are outlined in Table 9-1. Importantly Table 9-1 (of the Executive Summary of the Draft EIS) also refers to the Provisional Heritage Management Plan which outlines additional management controls including "chance find" requirements, whereby INPEX commits to ceasing construction work and to immediately notifying the NRETAS Heritage Branch if suspected archaeological material is uncovered during construction. Management controls for marine heritage will be further outlined in the final Heritage Management Plan which will developed and submitted for approval by NRETAS prior to the commencement of construction activities.

At the request of the NRETAS Heritage Branch, INPEX commissioned two independent marine archaeological experts to assess the adequacy and any limitations of the surveys methods employed by INPEX to identify the presence of marine heritage within the Project's development footprint. The findings from these assessments is contained within Section 4.7.2 of this EIS Supplement and within Technical Appendices S10 and S11 in this EIS Supplement.

Submission 123-19: There is reference to the Fugro remote sensing surveys, which although they appear substantial, were primarily conducted to locate engineering obstacles like Walker Shoal, not small but significant historic sites. Further detail should be provided about the Fugro surveys in terms of calibration and a formal statement claiming the surveys were adequate to locate previously undiscovered sites. The sub-bottom profiling survey would also be of particular interest. There is concern that previously undiscovered sites may be affected. The size of the proposed dredgers indicates that it may be difficult for a dredger to tell if they had dug up and destroyed a site like the wreck of the Rachel Cohen for example. The Heritage Management Plan also needs to include strategies to deal with any underwater archaeological sites discovered during the dredging process. There may be a need for more substantial remote surveys which could better capture any potential underwater heritage sites, prior to any dredging activities.

INPEX was aware of the potential for marine heritage to be present within the Projects' proposed development footprint and "contacts" identified during the Fugro surveys where subsequently investigated by divers. Tek Venture was engaged to undertake the diver surveys – a company with extensive experience in diving and interpretation of maritime heritage within Darwin Harbour. A range of surveys have been undertaken by INPEX within the development footprint which are suitable for the detection of marine heritage. At the request of the NRETAS Heritage Branch, INPEX commissioned two independent marine archaeological experts to assess the adequacy and any limitations of the surveys methods employed by INPEX to identify the presence of marine heritage within the Project's development footprint. The findings from these assessments is contained within Section 4.7.2 of this EIS Supplement and within Technical Appendices S10 and S11 in this EIS Supplement. The provisional Heritage Management Plan contained within Chapter 11 of the Draft EIS, commits to ceasing construction work and to immediately notifying the NRETAS Heritage Branch if suspected archaeological material is uncovered during construction. Management controls for marine heritage will be further outlined in the final Heritage Management Plan which will be developed and submitted for approval by NRETAS prior to the commencement of construction activities.

5.2.2.10 Infrastructure risk

Submission 16-20, 36-4, 89-20, 96-19, 101-21, 102-19: Release of updated storm surge mapping for Darwin to comprehensively assess the risks associated with developing significant infrastructure on Blaydin Point.

Submission 128-1: Oceanography and hydrodynamics. Storm surge levels appear to be based on the Northern Territory Government's 2003 edition of the map for the "Municipality of Darwin – Darwin Storm Surge Zones" which does not take into account current sea level rise estimates and predictions.

To work off the NT Government 2003 map may be a major underestimation. Any response to the Draft EIS and the project that does not take in the updated Storm Surge Zone data of 2010 as a starting point, is limited.

Within the document there is only partial reference to climate change information including sea level rise and predicted rises for either the early development of Ichthys Gas Field Development Project or the 40 year life of the project.

Council has previously provided information in regards to several sources of Australian and International research.

The Ichthys Project's Draft EIS was prepared on the basis of the best information available at the time of writing. Given the relatively short design life of the onshore processing facility at Blaydin Point and the associated return period of the design event (1 in 500 years), it is unlikely that any revised assessment of storm-surge levels for Darwin will impact on the levels adopted for the Project.

Most of the plant facilities, and all critical facilities, are sited above 6.5 m AHD. The exceptions are non-critical support infrastructure items associated with the flare complex and the operations complex. Both of these complexes have been designed to be above 5.8 m AHD at all locations, a level which corresponds to the 500-year storm surge level of 5.6 m AHD, with a 0.2 m allowance for the higher sea levels that are predicted to occur as a result of global warming. Although the flare pad itself will be at 5.8 m AHD, the flare apparatus will be supported by trestles and on average will be at a height of around 6.2 m AHD.

Similarly, the operations complex perimeter has been set at 5.8 m AHD, but its internal roads are at 6.0 m AHD and the building infrastructure is above 6.8 m AHD on average.

A flooding event at the plant site will therefore not result in catastrophic consequences for the plant facilities.

Submission 42-1: We've recently had a series of earthquakes that destroyed the centre of Christchurch NZ. Add to this the floods in Pakistan and unseasonal severe storms in southern Australia and this all points to more frequent and destructive natural disasters caused by poorly-thought-out development and lack of regard and respect for the global environment.

What precautions will you take to protect the people of Darwin and surrounding areas from the results of your development being caught up in the next cyclone to hit Darwin? As this is likely to be a Category 5 cyclone and will undoubtedly bring with it massive primary storm surge, what plans will you have in place should your irresponsible gasplant proposal be approved in the face of this?

What happens when your monster goes under water?

For Ichthys Project facility designs, the magnitude of the seismic (earthquake and tsunami) loads applicable for the Darwin area have been taken from *AS 1170.4:2007, Structural design actions—Earthquake actions in Australia*. INPEX's engineering design teams have also undertaken detailed seismic design risk assessments to determine the appropriate design standards for offshore and onshore infrastructure. Use of design standards have conservatively captured the expected possible ground motions anticipated from great earthquakes (M_w >8) on the Tanimbar, Java and Timor subduction zones, which are estimated to have average recurrence intervals of about 200–300 years, as well as the smaller ground motions from random regional shallow crustal earthquakes in the vicinity of the Blaydin Point site and offshore infrastructure. The application of these conservative design standards will ensure the integrity of the Project infrastructure from seismic events. The cryogenic tanks at the onshore processing plant which will comply with the (US) National Fire Protection standard NFPA 59A will be designed for the seismic spectra of a 1-in-2475 year earthquake.

Ichthys Project facilities are also being designed in accordance with *AS/NZS 1170.2:2002, wind actions*. In this standard, Darwin is located in Wind Region C and the design cyclone is a Category 4 cyclone. There is currently no proposal to include Darwin in Region D (where the design cyclone would be Category 5). Because the onshore processing plant at Blaydin Point will be designed for the most extreme situation following the applicable Australian standard (a 1-in-500-year event), the risk of structural damage during the life of the Project is considered to be negligible.

Most of the Blaydin Point plant facilities, and all critical facilities, will be sited above 6.5 m AHD. The only exceptions are non-critical support infrastructure which have been designed to be above 5.8 m AHD at all locations, a level which corresponds to the 500 year storm surge level of 5.6 m AHD, with a 0.2 m allowance for the higher sea levels predicted to occur as the result of potential global warming. A flooding event at the plant site would therefore not result in catastrophic consequences for the plant facilities.

Submission 110-10: I suggest that Inpex explores the option of using the facilities that already exist at the ConocoPhillips off loading jetty. I understand that there are issues for Inpex with this option. I take you at your word that the cost of a cryogenic loading line would be substantial but I am unsure, when measured against;

1. expected life of the project (40 to 50 years)
2. the initial cost of dredging
3. ongoing maintenance dredging
4. Possible cost to the environment.

It is not possible to use the Conoco Phillips facility for technical, commercial and practical reasons.

Submission 112-9: Inpex identifies a short list of anticipated local climate impacts, which comes down to:

- an increase in average annual temperatures
- a rise in sea level
- an increase in storm-surge inundations.

It is alarming that Inpex fail to acknowledge predicted increase in intensity and frequency of extreme weather, including cyclone events. (c.f. Scientific projections identified by the CSIRO report 'Climate 'Change Under Enhanced Greenhouse Conditions In Northern Australia' as referenced in NT Government's so-called 'Strategy for Greenhouse Action'). It remains unclear how Inpex's commitments to engineer for anticipated cyclone activities will factor in the projected increased intensity and frequency of these extreme weather events over the project lifetime. The document fails to acknowledge the important role of our mangroves in protecting the coast from storm damage and coastal erosion in the face of rising tide and increased storm activity due to global climate change.

Submission 112-12: The proponent must demonstrate that engineering standards are set to projected exacerbation of extreme weather events, including cyclones.

Submission 124-65: Recommendation:

Address:

a. The potential inadequacy of the current Wind Code for Darwin;
b. A thorough assessment of the likely impacts to arise if hazardous waste storage is compromised e.g. potential for soil and water contamination during or following a cyclone event.
c. The particular design specifications that INPEX will be using to ensure that its infrastructure can withstand a Category 5 cyclone, i.e. processing plant pad levels, the size of rock armour over the pipeline, chemical storage facilities etc.

The Ichthys Project facilities are being designed in accordance with Australian Standard *AS/NZS 1170.2:2002, Wind actions*. In this standard Darwin is located in Wind Region C and the design cyclone is a Category 4 cyclone. There is currently no proposal to include Darwin in Region D (a Category 5 cyclone region). Because the onshore processing plant at Blaydin Point will be designed for the most extreme situation following the Australian standard (a 1-in-500-year event), the risk of structural damage during the life of the Project is considered to be negligible.

Submission 124-9:
Inadequate assessment of cyclone risk

Inadequate assessment of risks to infrastructure posed by cyclones.

A failure to model the impacts of cyclones on the spoil dump and fate of sediments.

Recommendations:
Undertake a comprehensive assessment of risks from large cyclones for all aspects of the Project.

See response to comment 124-64 in respect of INPEX's design of the Blaydin Point onshore processing plant to cater for tropical cyclones.

Impacts of cyclones on the spoil disposal ground and sediment dispersion are discussed in the reponse to comment 124-10 in Section 5.2.2.11.

Submission 124-27: Oceanography and hydrodynamics. The Draft EIS outlines the likelihood of 'natural' or 'geological' hazards, such as tsunamis and extreme wave conditions and storm surge, to the project (Chapter 3, Section 3.3.2, p. 56). Tsunamis are noted to be unlikely, based on a study by GHDM (1997). Despite the lack of past tsunamis impacting Darwin Harbour, the Project is located in a region with a high frequency of earthquake activity sometimes associated with tsunami generation10. A low likelihood of tsunami occurrence does not mean that these events will never threaten Darwin Harbour. Maximum wave heights, tide heights and sea level in Darwin Harbour under storm surge and a range of other conditions are provided in the Draft EIS, yet there is no discussion of the impacts such increases in sea level, wave height and wave action may have on the onshore project infrastructure. Nor is there mention of any plan or an outline of actions that would be taken to avoid accidents at the onshore facilities should Darwin be threatened by these types of events. Recommendation: As Blaydin Point is a low lying area there must be some effective plan to mitigate spills or other accidents should the onshore facility be inundated due to extreme weather or geological events.

There are no reports of tsunamis affecting Darwin during the period of European presence there (approximately 140 years). The tsunami risk was assessed for the onshore processing plant at Blaydin Point and it was concluded that the impact of a tsunami would be negligible at the site.

Submission 124-64: Extreme weather events

A recent examination of simulated data and historical and satellite-era records suggests that the hazard from tropical cyclone winds is substantially underestimated for Darwin24. Effectively this means that Darwin's wind hazard could be greater than the value it is set at in the wind code. This has serious implications for the appropriate design and construction of INPEX's proposed facilities at Blaydin Point, and it raises a number of questions about the assurance of public and environmental safety. Additionally, the review of tropical cyclone hazard also has implications for the security of the dredge spoil disposal site and the potential for spoil to move further afield.

Extreme weather events must be comprehensively addressed when undertaking a risk assessment for Project infrastructure, particularly given three Australian Category 5 cyclones (maximum gusts > 78 ms-1) have passed within 350 km of Darwin in the last twelve years25. These cyclones were namely, Thelma (1998), Ingrid (2005) and Monica (2006), with maximum gust speeds estimated to be between 87 – 99 ms-1, according to a recent study by the Australian Bureau of Meteorology. These extreme weather events were comparable to Cyclone Tracy, which produced estimated maximum gust speeds of at least 90 ms-1 just before landfall26.

Unfortunately the Draft EIS fails to demonstrate an adequate assessment of potential risks associated with extreme weather events. It makes references to, or simple statements about, INPEX's preparedness for cyclones, for example:

- "cyclone procedures" (p. 284, Volume 1);
- "The jetty structure is being designed...taking cyclones into account" (p. 353, Volume 1);
- "...the onshore facility will need to be built to withstand the climatic conditions experienced in the Darwin region, for example, cyclones..." (p. 441, Volume 2)
- "Emergency-response plans will address cyclone and major accident scenarios..." (p. 442, Volume 2)
  but without going into any detail. Furthermore, Appendix 24, the "Onshore and offshore quantitative risk assessment summary report", fails to address cyclones. Overall, the Draft EIS' assessment of cyclone risks and impacts is seriously deficient.

Presently Darwin is located in Wind Region C as shown in Figure 2.1 of Australian Standard *AS 4055:2006, Wind loads for housing*. There has been a proposal to change some of the offshore areas of the Northern Territory to Region D; however, the suggestion to include Darwin in Region D was rejected. There are currently no proposals to redraw the boundary of Wind Region D (as shown in Figure 2.1 of *AS 4055:2006*) to include Darwin (ABCB 2010).

See also response to comment 130-9 in Section 5.2.2.16.

5.2.2.11 Marine

Submission 4-1: Since emailing the comment below, I have since listened to the ABC Radio interview on this issue with AFANTS John Harrison. The blasting I commented on below is an underestimate. The blasting is intended to continue 3 times a day for 14 months. I know AFANT stated in this interview that they are comfortable that most fish stocks will recover, however I still have concerns.

Submission 4-2: My secondary concern is what this will mean to the total ecosystem. I think it is underestimated because it does not take into account that most amateur fisherman and tour guides will fish elsewhere until fish stocks in Darwin Harbour return. This will put extra stress on other areas outside of Darwin Harbour and effect fish populations that are expected to be the basis of restocking Darwin Harbour.

Submission 9-1: The expected damage to marine life, from dolphins, dugong and turtles down to simple fishes is beyond what any civilised community should tolerate. If your plant and wharf must go on that site you will have to find another way to access it without blowing up the shoal and killing, injuring or even disturbing all that wildlife.

Submission 11-1: I am uncertain that the statement by Inpex is correct that only minimal injury and mortality of marine life in Darwin Harbor is to be expected as a consequence of the blasting. What independent data is this statement based on? Reports by independent sources tell a different story with an expected mortality zone of up to 500m and an injury zone of 1,250m. Furthermore, there is no data on the impact of blasting on dolphins and whales in a partly closed harbour. Therefore, I oppose the blasting of Walker Shoal. Alternative paths for a channel that does not involve blasting should be actively investigated.

Submission 12-2: You are also suggesting blasting to make a clear sea lane. You have done no recent research to back your reassurance that this should not damage significant marine life and this is a serious threat to already threatened wildlife in the marine environment.

Submission 13-1: I have recently read about the above project and the fact that there is no credible peer-reviewed information about the impact on wildlife such as dugongs, three species of coastal dolphins and four species of marine turtles from underwater blasting and dredging in Darwin Harbour.

Submission 18-5: Unfortunately, turbidity affects marine organisms and the impacts of noise pollution are evident, in particular if cumulative impacts are considered through the 3 % increase of traffic from vessels.

Submission 18-7: To cause the likelihood of marine mammals to be injured from a distance of 519 meters from one single blast event and to cause a 50% mortality of fish at a range of 263 (m), is unacceptable

Submission 19-1: We are totally against any explosive device being discharged under the water in Darwin Harbour.

Submission 37-1, 41-1, 55-2, 55-3, 58-1, 58-2, 75-1, 80-1, 117-1, 125-1: Japanese oil & gas giant INPEX wants to blast a rock bar for its shipping channel three times a day for over a year. By its own admission these blasts would create a kill zone that would kill dolphins within a 500m radius, and injure any within 1250m. .. INPEX arrogantly says the dolphins, dugong and turtles occur across much of Northern Australia, so even if it killed some in Darwin Harbour, or permanently excluded them due to underwater noise pollution, the impacts would only by minor.

Submission 40-1: I am deeply concerned about the plan that has such intensive blasting (3 times daily for a year) underwater without adequate and peer reviewed research into the impact on marine life that is so precious given the dramatic losses of fish stocks and the significant dolphin, dugong, turtle and other species that inhabit this area.

Submission 47-1: The oceans are home to some of the most astounding, complex creatures. We are forever finding and being amazed by the intricacies of marine life. How dolphins work together, their high frequency communications, how they are playful even with humans, the species that has distroyed much of its habitat and cruelly, ignorantly ended so many of their lives. The very thought of blasting rock bars sounds invasive, forceful, crude, and for what? an increase in carbon emissions, the potential exclusion of marine life from the darwin harbour? It doesn't sound worth it to me.

Submission 50-3: I condem the proposed blasting and dredging of walker Shoal in Darwin Harbour by INPEX or any other company that will wrecklessly kill marine wildlife and cause gross amounts of pollution. I also am concerned that the Northern Territory Govt has no strict dredging policy in place to protect the marine environment of Darwin Harbour against this type of wreckless development . There are other options to avoid this senseless killing and polluting so why doesn't the Territory Govt take a responsible stand and put a stop to this blatant aggression towards destroying our precious marine environment of Darwin Harbour

Submission 52-1: In its current form It will kill local dolphins, turtles and dugongs and destroy coral reefs. It is not acceptable to be damaging Darwin's beautiful Marine life to such an extent. If the project is to go ahead, it must be made more environmentally sustainable.

Submission 64-1: I read with concern that INPEX are planning to blast a rock bar for its shipping channel three times a day for over a year in Darwin Harbour, and the company admits to far reaching consequences for marine life (up to 1250m!!!!).

Submission 67-1: I find the blasting of Walker Shoal outlined in Chapter 4, Section 4.4.4 page 189 utterly unacceptable. The impact of the blasting (both mortality and injury zones) outlined in Chapter 7, Section 7.3.7 from page 357 disturbing and appauling. There are no studies of the imapct of this form of blasting on marine life such as dolphins and whales in a partly enclosed harbour.

Submission 71-1: I wish to oppose the plans by Japanese oil & gas giant INPEX to blast Walker Shoal in Darwin Harbour for its shipping channel. What a reckless act of environmental vandalism and how irresponsible to consider such vandalism with no proper underwater acoustic modeling, no specific research on adverse affects to wildlife and dolphins, dugong and turtles, let alone any other fish that call the habitat home. If INPEX plans to blast in Darwin Harbour three times a day for over a year then where is their peer reviewed scientific papers that show that this is OK? I understand by its own admission INPEX suggests that these blasts would create a kill zone that would kill dolphins within a 500m radius, and injure any within 1250m, this is not acceptable, there are other options for the company and they must explore them.

Submission 85-1: 1) Several protected species distribute and breed in the area The coast and waters of the Darwin harbour hold populations of endangered species, including, among others, the following: CETACEAN Australian snubfin (Orcaella heinsohni), species discovered only in 2005 (Easley et al. 2005) Indo-Pacific humpback dolphin (Sousa chinensis), There are strong indications that Australian humpback dolphins are not S. chinensis but may represent a distinct species in their own right (Frere et al. 2008). Estimates for Moreton Bay in 1984-1986, and 1985-1987, respectively, were 163 animals, and 119 animals ; preliminary results for Cleveland Bay, in the Central Section of the Great Barrier Reef, suggest a population less than 200 animals (Parra et al. 2004). Indo-Pacific bottlenose dolphin (Tursiops aduncus), listed in Appendix II of CITES SIRENIDS Dugong (Dugong dugon); classified by the IUCN as vulnerable to extinction, with habitat destruction and collisions as some of the main impacting factoris in the decline of this species (Reeves et al. 2002) REPTILES Flatback turtle (Natator depressus) endemic to the continental shelf of Australia and considered vulnerable to extinction in Western Australia (Burbidge et al.). This species nests in the Darwin Harbour Hawksbill turtle (Eretmochelys imbricata), classified as critically endangered by the World Conservation Union. Data submitted by the Marine Turtle Specialist Group (MTSG) showed that the worldwide hawksbill turtle population had declined by 80% in the three most recent generations, and that there was no significant population increase as of 1996. (Red List 2001) Green turtle (Chelonia mydas) is listed as endangered by IUCN and CITES. This species nests in the Darwin Harbour

Submission 88-1: As a previous resident of darwin I was saddened to hear of the gas plant project proposed by INPEX which has been handed in suggesting that the harbour be blasted to create a shipping channel. All parties agree this will kill and injure many native animals and 'waiting twenty minutes' until none are seen is simply a joke.

Submission 95-1: As a recreational SCUBA diver who uses the underwater environment of the harbour and enjoys the peaceful, natural world under the surface I strongly oppose the blasting of Walker Shoal and request that an alternative route be found which avoids the need for blasting. The death, injury or displacement of marine life would be nothing short of devastating.

Submission 107-46: An improved strategy for blasting of nearshore shoals should be developed. It might be possible to undertake this work at very low tide, when the population of pelagic fish and cetacean species that might be impacted by blasting would be at the minimum.

Submission 108-1: As a citizen of Darwin and user of the harbour, I can not accept that the blasting regieme you propose will not damage life in the harbour. I urge you to reconsider your options. I support the project and am not against progress, however we have a unique environment here and a company such as Inpex has the power to choose a more environmentally friendly option.

Submission 112-4: I totally oppose the project in its entirety. Among other issues, I find that the proposal should be disqualified on the grounds of unacceptable climate impacts; unacceptable loss and detriment of coastal ecological communities; the insane plan to endanger marine macrofauna by blasting Walker Shoal; and for simply posing too huge a dredging burden for our living harbour. But I realise that our Chief Minister has staked his career on insisting that Inpex can enjoy certainty in Darwin. I realise that this makes it next to impossible for Mr Henderson's environment minister to reach any conclusion other than to recommend the project can proceed, and so, while I'd rather dismiss this proposal outright, I will endeavour to offer some recommendations for lightening the severity of this project's local environmental impacts.

Submission 120-7: Most AFANT members and other recreational fishers we have spoken to would prefer not to have Walker Shoal removed by blasting and their continued acceptance of Inpex's plans for Darwin Harbour will be impossible to maintain if access to Lightning and Cossack Creeks cannot be assured. Inpex, the NT Government and/or other relevant regulators should put this issue beyond doubt without further delay and well in advance of the release of the Supplementary EIS.

Submission 122-1: Drill and Blasting (p 357 +): DHAC strongly recommends that alternative options to reduce the length of time proposed for blasting be explored and adopted, or ideally alternatives to blasting are explored including moving the Kelat and/or the Catalinas.

Submission 123-9: Walker Shoal. Options for avoiding Walker Shoal or removing the shoal by means other than blasting have not been presented. In addition, blasting areas other than Walker Shoal have been mentioned but no further details provided. Further discussion of alternatives is required and any additional blasting proposed should be discussed within the same context.

Submission 124-29: The Draft EIS proposes blasting Walker Shoal three times daily with six 50 kg explosive charges for over one year. This represents a serious and unacceptable risk to marine wildlife in the Harbour that is highly likely to result in the death, injury and long term exclusion of protected and threatened species such as three species of coastal dolphins (Australian snubfin, Indo-Pacific humpback and Indo-Pacific bottlenose), dugong and four species of marine turtles (Green, Flatback, Olive Ridley and Hawkesbill), plus fish and other wildlife.
We strongly disagree with the statement in the Draft EIS that the residual risk from underwater blasting is only 'medium'. The area of the Harbour in the vicinity of Walker Shoal (East Arm, Bleesers Creek, Sadgroves Creek and the Darwin CBD) is a hot spot for Indo-Pacific humpback and Indo-Pacific bottlenose dolphins. These dolphins are not highly mobile and spend significant periods of time resident in that section of the Harbour due to the presence of prey in the estuaries of the Elizabeth River and various smaller creeks.

Submission 96-1: Blasting of Walker Shoal at the entrance to the shipping channel will pose significant risk of injury and death to dolphin, turtle and fish species. INPEX is relying on an outdated and incomplete literature review to assess the level of risk.

Submission 101-3: Blasting of Walker Shoal at the entrance to the shipping channel will pose significant risk of injury and death to dolphin, turtle and fish species. INPEX is relying on an outdated and incomplete literature review to assess the level of risk.

Submission 102-1: Blasting of Walker Shoal at the entrance to the shipping channel will pose significant risk of injury and death to dolphin, turtle and fish species. INPEX is relying on an outdated and incomplete literature review to assess the level of risk.

A number of submissions made the comment that construction of the Ichthys Project's proposed channel through Walker Shoal using blasting methods was unacceptable due to perceived "significant risk of injury and death" to dugong, dolphin, turtle and fish species. In particular the estimated radius of potential impact from blasting was considered to be at an unacceptable level.

The severity of the impact to marine animals depends on a number of variables. These include the size of the animal, its orientation in relation to the blast and the depth at the time of exposure. Because of this variability a maximum worst-case range has been presented based on the most conservative assumption of each variable. The distance over which lethal effects may occur does not mean that all animals within this distance will die, and it is certainly not a "kill zone", as described in the AMCS petition. It is, however, recognised that by presenting the worst-case scenario in its Draft EIS, INPEX has overstated the likely effect of blasting and that the described scale of impact would be considered by many respondents to be unacceptable.

To address the perceived unacceptability of impact from blasting for construction of the shipping channel INPEX has acted as follows:

- It has reviewed the proposed methods for constructing the channel.
- It has conducted detailed numerical modelling of the propagation of underwater blast effects.
- It has reviewed Draft EIS's Technical Appendix 15 *Review of literature on sound in the ocean and on the effects of noise on marine fauna* and completed additional work to provide further information on the effects of blasting on marine animals.

Review of channel construction methods

Subsequent to the detailed assessment of the seabed geology, INPEX has been able to better predict the strength of sub-seabed rock materials that would be encountered during construction of the proposed shipping channel and the strata in which they occur. With this knowledge the volume of material that can be removed using techniques other than blasting has been recalculated (refer to Section 3.3.8).

The proposed base case for construction of the shipping channel at Walker Shoal is a combination of backhoe, trailing suction hopper, and cutter-suction dredgers for the removal of most of the material. Should any hard-rock material remain, other non-blasting methods (such as, for example, a hydraulic hammer or drop chisel) will be trialled. However should it be found that the hard-rock material cannot be removed by the use of non-blasting techniques then it will be necessary to revert to a limited blasting program. It is anticipated that, if required, the blasting campaign would take approximately 4 weeks. Readers are referred to Section 3.3.8 for a full description of the proposed revised Walker Shoal removal program.

Modelling of underwater blast propagation

Detailed numerical modelling has been carried out to assess the range and intensity of underwater blast effects. This was repeated for a number of blast scenarios. The results are presented in Section 4.1.11.

Review of the effect of blasting on marine fauna

The sensitivity of marine mammals, turtles and fish to underwater blasting has been reviewed. The results of this review are provided in Section 4.1.11 and Technical Appendix S7 in this EIS Supplement. The information gathered has been used to establish clear criteria to minimise the risk to marine fauna to as low as reasonably practicable.

Should it be necessary to conduct blasting, a range of appropriate management measures have been identified to reduce the risk of significant environmental harm to as low as reasonably practicable. These management measures are described in Annexe 11 *Provisional piledriving and blasting management plan* in Chapter 11 *Environmental management program* of the Draft EIS. Some additional measures are also outlined in Section 4.1.13 of this EIS Supplement.

Submission 6-2: I find it hard to be convinced that 'trained marine fauna observers' could successfully spot dolphins, turtles and dugongs in time to stop blasting. I know from personal experience over an extended time frame that dolphins can appear and disappear very quickly even when viewed from a fixed, elevated viewing area at a distances of 60-70 metres in clear calm weather conditions.

Submission 9-16: The limited availability of data on population numbers of various species in Darwin Harbour (such as dolphins) means it may be difficult to determine the true impact of the construction phase if the project proceeds, despite the control measures planned to minimise the impacts.

Submission 110-17: I would urge Inpex, should the blasting activities be approved, to develop a comprehensive plan to ensure that fauna be kept outside the impact zone of any blasting to absolutely and as far as possible ensure that not one loss of any life be sustained that could otherwise have been avoided.

Submission 123-147: Two species of coastal dolphins are recorded in and around the proposed blast zone. The dolphins are cryptic, have a low surface profile and the water is muddy and turbid making it all the more difficult to sight these dolphins. The current proposal provides no certainty that dolphins would not be present in these fauna protection zones. The proponents have not discussed the medium or long-term impacts of such a sustained blasting program on coastal dolphins.

Submission 123-148: However, there are significant breeding, foraging and aggregation areas for megafauna in the nearshore development area. Specific sighting locations indicate that Indo-Pacific humpback dolphins have been predominantly recorded around East Arm (Elizabeth River) and at the mouth of Reichardt and Blessers Creeks and foraging was the dominant behaviour (Fortune et al 2009; Palmer 2010). The Indo-Pacific bottlenose are recorded around at the mouth of Reichardt and Blessers Creeks and foraging was the dominant behaviour (Palmer 2010). Specific sighting locations indicate that mother/ calf pairs of Indo-Pacific humpback dolphins are recorded predominantly around East Arm (Elizabeth River) and at the mouth of Reichardt and Blessers Creeks (Palmer 2010). Three species of coastal dolphins have been recorded in and around the pile-driving area. Two species are cryptic, have a low surface profile and when combined with muddy and turbid waters sighting these dolphins is particularly difficult.

Submission 123-191: Trained marine fauna observers... Two species of coastal dolphins are recorded near the blast zones. These species are cryptic and difficult to see and when combined with the muddy, turbid water and low surfacing profile can make these species extremely difficult to sight. The current proposal provides no certainty that dolphins would not be present in these fauna protection zones. This increases the risk to coastal dolphins, particularly over the full duration of blasting.

Submission 123-192: For effective surveillance... Two species of coastal dolphins are recorded near the blast zones. These species are cryptic and difficult to see and when combined with the muddy, turbid water and low surfacing profile can make these species extremely difficult to sight. The current proposal provides no certainty that dolphins would not be present in these fauna protection zones. This increases the risk to coastal dolphins, particularly over the full duration of blasting.

Submission 123-194: Three species of coastal dolphins are recorded in and near the pile driving locations. These species are cryptic and difficult to see and when combined with the muddy, turbid water and low surfacing profile can make these species extremely difficult to sight. The current proposal provides no certainty that dolphins would not be present in these fauna protection zones. This increases the risk to coastal dolphins, particularly over the full duration of blasting.

Submission 123-195: As for above, insufficient information has been presented in the draft EIS. More detail will need to be provided in the EIS on techniques and protocols to ensure the safety of megafauna when blasting. Alternatives to the proposed blasting program need to be explored in depth.

Submission 123-196: Responses to large marine animals within the designated fauna protection zones... Two species of coastal dolphins are recorded near the blasting locations. These species are cryptic and difficult to see and when combined with the muddy, turbid water and low surfacing profile can make these species extremely difficult to sight. The current proposal provides no certainty that dolphins would not be present in these fauna protection zones. This increases the risk to coastal dolphins, particularly over the full duration of blasting.

Submission 16-3, 20-3, 24-3, 29-2, 89-3, 96-2, 101-4, 102-2: Marine mammals will be particularly threatened by the development because they occur in small and isolated populations, are slow-breeding and long-lived, and do not undertake large migrations.

Submission 123-97: The potential impacts table does not adequately identify the risks associated with all the activities listed in Table 7-29. The blasting activities result in the physical loss of habitat which will potentially affect the coastal dolphins prey availability and indirectly the loss of food supply (Jefferson et al. 2009). Dredging and trenching potentially influences coastal dolphins prey and affect the dolphins indirectly by loss of food supply due to disturbance of the seafloor and increased sedimentation (Jefferson et al. 2009). Furthermore, both Indo-Pacific humpback and snubfin dolphins are likely to exist as metapopulations (small and partially or completely isolated populations). This makes them susceptible to extinction if rates of dispersal between populations are adversely affected (Hanski, 1998, Tilman et al., 1994). Without knowledge of the meta-population structure and degree of dispersal and hence an understanding of how to manage the metapopulations, the conservation and long-term survival of these species in Australian waters could be at risk. The importance of Darwin Harbour to the three species of coastal dolphins within a regional context is currently unknown.

Submission 123-145: The risks to coastal dolphins from underwater blasting proposed over a substantial timeframe cannot be assessed with any certainty. Two species of coastal dolphins are recorded in and near the blast zones. These species are cryptic and difficult to see and when combined with the muddy, turbid water and low surfacing profile can make these species extremely difficult to sight. Therefore it is not considered that the current proposed protection zones can guarantee that dolphins are not present when blasting occurs. There is a high probability that losing a small number of individuals presents a high risk to the population. Based on dugong life history (Kwan 2002), which is similar to that of coastal dolphins, any losses greater than 1 or 2% of breeding females can lead to a population decline. Photo-identification data from the harbour suggest that there are less than 50 resident humpback and bottlenose dolphins in the harbour. This suggests that a maximum loss of 2 female dolphins could cause a decline. Therefore, in the absence of any empirical data to suggest otherwise, any dolphin mortalities could threaten the Darwin Harbour population with potential consequences for the sustainability of the regional population.

Submission 123-109: The development being proposed in Darwin Harbour will involve significant amounts of underwater noise and has the potential to impact on coastal dolphins normal activities. Coastal dolphins can use echolocation in turbid waters to provide information about their environment, communication and location of prey (David 2006). However, it is unclear whether this can occur in combination with the major disturbances associated with the proposed development such as piling works, blasting, dredging, and increased shipping traffic.

Submission 123-119: There is limited evidence to support this statement. With increasing underwater noise in the Darwin Harbour, dolphins' ability to echolocate will be compromised. In turbid and muddy waters coastal dolphins need to echolocate to find their food. The proposed development project produces underwater noise from blasting, piling works, dredging and increased shipping traffic that may impact on the coastal dolphins' ability to communicate and locate their food using echolocation.

Submission 100-17: Failure to adequately assess Darwin Harbour as potentially critical habitat for inshore dolphins (Orcaella heinsohnii, Sousa chinensis and Tursiops aduncus) as well as dugong (Dugong dugon) and marine turtles (Chelonia mydas, Natator depressus and Eretmochelys imbricata), and using the assumption that it is not critical habitat as a basis for determining risk for proposed nearshore activities such as dredging, piledriving and blasting activities. Throughout the EIS (Specifically Chapters 7 & 11) assessment of risk to species of nearshore activities including dredging, blasting and piledriving is often ranked as 'medium' or 'low' based on the caveat/assumption that Darwin Harbour is not a significant breeding or feeding habitat for these species.5 However, inshore dolphin surveys in Darwin Harbour (initiated in 2008) strongly indicate that the area is an important feeding and calving habitat for both the Snubfin dolphin and Indo-pacific humpback dolphins. Approximately 33 Snubfin dolphins (10 Schools) and four calves have been recorded) utilising the harbour. 284 Indo-pacific humpback dolphins (88 Schools) and 34 calves have also been recorded.6 It has been clearly identified that the Indo-pacific humpback dolphins (including a mother and calf pair) inhabit and actively forage in the area just past Blaydin point (close to blasting, piledriving and dredging activities) and exhibit high site fidelity.7 One of the critical features of the Snubfin dolphin also, is that they exist in small and highly localised groups, and are particularly vulnerable to site-specific threats.8 It is therefore inaccurate to assume that no important breeding and foraging areas have been identified, or are present, in the harbour and furthermore to determine level of risk based on this assumption WWF recommends both short-term targeted research and longer term research and monitoring to adequately assess the status of key marine species, particularly Orcaella heinsohnii & Sousa chinensis and Tursiops aduncus in the area potentially affected by the Project, including distribution, abundance, movement patterns and genetic structure. The EIS should be revised based on this short-term targeted research and based on the results of on-going research, to include more comprehensive and recent information on key marine species. Risk assessments should be revised in light of this information, and a new version of the EIA released for comment.

Submission 6-1: Over time I have seen a number of dolphins in the Darwin area and I wish to draw attention to the statement in the fact sheet "protection of marine animals" that there is no known "signifcant aggregation" of dolphins in Darwin harbour. Chapter 3, section 3.3.8, page 82 of the Draft EIS states that Palmer 2010 has recorded 284 humpback dolphins in Darwin harbour surveys. To me this is a very significant aggregation. I know of schools of humpback and bottlenose dolphins in the Nightcliff area which are possibly not part of the counted population.

Submission 123-60: The interpretation of information presented on population size and density of snubfin dolphins is not accurate and does not include more recent data. The paper that is referenced, Freeland and Bayliss (1989) conducted aerial surveys in the Gulf of Carpentaria, and estimated around 1,000 individuals. This estimate has been questioned due to the difficulty in distinguishing different species from aerial surveys in turbid waters (H. Marsh pers. comm. Cited in IUCN red List). Surveys undertaken between 1987 and 1995 in Queensland coastal waters revealed much lower population densities (Parra et al. 2002). Also, photo-identification studies conducted from 1999 – 2002 indicate a population of fewer than 100 individuals in Cleveland Bay, northeast Queensland (Parra et al. 2006a). A preliminary survey of the north-eastern Kimberley coast conducted by Thiele in May 2006 recorded 15 groups of animals, totalling 88 individuals (IUCN, 2010). The majority of identified snubfin populations are thought to be small (Jacob 2009).

Submission 123-62: This information [*Preliminary observations since 2008 have identified relatively high numbers of snubfin dolphins at Coberg Peninsula and in the South and East Alligator Rivers*] needs to be presented correctly and contextually in the EIS. Observations at Cobourg and Kakadu are based on repeated transects where a proportion of all sightings will include the same individuals sighted numerous times due to the residency and site fidelity pattern displayed by these species. Sighting data suggests the populations would be less than 100 snubfin dolphins at Cobourg and less than 80 for the Alligator Rivers region. These numbers are not considered to be high. Overall, despite its wide distribution, populations of snubfin dolphins appear to be rare in most areas, and those that are known are thought to be localised and discrete (Parra and Arnold 2008). It is inappropriate to use the data presented in Palmer 2010 to compare snubfin dolphin numbers in Cobourg to Darwin or Kakadu.

Submission 123-63 : Information on population size and density of Indo-Pacific humpback dolphins must be updated in the EIS. Data on the status of humpback dolphin populations in Australia are scarce however existing data suggests they are not a common species. Corkeron et al. (1997) have suggested that they are in decline. The only statistically defensible estimates for Australian waters are of 34-54 (CVs=13-27%) in Cleveland Bay, Queensland (Parra et al. 2006a), and 119-163 (95% CIs = 81-251) in Moreton Bay, Queensland (Corkeron et al. 1997). Coastal dolphins are under threat and in need of management intervention to reduce anthropogenic threats (Thomson et al 2000; DeMaster et al 2001, Parra et al. 2006a).

Submission 123-64: This statement [*shallow intertidal areas in Darwin Harbour are regularly used by Australian snubfin and Indo-Pacific humpback dolphins*] is overly simplistic. The EIS needs to acknowledge recent studies of Orcaella and Sousa, which have shown a heterogeneity in distribution and varied use of patches within a habitat and that there will be a few important key habitats (hotspot areas) (Stensland et al. 2006, Parra 2006). Such fine-scale habitat selection and spatial heterogeneity is important for the coexistence of sympatric species like Orcaella and Sousa (Parra 2006). Current and up-to-date specific sighting locations indicate that the Indo-Pacific humpback dolphins have been predominantly recorded around East Arm and at the mouth of Reichardt and Blessers Creeks (also Howard River and Hope Inlet, Shoal Bay) and foraging was the dominant behaviour (Fortune et al 2009; Palmer 2010). Snubfin have been recorded in East Arm, Woods Inlet and in Fannie Bay.

Submission 123-65: This statement [*humpback dolphin calves have been recorded throughout Darwin Harbour and Shoal Bay*] is incorrect. There are no data on the humpback dolphin calves throughout Darwin Harbour. Rather, there are specific sighting locations of mother/calf pairs where they have been recorded predominantly around East Arm and at the mouth of Reichardt and Blessers Creeks (also Howard River and Hope Inlet, Shoal Bay) (Palmer 2010).

Submission 123-66: This statement [*from the current understanding of the ecology of these two species, it is reasonable to conclude that potential habitat for snubfin and Indo-Pacific humpback dolphins occur throughout Darwin Harbour*] is overly simplistic and the draft EIS does not provide any new evidence to support this conclusion. The EIS needs to acknowledge recent studies of Orcaella and Sousa which have shown a heterogeneity in distribution and varied use of patches within a habitat and that there will be a few important key habitats (hotspot areas) (Stensland et al. 2006, Parra 2006). Such fine-scale habitat selection and spatial heterogeneity is important for the coexistence of sympatric species like Orcaella and Sousa (Parra 2006).

Submission 123-67: This statement [*A similar study on site fidelity* (to that of Parra, Corkeron and Marsh 2006) *has not been undertaken for the snubfin and Indo-Pacific humpback dolphins of Darwin Harbour*] is not correct. Investigation of site fidelity has been a component of a multi-species dolphin program undertaken by the Northern Territory Government in Darwin Harbour since 2008. This research has been focusing on three species of coastal dolphins; the Australian snubfin Orcaella heinsohni, Indo-Pacific humpback dolphin Sousa chinensis and Indo-Pacific bottlenose Tursiops aduncus. Initial results suggest that populations of Sousa and Tursiops are resident (site fidelity), whereas Orcaella occurs in low numbers and appears transient. Recent photo-identification and mark resighting analysis indicate resident populations of fewer than 50 individuals for both Indo-Pacific humpback and the Indo-Pacific bottlenose. Analyses of movement patterns via photo-identification for all three coastal dolphin species suggest very little movement between Darwin Harbour and Shoal Bay populations. All three species have been recorded foraging in Darwin Harbour with mother/calf pairs (Fortune et al 2009; Palmer 2010).

Submission 123-71: Additionally, Van Parjis and Corkeron (2001) also investigated the vocalizations of Indo-Pacific humpback dolphin. The variety of sounds produced by Indo-Pacific humpback dolphins is similar to those of related Delphinines, such as Tursiops sp. and Stenella sp. Rates of vocalization were greatest during foraging and socializing, and few vocalizations were emitted during either travelling or milling. They recorded 17 different types of frequency modulated narrow band calls (whistles) produced by Indo-Pacific humpback dolphins ranging in frequency from 1 kHz to 22 kHz.

Submission 123-73: This statement [*The ecology of the* (bottlenose dolphin) *population in NT waters has not been studies in detail*] in the draft EIS should be qualified by adding the following, "…however, initial studies undertaken by the NTG indicate that small numbers of bottlenose dolphins are resident and breed and forage in Darwin Harbour (Palmer 2010)." The current statement doesn't consider Northern Territory Government data and should make mention of the multi-species dolphin research program that has been conducted in Darwin Harbour since 2008. Initial results suggest that populations of Tursiops are resident. Based on photo-identification and mark resighting analysis, resident population size for the Indo-Pacific bottlenose is small < 50 animals. Analysis of movement patterns via photo-identification for coastal dolphin species has identified very little movement between Darwin Harbour and Shoal Bay.

Submission 123-118: Information provided [*in Table 7.31 Summary of impact assessment and residual risk for dredging*] does not include recent Northern Territory Government data from the coastal dolphin program (Fortune et al 2009; Palmer 2010). Specific sighting locations indicate that Indo-Pacific humpback dolphins have been predominantly recorded around East Arm and at the mouth of Reichardt and Blessers Creeks (also Howard River and Hope Inlet, Shoal Bay) with foraging being the dominant behaviour (Fortune et al 2009; Palmer 2010). Specific sighting locations indicate that mother/ calf pairs are recorded predominantly around East Arm and at the mouth of Reichardt and Blessers Creeks (also Howard River and Hope Inlet, Shoal Bay) (Palmer 2010).

Submission 123-149: Northern Territory Government data shows that the area may be significant for marine megafauna. Specific sighting locations indicate that Indo-Pacific humpback dolphins have been predominantly recorded around East Arm (Elizabeth River) and at the mouth of Reichardt and Blessers Creeks and foraging was the dominant behaviour (Fortune et al 2009; Palmer 2010). The Indo-Pacific bottlenose are recorded around at the mouth of Reichardt and Blessers Creeks and foraging was the dominant behaviour (Palmer 2010). Specific sighting locations indicate that mother/ calf pairs of Indo-Pacific humpback dolphins are recorded predominantly around East Arm (Elizabeth River) and at the mouth of Reichardt and Blessers Creeks (Palmer 2010). This statement [contained in summary table 7-41 that '*no significant breeding, foraging or aggregation areas for threatened species are known to exist in the nearshore development area*'] is speculative. Underwater noise modelling needs to be undertaken to improve assessment of the impact of the proposed development.

Submission 123-151: Northern Territory Government data shows that the area may be significant for marine megafauna. Relevant sighting data from the Northern Territory Government would help to inform this. Specific sighting locations indicate that Indo-Pacific humpback dolphins have been predominantly recorded around East Arm (Elizabeth River) and at the mouth of Reichardt and Blessers Creeks and foraging was the dominant behaviour (Fortune et al 2009; Palmer 2010). The Indo-Pacific bottlenose are recorded around at the mouth of Reichardt and Blessers Creeks and foraging was the dominant behaviour (Palmer 2010). Specific sighting locations indicate that mother/ calf pairs of Indo-Pacific humpback dolphins are recorded predominantly around East Arm (Elizabeth River) and at the mouth of Reichardt and Blessers Creeks (Palmer 2010).

Submission 123-153: Northern Territory Government data shows that the area may be significant for marine megafauna. Relevant sighting data from the Northern Territory Government would help to inform this. Specific sighting locations indicate that Indo-Pacific humpback dolphins have been predominantly recorded around East Arm (Elizabeth River) and at the mouth of Reichardt and Blessers Creeks and foraging was the dominant behaviour (Fortune et al 2009; Palmer 2010). The Indo-Pacific bottlenose are recorded around at the mouth of Reichardt and Blessers Creeks and foraging was the dominant behaviour (Palmer 2010). Specific sighting locations indicate that mother/ calf pairs of Indo-Pacific humpback dolphins are recorded predominantly around East Arm (Elizabeth River) and at the mouth of Reichardt and Blessers Creeks (Palmer 2010).

Submission 123-154: Northern Territory Government data shows that the area may be significant for coastal dolphins. Relevant sighting data from the Northern Territory Government would help to inform this. Specific sighting locations indicate that Indo-Pacific humpback dolphins have been predominantly recorded around East Arm (Elizabeth River) and at the mouth of Reichardt and Blessers Creeks and foraging was the dominant behaviour (Fortune et al 2009; Palmer 2010). The Indo-Pacific bottlenose are recorded around at the mouth of Reichardt and Blessers Creeks and foraging was the dominant behaviour (Palmer 2010). Specific sighting locations indicate that mother/ calf pairs of Indo-Pacific humpback dolphins are recorded predominantly around East Arm (Elizabeth River) and at the mouth of Reichardt and Blessers Creeks (Palmer 2010).

Submission 123-72: The EIS needs to be updated with more comprehensive and current information. Tursiops taxonomy is complex and currently the genus is divided into two species, truncatus and aduncus, which predominantly occupy different geographical ranges, although sympatric populations have been identified (Rice 1998, Wang et al. 2000a, b, Chilvers and Corkeron 2003). The taxonomic status of many populations of T. aduncus is unknown (Ross & Cockcroft 1990, Möller & Beheregaray 2001). There is limited information available about the status of Indo-Pacific bottlenose dolphin coastal populations and only one study in Australia has published abundance estimates (and site fidelity ranging patterns) for Indo-Pacific bottlenose dolphins inhabiting estuaries in Australia (Fury and Harrison 2008). Fury and Harrison (2008) estimated population abundance through mark-recapture analyses of 71 dolphins and 34 dolphins for the Richmond and Clarence Rivers respectively in northern NSW. Indo-Pacific bottlenose dolphins breed and forage in Darwin Harbour (Palmer 2010). Initial abundance estimates are less than 50 resident bottlenose dolphins in Darwin Harbour.

Submission 11-2: I am uncertain that the statement by Inpex is correct that only minimal injury and mortality of marine life in Darwin Harbor is to be expected as a consequence of the blasting. What independent data is this statement based on? Reports by independent sources tell a different story with an expected mortality zone of up to 500m and an injury zone of 1,250m. Furthermore, there is no data on the impact of blasting on dolphins and whales in a partly closed harbour. Therefore, I oppose the blasting of Walker Shoal. Alternative paths for a channel that does not involve blasting should be actively investigated.

Submission 124-29: Underwater blasting of Walker Shoal and impacts on marine wildlife The Draft EIS proposes blasting Walker Shoal three times daily with six 50 kg explosive charges for over one year. This represents a serious and unacceptable risk to marine wildlife in the Harbour that is highly likely to result in the death, injury and long term exclusion of protected and threatened species such as three species of coastal dolphins (Australian snubfin, Indo-Pacific humpback and Indo-Pacific bottlenose), dugong and four species of marine turtles (Green, Flatback, Olive Ridley and Hawkesbill), plus fish and other wildlife. We strongly disagree with the statement in the Draft EIS that the residual risk from underwater blasting is only 'medium'. The area of the Harbour in the vicinity of Walker Shoal (East Arm, Bleesers Creek, Sadgroves Creek and the Darwin CBD) is a hot spot for Indo-Pacific humpback and Indo-Pacific bottlenose dolphins. These dolphins are not highly mobile and spend significant periods of time resident in that section of the Harbour due to the presence of prey in the estuaries of the Elizabeth River and various smaller creeks.

Submission 123-193: PAM 's effectiveness requires dolphins to be vocalizing and dolphins do not vocalize continuously (Van Parijs, S. M. & Corkeron, P. J. 2001). It is understood that the use of PAM and active acoustic monitoring (AAM) is being investigated by INPEX. NRETAS expects that the findings, as well as the methodologies for determining the effectiveness of these technologies for targeted species, will be presented in the EIS.

The mitigation measures proposed are highly unlikely to prevent marine wildlife from being killed, injured or seriously disorientated by the blasting. The use of trained spotters, though admirable, should be seen as standard procedure for such projects rather than as an exceptional mitigation measure. The use of passive and active accoustic monitoring may reduce the likelihood of inadvertent death and injury to marine wildlife but does not sufficiently lower the risk of marine wildlife moving too close to the blast area. Coastal dolphins are highly cryptic and difficult to see. They have low profiles and spend much of the time submerged. Underwater accoustic monitoring cannot be guaranteed to alert blasting operators to their presence as they spend significant periods of time not vocalising.

A large number of submissions made reference to the potential impacts to coastal dolphin species from construction and operation of the Project. Three coastal species of dolphins, the Australian snubfin (*Orcaella heinsohni*), the Indo-Pacific humpback (*Sousa chinensis*) and the Indo-Pacific bottlenose (*Tursiops aduncus*) are the most common cetacean species in Darwin Harbour (Palmer 2009). All three are listed and are considered to be migratory under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act). The three species are considered to be of "least concern"[9] under the *Territory Parks and Wildlife Conservation Act* (TPWC Act). Aspects of the taxonomy, distribution and habitat of these three species, relevant to the environmental impact assessment, were described within the Draft EIS (Section 3.3.8).

1. Limited data

INPEX acknowledges the difficulty in separating human-induced changes in population structure from those caused by natural variability for highly mobile species, such as coastal dolphins, in a dynamic environment where there is a paucity of long-term data. Consequently INPEX has initiated the first stage of a comprehensive long-term marine mammal monitoring. This study will firstly provide a basis for integrating previous similar studies with ongoing work so that maximum use can be made of historical data, and secondly form the basis of the long-term monitoring program.

9 The listing is based on IUCN Red List categories. A taxon is of "least concern" when it has been evaluated against the criteria and does not qualify for "critically endangered", "endangered", "vulnerable" or "near threatened" status. Widespread and abundant taxa are included in this category (IUCN 2001).

2. Cryptic nature of coastal dolphin species

It is recognised that observations of coastal dolphin species may be difficult at times for a variety of reasons, such as their cryptic nature, low profile and occasions of inclement weather. The methods that will be used for carrying out observations prior to commencement of piledriving activity or blasting (if it is required) will be defined based on outcomes from the first stage of the comprehensive marine mammal monitoring (referred to above). The methods to be applied will be described in detail in the final construction management plan and blasting management plan (if blasting is required).

In addition, a project involving desktop modelling and field trials to test the effectiveness of passive acoustic monitoring (PAM) and active acoustic monitoring (AAM) techniques for detecting and tracking coastal dolphins, dugongs and turtles has been commissioned by INPEX. The results obtained to date are summarised in Section 4.1.12 of this EIS Supplement.

3. Seriousness of impact to small populations

The submissions appear to have assumed that individual dolphins would be killed or lost to the population as a consequence of construction and operation of the project. This opinion is not supported by analysis presented within the Draft EIS or this EIS Supplement. There is a risk of mortality associated with blasting activities but it is considered that the implementation of management measures as described in the Draft EIS and this document (Section 4.1.12) would mitigate the risk to very low likelihood. The reduction in the duration of a possible blasting campaign, described in Section 3.3.8, further ameliorates the risks to dolphin species.

4. Interference with dolphin echolocation

The level of noise predicted to occur as consequence of construction and operation activities has been described in the Draft EIS and is further described in Section 4.1.11 of this EIS Supplement. Some auditory masking may occur from vessel noise associated with proposed construction vessel types in Darwin Harbour. However, masking will only occur in the low frequencies (below approximately 5 kHz, with most noise below 1 kHz) and vessel noise is not likely to occur at the higher frequencies used by toothed cetaceans in echolocation.

5. Critical habitat

The distribution and abundance of the three coastal dolphin species has been the subject of several surveys carried out around the coastline of northern Australia. The findings indicate that the populations of each species are wide spread with localised areas of relatively high abundance separated by areas of very low, or no, presence. The Northern Territory Government has been involved in the monitoring of coastal dolphin species in Darwin Harbour and in the broader Anson–Beagle Bioregion since 2008. Preliminary data from this work, that have been made publicly available, are discussed in Section 3.3.8 in Chapter 3 *Existing natural, social and economic environment* of the Draft EIS and in Section 4.1.9 of this EIS Supplement.

A comprehensive long-term marine mammal monitoring project has been initiated by INPEX, the first phase of which will provide the basis for integrating previous similar studies with ongoing work. Preliminary results indicate that all three coastal dolphin species and dugong occur in the western parts of the Harbour (middle and western tributaries) beyond the potential zone of influence from dredging and piledriving activities. Further information on the preliminary results can be found in Section 4.1.9.

6. Taxonomy of the genus Tursiops

Further information on the taxonomic status of *Tursiops aduncus*, relevant to an assessment of environmental impact is provided in Section 4.1.9 of this document.

7. Secondary impacts from loss of prey species.

Construction of the shipping channel will lead to some long-term alteration of habitat, as described in the Draft EIS. However, because this habitat is neither rare nor unusual in Darwin Harbour (see Section 4.1.3.11 in this EIS Supplement) this is not likely to cause any detectable reduction in fish abundance. As discussed above the potential for masking of echolocation, and therefore interference to predation activities, is considered to be very low due the to differences in frequencies of construction noise and echolocation signals.

8. Blasting impacts

INPEX has committed to using methods other than drilling and blasting for the removal of Walker Shoal. However if the rock base underlying Walker Shoal cannot be removed by non-blasting methods then a short period of drilling and blasting (estimated to be approximately 4 weeks) may be required to complete the construction of the shipping channel.

Detailed numerical modelling has been carried out (see Section 4.1.11 of this EIS Supplement) to estimate the maximum noise and blast pressure that would be received at different distances from potential blast locations. Based on a comprehensive review of available data sources, including material presented in the Draft EIS, a supplementary assessment of potential impacts from blasting is presented in Section 4.1.11 and Technical Appendix S7 in this EIS Supplement.

Detailed numerical modelling has been carried out to assess the range and intensity of underwater blast effects and piledriving operations. This was repeated for a number of scenarios. The results are presented in Section 4.1.11 of this EIS Supplement.

Predictions of ranges of potential effect and management measures for the protection of sensitive marine fauna are described in Section 4.1.11 of this EIS Supplement.

9. Acoustic monitoring

INPEX has commissioned a detailed study to evaluate the feasibility of passive acoustic monitoring (PAM) and active acoustic monitoring (AAM) techniques. Further information is provided in Section 4.1.12 of this EIS Supplement.

Dugong and turtle foraging areas

Further information on the spatial distribution of turtle and dugong foraging areas within Darwin Harbour, and the potential impact to these areas, is presented in Section 4.1.10 of this EIS Supplement.

Submission 6-4: Casuarine Beach seagrass, Chapter 3, section 3.3.6, page 74. This seagrass bed is an important seasonal feeding area for dugongs (personal observation). Increase turbidity and sedimentation of this area could significantly affect the feeding patterns of these dugongs.

The sandflats inshore of Old Man Rock support very large populations of featherstars, brittle stars, sand dollars and sea urchins which could decline if sedimentation increases. Of more concern is that these populations extend eastwards from Lee Point to Buffalo Creek. Page 334 of 7.3.3 specifically indicates that the 'sediment build up is predicted to occur mainly between Lee Point and the Howard River.'

Between Old Man rock and Casuarina Beach area a number of small (some only 2-3m^2) rocky outcrops or reefs. These small reefs support very rich micro-colonies of gorgonians, fan corals, whip corals, soft corals, sponges and many algaes and other invertebrates. These micro-colonies are only exposed at very low spring tides. It is possible that these could be adversely affected by an increase in sedimentation.

Manta rays in small numbers make seasonal visits along these foreshroes, often within a few metres of the beach and rocks. These could also be affected by changes to the surrounding environment.

Submission 107-45: INPEX discusses the effects of turbid waters on algal communities. This should be extended to consider the impacts on local seagrasses — another source of food for dugong and marine turtles. If by algal communities INPEX mean, or include seagrass, this should be stated.

Submission 123-51: This section [3.3.6, Seagrass meadows] does not discuss the importance of these seagrass meadows for Dugong and that they are the only known seagrass meadows within the Darwin Harbour – Shoal Bay region. Seagrass meadows occur at Casuarina Beach and Fannie Bay.

Submission 123-54: This section [3.3.6, Significant marine communities] does not provide a full assessment of significant habitats as defined in the Executive Summary (p 34). Seagrass meadows/habitats at Casuarina Beach and Fannie Bay need to be included in this section.

Submission 123-68: This section [3.3.8 Protected species] needs to highlight that dugong are often seen at Casuarina Beach and Fannie Bay. Feeding trails have been recorded in these areas.

Submission 123-111: Information provided does not include recent Northern Territory Government dugong sighting data from Palmer (2010). Dugongs are regularly recorded foraging in Fannie Bay. Preliminary seagrass identification at Fannie Bay includes two seagrass species Halodule uninervis and H. pinifolia.

Submission 123-120: Information provided does not include the dugong sighting data from Palmer (2010). Dugongs are regularly recorded foraging in Fannie Bay. Preliminary seagrass identification at Fannie Bay includes two seagrass species Halodule uninervis and H. pinifolia. Sediment modelling indicates Fannie Bay will be impacted by turbid plumes.

Submission 123-171: Needs to add seagrass as a significant habitat.

INPEX recognises that seagrass meadows are known to be of importance to dugongs. However, it is understood that the relative importance to dugong feeding of the individual seagrass beds within Darwin Harbour and Shoal Bay (and potentially Beagle Gulf) has not yet been determined, that is, whether some seagrass beds are of greater importance than others.

INPEX realises that dugongs have been recorded at Casuarina Beach and in Fannie Bay (e.g. Palmer 2010a) and notes that feeding trails were clearly evident in the Fannie Bay meadow during an aerial survey undertaken by INPEX in November 2010. However, INPEX contends that the mere presence of dugongs within these more often observed seagrass areas does not necessarily indicate that these areas are more important to dugong feeding than more remote seagrass areas at which observations may be made infrequently (if at all).

During the November 2010 aerial survey, extensive patchy beds of seagrass were noted in the lower intertidal zone of the sand flats along the southern shore of Shoal Bay (i.e. between Lee Point and the mouth of the Howard River). During a tow camera survey undertaken by INPEX in December 2010 (refer Technical Appendix S6 in this EIS Supplement), very sparse *Halophila* seagrass was recorded across broad subtidal areas offshore from Casuarina Beach and Fannie Bay.

While increased turbidity and sedimentation certainly has the potential to impact upon seagrasses, figures 105 to 125 of Technical Appendix 13 of the Draft EIS show that:

- An additional 3–10 mg/L of suspended sediment above background is predicted to occur in the vicinity of the Casuarina Beach seagrass beds during Phase 5 (some 2.5 months) of the dredging campaign (see Figure 109).
- No sediment accumulation of greater than 5 mm is predicted to persist within the Casuarina Beach seagrass beds at any stage of the dredging campaign.
- During the 1.5 months of cutter-suction dredging during Phase 6 of the dredging campaign, an additional 3-5 mg/L of suspended sediment above background is predicted to occur in the vicinity of Fannie Bay, offshore from the seagrass beds observed during the aerial survey, but over the sparse *Halophila* patches recorded during the tow-camera survey, (see EIS Supplement Figure 4-6).
- Sediment accumulation of 5–10 mm is predicted to occur in Fannie Bay by the end of Phase 4 of the dredging campaign, increasing in area and thickness (up to 10–20 mm) through phases 5 and 6, then persisting unchanged through the remainder of the campaign (see figures 119–125 in the Draft EIS's Technical Appendix 13). However, most sediment accumulation is predicted to occur beyond the northernmost extent of the Fannie Bay seagrass meadow.

From the impact assessment presented in Section 4.1.3 of this EIS Supplement, it is predicted that:

- There will be no detectable effects of dredging and spoil disposal, either from elevated turbidity levels or sedimentation, on the Casuarina Beach seagrass meadow.
- There will be no detectable effects on the Fannie Bay seagrass meadow from elevated turbidity arising from dredging or spoil disposal.
- The northern half of the Fannie Bay seagrass meadow may experience increased sedimentation (3-14 mm) during Phase 5 of the dredging campaign (see Figure 4-13 of this EIS Supplement), though it is predicted that the rate of sedimentation will be sufficiently low that there will be no detectable impacts on seagrass.

At Old Man Rock and the surrounding areas there may be elevated suspended sediment levels (3–10 mg/L) during Phase 5 of the dredging campaign (see Figure 109 in the Draft EIS's Technical Appendix 13), but no sediment accumulation of more than 3 mm is predicted (see Figure 4-12 of this EIS Supplement). It is considered that the predicted additional suspended sediment concentrations over a limited period of time represent a minimal threat to the benthic communities present.

While it is stated in the Draft EIS that sediment build-up is predicted to occur between Lee Point and the Howard River, it is apparent from Figures 118 to 125 of Draft EIS Technical Appendix 13 that sedimentation of greater than 5 mm depth is predicted to only occur between Buffalo Creek and the mouth of the Howard River. This is to the east of the invertebrate communities of the inshore sandflat between Lee Point and Buffalo Creek, for which concerns have been expressed by the commenter.

Manta rays may well avoid certain areas if environmental conditions become temporarily unsuitable, however it is considered most likely that they would source their typical prey species (planktonic crustacean and small bony fishes (IUCN 2010a) in areas around the mouth of Darwin Harbour where environmental conditions are unaffected by dredging and spoil disposal at the time.

Submission 6-3: Chapter 7, section 7.3.3 Dredge spoil disposal, page 329 dump site area and tidal flows outside Darwin harbour. It is stated that tidal flow is approximately east for flood tides and west for ebb tides. This may be so for much of Beagle Gulf, however my observations indicate that these directions are reversed along Casuarina Beach, Nightcliff foreshore and inshroe of Old Man Rock.

Mention is made of possible deposition of some sediment from the spoil disposal near the mouth of Rapid Creen (page 338). No mention is made of the probable increase of silt and mud between the sand of Nightcliff beach and the coral reef platform approx 100-150 metres offshore from the beach. Any increase in this mud and silt could affect swimmers at the beach during the lower tides. Also it could have a detrimental effect on the corals and inhabitants of the reef.

The observations of tidal flows at these locations are noted. It should be noted, however, that all three are south of the "headlands of Darwin Harbour" (Charles Point and Lee Point) and the statement in the EIS refers to "typical" flow directions offshore (i.e. to the north) of the headlands.

As shown in Technical Appendix 13 of the Draft EIS (Figures 116 to 125), a small area of minor (5-10 mm) sediment accretion is predicted to occur to the south of Nightcliff by the end of Phase 6 of the dredging campaign, and to persist until the end of the campaign. This area is an intertidal flat where sediment deposition already occurs due to the prevailing hydrodynamic conditions. As the dredging activities will not influence these hydrodynamic conditions in the vicinity of Nightcliff, the deposition of any sediment arriving from the spoil ground will occur preferentially within existing depositional areas. It is considered that the addition of 5-10 mm of sediment to these areas (if it should occur) would be imperceptible to swimmers at the beach.

While the modelling does not predict any sediment accretion of more than 5 mm occurring over reef areas, corals and other reef inhabitants could be affected by substantial elevations in suspended sediments in the overlying water column if this were to occur. However, Figures 105 to 115 of Draft EIS Technical Appendix 13 show that no addition of suspended sediment above 3 mg/L is predicted in the vicinity of Nightcliff over the course of the dredging campaign. Typical suspended-sediment levels in the Harbour are in the order of 14 mg/L (see Table 3-5 in Chapter 3 *Existing natural, social and economic environment* of the Draft EIS), and therefore if sediments from the spoil ground were to reach Nightcliff they would be at concentrations that are likely to be imperceptible against background.

Submission 7-18: Models had not been used to gauge effects of blasting and dredging in proposed areas nor reported, only assumed.

Submission 8-2: The project poses unacceptable risks to dugongs, three species of coastal dolphins and four species of marine turtles from underwater blasting and dredging in Darwin Harbour.

Submission 8-3: The EIS provides no peer reviewed credible information that is directly relevant to the effects of blasting on Darwin Harbour's fragile marine wildlife. For example, it fails to model the underwater noise impacts on wildlife in the harbour, relying instead on a study for the US Defence Department that tested the effects of underwater explosions on live sheep, dogs, monkeys and ducks.

Submission 16-2, 16-4, 20-2, 20-4, 24-2, 24-4, 29-1, 29-3, 89-2, 89-4, 96-1, 96-3, 101-3, 101-5, 102-3, 102-4 Blasting of Walker Shoal at the entrance to the shipping channel will pose significant risk of injury and death to dolphin, turtle and fish species. INPEX is relying on an outdated and incomplete literature review to assess the level of risk.

The key reference used by INPEX to assess blasting zones of impact for marine mammals is a report from 1973 that has not been peer-reviewed and is based on a very limited study that bears no relationship to Darwin Harbour. INPEX have not actually sighted this report, even though it is their key reference.

No underwater noise modelling has been done, and hence, underwater noise impacts on marine wildlife are largely unknown.

Submission 16-5, 20-5, 24-5, 29-4, 89-5, 96-4, 101-6: No underwater noise modelling has been done, and hence, underwater noise impacts on marine wildlife are largely unknown.

Submission 17-1: I would like to respond and to express my concern over the Environmental Impact Statement for the proposed gas field development project. The statement is inadequate and inaccurate. There has been no underwater noise modelling and the key reference used for the impact of blasting zones is out of date, not peer reviewed and unrelated to the environment of Darwin Harbour. I have referred here to The Environment Centre NT's Preliminary Key Concerns Regarding the Draft EIS for the Proposed INPEX LNG Plant in Darwin Harbour, 31 August 2010, M Bradley & S Blanch, and I support the whole document.

Submission 32-3: I am very disturbed to read that your company has not done any noise modelling to predict the impacts on the harbour's dugongs, dolphins and turtles. Instead,I believe you are relying on modelling from the US Defence Department that tested the effects of underwater explosions on live sheep, dogs, monkeys and ducks which were held underwater!

Submission 40-3: I understand there is no research showing the impact of the noise on marine life – we know whales are guided by underwater sound. What will this do?

Submission 66-1: The development in Darwin Harbour is threatening its inshore dolphins, turtles and dugongs. Plans to detonate underwater explosives three times a day for a whole year in Darwin Harbour to build a new shipping channel are deeply flawed. The noise modelling is farcical. Relying on modelling from the US Defence Department that tested the effects of underwater explosions on live sheep, dogs, monkeys and ducks which were held underwater, to predict the impacts on the harbour's dugongs, dolphins and turtles, is appalling science!

Submission 71-2: I wish to oppose the plans by Japanese oil & gas giant INPEX to blast Walker Shoal in Darwin Harbour for its shipping channel. What a reckless act of environmental vandalism and how irresponsible to consider such vandalism with no proper underwater acoustic modeling, no specific research on adverse affects to wildlife and dolphins, dugong and turtles, let alone any other fish that call the habitat home. If INPEX plans to blast in Darwin Harbour three times a day for over a year then where is their peer reviewed scientific papers that show that this is OK? I understand by its own admission INPEX suggests that these blasts would create a kill zone that would kill dolphins within a 500m radius, and injure any within 1250m, this is not acceptable, there are other options for the company and they must explore them. For INPEX to say that the dolphins, dugong and turtles occur across much of Northern Australia is superciliousness and complete arrogance and shows a total lack of sensitivity. The health of Darwin Harbour and the wildlife that call it home is much more important. Any underwater noise pollution will have huge impacts that must not be tolerated, for we can be sure they will not be minor.

Submission 84-4: The literature review on the risk of injury and death to dolphins, turtles, fish, dugongs and other marine life is incomplete, outdated, based elsewhere and not relevant to the conditions of Darwin Harbour or the type of blasting proposed here. The risk to our marine life, and marine mammals in particular, is too great to be treated casually. Unless Inpex can produce studies which are relevant to our harbour and prove that the marine life is at no risk, I don't believe that any blasting should take place. This should include modelling of the impact of blasting noise on marine wildlife

Submission 87-4: Blasting of Walker shoal and its reliance on an ancient report (Yelverton et al 1973) is an appalling proposition

Submission 100-20: Inadequate and incomplete assessment of the direct and indirect impacts of blasting Walker Shoal for the shipping channel (Chapter 7 and Chapter 11 Annex) and inadequate exploration of alternative channel and jetty options. The EIS recognizes that the blasting of Walker Shoal at the entrance to the shipping channel 'has the potential to disturb, injure or even kill dolphins'. This confined blasting is predicted to continue up to 57 weeks, 3 times daily and around six 50Kg charges9 and yet it is still ranked low–medium risk. A population viability assessment of snubfin dolphins in Cleveland Bay, Queensland, suggests that the removal of just three dolphins per annum from the population could lead to their localised extinction (Parra et al., 2006). Given that only 33 Snubfin dolphins have been observed in Darwin Harbour to date, the loss of just one or two dolphins could pose an even greater impact/significant risk to the survival of the local population of this EPBC listed species. On page 35 EIS states that 'Alternative techniques to drilling and blasting are being investigated for the removal of the hard rock material within the shipping channel. At this stage, it is not possible to confirm whether there are any viable alternatives.' WWF-Australia believes that the EIS needs to be revised to include full assessment and provision of alternative options. WWF recommends all alternatives to blasting Walker Shoal need to be fully explored, for particular consideration to be given to moving the shipping channel either south or north of Walker Shoal to avoid the need for blasting and to re-examine the long jetty option. WWF considers the description and assessment of a full range of alternatives to one of the most important elements of EIA practise, and where some of the most useful and meaningful mitigation decisions can be taken. We urge the proponent and government to revise this EIS so that it provides the full range of alternatives, and relevant risk assessments.

Submission 100-16: Including on primary data on the distribution of coastal dolphin species in Darwin Harbour to more accurately inform development options and management and impact assessment planning

Submission 110-16: I would urge Inpex to do more research into the effects on flora and fauna of underwater blasting in particular reference to fauna that resides in Darwin Harbour.

Submission 116-1: Has modelling pr baseline data been compiled to test the effects of DAILY explosive activityand daily dredging in the harbor on • Fish • marine mammals and • the ocean floor What are those effects.

Submission 120-15: The proposed removal of a large amount of rock from Walker Shoal, particularly by using explosives to break up the rock, is another area of concern to recreational fishers. Inpex has been extremely open in presenting its EIS and we are grateful for this as, in relation to this operation, it does give us an understanding of the potential adverse impacts on fish and marine mammals on a worst-case basis. That said, our comments about the uncertainties of the dredging program above can also be applied to this area of the project and we note the comment that "Alternative techniques to drilling and blasting are being investigated…" but "…it is not possible to confirm whether there are any viable alternatives." (Draft EIS p. 215 and 358) We would assume that a removal technique that did not involve blasting would make a significant difference to the potential impacts of this operation on fish and other marine life in the vicinity of Walker Shoal and so such a process would be preferred if one is available. AFANT urges Inpex to explore all possible alternatives to this rock blasting program, including any other possible shipping channel alignment, before it presents the Supplementary EIS.

Submission 120-16: If there is no alternative to drilling and blasting to remove rock from Walker Shoal and with the potential for fish kills within close proximity to the blasting area, we would be interested in information on the potential impacts of a much shorter but more intense blasting program than the 14 months projected (Draft EIS p. 189). We note the projected fish and marine mammal mortality rates for various impact zones when a 300 kg confined blast is used (Draft EIS p. 357) but we do not have similar projections for smaller micro-delayed blasts to achieve the same result. We assume this would be considerably less and the technique could thus allow the blasting program to be completed in much less time and with less or at least no greater risk of mortality.

Submission 120-17: The projections for fish mortality do not appear to be derived from a particularly reliable source it being a technical report prepared for the Defense Nuclear Agency of the US Department of Defense in 1973. We also note that the projections are for fish of 10 kg (Draft EIS p. 357). We should have more up to date and reliable information on different blast impacts and we should have mortality projections for different species and particularly sizes of fish. Information we do have from observations of people who have dived on Walker Shoal indicates that there are unlikely to be many fish of 10 kg in close proximity.

Submission 124-1: Blasting of Walker Shoal. Explosive blasting of Walker Shoal (3 times a day over 57 weeks) for shipping channel dredging poses significant and unacceptable risks to coastal dolphins, marine turtles and fish species including species protected under the EPBC Act. There has been insufficient consideration of the impacts of blasting on Darwin Harbour marine wildlife, no underwater noise modelling has been done, proposed mitigation measures are inadequate and the proposed acoustic monitoring techniques have never been tested.

Submission 124-32: In assessing potential noise impacts on marine species (Chapter 7, Section 7.3.7, p. 358 – 360, and Appendix 15) the Draft EIS draws only loosely on the considerable body of literature available, omits key recent references (examples below13), and makes little attempt to analyse the broad thrust of the research findings in order to arrive at a considered assessment of risk.

Submission 124-33: Section 7.3.7 (Chapter 7) of the Draft EIS uses data gaps and paucity of research (in a very complex field) as excuses to justify their conclusion that the potential for underwater noise to result in cumulative negative impacts to populations of marine animals is considered to be low – and that this is in some part due to the lack of regionally significant habitat occurrence in the nearshore development area (p. 360).

Submission 128-2: Underwater noise. It is stated that noise levels below 20Hz is below the hearing range of most marine animals. The Baleen whales are just one species which is able to hear these low frequencies but because the report claims they only rarely visit the harbour it is assumed that this level of noise is not an issue. More research is required in order to assess the impacts of noise on a wider range of marine life that live in and pass through the harbour. The impact on the biodiversity of Darwin Harbour is based on modelling and incomplete research.

A number of submissions made the comment that the assessment of underwater noise and blasting effects contained within the Draft EIS was incomplete containing no research on the effect of noise on marine animals and that the assessment relied on outdated literature.

There is in fact a substantial body of scientific study regarding the effect of noise on marine life. More than 200 references were considered during preparation of the 100+ page *Technical Draft EIS Appendix 15 Review of literature on sound in the ocean and on the effects of noise on marine fauna* (including Yelverton et al. 1973 and Yelverton et al. 1975). The scope of the review was not restricted to recently published articles, instead it considered all available data. This is a legitimate approach because a valid observation does not become invalid merely through passage of time. The two experiments by Yelverton et al. (1973) and Yelverton et al. (1975), which were commonly identified by submissions as being outdated, are well accepted within the field of underwater impacts as authoritive studies on blast effects to marine fauna. For example they form the basis for the prediction of the Australian Defence Science and Technology Organisation's Aeronautical and Maritime Research Laboratory of lethal and safe ranges for fish, birds and marine mammals (Lewis 1996).

In regard to marine mammals, specific information on hearing in marine mammals is contained within the Draft EIS Technical Appendix 15 and this is further updated in sections 4.1.9 and 4.1.10 and the additional review presented as Technical Appendix S7 in this EIS Supplement.

Submission 7-10: "It is likely that at least those individual animals living well within the harbor, such as the portion of the National Estate registered co-ordinance area at Channel Island are in suboptimal habitats and are naturally stressed (LMD1997)." This report is now 10 years old with East Arm Port and a Darwin LNG Gas Plant since been installed with increased shipping so is there an updated reported on these animals?

The source of this quote is unclear—it does not appear in the Draft EIS. However, the Channel Island coral community can be considered as still surviving under naturally suboptimal environmental conditions. East Arm Wharf is sufficiently far removed for there to be no credible risk of influence from increased shipping. While the Darwin LNG Plant is closer to Channel Island than East Arm Port, the frequency of LNG tanker visits would be sufficiently low for any impacts associated with them to be insignificant in comparison with those from natural stressors (e.g. aerial exposure during daytime low tides in the hottest months of the year; potential exposure to rainfall during the same low tide periods; high turbidity during spring tide periods).

Submission 7-26: What is the long-term effect on Darwin Harbour and its use?

The Draft EIS together with this EIS Supplement describe in detail the activities and potential impacts of the Ichthys Project on Darwin Harbour. Section 7.3 of Chapter 7 Marine impacts and management of the Draft EIS and Section 4.1 of this EIS Supplement provide additional information in regard to potential impacts.

Submission 8-1: I am deeply concerned that the massive Ichthys Gas Field project proposed by INPEX will harm protected marine wildlife in Darwin Harbour and threaten the Kimberley coastline and Timor Sea.

Submission 30-4: Progress is inevitable and the economic injection that the INPEX project would bring to the Territory is desirable, but NOT AT THE COST of Darwin's beauty and the beautiful and in many cases endangered marine life.

INPEX has undertaken a detailed risk assessment which was presented in the Draft EIS. This EIS Supplement presents a further assessment of risks to protected marine wildlife in Darwin Harbour (see Chapter 7 Marine impacts and management of the Draft EIS and Section 4.1 in this EIS Supplement).

Similarly, although INPEX has undertaken an assessment of risks to the Kimberley coast of Western Australia and the Timor Sea from hydrocarbon spills, as discussed in Section 7.3.5 of the Draft EIS, a further assessment of risks to this area from an accidental uncontrolled release of hydrocarbons is presented in this supplement (see Section 4.2).

Submission 12-1: I'm a long-term NT resident of nearly 37 years. I have no objections to environmentally-sensitive or sustainable development. We have a harbour that the rest of the world would die for. Instead, you want to dredge it and kill its beauty. This is not environmentally-sensitive or ecologically sustainable.

INPEX has undertaken rigorous risk assessment, including computer modelling, to assess the level of risk to Darwin Harbour associated with the proposed dredging program and considers that risks from dredging fall within the boundaries of ecologically sustainable development. Turbid plumes will only occasionally be observable near Darwin city during spring tides when Harbour water in this area is invariably naturally turbid. Plumes will cease once dredging is completed: see Section 7.3.2 of the Draft EIS for a discussion of the water-quality impacts associated with dredging.

Submission 16-1: I am writing to express oposition to the new shipping channel for Darwin Harbour.as it is currently proposed. It is clear from the need for blasting 3 times daily that the environmental impact will be disastrous in terms of loss of carbon sink, apart from anything else. Australia is at great risk from global warming; development plans which accelerate that cluster of processes form a kind of criminal insanity.

There are other issues with the current proposal, also: loss of marine habitat and the risk of oil-spills among them. Alternatives must be found.

It is unclear how blasting will result in loss of carbon sink, which is a term used to describe a natural or artificial reservoir that accumulates and stores carbon-containing compounds.

Submission 16-6, 24-6, 29-5, 89-6, 96-5, 101-7, 102-5: Dredging for the shipping channel will generate ~17 million cubic metres of sediments over 3.5 years, with potential decreases in water quality; changed Harbour hydrodynamics; smothering of primary producer communities such as corals, mangroves and seagrass; direct impacts on marine wildlife by the dredge mechanism; and indirect impacts on wildlife via translocation and removal of habitat.

Submission 8-4: I also object to INPEX's plans to dredge 17 million cubic metres of harbour substrate for the shipping channel. This will destroy important mangrove habitats and potentially smother coral reefs and sea grass meadows. Furthermore, it will affect important breeding and foraging areas for coastal dolphins (Australian snubfin, Indo-Pacific humpback, Indo-Pacific bottlenose) and dugongs that are protected under the Federal Environment Protection and Biodiversity Conservation Act, as well as threatened marine turtles (Hawksbill, Flatback, Olive Ridley and Green).

Submission 13-2: The extensive dredging work will evidently be disastrous for wildlife in the area and will destroy local mangrove habitats, coral reefs and sea grass meadows.

Submission 14-1: "I am writing to urge you to reconsider the blasting and dredging that will take place in Darwin Harbour to build a new shipping channel. How badly must our oceans suffer before leading authorities take a stand to do the right thing? The marine ecosystem is already suffering staggering losses to population through continued overfishing and pollution. Australia stands out as one of the countries at the moment with a large share of its own rich biodiversity, some of which is thriving, but most of which is suffering from the same causes as everywhere else. Do we dare to be different? Do we dare show the world that our oceans can be managed in a better way? The devastation that will result is unable to be calculated, and far exceeds what would be ""expected"".

One imagines that populations can shift and move and that those forced out of the blasting and dredging zone (if they make it out) will relocate. But we are clearing out their land just as we are cutting down our rain forests, draining precious wetlands and driving out native species. The immobile part doesn't even stand a chance. Also, consider the marine mammals and fish with sensitive sonar capabilities that span numerous kilometers. What would it do to you to be blasted in your home three times a day for a year? Can you imagine what life is like for those experiencing such disastrous things in eastern countries? Instability creates devastation. The marine homes will be gone, bit by bit, with each explosion. Irretrievable ecosystems that have taken decades and even centuries to build, grow and network into a thriving home for life; all lost.

Compared to the greater ocean, it seems like a small area of marine real estate. But truly, and honestly, there is none to spare. We have already claimed more than our share. Please, do not bomb Darwin Harbour. It may be underwater, but the devastation will be as great as any war ever experienced there on land."

Submission 23-4: The focus of Sea Darwin tours is showcasing the habitat, the history and the intrigue of Darwin Harbour. Cetaceans including the three species of dolphins and dugongs, reptiles including crocodiles and turtles, fish, crabs and rays are all things that call Darwin Harbour home, and if they present themselves are a highlight of Sea Darwin tours. All of these animals, along with the mangrove habitat and inshore marine ecosystem, are acknowledged by INPEX as being impacted particularly by blasting and the dredging proposed (Ch 7 p357 – 361, 320-339,). Clearly what is unknown is to what extent this impact will be, due to lack of baseline whole of harbour benthic habitat data (Ch3 Fig3-16) and poor harbour flushing by tides (Smit N. 2003). Internet search shows that no harbour elsewhere in the world has been subjected to a continuous blasting programme of 14 months and four years of dredging.

Submission 32-1: The massive industrial development proposed for Darwin Harbour is threatening its inshore dolphins, turtles and dugongs.

Submission 40-2: Plans to dredge such vast amounts of seabed out of the harbour again without, it appears, adequately consider the impacts on this important environment. Mangroves and seagrasses are critical fish nurseries, feeding grounds and carbon sinks. They must be treasured, and protected to ensure adequate regeneration of fish stocks – we can't eat gas and minerals.

Submission 66-2: The plan to dredge 17 million cubic metres of seabed to make the shipping channel will kill important mangrove habitats and potentially smother seagrass meadows. Mangroves and seagrasses are critical fish nurseries, feeding grounds and carbon sinks. They should be treasured, not buried alive.

Submission 74-2: Investigate and utilise experiences gained in other similar projects to mitigate dredging and sediment pollution which I fear will drastically affect the biota in large areas within the harbour.

Submission 93-10: Dredging of the shipping channel and the impact that this will have on plant and wildlife during the installation period.

Submission 100-19: Dredging for the proposed shipping channel will generate 17 million cubic metres of sediments over 3.5 years. The impacts of this activity on the coastal dolphins, turtles, dugong and their habitat, is likely to be multifaceted and significant. Not only will it result in direct removal of habitat, and an increase in suspended solids concentration, it may influence humpback dolphins' prey and affect the dolphin indirectly by the loss of food supply due to disturbance of the seafloor and increased sedimentation. Sediments are likely to smother important habitats eg. mangroves in Elizabeth River and East Arm and coral reefs near Wickham Point, East Point and East Arm. The EIS likely underestimates this stressor, with the executive summary suggesting that only 2 hectares of mangroves are likely to be destroyed (p 34). The section on sediment effects on habitats needs revision and the additional more peer-reviewed research on tolerance of mangroves to being smothered with sediments and rates of recovery. Channel Island is a known foraging area for dugong. INPEX sediment plume modelling show potential impacts around Channel Island, but the described likely impact on dugong foraging habitats is portrayed as being minor. On p 324 of Section 7.3.2, it states that "Dugong foraging habitats in Darwin Harbour such as rocky reefs at Weed Reef and Channel Island are not expected to be impacted from plumes from dredging". This section needs to be revised to account for knowledge of important dugong habitat. There are many instances of incomplete data or poor habitat mapping and there are inconsistencies in the document in this regard. Therefore it is recommended that the EIS be required to be revised and resubmitted with more detailed and accurate information.

Submission 110-9: I urge Inpex to reconsider dredging Darwin Harbour because of the short and long term implications of possible damage to the environment

Submission 117-3: Dredging 17 million cubic metres of mud will also upset the mangroves and coral reefs.

Submission 122-3: Dredging in Darwin Harbour: The impact of sediment on mangroves and impacts on other marine biota as a result of dredging are also of significant concern. It has been suggested that corals (and other biota) experiencing turbid conditions (such as Darwin Harbour) will already be adapted to higher levels of turbidity compared with biota located in areas with higher water clarity. This is a critical assumption that as far as we are aware has yet to be tested. There is a need to improve the understanding of the susceptibility/tolerance of the biotic communities to the physical and chemical changes that are induced by dredging. Further there is a need to define dredging thresholds based upon a cumulative load response of corals, sponges and other sessile marine biota.

This response addresses comment pertaining to dolphins and turtles. Comments on potential effects upon dugongs are addressed in the response to submission 124-46. Comments related to mangroves are addressed in the response to submission 16-14.

INPEX recognises that the construction and operation of the Ichthys Project will pose risks of impacts to all of the receptors highlighted by the submitters. A detailed assessment of these risks was undertaken by appropriately qualified environmental professionals during the preparation of the Draft EIS; the outcomes from this assessment were incorporated into Section 7.3.2 of Chapter 7 *Marine impacts and management*.

Additional information to quantify risks from dredging and dredge spoil disposal on primary-producer habitats (and wider trophic effects including effects on high-order predators such as dolphins) within Darwin Harbour and Shoal Bay is provided in sections 4.1.1–4.1.8 of this EIS Supplement.

Additional information on the distribution of potential dugong and turtle foraging areas in Darwin Harbour is provided in Section 4.1.10 and new information on coastal dolphin usage of the Harbour is provided in Section 4.1.9.

Details on changes to the drilling and blasting program are addressed in Section 3.3.8.

Discussion of potential direct impacts to marine animals from dredging is provided on page 365 of the Draft EIS and in response to Submission 98-2 of this EIS Supplement.

Appropriate monitoring programs will be put in place to confirm predictions made during the impact assessment or to trigger additional management actions if necessary. INPEX believes that the proposed monitoring programs and management actions (as described in Annexe 6 *Provisional dredging and dredge spoil disposal management plan* to Chapter 11 *Environmental management program*) will reduce the risk of impacts to the receptors to an acceptably low level. These will be further developed, in consultation with the regulatory authorities, during finalisation of the operational dredging and dredge spoil disposal management plan, which will require approval by the regulators before dredging can commence.

Submission 16-7, 24-7, 29-6, 89-7, 96-6, 101-8, 102-6: The spoil dump may generate a significant sediment plume – the impacts on Shoal Harbour are largely unknown.

INPEX considers it likely that substantial sediment plumes will arise from the spoil ground, both during the dumping events and through the resuspension of dumped material (see Section 7.3.3 in Chapter 7 *Marine impacts and management* in the Draft EIS and also Technical Appendix 13 *Dredging and spoil disposal modelling*). Potential environmental impacts associated with spoil disposal are described in Section 7.3.3. These are either self-evident (e.g. smothering of benthic biota) or predictable on the basis of scientific reasoning, taking into account information presented in the published literature (e.g. indirect effects on macroalgae or seagrass). Potential impacts on the Shoal Bay environment are also detailed in this section.

Conservative predictions of impacts from the dredging program were presented in the Draft EIS, based upon the dredging methodologies described in Section 4.4.4 of Chapter 4 *Project description*. The predictions encompass the full range of activities and risks that may occur as a consequence of the proposed dredging activities. Impact predictions have been enhanced through additional mapping of the benthic habitats of Shoal Bay (see Section 4.1.2 of this EIS Supplement) and additional work to define zones within which benthic communities may potentially be affected by elevated suspended sediments or by increased sediment deposition (Supplement Section 4.1.3). The latter work demonstrates that, within Shoal Bay:

- The modelled Zones of Moderate Impact from suspended sediments are limited to areas within Howard River (see Figure 4-12 in this EIS Supplement). Within these zones, short-term effects on benthic communities susceptible to increased light attenuation are predicted, though it would be expected that the communities would recover over time. However, it is evident from the additional benthic surveys undertaken that no such communities exist within the modelled Zones of Moderate Impact from suspended sediments.
- The modelled Zones of Influence from suspended sediments occur within Howard River and Hope Inlet, with a small area on the southern shore of Shoal Bay, between Buffalo and Micket Creeks (see Figure 4-12 in this EIS Supplement). Within these zones, it is predicted that light attenuation above the natural range might be expected, though the intensity and duration is predicted to be such that effects on benthic biota or their habitats would be insignificant in scale and reversible in the short term. However, it is evident from the additional benthic surveys undertaken that no such communities exist within the modelled Zones of Influence from suspended sediments.
- Limited areas towards the northern end of Shoal Bay are predicted to lie within the Zones of Moderate Impact and Influence from sedimentation (see Figure 4-13 in this EIS Supplement). Some of these areas support <10% cover of benthic biota that may be susceptible to impacts from sedimentation in the short term, though it is predicted that they would recover over time. It is evident in Figure 4-13 of this EIS Supplement that far larger areas of similar habitat occur in the immediate vicinity of these zones, hence short term impacts could not be considered to pose risks of significant environmental effects.

Remodelling of dredge-plume dispersion from the spoil ground will be undertaken once the dredging methodology is finalised and will take place prior to the commencement of dredging. This will guide the need for the monitoring of impacts within Shoal Bay, which will be decided in conjunction with the regulators. Monitoring of dredge-plume dispersion in waters around the offshore spoil disposal ground (see Table 11-5 in Chapter 11 *Environmental management program* of the Draft EIS) will be undertaken during the dredging campaign to assess the accuracy of model predictions.

Submission 16-14, 24-14, 29-13, 89-14, 96-13, 101-15, 102-13: 83 ha of mangrove communities to be cleared, but more could be affected by sedimentation from the proposed dredging program. There is no data available on how much sedimentation mangroves can tolerate.

Submission 100-19: Dredging for the proposed shipping channel will generate 17 million cubic metres of sediments over 3.5 years. The impacts of this activity on the coastal dolphins, turtles, dugong and their habitat, is likely to be multifaceted and significant. Not only will it result in direct removal of habitat, and an increase in suspended solids concentration, it may influence humpback dolphins' prey and affect the dolphin indirectly by the loss of food supply due to disturbance of the seafloor and increased sedimentation. Sediments are likely to smother important habitats eg. mangroves in Elizabeth River and East Arm and coral reefs near Wickham Point, East Point and East Arm. The EIS likely underestimates this stressor, with the executive summary suggesting that only 2 hectares of mangroves are likely to be destroyed (p 34). The section on sediment effects on habitats needs revision and the additional more peer-reviewed research on tolerance of mangroves to being smothered with sediments and rates of recovery. Channel Island is a known foraging area for dugong. INPEX sediment plume modelling show potential impacts around Channel Island, but the described likely impact on dugong foraging habitats is portrayed as being minor. On p 324 of Section 7.3.2, it states that "Dugong foraging habitats in Darwin Harbour such as rocky reefs at Weed Reef and Channel Island are not expected to be impacted from plumes from dredging". This section needs to be revised to account for knowledge of important dugong habitat. There are many instances of incomplete data or poor habitat mapping and there are inconsistencies in the document in this regard. Therefore it is recommended that the EIS be required to be revised and resubmitted with more detailed and accurate information.

Submission 109-9: In addition to the clearing of 83 hectares of mangroves, the dredging for the shipping channel will generate in the vicinity of 17 million cubic metres of sediment – this will impact on the mangrove communities, potentially smothering their breathing roots.

There is limited information on how much sedimentation mangrove communities will tolerate. Section 7.3.2, page 319 estimates that sediment accumulation will amount to more than 50mm over 30 hectares of mangroves and within this 2 hectares will receive more than 100mm. Section 7.3.2, page 320 states 'the Ceriops tagal – Avicennia marina low closed forest assemblage is likely to be the most sensitive to sedimentation, because of the dependence of A. marina on fine pneumatophores that would potentially be coated or buried by sediment.' Section 7.3.2, page 321 states 'there are some 28 ha predicted to receive net sedimentations of between 50 and 100 mm... It is possible that the more sensitive mangrove species ...could be at risk of reduced plant growth or even localised death... and that some tree deaths are likely at net sedimentation rates of >100 mm.' and 'At sedimentation levels above 100 mm, tree deaths in S. alba and A. marina are considered likely.'

This information indicates there are likely to be detrimental effects on the mangroves. It is unknown to us how accurate and conservative the modelling to come up with these estimates is, there is the potential the situation could be even worse.

This response addresses comments pertaining to mangroves. Comments on potential effects upon dugongs are addressed in the response to submission 124-46. Comments related to dolphins and turtles are addressed in the response to submission 16-6.

During the preparation of the Draft EIS, INPEX undertook a thorough search of published literature on the tolerance of mangroves to sediment deposition. Consultation with one of Australia's pre-eminent mangrove ecologists, Dr Norm Duke of the University of Queensland, confirmed that the paper by Ellison (1998) quoted in Section 7.3.2 of Chapter 7 *Marine impacts and management* was the most current reference to use. Dr Duke was unaware of any more recent body of evidence upon which to base mangrove sedimentation criteria.

It is noted that the tolerances of the specific mangrove species at risk of impact from sediment deposition arising from the dredging campaign are unknown. Hence mangrove monitoring will be undertaken during dredging, and remedial management actions will be implemented in the event that mangrove mortality is detected that is not attributable to natural causes or activities external to the Project (see Section 4.3.2 of Annexe 6 *Provisional dredging and dredge spoil disposal management plan* to Chapter 11 *Environmental management program*). The monitoring program and management actions will be further developed, in conjunction with the regulators, during the development of the final plan, which will require approval by the regulators before dredging commences.

Technical Appendix 12 of the Draft EIS provides detailed assessment of the accuracy of the models used to predict sediment distribution associated with dredging and Section 4.1.3 of this EIS Supplement discusses conservatisms in the model.

Submission 16-17, 36-1, 89-17, 96-16, 101-18, 102-16: Extensive and accurate pre-disturbance, baseline measurement and reporting of marine biodiversity in Darwin Harbour to allow for an appropriate assessment of risks.

It is considered that the marine biological information presented in the Draft EIS's Chapter 3 *Existing natural, social and economic environment*, taken in conjunction with the additional information presented within this EIS Supplement, has permitted an appropriate assessment of risks to be undertaken.

Appropriately detailed baseline data will be collected prior to construction activities to allow for robust assessment of impacts through monitoring. The final selection of the biological communities to be monitored will be made in consultation with the regulatory authorities, through the process of finalising the many environmental management plans that will have to be approved before construction activities can commence for the Ichthys Project. An assessment of the total biodiversity of Darwin Harbour is considered unwarranted.

Submission 16-19, 36-3, 89-19, 96-18, 101-20, 102-18, 119-3: A noise modelling study to assess the impact of blasting on marine fauna, with trigger levels developed to guide appropriate management responses.

Submission 20-9: I re-iterate I am particularly concerned that noise impacts on marine life will be severe and there is a paucity of reliable information to assess this accurately. I expect the effect of blasting to extend well beyond the immediate zone keeping in mind the incompressibility of water and also its high conduction of sound.

Submission 85-2: To open the route for the shipping channel involves underwater blasting <http://inpex.com.au/media/20786/ichthys_eis_ch7.pdf> (cf p357) to remove a large rocky underwater navigation hazard (Walker Shoal) which sits in the middle of the reported preferred channel. The blasting would occur 3 times a day over more than 1 year to remove Walker Shoal which INPEX maintains presents an unacceptable safety hazard to large LNG tankers because it is very shallow (6m depth at low tide) and very hard. INPEX admit blasting could kill and/or exclude dolphins and other marine wildlife from that part of the harbour. It is not clear what is "that part" given that behavioural avoidance of intense noise sources have been recorded for some whales as far as 30 km from the source (Richardson et al. 1995)

Explosions are one of the strongest point sources of anthropogenic sound in the seas. Sound from explosives can also travel tremendous distances (Richardson et al. 1995). Underwater transmission of explosions is complex with an initial shock pulse followed by a succession of oscillating bubble pulses. Source levels vary with the type and amount of explosives used, and with the water depth at which the explosion occurs, and can range from 272 to 287 dB re 1 μPa zero to peak at 1 m distance (1 – 100 lb. TNT). Frequencies reported are rather low (range 2 – ~ 1 kHz; main energy between 6 – 21 Hz; duration < 1 – 10 ms; Richardson et al. 1995; NRC 2003).

Finneran et al. (2000) exposed two trained dolphins to sounds resembling distant blast explosions. They observed that disruptions of the animals' trained behaviours began to occur at exposures corresponding to 5 kg at 9.3 km and 5 kg at 1.5 km for the dolphins (sound flux density of 153 and 169 dB re 1 QPa2s, respectively)

It is well established that underwater explosions can kill fish (e.g. Aplin 1947), in fact so called 'blast-fisheries' has been used in many areas of the world and on a considerable number of fish species (review by Saila et al. 1993). Blasts occurring during the decommissioning of oil platforms are also able to kill fish (Gitschlag & Herczeg 1994). The use of underwater explosives can injure and even kill sea turtles (Klima et al., 1988; Gitschlag & Herczeg 1994)

INPEX's proposed mitigation measures include using trained spotters on nearby ships to call a halt to blasting if dolphins surface within the kill zone (radius: 500m, based on an assumed temporary threshold shift –TTS – of 183 decibels), as well as active acoustic monitoring by triangulating the location of submerged dolphins. There are no mitigation measures proposed for turtles or fish. These mitigation measures are clearly insufficient to prevent potential displacement of marine mammals and turtles from the large area at which blasting can produce behavioural effects. Furthermore, the extended duration of the blasting activities could make this displacement relevant, overlapping with breeding times. In addition to behavioural responses, the mitigation measures do not ensure lack of physiological impacts: the distance of 500m used to prevent TTS could be challenged depending on the local conditions of sound transmission leading to differences from simplistic spherical spreading models of acoustic pressure. There are no data on in situ calibrations in INPEX.

Submission 85-3: 3) Dredging The shipping channel is to be dredged (cf p305) for up to 3.5 years in the first instance to remove 16.9 million cubic meters of soft sediments using a backhoe dredge (and perhaps a cutter suction dredge). In addition, future maintenance dredging is required over the 40+ year lifespan of the project. Dredging emits continuous broadband sound during operations, mostly in the lower frequencies. In one investigation, estimated source levels ranged from 160 to 180 dB re 1 μPa at 1 m (maximum ~ 100 Hz). Bandwidth was between 20 Hz and 1 kHz (limited by the recording equipment; most energy was below 500 Hz; Richardson et al. 1995). In a recent study Defra (2003) measured sound spectrum levels emitted by an aggregate dredger at different distances and found most energy to be below 500 Hz. These frequencies overlap with the frequency range of most soniferous fishes and with the hearing range of turtles. Richardson et al. (1995) provide an overview of investigations into behavioural responses of cetaceans to dredging. Bowhead whales (Balaena mysticetus) did not apparently respond to a suction dredge in one study, but individuals avoided these dredges when exposed to 122 – 131 dB re 1 μPa (or 21-30 dB above ambient noise) in another investigation. Gray whales (Eschrichtius robustus) ceased to use a particular breeding lagoon after an increase in industrial activities, including shipping and dredging (Bryant et al. 1984). However, it is not clear if this was due to sound or the increased presence of ships; no studies were made of the increase in sound or of received sound pressure levels. There are, to our knowledge, no recent studies (post 1995) on the effects of dredging noise on marine mammals.

Submission 85-4: 4) Shipping – The increase of shipping that will be created by the project poses several types of impacts: i) Raise of underwater background noise levels A significant human contribution to the overall ambient underwater noise at low frequencies is generated by the growing use of the ocean for international shipping. Commercial ships, produce underwater noise as an incidental byproduct of operation (Southall, 2005; U.S.G., 2008). Large commercial vessels produce relatively loud and predominately low frequency sounds. However, in addition to their predominant low-frequency radiated noise, modern cargo chips can radiate high frequency noise with 1/3-octave band source levels over 150 dB re 1μPa @ 1m around 30 kHz (Arveson and Vendettis, 2000), or broadband (0.354 – 44.8 kHz in this case) maximum RMS levels of 136 dB re: 1μPa at >700 m distance (Aguilar Soto et al., 2006). Noise in these frequency bands has the potential to interfere (over relatively short ranges) with the communication signals of many marine mammals, including toothed whale species not commonly thought of in terms of shipping noise The production, perception, and processing of sound is critical for various life functions (including communication, foraging, navigation, and predatoravoidance) of most, if not all, marine mammals. Marine mammals use sound as a primary means for underwater communication and sensing. Specifically, the toothed whales have developed sophisticated bio-sonar capabilities to feed and navégate. Figure 1. Typical Typical frequency bands of sounds produced by marine mammals and fish compared with the nominal low-frequency sounds associated with commercial shipping. From OSPAR (2009) Vessel noise, in addition to potentially impacting marine mammals, also overlaps frequencies within the hearing and sound production ranges utilized by many fish species (Amoser et al., 2004). Masking of fish sounds by shipping noise is potentially of greatest concern for species that produce low frequency spawning sounds central to reproductive success. Over 800 species of fish from 109 families worldwide are known to be soniferous (Kaatz, 2002), although this is likely to be a great underestimate. Soniferous fish include some of the most important commercial fish species, including many codfish, drum fish, grunts, groupers, snappers, jacks, and catfish. However, little is known of hearing capacities in most fish species, and fish that are not acoustically active may rely heavily on their acoustic awareness for predator/prey detection or general orientations. Continuous exposure (30 minutes) to recorded noise from small vessels has been shown to increase cortisol levels (stress response) in fish (Wysocki et al., 2006). Additionally, hearing impairment (i.e., temporary threshold shifts [TTS]), associated with long-term, continuous exposure (2 hours), and masked hearing thresholds have also been recorded for fish exposed to noise from small boats and ferries (Scholik and Yan 2001; Vasconcelos et al., 2007). Furthermore, vessels (i.e., trawlers, ferries, small boats) can also alter behavior in fish (e.g., induce avoidance, alter swimming speed and direction, and alter schooling behaviour), similar to marine mammals (Engås et al., 1998; Sarà et al., 2007).

Submission 100-21: A significant amount of pile driving activity is planned during the construction phase (for 30-40% of an operational shift source level of up to 200dB re 1 UPa). Whilst pile driving energy tends to be below 1000Hz it is assumed that the activity can be more disturbing to baleen whales, there is still considerable energy into the single kHz digits.10 This is where Indo-pacific humpback dolphins, Indo – pacific bottlenose and snubfin dolphins produce much communication sound, and are acoustically sensitive.11 Currently both our understanding of the coastal dolphins Temporary Threshold Shift and acoustic repertoire are lacking in order to fully assess the impacts of this activity over such a prolonged period of time. Furthermore there is no underwater noise modelling to fully assess cumulative impacts from blasting, piledriving, dredging, dumping and increased vessel traffic which is a serious omission in the EIS. Instead, the level of risk for underwater noise is… "Given that no regionally significant habitat occurs in the nearshore development area the potential for underwater noise to result in cumulative negative impacts to populations of marine animals is considered to be low' (P 360 of Section 7.3.7). This is clearly incorrect.

Mitigating strategies fail to consider options such as temporal and geographic closures. The ability to mitigate these impacts would be improved by understanding temporal conditions when animals are not likely to be present or lower/density area times. For example, in Hong Kong activities such as percussive piling have been restricted to occur outside the main calving season.12 This provides even greater evidence for the need for improved research in the area to determine key population factors and associated mitigation techniques.

Other mitigating strategies that have not been investigated include the uses of bubble curtains and jackets to create an impedance to absorb/reduce some of the sound. Typically monitored exclusions zones for piledriving activities will monitor the site for cetacean species sightings for a great period of time than the 20 minutes as suggested in this EIS. Furthermore, consideration for increasing the exclusion zone in the presence of a mother and calf has not been considered. For example Temporary Threshold Shift (TTS) is likely to vary significantly between the same species with different life history traits (Nowacek et al., 2007).13 Concern for young animals, particularly calves should be taken into consideration, given adults tend to exhibit a narrower hearing range and poorer frequency hearing than young animals. At birth, ears are at their peak sensitivity (Ketten, 2003)14.

WWF recommends underwater noise modelling to fully assess direct, indirect and cumulative impacts, alongside further research into dolphin habitat, behaviour and acoustic repertoire. Subsequently, a more wide ranging and thorough assessment of available mitigation strategies is required.

Submission 100-22: 4. Inadequate and incomplete assessment of the direct and indirect impacts of underwater noise pollution and mitigation strategies. A significant amount of pile driving activity is planned during the construction phase (for 30-40% of an operational shift source level of up to 200dB re 1 UPa). Whilst pile driving energy tends to be below 1000Hz it is assumed that the activity can be more disturbing to baleen whales, there is still considerable energy into the single kHz digits.10 This is where Indo-pacific humpback dolphins, Indo – pacific bottlenose and snubfin dolphins produce much communication sound, and are acoustically sensitive.11 Currently both our understanding of the coastal dolphins Temporary Threshold Shift and acoustic repertoire are lacking in order to fully assess the impacts of this activity over such a prolonged period of time. Furthermore there is no underwater noise modelling to fully assess cumulative impacts from blasting, piledriving, dredging, dumping and increased vessel traffic which is a serious omission in the EIS. Instead, the level of risk for underwater noise is… "Given that no regionally significant habitat occurs in the nearshore development area the potential for underwater noise to result in cumulative negative impacts to populations of marine animals is considered to be low' (P 360 of Section 7.3.7). This is clearly incorrect. Mitigating strategies fail to consider options such as temporal and geographic closures. The ability to mitigate these impacts would be improved by understanding temporal conditions when animals are not likely to be present or lower/density area times. For example, in Hong Kong activities such as percussive piling have been restricted to occur outside the main calving season.12 This provides even greater evidence for the need for improved research in the area to determine key population factors and associated mitigation techniques. Other mitigating strategies that have not been investigated include the uses of bubble curtains and jackets to create an impedance to absorb/reduce some of the sound. Typically monitored exclusions zones for piledriving activities will monitor the site for cetacean species sightings for a great period of time than the 20 minutes as suggested in this EIS. Furthermore, consideration for increasing the exclusion zone in the presence of a mother and calf has not been considered. For example Temporary Threshold Shift (TTS) is likely to vary significantly between the same species with different life history traits (Nowacek et al., 2007).13 Concern for young animals, particularly calves should be taken into consideration, given adults tend to exhibit a narrower hearing range and poorer frequency hearing than young animals. At birth, ears are at their peak sensitivity (Ketten, 2003)14. WWF recommends underwater noise modelling to fully assess direct, indirect and cumulative impacts, alongside further research into dolphin habitat, behaviour and acoustic repertoire. Subsequently, a more wide ranging and thorough assessment of available mitigation strategies is required.

Submission 116-2: Has modelling pr baseline data been compiled to test the effects of DAILY explosive activity and daily dredging in the harbor on • Fish • marine mammals and • the ocean floor What are those effects

Submission 119-2: The use of blasting and dredging should be minimised and done in light of an NT Government policy on dredging and blasting in Darwin Harbour. Impacts of any dredging and blasting must be closely monitored and reported.

Submission 128-4: Preliminary dredging program. What effect will dredging operations running 24/7 have on marine life particularly the cumulative effects of other noise and vibration associated with the project i.e. blasting, pile driving, shipping, dumping of rock over the pipeline extension? How will the noise, generated from 24 hour dredging operations affect Darwin residents?

Submission 123-8: Underwater Noise. Underwater noise has not been adequately dealt with, particularly in regards to piling and blasting. Noise modelling should be conducted for Darwin Harbour. Methodologies must be based on best practice and exclusion zones must be determined using current and empirical scientific evidence as well as biological variables of species concerned. If current technology or current knowledge is inadequate then a report explicitly identifying the gaps and data needed should be produced.

Submission 123-138: Noise modelling for the pile driving is required. Pile driving noise modelling will be different from the blasting noise modelling.

Submission 123-139: Given the potential risks to coastal dolphins from underwater noise, the absence of any underwater noise propagation modelling is a major gap in the draft EIS. The scale and extent of underwater noise in a nearshore environment and semi-enclosed harbour in Australia is significant. The omission of underwater noise modelling does not allow for an assessment of impacts and adequacy of mitigation measures.

Submission 123-140: Given the potential risks to coastal dolphins from underwater noise, the absence of any underwater noise propagation modelling is a major gap in the draft EIS. The scale and extent of underwater noise in a nearshore environment and semi-enclosed harbour in Australia is significant. The omission of underwater noise modelling does not allow assessment of impacts and adequacy of mitigation measures. Further, the lack of studies and literature for Darwin Harbour suggests that there may not be an adequate understanding of the key receptors in the nearshore environment.

Submission 123-141: The risks to coastal dolphins from underwater blasting proposed over a substantial timeframe cannot be assessed with any certainty. Using the precautionary principle, the risk is presumed to be higher than stated. The draft EIS zones of impacts are based on a reference published in 1973 and the original paper was not cited directly, instead cited indirectly in Ecos (1996). A copy of the original article was sourced. The impact zones are derived from extrapolation of tests conducted on sheep, dogs, monkeys and ducks. There are obvious problems with the uncritical use of such a study. Tests were run to determine the far-field underwater blast effects on mammals and birds. The tests were conducted in a specially constructed test pond facility, 220 by 150 feet at the surface and 30 feet deep over the 30-by 100-foot centre portion. Explosive charges weighing up to 8 pounds were detonated at ten-foot depths. Sheep, dogs, and monkeys were suspended in the water, mostly with their long axis perpendicular to the surface at 1-, 2-, and 10foot depths. The duck was selected as a model to represent birds on the surface and birds that dive beneath the surface. Ducks were tested on the water surface and at 2-foot depths. The nature of the immersion-blast injuries was described and related to the impulse measured in the underwater blast wave. Impulse levels which were safe and which produce injuries in mammals and birds were presented. Underwater-blast criteria were presented which corresponded to safe and damaging impulse levels for birds and mammals along with curves relating the impulse criteria as a function of range and charge weight (Yelverton et al 1973). The proponents need to clearly identify the direct, indirect, on-site, off-site and cumulative impacts associated with underwater blasting (Jefferson et al 2009). Also, it is equally important to consider that sub-trauma levels of sound can have profound effects on individual fitness. These effects can take the form of masking of important signals, including echolocation signals, intra-species communication, and predator-prey cues; of disrupting important behaviours through startle and repellence; or of acting as attractive nuisances; all of which may alter or result in abandonment of important habitats (Ketten 2008).

Submission 123-142: Evidence supporting blast impact zones needs to be robust to ensure the safety of megafauna.

Submission 123-143: Currently there is no evidence provided in the draft EIS that micro-delays reduce underwater blast impacts. Micro-delays are understood to be an important part of the blasting action and should not be considered an impact mitigation measure. The risks to coastal dolphins from underwater blasting proposed over a substantial timeframe cannot be assessed with any certainty. Zones of impacts are based on a reference (Yelverton et al 1973) unseen and cited in Ecos (1996). Impact zones are derived from extrapolation of tests conducted on sheep, dogs, monkeys and ducks. There are obvious problems with the uncritical use of such a study. Using the precautionary principle, the risk is presumed to be higher than stated. Impact identification should include direct, indirect, on-site, off-site and cumulative (Jefferson et al 2009). Also, it is equally important to consider that sub-trauma levels of sound can have profound effects on individual fitness. These effects can take the form of masking of important signals, including echolocation signals, intra-species communication, and predator-prey cues; of disrupting important behaviours through startle and repellence, or of acting as attractive nuisances, all of which may alter or result in abandonment of important habitats (Ketten 2008).

Submission 123-144: Evidence supporting blast impact zones needs to be robust to ensure the safety of marine megafauna.

Submission 123-146: This statement [while some of the higher frequency components of pile driving noise will be audible to these dolphins the modulation and tonal characteristics of this noise would be different from dolphin vocalisations and would be highly unlikely to interrupt communication] is not supported by the available evidence and the information provided for assessment is insufficient. The Indo-Pacific humpback dolphin has a similar range to many of the related Delphinines including Tursiops sp. and Stenella sp. Seventeen different types of frequency modulated narrow band calls (whistles) produced by Indo-Pacific humpback dolphins ranging in frequency from 1 kHz to 22 kHz have been recorded (Van Parjis and Corkeron 2001). Increasing noise impacts on coastal dolphins' ability to access critical resources and habitats (Jefferson et al. 2009). A comparison of tonal characteristics and modulation between the coastal dolphins and pile driving noise should be provided in the EIS to support this conclusion.

Submission 123-150: Currently there is no evidence presented in the draft EIS that micro-delays reduce underwater blast impacts. Micro-delays are understood to be an important part of the blasting action and should not be considered an impact mitigation measure. Evidence supporting blast impact zones needs to be robust to ensure that megafauna are protected.

Submission 123-152: Currently there is no evidence provided in the draft EIS that micro-delays reduce underwater blast impacts. Micro-delays are understood to be an important part of the blasting action and should not be considered an impact mitigation measure. Evidence supporting blast impact zones must be robust to ensure megafauna are protected.

Submission 123-190: Currently there is no evidence presented in the draft EIS that micro-delays reduce underwater blast impacts. Micro-delays are understood to be an important part of the blasting action and should not be considered an impact mitigation measure.

Submission 123-232: The proponent needs to conduct noise modelling for the variety of noise generating activities in Darwin Harbour (pile driving, dredging, blasting, shipping, construction activities)

Submission 124-31: The mitigation measures proposed are highly unlikely to prevent marine wildlife from being killed, injured or seriously disorientated by the blasting. The use of trained spotters, though admirable, should be seen as standard procedure for such projects rather than as an exceptional mitigation measure. The use of passive and active accoustic monitoring may reduce the likelihood of inadvertent death and injury to marine wildlife but does not sufficiently lower the risk of marine wildlife moving too close to the blast area. Coastal dolphins are highly cryptic and difficult to see. They have low profiles and spend much of the time submerged. Underwater accoustic monitoring cannot be guaranteed to alert blasting operators to their presence as they spend significant periods of time not vocalising.

Submission 128-11: Marine noise and vibration. How will marine noise be monitored and reported (noise from construction, shipping, blasting, vertical seismic profiling, drilling, dredging operations etc.)? What plans are in place to monitor the impacts of the noise on marine species be monitored and reported pre post and during operations?

Submission 128-16: Impacts nearshore marine impacts and management. Table 7-28 Summary of impact assessment and residual risk for marine mega fauna offshore. The Management Controls and Mitigating Factors state that, general noise and activity would deter marine animals from entering the area. Why does this differ from the reported impacts of noise for near shore environments i.e. in Darwin Harbour?

INPEX has committed to using methods other than drilling and blasting for the removal of Walker Shoal. The methods proposed are to use a specialised cutter-suction dredger with sufficient power to remove the greater part, if not all, of the hard material and, if necessary, to employ a hydraulic hammer or other mechanical methods, such as a drop chisel. As INPEX cannot be completely certain that these methods will be fully effective, it is considered appropriate that a fall-back option is maintained within the environmental assessment and subsequent approval for the Project for drill-and-blast methods to be employed for approximately 4 weeks. In the unlikely event that drilling and blasting will be required, INPEX will have best-practice procedures and a monitoring plan in place to reduce risks to marine animals to a level that is as low as reasonably practicable.

The Draft EIS's Technical Appendix 15 *Review of literature on sound in the ocean and on the effects of noise on marine fauna* contained a review of underwater noise characteristics and its effect on marine animals. This work has been supplemented by detailed numerical modelling to assess the range and intensity of underwater blast effects and noise from various construction operations. This was repeated for a number of scenarios. The results are presented in Section 4.1.11 in this EIS Supplement and also in Technical Appendix S7. The prediction of "safe ranges" for the different animal species included the consideration of potential overlap between frequencies of hearing sensitivity with the characteristics of the sound received. The thresholds established for acceptable levels of exposure to underwater noise and blast effects are conservative and are based on the best available research.

A review was carried out of national and international practices for the management of underwater noise and blast effects to marine mammals arising from construction and operational activities, such as vessel movements, piledriving and blasting (see Section 4.1.13 of this document). This included consideration of noise mitigation measures (such as selection of equipment, acoustic decoupling, use of bubble curtains and soft starts to activities) and has resulted in some modifications to the proposed management measures to ensure that they are consistent with best-practice methods (as defined in Section 4.1.13).

Micro-delays of 25 ms between detonations will lead to a reduction in the received peak pressure compared with multiple charges detonated instantaneously. The magnitude of the received peak pressure from a detonation, which lasts about 1 ms or less, is directly correlated with the mass of the charge being detonated. A small charge mass causes a smaller received peak pressure than a large charge mass. Separating a charge mass into a number of smaller blasts by 25 ms prevents the pressure wave from each of the smaller blasts from combining and thereby results in a reduction in the received peak pressure.

The level of noise predicted to occur as a consequence of activities in the construction and operations phases of the Ichthys Project has been described in the Draft EIS and further described in Technical Appendix S7 to this EIS Supplement. Some auditory masking may occur from vessel noise associated with the types of construction vessels proposed to be used in Darwin Harbour. However, masking will only occur in the low frequencies, below approximately 5 kHz and with most noise below 1 kHz, and vessel noise is not likely to occur at the higher frequencies used by toothed cetaceans in echolocation. Blasting is not likely to cause a significant masking effect on cetaceans' echolocation abilities because of the short period of exposure.

The cumulative noise from concurrent activities has been included as a consideration in piledriving, where a number of scenarios with multiple piledriving rigs operating simultaneously has been modelled. The results of this are presented in Section 4.1.11 of this EIS Supplement.

It is not relevant to include blasting as an additional cumulative noise source because of its short period of exposure.

The underwater noise from dredging vessels and rock-breaking equipment has been modelled and the results are presented in Section 4.1.11. However it is not feasible to combine piledriving, vessel noise and rock-breaking noise into a single noise propagation model. This is mainly because the inherent uncertainties and unknowns regarding noise propagation of single sources, let alone multiple ones, which would require the would-be modeller to make numerous assumptions and estimates. Furthermore, even two separate sources with exactly the same frequency and signal (i.e. tonal) characteristics would add together differently in different locations, varying between being complementary and hence additive, and being antagonistic and hence cancelling each other out, depending upon the distance from sources and the relative phase differences between the two signals at the point being measured. In addition, the reality of cumulative noise effects can be counterintuitive, as a "doubling" of received noise would result in only a 3-dB increase in noise. For example, if two exactly synchronous 200-dB signals are combined, the effective signal strengths would be "doubled" to a level of 203 dB.

Submission 16-25, 87-7, 89-27, 96-25, 101-27, 102-25: Development of a NT Government dredging policy for Darwin Harbour. This could include the imposition of an environmental levy on developers based on environmental risk alternatives and cubic metre of spoil disposed, as per the dredging policy for the Great Barrier Reef Marine Park.

Decisions around policies of this nature are the responsibility of the Northern Territory Government and fall out of the bounds of what INPEX is positioned to respond to in terms of submissions on the Ichthys Project.

Submission 18-2: Other cumulative disruptions include pest species, turbidity, water pollution and noise/blast emission disruption and injuries.

It is accepted that the construction and operation of the Project will contribute in a cumulative manner to the risks posed by other sources of potential pest species introduction, turbidity, water pollution, noise emissions and blast emissions (if any). Through the measures outlined in Chapter 11 of the Draft EIS, INPEX intends to minimise its contribution to the overall risk posed by these sources. The contributions of other known sources of these stressors were taken into account during the impact assessments detailed in Chapter 7 of the Draft EIS.

Submission 18-4: The majority of the EIS focuses only on benthic organisms and has not been able to compile any evidence or research studies for other marine organisms in the area. To consider that there are no significant species in the development zone due to lack of information is clearly showing that this proposal requires a thorough study and identification of the marine biota and fauna of this sensitive location. In an area where different ecosystems mix such as beaches and mangroves, the diversity of species will be high.

Information on marine biota other than benthic organisms is presented in Draft EIS Sections 3.2.8, 3.2.9, 3.3.6 and 3.3.8. Further information on coastal dolphins is presented in Section 4.1.9 of this EIS Supplement. It is considered that the available information is adequate for the purposes of assessment of potential impacts from the construction and operation of the Project.

Submission 18-8: I have no words for the following: "Trailing suction hopper dredgers (TSHDs) can occasionally injure or kill marine turtles near the seabed by accidentally sucking them into the equipment.

Chapter 7 *Marine impacts and management* of the Draft EIS presents an accurate description of the predicted and potential impacts of the proposed action. The remote possibility of entrainment of marine turtles in the dragheads of the trailing suction hopper dredger are discussed in Section 7.3.10. Mitigation measures have been proposed for the protection of turtles to ensure that the risk is reduced to as low as reasonably practicable.

See response to comment 98-2 in Section 5.2.2.11.

Submission 19-2: # (2) The restrictions to fishing areas around the Catalina Creeks and at times of loading of ships is totally unacceptable, the harbour does not belong to anyone but the people of Australia, in particular the residents and the tourists to Darwin.

Preliminary quantitative risk analysis (QRA) indicates that public access to recreational fishing areas in Lightning and Cossack creeks ("Catalina Creeks 1 & 2") can be maintained. However, exclusion zones are likely to apply to the eastern "fingers" of Lightning Creek. Access will, however, be subject to the results of the final QRA to be completed in the detailed design phase and the demonstration and acceptance by the Northern Territory safety regulator (NT WorkSafe) that safety risks to the public engaged in recreational activities in this area are as low as reasonably practicable.

Submission 24-1: Darwin Harbour is in the unique position of being in relatively good health despite being a major shipping port. Essentially, within the harbour ecosystem services have been maintained. The developments outlined in the proposed EIS will compromise these ecosystem services and impact directly on the health and wellbeing of Darwin Harbour.

INPEX agrees that any new developments within Darwin Harbour have the potential to compromise the ecosystem services and impact directly on the health and wellbeing of the Harbour. However, INPEX believes that the environmental management controls summarised in Chapter 12 of the Draft EIS, and discussed in greater detail in chapters 7–11, will reduce the risk of impacts to the Harbour ecosystem to as low as is reasonably practicable.

Submission 53-4: On page 245, the proposal describes submarine structures as 'artificial habitats', and cites a 30 year old reference (Gallaway et al. 1981). Statements in this section imply that artificial habitats are good for this marine environment. The reality is the habitat provided for artificial structures will be different to the current habitat (low reef, sandy/muddy areas, rubble) and will attract and support a different community of marine organisms. The proponent should include this point regarding the probability that different communities are likely to be established around artificial habitats than currently present. Comments about the structures contributing to the food availability for seabirds are totally unsubstantiated. References are required for this point. This section should be modified, and an additional monitoring program considered to determine what change in community structure has resulted from the construction process.

That the subsea and surface structures will provide a different habitat (and hence attract a different community of marine organisms) to that of the seafloor is considered self-evident. The potential impact is addressed in the Draft EIS in Section 7.2.1 of Chapter 7 *Marine impacts and management* and a summary assessment was included in Table 7-2 in the same chapter.

Simple predator–prey dynamics support the contention that increased fish numbers *could* provide food for seabirds. However, that there is no documented evidence for this is clearly stated within the same paragraph as follows: "Anecdotal evidence suggests that existing offshore oil & gas facilities in north-western Australia are rarely visited by seabirds, with the exception of seagulls in some cases."

As described in Section 7.2.1 of the Draft EIS, the artificial habitats will represent only a minor (and temporary) modification of the regional habitats and any changes are unlikely to be of significance. The residual risk of adverse impacts is deemed to be "low" (see Table 7-2 in Chapter 7) and it is considered that monitoring is unwarranted. It should be noted, however, that some information on the fouling communities may be obtained during engineering inspections of growth upon subsea infrastructure over the life of the Ichthys Field.

Submission 53-5: The ecotoxity results displayed in table 7-20 (p 282) rely on information from previous studies on temperate species (pink snapper, brown kelp and rock oysters). These results are likely to have little relevance to the area in question. The subsequent section on the effects of oil spills on a range of taxa is very brief and highlights the lack of relevant studies in this field. The proponent should consider using information on more relevant tropical species. Additionally, a strategic project on local species (e.g. goldband snapper, corals, etc) should be considered. The affect of dispersants on marine organisms does not appear to have been discussed

Relevance of species

The ecotoxicity data presented in Table 7.20 of Chapter 7 *Marine impacts and management* of the Draft EIS are the result of studies commissioned by INPEX. These are standard ecotoxicity tests and the species were selected to provide data across a range of trophic levels. In addition, Microtox® testing was carried out because it allows for cross-comparison with a large national and international data set of ecotoxicity results.

Two of the species listed in Table 7.20, the phytoplankton species *Isochrysis galbana* and the rock oyster *Saccostrea commercialis*, can be considered to have a distribution that includes tropical waters, while the other two, the brown kelp *Ecklonia radiata* and the pink snapper *Pagurus auratus*, are temperate species. Both the *E. radiata* and *P. auratus* tests were ecotoxicity tests accredited by the National Association of Testing Authorities (NATA) (germination assay and 7-day larval fish growth) and there is no scientific reason to assume that tropical macroalga or fish species would exhibit significantly different responses from those observed for these two species.

Dispersants

Before any oil-spill dispersants can be accepted for use under Australia's oil pollution national plan prepared by the Australian Maritime Safety Authority (AMSA 2011a), each manufacturer and/or distributor must provide written documentation and test results to the AMSA to show that it complies with the AMSA guidelines (AMSA 2011b). Only dispersants that pass a specified minimum level of effectiveness and a specified maximum level of acceptability are approved for use in Australian waters. The required testing data include consideration of the following (among other matters):

- LT_{50} and LC_{50} (see *Glossary*) 96-hour testing on Australian fish and crustaceans from both tropical and temperate waters
- biodegradability
- efficiency testing by the Mackay dispersant performance test (see *Glossary*) using a known test crude oil
- storage life
- transport requirements
- the existence of full material safety data sheets (MSDSs), which include occupational health and safety requirements and product spill clean requirements.

According to AMSA (2011c), "for the majority of laboratory tests the Australian approved oil spill dispersants rate predominantly as "*slightly toxic*" to "*practically non-toxic* ". AMSA also notes that "the toxicity of dispersed oil is primarily due to the toxic components of the oil itself. Many laboratory studies on a range of test species have confirmed the fact that 'the acute toxicity of dispersed oil generally does not reside in the dispersant but in the more toxic fractions of the oil'."

Submission 53-6: Very little information is given in this section in relation to fish despite the fact that literature is available for this region. McCauley (1998) undertook a study investigating underwater noise radiated from a drilling rig, rig tender, fishing vessel and natural sources (including fish) in the Timor Sea in 110 m of water. This information should be used in the analysis of potential effects on fish.

As sound can be propagated a long distance underwater, fish avoidance of an area due to noise may have serious implications for commercial fishing. This needs to be considered given the large – scale nature of this development and the length of time construction will be undertaken. Targeted studies may need to be considered.

McCauley (1998) as well as the more recent Popper et al. (2003) and numerous other sources relating to the effect of noise to fish have been reviewed in preparation of the Technical Appendix 15 of the Draft EIS. There is no evidence from any of the existing facilities in Australia or internationally to suggest that fish are repelled from drilling rigs or platforms by underwater noise. In contrast there are numerous studies demonstrating that the platforms act both as habitat for marine fauna and (due to the exclusion of fishing activity within 500 m) a refuge from fishing pressures.

Submission 65-6: I am confident that others will delve into greater detail on these issues. If the reefs, cetaceans, and functioning marine ecosystems are destroyed, they are difficult, if not impossible to replace, yet our quality of life is as dependent on such systems as it is on access to energy sources. The government's role must be to balance the long-term interests of the people with the short-term needs of people and business.

INPEX acknowledges that marine ecosystems are a valuable resource that need to be managed carefully to prevent significant long-term or permanent impact; however, INPEX is not in a position to comment on the role of the government in terms of management of this resource.

Submission 71-3: We must also continue to vigilantly protect areas such as mangroves, coral and sea grass habitats for they are vitally important to the biodiversity of the area and blasting will significantly affect them in a most deleterious manner.

INPEX contends that blasting does not pose a threat to mangroves, coral and seagrass habitats, while recognising their importance to the biodiversity of the area.

Submission 74-3: As a long term resident of Darwin I fear aspects of your project will have devastating impacts for the biota within Darwin Harbour from which some populations may not recover. As a pragmatist I believe developments like this are inevitable but I feel as responsible corporate citizen you are morally required to initially minimise disturbance and retrospectively effect rehabilitation of the natural environment to the state prior to commencement of this project.

INPEX is committed to minimising any negative impacts from the construction and operations phases of the Ichthys Project. The Draft EIS presented a range of risk assessments to identify risks to the biota of Darwin Harbour and it provided details of management measures that INPEX has committed to in order to reduce impacts to as low as reasonably practicable. INPEX does not believe that the Project will result in plant or animal populations in Darwin Harbour being impacted to an extent that populations will not recover. In addition, INPEX has committed to carrying out rehabilitation if mangrove tree deaths occur as a result because of sediment deposition from the Project's dredging program (and are not attributable to natural causes or activities external to the Project). Rehabilitation of any affected areas will be undertaken after the completion of dredging activities through a combination of natural recruitment, facilitated natural recruitment and active planting.

Submission 84-5: In the same way, Inpex should do precise modeling of the impact of the proposed dredging. How will it affect the marine fauna and flora? What will it do to the water quality? How often will it have to be re-dredged considering our big tidal range? Additionally, modeling of movement patterns of the spoil dumb should be done to ensure that it will not create silting up of other areas or deposits in the mangroves where it would again be damaging to our marine fauna and flora.

Conservative predictions of impacts from the dredging program were presented in the Draft EIS, based upon the dredging methodologies described in Section 4.4.4 of Chapter 4 *Project description*. The predictions encompass the full range of activities and risks that may occur as a consequence of the proposed dredging activities. Remodelling will be undertaken once a dredging company has been engaged and a final dredging methodology has been developed. The outcomes of this modelling will inform the development of the final dredging and spoil disposal management plan (see Annexe 6 of the Draft EIS Chapter 11 for a provisional plan), which will require approval by the appropriate regulatory authorities before commencement of dredging.

Potential effects on marine flora and fauna (including mangroves) are comprehensively assessed in sections 7.3.2 and 7.3.3 of the Draft EIS. Additional information is provided in Section 4.1 of this EIS Supplement.

Predicted maintenance dredging requirements are discussed in Draft EIS Section 4.4.5.

Submission 85-5: Shipping – The increase of shipping that will be created by the project poses several types of impacts:

ii) Danger of collisions with marine mammals and turtles.

Collisions with boats are one of the main risk factors for the endangered manati (Trichechus manatus), a sirenid with similar habits than the dudong. There is a potential for a raise in the number of collisions of ships with dudongs and turtles in the Darwin harbour

Submission 100-23: Inadequate and incomplete assessment of the direct and indirect impacts of increased vessel traffic. International evidence clearly indicates that increased vessel traffic is highly likely to impact coastal dolphins. Increased boat traffic is causing a dramatic increase in serious injuries to snubfin dolphins in Western Australia. 15 16Not only can vessel traffic cause death or injury to these species directly, indirect impacts such as increased noise pollution and the increased risk of chemical contamination are likely.

During operations the project will require 200 tanker vessels per year to load at Blaydin Point. The EIS infers that marine species would be expected 'to be attuned to the large slow-moving vessels which presently frequent the harbour, especially in the vicinity of East Arm Wharf 17 (p 364, Section 7.3.10). Boat strike has and continues to be a major problem for marine turtles and dugongs in Moreton Bay Queensland, with approximately 50% of boat strike incidents recorded along the entire Queensland coast actually occur in the Bay.18 The concept of 'attunement' has no scientific basis. 'The potential for injury or death by vessel collisions or entrainment is very slight and would affect individuals without impacts to the broader populations of these species.' p 365 of Section 7.3.10. It is premature to state this as, for example, the ability of dugong to recover along the urban coast of Queensland requires management to reduce human related mortality to zero.19 Equally, the loss of a few snubfin dolphins in the harbour could have significant impacts on the persistence of this local population given the small localised populations as discussed above.

Submission 124-72: Increased vessel traffic. The proposed increase in vessel traffic associated with the Project is considerable and long term. The increased traffic overlaps with the habitat of dolphins and dugong (Channel Island, East Arm, Blaydin Point). Vessel strike is known to cause injuries and death to marine species, particularly dolphins and dugong (e.g. Panigada et al. 2006, van Waerebeek et al. 2007, Campbell-Malone et al. 2008, WWF 201029). No attention has been paid to the impacts on these species of such a large increase in shipping in key habitat areas, or the cumulative impacts likely from a combination of blasting, increased shipping and other activities.

Recommendation: Model likely impacts of increased vessel traffic – including aspects such as discharge of ballast water and noise.

Indo-Pacific bottlenose dolphins and Indo-Pacific humpback dolphins are known to be affected by vessel strikes (Van Waerebeek et al. 2007). Snubfin dolphins are presumably also at risk. However, in Australia, recent small cetacean collision reports are scarce, with only two (one bottlenose dolphin and one unknown dolphin species) documented for 2007 and 2008, one of which was fatal (IWC 2008, 2009).

INPEX activities will only result in a 1–2% increase in total monthly vessel calls to Darwin Harbour during the construction phase (see Section 10.3.5 in Chapter 10 *Socio-economic impacts and management* of the Draft EIS). During the operations phase, the LNG and condensate tanker visits would represent a 3% increase in ship visits to Darwin Harbour, based on 2008–2009 shipping data in Darwin Harbour (see Section 10.3.5 of Chapter 10 of the Draft EIS). Therefore, this is not a significant increase in comparison with existing shipping traffic.

Vessel impacts with cetaceans (and presumably dugongs and turtles) are typically caused by high-speed vessels. High vessel speeds are implicated both in more severe injuries and fatalities and with increases in the rates of cetacean collisions with vessels (Jensen & Silber 2004; Laist et al. 2001; Lammers, Pack & Davis 2003; Vanderlaan & Taggart 2007). Laist et al. (2001) suggest that vessel speeds greater than 14 knots cause the most severe and lethal effects of vessel strikes on cetaceans. Vanderlaan and Taggart (2007) conducted modelling which indicated that the probability of lethal injury is below 0.5 at a vessel speed of 11.8 knots but approaches 1 at vessel speeds above 15 knots, and that the probability of a lethal collision increases rapidly from 0.21 at vessel speeds of 8.6 knots to 0.79 at vessel speeds of 15 knots.

LNG and condensate tanker vessel speeds will typically be 8 to 10 knots at the beginning of the main shipping channel, and further reducing to approximately 3 to 4 knots within the INPEX shipping channel and during berthing operations. These slow vessel speeds will significantly reduce the likelihood of a collision with the coastal dolphins, dugongs and turtles in Darwin Harbour. More significant risks are posed by smaller faster vessels including recreational and charter vessels that have operated for many years, and continue to increase in levels of operation in Darwin Harbour.

Management measures used to minimise the risk of vessel strike are contained in Annexe 4, Chapter 11 of the Draft EIS and include approach distance and vector limitations consistent with the Australian National Guidelines for Whale and Dolphin Watching.

Shipping operations do not on a routine basis result in chemical contamination. Bilge discharges limits are managed through International Maritime Organization regulations for prevention of pollution to the sea for large vessels. Furthermore, the *Marine Pollution Act* (NT) also sets in place the requirements for oil discharges in Darwin Harbour. Accidental spill from vessels in the Harbour and the associated risks to large marine animals and the proposed management measures are addressed in Section 7.3.5 in Chapter 7 *Marine impacts and management* of the Draft EIS.

Other vessel-based risks such as noise and ballast water are addressed in sections 7.3.7 and 7.3.9 of Chapter 7 of the Draft EIS.

Ballast water will be managed in accordance with international standards, consistent with all other international shipping operations which occur within Darwin Harbour. As previously stated, INPEX's operations will only increase international shipping visits by 3% per annum, based on 2008–2009 shipping data for Darwin Harbour.

Increased noise from increased vessel shipping traffic is unlikely to result in significant risk to dolphin, dugong or turtle populations due to the slow speeds of ship vessel traffic, meaning cavitation (and associated noise) from ships is unlikely to occur. General shipping noise is below the optimum hearing range of coastal dolphins; however smaller recreational vessels, which are commonly used in Darwin Harbour, produce noise of a higher frequency that is within the optimum hearing range of coastal dolphins (see page 359 in Section 7.3.7 of Chapter 7).

Submission 86-4: Marine Impacts – In regard to the offshore disposal of dredge spoil, the proponent should extend its proposed monitoring program to areas adjacent to the immediate disposal areas to ensure that there is early identification of any potential adverse impacts from disposal and potential seasonal re-mobilisation of sediments.

Submission 123-130: This statement assumes that the soft sediments deposited from dredging would revert to the pre-impact substrates, which suggests that they will be dispersed and incorporated in the marine environment. A key issue is whether these sediments will be mobilised from the site to adjacent areas and returned in large amounts and in the short/medium term to the estuaries in the region. This statement is an assumption that needs to be established through monitoring.

As discussed in Section 7.3.3 (p. 335) of Chapter 7 *Marine impacts and management* of the Draft EIS, it is considered inevitable, given the tidal currents at the offshore spoil disposal ground, that the finer sediment fractions of the dredge spoil will be dispersed over a broad area around the spoil ground (see also the Draft EIS's Technical Appendix 14 *Dredge spoil disposal ground selection study*). However, modelling does not predict the return of this material "in large amounts" to the estuaries in the region (see also figures 116 to 125 in the Draft EIS's Technical Appendix 13 *Dredging and spoil disposal modelling*).

Proposed monitoring in the vicinity of the spoil ground is summarised in Table 11-5 in Chapter 11 *Environmental monitoring program*. The details of this monitoring will be developed for approval from the appropriate regulators before dredging commences.

Submission 86-16: The proponent should note the following:

- that a permit is required under S16 of the Fisheries Act for the dredge spoil site and the removal of Walker Shoal. In addition the proponent should note that permit conditions are to include:
  - the regular reporting (monthly) on the impact of dredge and blasting activity on aquatic life including any fish kills:
  - Any fish kills are to be appropriately documented and analysed to help inform the ongoing rock removal operations (i.e. are there trends apparent in terms of time/tide etc which would help limit the effect of blast operations); and
  - agreed thresholds

INPEX notes that a permit issued under Section 16 of the *Fisheries Act* (NT) is required prior to commencement of any action relating to the removal of rock at Walker Shoal or the disposal of dredged material at the offshore spoil disposal ground. It is further noted that under the authority of Section 16 of the Act any such permit is subject to "such conditions as the Director considers appropriate or as may otherwise be prescribed".

Submission 87-1: 1. Major industrial development on the harbour as this will have extremely negative effects on coastal life.

INPEX notes the concern expressed in this submission and believes that the environmental management practices to which the company has committed within the Draft EIS and this EIS Supplement will ensure that negative effects on coastal life from the operations of the Ichthys Project will be reduced to as low as reasonably practicable.

Submission 87-3: Dredging will have a great impact on marine life. Any effect of a spoil heap at Lee Point would be disastrous for the thousands of Red knots hundreds of Godwits, Sanderlings, Plovers and accompanying Eastern Curlews, Whimbrels, Stilts and other shorebirds that use this area as a feeding ground.

Submission 123-121: There is no assessment of potential impacts to migratory bird species due to sedimentation of intertidal habitats. Sedimentation may alter availability of food resources for bird species at different times of the year. This is possible in Darwin Harbour as well as Shoal Bay from sedimentation associated with the dredge spoil.

Migratory shorebird species forage on the extensive areas of low-tidal mud and sand flats that are exposed during low tides. These tidal flats are located seaward of the mangrove shoreline. Surveys of shorebirds along the Northern Territory coast included a survey block that extended from Fog Bay to Point Stephens; this took in Bynoe Harbour and the islands to its west, Darwin Harbour and the Vernon Islands (Survey Block 4 in Chatto 2003). Within this block shorebirds were found to be widely distributed but, owing to the coast being thickly lined with mangroves, overall densities were not generally high. On the basis of the shorebird counts the most important parts of the survey block were the coast between Lee Point and Tree Point and also Bare Sand Island and the associated chain of islands to the south-east. During low tide, the shorebirds forage on marine invertebrates that reside within the low-tidal mud and sand flats. Section 7.3.2 in Chapter 7 *Marine impacts and management* of the Draft EIS acknowledges that both increases and decreases in invertebrate abundance may occur because of sedimentation from dredging.

It should also be noted that the sedimentation expected in these areas as a result of dredge spoil disposal will generally be at a very low level and will occur at a low rate, with accretion modelling forecasts >100 mm of sediment accretion over two ha of mangrove habitat and 50 to 100 mm over 28 ha of mangrove habitat over four years. Generally sediment depositions of 17 to 35 mm thickness per year are expected in affected areas.

A detailed benthic invertebrate fauna literature review has been conducted (Technical Appendix S1) including a review of the potential impacts of sedimentation on infauna and epifauna within the mangroves and other intertidal zones of Darwin Harbour. Section 6.3 of Technical Appendix S1 provides significant detail on the tolerances of a range of infauna and epifauna to sedimentation. The literature review has concluded that the tolerance levels for invertebrate fauna typical of the mangrove and intertidal soft sediment habitats far exceed the accretion rates predicted as a result of INPEX's dredging program. It is therefore unlikely that effects from sediment deposition will be lethal for most invertebrates in the accretion areas. Any effects would only be temporary, due to the ability for recolonisation as discussed in Section 4.1.3.11 and in Technical Appendix S1.

When the factors discussed above are considered together, with the wide distribution and mobility of migratory shorebirds and low levels of sedimentation, there should be no significant impact to food availability for migratory bird species utilising these areas. Therefore, it is unlikely that any long-term change to shorebird distribution or abundance will occur in the region.

Submission 89-1: Darwin Harbour has been listed by the Northern Territory Government as a site of international conservation significance. It is important habitat for a range of marine turtles, dolphins and dugongs. The mangroves of Darwin Harbour support a highly specialised fauna and 14 bird species that are entirely restricted to mangrove environments (Harrison et al 2009).

INPEX acknowledges that Darwin Harbour provides habitat for a large number of plant and animal species. It is INPEX's intention, as discussed at length through the Draft EIS and this EIS Supplement, to minimise any adverse impacts the Ichthys Project might have on Darwin Harbour biodiversity.

Submission 98-1: Dredging and sea turtles. I find a lack of detail in the Management of Marine Megafauna and in the Provisional Dredging and Dredge Spoil Disposal Management Plan.

Submission 98-2: Dredging and sea turtles. Chapter 7 Pg 365 "As part of this plan practical options for reducing the risks of marine animal entrainment in TSHDs will be explored in consultation with the dredging contractor. These will be incorporated as management controls into the final dredging management plan. Options could include installing deflectors on dragheads and using turtle 'tickler' chains on the trailing arms." Chapter 11, Annexe 6, 3.1 Dredging 3.1.1 Engineering Controls Pg 543 "A range of options for reducing risks of fauna entrainment (especially turtles) by trailing suction hopper dredges will be explored in consultation with the dredging contractor." In both sections, the document states "in consultation with the dredging contractor". This is surprising as I am of the opinion that deflectors should be a contractual requirement given the unspoiled nature of Darwin Harbour and this is a major dredging operation in turtle feeding habitats. Given the amount of dredging planned for tropical Australia, including the Pilbara, the Kimberley, Northern Territory and Queensland with port developments and the limited number of dredge contractors, INPEX could adopt Worlds Best Practice in dredging in habitats frequented by sea turtles. Once fitted with turtle deflectors contractors are unlikely to remove them from the dragheads and their use would become standard practice in turtle sensitive areas. I refer the reader to the dredging protocols used recently in India for the Dhamra Port development (Anon 2007; 2009).

Submission 123-169: This section aims to mitigate against dredging impacts. In item 1.2, point number 5 lists accidental entrainment of marine fauna – but provides no mitigation or observation methods. 2) In section 2, Table 2-1 states that indicators will include: marine protected species observations and incident records – however there are no methods provided for this. It is extremely difficult to detect marine fauna entrainment in dredges and it requires a dedicated approach and techniques. The proponent needs to outline the detection approach in this section.

Submission 124-51: It is well-recognised that turtles occur as bycatch in dredging operations (e.g. Greenland et al. 200221). To address this problem, all dredging activities in the US have observer programs to determine the actual catch of turtles (C. Slay pers. comm.). Recommendation: A turtle by-catch program to be established (based on C Slay Coastwise Consulting methodology approved by US NOAA) for dredging during the Project.

While INPEX is not aware of any US requirement, or evidence otherwise, to support the claim that "all dredging activities in the US have observer programs", practical options for reducing the risks of marine animal entrainment in trailing suction hopper dredges will be explored in consultation with the dredging contractor. These will be incorporated as management controls into the final dredging management plan. Options could include installing deflectors on dragheads and using turtle "tickler" chains on the trailing arms.

The dredging contractor will be required to demonstrate, using the structured selection approach described by the Permanent International Association of Navigation Congresses in its PIANC Report 100 (PIANC 2009), that the proposed management measures for reduction of risk to turtles is best practice. The water and sediment slurry entering the hopper during trailing suction hopper dredging operations will be screened to capture entrained fauna. Because the internal piping arrangements of hoppers vary between vessels it is not possible at this stage to describe the actual screening mechanism. The dredger's crew will be aboard the hoppers to conduct periodic examination of the screens. Further detailed description of the actual configurations and management processes will be provided in the final dredging and dredge spoil disposal management plan.

Submission 98-3: 2. Sea snakes and their Susceptibility to Oil Spills. In 2009 the Marine Snake Specialist Group was formed under the Species Survival Commission of the IUCN. This involved a Red List assessment of over 100 species of marine and freshwater snakes. At least two species that inhabit the Sahul Shelf have been nominated as Endangered in addition to being listed under the EPBC Act as protected marine species. Although your document lists the species correctly the Environmental Management Plan is static and does not make provision for species whose conservation status changes during the life of the IGFD project.

In Chapter 7 Marine Impacts and Management: pg 283.

"Sea snakes are known to occur in the offshore developmental area, but there is no information available regarding the susceptibility of sea snakes to oil spills." Three publications list sea snakes as being after sea birds the second most vulnerable group to the negative impacts of oil spills. As a consequence of the 1991 Gulf War sea snakes were a noticeable component of the mortality on Saudi Arabian shores (Tawfiq and Olsen 1993). A recent spill in Queensland recorded an injured and a dead sea snake (Anon 2010).

The PTTEP Aust. Montara oil release in September 2009 resulted in the injury and death of sea snakes

(Watson et al. 2009).

The quoted statement was intended to convey that INPEX had been unable to locate any studies into the concentrations of hydrocarbons at which seasnakes may be susceptible to impact. The references provided that document the adverse impacts of oil spills upon seasnakes are appreciated.

Changes in conservation status of protected species will be captured within the environmental management plan review process (see Section 11.2.10 in Chapter 11 *Environmental management program* of the Draft EIS).

Submission 100-4: Inadequate information on persistence of Ichthys condensate as part of the spill modelling. Useful information on the persistence of Ichthys field condensate in surface spills or remaining in the water column as fine droplets from a subsea spill, is included on p 268 and 269, Section 7.2.4. As part of the spill modelling for the full range of scenarios, quantitative estimates of the volume and persistence of Ichthys condensate should be provided as part of the EIS.

INPEX has conducted detailed laboratory tests of the weathering of Ichthys Field condensate. The results of the laboratory tests were provided to INPEX's marine modelling consultant Asia-Pacific Applied Science Associates (APASA) to utilise in the development and input of the weathering rates for Ichthys condensate into the oil-spill modelling. The data in the discussion on the properties of Ichthys condensate in Section 7.2.4 of Chapter 7 *Marine impacts and management* of the Draft EIS are from the laboratory weathering tests. The graphs in figures 7-4 and 7-5 in Section 7.2.4 are the APASA outputs from the analysis of the laboratory test data.

In relation to volume and persistence of Ichthys condensate, the model outputs provided in the Draft EIS's Technical Appendix 7 *Marine hydrocarbon spill modelling* are the quantitative estimates of oil spill persistence and thickness for all spill scenarios.

Submission 100-5: Whales and dolphins. There is inadequate information on whales and dolphins in the development area. There is a large body of knowledge on whales and dolphins in the development area and vicinity that is inadequately referenced. This section should be revised and updated. The density of dolphins based on the one study cited, is described as 'sparse'. However other studies of dolphins in the region, such as those carried out as part of the Montara Oil spill assessment, would characterise the region differently and as important for a range of migratory marine species. If a hydrocarbon spill the size of the Montara spill were to occur ~ > 50,000 sq km, then this would potentially affect hundreds of dolphins per day, even using the low densities included in the EIS.

Submission 106-1: Lack of scientific knowledge about the region

Compared to the Great Barrier Reef, there is a dearth of scientific information on the Kimberley marine life, both large and small, as well as the marine ecosystem processes offshore. For example while the general path of the dominant oceanographic feature, the Indonesian Throughflow, is reasonably well understood, very little is known of the exact pathways and movements of Throughflow waters through the Northwest Shelf Transition.

Behaviour of our large megafauna is not well understood. For example sightings of humpback whales feeding have also been reported from waters around Browse Island. This observation is significant as humpbacks are currently known to feed only in Antarctic waters, but further investigation is necessary (DEWHA 2008).

INPEX must commit to improving the scientific knowledge of marine life nearby to Ichthys Field and its pipeline to improve environmental procedures and measure impacts of industrial development in the region. E.g. provide ongoing monitoring of the migration behaviour of cetaceans found in the area.

Submission 106-2: Lack of scientific knowledge about the region. Behaviour of our large megafauna is not well understood. For example sightings of humpback whales feeding have also been reported from waters around Browse Island. This observation is significant as humpbacks are currently known to feed only in Antarctic waters, but further investigation is necessary (DEWHA 2008).

INPEX must commit to improving the scientific knowledge of marine life nearby to Ichthys Field and its pipeline to improve environmental procedures and measure impacts of industrial development in the region. E.g. provide ongoing monitoring of the migration behaviour of cetaceans found in the area.

Submission 106-11: General impacts on listed threatened species

The Ichthys Field is nearby to an important breeding, feeding and resting areas for species listed as threatened or migratory under the EPBC Act. Listed species may migrate through, forage or breed within or near to the Ichthys Offshore Development. For example nearby Browse Island is a major rookery for green turtles (Chelonia mydas) and an aggregation area for cetaceans.

Vessel movements, drilling and installation of wells, pipelines and facilities may disturb the migratory routes and behaviours associated with migratory species of marine mammals (cetaceans and dolphins), turtles and birds, including those listed as threatened species under the EPBC Act.

Potential direct impacts include

- changes in water quality causing avoidance or effects to threatened marine fauna;
- attraction or avoidance behaviour due to artificial light sources;
- avoidance or physiological impacts associated with noise and vibration
- loss of feeding grounds
- behavioural and/or physiological responses and potential injury to marine organisms associated with routine and non-routine discharges to the marine environment; and
- injury caused by accidental vessel collisions with marine fauna.
- toxicity arising from accidental hydrocarbon spills , Seabirds may be highly susceptible to hydrocarbon spills if they are known to be foraging, resting and/or, migrating through the affected areas.

INPEX should fund long-term research on populations and behaviours of some of the listed species at nearby islands eg, green and flatback turtles, blue whales.

Submission 124-78: The INPEX risk assessment ignores the presence of a very high diversity of marine species (turtles, sea snakes, whales, sharks and dolphins) and the presence of large (100s of individuals) mixed species pods of feeding pelagic dolphins in the Browse area (DEWHA 201034). Impacts on these species have been dealt with inadequately (Volume 1, Chapter 7, Section 7.2.4, p 282 – 285 & Table 7-21).

Submission 124-86: Acknowledge the high diversity of marine species, including protected marine species, which are regularly found in the offshore region in large aggregations and the potential for impacts on these species from:

a. Hydrocarbon spills from the Ichthys Field or the pipeline;
b. Other Liquid discharges from the Ichthys Field (as listed at Section 7.2.3 and relevant to Section 7.2.7 Light emissions); and
c. Seismic surveys and vessel collisions.

3. Acknowledge and outline the impacts on marine species in the region given spill direction scenarios outlined in the Draft EIS at Figures 7-6 to 7-12.

The Ichthys Project's Draft EIS has added substantially to the available information on the large marine animals of the Kimberley and the Browse Basin. This information includes studies of the diversity and abundance of cetaceans and other large marine animals.

Survey methods were diverse and extended over several years. They included numerous vessel-based, aerial, acoustic-logger, satellite-tracking and genetic studies. Section 6 of the Draft EIS's Technical Appendix 4 *Studies of the offshore marine environment* provides a summary of the key findings of this extensive research conducted by INPEX. Key surveys included migration studies of pygmy blue whale and humpback whale, and humpback whale density estimates. Contrary to the statements above, the Draft EIS clearly acknowledges the high diversity of large marine animals in the region, including statements of observations of high densities of dolphin species in the Browse Basin; see, for example, the section on toothed whales and dolphins on page 52 of Chapter 3 *Existing natural, social and economic environment* and also sections 6.3.3 and 6.4.1 in Technical Appendix 4.

INPEX's studies have also added significant information to the scientific literature in relation to green and flatback turtle preferred nesting beaches, genetics, and post-nesting migrations from turtles nesting along the Kimberley coastline.

Seabirds and other large marine animals were also characterised in the 2008 vessel-based surveys (see Section 8.3.3 of Technical Appendix 4), again adding significantly to the information available on the diversity and abundance of these animals in the Browse Basin. The seabird information has been further evaluated in a wider regional context since the publication of the Draft EIS and is presented in Technical Appendix S3.

As appropriate, INPEX will continue to fund ongoing research programs for EPBC listed species affected by its operations.

Risks assessments and mitigation measures proposed for these species and communities are provided in Chapter 7 of the Draft EIS. Specifically, issues raised in comments 106-11 and 124-86 are addressed in the following sections:

Changes in water quality

Liquid discharges are discussed in Section 7.2.3 of the Draft EIS and modelling shows very small mixing zones for both acute and chronic toxicity effects (maximum radius of 3.6 km for chronic toxicity mixing zone). Only animals remaining within this mixing zone for weeks to months would be at risk of adverse affects. Given the water depth and distance to Browse Island (the nearest shallow area) impacts to EPBC listed species are not anticipated.

Artificial light sources

The offshore facilities including the CPF and FPSO will be located approximately 30 km from Browse Island, the nearest turtle – and bird-breeding location to the Ichthys offshore development area. At this distance, no significant impacts to turtle-nesting or seabird-breeding on the beaches of Browse Island are anticipated. Scott Reef and Adele Island (the next closest bird – and turtle-breeding islands) are more than 150 km from the CPF and FPSO locations. There is no evidence of light-related impacts to migratory bird species from petroleum facilities on the North West Shelf.

Loss of feeding grounds

No loss of feeding grounds is anticipated as a result of the Project in the Browse Basin, except perhaps short-to-medium-term effects as a result of a large oil spill, as discussed below. The presence of exclusion zones around the offshore processing facilities will preclude some fishing activities and this will result in less fishing pressure on the food sources for EPBC-listed species.

Seismic surveys and underwater noise

No 3D seismic surveys are proposed as part of the Project. Vertical Seismic Profiling (VSP), using very small acoustic sources will occur during production well drilling. Section 7.6.2 of the Draft EIS discusses underwater noise generally and specifically addresses VSP activities. Only minor behavioural avoidance from large cetaceans is anticipated within a 100 m radius of VSP activities. Other general sources of noise from the Project include the operation of the MODU, Support Vessels, and Condensate Tankers. A model output showing attenuation of all noise sources combined is presented in Figure 7-16 of the Draft EIS. As can be seen in this figure, due to the generally low source levels from these Project activities, underwater noise associated with the Project in the Ichthys Field rapidly attenuates to levels close to background. There are no known cetacean breeding or critical feeding areas near the offshore infrastructure, with the boundary of the Camden Sound humpback whale breeding area located >100km from the proposed CPF location.

Vessel collisions

Vessel collision with cetaceans and other large marine animals in the offshore area is considered a low risk for the reasons presented in Table 7-28 of the Draft EIS, including no routine aggregations of large cetaceans in the offshore development area, slow vessel speeds and procedures for vessel interaction with cetaceans. The volume of shipping traffic in the offshore development area will be far less than currently occurs on the North West Shelf off the coast of Western Australia and vessel collisions are not resulting in significant risks or losses to EPBC-listed species as a result of the petroleum operations on the North West Shelf.

Oil spills

Oil spills pose the most significant risk to the greater open water foraging areas of the Browse Basin and also reefs and islands of the region. The risks to groups of EPBC listed species (cetaceans, seabirds, turtles etc) are discussed in detail in Section 7.2.4 of the Draft EIS, with INPEX acknowledging that all trophic levels, from plankton to cetaceans, have the potential to be affected though contact, adsorption, ingestion etc of oil from a large oil spill and that the effects could be wide spread.

It is acknowledged that the Montara and Macondo (Deepwater Horizon) incidents are both recent events, however large oil spills are typically rare events. Statistical analysis shows that the probability of a well blow-out during drilling is $9.2x10^{-5}$ and $5x10^{-6}$ during production (refer Table 7-17 of the Draft EIS). Due to the low likelihood of occurrence, these risks are considered as low or medium (depending on the scenario) as discussed in Table 7-21 of the Draft EIS.

INPEX and the petroleum industry as a whole are however taking additional steps to further reduce the risks of large oil spills occurring (i.e. oil spill prevention) and also improving oil spill response capability across the industry. Further details on the steps being taken by INPEX and the petroleum industry in relation to oil spill prevention, preparedness and response, including lessons learned from the Montara and Macondo incidents are provided in Section 4.2 of this EIS Supplement.

Submission 100-6: b) Turtles and Sea Snakes. This is an extremely important region for marine turtles and is one of the world's richest regions for sea snakes. The current description in the EIS does not adequately represent the importance of this region for both these groups of marine reptiles and should be revised substantially to more accurately reflect the importance of these environmental values, including maps of the nesting sites and foraging areas. The density of data characterises encounters as "very infrequently", however compared to other regions, these are relatively frequent encounters. The section on densities of individuals needs to be substantially, revised, encounter rates compared to other studies in the region, and put in a regional and global perspective to show the importance of the region for marine turtles and sea snakes and the potential numbers affected by a slick the size of a Montara spill.

Turtle nesting sites are described in Section 3.2.8 of the Draft EIS, with references to locations shown in Figures 3-9 and 3-10. Potential turtle foraging habitats in the offshore environment are described in Section 3.2.8 of the Draft EIS; those within Darwin Harbour are described in Section 3.3.8 of the Draft EIS and are shown in Figures 3-24 to 3-26. Further information on turtles in the offshore environment, including data from aerial surveys and satellite tracking exercises, is presented in Technical Appendix 4 of the Draft EIS.

INPEX considers that there are insufficient data available to conduct robust comparisons with encounter rates for other regions, and globally. INPEX also considers that such comparisons are unwarranted; the company is committed to reducing the risks of impacts from hydrocarbon spills on all aspects of the marine environment (including turtles and seasnakes) to as low as reasonably practicable. INPEX also considers that there are insufficient data available to predict "the potential numbers (of marine turtles and seasnakes) affected by a slick the size of a Montara spill".

It should be noted that the prevention and management measures discussed in the Draft EIS Section 7.2.4 will be developed in greater detail during detailed design and Oil Spill Contingency Plans will contain provisions for wildlife rescue. These plans and procedures will be subject to regulatory approval prior to commencement of the construction and operational phases of the project. The measures will be revised as new technologies become available over the lifetime of the project, to ensure that the most effective contemporary measures are available. In addition, INPEX is developing, in consultation with other Browse Basin operators, or independently if required, an environmental sensitivities map of the Browse Basin and an operational and scientific monitoring program which will identify response priorities to help guide oil-spill-response actions in the event of a significant oil spill. Further details are provided in Section 4.2.3 of this EIS Supplement.

Submission 100-9: Benthic Communities. The benthic community section focuses on the intertidal community and characterises the benthic community as being 'common' throughout the region, whilst noting that Scott Reef has high coral-reef biodiversity. There is inadequate information provided on these sensitive and vulnerable marine habitats and their associated species, including on the benthic fringing reefs of the Kimberley. These are some of the richest and most intact reefs on the planet, yet their global importance is not highlighted in any way. Within the entire EIS, the information on benthic communities is inadequate for assessing the impacts of the development. Relevant sections of the EIS need to be substantially revised and latest information on species and habitats and their global importance and extent, included.

Submission 107-37: Figure 7-6 suggests that Seringapatam, North Scott Reef, South Scott Reef and Sandy Islet may be impacted by surface oil exceeding a threshold limit of 1 g/m 3 if a subsea flowline ruptures in the dry season. In the wet season there is also a significant risk that waters around Browse Islet and the Kimberley coast would be impacted, but to a higher degree.

Submission 124-75: The Draft EIS states that the nearest sensitive marine habitats to the Ichthys Field are Browse Island and Echuca Shoal (Executive Summary, Chapter 4, Section 4.1, p. 21). This remark is indicative of the information contained in the Draft EIS regarding descriptions of the existing environment – important details are omitted, descriptions are inconsistent across related sections and there is no real depth in the level of information supplied. Risk assessments are generally overly optimistic and plans for management and mitigation are lacking in detail.

In contrast to the Executive Summary reference cited above, Volume 1, Chapter 3, Section 3.2.2, describes the same area as a rich biogeographical setting for the Ichthys Field. In fact, the Browse Basin sits off a highly convoluted continental shelf edge and slope habitat which due to its rugged topography and strong tides provides rich, and transient, feeding events for massive schools of seabirds, cetaceans and fish.

The proposed location for the offshore facility is primarily within the Oceanic Shoals Bioregion. This is a strong province for demersal fish species (high degree of endemism) and includes islands, coral reefs, rich fish fauna, seabird breeding colonies and cetaceans, dugong and turtles which also breed and feed here. The bulk of the pipeline passes through the Oceanic Shoals, Bonaparte Gulf and Anson-Beagle Bioregions. The pipeline route also passes between two areas identified for further assessment under the Commonwealth Marine Bioregional Planning (North) process: Joseph Bonaparte and the Anson-Beagle are areas of interest for marine protected areas due to high biodiversity and unique species and communities32.

The offshore area of interest for this Project must include the areas identified in the Draft EIS modelling of spill trajectories (Volume 1, Chapter 7, Section 7.2.4, Figures 7-6 to 7-12). These include the North West Kimberley Coast (modelled trajectories show spills reaching from the Cape Londonderry area in the north to Prince Regent River in the south); Joseph Bonaparte and the Anson-Beagle Bioregions and Scott Reef, Seringapatam Reef and Browse Island.

With the exception of oil spills, the Project poses no significant risk to the benthic communities and associated flora and fauna in either the offshore area or along the Kimberley coastline.

INPEX acknowledges that the offshore shoals and reefs of the oceanic shoals bioregion are high in diversity and abundance of a wide range of marine fauna and play an important functional role in this offshore ecosystem.

INPEX also acknowledges that amongst a range of sensitive habitats on the Kimberley coastline, there are extensive and diverse coral reefs. INPEX conducted extensive coral-reef surveys of the islands of the Bonaparte Archipelago. This work identified some of the highest diversity coral reefs in Australia and INPEX will be publishing the results of these corals surveys in the near future.

In addition, INPEX is developing, in consultation with other Browse Basin operators, or independently if required, an environmental sensitivities map of the Browse Basin including the Kimberley coastline and an operational and scientific monitoring program which will identify response priorities to help guide oil-spill-response actions in the event of a significant oil spill. Further details are provided in Section 4.2.3 of this EIS Supplement.

The scientific monitoring components will include provisions for monitoring plans to evaluate and determine the extent of any impacts on coral reefs and other benthic habitats in the event of a significant oil spill. The scientific monitoring program will incorporate lessons learned from the Montara and Macondo well blow-out incidents. Further details are provided in Section 4.2.3 of this EIS Supplement.

Submission 100-10: Mangroves. There is no mention of mangroves or other low energy environments. Instead there is a general characterisation of the shorelines as mostly being exposed and high energy. A section on mangroves and other intertidal habitats needs to be included.

INPEX acknowledges that among a range of sensitive habitats on the Kimberley coastline, there are extensive and diverse mangrove communities. INPEX conducted extensive surveys of the islands, including mangrove areas of the Bonaparte Archipelago, and has also more recently conducted extensive mangrove surveys in King Sound.

INPEX is developing, in consultation with other Browse Basin operators, or independently if required, an environmental sensitivities map of the Browse Basin including the Kimberley coastline and also an operational and scientific monitoring program which will identify response priorities to help guide oil-spill-response actions in the event of a significant oil spill. Further details are provided in Section 4.2.3 of this EIS Supplement.

The scientific monitoring components will include provisions for monitoring plans to evaluate and determine the extent of any impacts on mangrove communities in the event of a significant oil spill. The scientific monitoring program will incorporate lessons learned from the Montara and Macondo well blow-out incidents. Further details are provided in Section 4.2.3 of this EIS Supplement.

Submission 100-13: Dredging, Piledriving and Blasting activities in Darwin Harbour and Environmental Impacts on Coastal Dolphins and other threatened marine wildlife

The Australian Snubfin dolphin (Orcaella heinsohnii) and Indo-Pacific Humpback Dolphin (Sousa chinensis) are rare and unique. In 2008 The World Conservation Union (IUCN) Redlist of Threatened Species upgraded the status of both Snubfin and Indo-Pacific Humpback dolphins to "Near Threatened".1 Habitat destruction and degradation arising from development of this kind such as sedimentation and physical disturbance to these habitats combined with the associated noise and chemical pollution could have a major impact on the species2. The Indo-Pacific Bottlenose dolphin T.aduncus is classified as Data Deficient, however it too is widely recognised that those animals inhabiting coastal areas are exposed to reduced prey availability caused by environmental and habitat degradation due to marine construction and demolition. The cumulative impact of these threats could lead to longitudinal population declines3. Darwin Harbour is emerging as critical habitat for these coastal dolphins, which will be vulnerable to activities that potentially impact on their behaviour or on their habitats.

The submission is a position statement that raises several points. Dealing with each of these in turn:

1. IUCN Red List

The International Union for Conservation of Nature and Natural Resources (IUCN) has prepared guidelines for assessing and defining the conservation status of species (IUCN 2010b). The submission correctly notes that the IUCN lists the Australian snubfin and Indo-Pacific humpback dolphins as "near threatened". It is important to note, however, that "near threatened" does not mean that a species' status has been assessed as "threatened" (either "vulnerable", "endangered" or "critically endangered") as the submitter implies. Figure 2.1 in the IUCN guidelines illustrates the distinction between "threatened" and "near threatened". In a similar vein a status of "data deficient" does not equate to a status of "threatened".

The IUCN Red List is recognised by the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) (EPBC Act) in terms of categories and management principles for marine reserves (s.348). The IUCN does not set threatened species status for either the Commonwealth or Northern Territory governments. Each of the three species of coastal dolphins is listed under the "migratory" and "cetacean" protected species provisions of the EPBC Act. None, however, are listed as threatened species by either government.

2. Threatening processes

The submission has selectively drawn from the inventory of threatening processes contained within the IUCN listings, and simply quoted these without regard to the information provided in the Draft EIS. Each of the factors referred to, namely sedimentation, noise, and chemical pollution, has been addressed in the Draft EIS. Additional data on underwater noise are provided in Section 4.1.11 of this EIS Supplement.

3. Longitudinal population decline

Longitudinal population studies are correlation research studies that involve repeated observations of the same individuals from a population over time. The submission statement that "cumulative impact of these threats could lead to longitudinal population declines" is perhaps mis-stated.

4. Darwin Harbour as emerging critical habitat

The submission states an opinion that "Darwin Harbour is emerging as critical habitat". However, no supporting evidence is provided for this statement. A review of studies documenting the residency pattern and degree of dispersal of the coastal dolphin species present in Darwin Harbour suggests that there is a low-to-moderate proportion of exclusive residency.

Submission 100-15: As well as the proponents be required to substantially revise and produce more accurate, up to date and more accurately referenced assessment of marine impacts and management.

Through the process of responding to comments, INPEX has reviewed its assessment of marine impacts and management and believes that a substantial revision is not required, though certain aspects have been revised and updated in Section 4.1 of this EIS Supplement.

Submission 100-18: Inadequate and incomplete assessment of the direct and indirect impacts of dredging and dredge spoil disposal on coastal dolphins, marine turtles and dugong. (Chapter 7 and Chapter 11)

The potential direct impacts from dredging on coastal dolphins, marine turtles and dugongs will be from collisions with vessels and from entrainment of marine mammals or turtles in a dredging draghead. These possibilities are assessed in Section 7.3.10 of Chapter 7 *Marine impacts and management* of the Draft EIS.

Indirect impacts on marine mammals and turtles from dredging and spoil disposal are described in Section 7.3.2 of the Draft EIS. Further information regarding indirect impacts to marine mammals and turtles as a result of habitat disturbance is provided in Section 4.1.3.

Submission 124-46: Dugong foraging habitat includes Channel Island, an area where sediment plume modelling shows high levels of suspended sediment. The Draft EIS states that dugong may avoid Channel Island during the period of dredging activity (Chapter 7, Section 7.3.2, p. 324), yet there is no explanation as to why they would do this, nor any assessment of the potential impacts on the animals of a loss of access to this foraging site for the 'five week dredging period'. Any increase in the sedimentation disturbance footprint could greatly increase the period over which loss of foraging access occurs, thus increasing the level of impact on this species.

Submission 100-19: Channel Island is a known foraging area for dugong. INPEX sediment plume modelling show potential impacts around Channel Island, but the described likely impact on dugong foraging habitats is portrayed as being minor. On p 324 of Section 7.3.2, it states that "Dugong foraging habitats in Darwin Harbour such as rocky reefs at Weed Reef and Channel Island are not expected to be impacted from plumes from dredging". This section needs to be revised to account for knowledge of important dugong habitat. There are many instances of incomplete data or poor habitat mapping and there are inconsistencies in the document in this regard. Therefore it is recommended that the EIS be required to be revised and resubmitted with more detailed and accurate information.

It would seem reasonable to assume that dugongs *may* avoid the Channel Island area "because of the turbid plumes, noise and general vessel movements" if they find any of these stressors occurring at an intolerable level. It should be noted that this refers to the period of dredging activity at the pipeline shore crossing in Middle Arm, where the gas export pipeline will come ashore on to Middle Arm Peninsula. The text referring to an absence of impacts from plumes pertains to dredging in East Arm.

It is considered unlikely that Channel Island represents critical foraging habitat for dugongs as similar rocky reef communities occur elsewhere in the Harbour, beyond the influence of construction activities. Therefore, a "medium" residual risk could be deduced; see Table 7-31 of Chapter 7 *Marine impacts and management* and Table 6-3 of Chapter 6 *Risk assessment methodology* of the Draft EIS where any disruption to dugong activity at Channel Island was deemed to fall into the category "Minor and temporary disruption to small portion of the population".

Submission 106-10: 5. Impact of pipeline from Ichthys Field to the mouth of Darwin Harbour

A subsea gas export pipeline (outside diameter 1.07 m) of an approximate length of 852 km will be installed between the offshore development area and the entrance to Darwin Harbour. The pipeline will be weight coated with concrete for stabilization on the seabed with sections of additional protection by trenching or rock dumping depending on depth and location. INPEX estimates that the seabed up to 500 m either side of the pipe can be disturbed during the laying. This pipeline will be the second longest subsea pipeline in the world.

Impacts of pipeline include seabed disturbance during laying

Although most of the seabed route is considered featureless benthos, approximately 2% of the seabed route is not. As the pipeline is over 850 km long, around 17 square km of non-featureless benthos will be impacted by the laying of the pipe. This cannot be considered insignificant. Also, the EIS is unclear when and where it will have to use the more destructive methods of pipe laying – trenching or rock armouring. Therefore, it is impossible to determine the impact of the pipe laying on the benthic environment.

Trenching and rock armouring would disturb more of the benthic community would generate localized turbidity and sedimentation in the area.

The EIS discounts any impacts of pipe laying due to the small proportion of non – featureless benthos occurring along the total route of the pipe. The EIS must address what will occur in the 17 km of varied seabed (the 2% of nonfeatureless area). Is this seabed likely to require the more destructive forms of pipe laying – trenching and rock armouring? If so how much of the 17 km is expected to be impacted? Only when this is done, can the impact of laying the pipe be quantified. The impacts of laying of the pipe need to be properly quantified in the EIS. e.g Where will the destructive methods of laying the pipe laying (trenching and rock armouring) be used? What habitat will be impacted?

As indicated in Section 4.3 of the Draft EIS, a detailed seabed route survey will be undertaken during the laying of the pipeline. This will enable the pipeline to be routed around hard seabed areas where practicable, which is preferred from both environmental and engineering perspectives. The surveys completed to date have identified areas where trenching and rock-armouring may be required. Of the 18 hard-bottom sites identified between outer Darwin Harbour and the Ichthys Field (Draft EIS, Technical Appendix 4, Section 4) the only hard-bottom area outside Darwin Harbour requiring additional protection is located at KP 848.1. Through this area, pre-lay or post-lay trenching of the gas export pipeline will be required. For the remainder of the pipeline route to the Ichthys Field, the pipeline will be laid directly on to the seabed, held in place by its concrete weight coating only. Hence, trenching or rock-armouring is not required.

The area of hard seafloor that may be disturbed during pipelay is adequately small, especially as it will represent far less than 2% of similar habitat in the region. In addition, it is considered that disturbed areas will be recolonised, as has been observed elsewhere in northern Australia (see Section 7.2.1 in Chapter 7 of the Draft EIS). It also needs to be recognised that any rock-armouring that needs to be placed will increase the amount of hard substrate available for recolonisation along the pipeline route, as discussed in Technical Appendix S1 (though this is additional hard substrate is most unlikely to be of regional significance).

Submission 106-12: 7. Monitoring and Risk management

Activities in the offshore development area that have the potential to impact on the environment include the installation of facilities, routine discharges and emissions (produced water, drilling muds and noise) and accidental events such as spills of condensate and diesel. Baseline surveys and modeling informed an assessment of the potential environmental impacts of these activities.

Throughout the EIS INPEX tended to write off impacts if they were a small proportion of the total (eg 2% of benthic habitat in the pipeline was nonfeatureless) or if the modeling showed a small chance of occurring (eg oil spill modeling). Such an approach is not environmentally responsible for a company embarking on a physically large (extending over 900 km) and longterm (40 year) project in a pristine environment.

INPEX acknowledges that this is a large project. As such, INPEX has conducted a through environmental impact assessment and has conducted detailed evaluation of the direct, indirect, certain and potential environmental impacts on the habitats known or likely to be impacted compared with the areas of existing and undisturbed habitat.

This is the appropriate manner in which to conduct an environmental impact assessment, and is consistent with the environmental impact assessment approach required by the regulatory authorities for other major resource development projects in Australia.

Submission 107-14: Condensate is described as "light oil" that will be pumped from the Ichthys Field at the rate of 85000 per day at the start of production, but no volumes for maximum production appear to have been provided. The anticipated volumes of condensate at maximum production should be provided, along with a breakdown of the amounts of each hydrocarbon having chain length >C4. and the environmental impact of each described at their anticipated concentrations. A description of the toxicity of each of these should then be provided. If this information is present already in the EIS, then links to it should be provided to clarify the impacts for each respective oil fraction.

Section 1 of Chapter 1 *Introduction* of the Draft EIS stated that the Project would produce condensate offshore at a rate of 85 000 barrels per day (bpd) at the start of production, and a further 15 000 bpd onshore, that is, a total of 100 000 bpd at the start of production, but that production would thereafter decline.

Though not stated in the Draft EIS, up to an additional 5000 bpd of condensate were to be burned as fuel onshore, that is, of the estimated maximum of 105 000 bpd of condensate extracted from the reservoirs, 85 000 bpd would be exported directly from the offshore facilities, and of the 20 000 bpd travelling through the gas export pipeline to shore, 15 000 bpd were to be exported and 5000 used as fuel. Section 3.3.7 of this EIS supplement describes how INPEX may now wish to export the entire 20 000 bpd that arrives onshore, instead of burning 5000 bpd as fuel onshore and exporting only 15 000 bpd from Blaydin Point.

Most of the hydrocarbons in the condensate arriving onshore will contain between 4 and 8 carbon atoms. Heavier hydrocarbons, containing significantly more than 8 carbon atoms, will tend to end up in the offshore condensate, and not in the condensate sent to shore through the gas export pipeline.

In the unexpected event of a condensate leak or spill, once in the marine environment, the condensate would then be subject to weathering, evaporation and biodegradation processes as described in Section 7.2.4 of Chapter 7 *Marine impacts and management* of the Draft EIS. The ecotoxicity of condensate after different stages of weathering is also described in this section.

Submission 107-26: Oils associated with synthetic based muds are said to persist for long periods of time. This implies the possibility of a long-term environmental impact that has not been fully described. The nature of these oils along with a measure of their ecotoxicity and expected longevity in Darwin Harbour is required to assess the level of risk they impose.

Submission 107-27: INPEX raises concern with the discharge of drilling muds to the marine environment, citing that they may be toxic to marine biota. However, the extent of toxicity and the potential longevity of the mud in the marine environment are not made clear. The full extent of the impact and data related to ecotoxicity should be provided.

Synthetic-based drilling muds will only be used for certain sections of the production wells in the Ichthys Field in the Browse Basin as described in Section 7.2.2 of Chapter 7 *Marine impacts and management* of the Draft EIS.

No wells will be drilled in Darwin Harbour and therefore no synthetic-based drilling muds will be discharged into the Harbour.

The toxicity and persistence of drilling muds, both water-based and synthetic based, in the offshore marine environment are described in Section 7.2.2 of the Draft EIS.

Submission 107-32: At 6.6km2 and 9.3km2 the mixing zones around the FPSO (where chronic toxicity is at a maximum) appear to be quite large and this may take a heavy toll on any subsea communities that might be impacted (even in deeper water).

Submission 124-80: Liquid discharges: Small fish are attracted to floating objects in the sea as they provide some cover and larger fish, squid and other predators are known to congregate under rafts of weed, rope coils and offshore facilities such as oil and gas platforms. In determining the risk of exposure of marine biota to toxic liquid discharges – such as subsea control fluid, hydrotest water, produced water, various forms of waste water, the Draft EIS assumes that only barnacles attached to the platform will be likely be in the localised area of affected water (Chapter 7, Section 7.2.3, p. 263). Yet small to large fish and other predators are known to congregate around and under these platforms and could be exposed to toxic levels of some chemicals. These species could then be consumed by larger predators, including sharks, dolphins and whales, either in the vicinity of the platform or far removed. The possible impacts of this toxicity moving along the food chain over 40 years are unknown, but could be significant.

Submission 124-88: Acknowledge that marine species are attracted to the lights and cover of offshore facilities and can therefore be exposed to higher levels of toxic substances from liquid discharges. The concentration of marine species around the offshore field and the implications for lengthy exposure to toxins and consumption of toxic species to higher order predators is ignored in the Draft EIS assessment of risk/impacts of toxic liquid discharges (Section 7.2.3).

The presence of the central processing facility (CPF), floating production, storage and offtake (FPSO) facility and other subsea infrastructure, such as moorings, wellheads and flowlines, provides hard substrate for the settlement of marine organisms that would not otherwise be capable of colonising the area. Further colonisation of the structures over time by other species leads to the development of a fouling community similar to that which is found on subsea shipwrecks. The environmental effects associated with the provision of artificial habitat are locally increased biological productivity and diversity.

All routine and non-routine (accidental liquid) discharges from the offshore facilities have been described within the Draft EIS. The toxicities of the liquid discharges have been discussed in terms of their potential acute and chronic impacts upon marine biota.

A central concept of toxicity is that toxic effects are dose-dependent. For a marine animal at the offshore facilities to receive a dose sufficient to result in a toxicological response would require it to be in an area that is regularly "washed" by discharged liquids or else it would need to actively follow the plume before the plume is diluted to undetectable levels the strong current regime in the offshore marine environment. Non-motile species, or animals with a restricted range, such as fouling organisms, may suffer toxic impacts. However the environmental significance of this is considered to be minor and the environmental risk was ranked as "medium" in Section 7.2.3 of Chapter 7 *Marine impacts and management* of the Draft EIS.

The term "bioaccumulation" is used to describe the increase in concentration of a (usually toxic) substance in the tissues of a plant or an animal through all routes of exposure. The ability of a substance to bioaccumulate in an organism from water may be measured by calculating the octanol–water partition coefficient (P_{ow}). This coefficient is based on the preferential partitioning of lipophilic ("lipid-loving") organic compounds into the octanol phase of the octanol–water mixture. Partitioning into octanol can be correlated with the affinity such compounds have for the fatty (lipid-containing) tissue of organisms.

Organic chemicals with a bioaccumulation factor (log P_{ow}) less than 6 to 7 will have a low potential to bioaccumulate under most circumstances (Vik et al. 1996). The log P_{ow} values for monocyclic aromatic hydrocarbon compounds, such as the BTEX compounds, are reported to range from 2.13 to 3.3 (Eastcott, Shiu & Mackay 1988). At this level of partitioning, it is not expected that these compounds will bioaccumulate in the marine environment.

In contrast to the BTEX compounds, polycyclic aromatic hydrocarbons (PAHs) have high log P_{ow} values, indicative of a higher potential for bioaccumulation (Vik et al. 1996). Neff and Sauer (1996) reviewed the available literature from laboratory and field studies which have investigated the bioaccumulation of PAHs. They concluded that all PAHs (with the exception of naphthalenes) have a strong tendency to bioaccumulate in the tissues of marine organisms. However, where bioaccumulation has been reported for marine organisms, the PAH profile and tissue concentrations were highly variable (Neff & Sauer 1996) and found to be generally much less than would be predicted from the log P_{ow} value. This reflects both the ability of organisms to metabolise and/or purge themselves of low levels of hydrocarbons and the intermittent and brief nature of their exposure to these substances.

Biomagnification is the process by which tissue concentrations of a bioaccumulated substance increase as a substance passes up the food chain through at least two trophic levels. This process is a matter of environmental concern in the case of synthetic organic substances and for some "heavy" metals, such as lead and mercury; however these compounds and metals are not present in Ichthys Field discharges at concentrations high enough to warrant concern. Naturally occurring hydrocarbons can be broken down into simpler components by an organism's metabolic processes and do not biomagnify under normal conditions in the marine environment.

Submission 107-71: To assist, the proponent should be directed to state specifically what chemicals will be present at the project, and to provide greater detail on their chronic and acute effects (both individually and cumulatively) on the biota and system will be.

Production and hydrotest chemicals have yet to be selected for the Project. Chemicals will be selected using INPEX's chemical selection procedure to ensure that chemicals with the lowest possible environmental toxicities are selected, subject to meeting technical and safety requirements. Where appropriate, operational phase environmental plans which require the approval of the regulatory authorities will provide details including an environmental assessment of key production chemicals. Details on hydrotest chemicals will be included in the hydrotest management plans which will be submitted for approval to the regulatory authorities.

Submission 109-12: The spoil dump is likely generate an ongoing sediment source, further contributing to the smothering effect on mangrove roots. This smothering is likely to impact on many hectares of mangroves around the harbour.

As stated in Section 7.3.2 of Chapter 7 *Marine impacts and management* of the Draft EIS, modelling predicts that approximately 30 ha of mangroves will receive more than 50 mm of sediment from dredging activities, with 2 ha receiving more than 100 mm. These levels of sedimentation have the potential to have a deleterious effect on mangrove health, and especially for those areas predicted to receive more than 100 mm there is the possibility that mangroves will die. As stated in the Draft EIS, if mangrove tree deaths result because of sedimentation from the dredging program (and are not attributable to natural causes or activities external to the Project), rehabilitation of the affected areas will be undertaken after the completion of dredging activities through a combination of natural recruitment, facilitated natural recruitment and active planting.

Submission 109-14: It will be essential to carry out monitoring to establish the sediment effect on the mangrove communities. The Northern Territory Government(1) has carried out mangrove monitoring in the harbour between 1997 and 1999 and established a network of monitoring sites throughout the harbour. Additional community monitoring occurred between 2002 and 2002 and in 20003 further monitoring was undertaken at the existing LNG plant at Wickham point. This monitoring program could be reinstigated and tailored to monitor the effects of the INPEX project. It is essential this commences before any work commences in order to get solid baseline data about the mangrove community. This needs to occur throughout the harbour, not just in the vicinity of Blaydin Point.

As described in Section 4.3.2 of Annexe 6 to Draft EIS Chapter 11, an Intertidal sedimentation monitoring program will be developed (in consultation with regulators) as a part of the final dredging and dredge spoil disposal management plan, which will require approval prior to the commencement of dredging.

Submission 110-1: My concerns over the proposed development run mainly to the blasting and dredging of Darwin Harbour in its entirety. I believe that the data used in the modelling is imprecise and relies on assumptions that may make the modelling nothing more than academic in its relevance. I offer the extracts from the EIS and appendix 13 in support of this statement. Further I offer some data from the EIS and Appendix 13 that may contradict some assumptions and or stated information.

Submission 110-12: Failing that, I urge Inpex to rework the dredging model

While assumptions have been made with respect to various aspects of technical appendices 12 and 13 of the Draft EIS, they were not made without due cause, justification or investigation of sensitivities to these parameters. Further discussion regarding assumptions made in the modelling, including details of conservative assumptions made throughout the modelling process, is provided in Section 4.1.3.2 of this EIS Supplement. As described throughout technical appendices 5, 12 and 13 of the Draft EIS, well-proven modelling packages were used and model validation exercises, using measured data, showed appropriate accuracy for the hydrodynamic model. Note that responses to comments 110-3 to 110-8 individually address further specific concerns referred to in Submission 110-1.

Submission 110-2: Dredging methods can only be planned conceptually and Inpex's dredging program will only be finalised once the contractor has been appointed. I would like to see more clarity in the planning especially as the public don't have an opportunity to comment on any subsequent amendments to the EIS. The dredging concept and the actuality could be vastly different. I know that you have stated that (EIS chapter 4 page 182) the final dredging program will be designed so that any changes in methodology do not result in any significant increases to the predicted environmental and social impacts…. We can only comment on what is presented and not any changes made later for whatever reason.

Submission 120-9: Our consideration of the dredging and rock removal program for the Ichthys Project is made significantly more difficult at this time as there is still so much uncertainty with the plans and processes described in the EIS. We understand the difficulty that Inpex has in not being able to identify a dredging contractor or contactors and in not being able to identify dredge types and processes that may be available for various elements of the project but this has meant that "dredging methods can only be planned conceptually and Inpex's dredging program will only be finalised once the contractor has been appointed."(Draft EIS p. 181-182)

We acknowledge that Inpex has responded to the initial concerns expressed by the community about possible dredging impacts by indicating dredging equipment, methods and timetables that will minimise impacts but, with only a "Provisional Dredging Management Plan" (Draft EIS p. 325 and 539-551), there is little certainty. At its best, the proposed work could be carried out with acceptable impacts — at its worst, it could not.

In terms of the actual dredging aspects of this proposal (we will refer to rock removal and spoil dumping elsewhere in this submission) we can do little more at this stage than to indicate that only a dredging contractor and dredging equipment and methods that can deliver the lowest possible impacts in Darwin Harbour should be considered. Further, we believe that the actual dredging program, when finalised in terms of contractor, equipment and least impact options, should be made available for public scrutiny."

Submission 124-37: Alteration of habitat (nearshore) – The "Management controls and mitigating factors" outlined in the Draft EIS (Table 7-29, p. 307) state that soft-bottom habitat is widespread in Darwin Harbour – yet this is not known as only a strip of the Harbour was sampled and used for habitat mapping. The fact that dredging vessels will be fitted with navigational aids to ensure dredging occurs in the 'footprint' area is not 'management', it is a basic logistic and operational action. Table 7-29 also states that the disturbance footprint will be minimised where possible but then goes on to note that this will be within the constraints of infrastructure engineering and operability. Recommendation: There are no details as to how the disturbance footprint will be minimised and what the specific type and importance of any constraints might be that would make minimising the footprint impossible. A detailed plan should be developed of the decision making process that will occur and scenarios that might trigger actions that produce an increasing footprint. In addition, INPEX should outline what spatial scale of footprint would be considered too large, given likely alteration to the marine environment, and how this will be monitored and prevented to ensure that disturbance does not continue to increase. Details of the 'soft bottom benthos monitoring program' should be provided.

As indicated in this submission, until the final dredging contractor is engaged, final detailed methodology can not be developed. The dredging methodology provided in the Draft EIS reflects the level of detail currently available and practical for this stage of the Ichthys Project. Conservative predictions of impacts from the dredging program were presented in the Draft EIS, based upon the dredging methodologies described in Section 4.4.4 of Chapter 4 *Project description*. The predictions encompass the full range of activities and risks that may occur as a consequence of the proposed dredging activities. While changes in dredging design may occur once the dredging contractor has been engaged, the final dredging design will be remodelled to ensure that predicted environmental impacts do not exceed those presented in the Draft EIS. The final methodology, accompanied by modelling and detailed management and monitoring plans, will form part of the dredging and dredge spoil disposal environmental management plan which is required for approval by the Northern Territory Government as part of the secondary approvals process. The Northern Territory Government's environmental impact assessment process allows for one public review period only. It's worth noting that the level of detail provided in the Ichthys Project's Draft EIS is comparable to that provided in EISs for other contemporaneous projects with large-scale dredging components. It is also worth noting that DSEWPaC may also review and approve the dredging and dredge spoil disposal environmental management plan.

The Draft EIS stated in Table 7-29 of Chapter 7 *Marine impacts and management* that soft-sediment habitat in Darwin Harbour is widespread. INPEX believes that this is a widely agreed understanding of the nature of the seabed in the Harbour. Refer to Section 4.1.2 of this EIS Supplement for further discussion of benthic habitat in the Harbour and for updated benthic-habitat maps.

Regarding the inclusion in Table 7-29 of Chapter 7 of the statement that "Dredging vessels will be equipped with navigational aids to ensure that dredging occurs within the specified dredge footprint", it should be noted that this is considered to be a mitigating factor—the column heading in the table is labelled "Management controls and mitigating factors" and is not necessarily an environmental management control.

As far as the dredging footprint is concerned, the footprint presented in the Draft EIS represents the most up-to-date design and the statement in Table 7-29 of Chapter 7 that INPEX will minimise this footprint where possible refers to INPEX's ongoing commitment to exploring opportunities to reduce environmental impacts through design. This commitment does not imply that a footprint beyond the areal extent presented in the EIS will be dredged, but rather that opportunities to reduce this footprint will be explored during design. For example, since the publication of the Draft EIS in July 2010, INPEX has indentified an opportunity to change under-keel clearance depths in the shipping channel while maintaining safety standards; this has resulted in a reduction in dredging volume by approximately 1 Mm^3; see Section 3.3.6 in this EIS Supplement for further details.

Details of the soft-bottom benthos monitoring program will be provided in the final dredging and dredge spoil disposal management plan.

Submission 110-3: Approach to study (from Appendix 13) – 2. Geotechnical conditions – information relating to the type and properties of the prevailing ground conditions was collected by Coffey Geotechnical. Some of this information (strength and grain size classification) formed inputs to the Dredging Research Simulation (DRS) models. However, the geotechnical information provided was limited in spatial extent so assumptions on the location, volume and specific grading of the material to be dredged have been made.

This is unsatisfactory. If the geotechnical information is limited, send them back out so that you know with a high degree of certainty what is there in respect to location, volume and specific grading of the material to be dredged. I.e. take more core samples.

The data used for derivation of input parameters for the Dredging Research Simulation (DRS) models used all available geotechnical data. The amount of data in this data set was comparable to that used in other similarly sized dredging projects and is considered appropriate to sufficiently characterise spatial distribution, volume and nature of the material to be dredged for the purposes of modelling for the EIS.

Submission 110-4: It is quite difficult to find specific reference to material amounts to be transported to the offshore disposal site in both the EIS and appendices. Any numbers with regard to volume have to be gleaned, more often than not, from references to them in relation to another matter. In order to check the figures I have had to go about it in a round about way.

Table 17 (app 13) states clearly that 8,731,800 tonnes of fines (<75µm) will be transported to the offshore disposal ground. Page 46 of App 13 states, "37% of material placed offshore during the proposed dredge plan are between 75 and 150µm. The potential transporting capacity of the tidal flows (without wave-stirring) is approximately 12 to 13 million tonnes of 150 µm median diameter material". Table 6 states the amounts of dredge material as a percentage and tonnage and puts material greater that 200 µm at 6,238,00t. Further there only reference to material of particle size between 150 and 200 µm being transported to the offshore disposal site is in 5.5.1 table 32 page 40 app 13 as being 14% of the total material being placed at the offshore disposal site which would be approximately 4,000,000 tonnes. If we add all the given numbers for dredged material,

1,000,000t released in Darwin Harbour (Summery app 13 page iii)

8,731,800t fines <75µm transported to offshore disposal ground (4.5.1 table 17 page 23 app 13)

12 to 13,000,000t between 75 and 150µm transported to offshore disposal ground (5.5.3 page 46)

6,238,000t >200 µm transported to offshore disposal ground (2.6 table 6 page 9 app 13)

If we do the math and add all of these together we end up with a total dredge of 28,969,800 tonnes, add 14% (5.5.1 table 32 page 40 app 13)or 4,055,772tonnes (material between 150 and 200 μm) the total tonnage comes to 33,025,572 tonnes. Subtract that from the published total dredge tonnage of 23,857,000 and we end up with an extra 8 or 9,168,572 tonnes dredged depending on whether you add 12 or 13 million tonnes from approximately 12 to 13 million tonnes of 150 μm median diameter material.

1,000,000t +	released in Darwin Harbour
8,731,800+	fines <75μm transported to offshore disposal ground
13,000,000+	between 75 and 150μm transported to offshore disposal ground
6,238,000+	>200 μm transported to offshore disposal ground
28,969,800+	Total tonnage stated in document to be transported offshore
4,055772=	14% material between 150 and 200 μm
33,025572	Total tonnage to be transported to offshore disposal site

From the geotechnical data available and summarised in Technical Appendix 13 of the Draft EIS, approximately 8.6 Mt of fine-grained material (less than 75 μm in diameter) and approximately 15.2 Mt of coarse material (greater than 75 μm in diameter) will need removing and placing offshore.

The DRS models indicate that the mass of fine material and coarse material lost within East Arm will be around 0.47 Mt and 0.4 Mt respectively; these values were rounded to 500 000 Mt each in the Executive Summary (page iii of Technical Appendix 13 referred to by the submission). Thus it can be reasonably assumed that approximately 8.1 Mt of 'fine' material and 14.8 Mt of 'coarse' material will be placed offshore.

For the plume dispersion modelling, it is simulated that approximately 8.7 Mt of fines (less than 75 μm) will be placed offshore. This value is *conservative* compared with the 8.1 Mt indicated above, owing to the simplifying assumptions made to enable the effective modelling of the dredging period. (See Technical Appendix 13 Table 17), it is effectively double counting of the 0.47 Mt of fines lost within East Arm.

A point of clarification is required in relation to the total dredge volume of 33 025 572 Mt given by the submission. The mass of 12 to 13 Mt of 150 μm median diameter material given on page 46 refers to the potential hydrodynamic transporting capacity of the prevailing currents (without wave effects) across the disposal ground over a 48-month period for material of size 150 μm (including the effects of bathymetric changes associated with placing material at the offshore disposal ground). It is not additional dredge spoil disposal.

Submission 110-5: Page 46 of App 13 states, "37% of material placed offshore during the proposed dredge plan are between 75 and 150μm. The potential transporting capacity of the tidal flows (without wave-stirring) is approximately 12 to 13 million tonnes of 150 μm median diameter material"

This statement, one of only a few that directly refers to an amount to be transported to the offshore disposal ground, would seem ambiguous in its meaning. If for example, it was an amount that included existing natural transport of 150 μm materials at the disposal site then the amount transported to the disposal ground remains unclear.

The 12 or 13 Mt referred to is the potential hydrodynamic transporting capacity of the prevailing currents (without wave effects) across the disposal ground over a 48 month period for material of size 150 μm. It is not a measure of the mass of material to be placed at the site.

Note that summing up the percentages between 75 and 150 μm in Table 32 indicates the value is 26% and not 37% as stated in the text. This is an error in the report.

The volume of material to be dredged, and the sequence of operations, is given in Table 4-2 in the Draft EIS. The dry mass of material to be dredged is given in Table 5 of Technical Appendix 13. The dry mass of fines is given by Table 6 in Technical Appendix 13. The reader is also referred to Section 3.3.6 of this EIS Supplement which discusses reduction in shipping channel dredged depth and the resultant reduction in dredge volumes.

Submission 110-6: Offshore Disposal Ground

Nearly all mass dredged within the East Arm is expected to be placed offshore.

Possible inaccuracies in the modelling with respect to particle size.

I accept the model using <75µm as the definition of fines but I have a problem with the assertion that every particle >75 µm being classified as 'coarse'. The table below shows the accepted International classification system for particle size and, while clays and silts certainly fall into the category of fines, very fine sand (50 to 100µm) and fine sand (100 to 250µm) could also be classified as fines.

Two approaches have been used for the sediment transport modelling for the EIS. Fine material (less than 75 µm) and coarse material (more than 75 µm) have been modelled separately.

The term "fine" material should be considered a qualitative description, to distinguish between cohesive and non-cohesive sediment transport. For example, the Udden–Wentworth scale (Udden 1914; Wentworth 1922) defines a boundary between sand and silt at 62 µm; this can also be interpreted as the "fine" and coarser material boundary for the purposes of modelling.

As the transport of cohesive and non-cohesive sediment is governed by different processes (Whitehouse et al. 2000), HR Wallingford chose to use different numerical models to simulate the transport of the different material types effectively. A grain size was chosen to separate the finer material from the coarser material generated during the dredging and in this case, in line with Australian Standard *AS 1726:1993, Geotechnical site investigations* that defines the boundary of silts and sand at 75 µm, this was specified at 75 µm for modelling purposes.

Submission 110-7: Particle Size in Hydrodynamics

The model seems to imply that <75µm is 'Fines' and the remaining material > 75µm 'coarse'. As argued previously this assumption cannot be made with any degree of confidence.

The assumption that coarse material will settle in the dredge foot print can and should be made but only if the classification criteria used to determine what is and isn't 'coarse' material is accurate.

The proposal states that, (app 13 summary page iii) approximately 500,000 tonnes of fine grade material and a similar quantity of coarse-grained material will be released within the Darwin harbour during the proposed dredge schedule.

Much of the literature on this subject suggests that particles up to 200µm can remain suspended in solution for an indefinite period and, therefore, be easily transported. This would be most relevant in an environment like Darwin Harbour where the tides are large and as a result, the currents strong. The agitation effect of the strong tidal movement would encourage the finer particles to remain in solution and mobile. To make the assumption that only fines <75µm will be mobile in solution and therefore responsible for the plume and sediment deposition would seem incorrect.

If, as by the models own qualification, 5.5.3 app 13 page 46 states (In respect to the off shore disposal ground). Hence, during placement, if this fine fraction is not buried or otherwise lost to transport through armouring processes, all of this fine sand might be dispersed from the site by tide alone. Naturally as the grain size increases, the transporting potential of the hydrodynamics reduces. It is likely that that most of the material removed will be below 250 µm as the critical velocity for the threshold of motion magnitude for this size of material is lower.

This seems to read that your model believes that <250µm particles when placed in solution will be lost to tide movement alone if not armoured. Should this benchmark, <250µm, not also be applied to the model for Darwin Harbour? If this were the case and the proposed release of material into Darwin Harbour of 1,000,000 tonnes Table 6 page 9 of app13 states that 74% of total dredged material is under 200µm, then the effects of particle movement and, therefore, siltation could be 50% greater than predicted by the model. This would indicate that the stated expected deposits of sediment such as 100mm could be as high as 150mm, 50mm – 75mm, 20mm – 30mm etc, and, the impact on the affected communities of sponge, coral and mangrove compounded and therefore much greater.

It would also make the assumption that, 5.4.1 (app 13 page 37) The sandy material released will quite rapidly descend to the sea bed because of the relatively high settling velocities of the sand particles. Further, The assumption is made that the released sands initially accumulate within the footprint of the approach area. Incorrect. This assumption, will quite rapidly descend to the sea bed, cannot be made with any degree of confidence for up 74% of the material released as it is <200 μm (Table 6 page 9 of app13) and not only highly mobile but likely to remain in solution for an indefinite period once released.

It is agreed that the principal mode of transport for fine sand is in suspension as opposed to bed-load but, as noted above, the transporting processes for fines and sands are different.

The qualification for using a bimodal grain size approach to the modelling has been described in the responses to Submission 110-6 above. In addition to this, the extent to which the material disperses is significantly governed by the settling velocity; related to the sediment grain size. For example, the settling velocity for a 75 μm sized particle is approximately 3.2 mm/s, whereas for a particle of 250 μm it is around 29 mm/s (based on Soulsby 1997). An average settling velocity of 1 mm/s was chosen for the "fine" material.

Thus, the distance the larger particle may be transported in suspension by similar hydrodynamic conditions is *significantly* smaller; ultimately reducing the dispersion from source by an order of magnitude when comparing these particle sizes.

The potential transport pathways for uniform 150 μm sand at the offshore disposal site are presented in figures 137–140 and 143–146 in the Draft EIS's Technical Appendix 13 *Dredging and spoil disposal modelling*. Sensitivity tests to a uniform particle size of 350 μm were also conducted. From this analysis, it was suggested that the potential exists for sand of up to 250 μm to be transported away from the site under the prevailing hydrodynamic conditions.

The rate and mass of transport is governed by the ability of the hydrodynamics to transport the material. If the flow is saturated with sand entrained from the seabed around the disposal site (existing material) before it passes over the disposal ground, the uptake and subsequent transport of sand will be very small, associated with acceleration of the flow over the mound and drop-out as the flow decelerates over the opposite slope. Figures 149 and 150 indicate the differences in bed-level change due to the proposed placement of sand material (150 μm) at the offshore disposal ground; note that the largest changes occur at the fringes (slopes) of the disposal ground.

For the purposes of modelling, a potentially mobile sandy seabed with abundant availability of sand was assumed across the model domain, with the exception of the Clarence Strait where, owing to the strength of the prevailing tidal currents, a source of readily mobile sand is highly unlikely to exist.

Figures 138 and 140 of Technical Appendix 13 of the Draft EIS show the simulated patterns of accretion and erosion over the seabed outside Darwin Harbour for a spring to neap tidal cycle for 150 μm. The figures indicate that under modelled tide only and tide plus wave conditions the existing seabed is dynamic.

Figures 149 and 150 indicate the difference in accretion and erosion with and without the presence of the disposal ground, all other parameters and bathymetric features are identical.

Thus the extent of deposition generated by the dispersion of the 150-μm material from the disposal ground is seen under "tide only" conditions and "tide plus wave" condition in figures 149 and 150 respectively and highlights the significantly reduced extent to which non-cohesive material of this grain size is redistributed when compared with the cohesive (fine grained) sediment. The simulated changes to bed level that occur at the offshore disposal ground are largely a function of the modification to the local flow velocities over the slopes of the placement area.

Submission 110-8: I believe that the science employed in the model should be more precise and the conclusions should be presented in a much clearer manner. I find appendix 13 very confusing and hard to follow. I took the liberty of discussing my concerns with a learned and credentialed Professor in this field and he confessed to finding the data layout very confusing and not at all conducive to thorough examination. I believe the dredging model should be peer reviewed.

It is accepted that the technical appendices can, in sections, veer towards being technically complex. However the subject area referred to in the Draft EIS's Technical Appendix 13 *Dredging and spoil disposal modelling* has been presented as clearly as practical given the constraints of the discipline. The summary of results presented in Section 7.3 in Chapter 7 *Marine impacts and management* is intended for the lay reader.

Technical appendices 5 and 9 provide information on comparisons of predicted versus measured data for the validation of model parameters.

Submission 110-14: I would like you to clarify the meaning of Table 36 app 13 page 46 as it has no accompanying explanation but would seem to suggest that up 141,396,872 tonnes of material may migrate over 48 months, possibly, eventually ending up in Darwin Harbour where it may then need to be removed by further dredging.

Table 36 provides information on the *potential* sand transporting capacity (and associated masses) of the differing modelled hydrodynamic conditions, including the effects of bathymetric changes associated with placing material at the offshore disposal ground.

Specifically, the addition of wave effects indicates that the gross potential sediment transport from the offshore disposal ground is an order of magnitude higher than under tide only conditions. Secondly, the apparent shallowing of the bathymetry because of the placement of material at the offshore disposal ground causes a relatively small increase of the potential sand transport capacity of the modelled hydrodynamic conditions (in the order of a 10% increase).

Submission 110-15: I would like the dredge model be expanded to include the possible effect of a high category cyclone and the likely impact on Darwin Harbour with respect to the dredge material released and where it may end up in such an event.

Submission 120-28: Although the incidence of cyclones in the Darwin area is considered in the dredge spoil dispersal modeling (Technical Appendix 14) we note that only Cyclone Helen is mentioned. Helen was a Category 2 tropical cyclone that crossed the coast near Darwin in January 2008. This raises questions of how much more dredge spoil would be mobilized by higher intensity Category 3, 4 and 5 cyclones which are highly likely to be experienced in this region and what will be the level and impact of suspended and deposited sediments from the dredge spoil ground on the Howard River, Shoal Bay, Gunn Point and the Vernon Islands areas?

Submission 124-3: Dredging and sedimentation

Significant dredging in Darwin Harbour for the shipping channel will potentially impact water quality; Harbour hydrodynamics; corals; other marine wildlife; mangroves and seagrass.

There has been no modelling of impacts on the spoil dump from large cyclones.

Recommendations:

1) Perform appropriate sedimentation modelling and information analysis.

Submission 124-10: A failure to model the impacts of cyclone on the spoil dump and fate of sediments.

Submission 124-52: Based on various statements in the Draft EIS, e.g. "Extraordinary events such as cyclones may necessitate more frequent maintenance dredging" (Chapter 4, Section 4.4.5, p. 190); severe tropical cyclones "…are likely to have significant impacts on sediment distributions" (Chapter 3, Section 3.2.1, p. 36); "…sediment burial events…resulted from instances of rapid sediment deposition (e.g. from floods, cyclones or short-term human disturbance)" (Chapter 7, Section 7.3.2, p. 321); and "The intertidal zone in Darwin Harbour is an inherently dynamic environment and…extreme events such as cyclones, causes natural sediment movement" (Chapter 7, Section 7.3.2, p. 321); it would seem that there is a real risk that cyclonic activity could move sediment from the dredge spoil disposal ground, with potential impacts on the surrounding marine environment. This risk, however, has not been addressed in the Draft EIS.

Recommendations: The selection of the spoil disposal site (in the ocean or onshore) should be based on the provision of the best overall environmental outcome.

Prepare a long term management plan for the spoil disposal site that accounts for the risks posed by extreme weather events.

The predicted and potential impacts of dredging activities on water quality, hydrodynamics and marine flora and fauna are described in the Draft EIS, Section 7.3.2 and Technical Appendices 12 and 13.

The quote from Section 3.2.1 referred to in submission 124-52 regarding cyclones ".. are likely to have significant impacts on sediment distributions" was a general reference to the effects of natural disturbances in the offshore marine environment. Specific information pertaining to cyclonic disturbance at the spoil ground is contained within Section 7.3.2 and Technical Appendices 12 and 13 of the Draft EIS.

Under cyclonic conditions, significant volumes of bed material are likely to be mobilised in the offshore area. The volume of material that may be mobilised from the disposal site is likely to be small in comparison with the overall volume of material mobilised in the offshore area.

Sensitivity analysis was also undertaken to the assumed proportion of fines that may be released from the proposed disposal site under prevailing hydrodynamic conditions. The case presented in the draft EIS suggested that a total of 50% of the fines material transported to the disposal ground may be released; the higher case sensitivity test assessed the dispersion of 100% of the material placed to the offshore disposal ground. While this simulates the maximum mass of dispersed fine material, these tests do not consider the effects of potentially modified dispersion patterns generated by hydrodynamics associated with cyclone events.

However, results from the dispersion of 100% of the fine material placed at the offshore disposal ground indicated elevated suspended sediment concentrations around the proposed disposal ground. In the context of cyclone events these elevated concentrations would be part of a large elevated concentration field generated by mobilisation of existing seabed sediments.

The effect of sediment mobilisation on maintenance dredging intervals has been addressed in Section 4.4.5 of the Draft EIS. Modelling was carried out for ambient tide conditions over 10 – and 20-year periods for a 100-year average return interval storm-surge level combined with the inclusion of waves generated by cyclonic winds. It was considered that maintenance dredging would be required after approximately 10 years.

The selection of the site for offshore disposal of dredge spoil was made after an iterative process that included consideration of environmental outcomes (refer to Section 4.4.6 and Technical Appendix 14 of the Draft EIS).

Submission 119-1: The use of blasting and dredging should be minimised and done in light of an NT Government policy on dredging and blasting in Darwin Harbour. Impacts of any dredging and blasting must be closely monitored and reported.

Submission 112-10: Inpex must not be allowed to blast Walker Shoal.

INPEX acknowledges concerns associated with the blasting of Walker Shoal. However, INPEX has continued to investigate the geological characteristics of the hard-rock areas at Walker Shoal through geotechnical investigations and has obtained new information on alternative rock-removal techniques. This has provided INPEX with confidence that most, if not all, hard-rock areas within the shipping channel can be removed without the need for a drill-and-blast program. Further details on the options for the removal of hard rock are provided in Section 3.3.8 of this EIS Supplement. See also sections 4.1.12 and 4.1.13 of this EIS Supplement for details of how INPEX proposes to manage visual and acoustic monitoring of large marine animals such as dolphins during any blasting activities that might prove to be necessary.

INPEX has also continued to investigate opportunities to reduce the amount of dredging required. Since publication of the Draft EIS, INPEX has indentified an opportunity to change under-keel clearance depths while maintaining safety standards; this has resulted in a reduction in dredging volume by approximately 1 Mm^3; see Section 3.3.6 for further details. As described in Chapter 7 *Marine impacts and management*, Chapter 11 *Environmental management program* and Chapter 12 *Commitments register* of the Draft EIS, specific detailed management plans, including monitoring plans, for dredging and blasting will be developed in conjunction with and for approval by the Department of Natural Resources, Environment, the Arts and Sport.

Submission 120-5: Access to Lightening and Cossack ('Catalina') Creeks and the Short Jetty Option

A major concern for AFANT and recreational fishers since this project was first mooted was the need for continued recreational fishing and other access in Darwin Harbour and particularly to Lightning and Cossack Creeks (the 'Catalina' Creeks). We have been very clear about our position on this issue to Inpex, the NT Government and the public. We note that the jetty option now favoured for the project was selected with some consideration of this concern (Draft EIS p 179). We also note that the location of the shipping channel and the jetty design have taken into account the presence of a number of listed and unlisted heritage wrecks. For these and other reasons we support the so called "short jetty option" but we are extremely concerned that there is still no certainty that access to these creeks will be allowed.

It appears that access may or may not be possible depending on a quantitative risk assessment on the final design of the plant at Blaydin Point (Draft EIS p. 480) and we infer from this that there are different design options — some that could provide for continued access, some that could not. If this is correct then those options that rule access out should not be seriously considered. For example, if access needs to be restricted because of the location of the flare system structure indicated in the current plant design (Draft EIS p. 201) there should be some consideration of alternate locations for this structure that would reduce the need for access restrictions in Lightening Creek. We do note that both Lightening and Cossack Creeks would appear to fall largely outside the risk zone identified as meeting "government safety criteria" (Technical Appendix 24 p. 19).

The recreational fishing community's desire for continued access to Lightning and Cossack creeks ("Catalina Creeks 1 & 2") is recognised by INPEX and has been one of a number of factors which has been taken into account in determining the preferred jetty design for the Project. Details on the selection process for the jetty concepts are provided in Section 4.10.2 of this document. Preliminary quantitative risk analysis (QRA) indicates that public access to recreational fishing areas in Lightning and Cossack creeks can be maintained. However, exclusion zones are likely to apply to the eastern "fingers" of Lightning Creek. Access will, however, be subject to the results of the final QRA to be completed in the detailed-design phase and the demonstration to, and acceptance by, the Northern Territory safety regulator NT WorkSafe that safety risks to the public engaged in recreational activities in this area are as low as reasonably practicable. INPEX can assure that there are not different design options being considered which would clearly exceed "interim" safety criteria, in fact, to the contrary, changes have been made to early plant-layouts during FEED which minimise the risk profile in Lightning and Cossack creeks.

Submission 120-6: There are significant implications for the short jetty option and the current shipping channel alignment that will impact on Darwin Harbour and that are of concern to recreational fishers — most notably, the extensive dredging and rock removal programs associated with it. If recreational fishing access considerations are part of the reason this option was chosen then such access should now be assured.

The requirement to remove rock from the Walker Shoal area is essential to maintain safe shipping operations and is required irrespective of whether a short – or long-jetty option had been selected for the Project. While the recreational fishing community's desire for continued access to Lightning and Cossack creeks ("Catalina Creeks 1 & 2) was one of a number of factors taken into account in determining the preferred jetty design for the Project, other factors, and in particular the improved safety outcomes associated with the short-jetty option, were key determining factors in the selection process. Further details on the jetty selection process are outlined in Section 4.10.2 of this document. Preliminary QRA indicates that public access to recreational fishing areas in Lightning and Cossack creeks can be maintained. However, exclusion zones are likely to apply to the eastern "fingers" of Lightning Creek. Access will, however, be subject to the results of the final QRA to be completed in the detailed-design phase and the demonstration to, and acceptance by, the Northern Territory safety regulator NT WorkSafe that safety risks to the public engaged in recreational activities in this area are as low as reasonably practicable.

Submission 120-10: We note the comment (Draft EIS p. 321) that "sediment accumulation could displace some crab species but could provide a suitable environment for others" but we have not been able to identify any findings in respect of the possible impacts on mud crabs (Scylla serrata and Scylla olivacea). More detailed information on the possible impacts on mud crabs should be provided in the Supplementary EIS. Recreational mud crab fishing in Darwin Harbour is a very important activity and, unless it can be demonstrated that the anticipated levels of suspended and deposited sediments from proposed dredging operations will not adversely affect mud crabs, consideration will need to be given to measures to mitigate the amount of such material in sensitive areas of Darwin Harbour. Figure 7-23 (Draft EIS p. 319) indicates 20 to 50 mm of accumulated sediments in a number of known mud crab fishing locations such as the creeks in Francis Bay, the area behind East Arm Port, Hudson Creek and up the Elizabeth River. Figure 7.19 (Draft EIS p. 314) indicates high levels of suspended sediments in the same areas on spring tides during dredging operations.(We have similar concerns about impacts on mud crabs from dredge spoil sediments in Shoal Bay and this is dealt with elsewhere in this submission.)

Submission 120-25: Shoal Bay is also a significant area for recreational fishing for barramundi, salmon and particularly mud crabs. We estimate that something like two thirds of all recreational mud crab fishing in the NT takes place in Darwin Harbour, Shoal Bay and the Howard River. Whilst the small increase in sediments predicted is unlikely to have a significant impact on fin fish such as barramundi and salmon (other than the possible impacts on breeding addressed above) there is less certainty about the possible impacts on mud crabs. We note the comment (Draft EIS p. 321) that "sediment accumulation could displace some crab species but could provide a suitable environment for others" but we have not been able to identify any findings in respect of the possible impacts on mud crabs (Scylla serrata and Scylla olivacea).

More detailed information on the possible impacts on mud crabs should be provided in the Supplementary EIS and, unless it can be demonstrated that the anticipated levels of dredge spoil in Shoal Bay will not adversely affect mud crabs there, steps to mitigate the amount of suspended and deposited dredge spoil on coastal fringes should be considered.

INPEX acknowledges the importance of the two mud crab species found in Darwin Harbour and in Shoal Bay and the significant contribution they make to the recreational fishery catch. INPEX has undertaken a literature review and risk-assessment process to examine the potential for dredging-related impacts to the mud crabs of Darwin Harbour and Shoal Bay (SKM 2010). See Section 4.1.8 of this EIS Supplement for a summary of the assessment findings and also Technical Appendix S8 for the full report.

Submission 120-11: Mangrove loss due to sediment deposition from dredging activities should be anticipated (Draft EIS p. 321) and a rehabilitation program developed with seedlings ready to be replanted at the end of the dredging program or as appropriate in the future if mangrove loss is detected.

Submission 124-43: Review research (or conduct where necessary) to identify how much sedimentation mangroves can tolerate.

Information and mapping of mangroves is provided in Section 3.4.8 in Chapter 3 *Existing natural, social and economic environment* of the Draft EIS. Information on the invertebrate fauna in mangrove habitats is provided in Section 3.4.14.

It should be noted that the potential mangrove loss estimates from dredging-related sedimentation described in Section 7.3.2 (page 321) in Chapter 7 *Marine impacts and management* of the Draft EIS are considered to be conservative (i.e. an overestimate) because the threshold levels were derived from case studies involving impacts to mangroves from rapid sediment burial events such as floods or cyclones. By comparison, the dredging-related sedimentation from the Ichthys Project would occur at a much slower rate and the mangroves would have more opportunity to adjust to the sedimentation. Section 4.3.2 of Annexe 6 *Provisional dredging and dredge spoil disposal* in Chapter 11 *Environmental management program* of the Draft EIS confirms the commitment by INPEX to monitor sediment accretion and mangrove health during the dredging program and to undertake the rehabilitation of affected areas should such impacts occur and be attributable to the dredging program.

Should replanting be required, propagule collection and planting will be initiated at the earliest practicable time, recognising the fruiting cycles of affected mangrove species.

A review of the literature to derive conservative mangrove sedimentation thresholds was undertaken during the development of the EIS. A discussion of these thresholds is presented on pages 320–321 in Section 7.3.2 of the Draft EIS.

Submission 120-13: We note the proposed depth of the dredged channel is to accommodate gas ships with a draught of 14 metres (Draft EIS p. 181). Is this sufficient for other ships (say bulk carriers required for the BHP Billiton proposal for example) that may be expected to use the East Arm basin in the future? If such an extensive dredging program is to be undertaken it must satisfy all shipping requirements that can now be reasonably anticipated. We do not wish to see this done more than once in this area of Darwin Harbour. The NT Government and INPEX should be consulting on this issue.

Submission 120-19: The comments we made above in relation to the dredging program and the need to ensure that the depth of the dredged channel is sufficient to satisfy all shipping requirements that can now be reasonably anticipated should apply equally to the Walker Shoal rock removal. Again, we would not want it to become necessary for further blasting in this area in the future.

INPEX has maintained continual dialogue with the Northern Territory Government including the Darwin Port Corporation regarding synergies and opportunities for mutually beneficial construction activities in East Arm. The expansion plans and schedule for upgrades to the government operated facilities including shipping channels in the East Arm Wharf precinct is ultimately a decision for the Northern Territory Government. As presented in Figure 4-21 of Chapter 4 *Project description* of the Draft EIS, the dredging footprint had been designed to remove Walker Shoal to a depth of 14m below Lowest Astronomical Tide (LAT). As discussed in Section 3.3.6 of this EIS Supplement the actual dredge depth will now be – 13.5m LAT which will be adequate to meet all of INPEX's under-keel clearance requirements.

Submission 120-21: We note that the proposed removal of rock from Walker Shoal combined with the dredging program is projected to have an impact on the hydrodynamics of the East Arm area including a 3-7% reduction in flushing rates and localised decreases of current rates by as much as 45% (Draft EIS p. 306). While the conclusion reached in the Draft EIS is that such changes are unlikely to impact on tidal inundation, sedimentation or erosion, there does not appear to be any consideration of the impact on the exchange rates of water from East Arm and the Elizabeth River into the main body of the harbour. Flushing of the area upstream of the proposed shipping channel is significant in both wet and dry seasons as there is already one major sewerage treatment plant (Palmerston in Myrmiden Creek), one required for the new city of Weddell and another near Hudson Creek in forward concept plans for the NT Power and Water Corporation. In addition there is East Arm Port and a number of industries located upstream of the work area. With poor water quality in some areas of Darwin Harbour related to sewerage outflows and slow water exchange rates, the potential impacts of this project on flushing and water exchange rates need to be carefully considered. One of our members observed: "…the tidal movement in East Arm was altered slightly when the new wharf was constructed years ago. The tide changes were delayed up in the Elizabeth River area and appeared that the early tidal flow was stifled initially but them comes through with a bigger rush than it did before the new wharf rock wall was built."

The alteration to the flushing regime of East Arm and Elizabeth River in relation to the whole of Darwin Harbour is discussed in the Draft EIS's Technical Appendix 11 *Nearshore geomorphological modelling*, prepared by INPEX's marine-modelling consultant Asia-Pacific Applied Science Associates. Discussions relating to the potential impacts from reduced flushing of areas like East Arm and Elizabeth River are discussed in Section 2.2 of Technical Appendix 11. Section 3.1 of Technical Appendix 11 states that the alterations to the bathymetry of East Arm for the Ichthys Project (which includes the removal of Walker Shoal), would result in only small decreases in the flushing rate at some locations, but no significant alteration to the flushing capacity of East Arm and Elizabeth River as a whole. Detailed figures and model outputs are provided in figures 3 and 5 of Technical Appendix 11 of the Draft EIS, which show the very minor modifications to the flushing of East Arm and Elizabeth River into Darwin Harbour as a result of the Project's dredging program.

However, INPEX has conducted a more detailed review of the hydrodynamic model for the evaluation of the removal of Walker Shoal to specifically address this query.

Figure 5-1 shows the bathymetry that was represented around Walker Shoal at the scale of the model for both the "base case" and the "modified case". The base case represented the existing morphology of Darwin Harbour, while the modified case incorporated proposed channels and structures that extended into the hydrodynamic environment. At the scale of the Harbour model, it can be seen that Walker Shoal, being a relatively small feature, was represented by four grid cells. The model that was applied to this assessment was three-dimensional, hence the structure of Walker Shoal was represented as a blockage to flow extending vertically from the deeper extent up to the height of the shoal and not to the shallower layers. Thus, the model would conserve the migration of mass through these layers, with the mass blocked in the lower layers diverted over (into the upper layers) and around the blocking structure.

Examples of the currents predicted by the model over Walker Shoal during ebb and flood tides for both the base case and modified case are presented to provide indications of the expected change in current axis and magnitudes (see Figure 5-2 and Figure 5-3). The comparisons indicate that the bathymetric modifications proposed around Walker Shoal are likely to have only minor and localised effects on the current directions at the scale of the current modelling, with the direction of the tidal currents in the modified case following the existing current axis closely. This is attributed to the alignment of the proposed channel, which follows the existing tidal axis in the area of the shoal.

Tidal current speeds around Walker Shoal were calculated by the model as marginally (<5%) slower in the modified case. The speed reduction calculated in this area is attributable to the larger cross-sectional area that would be available for tidal exchange of a similar mass of water.

The current data produced by the base-case and modified-case models were applied in flushing analyses for East Arm, with minor changes indicated at the scale of East Arm. Any effect on the mobility of sediment deposits is also expected to be highly localised to Walker Shoal because tidal current speeds are strong over the shoal in both the base case and the modified case, compared with the currents required to mobilise the fine bed sediments of the Harbour.

Submission 120-26: The Gunn Point/Vernon Islands area is also very significant for recreational fishing. It was potential threats to this area from an inappropriate development proposal which caused AFANT and others to advocate for Darwin Harbour as a site for gas industry development back in 2007. The area is relatively rich in coral and has a number of ‘blue holes’ which are in near pristine condition with prolific fish and other sea life. It is also an area of strong tidal flows which, we assume, could make sediment deposition modeling in the area particularly difficult.

More detailed information on the possible impacts of dredge spoil on coral, blue holes, fish and other marine life in the Gunn Point and Vernon Islands area should be included in the Supplementary EIS.

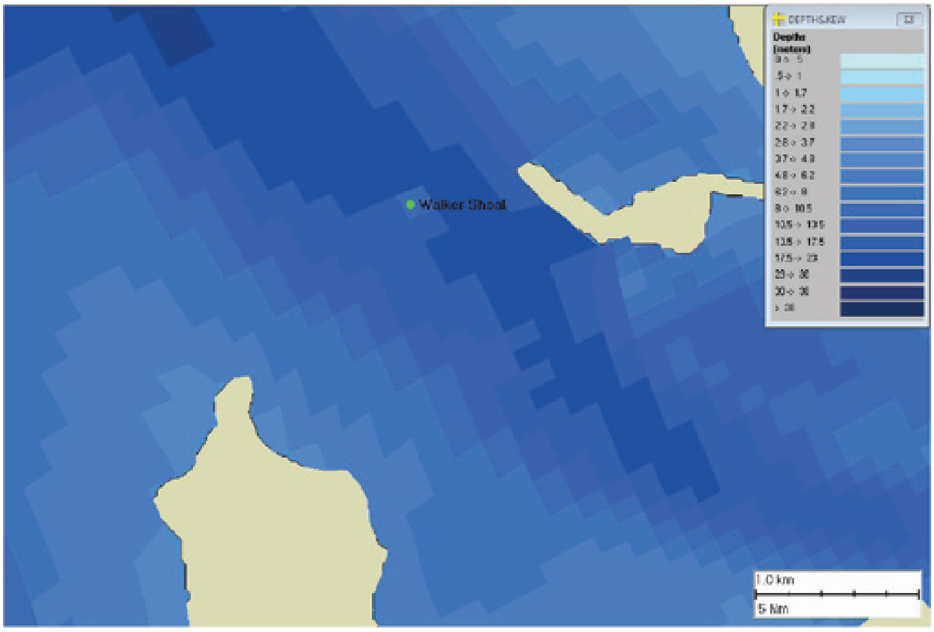
Submission 120-22: We note the discussion on dredge spoil site selection in the Draft EIS and acknowledge the consultation that took place with us on this issue. We are satisfied that the selected site meets the criteria we initially determined with Inpex. There is however a number of new issues that have arisen as a result of studies undertaken during the EIS development process. These are the potential for spoil sediment to be transported into the Howard River, onto the shores of Shoal Bay and around Gunn Point and the Vernon Islands. (Draft EIS p. 333-338, 540-551 and Technical Appendix 14).

Submission 123-131: This section does not discuss the possible impacts to the unique coralline algae platforms found at The Vernon Islands. This needs to be discussed and due to its uniqueness a monitoring program needs to be established to monitor their health.

Additional information on the Gunn Reef Blue Holes is provided in Section 4.1.6 and Technical Appendix S4 in this EIS Supplement.

Figures 107 to 111 of EIS Technical Appendix 13 show that plumes from the spoil ground are predicted to enter the Gunn Reef Blue Holes, South Channel and around South West Vernon Island during Phases 3 to 6 of the dredging program (a period of some 3.5 years). However, Figure 128 shows a time series of simulated sediment concentrations at “Gunn Point” (actually at the western entrance to the northern Blue Hole on Gunn Reef). This shows that peak concentrations are not predicted to exceed 10 mg/L at any stage of the dredging program, with concentrations typically below 5 mg/L.

With respect to sediment accretion, Figures 116 to 125 of Draft EIS Technical Appendix 13 show that accretion of more than 5 mm is not predicted to occur in these areas at any stage of the dredging program. This suggests that spoil ground sediments which reach this area will typically stay in suspension as the tidal waters flood and ebb through South Channel, across the reef flats on either side, and through the Blue Holes.



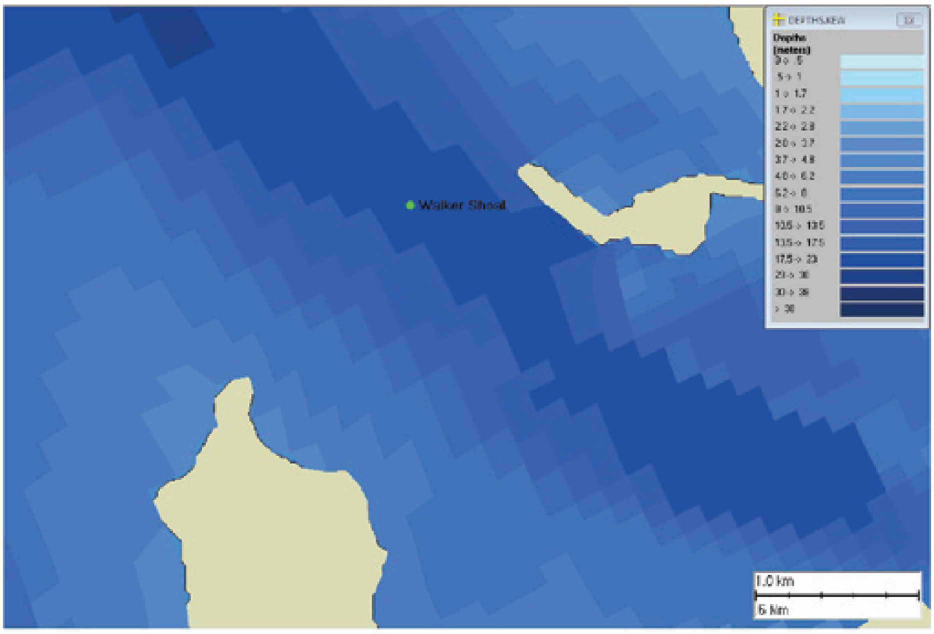


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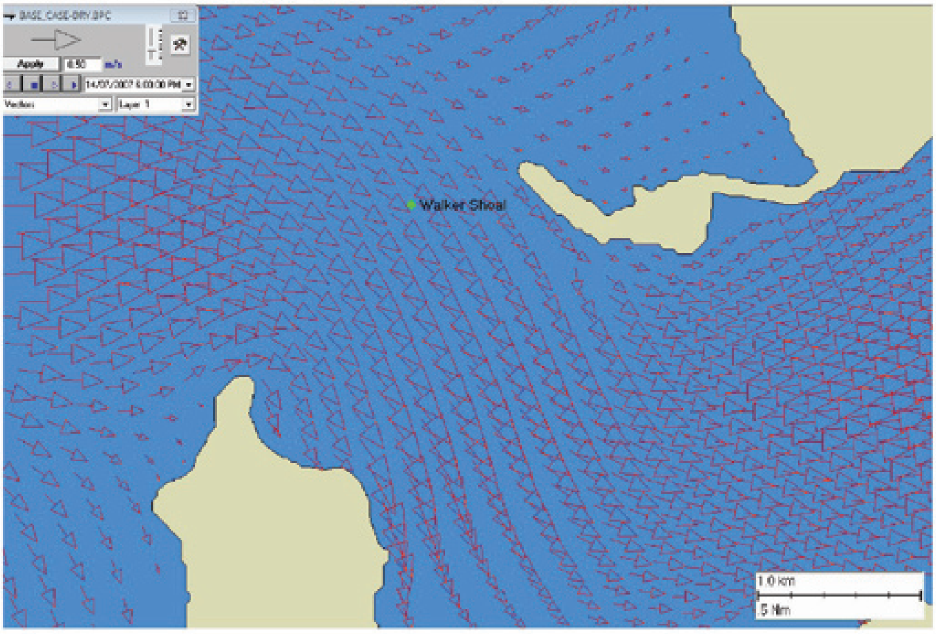
Figure 5-1: Bathymetry used in morphological assessment for the base case (top) and the modified case (bottom)



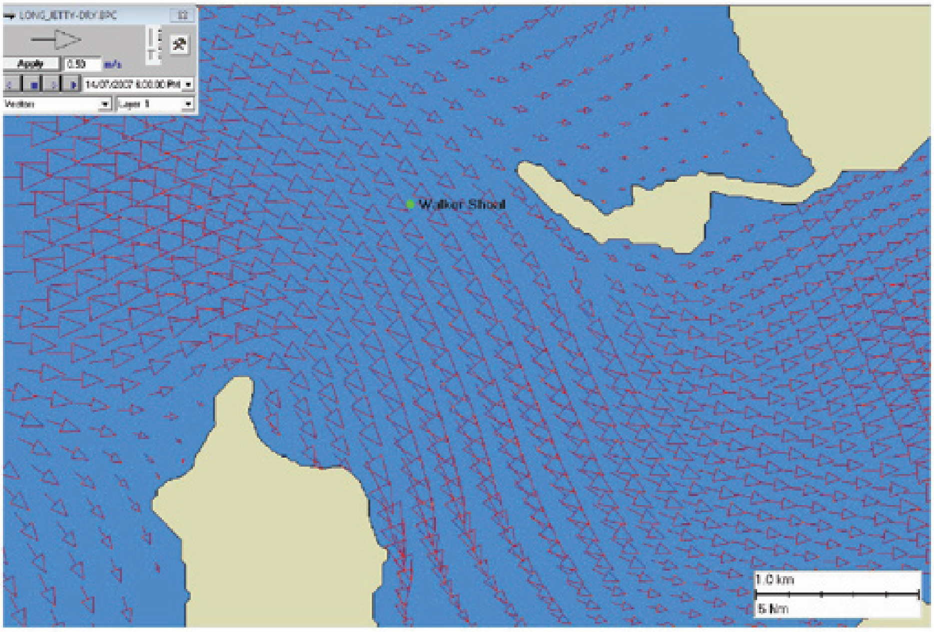


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Figure 5-2: Comparison of peak ebb current speed and direction for the base case (top) and modified case (bottom)

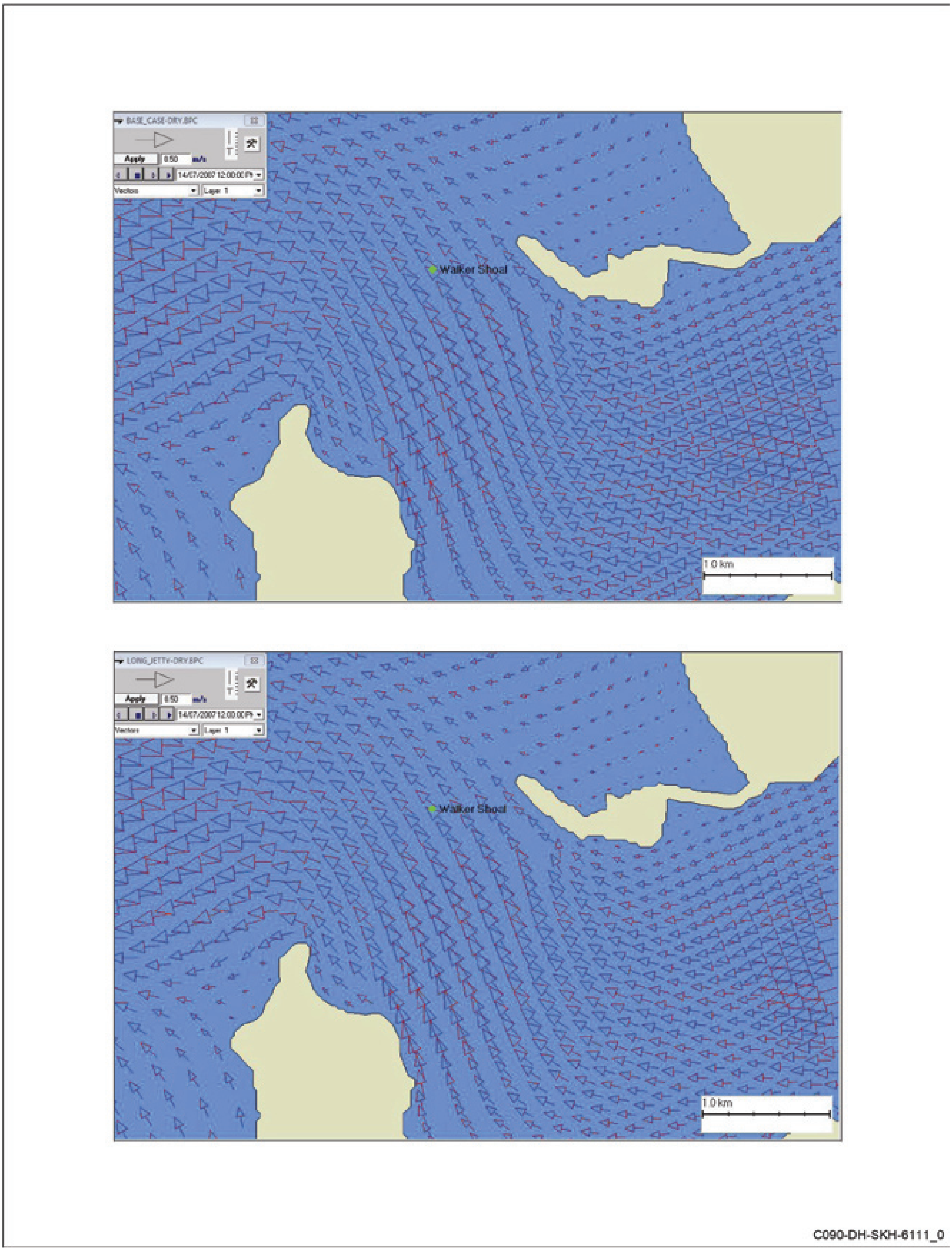

Figure 5-3: Comparison of peak flood current speed and direction for the Base Case (top) and Modified Case (bottom)

Water clarity is considerably higher within the Blue Holes (those on both Gunn Reef and the reef around South West Vernon Island) than in South Channel, through which most of the sediments will be carried. For the Gunn Reef Blue Holes, this is due to the water bodies within them being isolated from South Channel during a large part of each tidal cycle, and only receiving tidal waters towards the end of each flood tide, when the most turbid waters have been forced east towards Adam Bay (see Section 4.1.6 of this EIS Supplement). It is considered likely that the South West Vernon Island Blue Holes have similarly restricted connection to South Channel, otherwise they would contain turbid water and not have their distinctive blue colour.

Given the distance of Gunn Reef and South West Vernon Island from the spoil ground (some 20-30 km), spoil particles will be highly dispersed into the background suspended sediments as they are transported to the east. EIS Supplement Figure 4-12 and Figure 4-13 show that the Northern Blue Hole on Gunn Reef and the reef platform around South West Vernon Island are beyond the zones of influence (from suspended sediment and from sediment accumulation) of spoil disposal. Hence, it is considered that any increase in light attenuation would be imperceptible to the primary-producer communities (e.g. hard corals, algae) present and it is predicted that any sedimentation would represent an insufficient increase in natural rates to result in a detectable impact upon them.

It should be noted that tidal and current data have been collected in South Channel and the northern Blue Hole on Gunn Reef since the Draft EIS was released (refer Section 4.1.6 of this EIS Supplement. Higher resolution bathymetry has also been determined for the water to the west of the entrance to the northern Blue Hole on Gunn Reef, and for the intertidal areas on Gunn Reef. These data will be incorporated into the revised spoil dispersion modelling, to be conducted once the detailed dredging methodology has been developed. The outcome from this modelling will inform the scope and extent of monitoring during dredging and spoil disposal. If the need for monitoring is indicated, then it will be incorporated into the dredging and dredge spoil disposal monitoring plan, which will be fully developed (in consultation with the regulatory authorities) and approved prior to the commencement of dredging.

During dredging, monitoring of plume dispersion in waters around the offshore spoil disposal ground (refer Table 11-5 of the Draft EIS) will enable assessment of whether there is any potential for significant levels of sediment deposition to occur in these areas as a result of dredge spoil disposal.

Submission 120-23: The area of greatest concern is the Howard River which, as far as we know, has the only barramundi nursery habitat in the Darwin Harbour area and, as such, requires the highest possible level of protection. Any adverse impacts on barramundi breeding activity in the Howard River could have very significant implications for recreational fishing in the whole Darwin Harbour area. In addition, Howard River is an important recreational barramundi and mud crab fishing area in its own right. We note the conclusion reached (Draft EIS p. 338) that suspended sediment levels flowing from the dredge spoil grounds are not likely to have an impact on barramundi larvae but it appears that only one reference source has been relied on in reaching this conclusion (Jenkins and McKinnon 2006) and that was a Victorian Government report related to the dredging of Port Phillip Bay. It is not at all clear if this information is relevant to barramundi breeding or breeding habitat in tropical Australia. Even if it were, there is still the possibility of up to 10 mm of sediment deposition in the lower Howard River each year. We have some concerns that there could still be habitat impacts in the breeding areas and on the barramundi breeding cycle.

Refer to sections 4.1.7 and 4.1.8 of this EIS Supplement for discussions of barramundi suspended-sediment tolerance and mud crab sediment tolerances respectively.

With respect to the prediction of sediment deposition in the Howard River; the area of deposition shown in Figure 7-30 in Chapter 7 *Marine impacts and management* of the Draft EIS is a function of the model boundary and overstates the degree of sedimentation with an obvious area of accretion of up to 200 mm by the end of the dredging phases (approximately 50 mm/a). The model in this area is not suitable for simulating the detail of sediment deposition patterns, owing to its proximity to the boundary and resolution. Importantly, the process of wind wave redistribution is not included in this modelling. However it is reasonable to assume that the volume of material represented by the coloured area shown within the inner mouth of the Howard River will be transported further into the river mouth and dispersed over a wider area, as opposed to collecting at the location indicated by the model. Final modelling of the final dredge design (once the dredging contract is awarded) will account for these aspects and will better define the distribution of this sediment.

The model represents the effect of wind-wave redistribution well within Darwin Harbour, particularly over the intertidal areas around Cossack Creek and Lightning Creek. Allowing for the additional redistribution of material by wind-wave action, once the model at the Howard River location is refined, deposition patterns from the released dredge material are expected to be comparable to those predicted in Cossack and Lightning creeks where sediments are distributed more widely.

This can be converted to an average depth of accretion of less than 2 mm (based on a dry density of 700 kg/m^3) over the 4-year period. This accretion is an average value and will be subject to similar degrees of spatial variability as seen around Cossack and Lightening Creek. Any accretion is likely to be mitigated by surface runoff during the wet season and will not result in impacts on inundation of supratidal habitat acknowledged as important nursery areas for barramundi.

Submission 120-24: Further research may be necessary to gain a clear understanding of the potential impacts of suspended and deposited sediments emanating from dredge spoil on barramundi breeding habitat and activity in the Howard River. Unless it can be clearly demonstrated that there will not be adverse impacts on barramundi breeding, steps to mitigate dredge spoil impacts on the Howard River will need to be considered.

Information presented in the Draft EIS indicated that:

- spoil material from dredging operations in Darwin Harbour will not migrate to the Howard River estuary or the Shoal Bay area
- dumping of fines at the offshore spoil disposal ground will lead to a low incidence of elevated suspended solids (SS) concentrations in the Howard River estuary and the Shoal Bay area as indicated by figures 106–114 in the Draft EIS's Technical Appendix 13 *Dredging and spoil disposal modelling*.

In the figures in Technical Appendix 13, the 95th percentile plots present contour lines joining the 95th percentile of the calculated SS in each grid cell over all time steps in the particular phase of dredging. It is important to recognise that it does not represent a plume in place over the duration of the dredging phase; rather it is the boundary of where the plume would be.

Figure 127 shows the calculated concentration of SS at the Howard River estuary that is attributable to dredge spoil disposal. The figure indicates peaks of approximately 13 mg/L of SS during Phase 5 of the dredging program. The peaks are correlated with tidal cycles and the maximum concentrations occur during spring tides. The scale of the figure does not adequately allow for an evaluation of the duration of the peaks.

Table 31 of Technical Appendix 13 presents the percentage exceedance of different SS concentrations at Howard River. This shows that SS concentration is calculated to exceed 10 mg/L for 0.05% of the time. Over the duration of dredging this equates to approximately 17 hours.

The supralittoral wetlands on the floodplains of rivers draining into Shoal Bay have been identified as critical habitat for juvenile barramundi. High turbidity is a defining characteristic of tide-dominated estuary systems. The natural background range of SS in the Howard River estuary is not known, but in the absence of data it is assumed that it approximates that of Darwin Harbour, which has a mean of about 15 mg/L with a peak maximum of about 80 mg/L.

Based on the modelling of suspended sediments presented in the Draft EIS, the fish at Howard River would likely be exposed to elevated concentrations of up to about 15 mg/L above background concentration for relatively short periods of less than a few hours at a time. Under most circumstances, because of their limited swimming ability, larval and juvenile fish would be unable to move away from the SS plume.

A study was undertaken to evaluate the potential effect of suspended sediment on barramundi eggs and larvae. The results of this study are provided as Technical Appendix S5 and summarised in Section 4.1.7.

Submission 120-27: Some detail on the validity of the dredge spoil dispersal model to the specific tidal and current conditions in the area should also be included.

The hydrodynamic model was constructed with the most accurate and recent data available at that time. The sediment transport models were chosen to represent the appropriate “fines” and “coarse” material.

Appendix 12 of the Draft EIS presents detail of comparative analysis between modelled and measured data that was undertaken to test validation of the hydrodynamic and wave models for dredging and spoil disposal. Results indicate that the predicted wave heights and peak characteristics agree reasonably with the measured conditions. The agreement between predicted and measured current speed and direction was also considered to be acceptable.

Submission 123-4: Habitat Mapping. The proponent has not undertaken any broad scale habitat mapping to understand the location and extent of marine habitats in the region. This is in clear contrast to other marine EIS' that have been conducted. A lack of understanding of habitat extent in the harbour means that predictions of potential impact are not substantiated. For example, the proportion of the total hard substrate or coral communities in the harbour is unknown so there can be little understanding about how these communities will be impacted or the implications that impacts to one area might have on the sustainability of that habitat type in the harbour.

The habitat mapping presented in Figure 3-16 in Chapter 3 *Existing natural, social and economic environment* of the Draft EIS is considered adequate for the purpose of assessing impacts that are predicted to arise from the direct construction activities that will take place in East Arm and Middle Arm of Darwin Harbour. However, it is recognised that the extent of the mapping did not provide adequate descriptions of the marine habitats and communities that may be reached by turbid plumes arising from disposal of dredged material at the offshore spoil disposal ground. This has been rectified by undertaking further investigations into the habitats and communities in those areas (see Technical Appendix S6 to this EIS Supplement).

Revised habitat maps have been prepared (see Section 4.1.2 of this EIS Supplement). Using these maps, the proportions of the various habitats at risk of impacts from dredging (relative to the total areas of these habitats within the Harbour) have been calculated (refer Section 4.1.3 of this EIS Supplement).

Submission 123-16: The draft EIS mentions that the "Broad-scale oceanography in the north-west Australian offshore area is complex ….", however the draft EIS does not describe the oceanographic characteristics in sufficient detail. For example, factors such as seasonal changes in surface current direction (including maps); sub-surface currents; upwelling characteristics; combined effect of sea-surface currents, and seasonal meteorological conditions in water transport; Leeuwin and Holloway currents; and the importance of currents to productivity of the region need to be considered and discussed in the EIS. The EIS could provide conceptual models of processes in the marine environment and the geomorphological features within the development area and Darwin Harbour to better understand the linkages between key processes. Key references: Baker 2008 and Brewer 2007

Submission 123-23: This is the first time upwelling is mentioned and used as an explanation of a result. This is a key oceanographic characteristic for the North West region and needs to be reviewed and discussed in the relevant introductory section (3.2.1).

Submission 123-24: Phytoplankton characteristics have not been reviewed in the introduction section of this chapter. CSIRO and GA publications may assist in providing a context on the subject.

INPEX maintains that the level of detail presented in Section 3.2.1 in Chapter 3 *Existing natural, social and economic environment* of the Draft EIS is appropriate to inform the assessment of the potential impacts arising from the construction and operation of the Ichthys Field infrastructure and the gas export pipeline to Darwin.

The following oceanographic information, additional to that presented in the Draft EIS, adds to the overall understanding of the functioning of the offshore ecosystem, though it does not alter the consequence rankings for any of the potential impacts presented in tables 7-2, 7-5, 7-6, 7-7, 7-12, 7-13, 7-16, 7-21 and 7-22 in Chapter 7 *Marine impacts and management* of the Draft EIS. Hence the residual-risk rankings also remain unchanged.

- The Indonesian Throughflow is a warm mass of saline water that flows at 0.01–0.015 $km^3 \cdot s^{-1}$ in response to a steric height gradient in the Pacific Ocean (Farrand 1964, not seen, cited in Baker et al. 2008). The maximum net relative transport of the Indonesian Throughflow into the Indian Ocean (in August–September) has been calculated as 12×10^6 $m^3 \cdot s^{-1}$ (Meyers, Bailey & Worby 1995, not seen, cited in Brewer et al. 2007).
- The North West Marine Region is an oligotrophic (low-nutrient) environment, in which nutrient enrichment occurs through river runoff, tidal mixing, internal tides, low frequency circulation, upwelling, and tropical cyclones that induce oceanic mixing and further upwelling (Holloway et al. 1985, not seen, cited in Baker et al. 2008).

- In the outer Kimberley Shelf subregion, within which the Ichthys Field lies, the productivity of the surface waters is depressed by the Indonesian Throughflow. Nutrient influx comes from mixing brought about by internal breaking waves on the shelf and by benthic resuspension of sediments stripped from the ocean floor by currents (Brewer et al. 2007; Katsumata 2006).
- Subsurface upwelling of deep water occurs on the continental slope at the outer boundary of the Kimberley Shelf subregion. Mixed water masses at the edge of the continental shelf intrude into the offshore water masses at a depth of about 100 m, suggesting that the shelf-break is an intense area of boundary mixing (Brewer et al. 2007).
- The boundary mixing enhances the flow of nutrients that supports a “subsurface chlorophyll maximum” (SCM), which was determined from modelling by Herzfeld et al. (2006) to occur below the surface mixed layer on the North West Shelf, at depths of approximately 70 m.
- The model of Herzfeld et al. (2006) showed that the SCM varied in response to the tidal cycle, increasing in concentration and moving offshore during spring tides when mixing is more vigorous and higher turbidity decreases light availability. Seasonal variability was also shown, with the SCM occurring further offshore in the dry season than in the wet season, due to changes in mixed layer depth resulting from atmospheric forcing.
- The phytoplankton community in a large part of the Kimberley Shelf subregion is noted by Brewer et al. (2007) to be characterised by diatoms, though it is acknowledged that the community is “not described and likely to be quite complex”.

A conceptual trophic model of the Kimberley Shelf subregion is presented in Brewer et al. (2007) and reproduced below:

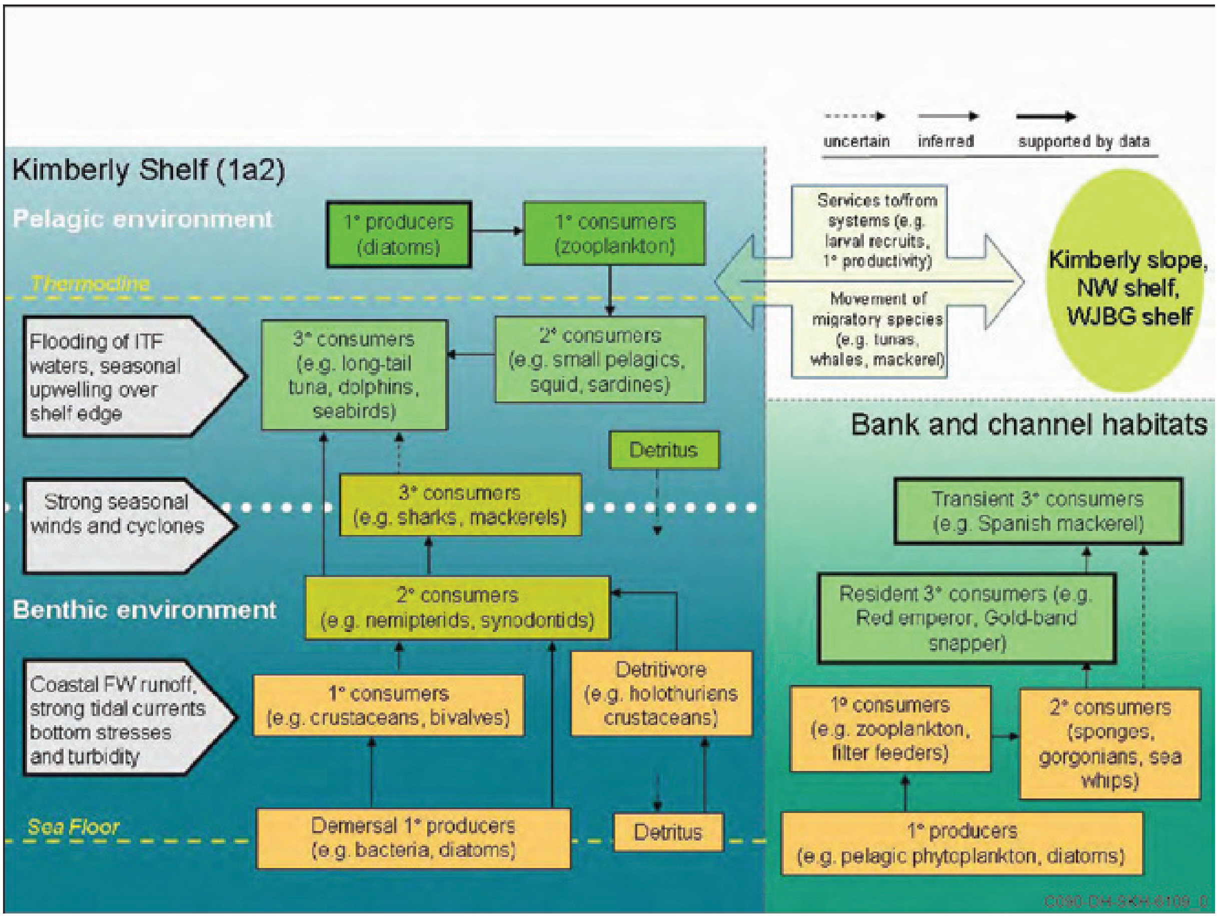

Figure 5-4: A conceptual trophic model of the Kimberley Shelf subregion (from Brewer et al. 2007)

Brewer et al. (2007) also provided a habitat diagram of the Kimberley Shelf subregion that shows selected important drivers and features. This is reproduced below:

Submission 123-6: Dredging and spoil disposal. The draft EIS has not adequately addressed the impacts from dredging, dredge spoil disposal, increased suspended sediments and changes in light attenuation associated with the trophic component of the Darwin Harbour ecosystem. In general terms, the draft EIS has not provided a comprehensive review of existing information and presented these data. The draft EIS has relied very much on the proponent's own collected data sets and "models". For example, seabed surface sediment figures show only URS sample sites; however, the Department of Natural Resources, Environment, the Arts and Sport (NRETAS) provided INPEX with a much larger data set that would have enabled the mapping of seabed surface sediments. There is no mention of these additional data in the draft EIS and they have not been used to fully describe and map seabed characteristics for Darwin Harbour. Additionally, there are no suitable marine monitoring control sites proposed. Without suitable control sites, any localized or regional impact such as coral bleaching caused by a warm water event could be attributed to the project.

Subsequent to the publication of the Draft EIS, INPEX has collected a considerable amount of data on the benthic communities and habitats of the Harbour, including collation and use of existing data (e.g. NRETAS sediment quality data sets), that has allowed a robust assessment of potential impacts to these habitats and communities and to the trophic component of the Harbour ecosystem. These data have been included in the production of habitat maps (Section 4.1.2) upon which delineation of impact and influence zones associated with dredging and spoil disposal were based (Section 4.1.3). Calculation of areas and proportion of Harbour for each habitat type within these zones, which reflected areas of potential impact, revealed very small proportions of available habitat and benthic communities at risk. Direct impact areas (areas within the footprints of the dredging, spoil disposal and pipeline) and indirect impact areas (areas potentially exposed to suspended sediment and sedimentation above particular thresholds) for benthic communities as a percentage of available community area in Darwin Harbour were as follows:

- seagrass: direct = 0%; indirect = 0% (total = 0%)
- hard coral: direct = 1%; indirect = 14% (total = 15%)
- filter feeders: direct = 2%; indirect = 3% (total = 5%)
- macroalgae: direct = 1%; indirect = 4% (total = 5%)

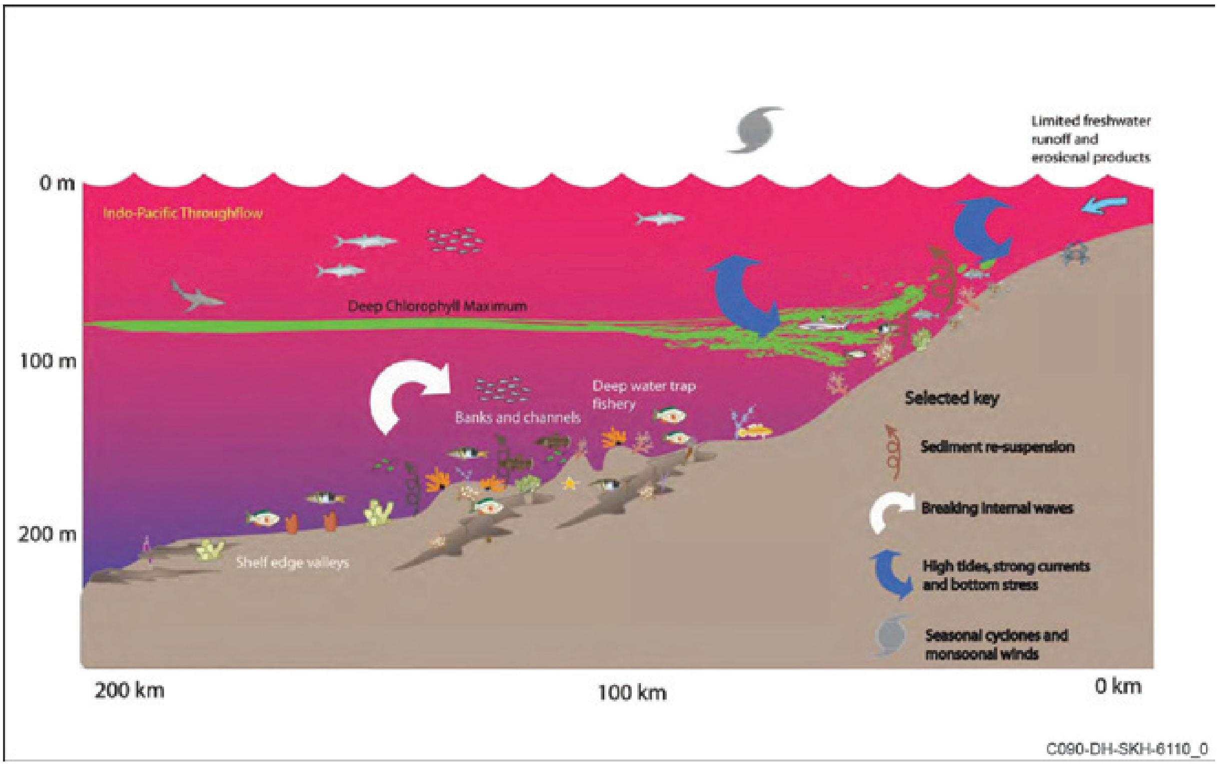

Figure 5-5: Habitat diagram of the Kimberley Shelf subregion showing selected important drivers and features (from Brewer et al. 2007)

In addition, an extensive review of the literature indicated a high likelihood of recovery for communities and low risk of impacts to localised or endemic species or wider impacts to Harbour trophic systems. The additional data collected on the distribution of benthic communities and habitats within and around Darwin Harbour as well as the conservatisms in the dredging modelling and development of zones of impact and influence have provided a high level of confidence in impact prediction.

Suitable control sites will be included in the various monitoring programs to be undertaken during the construction and operation of the Project. The relevant monitoring and management plans will be developed in consultation with, and approved by, NRETAS prior to the commencement of dredging.

Submission 123-12: This is dependant on (1) the correct application of mitigation control/management controls and (2) quality and appropriateness of baseline data collected and modelling conducted. In many instances the management controls are yet to be determined or developed and therefore risk assessment can not include mitigation factors. Further, many of the assessments are based on poor data sets and more often on assumptions.

INPEX maintains that the data sets are adequate for the purposes of impact assessment to the level of detail required at this stage of the environmental approvals process. Assumptions are a necessary part of any qualitative risk-assessment process and it is considered that there are no instances in which assumptions have led to the prediction of unrealistically low levels of residual risk. For specific aspects of the assessment of impacts upon the offshore marine environment, see responses to comments 123-5, 123-17, 123-18, 123-20, and 123-24 to 123-28.

Management controls will be elaborated as the enviromental management systems for the construction and operations activities are developed, in conjunction with the appropriate regulators, during the secondary approvals process. It is considered that the controls which INPEX has committed to implement (refer Chapter 12 of the Draft EIS) represent an adequate management framework within which a valid impact assessment has been undertaken.

Submission 123-17: This section [*Biogeographical setting*] would benefit from a more detailed review of the existing literature, including recent publications by CSIRO and GA. Maps showing existing knowledge (such as geomorphic features, sediment facies) would be useful.

It is acknowledged that further information on biogeography could have been included, from publications such as Brewer et al. (2007) and Baker et al. (2008), though INPEX maintains that Section 3.2.2 of the Draft EIS presented an appropriate level of detail on the biogeographical setting of the offshore development area (i.e. Ichthys Field and the pipeline route to the mouth of Darwin Harbour) to inform the impact assessment process.

While the information in these publications (summarised below) would not have had a bearing on the outcomes of the environmental impact assessment, it does lend weight to the assumptions made during the assessment process that the benthic communities at the Ichthys Field and along the pipeline route are likely to be widely distributed across the region. While species may vary across the region, the fundamental trophic structure of the communities at risk of impact from development of the Project is likely to be repeated across vast areas of the region.

Marine regional classifications

In addition to the benthic and meso-scale bioregions within the IMCRA Framework (DEH 2006), other classifications of the offshore marine regions within northern Australian waters are provided by Brewer et al. (2007) and Baker et al. (2008):

- At the broadest level, the Ichthys Field lies within the North West Marine Region (NWMR), with the pipeline passing eastwards from this region into the Northern Marine Region. The marine region classifications are based upon regional oceanographic, climatic, geological and biological drivers (Baker et al. 2008; Brewer et al. 2007).
- As described in Section 3.2.2 of the Draft EIS, at the bioregion level the Ichthys Field lies within the Timor Province and the pipeline traverses the Northwest Shelf Transition to Beagle Gulf (Baker et al. 2008; Heap et al. 2005).
- The NWMR is divided into physiographic regions; the Ichthys Field lies within the Outer Shelf and Slope region with the pipeline passing eastwards from this region into the Middle Shelf region (Baker et al. 2008).
- Brewer et al. (2007) have also divided the NWMR into a series of trophic systems: the offshore development area lies within the Indo-Pacific Throughflow (ITF) Influence system. Trophic systems are classified on the basis of differences in tidal, seasonal, interannual and climatic drivers (Brewer et al. 2007).

- Within the ITF Influence trophic system, the Ichthys Field lies near the boundary between the Kimberley Shelf and Kimberley Slope subregions and the pipeline passes eastwards into the Western Joseph Bonaparte Gulf (WJBG) subregion. These subregions are classified on the basis of differences in depth, with a Shelf defined as the seafloor from the coast out to a shelf-break, and with a Slope descending from a shelf-break down to 3000 m depth (Brewer et al. 2007).

Western Joseph Bonaparte Gulf (WJBG) subregion

Brewer et al. (2007) considered the WJBG subregion to be unique in the NWMR because of its relatively shallow depth, high surface currents, high tidal exceedance (the percentage of time that currents are predicted to mobilise sediments of mean grain size), high mud content, low carbonate content, high sea-surface temperatures, high nitrogen and phosphorus concentrations, and high chlorophyll concentrations. The WJBG includes the western portion of the Bonaparte Depression (described below).

Brewer et al. (2007) present criteria for assessing "important habitats", being habitats that have several or all of the following features:

- Substantially different from the most common habitat and trophic system in the subregion
- Relatively high species diversity and/or biomass
- Relatively unique in the NWMR.

The pinnacle habitats on the mid-shelf of the WJBG subregion were considered by Brewer et al. (2007) to be potentially very important habitats along the migration paths for green turtles (*Chelonia mydas*) and hawksbill turtles (*Eretmochelys imbricata*). The pipeline route passes well to the south of these pinnacles and the near-stationary laybarge and slow-moving support vessels will not pose a credible risk to turtles that may traverse the route during their migrations.

Kimberley Shelf subregion

Brewer et al. (2007) considered the Kimberley Shelf subregion to be unique in the NWMR because of its relatively high degree of cyclone activity (calculated as the length of recorded cyclone tracks through the subregion, per unit area, per unit time), low mud and high gravel content in the sediments and high silicate concentrations.

The outer-shelf islands and shoals (including Browse Island, Echuca Shoal and Heywood Shoal) are considered by Brewer et al. (2007) to be important habitats due to their topographical structure that provides habitat for sessile megabenthos, which benefit from shelf-edge upwelling. This results in biomass hot spots, due to elevated productivity which supports suspension-feeding sponges, corals, crinoids, and ascidians (Rogers 1994, not seen, cited in Brewer et al. 2007) that are rare or absent from surrounding habitats (which are dominated by deposit feeding invertebrates). The potential for impacts upon these features are assessed in sections 7.2.2 to 7.2.4 of the Draft EIS.

Significant geomorphic features

Baker et al. (2008) present criteria for assessing significance of geomorphic features in the NWMR or one of its provincial bioregions:

1. The feature is best represented in the NWMR or bioregion; i.e. the feature covers a significant area of the NWMR or bioregion or the feature is not abundant elsewhere in Australia's exclusive economic zone (EEZ).
2. The feature is unique to the NWMR or bioregion (its extent, sedimentology, bathymetry or latitude differs from that of other occurrences of the feature in the NWMR or bioregion.

The only significant (under criterion 2) geomorphic feature within the offshore development area is the Bonaparte Depression, a basin in which sediments typically contain large proportions of mud and gravel (Baker et al. 2008). A section of the pipeline (approximately KP500 to KP700) will traverse this basin but, given the sediment type, it is likely that the pipeline will be laid upon the seafloor without the need for any intervention (such as trenching or rock dumping), hence direct physical impacts upon the benthic communities therein will be minimal. The extent of direct impact will be very small in comparison with the extent of the basin; this section of the pipeline corridor represents an area of 400 km^2, less than 1% of the area of the Bonaparte Depression (some 45 000 km^2 according to Baker et al. 2008). Within this 400-km^2 section of corridor, the pipeline itself will impact only about 0.2 km^2; within the remainder of the corridor there will be patchy impacts where the laybarge anchors are laid.

Some indirect impacts are possible within the corridor, as fine sediments will be suspended when the pipeline is laid upon the seafloor and these sediments will settle on the soft-bottom areas adjacent to the pipeline. These sediments may smother some benthic fauna communities, but it is intuitive that biota from adjoining areas would recolonise these areas over time.

Submission 123-18: This statement can only be supporting if the supporting data is referenced and presented or summarised within the EIS. Currently, the data provided in the draft EIS is based on a relatively small number of sampling sites can not be considered representative for determining differences within the region (see also comments for Appendix 4).

Submission 123-20: Many statements are made about the general characteristics of bathymetry, substrates and seabed communities. However, this section needs to provide the data that underpins these statements. The following maps may assist the reader in assessing the statements made in this section: (1) results from acoustic methodologies; (2) a bathymetric profile of the pipe line route

Submission 123-25: Given the variability of sediment types (see later section), the size of exploration area and the pipeline length, the sampling intensity (10 sites) seems inadequate. There needs to be a clear justification for the selection and the number of sites used. Further, the EIS needs to review and include existing data into its assessment. For example, offshore sediments maps, geomorphological maps should be added to the EIS.

Submission 123-26: The EIS needs to list the internal and external source data sets accessed. This would ascertain whether there are any key data sets missing. For example, the draft EIS does not mention the GA MARS data base which holds marine sediment data. They have considerable number of data points within the NW Shelf and Gulf of Bonaparte regions.

The purpose of the Draft EIS is to provide adequate information to enable the general public and government regulators to evaluate the impacts and risks of the proposed development on the environment. While the Draft EIS does not provide an exhaustive literature review, appropriate study data and information are provided for the purpose in relation to offshore sediments. The environmental impact studies were also not intended to conduct a scientifically rigorous investigation into the fine-scale physical variations and boundaries of sediments in the offshore environment; rather they were to broadly characterise the offshore sediments, benthic fauna and natural contaminant status of the sediments. Given the nature (physical disturbance only) and scale (very small percentages of sediment in relation to the surrounding areas) of the proposed impacts in the offshore environment, INPEX maintains that the number and locations of sites selected were adequate for the purposes of impact assessment.

With regard to the data used to describe the offshore sediments, INPEX has conducted extensive geophysical and geotechnical investigations, including multibeam bathymetry, sidescan sonar, drop-core and grab-sampling, at the Ichthys Field and at a number of pipeline route options to locations such as Darwin, Echuca Shoal, Heyward Shoal and the Kimberley coastline. These geophysical and geotechnical investigations were carried out by Fugro and included the following:

- 2004 Titanichthys geotechnical investigation
- 2005 Eastern Ichthys Field geophysical survey
- 2005 Ichthys drilling location geophysical surveys
- 2005 Western Ichthys Field geophysical survey
- 2007 Ichthys Field and Maret Islands geotechnical investigation
- 2008 Browse Shelf geotechnical investigation
- 2008 Darwin Harbour geophysical survey
- 2008 Darwin Harbour refraction survey
- 2009 offshore pipeline UXO (unexploded ordnance) survey
- 2010 infield geotechnical investigation.

A brief summary of the Fugro 2005 Eastern and 2005 Western Ichthys Field geophysical surveys (Fugro 2005a, 2005b) follows. Fugro identified four types of seabed based on acoustic reflectivity. The surveys also included some 120 gravity cores and grab samples which were used to verify the acoustic interpretations. The qualitative descriptions of these samples were not included in the Draft EIS as it was considered that they did not provide information of sufficient significance to the environmental impact assessment process; however, for completeness, the four main sediment types of the Ichthys Field identified through Fugro's surveys are as follows:

1. *featureless sandy silt:* the general seabed has featureless low acoustic reflectivity which is interpreted as meaning that it is composed of soft sandy silt
2. *fine to medium sand:* this sediment type has variable low to high acoustic reflectivity which is interpreted as meaning that it is composed of loose fine to medium calcareous sand, generally in the form of sand waves
3. *medium to coarse sand:* this sediment type has moderate to high acoustic reflectivity which is interpreted as meaning that it consists of loose medium to coarse gravely sand, generally in the form of sand waves
4. *coarse gravelly sand:* this sediment type has high acoustic reflectivity which is interpreted as meaning that it consists of loose, coarse gravelly sand with shell fragments, generally in the form of sand waves.

Through the Fugro geophysical surveys, INPEX has calculated that only 2% of the proposed pipeline route to Darwin is hard substrate, that is, 98% of the approximately 850-km pipeline route is unconsolidated clay or silty sands (see Section 7.2.1 in Chapter 7 *Marine impacts and management* of the Draft EIS).

This work is in addition to the more targeted environmental surveys (e.g. by INPEX's consultants RPS Environmental Pty Ltd and URS Australia Pty Ltd) focusing on specific habitats and biological communities. For example, the extensive sidescan sonar data set was used to identify target locations for the pipeline route drop-camera survey, as described in Section 4 of the Draft EIS's Technical Appendix 4 *Studies of the offshore marine environment*.

Sediment samples from the Ichthys Field, subsequently analysed for particle size distribution, were collected in September 2005 and May 2007 (RPS Environmental Pty Ltd 2007).

Erratum: Sediment samples were collected from 20 sites (not 10 sites) at the Ichthys Field and in the vicinity of the western end of the pipeline corridor (refer Figures 5-7 and 5-8 in Technical Appendix 4 of the Draft EIS). From each of these samples, benthic infauna were extracted (Section 3.3.3) and particle size analysis was undertaken (Section 5.3.2). At 10 of the sites, samples were also extracted for analysis of contaminants (refer Section 5.3.2 of Technical Appendix 4 of the Draft EIS).

Results of these sediment samples indicate that the composition of sediments varied across the Ichthys Field, however most of the variation was found in the vicinity of the Echuca Shoal, where the sediments consisted mainly of calcareous shell grit with abundant inclusions of coral debris and varying minor proportions of silts and fine-to-medium grained sands. In general, the proportion of silts, clays and fine sands increased rapidly with increasing distance from Echuca Shoal into the Ichthys Field. In general, the Ichthys Field was dominated by olive-green to grey silty sands with varying proportions of clay and shell fragments.

In describing the sediments of the offshore development area in Section 3.2.6 of the Draft EIS, only those data collected specifically for the Project between 2005 and 2008 were used. It is recognised that information in the Geoscience Australia Marine Sediment (MARS) database, as described in Baker et al. (2008), lends weight to the assumptions made during the impact assessment process that the sediment types at the Ichthys Field and along the pipeline route are widely distributed across the region. It can be seen that the more detailed information on the sediment types presented below does not materially affect the residual-risk rankings presented in EIS Table 7-2 however for completeness, it is discussed here.

Baker et al. (2008) consider that the texture and composition of the outer shelf sediments of the North West Shelf are influenced by bottom currents, oceanic upwelling and large scale currents. Jones (1973, not seen, cited in Baker et al. 2008) described the seafloor of the outer shelf region as dominated by fine-grained sediments, with thicker accumulations of carbonate deposits at the shelf edge, where the Ichthys Field lies. The sand fraction of the sediments is described as consisting mainly of planktonic foraminifera.

Heyward et al. (1997) also concludes that the seabed in the offshore locations around the Ichthys Field on the continental shelf are generally flat, relatively featureless plains characterised by soft sandy/silt marine sediments that are easily resuspended. Similarly, the substrate of the Scott Reef – Rowley Shoals Platform, located immediately south-east of the Ichthys Field in depths of 200 to 600 m, was found to be a depositional area with predominantly fine, muddy sediments (McLoughlin et al. 1988).

As the pipeline route progresses eastwards from the Ichthys Field, it leaves the outer shelf region of the Northwest Shelf and crosses an area of Middle Shelf seafloor (the western Sahul Shelf), where sediment transport is influenced by winds, tides, waves, coastal turbidity and slope processes (Baker et al. 2008). Sediments on the western Sahul Shelf were described by Carrigy and Fairbridge (1954, not seen, cited in Baker et al. 2008) as having a high concentration of mud with localised bands of sand and gravel.

The pipeline route then traverses the Bonaparte Depression, a basin in which the sediments typically contain large proportions of mud and gravel (Baker et al. 2008) before emerging back on to the Sahul Shelf. The sediments of the eastern Sahul Shelf are predominantly composed of coarse-grained calcareous material that is mostly transported by strong tidal currents and seasonal cyclones (Porter-Smith et al. 2004, not seen, cited in Baker et al. 2008).

The preceding descriptions of sediment types at the Ichthys Field and along the pipeline route accord with the mapping of Baker et al. (2008, refer Figures 4.15a and 4.33a) which shows how broadly distributed are the sediment classes which will be disturbed through the construction of the Project infrastructure. The greater part of the pipeline route runs through "gravelly muddy sand" on the Sahul Shelf, except within the Bonaparte Depression where the sediments are classified as "gravelly mud" or "slightly gravelly sandy mud".

Although, as demonstrated above, there are other data sets and literature which could be referenced to more broadly describe the NW Shelf region, INPEX has chosen to utilise its extensive data sets of the Ichthys Field and pipeline route to describe the sediments of the offshore area in the Draft EIS.

INPEX's geophysical and geotechnical data sets can not be presented in full in the Draft EIS both due to the extensive size of the reports and the commercial confidentiality associated with these data sets. However, these extensive geophysical and geotechnical data, in conjunction with the environmental surveys has enabled INPEX to derive the conclusions presented in the Draft EIS, that the greater part of the vast offshore area is dominated by soft sediments, and include in the Draft EIS interpolated maps and descriptions to summarise these extensive data sets. The interpreted outputs from these surveys are included in sections 3.2.3 and 3.2.6. A bathymetric profile of the pipeline route is presented as Figure 4-15 of the Draft EIS. Further data on the characteristics of the pipeline route are included in Technical Appendix 4 of the Draft EIS.

It is well recognised that relationships exist between seafloor sediment characteristics and the biota that inhabit the seabed (e.g. Post, Wassenberg & Passlow 2006; Roff, Taylor & Laughran 2003). Hence the widespread distribution of similar sediment types shown by Baker et al. (2008) supports the premise within the EIS that the benthic communities disturbed during construction of Project infrastructure are widespread within the region. This in turn supports the assessments of impacts to ecological diversity as being of only slight to minor consequence (refer Table 7-2 of the Draft EIS).

Submission 123-21: This statement needs to be substantiated with data. Hard substrates are biodiversity hotspots. The draft EIS states that these substrates are rare in this region. The pipeline route should minimise detrimental impacts on these substrates these may play an important role in maintaining biodiversity in the region (island principle).

The ratio between non-mobile and mobile substrates should be determined.

The Draft EIS actually states that exposed outcrop was very rare *along the pipeline route*, not in the region. One of the key criteria in the selection of the pipeline route was the deliberate avoidance of exposed outcrop areas (see Section 4.3.1 in Chapter 4 *Project description* of the Draft EIS).

The proportion of the pipeline route that passes through mobile substrates is >98%, as shown in Section 3.2.3 in Chapter 3 *Existing natural, social and economic environment* of the Draft EIS.

Submission 123-22: The term pockmarks needs to be explained and described; a discussion on their relevance should also be provided.

Information on pockmarks was provided on page 48 in Section 3.2.7 of the Draft EIS and in Table 4-1 of the Draft EIS's Technical Appendix 4 *Studies of the offshore marine environment*, where it was noted that pockmarks were "thought to be related to the emission of interstitial pore water or biogenic gas derived from underlying decaying carbonate sediments".

Submission 123-27: The sampling program and methods used are insufficient to establish meaningful characterisation of community composition of offshore substrates. No benthic trawls were conducted to describe community composition. A single grab is an inappropriate method.

Submission 123-29: Methods used can not establish meaningful species richness and abundance estimates. In describing benthic communities, the EIS needs to determine the assemblages that correspond with the different sediment types encountered.

Submission 123-31: In general, this study is considered to be inadequate in describing the marine benthic habitats. See comments for Appendix 4.

Submission 123-33: This comment cannot be substantiated with any confidence. The survey conducted is not considered to be adequate, systematic, or representative of the pipeline route to enable reliable establishment of differences between sites along the pipeline. As mentioned previously, no data have been provided to allow robust comparison of results with other areas within the region.

Submission 123-200: Evidence to support this statement is limited. Data was collected using ROV and towed video and the number of sample sites is low and unlikely to account for the patchy nature of distribution of epibenthic communities. The data presented is descriptive and does not allow statistical analysis and comparison of sites. This chapter should incorporate data from other studies and discuss its findings with other studies completed for the North-West shelf. (e.g. Brewer et al 2006 and Baker et al 2008).

Submission 123-202: These data [*from geotechnical and geophysical survey of pipeline route*] need to be presented. In particular, maps and interpretation from multibeam and side scan data needs to be presented as they form the basis for site selection. This chapter needs to incorporate data from other studies and discuss its findings with other studies completed for the North-West shelf. (eg Brewer et al 2006 and Baker et al (2008). The reason why so few sites were selected needs to be explained, as the existing bathymetry shows there are numerous other sites that could have been equally as important as the ones chosen for this study. Further, sites only appear to have been chosen in areas where there is change in bathymetry. This seems appropriate for understanding the nature of the seabed in regards to laying the pipeline, but is not necessarily appropriate for a systematic description of marine epibenthic biodiversity.

Submission 123-203: (N194 offshore pipeline route benthic diversity) – To understand the importance of hard substrate vs soft substrate, the proportion between unconsolidated and consolidated substrates needs to be discussed. In general terms, hard substrates contain roughly 80% of biodiversity. Consequently, losing small areas of hard substrate may lead to substantial biodiversity loss. The methods used to semi-quantitatively assess the under water environment are unclear as is the number of sites sampled to describe the epibenthic fauna. The data presented are descriptive and are not sufficient for comparison between sites. To establish effective monitoring programs, more detailed studies will have to be undertaken.

Submission 106-5: Seabed disturbance The subsea system will consist of wellheads, “subsea trees” and associated manifolds and flowlines connected to the CPF. These wells will be drilled in the Brewster and Plover reservoirs over the life of the project in cluster formations. A MODU will be used for drilling the wellheads. The MODU, CPF and FPSO will all be fixed using anchors. The seabed will be modified by infield infrastructure including moorings, subsea trees, flowlines, manifolds, and other subsea production equipment. INPEX has calculated that 736 814 square m (or 74 ha) of the seabed in the Ichthys field will be impacted long-term and physically changed due to infrastructure.

Most of the disturbance to the offshore benthic environment is through physical disturbance only, through the placement of anchors, flowlines, manifolds and other seabed infrastructure. The physical area of disturbance caused by this infrastructure in comparison with the size of the Ichthys Field is 0.09% (Section 7.2.1 in Chapter 7 *Marine impacts and management* of the Draft EIS).

The pipeline, although of considerable length, has an outside diameter of only 42 inches (*c*.1.07 m) and hence will disturb an extremely small percentage of physical area when considering the other similar habitat in areas adjacent to the pipeline route which will remain undisturbed. As discussed in Section 7.2.1 of the Draft EIS, less than 2% of the pipeline route traverses hard or consolidated substrate. This is because extensive geophysical and geotechnical surveys were conducted to identify a pipeline route that would minimise its intersection with hard substrates.

Therefore, the 2% hard substrate is by design and not a reflection of the percentage of hard substrate in the offshore environment. There are other significant areas of hard substrate around the pipeline route which will remain undisturbed.

INPEX's benthic habitat environmental studies were designed to characterise and describe the key biological components of the offshore habitats and put them into broad context with the rest of the NW Shelf/Timor Sea.

The studies including grab sampling for infauna and pipeline route drop-camera surveys were not designed to provide a detailed quantitative comparison or statistical analysis of infauna or epifauna species community variability or evaluation of infauna community composition in relation to sediment grain size between sampling locations, or to establish a monitoring program, all of which would have required implementation of a quantitative approach. The descriptive characterisation of the offshore substrates and benthic fauna they support is an appropriate level of detail for an EIS, where the intent is to determine if the impacts of the Project will significantly alter the structure or function of an ecosystem or pose a significant threat to the biodiversity of the region.

The effort and range of benthic studies completed by INPEX is far greater than is suggested by some of the public submissions on the Draft EIS. One public submission suggests that sledge samples were not conducted by INPEX; however Section 3.2.3 of Technical Appendix 4 of the Draft EIS clearly discusses the sledge samples taken in the offshore area. Another public submission stated that "a single grab is an insufficient method". However, INPEX conducted sampling at 20 sample sites in and around the Ichthys Field, with triplicate grabs conducted for each grab sampling location (RPS Environmental Pty Ltd 2007). Further information on these benthic studies conducted is contained in Section 3.2 of Technical Appendix 4 of the Draft EIS.

The raw data sets from the geophysical and geotechnical surveys were too large to be included within the Draft EIS; the interpreted outputs from these surveys are included in sections 3.2.3 and 3.2.6 of the Draft EIS.

The sites selected for deployment of the drop camera were those at which there was the highest likelihood of encountering epibenthic biota, i.e. hard substrates, either outcrop or subcrop. A drop-camera can return limited data on benthic infauna, apart from an indication of the level of bioturbation. Hard substrates tended to coincide with changes in bathymetry, but it was the interpreted nature of the seabed (from the geophysical and geotechnical surveys), not bathymetry, that guided the selection of camera deployment sites. The number and locations of sites were agreed through discussion with Commonwealth regulators prior to undertaking the survey.

The survey deliberately focused upon epibenthic biota as they are likely to be at greater risk of impact from the pipelay operation than would benthic infauna (as described in Section 7.2.1 of the Draft EIS). This focus was considered appropriate for a number of reasons, as follow.

1. Hard substrates often have high biodiversity relative to soft-bottom substrates (Brewer et al. 2007). The submitter also notes, in NRETAS's Comment 123-203, that they may "contain roughly 80% of biodiversity".
2. Soft-bottom benthic fauna communities in the broad open ocean expanses in the region have previously been shown to be similar in structure over distances of hundreds of kilometres. Examples are as follows:
   - the Bayu–Undan pipeline route to Darwin, sites sampled between 2 km and 150 km from the INPEX pipeline route at its closest points (LeProvost Dames & Moore 1997).
   - the Prelude field, approximately 20 km to the north-east of the pipeline route at its closest point (Shell 2009).
   - the continental shelf adjacent to Big Bank Shoals, approximately 150 km to the north of the pipeline route at its closest point (Heyward et al. 1997).
   - Sunrise field, approximately 350 km to the north of the pipeline route at its closest point (SKM 2001).

   Polychaete worms and crustaceans (mainly amphipods) were the strongly dominant taxa in each of these studies, typically accounting for 80-90% of the species and individuals present. While the species of polychaetes and amphipods may have differed between locations, they would have filled similar ecological niches at each location.
3. Except where soft-bottom substrates are replaced by hard substrate (e.g. because of trenching or rock dumping), as is discussed in detail in the literature review conducted by AECOM Australia Pty Ltd (AECOM) (see Technical Appendix S1 to this EIS Supplement), these substrates will be recolonised following the completion of construction by invertebrates (with worms and crustaceans most probably dominant) that are either motile or have a planktonic larval phase.

INPEX maintains that the level of investigation was adequate for the purposes of impact assessment. It is considered that any impacts from construction of the pipeline would have only a minor consequence to the benthic communities along the route, as per Tables 6-3 and 7-2 of the Draft EIS. Any loss of ecological diversity will be on a localised scale; the community will maintain ecological integrity, even if some change in species composition or abundance does occur; and the communities, habitats and species are well represented regionally.

To support the results and conclusions of INPEX's original studies of the offshore benthic environment, as noted above INPEX commissioned a more thorough literature review of the offshore benthic environment by AECOM. This review addresses a range of issues raised in public submissions to the Ichthys Project's Draft EIS.

Specific issues addressed in relation to the offshore benthic environment include:

- appropriate levels of taxonomic identification for environmental impact assessment purposes
- comparison of INPEX's soft-bottom benthic community study results with other soft-bottom benthic community studies in Northern Australia.
- comparison of INPEX's soft-bottom benthic community study methods and effort with other major petroleum project environmental impact assessments.

A brief summary of the AECOM literature review provided the following conclusions.

Taxonomic identification to species or even family level may not always be required and in the context of assessing the potential impacts of disturbances at ecosystem level an analysis based on the diversity and distribution of habitats and functional groups is meaningful and provides insights into biodiversity, trophic structure, interconnectivity and resilience.

The results of three offshore benthic infauna studies, conducted in the Beagle Gulf, Big Bank Shoals and Gulf of Carpentaria, were compared with the benthic infauna studies of the Ichthys Field.

The comparison identified that Beagle Gulf infauna was dominated by crustaceans, molluscs and echinoderms (Smit, Billyard & Ferns 2000). At the Big Bank Shoals, polychaetes and crustaceans made up over 84% of species diversity and were also the most abundant taxa, accounting for 88% of all individuals (Heyward, Pinceratto & Smith 1997). In the Gulf of Carpentaria, again polychaetes and crustaceans accounted for 79% and echinoderms 5% of species abundance (Long & Poiner 1994). Results of sampling at the Ichthys Field are consistent with the findings of these three studies, with polychaetes and crustaceans contributing 60% of species diversity and 75% of species abundance in the Ichthys Field. In the Gulf of Carpentaria, a significant decrease in species abundance with increasing depth was identified; a result which is also consistent with the results of the Ichthys benthic infauna studies.

Furthermore, finding of underwater video, drop-camera and sledge-sampling surveys of the Ichthys Field and pipeline route were consistent with comparable studies of the Canning Bioregion off the Kimberley Coast (Fry et al. 2008).

The AECOM report also evaluates the level of detail in the offshore soft-bottom benthic community studies conducted by INPEX in relation to a range of other environmental impact assessment studies for petroleum development projects on the North West Shelf and the Timor Sea, including Gorgon, Pluto, Sunrise, Darwin LNG and Wheatstone. The review shows that investigative effort conducted by INPEX to collect information on benthic habitats and their fauna is very similar and the information is of a similar quality to these other projects.

Further details for consideration into the soft-bottom benthic communities of the Ichthys Field and pipeline route are available in the AECOM literature review provided in Technical Appendix S1 to this EIS Supplement.

Submission 123-28: The EIS needs to provide a discussion about how their community structure findings compare with other shoals within the oceanic shoal marine bioregion.

The hard coral community described in the Draft EIS as typical for the shallower areas of Echuca Shoal (<25 m depth) is similar to those described by Smith et al. (1997) for the shallower areas (15–26 m depth) of three banks (Kepah, Kepiting and Tiram) on the edge of the continental shelf in the Timor Sea, some 450 km to the north-east of the Ichthys Field. Smith et al. (1997) note that these coral communities share some similarities in composition with communities in moderately sheltered, shallow areas of Scott Reef (some 200 km to the west of the Ichthys Field), which in turn are considered a part of a broad regional association of coral communities along the outer edge of the Sahul Shelf, including Rowley Shoals (some 600 km to the south-west of the Ichthys Field) and Ashmore Reef (some 200 km to the north of the Ichthys Field).

The soft-coral and sponge communities described in the Draft EIS between 25 m and 100 m depth at Echuca Shoal are similar to those described by Smith et al. (1997) for similar depths at Sneezy and Wicked banks, also some 450 km to the north-east of the Ichthys Field.

Submission 123-32: It is unclear what the minimum size of substrate type is to qualify as “notable”. Further, why was the calcarenite outcrop not described if it was the only “notable” hard substrate type within a 97 km stretch of pipeline?

In the context of the sentence “notable” is used in a qualitative, rather than a quantitative, sense. It is intended to portray that the outcrop was the only feature of note within a section of the pipeline corridor otherwise dominated by soft sediments.

The outcrop was not located during the (unpowered) drop-camera survey due to an inability to actively search the area. While the vessel was positioned at the location of the outcrop, unquantifiable influences on the position of the drop camera by water currents, etc., over the 230-m water column prevented the outcrop from being observed.

Submission 123-34: Crocodiles (CITES II) should be included here for completeness.

Addendum – Crocodiles (pipeline route only) to Table 3-1 of the Draft EIS.

Submission 123-35: [*Dugongs*] 1st paragraph. – ensure that peer-reviewed, source references are used where possible. 3rd paragraph – cite Bayliss 1986, and also Elliott 1981. 5th paragraph – 1st sentence replace reference with better reference – e.g. Bayliss 1986.

The information presented in the first paragraph is also contained in the paper by Marsh et al. (2002).

The third paragraph refers to dugongs in the vicinity of the offshore development area, while the Elliott (1981) and Bayliss (1986) papers relate to surveys for dugongs in Northern Territory coastal waters.

The information presented in the first sentence can indeed be attributed to Bayliss (1986), as cited in Marsh et al. (2002).

Submission 123-36: There is little mentioned of foraging turtles. The likelihood that each species forages in the harbour should be provided – references that could be used include Whiting 2002

Foraging by turtles in the Harbour is discussed in Section 3.3.8 of the Draft EIS, with maps of potential foraging habitat presented in Figure 4-21, Figure 4-22 and Figure 4-23 of the EIS Supplement. Whiting (2001, 2003) are cited.

Submission 123-37: Citation needed for Fog Bay feeding turtles Whiting 2000 thesis (CDU)

The citation used for Fog Bay feeding turtles (Chatto & Baker 2008) is considered appropriate.

Submission 123-40: This section needs to discuss the strength of currents; the duration of strong currents and net exchange for areas within Darwin Harbour. Also, the meaning of “tidal excursions range” is not clear.

The strength of currents, the duration of strong currents and net exchange within Darwin Harbour have been taken into account in the hydrodynamic models used to predict the dispersal of hydrocarbon spills (Draft EIS Technical Appendix 7 *Marine hydrocarbon spill modelling*), wastewater (Draft EIS Technical Appendix 10 *Wastewater discharge modelling*) and dredge plumes (Draft EIS Technical Appendix 13 *Dredging and spoil disposal modelling*). Attention is also drawn to Technical Appendix 5 *Description and validation of hydrodynamic and wave models for discharges, spills, geomorphology and dredge spoil disposal ground selection* in which model validation is described. It is considered that the level of detail presented in the main text of the Draft EIS is appropriate.

The term “tidal excursion” was defined in the Glossary to the Draft EIS as “the net horizontal distance covered by a water molecule or particle during one complete tidal cycle of flood and ebb”. As this will vary within different parts of the Harbour, ranges (smallest tidal excursion and largest tidal excursion) for neap and spring tides are presented.

Submission 123-42: This statement ‘relatively minor’ is misleading. The NTU measurement is a surrogate for suspended solids and the relationship between NTU and suspended solids is not linear. The relationship has not been established and varies depending on the nature of the particles in suspension but a 3-fold increase in the NTU value, for example, may represent a 30-fold increase in suspended solids. If turbidity is to be used for monitoring and the description of environmental conditions, the relationship between suspended solids and turbidity measurements must be demonstrated.

Relationships between suspended solids and NTU have been established for East Arm and Middle Arm (pipeline shore crossing). These are presented in Technical Appendix S9 in this EIS Supplement.

Submission 123-43: If limited data is available on the nutrients in sediments in Darwin Harbour, detailed baseline studies need to be undertaken. Ongoing monitoring should continue during periods of waste discharge activities for both construction and operation phases.

This was an error—the sentence should refer to nutrients in water. Nutrients in sediments are discussed in Section 3.3.4 of Chapter 3 *Existing natural, social and economic environment* of the Draft EIS.

Water-quality monitoring will be undertaken during construction and operation of the Project, as described in Annexe 10 *Provisional liquid discharges, surface water runoff and drainage management plan* to Chapter 11 *Environmental management program* of the Draft EIS.

Submission 123-44: No sampling of phytoplankton through chlorophyll a measurements was undertaken in Darwin Harbour and its tributaries for this project. Again, monitoring of these parameters needs to be conducted prior to and during the construction phase. Monitoring should then be continued for any water discharge activities during the operational phase.

A water quality monitoring program is proposed (refer Annexe 10 to Chapter 11 of the Draft EIS). Appropriate monitoring parameters will be agreed with Northern Territory regulators prior to its implementation.

Submission 123-46: This subchapter fails to incorporate existing data (from other studies) to value add to the review and description of marine sediments in the harbour. The existing data plus additional collected data need to be shown in a figure and need to be discussed within the text.

INPEX welcomes the provision of additional sediment data to those described in the Draft EIS. These additional data were used to enhance the benthic habitats map provided in Section 4.1.2 of this EIS Supplement.

Submission 123-47: A number of statements are incorrect in the table: coral is not a geological unit, it is a community description; there are no carbonate deposits by corals in Darwin Harbour (unlike the Great Barrier Reef, for example); Coral “reefs” in Darwin Harbour are all coral communities on conglomerate sandstones.

INPEX contends that “coral” can also be considered a geological unit as it comprises recently deposited calcium carbonate, which does not fall within any of the other geological units within the table. Regardless, its inclusion within the table does not affect the value of the section in providing a description of the existing geological setting against which potential Project impacts can be assessed.

INPEX is in agreement with the other statements made by the respondent.

Submission 123-48: The mapping of Darwin Harbour sea floor is inadequate for the purpose of the EIS. The following issues contribute to this: • The mapping does not describe habitat in the harbour. Instead, it is a mixture of substrate data with the occasional community type added. • Neither the map nor any data provided describes the extent of biological communities. • The EIS needs separate maps for substrate type and benthic fauna/flora community types. • The data provided here is not suitable to be used for risk assessments and the development of management plans. The figure showing mangrove communities is a good example of a habitat map (Figure 3-37, page 104). This chapter is more a review of existing data and contains limited new data. The draft EIS has not described seabed communities within the footprint of impacts (should include areas that can be identified through modelling as possible impact areas and not focus alone on Darwin Harbour (ie South of the line between East Point and Mandorah). Nor has it used appropriate methods to allow assessment of community structure and differences between sites/areas. Broad community types can be described through underwater video/diver transects using higher taxonomic level species descriptors. For monitoring purposes, species specific information is required to allow development of robust monitoring programs that can deliver impact assessments and management actions. The draft EIS does not present a comprehensive description of the species assemblages found in the impact areas and reference areas. The data is descriptive, and does not allow a robust assessment of biodiversity importance/uniqueness nor does it allow a comparison between sites within impacted and non-impacted areas. It is essential to have site-specific species information. The level of species identification should be described to at least family if not genus level. The review of the marine community has only provided species level information for coral communities and skimmed over describing site-specific species level community structures at non-coral communities on hard or soft substrates. It has resorted to phylum level identification, which is inadequate.

Submission 16-18, 36-2, 89-18, 96-17, 101-19, 102-17: Production of a whole-of-Darwin Harbour habitat map to allow for rigorous assessment of the scale of impacts on marine biodiversity both spatially and temporally.

Submission 123-53: The equivalent information is also available for polychaetes, viz. It is estimated that there are about 70 species of polychaetes in the mangrove sediments in Darwin Harbour (Metcalfe & Glasby 2008). [Metcalfe, K. N. and C. J. Glasby (2008). Diversity of Polychaeta (Annelida) and other worm taxa in mangrove habitats of Darwin Harbour, northern Australia. Journal of Sea Research 59(1-2): 70-82.]

Submission 123-75: It is difficult to differentiate some of the proposed habitats in the maps. Clarification should be provided in the EIS of the areas that were surveyed to produce the habitat map or the methods used to derive the maps in the absence of habitat surveys.

Submission 123-91: The draft EIS has not been able to support this statement with data (either published in peer reviewed publications or newly collected data) as there is no evidence of the extent of this habitat in the harbour. Given this level of uncertainty in the data, the risk assessment is limited.

Submission 123-92: The assumption that disturbed areas will be recolonised rapidly is not supported by the existing literature. Many motile fauna need non – motile seabed fauna as a refuge. The full recovery of motile fauna can only occur when non-motile fauna has been established. For example, the rock armour that has been placed on the Conoco Phillips pipe line which, after 10+ years, still has not reached similar assemblage compositions as that of other hard substrate environments in the harbour. Further, dredging activities, both for this project and others, would be continual increasing suspended sediment loads and sediment deposition in the Darwin Harbour region. These factors have well known negative effects on recruitment of epibenthic communities. Therefore, the recovery of these substrates is very long-term and monitoring should be put into place to assess its recovery. The EIS should also discuss the impact from the scouring effect of propellor currents, which may delay the return of assemblages to their pre-disturbance composition.

Submission 123-93: The draft EIS has not been able to support this statement with data (either published in peer reviewed publications or newly collected data). Currently there is no documented evidence of the extent of this habitat in the harbour.

Submission 123-94: The draft EIS views the consequences of replacing soft substrate with hard substrates as a positive, however, this is an assumption. There are implications to the trophic systems of the Darwin Harbour ecosystem. These have not been considered in the draft EIS. If this is used as a mitigating factor, then a discussion of how this change may impact on the Darwin Harbour ecosystem and to what degree changes may occur should be provided, supported by documented evidence where appropriate.

Submission 123-95: As there is no habitat map for Darwin Harbour (as a whole) this statement needs to be supported by the appropriate data. There is also very little information provided on Walker Shoal to inform its significance in Darwin Harbour.

Submission 123-96: The residual risk should be considered at least to be medium to high, as these habitats might be at risk of being altered (with unknown recovery rates) or lost with no recovery. Very little is known about these habitats to make informed decisions and therefore a precautionary approach should be taken.

Submission 123-99: A key habitat has been omitted from the discussion: subtidal deposition areas (i.e. soft substrate areas in low tidal energy environments). Subtidal soft substrates are important feeding grounds for many species of fish (eg Blaber, 2000). Subtidal flats also play an important role in the trophic ecosystem (eg McKinnon 2006). The EIS needs to provide an assessment of all areas (including seagrass meadows) that are likely to be impacted by sediment deposition (short or long-term perspectives) and not solely devote its assessment to corals.

Submission 123-102: There is no discussion of what is a tolerable threshold for burial of infauna (as done with mangroves). Infauna play an important role within the trophic ecosystem structure of Darwin Harbour. Assuming the impact as minor without supporting data is inappropriate. Any assumptions should be explicitly stated. If the information is not available, then monitoring should be designed to establish the sedimentation thresholds and identify if there are any impacts from additional sedimentation. This should not only focus on mangroves, but also on other benthic communities where sediment deposition is expected (e.g. seagrass meadows at Fannie Bay and Casuarina Beach and subtidal soft bottom substrate communities).

Submission 123-103: This is a possibility, but the seaward zone is dominated by herbivorous polychaetes (Metcalfe & Glasby 2008), which may well decrease in abundance/diversity as a result of increased sedimentation.

Submission 123-104: No evidence to support the statement is provided. This is a major weakness in the assessment of potential impact on a very important ecological community in Darwin Harbour.

Submission 123-115: Monitoring before and after impacts is not sufficient and needs to be conducted throughout the development stage of the project and a number of years after dredging and dredge spoil disposal have been completed. Monitoring sites need to be established in all areas that are identified as possible impact areas by sediment and hydrodynamic modelling.

Submission 123-126: Information presented does not adequately identify the risks of sedimentation to coastal dolphins. Sediment build-up between Lee Point, the Howard River and in Shoal Bay has the potential to impact indirectly upon the Indo-Pacific humpback and the Indo-Pacific bottlenose dolphins due to loss of prey. Northern Territory Government sighting data locations indicate that the Indo-Pacific humpback dolphins are regularly recorded at Howard River, Hope Inlet and Shoal Bay and foraging was the dominant behaviour recorded (Fortune et al 2009; Palmer 2010). Bottlenose are regularly recorded around Lee Point and between Buffalo Creek and Shoal Bay (Palmer 2010).

Submission 123-128: The statement is based on the assumption that mobile species will be able to dig themselves out of the pile of dumped dredge spoil. There is no mention how thick these piles will be. Monitoring needs to establish: (1) a baseline of infauna present (not adequately described in relevant chapters); (2) The levels of burial that species may be able to recover from and; (3) The time required for dumped substrates to establish fauna assemblages comparable with surrounding non-impacted substrates.

Submission 123-132: The sampling design (3 nm grid sampling effort) for Smit et al (2000) is appropriate for a large scale biodiversity survey. Additional, finer-scale surveys should take place to describe benthic communities in more detail. Dugong surveys have identified the area as important feeding grounds. The presence of dugongs is indicative of the presence of seagrass meadows. That these sites are a focal point for dugongs would appear to indicate that seagrass meadows are sufficient enough to support a significant number of dugongs. Monitoring programs need to include these sites.

Submission 123-168: Surveys conducted were inadequate to assess possible impacts from dredging and dredge spoil disposal. Further, they were not comprehensive and excluded key habitats such as seagrass meadows and subtidal benthic environments.

Submission 123-135: Monitoring before and after impacts is not sufficient and needs to be conducted throughout the development stage of the project and a number of years after dredging and dredge spoil disposal have been completed. Monitoring sites need to be established in all areas that are identified as possible impact areas by sediment and hydrodynamic modelling.

Submission 123-136: There remain a large number of uncertainties in establishing an appropriate risk level. The draft EIS has not provided sufficient detail of community structure of epibenthic communities in impacted and reference areas; it has not provided detailed methodologies and the resolution for which it can measure an impact. A precautionary approach should be adopted thus giving dredging and dredge spoil disposal a high risk level, until additional data has been provided.

Submission 123-172: Information for subtidal, soft-bottom monitoring needs to be provided.

Submission 123-205: This report has not provided sufficient information to allow mapping and analysis of existing biodiversity/seabed habitats. The information provided does not allow an assessment of the status and condition of seabed habitats, seagrasses and benthic biodiversity in the complex ecosystem of Darwin Harbour and surrounding marine environments. It does not provide baseline data that will allow the establishment of benchmarks and performance indicators for feedback to management, or facilitate risk assessment and detection of anthropogenic impact in seabed ecosystems (e.g. dredging/ dredge spoil disposal) among the range of other natural environmental variability. Additional surveys need to be conducted to describe benthic communities that will allow robust analysis of community structure; comparison between sites; and allow for mapping the extent of broad community types.

Submission 123-209: Methods used in the field study don't allow assessment of conditions of biological communities. A more comprehensive description of ambient factors and community components is required.

Submission 123-210: The outcomes and discussion from the literature review??, and the list of external and internal data that were used to assist in characterising marine habitats, should be provided.

Submission 123-211: The purpose of the surveys was to describe seabed habitats and characterise epibenthic fauna and flora communities. The EIS needs to define 'significant communities' and clarify why they are considered significant. The methods used are descriptive and do not allow quantitative assessment of community composition within Darwin Harbour. To allow comparison between sites, a minimum of six sites (transects with replication) would be needed to allow some form of robust analysis. This survey design must enable the following: (1) A comprehensive and adequate assessment of spatial distribution of assemblages. There are currently no maps presented with the extent of assemblages found in Darwin Harbour. Site selection seems to be based on prior knowledge and areas primarily targeted with preconceived ideas of what constitutes a significant habitat. (2) An assessment between sampled sites to identify if any areas are more important (for what ever reason) than others. The survey design only allowed site inspections of the foot print of the development but failed to include an assessment of seabed communities within impact areas that have been identified by hydrodynamic modelling and sediment modelling. This section must present existing data or combine existing data with collected data to show existing knowledge. Macro algal communities appear to have been ignored.

Submission 123-219: Given that Walker reef/shoal has been identified as a major impact area (total loss of habitat), it is a major oversight that this reef has not been included in the assessment process, and has not been fully mapped, described and assessed against similar assemblages in Darwin Harbour. The EIS needs to contain this information.

Submission 123-222: Identification of specimens is inadequate and does not allow robust analysis of community assemblages. Grouping into major taxonomic units may be the first step towards identifying where comprehensive sampling should take place, but is not adequate for community structure assessment. Diversity assessment is inappropriate at this level. Identification at Phylum level may only account realistically for 20% of the existing diversity, where as if specimens were identified to genus level, then 80% of existing biodiversity would be accounted for. Species identification should at the least be at a Family level, but preferably at a genus level.

Submission 123-229: This survey cannot be conclusive for the following reasons: (1) no areas outside the development footprint were surveyed; (2) biodiversity measures are not comparable with other studies; and results between methods are not comparable; (3) no studies have been conducted to determine the extent of existing seabed communities and therefore it cannot be stated with any confidence that a particular community type is widely distributed or not; and (4) survey design has not established the nature of patchiness of seabed communities and therefore cannot determine if the composition of seabed communities is uniform or not. The EIS needs to address these issues.

Submission 123-230: This statement is not supported by the data presented: no thorough, consistent studies of benthic communities composition (such as benthic fauna and flora density and biomass assessment) was undertaken, no thorough taxonomic identification of fauna was completed, sampling design chosen for field works was inappropriate and no statistical analyses were conducted to process the data (only percentage was calculated). The benthic communities' biodiversity and abundance assessment study needs to be a quantitative study.

Benthic habitat comments are addressed in sections 4.1.1 to 4.1.6 of this EIS Supplement.

Submission 123-49: East Point Aquatic Life Reserve, Dudley Bommies and the Pinnacle are also localities of well known coral-dominated communities within Darwin Harbour.

Noted. It was not the intent of the section to describe all of the known coral communities within Darwin Harbour.

Submission 123-50: The epibenthic community on Walker shoal would be lost due to blasting. The draft EIS has not dedicated a section to describing in detail (to species community level) the fauna and flora present; discussed its importance/relevance within the Darwin Harbour ecosystem; and likely implications of loss of biodiversity for Darwin Harbour.

The Walker Shoal epibenthic communities have been the subject of an additional survey, the outcomes of which are presented in Section 4.1.5 of this EIS Supplement.

Submission 123-52: The reference Whiting 2004 is probably incorrect. If so, replace with Whiting, S. D. (2002). Rocky reefs provide foraging habitat for dugongs in the Darwin region of northern Australia (Whiting 2002).

The submitter is correct: the reference should be to Whiting (2002). This reference was used in the Draft EIS's Chapter 3 *Existing natural, social and economic environment* and it has been added to the reference list for this EIS Supplement for the record.

Submission 123-55: The EIS needs to provide an assessment of the degree to which the community structure associated with the pipeline compares to similar naturally occurring habitats. The draft EIS uses the rock armour and pipe line as a positive outcome by creating additional hard substrate for epibenthic communities to establish. However, it does not discuss to what extent this will happen, how long it will take for an assemblage to develop into comparable habitats that have developed under natural conditions.

INPEX maintains that the suggested research, while potentially of scientific interest, is not necessary for the purposes of this impact assessment. It is considered that the epibenthic communities which will establish on the rock-armour and pipeline will not need to be identical to those occuring on natural hard substrates for them to provide a similar ecological function. It is noted that in comment 123-21 the respondent refers to hard substrates as "biodiversity hotspots", which supports the notion that replacing the existing soft-sediment substrate along parts of the pipeline route with hard substrate will lead to an increase in biodiversity. It should also be noted that in Section 7.3.1 of Chapter 7 *Marine impacts and management* of the Draft EIS it is stated merely that this change "may be viewed as a positive impact by some stakeholders" (page 305) and that it "may benefit recreational fishing resources" (Table 7-29); it is not used as a mitigating factor to reduce the residual-risk ranking. The popularity with recreational fishermen of the numerous artificial reefs within and outside Darwin Harbour suggests that they support biological communities which are sufficiently similar in nature to those associated with natural hard substrates.

Submission 123-57: All these species are listed as Data Deficient under the Territory Parks and Wildlife Conservation Act. Additionally, the whale shark is also data deficient under NT legislation and the flatback turtle is data deficient on IUCN.

As indicated in the text introducing the table, it lists those species that are categorised as "critically endangered", "endangered" or "vulnerable". The en rule "–" symbol was not intended to indicate that a species is not listed under the particular Act or Convention. It is accepted, however, that a footnote to this effect would have been helpful.

Submission 123-58: Remove Whiting 2003 from 2nd paragraph as it doesn't relate to this group.

It is agreed that Whiting (2003) is not an appropriate reference in this instance.

Submission 123-59: Although data are lacking on the location and range of Humpback whales, anecdotal reports of sightings from Coastwatch Flights and the public suggest there are more regular sightings of the species in NT waters. An NTG project has recently identified the NW coast of the NT as becoming increasingly used by humpback whales, on the southward migration at least. This information suggests that humpback whales might be more common in NT Waters than previously thought, but there is a lack of quantitative data to support this.

INPEX would welcome the provision of the sighting reports from Coastwatch flights (and from the public, if available) and information from the Northern Territory Government project, in order to enhance its understanding of humpback whale movements in the vicinity of the proposed pipeline. While it is accepted that humpback whales might be more common in Northern Territory waters than previously thought, the greater numbers would not elevate the residual-risk categories pertaining to the potential stressors described in sections 7.2.6 and 7.2.9 in Chapter 7 *Marine impacts and management* of the Draft EIS. It is considered that the risk of impacts upon humpback whales will be adequately mitigated through the implementation of the final cetacean management plan (see Annexe 4 *Provisional cetacean management plan* to Chapter 11 *Environmental management program* of the Draft EIS).

Submission 123-61: Remove Mustoe 2008 and use a better reference such as Parra et al. 2004. The former reference is an unpublished report; peer-reviewed references should be used preferentially where possible.

Mustoe (2008) is a valid reference, but the reviewer's preference for peer-reviewed references is noted. Parra, Corkeron and Marsh (2004) also describe the distribution of Indo-Pacific humpback dolphins within northern Australian waters; this paper has been placed in the reference list of this EIS Supplement.

Submission 123-69: General comment: there have been no formal studies or assessments of sea turtles in Darwin Harbour. For this reason it is difficult to assess likely impact. It is known from other studies and observations that significant foraging areas occur outside Darwin Harbour in adjacent areas. Anecdotal observations indicate that green, hawksbill, flatback and olive ridley turtles occur inside Darwin Harbour but the significance of the harbour to these species is not understood.

INPEX has taken the approach that areas of the Harbour known or inferred to contain food items for species of turtle known to utilise the Harbour (such as fringing mangrove for green turtles and filter-feeding communities for hawksbill turtles) are potential turtle habitat and should be assessed as such. See Section 4.1.3 of this EIS Supplement for a discussion of the proportion of these habitats at risk of impact from construction activities (i.e. indirect impacts to turtles).

Submission 123-70: Mention should be made within the EIS of the educational importance and thus significance of nesting turtles on Casuarina Beach, which is the only capital city beach in Australia where this occurs.

The educational value of having turtles nest on Casuarina Beach is recognised. This could be considered to be of social, rather than ecological, significance.

Submission 123-74: This statement is not substantiated. The EIS needs to cite the most current information and should include recent Northern Territory Government data. Dugongs are regularly recorded foraging in Fannie Bay (Palmer 2010).

The full statement, that "dugongs could occur anywhere in the Harbour that could support seagrass or algae" is self-evident as there are no barriers to their movement within the Harbour. It is recognised that Palmer (2010a) recorded the presence of dugongs in Fannie Bay, though it is noted that foraging behaviour is not mentioned in this report.

Submission 123-76: More discussion is required on protected species such as seahorses, which do occur in Darwin Harbour and are associated with fringing reefs and mangroves. All seahorse species are listed as "Marine fauna" under the EPBC Act. Generally, more attention needs to be given to sea turtles, sharks, rays and sawfish in the EIS.

The presence in Darwin Harbour of syngnathids (seahorses and pipefishes) is recognised in sections 3.3.6 and 3.3.8 in Chapter 3 *Existing natural, social and economic environment* of the Draft EIS. However, there appears to be a paucity of literature, either in the form of peer-reviewed published reports or unpublished reports, that provides information on the likely habitats for these fishes within Darwin Harbour. In addition to Larson (2003) and Larson and Williams (1997), both of which are cited in the Draft EIS, Pogonoski, Pollard and Paxton (2002) list the following species as being recorded from within Darwin Harbour or in the Darwin region:

- ringed pipefish (*Dunckerocampus dactyliophorus*), which is recorded as inhabiting protected coastal reefs (Pogonoski, Pollard & Paxton 2002) and therefore may possibly inhabit some of the rock platform habitats within Darwin Harbour. This species is listed on the IUCN Red List as "data deficient" (Sorensen & Vincent 2009), signifying that there is inadequate information to make an assessment of its risk of extinction based on its distribution or population status (IUCN 2001). Pogonoski, Pollard and Paxton (2002) suggested an Australia-wide conservation status of Lower Risk (least concern) was appropriate, meaning that the species does not qualify as critically endangered, endangered, vulnerable or near threatened (IUCN 2001).
- shortkeel pipefish (*Hippichthys parvicarinatus*), collected from mudflats; mangroves; gravel, sandy and rocky habitats; and coral and shell rubble. This species does not appear on the IUCN Red List (IUCN 2010c), though Pogonoski, Pollard and Paxton (2002) suggested that an Australia-wide conservation status of "lower risk" ("least concern") was appropriate.
- low-crown seahorse (*Hippocampus dahli*), collected from rubble substrates and estuary channels (Pogonoski, Pollard & Paxton 2002) which do occur within Darwin Harbour. This species does not appear on the IUCN Red List (IUCN 2010c), though Pogonoski, Pollard and Paxton (2002) suggested an Australia-wide conservation status of "lower risk" ("near threatened") was appropriate, signifying that it does not qualify as critically endangered, endangered or vulnerable now, but that it is close to qualifying for, or is likely to qualify for, a threatened category in the near future (IUCN 2001).
- common seahorse (*Hippocampus taeniopterus*), a coastal shallow-water species that has been recorded along the edges of seagrass beds or in mangroves (Pogonoski, Pollard & Paxton 2002). This species does not appear on the IUCN Red List (IUCN 2010c), though Pogonoski, Pollard and Paxton (2002) suggested that listing the species as "data deficient" was appropriate.

In regard to sea turtles, sharks and sawfish, INPEX contends that, for the purposes of impact assessment, an appropriate level of detail for each group is presented in Section 3.3.8 in Chapter 3 of the Draft EIS.

Submission 123-79: Table 3.14 does not list any migratory bird species protected under the EPBC Act. A large number of migratory bird species use Darwin Harbour and Shoal Bay area. The overall objectives and justification for the project, as requested in Section 4.2 of the guidelines, are not clear in the draft EIS.

As indicated in the text introducing the table, it lists those species that are categorised as "critically endangered", "endangered" or "vulnerable". As also indicated, a full list of species, including those listed as migratory under the EPBC Act, is provided in Technical Appendix 16 of the Draft EIS.

It should be noted that surveys by Chatto (2003) showed that the number of shorebirds within Darwin Harbour was "modest" compared with the islands off Bynoe Harbour and along the coast to the east of Darwin and it was concluded that the Harbour was not a significant area for shorebirds.

Submission 123-81: The construction of the causeway to Blaydin Point, potential impacts and mitigation measures needs to be discussed. The causeway has the potential to impact tidal flows and ecological functioning of the tidal flats. Shorebirds in the area may be affected (see Ray Chatto, Technical Report, 73/2003, The Distribution and Status of Shorebirds around the Coast and Coastal Wetlands of the Northern Territory, Parks and Wildlife Commission of the Northern Territory). Mapping of shorebird habitat is required.

The proposed alignment of the causeway between the MOF and Blaydin Point is orientated perpendicular to the mangrove fringed shoreline and it does not truncate any tidal creeks or channels that direct tidal flows into mangroves or adjacent tidal flats. Therefore it is not expected that tidal flows into adjacent mangrove and tidal flat areas will be modified by the presence of the causeway or that the ecological functioning of these areas will be impacted by this factor. In addition, culverts will be installed in the causeway to allow tidal flow. The mangroves adjacent to the MOF (and causeway) will be monitored as part of a Mangrove Health Monitoring Program (see Table 11-5 of the Draft EIS).

In Darwin Harbour, shorebirds forage on the extensive areas of low tidal mud and sand flats (when exposed during low tides) that are located seaward of the mangrove shoreline. In the context of these extensive areas of tidal flats, the area to be directly impacted by the MOF and causeway is very small and hence the construction of the MOF is unlikely to present any significant threat to shorebird populations in Darwin Harbour. Surveys of shorebirds along the Northern Territory coast included a survey block that extended from Fog Bay to Point Stevens, this including Bynoe Harbour and the islands to its west, Darwin Harbour and the Vernon Islands (Survey Block 4 in Chatto 2003). Within this block, shorebirds were found to be widely distributed and due to the coast being thickly lined with mangroves, overall densities of shorebirds were not generally high. The Blaydin Point area was not recognised as an important area for shorebirds or an area that had significant populations of shorebirds by comparison with other sites in the survey block.

Submission 123-82: The Final Dredge and dredge spoil management plan needs to be resubmitted and reviewed with all updated information before dredging commences

As indicated in Section 11.4 in Chapter 11 *Environmental management program* of the Draft EIS, INPEX will submit a final dredging and dredge spoil disposal management plan in accordance with the requirements for dredging and spoil disposal approval under the *Waste Management and Pollution Control Act* (NT) and the *Water Act* (NT). This management plan will be developed, in consultation with the Department of Natural Resources, Environment, the Arts and Sport (NRETAS), once a dredging contractor is engaged and will include an updated description of the dredging methodology, should this change, and updated modelling. The plan will require approval by NRETAS before dredging commences.

Submission 123-83: This creates significant uncertainty regarding predictions from sediment modelling and therefore ability to assess risk to benthic habitats and marine species. Finalised dredging methodologies and the duration of dredging is required to assess associated impacts. If the final dredging operation is altered from that proposed in the EIS such that the environmental significance of the project could be changed, a notification of alteration to the project must be referred under clause 14A of the Environmental Assessment Administrative Procedures.

Submission 123-84: Figures need to be provided to illustrate the increase in the number of trips to the spoil ground based on this modification. This increases shipping traffic and extends the duration of total dredging.

Conservative predictions of impacts from the dredging program were presented in the Draft EIS, based upon the dredging methodologies described in Section 4.4.4 of Chapter 4 *Project description*. Remodelling of the dredging program will be undertaken once the methodologies are finalised. It is recognised that notifications will be required if the predicted environmental impacts are greater than those presented in the Draft EIS. However, because of the conservative assumptions made throughout the environmental assessment process, INPEX is confident that the predictions of potential impacts encompass the full range of activities and risks that may occur as a consequence of the proposed dredging activities. The dredging tender which is to be released by INPEX specified that the selected method of dredging must not result in any significant change to the predicted levels of impact described within the Draft EIS.

Numbers of hopper barge trips can not be provided until the dredging contractor is appointed and dredging methodologies and schedules finalised. Therefore, data on proposed hopper barge movements to the dredge spoil disposal ground will be provided through the submission of the final dredging management plan, which will be prepared by the dredging contractor.

Submission 123-85: More information regarding measures to avoid, mitigate and manage impacts of lighting on marine megafauna and migratory birds is required for both onshore and offshore components of the proposal. Lighting has the potential to attract marine megafauna and migratory birds. For example, the light glow of Darwin Harbour is known to impact on the orientation of adult turtles at Bare Sand Island (50 km west of Darwin). Lighting design and luminaries should be best practice and should not add significantly to light pollution.

Appropriate lighting is required to provide safe working conditions and to minimise the potential for safety and environmental hazards. Lighting will be designed in accordance with the relevant Australian and international standards.

The offshore facilities including the CPF and FPSO will be located approximately 30 km from Browse Island, the nearest turtle – and bird-breeding location to the Ichthys offshore development area. At this distance, no significant impacts to turtle-nesting or seabird-breeding on the beaches of Browse Island are anticipated. Scott Reef and Adele Island (the next closest bird – and turtle-breeding islands) are more than 150 km from the CPF and FPSO. There is no evidence of light-related impacts to migratory bird species from petroleum facilities on the North West Shelf.

Large marine animals in Darwin Harbour are not anticipated to be significantly affected by light from the onshore processing plant and related facilities, as these animals in the Harbour are already continually exposed to lights from many sources, including the Darwin central business district waterfront, East Arm Wharf and the Darwin LNG plant facilities. In the absence of an integrated and regional approach to lighting management across Darwin Harbour there is no benefit in unilateral light reduction in respect of either the large marine animals of Darwin Harbour or the turtles nesting on Bare Sand Island.

Submission 123-98: Wolanski et al (2006) identified that flocculation is a key sedimentation process in the harbour where freshwater and saline water mix. No modelling of suspended sediments for dredging activities appears to have been undertaken. The EIS also needs to explain the extent to which the model will be verified with evidence-based data and how this will be incorporated into management actions.

The submission refers to Table 7-29 in Chapter 7 *Marine impacts and management* of the Draft EIS which is a summary of impact assessment and residual risk. There is substantial evidence of the use of sediment transport models presented in the Draft EIS's Technical Appendix 13 *Dredging and spoil disposal modelling* which was summarised in Section 7.3.2 of Chapter 7.

Flocculation (in this context) is the process of small particles aggregating to form large ones which then sink more rapidly to the seabed. The gross effect of flocculation has been included within the fine grained sediment transport model; the average settling velocity for fine material of 1 mm/s has been simulated. This property is fixed across the model domain. The model does not consider the interaction of freshwater flow and any potential stratification/interface within Darwin Harbour. Although INPEX acknowledges that the level of background turbidity in Darwin Harbour varies with tidal state and location, the input of fresh water within the Harbour is relatively small in comparison with the tidal volume and exchange and therefore the Harbour is likely to be well mixed, unless a freshwater flow event of significant magnitude occurs. Therefore, it was considered appropriate to represent settling velocity uniformly across the model domain.

In regard to verification using "evidence-based data", the reader is referred to Technical Appendix 12 *Description and validation of hydrodynamic and wave models for dredging and spoil disposal* which provides in detail the process used for validation of the model by comparison of predicted with measured values and the application of sensitivity analysis to test the significance of assumptions made.

Submission 123-100: Figures 7-18a to 7-20b Legends are not clear. Are suspended solids concentrations absolute values or above background levels?

As indicated in Section 7.3.2 (page 309) in Chapter 7 Marine impacts and management of the Draft EIS, the predicted suspended-sediment concentrations (shown in figures 7-18 to 7-20) are additional to background concentrations. INPEX acknowledges that a statement to this effect within either the legends or captions to the figures would have made this more evident.

Submission 123-101: This statement [*sediment accumulation on the subtidal seabed in Darwin Harbour occurs mainly within the dredging foot print*] is incomplete and disregards the potential for sediments to be deposited in low energy environments. For example, NTG hydrodynamic model shows eddies in the vicinity of East Arm Wharf; Power and water information has shown a bathymetric depression just north of East Point between the intertidal areas and sand waves just in front of East Point. Any subtidal areas with a large proportion of fine sediments should be regarded as deposition areas and should be monitored because these are the areas where sediments will accumulate in the long-term.

This statement relates to the settlement of sediments disturbed by dredging. The accretion of sediments in the vicinity of East Arm Wharf throughout the dredging program is clearly shown in Figures 84 to 93 of Technical Appendix 13 of the Draft EIS. These figures also show that no sediment accumulation of more than 5 mm is predicted to the north of East Point.

Figures 120 to 124 of Technical Appendix 13 of the Draft EIS show minor (5–10 mm) sediment accumulation on the north side of East Point, but not within the bathymetric depression described by GHD (2009), as a result of dredge spoil disposal.

Submission 123-105: The interpretation of the tolerance limits of corals by Erftemeijer and Reigl (2008) is not complete.

Erftemeijer and Reigl (2008) wrote about ranges rather than minimum thresholds. For example, the following passages from the original text illustrates this point:

- "Minimum light requirements of corals range from <1% to as much as 60% of surface irradiance."
- "Tolerance limits of corals for suspended sediment concentrations range from <10 mg l^{-1} in pristine reef areas to 40 or even 165 mg l^{-1} in marginal near shore reefs."
- "Maximum allowable sedimentation rates for corals range from <10 mg cm^{-2} day^{-1} to >300 mg cm^{-2} day^{-1}. The duration that corals can survive high sedimentation rates range from <24 hours for sensitive species to >14 days (complete burial) for very tolerant species."

The disparity between the interpretation of the literature and what is written in the draft EIS has considerable implication for management of impacts associated with coral communities and the proposed dredging program.

The text in the Draft EIS was tailored to address the tolerance limits of corals within Darwin Harbour, which live under conditions of naturally elevated turbidity levels, suspended sediment concentrations and sedimentation rates. INPEX contends that the thresholds quoted by Erftemeijer and Reigl (2008) for pristine reef areas and (sedimentation) sensitive species would not be applicable to the coral communities in East Arm or at Channel Island.

In addition, it should be noted that the tolerance limits quoted are not being used to set threshold limits for monitoring during dredging. These thresholds will be set from a water-quality data set collected over a 12-month period prior to the commencement of dredging, as described in Section 4.1.1 of Annexe 6 *Provisional dredging and dredge spoil disposal management plan* to Chapter 11 *Environmental management program* of the Draft EIS). This management plan will be fully developed in consultation with the regulatory authorities and approved by them prior to the commencement of dredging.

Submission 123-106: These statements are largely unsubstantiated and do not account for a clear lack of understanding of the potential for impacts from dredging. The following points can be made in relation to this:

4. No turbidity and sedimentation rate measurements have been presented in the draft EIS to support the idea that the environment at Channel Island, at South Shell Island, off the north-east coast of Wickham Point and at Weed Reef is as turbid as elsewhere in Darwin Harbour. No comparison of turbidity and sedimentation rate was made for coral communities locations and other areas of Darwin Harbour.
5. Information in Figure 3-16: Marine habitats in Darwin Harbour (Chapter 3, Existing natural, social and economic environment) suggests that hard bottom habitat areas are common in Darwin Harbour. However coral communities are confined to only a few locations with relatively low water turbidity and low sedimentation rate/ high hydrodynamics – “refuges” where coral can growth. Alteration of water quality resulting from dredging may severely degrade coral communities in these locations.

Turbidity data for South Shell Island and two other sites (one in East Arm, the other in the main body of Darwin Harbour) are presented in the Draft EIS’s Technical Appendix 9 *Nearshore marine water quality and sediment study*. Comparisons between the sites are presented in Chart 3-5 of the appendix, which shows that turbidity levels at South Shell Island (site 5) are typically not dissimilar to those in the body of the Harbour (site 3). It should be noted that the Draft EIS text to which this comment refers does not make reference to comparisons of turbidity or sedimentation between coral community locations and other areas of the Harbour.

As indicated in Technical Appendix 9, data were also collected at the north-east Wickham Point and Channel Island coral communities. Data from only three sites were presented, however, to enable a clear discussion of the water-quality gradient within East Arm. Further, a substantial turbidity data set has been collected over a 12-month period at the aforementioned coral communities, and also at the Weed Reef community.

The risk of degradation to the coral communities from dredging is acknowledged in Section 7.3.2 in Chapter 7 *Marine impacts and management* of the Draft EIS. However, INPEX maintains that any degradation that does occur will be reversible over time as the conditions improve to the extent that the surviving corals within the community can continue to grow, and that larvae from unaffected corals elsewhere in the Harbour can settle and grow.

Submission 123-108: This statement ignores a key contextual factors relating to the amount of accretion occurring. If this hypothesis is used as a mitigating factor, then there is a clear need to collect data to establish the maximum amount of sedimentation infauna can tolerate before adverse effects are seen. This would help to establish trigger values for monitoring purposes.

Submission 128-18: Dredging. Disturbance of sea bed sediments will cause sediment transport and deposition to adjacent parts of the harbour as well as increased turbidity over a period of time.

The Draft EIS requires further information on the impacts on water quality and biodiversity of increased turbidity over an extended period of time. It is not clear how long the elevated levels of turbidity in the harbour will be sustained and how long for.

Water quality objectives for Darwin Harbour state: 10mg/l suspended sediment concentrations in the dry season. Given this, the amounts quoted in the EIS means this figure will be exceeded. What is the management arrangement for this situation and is it anticipated that there is some special dispensation for INPEX in this regard by the NT Government?

The sediment accumulation along the shoreline and in the tidal creeks will increase areas where water will pond. This in turn this has the potential to add to the availability of mosquito breeding habitat. How will this be monitored and managed? Ref. Table 7-23

The effects of sediment smothering on invertebrate fauna and mangrove habitats need to be appropriately monitored. Desk top analysis of mangrove density and coverage does not provide the detail required to fully understand these impacts. Stringent monitoring and control measures will need to be in place to measure the actual impacts.

The effects of increased turbidly and sediments on the coral communities in the harbour need to be quantified as the assumption made in the Draft EIS is that what is quoted is appropriate. The “Precautionary Principle” should be applied to these habitats as these communities do not appear to be well represented in the harbour. Again due to the lack of available data these habitats should be considered as an important part of the biodiversity of the harbour and protected and monitored closely.

The potential impacts of increased turbidity on water quality and biodiversity are addressed in sections 7.3.2 and 7.3.3 of Chapter 7 *Marine impacts and management* of the Draft EIS. The durations over which elevated turbidity levels are predicted to be sustained, at four locations in Darwin Harbour, are presented as figures 8, 10, 12 and 14 of the Draft EIS’s Technical Appendix 13 *Dredging and spoil disposal modelling.* Figures 28 and 39 in the same appendix show that there are very limited areas within Darwin Harbour where the additional suspended-sediment concentration will be greater than 10 mg/L over the 6-month period following the completion of the dredging program (Phase 10). It is considered reasonable to expect that with no further sediment inputs from dredging, these areas will diminish in size as the settled sediments become incorporated into the natural seabed.

It is clear from figures 18 to 39 in Technical Appendix 13 of the Draft EIS that at times during the dredging campaign large areas of East Arm will be subject to temporary elevations in suspended sediments greater than 10 mg/L (as described in Section 7.3.2 of Chapter 7 of the Draft EIS). While the water-quality objective for total suspended solids (TSS) will be exceeded at these times, it is important to note that the objective is not a strict criterion but a measure of management performance (and that suspended-sediment concentrations routinely exceed 10 mg/L under natural conditions because of tidal currents, wave action, etc.). The acceptability (or otherwise) of the predicted magnitude, duration and areal extent of suspended sediments greater than the objective value will be assessed by the appropriate regulatory authorities during the dredging approvals process. Management measures will be implemented through an approved dredging and dredge spoil disposal management plan (see Annexe 6 *Provisional dredging and dredge spoil disposal management plan* in Chapter 11 *Environmental management program* of the Draft EIS).

With respect to concerns over the potential for sediment accumulation along the shoreline and in creeks to increase mosquito-breeding habitat, INPEX contends that the sediments are most likely to be deposited as a succession of thin layers over the areas of deposition rather than forming barriers behind which water can become trapped.

Monitoring effects of sedimentation on invertebrate fauna

It should be noted that INPEX does not consider Smit’s hypothesis to be a mitigating factor. Rather, it provides potential explanations as to why worms continue to be present in areas of (natural) sand waves in East Arm.

Attention is drawn to Table 11-5 in Chapter 11 of the Draft EIS, which summarises the monitoring programs for the receiving environment which will be developed and implemented by INPEX. The list includes a monitoring program to document the effect of increased sedimentation on soft-bottom benthos communities in zones potentially impacted by dredging. This does not constitute *reactive* monitoring, that is, monitoring in which management actions are implemented if predetermined thresholds are exceeded. Discussion on the tolerance of infauna to sedimentation is included in Section 4.1.3 of this EIS Supplement. It is hypothesised that infauna will recolonise the areas of sediment deposition within East Arm; this will be tested through the monitoring program mentioned above, the details of which will be developed in consultation with the regulatory authorities prior to the commencement of construction activities (as indicated in Section 11.4 of Chapter 11 of the Draft EIS).

Monitoring sediment accumulation within mangrove areas

With respect to the “desk top analysis of mangrove density and coverage”, sensitivity analyses conducted by HRW of its sediment dispersion model indicated that the predicted levels of sedimentation in mangroves were insensitive to differences in the density of mangrove trees or pneumatophores. Sediment accumulation within mangrove areas will be monitored as described in Section 4.3.2 of the Provisional Dredging and Dredge Spoil Disposal Management Plan (Annexe 6 to Chapter 11 of the Draft EIS). This will entail baseline monitoring of selected mangrove habitats; hence there will be no reliance on desktop analysis of mangrove density and coverage.

Monitoring effects of turbidity and sedimentation on coral communities

The effects of turbidity and sedimentation on coral communities will be monitored as described in Section 4.1 of the Provisional Dredging and Dredge Spoil Disposal Management Plan (Annexe 6 to Chapter 11 of the Draft EIS), or as adjusted and agreed with NRETAS.

Submission 123-110: Darwin Harbour is one of only two macro-tidal harbours in the NT and the stated marine environments do not occur widely throughout the region. Darwin Harbour is unique in a regional context and the lack of habitat mapping for the harbour makes this statement indefensible.

With the exception of coral reefs, INPEX is surprised that the submitter could consider that the marine environments described in the paragraph (i.e. coastal and estuarine waters less than 20 m deep, close to river mouths and creeks; mangrove communities; sandy-bottom environments; and open coastal waters with rock and/or coral reefs) do not occur widely throughout the region. INPEX recognises that true biogenic coral reefs do not occur widely within the region and that a more appropriate term would have been "rock reefs supporting coral communities". However, it is considered that admiralty charts and satellite imagery provide sufficient evidence of the broad regional presence of the other environments (perhaps more correctly referred to as "habitats").

It is unclear how Darwin Harbour can be considered unique if, as stated by the submitter, there is another macrotidal harbour (presumably Bynoe Harbour) within the region.

INPEX has undertaken more extensive habitat mapping during the preparation of this EIS Supplement (see Section 4.1.2 and Technical Appendix S6 in this EIS Supplement).

Submission 123-113: The plan needs to be broadened and include infauna within the mangrove system and intertidal flats fronting the mangroves.

The final monitoring scope will be agreed, in consultation with NRETAS during the development of the final dredging marine monitoring plan, which will require approval by NRETAS before dredging commences. The plan will include monitoring of detectable effects upon infauna within mangroves.

Submission 123-114: Coral health needs to be defined and further consideration needs to be given to the selection of appropriate reference sites. Some examples of reference sites might be Old Man Rock in front of Casuarina beach as a non-coral community or Bynoe Harbour as a reference site for coral communities. Both are possibly very similar ecosystems to Darwin Harbour. Video may not be an effective technique to measure coral health. AIMS and GBRMPA have well established monitoring techniques for dredging activities and these should be considered in the Supplement.

"Coral health" is a term widely used in the published literature. In the coral monitoring program discussed on p. 325 of the Draft EIS, it is proposed the colour of the coral tissues will be used as an indicator of coral health. This is consistent with the approach adopted by the University of Queensland for their CoralWatch program (www.coralwatch.org), in which tissue colour is deemed to reflect the concentration of algal symbionts within the tissues.

The suggestion of using Old Man Rock (in front of Casuarina Beach) as a "non-coral" reference site is interesting, given that there are extensive hard coral communities adjacent the western half of the rock. Also, Figure 109 of Technical Appendix 13 of the Draft EIS shows that elevated suspended sediment concentrations (up to 10 mg/L; arising from the spoil ground) are predicted to occur during Phase 5 of the dredging campaign. As suspended sediment concentrations at the South Shell Island and north-east Wickham Point coral communities are also predicted to be elevated (up to 5 mg/L) within this phase of the dredging campaign, Old Man Rock is clearly unsuitable as a reference site.

The purpose of reference sites will be to provide an indication of changes in coral communities due to natural perturbations that will equally affect the putative impact sites. It is considered there is a high likelihood that coral communities in Bynoe Harbour could be impacted by natural perturbations that do not affect the East Arm coral communities (and vice versa). Such perturbations may include severe thunderstorms (wind and reduced salinity due to freshwater runoff), which may be only a few kilometres in diameter, or prolonged elevations in water temperatures, both of which may impact upon coral communities.

As in previous coral monitoring programs within Darwin Harbour, and given it falls outside the dredging Zones of Impact and Influence (see Section 4.1.3 of this EIS Supplement for details), Weed Reef is considered to be the most suitable reference site for the putative impact sites in East Arm. Further reference sites on the western side of the Harbour may be included, pending assessments of their suitability.

Coral health measurements will be undertaken from still photographs and diver observations (potentially using the CoralWatch coral health chart). Video records will be used to ascertain changes in coral cover. Details of the monitoring program will be developed in consultation with NRETAS prior to the commencement of construction activities (as indicated in Section 11.4 of the Draft EIS).

Submission 123-116: It is unclear what a "significant coral mortality" means. A baseline study could derive this parameter, and determine how robust it will be in actually predicting a mortality event above the natural conditions (including confidence levels etc). If it cannot do that, then it should not be used as an assessment method. Coral die back due to non-natural causes is not an option for a heritage listed area, therefore triggers need to be preventative and not after the fact. Furthermore, turbidity should not be the sole parameter for monitoring coral health. If this is used, then a baseline study needs to establish linkages between turbidity and the causes of declining coral health. The following linkages are required: (1) Turbidity levels, suspended solid content (type) and sediment/suspended solid settling rates; (2) Turbidity, sedimentation rates and coral health (e.g. growth, respiration, algal content, mortality) so it can identify appropriate turbidity trigger levels associated with coral health that are linked to sedimentation rates (net (as best as possible) and gross). The initial relationship between turbidity and coral health can be established under controlled circumstances (AIMS has a dedicated lab to do this). Then this can be verified under Darwin Harbour conditions. (3) The nature of the settling suspended solids with coral health (e.g. sediment type, organic content of settling sediments). Fine sediments with high organic content have been shown to lead to higher mortality rates for certain species which is noticeable within 48 hours. (4) Sedimentation/suspended solid settling rates vs short and long term tidal cycles species vulnerability to turbidity, sedimentation rates. Also, the justification for the "representative" coral species selected needs to be provided. The lack of a baseline study limits any future work in this area due to the complex nature of the environment. Although this baseline study is only for corals, it is also important that (from a long-term perspective) that areas with a low energy environment are more at risk. Baseline studies need to be developed for these environments to establish possible impacts on infauna and to determine if monitoring is required and to what extent.

Submission 123-170: Significant hard coral mortality needs to be defined. See comments on coral monitoring (p 325 326).

Submission 123-173: See comments above relating to coral monitoring (pages 325 – 326).

INPEX acknowledges that "significant" might have been an inappropriate term to use. As explained in the Draft EIS in Annexe 6 *Provisional dredging and dredge spoil disposal management plan* to Chapter 11 *Environmental management program*, 5% and 10% coral mortality trigger levels are proposed as indicators of the need to implement further management actions to reduce the risk of further impact. In Section 4.1.2 of the plan it is noted that these are based upon trigger levels implemented during a dredge monitoring program in Western Australia undertaken in a similar environmental setting to that of Darwin Harbour. Exceedances of the mortality levels would not necessarily lead to significant (i.e. long-term or irreversible) impacts upon the Channel Island coral community. If the Department of Natural Resources, Environment, the Arts and Sport (NRETAS) determines for the Channel Island coral community a different level of unacceptable impact to that provided by Western Australia's Environmental Protection Authority (EPA) for the corals of Dampier Harbour (30%), then alternative trigger levels will be considered during further development of the operational dredging and dredge spoil disposal management plan.

INPEX contends that the proposed monitoring approach (described in Section 4.1.2 of the provisional plan), in which mortality levels at the putative impact site (Channel Island) will be adjusted to account for mortality levels at the Weed Reef reference site (referred to in Section 4.1.1 of the provisional plan), obviates the need for an assessment of mortality levels over a prolonged baseline period. That is, mortality will be calculated on an absolute basis relative to a "zero mortality" baseline established at the commencement of dredging rather than relative to "natural" *rates* of mortality.

It should also be apparent from the approach presented that INPEX was not intending to be reliant upon turbidity as "the sole parameter for monitoring coral health". Notwithstanding this, INPEX is now proposing to implement regular diving surveys to assess the health of the Channel Island coral community during construction of the pipeline shore crossing, rather than relying upon the exceedance of turbidity levels to trigger diver observations. This will reduce the risk of undetected impacts upon the coral community from the construction works and improve the ability to apply timely management actions to prevent significant impacts from occurring. INPEX contends that this direct monitoring of coral mortality obviates the need to undertake the research described by the submitter. The revised approach will be contained within the dredging and dredge spoil disposal management and marine monitoring plans that INPEX will submit to NRETAS for approval prior to the commencement of dredging.

Justification for the selection of the coral taxa proposed for monitoring is provided in the response to comment 123-180 in Section 5.2.2.11.

Commitments to monitor impacts upon infauna are provided in the Draft EIS in Section 7.3.2 of Chapter 7 *Marine impacts and management* and in Table 11-5 of Chapter 11 *Environmental management program*.

Submission 123-117: There are too many uncertainties to establish a risk level. Methods and mitigating factors are not yet clearly defined. A precautionary approach should be adopted thus giving sedimentation and turbidity a high risk level, until additional data has been provided.

The residual-risk ranking of "medium" is based upon assessments of "consequence" and "likelihood", as described in Chapter 6 *Risk assessment methodology* of the Draft EIS. For any of the sedimentation and turbidity impacts described in Table 7-31 of the Draft EIS to be ranked as "high" (as suggested by the submitter), then:

a) loss of ecological diversity due to impacts to the East Arm hard coral communities would need to be adjudged to occur on a "medium" (Consequence D) rather than a "localised" (Consequence E) scale. INPEX contends that the north-east Wickham Point and South Shell Island coral communities are sufficiently discrete that any loss of ecological diversity could only be considered as localised.
b) loss of ecological diversity due to impacts from dredging activities in East Arm to soft coral and sponge communities, to soft-sediment biota and to fish eggs and larvae, would need to be adjudged to occur on a "medium" (Consequence D) rather than a "localised" (Consequence E or F) scale. As impacts to these receptors could conceivably occur outside of East Arm, then it could be considered that there is a risk of loss of ecological diversity on a medium scale, in which case the residual risk would be ranked as "high". As described in Section 6.2.4 of the Draft EIS, the aspect register (from which the Table 7-31 entries have been extracted) will be reviewed and updated throughout the process of developing enviromental management and monitoring strategies, to ensure "high" risk aspects are managed to an ALARP level (as indicated in Table 6-1 of the Draft EIS).
c) it would need to be considered that impacts to the Channel Island hard coral community could represent significant and permanent effects on ecological diversity on a "medium" scale (Consequence C) rather than a loss of ecological diversity on a "localised" (Consequence E) scale. INPEX contends that, with the management controls and mitigating factors listed, there is little potential for significant and permanent effects on ecological diversity; and that the Channel Island hard coral community is sufficiently discrete that any loss of ecological diversity could only be considered as localised.
d) impacts from sedimentation on mangroves and associated invertebrate fauna would need to be considered as "recoverable loss" on a "medium" scale (Consequence D) rather than "permanent loss" (of a portion) on a "localised" scale (Consequence E). As these impacts could conceivably occur outside of East Arm, then it could be considered there is a risk of (recoverable) loss on a medium scale, in which case the residual risk would be ranked as "high".

Regardless of the risk ranking outcome, management controls have been identified to reduce the impacts associated with sedimentation and turbidity to as low as reasonably practicable. The management controls are outlined in the Draft EIS represent best practice for dredging.

Submission 123-122: There is no assessment of the potential alteration of hydrodynamics and tidal energy from the removal of Walker Shoal, resulting in altered bathymetry and the resulting change of deposition sites in East Arm.

Alterations to hydrodynamics and tidal energy in East Arm as a result of the dredging of the shipping channel, including the removal of Walker Shoal, have been modelled and are described in Section 7.3.1 of the Draft EIS and Technical Appendix 11 *Nearshore Geomorphological Modelling* of the Draft EIS. The influence of these changes on erosion and deposition patterns in East Arm are shown in Figures 130 to 133 of EIS Technical Appendix 11.

It should be noted that East Arm is a dynamic system, in which sediment is naturally accreting and being redistributed by forces such as tidal currents, river flows and the effects of storms (e.g. Williams, Wolanski & Spagnol 2006). The removal of Walker Shoal may lead to enhanced sediment deposition in some areas and increased erosion in others. The potential impacts of these changes were considered as a part of the assessment of impacts from the overall development of the nearshore infrastructure and dredging area (refer Table 7-29 of the Draft EIS), for which the consequence was ranked as minor, but with a high likelihood of occurrence, resulting in medium residual risk.

Submission 123-123: Table 7-31 (Acid sulfate soils) does not adequately identify the risks associated with acid sulfate soils and the indirect affect on fauna through the potential loss of food supply.

Food web effects were considered during the assessment of potential impacts arising from disturbance of acid sulfate soils. However, the consequences were assessed to be no higher than 'minor' (as defined in Table 6-3 of the Draft EIS) across any of the biodiversity and ecological processes and environmental qualities considered.

INPEX has committed to monitoring sediments, surface and groundwater and vegetation in areas adjoining AASS and PASS disturbance and has identified controls such as the use of lime (as required) to neutralise exposed soil surfaces and trench beds in ASS risk areas. Daily tidal movement will also assist by naturally diluting and buffering any acid leachate in intertidal areas.

Submission 123-124: These areas have not been incorporated into proposed management programs.

Submission 123-133: Casuarina beach and Fannie Bay are the only known areas with seagrass meadows that support local dugong populations. Given the importance of seagrass to dugongs, these seagrass meadows should be monitored throughout the duration of dredging and dredge spoil disposal, and for a number of years after these activities have stopped. This will validate the modelling results and ensure that there is a robust data set that will identify if there are any long-term impacts from dredging and dredge spoil disposal.

Submission 123-164: Soft-bottom benthos monitoring program and intertidal sedimentation programs need to specifically mention seagrass habitats and broaden monitoring areas to the impact footprint identified through hydrodynamic modelling and sediment modelling in addition to East Arm and/or dredge spoil disposal areas.

Submission 123-228: It is unlikely that sea grass meadows occur at this depth [*15-20 m, in the vicinity of the spoil ground*], however, dredge spoil modelling has shown that sediments will be deposited in known seagrass areas. Therefore surveys should be conducted to determine seagrass areas and to provide a baseline of seagrass health.

INPEX has undertaken further surveys to more clearly define the areas of seagrass that occur within predicted areas of elevated suspended sediments and of sediment accretion (see Technical Appendix S6 in this EIS Supplement).

The areas to which the submitter is referring are Darwin's northern beaches and adjoining seagrass zones and dredged shipping channels. As shown in Section 4.1.3 of this EIS Supplement, it is predicted from modelling that the Casuarina Beach and Fannie Bay seagrass meadows will be outside of the Zones of Impact from suspended sediments and sedimentation during the dredging campaign. Modelling outputs presented in Figures 116 to 125 of Technical Appendix 13 *Dredging and spoil disposal modelling* of the Draft EIS show that the only part of the northern beaches that may receive some sediment accretion (5–10 mm in thickness) is at the mouth of Rapid Creek (at the southern end of Casuarina Beach). These figures also show that no sedimentation of >5 mm thickness is predicted to occur within shipping channels.

Given the predicted absence of potential impacts upon seagrasses and the predicted minor accretion of sediment on a small portion of the northern beaches, it is considered that there are no grounds for including these areas within the dredging management program. However, monitoring of dredge-plume dispersion in waters around the offshore spoil disposal ground will be undertaken during dredge spoil disposal (see Table 11-5 in Chapter 11 *Environmental management program* of the Draft EIS). This monitoring will enable an assessment to be made of the degree to which actual dredge plume dispersion corresponds to the modelled dispersion.

If substantial discrepancies are found between the characteristics (e.g. suspended sediment concentrations) or behaviour (e.g. directions of predominant dispersion) of the modelled and actual plumes, then the risks of significant impacts to seagrasses and the northern beaches will be reviewed in conjunction with NRETAS and appropriate monitoring and management actions agreed. These actions will need to be cognisant of:

- The distances between the spoil ground and the Casuarina Beach and Fannie Bay seagrass meadows (some 15–20 km), which will limit the ability to discriminate between sediments that may reach these areas from the spoil ground and those which are deposited naturally throughout each year, especially as a result of storm events.
- The typically ephemeral nature of the seagrass species present, the interannual variability in their distribution, and the patchiness of seagrasses within the meadows, which would also confound attempts to develop causal links between any observed changes in seagrass distribution, density or condition and the sediments arising from the spoil ground. These characteristics of the seagrass meadows also dictate that a meaningful baseline assessment of seagrass health at putative impact sites could only be undertaken just prior to the commencement of dredging. Otherwise, natural changes could occur between the setting of the baseline and the commencement of dredging; these changes could then be incorrectly ascribed as impacts from spoil disposal.

Submission 123-125: More information is required on site 10 – how far to the north-east is site 10 from site 9? Please indicate on figure 7-24. Hydrodynamic modelling should be conducted on site 10, especially because the Vernons, which are predicted to have an increased sedimentation rate, are closer to the preferred site 10, than the site actually modelled (site 9).

Figure 5-6 below shows the distance (metres) and direction of shift (degrees) for each corner of the dredge spoil disposal ground from the site 9 to site 10 positions. The largest shift was the south east corner, moving 6359m to the north east.

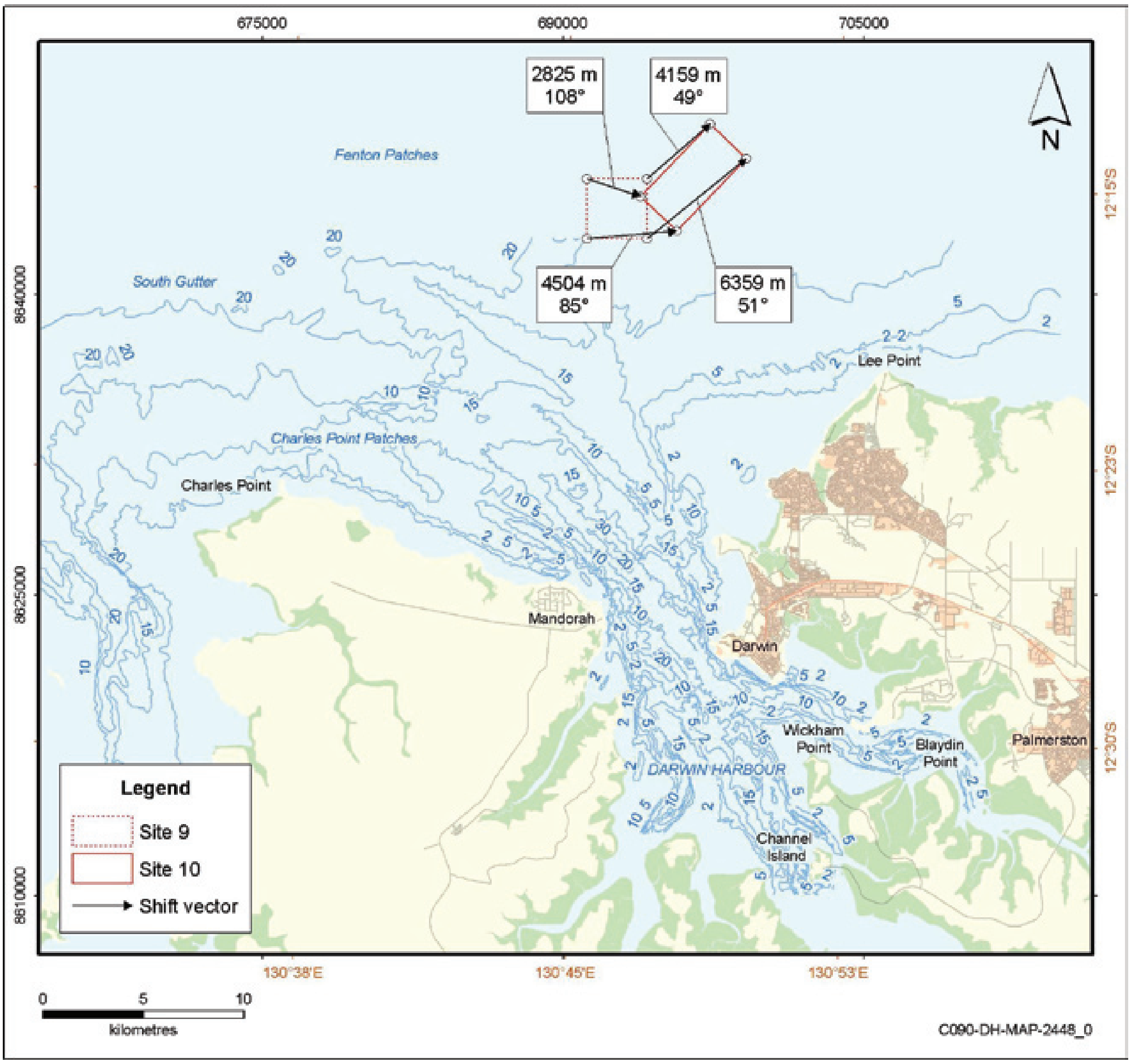

Figure 5-6: Vector shift of corners of dredge spoil disposal Site 9 to Site 10

As stated on page 331 of the Draft EIS, predictive modelling of sediment dispersal at the selected offshore spoil disposal site . . . was carried out by HRW. This means that hydrodynamic modelling/dredge plume modelling was conducted on site 10. This can be seen in Figure 7-28, 7-29 and 7-30 with the boundary of site 10 clearly indicated on these Figures in the Draft EIS.

Submission 123-127: Please provide maps showing these data for assessment.

The EGS (2009) report (C036AH0038) was provided to the Department of Natural Resources, Environment, the Arts and Sport on 20 August 2010. The reference is as follows:

EGS Earth Sciences and Surveying. 2009. *2009 URS dredge material disposal area survey: side scan sonar and echosounder survey*. Report prepared by EGS Earth Sciences and Surveying, Perth, for INPEX Browse, Ltd., Perth, Western Australia.

Submission 123-129: There don't appear to be any graphs in the main draft EIS showing depth (mm) of sediment deposition for all phases in the disposal ground in Shoal Bay. Only shown is Phase 6, and 0-5 mm sediment deposition is not shown.

As there are 10 phases of dredging modelled for both sedimentation and suspended sediment it was not considered practicable to include all model outputs in the Draft EIS. As stated in Section 7.3.2 of the Draft EIS the figures provided show cumulative sedimentation up to and including Phase 6. From Phase 7 onwards no net increases in accretion is predicted due to lower dredging activity. Phase 6 therefore represents the worst case phase. The complete set of figures for all phases dredging are provided as Figures 116 to 125 in Technical Appendix 13 of the Draft EIS. There is considered to be no credible risk of significant impacts from sediment deposition depths of <5 mm over 4 years in an environment within which similar thicknesses of sediments are likely to be suspended and deposited on a daily basis through natural tidal movements.

Submission 123-134: The draft EIS and Appendices have not stated the minimum amount of dredge spoil thickness that can be measured from bathymetric surveys. Alternative methods may need to be used to establish/verify the footprint of the dredge spoil disposal ground. The management plan needs to discuss which methods are most appropriate and why, and the survey's resolution.

Bathymetric surveys proposed are to monitor the deposition patterns and relative heights and dimensions of sediment at the dredge spoil disposal ground and to determine if there are any accumulations in areas such as East Arm Wharf which could hinder vessel movements. They are not designed to determine fine-scale sedimentation patterns around the dredge spoil disposal ground.

As part of INPEX's commitment to assess the impacts on soft sediment communities on and adjoining the dredge material spoil ground INPEX will consider various survey methodologies, in consultation with NRETAS, during further development of the dredging marine monitoring plan, which will require approval prior to the commencement of dredging.

Submission 123-137: Information presented does not identify the risks to coastal dolphins in the event of a hydrocarbon spill.

Coastal dolphins could be exposed to spilt hydrocarbons when they surface to breathe, which may cause damage to their respiratory and nervous systems, though this may not occur at the concentrations predicted to occur in the event of a hydrocarbon spill within Darwin Harbour. Hydrocarbons could also be ingested, with potentially toxic effects. Cetaceans are not vulnerable to the physical effects of oiling as oils tend not to stick to their skin or affect insulation.

As described in Section 7.2.4 in Chapter 7 *Marine impacts and management* of the Draft EIS, experiments on bottlenose dolphins found that this species was able to detect and actively avoid a surface slick after a few brief contacts and that there were no observed adverse effects of the brief contacts with the slick (Smith, Geraci & St. Aubin 1983). It is not known if other marine mammals are able to similarly detect and avoid oil slicks. It has been observed in some oil spill incidents that dolphins have detected oil and avoided it, but at other times have not done so and have been exposed to floating oil (Geraci & St. Aubin 1990). The strong attraction to specific areas for breeding or feeding may override any tendency for cetaceans to avoid the presence of oil.

The more credible spill release scenarios for Darwin Harbour are for condensate from loading operations and diesel from refuelling operations. Figure 7-32 in the Draft EIS indicates that condensate will completely evaporate from the water surface within two hours, hence significantly reducing the potential for exposure should coastal dolphins or other surface breathing marine fauna be present within the spill location. Diesel is also expected to weather relatively rapidly from the warm tropical waters (refer to Figure 8, Technical Appendix 7 of the Draft EIS). The risk of spill events having a detrimental impact on coastal dolphins is considered to be a medium risk.

Submission 123-156: The potential alteration to mangroves from the proposed dredging should also be mentioned in this section. Additionally, there is the potential for alteration of Mangroves vegetation due to changes in the amount of freshwater during the wet season discharging from adjacent land (e.g. storm water management). A decrease in freshwater has the potential to increase soil salinity and potentially reduce the number of mangroves species (Ball 1998).

Potential impacts to mangrove from dredging are discussed in Section 7.3.1 of the Draft EIS. The potential for alteration to freshwater input to the narrow hinterland fringe mangrove zone (i.e. the zone that is partly dependent of freshwater input) is discussed in Section 8.2.3 of the Draft EIS. The extensive suite of mangrove zones located seaward of (or downslope of) the hinterland fringe mangrove zone are reliant of tidal inundation for the maintenance of the suitable groundwater/soilwater conditions and hence will not be influenced by any modification to fresh surface-water and subsurface seepage from the Blaydin Point hinterland. A mangrove monitoring program will be established at Blaydin Point that will include sites within the hinterland fringing mangrove zone (although most, if not all, of this community is likely to be cleared) to monitor both shallow groundwater conditions and mangrove health. It should be noted that a similar scenario (i.e. including potential modification to freshwater input to mangroves) has occurred at the Darwin LNG plant sites at nearby Wickham Point since 2003 and to date there has been no deterioration of mangrove health related to potential modification of freshwater input.

Submission 123-166: (This comment refers to page 531 of the draft EIS) A monitoring program rather than an incident reporting program should be presented. To evaluate the impacts on coastal dolphins in Darwin Harbour a monitoring program should be based on a pre-impact, construction-phase and operational-phase population assessment.

Annexe 4 *Provisional cetacean management plan* to Chapter 11 *Environmental management program* of the Draft EIS refers to monitoring and reporting during vertical seismic profiling (VSP) at the Ichthys Field. Monitoring during the VSP program is described in Section 3.1 of Annexe 4. To evaluate potential impacts on coastal dolphins that occur in the nearshore development area as a result of construction activities, INPEX will undertake monitoring before, during and after construction. This monitoring program will consider using existing data collected by the Northern Territory Government's recent coastal dolphin research program and will also aim to collect baseline (preconstruction) data. INPEX is currently undertaking vessel-based coastal dolphin surveys in Darwin Harbour's Middle Arm and West Arm; this work will also assist in the design of the monitoring program for the periods before, during and after the construction of the facilities.

Submission 123-174: If the modelling indicates that "there will be little, if any sediment accumulation" – then it will be very difficult to investigate the degree of resilience of corals in East Arm to sedimentation. In meeting with the proponent, the corals in these areas were considered to be at high risk of being lost, particularly at South Shell. It should be stated in the Supplement that monitoring will be used to validate the model outputs. Also, there is no indication in the Management Plan that the increased level of sedimentation due to the dredging activities will be measured/monitored. Section 4.1.1 Water-quality baseline monitoring program describes where and how turbidity, salinity and temperature will be measured and how trigger levels will be set (pages 13-15).

The text was intended to convey that the monitoring will investigate the resilience of corals in East Arm to the *combined* effects of exposure to sedimentation and turbidity. If the current developmental instrumentation for the measurement of net sedimentation rates (e.g. Thomas & Ridd 2005) can be proved as reliable in field applications, then consideration will be given to its deployment in East Arm during the dredging program; this will assist in validating the model outputs. Gross sedimentation rates in East Arm may also be determined, using sediment traps, during dredging. Methodologies for the measurement of sedimentation rates will be agreed with the regulators prior to the commencement of dredging.

Submission 123-175: The proposed reliance on water turbidity as a response variable for coral monitoring is inadequate.

According to the published literature, the reaction of a coral colony to increased water turbidity, suspended sediment concentrations and sedimentation rate is a complex process. Corals experience stress from high suspended sediment concentrations (polyps) and their effects on light attenuation (algal symbionts). Enhanced sedimentation causes smothering and burial of coral polyps, shading, tissue necrosis and population explosions of bacteria in coral mucus. Fine sediments have greater effects on corals than coarse sediments. Sedimentation also reduces the recruitment, survival and settlement of coral larvae. It is well documented that sedimentation from dredging constitutes one of the biggest potential sources of reef degradation (Johannes 1975, Dahl 1985, Rogers 1985; Bothner, Reynolds, Casso, Storlazzi, and Field, 2008; Carr and Nipper, 2008; Elias, Storlazzi, Field and Presto, 2010). Rogers (1990) in her literature review analysed the number of coral responses to sediment application both in the field and laboratory. Lewis (1995) demonstrated in the experimental conditions that in the relationship between turbidity and suspended solids concentration can be linear when grain size is constant, but when grain size varies as a function of concentration, the turbidity response will have a non-linear form. Therefore it is crucial to construct the relationship between turbidity and suspended solids concentration for each location and for each distinct hydrological condition (Reservoir sedimentation Handbook, Morris & Fan, 1997).

Submission 123-176: The key potential mechanism of impact on coral communities – settling sediments –is disregarded in the reactive monitoring program. The reason given for that is unsupported by the published literature. The perception of processes of sediments settling/resuspending in a coral environment is far too simplistic – "sediments settle from the water column on to corals during slack tide periods (when current flow is minimal) but are then remobilised into the water column as tidal currents increase".

The presence of coral colonies alters bottom profile and current flow. Mucus production by coral polyps is the only reaction observed at high levels of siltation (Fabricius & Wolanski 2000). Mucus trapping tends to delay clearing of detritus from the polyp surface (Johnson 1987).

The implementation of turbidity and "coral health" monitoring will not provide appropriate protection for the Channel Island coral community.

The terms "coral health" and "coral condition" are both ill-defined in the proposed Reactive Monitoring Program (Section 'Assessment of coral condition', page 548). It is impossible to understand if in fact, "mortality will be scored" or some parameters of coral health will be assessed.

Turbidity is a measurement of the decrease in transparency of water as light is scattered by suspended particulate matter (Ziegler 2002).

Relying entirely on turbidity predictions of sediment loads may have substantial limitations, including issues with equipment and physical characteristics of environment. As stated by Ankcorn (2003), "turbidity is not an absolute value, but a relative value representing a qualitative measurement that can yield different readings based on the method used."

Turbidity readings may vary between locations due to water colour and suspended particle size and composition. Due to the logarithmic relationship, slight changes in total suspended solid (TSS) concentration have large effects on a turbidity reading. This is probably due to natural variability in suspended solids size, shape and composition as well as water color. (Packman et al. 1999). When particle sizes are changing, one might expect the usefulness of turbidity as a surrogate for TSS concentration to be limited. Variability in particle size can result from changes in source materials or other factors. If source materials are changing, there could be considerable variability in turbidity for a given suspended solid concentration (Lewis 2002).

Organic particles have been shown to absorb light, and therefore provide different turbidity values than mineral particles (Lewis 1996).

In a number of studies of suspended sediment concentrations and sedimentation in coral environments; sedimentation rate was successfully and accurately measured with a variety of methods. (Ridd, 1992; Larcombe et al. 1995; Bale, 1998; Ridd et al., 2001; Thomas, 2002; Thomas, Ridd, Day, 2003; Draut et al. 2009; Elias et al., 2010). A good review of the number of methods available to measure sediment accumulation over a short-term period (order of days to months) is made by Thomas & Ridd (2004).

Sediment accumulation was assessed during several dredging projects in Australia:

Port Hedland Harriet Point dredging referral document http://www.bhpbilliton.com/bbContentRepository/docs/mangroveManagementPlan.pdf

Hay Point, Mackay – Dredging and Spoil Disposal http://www.gbrmpa.gov.au/corp_site/management/eim/project_examples/hay_point

Gladstone Ports Corporation Port of Gladstone Western Basin (Queensland) Strategic Dredging and Disposal Project Initial Advice Statement March 2009 http://www.dip.qld.gov.au/resources/project/port-gladstone/initial-advise-statement.pdf

Shute Harbour Dredging, Environmental Assessment & Monitoring Program, Whitsunday Shire Council http://www.frc-environmental.com.au/new/dredge.html

Ecological Monitoring of Kirra Reef, Gold Coast; NSW Dept. Public Works http://www.frc-environmental.com.au/new/dredge.html

Given the importance of this habitat in Darwin Harbour, it is essential to include sedimentation rate measurement in any "Coral Monitoring" program associated with this development.

Submission 123-107: Based on this statement [*Whilst some coral polyps may be able to remove this sediment by secretion of mucus, there may be small patches or parts of individual corals that may suffer some reduced growth or death as a result of sedimentation*], the absence of sedimentation rate measurement in the "Reactive Coral Monitoring Program" is a serious flaw.

Submission 123-177: No descriptions of how coral communities' condition will be assessed (and what the authors mean by "coral condition") is given in this section. A reference to a GHD 2002 report is provided but it is unclear if the line-intercept method will be used to assess live percent coral cover or another technique. It is important to specify the method being proposed.

The potential for adverse impacts upon corals from sedimentation is discussed in EIS Section 7.3.2 and was taken into account during the impact assessment process (refer Table 7-31 of the Draft EIS). INPEX recognises that although there have been many techniques developed to measure sedimentation rates (as evidenced by the references cited by the Respondent) they have not always proved suitable for field applications associated with dredging (e.g. MScience 2007; SKM 2008a).

The use of measurements of turbidity, rather than sedimentation, for the purposes of dredge management is consistent with contemporary coral monitoring programs for major dredging programs in Western Australia:

- Pluto LNG Project (approximately 14 Mm^3). Instruments for the measurement of sediment accumulation (optical backscatter [OBS] loggers developed by Dr Peter Ridd at James Cook University) were found to be of limited reliability in capturing data (MScience 2007). Management of the dredging campaign was based upon turbidity data from telemetered loggers, with data transformed to total suspended sediment (TSS) values for comparison against trigger criteria (SKM 2008b).
- Robe River Iron Associates, Cape Lambert (2.5 Mm^3). The Dredging and Spoil Disposal Management Plan for the 85-Mt/a upgrade (SKM 2007) referred to the deployment of OBS loggers developed by Dr Peter Ridd. However sedimentation data were not presented in the Marine Monitoring Report (SKM 2008a) which stated simply that "this new technology failed". Management of the dredging and spoil disposal operation was in response to turbidity levels and to levels of coral mortality.
- Pilbara Iron Pty Ltd, Cape Lambert (up to 14 Mm^3). The Dredging and Spoil Disposal Management Plan for the Port B development (SKM 2008c) indicates that water quality (turbidity) and coral mortality trigger levels will be used to manage the dredging and spoil disposal operation. Gross sedimentation data will also be collected, using sediment traps (SKM 2009), though there will be no trigger levels based upon sedimentation.
- Gorgon LNG Project (7–8 Mm^3). Light, Turbidity and Deposition (LTD) loggers were deployed as a part of the Marine Baseline Program. Data recovery rates were in the order of 80% across all sites and parameters over a period of some two years. However, it appears that the amounts of deposition upon the sensors were generally below the detection limit of the instruments, which was hypothesised to occur because of "removal of deposited sediments by hydrodynamic forces prior to accumulation" (RPS 2010). During dredging, it was planned by

Chevron to monitor sediment deposition only "as a part of the investigation into the link between water quality, sediment deposition and coral health, there will be no Sediment Deposition Criteria established". Rather, there are Water Quality Criteria, based upon turbidity, and Coral Health Management Triggers, based upon bleaching or mortality of corals (Chevron 2009).

With respect to the references provided by the Respondent pertaining to sediment accumulation assessment during dredging projects in Australia:

- The Port Hedland Harriet Point reference is a Mangrove Monitoring Plan, which refers to monitoring of sedimentation within mangroves. Application of the same monitoring technique (pegs secured in the ground) is unlikely to be suitable for measuring the predicted small amounts of sediment accumulation in the East Arm coral communities. In the Dredging Management Plan (BHP Billiton 2008), no sedimentation monitoring within coral communities at Port Hedland was proposed.
- Hay Point, Mackay. The inclusion within the monitoring program of measurements of sediment deposition (using a telemetered logger) is described in Trimarchi and Keane (2007). However, no deposition data are presented in the environmental review. Compliance was based upon a trigger value for TSS (100 mg/L for a period of at least six continuous hours), which was derived from measurements of turbidity. No mention is made of the reliability of the deposition sensor, or of the value of the sedimentation data recorded, though it is mentioned in the "lessons learned" chapter of the report that recommended changes to the coral monitoring methods included "continued measurement of sediment deposition, but the preferred method to be further investigated".
- Gladstone Ports Corporation, Port of Gladstone Western Basin. The Initial Advice Statement does not mention the monitoring of sediment deposition. The Port of Gladstone Western Basin Master Plan (DIP 2010) mentions only the monitoring of seagrass, not of coral. This is undertaken as a part of the Port Curtis Integrated Monitoring Program (PCIMP 2011) which also does not include the monitoring of coral. Light, turbidity and temperature have been measured over seagrass communities (Storey et al. 2007), but there is no indication that sediment deposition is monitored.
- It is noted that the deployment of in situ data loggers to "provide an estimate of suspended sediment or sedimentation" is proposed to be included within the Dredging Management Plan that is in preparation for the QCLNG Project in Gladstone (QGC 2010). These loggers are destined for inshore potential impact sites which support seagrass, but not corals.
- Whitsunday Shire Council and NSW Dept. Public Works. The web links provided are no longer valid, hence the veracity of the Respondent's claim that monitoring of these projects included sediment accumulation assessment cannot be verified.

It should be noted that the reactive coral monitoring program presented in the Provisional Dredging and Dredge Spoil Disposal Management Plan (Annexe 6 of Chapter 11 of the Draft EIS) was based upon previous monitoring programs undertaken within Darwin Harbour. However, INPEX recognises there are aspects of the program that may need to be revised in order to obtain regulatory approval prior to the commencement of dredging. These revisions will be made in consultation with regulators and will take account of the experiences of recent and current coral monitoring programs for large dredging campaigns in Western Australia, including the Cape Lambert 85 Mtpa upgrade (SKM 2007) and Port B development (SKM 2008c), Pluto LNG (SKM 2008b) and Gorgon LNG (Chevron 2009).

The monitoring approaches within the dredging and spoil disposal management and monitoring plans for these major projects were deemed acceptable for protection of the environment by Western Australia's Environmental Protection Authority (EPA 2007a, 2010, 2007b, 2009 respectively) and it is considered reasonable to use them as the basis for the further development of the reactive coral monitoring program for the Channel Island coral community. The following aspects will be among those considered for the program:

- Regular, frequent monitoring of coral condition by divers, rather than having diver assessments triggered by exceedences of turbidity thresholds. "Coral condition" refers to the proportion of partial mortality (if any) of a coral colony. The proposed approach to assessing coral condition (described on p. 548 of the EIS) was adopted to be consistent with the methodologies used in the two referenced studies. However, INPEX will consider alternative methodologies and parameters such as those presented in the aforementioned Dredging and Spoil Disposal Management and Monitoring Plans and by Gilmour et al. (2006).
- Measurements of gross sedimentation using sediment traps.
- Measurements of net sedimentation, if reliable OBS loggers (or similar) are available at the time of monitoring.

It should be noted that relationships between suspended sediment concentrations and turbidity levels have been established and are presented in Technical Appendix S9 in this EIS Supplement.

Submission 123-178: The EIS needs to justify why only two turbidity probes are used to describe and monitor turbidity. Turbidity is highly spatially variable and is dependent on local currents and local substrate types.

Submission 123-181: The timing and intensity of sampling is insufficient to detect changes associated with the dredging. The use of a single turbidity logger at the site will not allow assessment of high spatial variability in turbidity at the site. This design will only allow assessment of turbidity changes through time for the point where the logger is located. Therefore, it is suggested that at least three, randomly-placed loggers at each site should be deployed as part of a pilot study. Power analyses could then be conducted using the data to inform the number of loggers required for meaningful turbidity measurement. Bynoe Harbour should be considered as a reference site.

INPEX acknowledges that turbidity is highly spatially variable and is dependent on local currents and local substrate types. However, INPEX contends that a single logger at each location is appropriate as any plumes arising from dredging activities at the shore crossing that impinge upon the Channel Island coral community would elevate turbidity equally over the entire area. That is, there is no reason to suspect that the increase in turbidity within the clearer waters overlying the coral community would be greater than that within the adjacent, more turbid waters.

INPEX also notes that all contemporary coral monitoring programs for major dredging programs within Western Australia (e.g. SKM 2007, SKM 2008a,b, Chevron 2010) have only a single logger deployed at each monitoring site. However, INPEX will consult further with regulators during finalisation of the dredging marine monitoring plan and the number of loggers required at each site will be agreed with the regulators prior to the commencement of dredging.

Submission 123-179: Explain how the aerial survey information would be used and compared with hydrodynamic modelling results. A descriptive assessment is not considered appropriate. A two week aerial survey is considered inappropriate as it does not take into account the meteorological conditions that are variable from day to day, and season to season.

Submission 123-182: The use of aerial surveys for only two weeks to monitor plume impacts in Darwin Harbour is considered inadequate because of complex hydrodynamics and intensive tidal water movements. Very high patchiness is typical for turbidity plumes in the harbour. According to "Predicted suspended –sediment concentrations at East Arm coral sites during the dredging program" Table 7-30, page 127, Chapter 7 "Marine Impacts and Management" the percentage of time during which concentrations will exceed a background level during the dredging program is extremely low – ranging from 2.33% at South Shell Island to 0.01% at Weed Reef.

As indicated in the text in Section 4.1.2 of Annexe 6 *Provisional dredging and dredge spoil disposal management plan* to Chapter 11 *Environmental management program* of the Draft EIS, the aerial survey pertains to the pipeline shore crossing north-east of Channel Island in Middle Arm, not to dredging within East Arm.

The purpose of the aerial survey is to assist in developing an understanding of surface plume behaviour, with only a qualitative comparison made against the hydrodynamic modelling results. This technique proved valuable during the monitoring program for the Bayu–Undan Gas Pipeline installation (I. Baxter, marine scientist, URS, pers. comm. February 2011), to assess the potential efficacy of management measures that it might have been necessary to implement.

It is considered that a descriptive assessment is entirely appropriate, given that triggers for management actions will be based upon logger data and coral condition assessments, not upon aerial survey observations.

The intent of the *initial* two-week survey is to ascertain plume behaviour over a full neap and spring tidal cycle. The frequency of subsequent flights will be determined on the basis of the observations made during the initial survey. It should be noted that the proposed pipeline shore crossing construction period is only 4 to 5 months (see Figure 4-26 in Chapter 4 *Project description* of the Draft EIS), hence seasonality may not be a major factor affecting plume behaviour (which is anticipated to be largely driven by tidal currents).

It should be noted that methods for monitoring dredging plumes (and their potential impacts) within Darwin Harbour are still under development and will be finalised in consultation with NRETAS. They will be detailed in the dredging marine monitoring plan, which will require approval by NRETAS before dredging commences.

Submission 123-180: The EIS needs to justify the selection of coral taxa for monitoring. All three taxa represent corals resistant to high turbidity and low light. This inevitably will reduce the sensitivity of this monitoring to detect changes in coral conditions because of altered turbidity and light. In addition, Mycedium elephantotus abundance at Wickham Point is low; Herpolitha limax and other Fungiidae corals have extremely low abundance at Wickham Point and Channel Island; corals from genus Turbinaria virtually absent at Channel island and not rare in other coral communities (Darwin Wharf Project Coral Monitoring – 2006 Post Dredge Survey). This may lead to difficulties in locating 25 colonies of each taxa necessary for monitoring and hinder monitoring program success. Based on the above, the following species should be included in any coral monitoring associated with the development: 1) Inclusion of sensitive to low light and high turbidity coral species and, 2) Inclusion of more common widespread species from Favids, Pectinids and Acroporids corals.

The coral taxa were selected to be consistent with previous monitoring programs within Darwin Harbour as referenced in Section 4.1.2 of Annexe 6 *Provisional dredging and dredge spoil disposal management plan* to Chapter 11 *Environmental management program* of the Draft EIS. INPEX contends that all coral taxa present at the proposed monitoring sites will necessarily be adapted to conditions of high turbidity and low light, otherwise they would not be present at those sites. The abundances of the three taxa quoted by the submitter would appear to be inconsistent with the results of surveys undertaken in 2008 (refer to the Draft EIS's Technical Appendix 8 *Nearshore marine ecology and benthic communities study*), though INPEX recognises that qualitative terms such as "very low" are subjective and would not necessarily indicate that there were insufficient numbers of colonies present for the proposed monitoring methodology to be implemented. If the Department of Natural Resources, Environment, the Arts and Sport (NRETAS) is agreeable to deviations from the methodology applied during previous monitoring programs within Darwin Harbour, then an alternative methodology will be developed in consultation with NRETAS during the finalisation of the operations-phase dredging and dredge spoil disposal management plan, which has to be approved by NRETAS before dredging commences.

Submission 123-183: More information should be provided for the coral monitoring program on the following issues: 1) An explanation of the procedure "scoring for mortality". References to published techniques must be given. Explain how a score will distinguish between freshly dead and live coral colony tissue – this is a key issue. 2) The phrase "photographs scoring may not be performed at all" creates a degree of uncertainty and conflicts with earlier statements in the section "Baseline assessment of coral communities". On page 16 the draft EIS states: "If visibility permits, a photographic record will be made of the colonies and the surrounding coral communities. If turbidity levels are too high to permit photography, a semi quantitative assessment of coral condition will be recorded from diver observations." A description needs to be given for "semiquantitative assessment of coral condition" technique.

Through the engagement of suitably qualified personnel, INPEX will ensure that, in common with recent and current coral monitoring programs implemented in other parts of northern Australia, scoring for mortality will be undertaken by personnel with appropriate training who are able to distinguish between live and dead coral tissue. This is a fundamental requirement for the use of computer-based analytical programs such as the Australian Institute of Marine Science's AIMS Video Transect Analysis System (AVTAS) (Abdo et al. 2004) and the Coral Point Count (CPCe) program of the Nova Southeastern University Oceanographic Center in Florida (Kohler & Gill 2006). Coral tissue that has a white or off-white colour and has not yet been colonised by turfing algae is typically classified as "recently [= freshly?] dead coral" (e.g. Abdo et al. 2004; Jonker, Johns & Osborne 2008).

The phrase "photographs scoring may not be performed at all" does not appear in Annexe 6 *Provisional dredging and dredge spoil disposal management plan* to Chapter 11 *Environmental management program* of the Draft EIS.

The passage ascribed by the submitter to page 16[10] of the Draft EIS actually appears on page 547 of the Draft EIS in Annexe 6 to Chapter 11.

The proposed semi-quantitative assessment of coral condition would be undertaken by personnel who have appropriate training to distinguish between live and dead coral tissue and are adequately adept at estimating the proportion of each coral colony that is live or dead. It should be noted that the monitoring techniques to be applied during the program will be developed in consultation with the NRETAS and will be included in the dredging monitoring plan, which will require approval by NRETAS before dredging commences.

10 The submitter's "page 16" in fact refers to an earlier electronic draft of Annexe 6 submitted to NRETAS before the formal publication of the Draft EIS.

Submission 123-184: Monitoring should also continue for a reasonable period post dredging. This is particularly the case given that high suspended solid concentrations are predicted in later phases of the dredging program.

The duration of post-construction monitoring will be amongst the recommendations presented to the Department of Natural Resources, Environment, the Arts and Sport (NRETAS) at the conclusion of the dredging program. This was stated in the last paragraph of Section 4.1.2 in Annexe 6 *Provisional dredging and dredge spoil disposal management plan* to Chapter 11 *Environmental management program* of the Draft EIS.

A phased approach is anticipated, with the duration of monitoring being proportional to the level of mortality (if any) recorded during the program. It is recognised that there may be a requirement for post-dredging monitoring of the Channel Island corals if elevated turbidity levels persist, even if there is no evidence of coral mortality during the program. This will be agreed with NRETAS at the conclusion of the dredging program.

Submission 123-185: There are very few details, apart from incident reporting, on what monitoring information would be reported and made available to the public or to NRETAS. Further details are needed.

The types of monitoring information available to the public and to the Department of Natural Resources, Environment, the Arts and Sport (NRETAS) will be agreed with NRETAS during the finalisation of the operations-phase dredging and dredge spoil disposal management plan, which has to be approved by NRETAS before dredging commences.

Submission 123-189: There is a need for a suite of relevant ecotoxicological tests for water and sediment to be developed for use in the event of a spill and wastewater discharges. It is expected that monitoring requirements will be included as license conditions. Development of a basic conceptual model is an integral part of the assessment process. A conceptual design for ecological and human health risk assessment should be developed. The EMP also discusses a groundwater study conducted by URS, but INPEX makes no commitment to monitor the groundwater bores during construction and operation phases. Corresponding surface water monitoring points should also be monitored. Regional Groundwater Dependant Ecosystems (GDEs) should be identified and their reliance on inputs from current groundwater regimes assessed. An assessment of GDEs is critical given URS's claims of changes in groundwater regimes pre and post-development. Further consideration should be given to establishing baseline data now, given claims of the transmissivity of sands in the Bathurst Island Formation and highly fractured units of the Burrell Creek Formation. Groundwater and surface water monitoring of this nature will be required under the Waste Management and Pollution Control Act during the operational phase. More information should be provided in the supplement regarding investigation of options for artificial recharge of groundwater (or, if not a feasible option, this should be clarified).

Submission 123-38: There is a need for a suite of relevant ecotoxicological tests for water and sediment to be developed for use in the event of a spill and wastewater discharges.

The need for ecotoxicological tests will be discussed and agreed with regulators during the preparation of the environmental plans for the operations phase.

It should be noted that INPEX has already undertaken ecotoxicity tests for Ichthys condensate and these results are provided in Section 7.2.4 of the Draft EIS. The value of a sediment based ecotoxicity test for oil spills will need to be discussed as ecotoxicity testing for oil is based on the water accommodated fraction, and the potential for biological significant accumulations of hydrocarbons in sediments from both routine discharges and accidental spill events is considered low. INPEX will undertake a full characterisation of chemicals in the wastewater discharge stream once the onshore plant is operational and subject to this assessment, INPEX will evaluate the need for ecotoxicity testing of the stream in consultation with NRETAS.

Sampling and testing of sediments in the vicinity of the wastewater outfall will also be undertaken periodically during the operations phase, and subject to evaluation of the results, INPEX will discuss the need for conducting sediment reworker ecotoxicity tests.

It should be noted that most of the vegetation (with the exception of mangroves) from the onshore site will be cleared and will therefore not be affected by changes in groundwater quality. As discussed in Section 8.2.3 of the Draft EIS, a mangrove health monitoring program will be developed; a component of which will assess the effects (if any) on mangroves from any changes to surface and groundwater flows during the construction and operations phases. It should be noted that monitoring of the mangrove health, including the hinterland mangrove fringe around the Darwin LNG plant has not identified any impacts as a results of changes in surface or groundwater flows.

Surface and ground water monitoring programs and marine sediment and bio-indicator monitoring programs to assess any accumulation of metals and hydrocarbons from surface water or ground water flows from the onshore facility have been committed to Section 8.2.3, Table 8-16 and in the Provisional Onshore Spill Prevention and Response Management Plan (Annex 11) of the Draft EIS.

Submission 123-197: Triggers [*within the Provisional Piledriving and Blasting Management Plan presented in Chapter 11 of Draft EIS*] are currently too vague and would need to be developed in a lot more detail. Responses to adverse findings occur only during an annual review, which is too infrequent. Management of a serious incident such as death or injury to listed/protected species includes 1) reporting and 2) refresher training. Blasting is a controversial issue and there needs to be clear guidelines on what is acceptable and how incidents would be handled. The triggers are very vague and the description of what constitutes an incident is also vague.

Section 4 of Annexe 12 *Provisional piledriving and blasting management plan* to Chapter 11 *Environmental management program* of the Draft EIS provides a list of example incidents which would trigger an investigation. This is considered to be a reasonable approach because it is not practicable to foresee all possible incidents.

The statement in the comment that “responses to adverse findings only occur during an annual review” is incorrect and appears to be based on incorrect reading of the description of incidents that would trigger a management response in Section 4 of Annexe 12.

INPEX will submit a final piledriving management plan to the regulatory authorities in accordance with the requirements for dredging and spoil disposal approval under the *Waste Management and Pollution Control Act* (NT) and the *Fisheries Act* (NT). This management plan will be developed in consultation with the Department of Natural Resources, Environment, the Arts and Sport (NRETAS) once a piledriving contractor is engaged. The plan will require approval by NRETAS before piledriving commences.

A separate final blasting management plan will only be prepared if blasting is found to be necessary.

Submission 123-199: There is no discussion and comparison [*of offshore water quality and marine sediments*] with other studies and findings.

Comparing the offshore water – and sediment-quality data with the findings of other studies may help in placing the Ichthys Field in context with oceanographic models of the region (e.g. Brewer et al. 2007; Herzfeld et al. 2006). Comparisons of Ichthys data with data collected from the nearby (approximately 25 km distant) Prelude Field (Shell 2009) provide an indication of meso-scale variations on the parameters measured. However, it should be noted that the comparisons do not alter the consequence rankings for any of the potential impacts presented in Tables 7-2, 7-5, 7-6, 7-7, 7-12, 7-13, 7-16, 7-21 or 7-22 in Chapter 7 *Marine impacts and management* of the Draft EIS. Hence the residual-risk rankings also remain unchanged.

Water

- The average sea surface temperature for the Kimberley Shelf subregion has been reported as 28.5 °C (Brewer et al. 2007). This lies within the range of seasonal average temperatures measured at the Ichthys Field (about 30 °C in summer and 26–27 °C in winter—see Section 3.2.5 in Chapter 3 *Existing natural, social and economic environment* of the Draft EIS).
- The observed seasonal difference in the depth to the thermocline at the Ichthys Field (see Section 3.2.5 in Chapter 3 of the Draft EIS) is consistent with the seasonal pattern described by Brewer et al. (2007), that is, the thermocline was found to be deeper in winter (70–120 m) than in summer (30–50 m) when the Indonesian Throughflow is at its strongest.
- Seabed water temperatures at the Ichthys Field were as low as 12–15 °C at depths of 150–250 m (see Section 3.2.5 of the Draft EIS), marginally below the minimum seabed temperature measured at the nearby Prelude Field (16 °C at depths of 150–250 m, Shell 2009).
- The average salinity for the Kimberley Shelf subregion has been reported as 34.8 ppt (Brewer et al. 2007). This lies within the range of salinity measured at the Ichthys Field (34–35 ppt, Section 3.2.5 of the Draft EIS). A similar salinity range (33.61–34.71 ppt) has been measured at the Prelude Field and, as at Ichthys, slightly lower salinities were recorded in deeper waters (Shell 2009).

- Dissolved oxygen concentrations varied with depth in a similar manner at the Ichthys and Prelude Fields (refer Section 3.2.5 of the Draft EIS and Shell 2009), with minima of 3–5 ppm at the seabed and maxima of 6–7 ppm at the sea surface. At both locations, it was noted that variations in dissolved oxygen concentrations showed a similar pattern to temperature variations.
- The average pH at the Ichthys Field (approximately 8.4, see Section 3.2.5 of the Draft EIS) was marginally above the upper end of the range measured at the Ichthys Field (7.51–8.21, Shell 2009).
- The increase in nutrient (nitrogen and phosphorus) concentrations with depth at the Ichthys Field (described in the Draft EIS Section 3.2.5) is consistent with the pattern reported at the Prelude Field (Shell 2009) and is consistent with observations and models for the Kimberley Shelf subregion (Brewer et al. 2007).
- The low chlorophyll-*a* concentrations measured at the Ichthys Field (refer Section 3.2.5 of the Draft EIS) were consistent with the general levels for the Kimberley Shelf subregion (Brewer et al. 2007). The key groups and most abundant species were similar to those recorded at the Prelude Field (Shell 2009).
- The concentrations of some metals in the water column differed between the Ichthys Field (refer Table 5-5 of Technical Appendix 4 of the Draft EIS) and the Prelude Field (Shell 2009), with only mercury undetected at both locations. Cadmium was detected at Prelude, but not at Ichthys. Chromium was not detected at Prelude and was only detected at ultra-trace levels at Ichthys. Lead was not detected at Prelude but was detected at one site at Ichthys. The measured concentrations of nickel at Prelude were an order of magnitude greater than those at Ichthys. Zinc was detected in many samples from Prelude, but in only one sample from Ichthys.

Sediments

- Hydrocarbons were not detected in any of the sediment samples collected at the Ichthys Field, whereas some hydrocarbons were detected in sediments collected from the Prelude Field (Shell 2009).
- Barium concentrations were highly variable between sites at both locations.
- Cadmium and lead were detected in two samples from the Ichthys Field, but were not detected at the Prelude Field.
- Mean chromium concentrations were similar at both fields.
- Iron concentrations were typically higher at Ichthys than at Prelude.
- Mercury was not detected in the sediments from either field.
- Nickel concentrations were typically higher at Prelude than at Ichthys.
- Mean concentrations of zinc were quite variable at Prelude; at Ichthys zinc was only detected in two samples.
- Concentrations of all contaminants at both locations were well below criteria levels at which there may be adverse effects upon biological communities.
- Organic carbon content was higher at Prelude than at Ichthys, where it was below the laboratory detection limit.

It should be noted that some of the differences presented above may be artefacts of differences in analytical techniques applied by the laboratories analysing the water and sediment samples at the two fields. It is emphasised that none of these differences alter the consequence rankings for any of the potential impacts assessed during preparation of the Draft EIS.

Submission 123-201: As stated previously, this is not a habitat map. It is primarily a geomorphological (substrate) map as there is no community data presented.

It should be noted that there are no direct or routine indirect impacts on Browse Island as a result of the Ichthys development and therefore, it was not considered relevant to include detailed habitat maps in the Draft EIS.

INPEX notes that the map of Browse Island in Figure 3-3 of the Draft EIS's Technical Appendix 4 *Studies of the offshore marine environment* is not strictly a "habitat map" but is more a combined map of substrate types with occasional notes on dominant taxa. However, the details of the benthic community structure and zonation identified through the intertidal surveys and post-survey aerial-photograph interpretation are discussed in Section 3.3.4 of Technical Appendix 4. This community information was obtained through conducting four transects from the Browse Island upper intertidal beach to the subtidal zone, as shown in Figure 3-1 of Technical Appendix 4.

Additional data from the Browse Island intertidal surveys are contained in reports which have been provided to the Commonwealth Government, and the relevant data will be incorporated into oil-spill contingency plans as appropriate.

Submission 123-204: Besides validating the model against collected data, the model needs to be reviewed against existing models for Darwin Harbour, including a clear discussion of its limitations and confidence levels for modelled outputs. The report has not discussed its performance for intertidal areas, including mangrove areas or shallow subtidal areas. This is important given that mangroves are depositional areas and sedimentation modelling is dependant on the performance of the hydrodynamic models in these areas.

HR Wallingford were the modelling company who conducted the dredge plume modelling. The model validation procedure has been described in Section 3 of Technical Appendix 12 of the Draft EIS. A full description of how the mangrove areas are defined and treated by the hydrodynamic model is provided in Appendix 2 of Technical Appendix 12.

As stated in Section 5 and Appendix 2 of Technical Appendix 12 of the Draft EIS, existing literature was used to evaluate mangrove communities tree trunk and root/pneumatophore diameter and density to derive friction/drag coefficients for each mangrove community type. The resulting coefficients are within appropriate physical ranges, but there remained some degree of uncertainty and therefore a sensitivity analysis was conducted to investigate the impact of the mangrove friction coefficient on levels and velocities in the main channels of Darwin Harbour.

This analysis indicated that the hydrodynamics in Darwin Harbour are relatively insensitive to the representation of the mangroves in the model. Although it was not possible to calibrate the flow model in these areas, the analysis presented in Appendix 2 of Technical Appendix 12 of the Draft EIS is thorough and deemed appropriate for this study.

The APASA hydrodynamic model of Darwin Harbour was used for submitted assessments of:

1. oil-spill exposure risks
2. fate of wastewater
3. effects of the development on circulation, waves and flushing.

None of these required a model with high performance across the intertidal areas. However, APASA did use a three-dimensional model which incorporated wetting and drying the intertidal zones due to the tides. This model was calibrated using pressure gauge measurements in East Arm. The full model validation description for the APASA modelling is provided in Technical Appendix 5 of the Draft EIS.

Regarding the request for "review against existing models of Darwin Harbour" it is interpreted that the author of the comment is potentially referring to the model developed by UNSW Water Research Laboratory and extended/used by David Williams, but there are other existing models of Darwin Harbour, such as one developed by Charles Darwin University.

The only valid quantitative comparison that could be made between models is to compare various models against sets of measured data, which would require the production of data by the two models for the same field measurements, and then conduct a comparison of the two outputs. Otherwise, any claims of which model is superior to another would be based on personal opinion only.

A more qualitative comparison could be made between models based on a comparison of the levels of sophistication. However, a literature review was conducted and David Williams approached for these details, but no information of the performance of the existing models was identified in the scientific literature and therefore comparisons or comments on the sophistication and performance of various models cannot be made with any rigour.

Both HR Wallingford and APASA hydrodynamic models have conducted a model validation of the Harbour and offshore waters, using comparisons of model predictions against tidal gauge records and ADCP current measurements at multiple locations. These model validation exercises should provide an ample assessment of the performance of the models for the purpose of the Draft EIS.

In addition, INPEX facilitated meetings between Mr David Williams (who has a detailed knowledge of Darwin Harbour hydrodynamics and the "Darwin Harbour Model") and APASA and HR Wallingford to discuss their approaches to modelling and to seek advice on their respective models' suitability and opportunities for improvement. Mr Williams' expert advice was most useful.

Submission 123-206: This statement conflicts with the general perception of Darwin Harbour ecosystem function. For example, Williams et al (2006) note that Darwin Harbour is well mixed (not stratified) during the Dry. This statement needs clarification.

Submission 123-207: This statement needs clarification. Other reports and publications suggest that freshwater input into Darwin Harbour can stratify harbour waters, and persist up to several weeks after a large rain event (e.g. Williams et al 2006).

It has been confirmed with the author that these are typographic errors in this technical appendix. The technical appendix should have stated that:

- Darwin Harbour is not stratified (i.e. well mixed) during the dry season, as per Williams et al (2006).
- Because of the tidal currents, the water column typically remains well mixed (not stratified) with only relatively small changes in salinity extending as far upstream as the back of East Arm, except during occasional and short-lived rainfall events where a freshwater lens extends over the saltwater and some areas of the Harbour do become stratified.

Submission 123-208: The draft EIS notes that the sites used for validating the model(s) are in areas with substrates dominated by relatively course sediment types. Further, the sites are all in relatively deep water, where wave action would have little impact on seabed substrate. The model requires a suitable site to verify this statement. Wave induced resuspension of fines will most likely occur in shallow environments (mangroves, mud/sand flats). Consequently the review has only partially fulfilled its aim and needs further verification in the EIS.

It is agreed that the offshore disposal ground represented in Technical Appendix 13 of the Draft EIS appears to be located in an area of sandy gravel (pers. comm. N. Smit of NRETAS). However, the location experiences tidal currents that are likely to govern long-term sediment transport patterns at the site. The resuspension of fine material due to wave action at this site is likely to be dominated by the prevailing tidal currents under typical meteorological/ wave conditions.

It should be noted that sensitivity analysis has been performed on the assumed mass of fines that may be mobilised from the placed material at the offshore disposal ground, with a representative case of 50% presented in the Draft EIS. This is assumed to be appropriate given the prevailing typical hydrodynamic conditions and likely protection afforded by coarser material contained within the same hopper load when placed to the seabed.

The effect of locally generated waves has been included in the fine grained sediment transport modelling for Darwin Harbour (refer to Technical Appendix 13 Section 4 of the Draft EIS), where wave induced resuspension of fines is thought to be a key process in the redistribution of fine sediment.

Figure 36 and 37 of Technical Appendix 12 of the Draft EIS show that the comparison of wave predictions against observed wave data were generally in agreement at the Pressure Sensor 03 site next to Blaydin Point (Figure 2, Technical Appendix 12 of the Draft EIS). It should also be noted that wave activity is generally limited (less than 0.3m) in East Arm and the waves in East Arm are generally generated not by ocean swells from Beagle Gulf but through wind.

Wind-forcing data were derived from the wind record at the NOAA Data Point (Figure 2, Technical Appendix 12 of the Draft EIS) and the wind data were blown over the entire model area, including the shallow intertidal zones in East Arm. The wind-induced waves on the surface of the water are not affected by substrate type or depth. Therefore the calibration of the wave model at PS03 shows that the wind-forcing data were accurately representing the wind-induced waves on the surface of the water in East Arm, and that these results can be extrapolated over the shallower areas of East Arm.

Submission 123-212: There are a number of uncertainties associated with the methods used. The EIS needs to explain:

- How abundances from underwater video techniques were determined;
- How these were calibrated against more robust techniques (eg line transects);
- What the limitations are of this technique; and
- What the taxonomic resolution using this technique is.

Submission 123-214: See comments above for the ROV method.

The relative abundances of different biota were visually assessed (by suitably experienced personnel) from the video records to determine the predominant community type at each site. This information was not incorporated into the Draft EIS habitat map (Figure 3-16) as it was decided that habitats, rather than communities (with the exception of hard coral) should be shown. However, it has been utilised during the preparation of the benthic communities maps presented in Technical Appendix S6 in this EIS Supplement. As the data have been used for broadscale community mapping at low taxonomic resolution (e.g. filter feeder community, macroalgal-dominated community), and not for monitoring, it is considered that calibration against "more robust" techniques is not warranted.

Limitations of the ROV technique included the degree of water clarity required; the speed of travel of the ROV; and the level of experience of the reviewer of the video records in recognising the different biota present.

Submission 123-213: Sampling intensity is low considering the scale of the impacts. The EIS needs to explain:

- Why only six sites were sampled using transects;
- Whether there was any replication; and
- Why only hard substrates were sampled. A comprehensive sampling regime is required to allow establishment of a comprehensive baseline and therefore an adequate assessment of seabed community types to be undertaken for the harbour.

The purpose of the diver investigations was to provide semi-quantitative information on the types and benthic cover of the communities present at each site, to assist with habitat and benthic community mapping. Temporary transects were laid at some sites to enable quantitative assessments of hard-coral cover to be made; each separate transect at a site could be considered as a replicate for that site. The investigations were not designed to set "comprehensive baselines": this will be done just prior to the commencement of construction works, using techniques that will have been approved by the regulatory authorities.

Submission 123-215: Sample sites chosen are only from within the development footprint; impact areas identified through modelling need to be included. Grab sampling is highly variable within a site; clarity is required on whether there was any replication within sites. The taxonomic level to which infauna were described should be explained.

As discussed in Section 1.1 of the Draft EIS's Technical Appendix 8 *Nearshore marine ecology and benthic communities study*, the objective of the marine benthic ecology study, of which the grab survey was one component, was to characterise the types of benthic biota present in the nearshore development area in order to provide input to the environmental impact assessment process. The grab survey was focused upon areas of direct impact from the construction of the Ichthys Project, as it is intuitive that in areas identified through modelling as areas of potential sediment accumulation (i.e. indirect impact) soft-bottom benthic communities would re-establish over time. See the response to comment 123-115 (see Section 5.2.2.11) for further details, including the rationale for the proposed soft-bottom benthos monitoring program.

It is agreed that grab sampling is highly variable within a site; however the purpose of the sampling was to provide an indication of the types of biota present within two broad development areas, Blaydin Point and the pipeline shore crossing, not to set a baseline for monitoring. Hence each grab site can be considered a "replicate" sample for either of the two broad areas, providing an indication of variability in benthic communities at an appropriate scale. Taking multiple grabs at each site would have given an indication of variability on a smaller scale, but this was not considered necessary in order to achieve the study objective.

Infauna were identified to a taxonomic level that is considered appropriate for the purposes of conducting the impact assessment. For example, it is considered adequate to know that the soft-bottom communities around Blaydin Point are dominated by amphipods and polychaete worms, and are comparable to those in soft-sediment habitats elsewhere in Darwin Harbour. Knowledge of the families, genera or species of these organisms would not improve the robustness of the impact assesment. It is accepted that greater taxonomic resolution will be required for the proposed soft-bottom benthos monitoring program (referred to in the Draft EIS in Table 11-5 of Chapter 11 *Environmental management program*), the details of which will be developed in consultation with regulatory authorities prior to the commencement of construction activities (as indicated in Section 11.4 of Chapter 11).

Submission 123-216: Explain in the EIS what the results from these techniques were and the methods for obtaining these results (eg. data manipulation, interpretation). Sampling methodology and intensity must be suitable to permit quantitative assessment of benthic fauna (and flora); risk assessment; and development of monitoring programs. The current information does not demonstrate this.

The results from the spoil disposal ground survey are presented in Section 3.2.11 of the Draft EIS's Technical Appendix 8 *Nearshore marine ecology and benthic communities study* and are discussed in Section 3.3.7 in Chapter 3 *Existing natural, social and economic environment*. The sidescan-sonar and echo-sounder signals were processed into images using appropriate commercial software.

The sampling methodology and intensity are considered appropriate for the purposes of impact assessment, which also took account of existing information on benthic communities in the vicinity of the spoil ground (see Section 7.3.3 in Chapter 7 *Marine impacts and management* of the Draft EIS).

It is recognised that baseline data on the benthic communities in and around the spoil ground will need to be collected for the proposed soft-bottom benthos monitoring program (see Table 11-5 in Chapter 11 *Environmental management program* of the Draft EIS), the details of which will be developed in consultation with the regulatory authorities prior to the commencement of construction activities as noted in Section 11.4 of Chapter 11).

Submission 123-217: The dredge spoil disposal area is 3 by 7 km, (i.e. 21 km^2). One sample per km^2 was undertaken. Explain in the EIS the number of sites outside the identified dredge spoil disposal area and how these overlapped with impact areas identified through modelling of sediments and hydrodynamics. Sampling methodology and intensity must be suitable to permit quantitative assessment of benthic fauna (and flora); risk assessment; and development of monitoring programs.

Submission 123-221: Samples of the infauna should have been taken at the dredge spoil area. The justification for not sampling is an acknowledgment in the draft EIS that some destruction of the infauna at the dredge spoil site will occur. However, monitoring of the spoil ground is required to effectively monitor other areas that may be impacted by spoil disposal.

As indicated in Figure 6 of the Draft EIS's Technical Appendix 8 *Nearshore marine ecology and benthic communities study*, the 3 by 7 km area includes a buffer zone around the actual proposed spoil disposal area. Six sites lie within this buffer zone. As shown in Figures 105 to 111 of Technical Appendix 13 *Dredging and spoil disposal modelling*, these six sites typically lie within the predicted area of elevated suspended sediments during the first six phases of the dredging program. However, Figures 116 to 121 show that no persistent sediment accretion is predicted to occur at any of the sites at the end of each dredging phase.

It is recognised that baseline data on the benthic communities in and around the spoil disposal ground will need to be collected for the proposed soft-bottom benthos monitoring program (see Table 11-5 in Chapter 11 *Environmental management program* of the Draft EIS). The details of this monitoring program will be developed in consultation with the regulatory authorities prior to the commencement of construction activities, as indicated in Section 11.4 of Chapter 11.

Submission 123-218: Results need to be provided for the following sampling methods: (1) side scan sonar and single beam acoustic; (2) multibeam; and (3) transect data.

The results from the sidescan-sonar and single-beam echo-sounder surveys are discussed in Section 3.2.11 of the Draft EIS's Technical Appendix 8 *Nearshore marine ecology and benthic communities study* and in Section 3.3.7 in Chapter 3 *Existing natural, social and economic environment*.

No multibeam data were collected during the surveys described in Technical Appendix 8 of the Draft EIS.

Transect data are presented in tables 1 and 5 of Technical Appendix 8 of the Draft EIS.

Submission 123-220: The study is not considered to be a sufficient description of the existing marine benthic community in Darwin Harbour and the dredge spoil disposal grounds. The report provides a list of some animals and plants found at different bottom substrates, but needs to show that the infauna organisms, including abundant crustaceans and polychaetes have been identified to nominal species level. This should be a basic level of reporting to ensure assessment of impacts and future monitoring can occur. Also, it is difficult to understand why epibenthic animals such as sea anemones, ascidians, and soft coral and nektonic fish have been categorised as "infauna". This category includes benthic fauna living in the substrate and especially in a soft sea bottom.

Submission 123-222: Identification of specimens is inadequate and does not allow robust analysis of community assemblages. Grouping into major taxonomic units may be the first step towards identifying where comprehensive sampling should take place, but is not adequate for community structure assessment. Diversity assessment is inappropriate at this level. Identification at Phylum level may only account realistically for 20% of the existing diversity, where as if specimens were identified to genus level, then 80% of existing biodiversity would be accounted for. Species identification should at the least be at a Family level, but preferably at a genus level.

Submission 123-224: This information [*the number of individuals identified*] is not tabulated. An indication of the families identified should be provided. It would seem that the lowest level of identification in the study was order to subclass (Table 3.1), not family. Family-level identification is the minimum level recommended for assessment of environmental impact in the marine environment (references can be supplied if required). This was done in the offshore survey (Appendix 4) but not for the Darwin Harbour survey. The study represented in Appendix 8 needs to be enhanced for the EIS.

INPEX contends that the taxonomic resolution applied to the identification of benthic fauna within Darwin Harbour was appropriate to inform the assessment of potential impacts arising from the construction and operation of the Project. It is accepted that greater resolution (to the Family level) will be required for the soft-bottom benthos monitoring program (refer Table 11-5 of the Draft EIS) which will be developed, in consultation with regulators, prior to the commencement of dredging. However, for the assessment of environmental impacts it was considered adequate to know that the predominant taxa present were amphipods and polychaetes, which are either highly motile or have planktonic larval phases that will ensure they are able to recolonise those disturbed areas that remain as, or return to, soft-bottom habitats after disturbance. Knowing the names of the species, genera or families present would not have assisted the impact assessment process.

It could be postulated that greater taxonomic resolution would enable the degree of similarity to be ascertained between the benthic communities that will (or may) be impacted and those in areas distant from potential impact. However, the patchiness (on scales of centimetres though to tens of metres) in distribution of infauna typically confounds the ability to make meaningful comparisons between communities unless considerable replicated sampling effort is applied. This level of effort is appropriate for a monitoring program, however it would have been impractical to apply a similar level of sampling effort across the large areas of seabed potentially subject to direct and indirect impacts from the Project.

Further, while finding the same species in potentially impacted areas and in areas distant from potential impact may afford some comfort that the species are widely distributed, the reverse does not apply. That is, just because a species is found in a potentially impacted area but not beyond the zone of impact, it cannot be assumed that it is "rare" and does not occur outside the area of potential impact—it may well be widespread, but present at low abundance. The numbers of animal species within Darwin Harbour that have been identified to species level (or even collected) are considered to represent only a small proportion, perhaps 10% (McKinnon et al. 2006), of the total number of species present. Therefore the potential to collect previously undescribed species is high, though it would be difficult to nominate any new species as "rare"—it may be widespread and possibly abundant, but may have a very patchy distribution.

In developing the soft-bottom benthos monitoring program, a statistical power analysis will need to be undertaken to ascertain the level of replication that will be required to detect any statistically significant changes between pre-dredging and post-dredging benthic communities.

Errata:

- The term "benthic infauna" is incorrectly used in Sections 2.2.4 and 3.3 of Technical Appendix 8 of the Draft EIS and in the associated figures and tables. "Benthic fauna" is the correct term as some epibenthic fauna, in addition to infauna, were collected.
- In Section 3.3 of Technical Appendix 8 of the Draft EIS, it should be stated that the "total number of individuals identified was 416 from "17 *taxa*" (not "17 families").

Submission 123-225: Comparisons need to be made between draft EIS findings and other study findings (eg Smit et al 2000, P&W reports, East Arm EIS report, Museum data).

Rather than comparing the findings of the studies, INPEX has incorporated the findings of the other studies into the expanded habitat maps presented in Technical Appendix S6 in this EIS Supplement. This has improved the veracity of the impact assessment, but has not altered the residual-risk rankings associated with any of the Project activities.

Submission 123-226: Comparison of diversity between this survey(s) and other surveys is not valid. The methods used in the draft EIS will always have low diversity outcomes as only phyla or major taxonomic groups are used, where as in other surveys, identification was conducted to a lower taxonomic level.

INPEX recognises that, for valid comparisons of diversity to be made, the same level of taxonomic resolution is required within the different studies. For this reason, no comparisons of diversity were made between the Draft EIS studies and other studies. It is noted that such comparisons of diversity would not have enhanced the impact assessment that was undertaken for the Draft EIS.

Submission 123-227: This comparison is confusing. It is comparing two very different substrate types (hard substrate vs soft substrate). In all circumstances, hard substrates are more diverse than soft substrates. Further, this paragraph seems to infer that rock armour is preferable above the existing substrate type. This does not necessarily hold true and depends very much on how and for what reason the assessment takes place.

The statement indicates the change in benthic community which is likely to occur once the pipeline has been laid. No judgment is made as to which of the communities is "preferable".

Submission 123-231: It is evident from the document that dredging plume simulated modelling has been conducted only for East Arm and not for the proposed pipeline route. Table 14 gives calculations of the mass of fine material loss during dredging activity for the pipeline channel approach – 11000m3. Three coral communities: the heritage listed Channel Island coral community and another two coral communities unique to Darwin Harbour, Weed Reef and north-east Wickham Point, lie in close proximity to the pipeline channel. These are likely to be impacted by increased water turbidity and sedimentation resulting from dredging operations. Plume dispersion and sediment modelling for the area along the pipeline trench should have been presented in the modelling report (Appendix 13). Existing results are based on simulation when fine material was released into the specific, rather small area, Figure 3, page 17 (total length ~ 6000m).

"Fine" sediment transport modelling for the pipeline dredging in Darwin Harbour was undertaken and is described in detail in the Draft EIS's Technical Appendix 13 *Dredging and spoil disposal modelling* (in pages 16–26 for example). Apart from at the pipeline shore crossing (and adjacent to the dredger), suspended-sediment concentrations simulated during the pipeline trenching do not exceed a significant level (greater than 3 mg/L) above background level. Therefore the colour contours are not apparent in the outputs of the modelling (except at the pipeline shore crossing) given the lowest concentration shown is 3 mg/L. This is because of the nature of the trenching method (backhoe dredger), the material to be trenched in this area (lower fines content compared with the shoreline crossing area), and the greater water depth towards the offshore area.

The simulated mass of fine material lost during dredging of the pipeline approach is approximately 11 000 t, not cubic metres as indicated in the submission. For modelling the material was released into the specific area where the dredge activities would occur.

The potential impact on coral-reef communities has been described in Section 7.3.2 of the Draft EIS. Further information regarding the extent of potential impact is presented in Section 4.1.3 of this EIS Supplement.

Submission 123-243: The EIS needs to clearly show at the various dredging and dredge spoil disposal phases what the equilibrium state will be for suspended sediments in combination with light attenuation aspects. The combined effect of light attenuation, sediment load and currents will be key drivers for the health of flora and recruitment parameters for benthic fauna.

The Draft EIS presents results of numerical modelling to predict the suspended sediment concentrations in the water column and mass of settled sediment for each phase of dredging (Section 7.3 and Technical Appendix 13). For both of these parameters the median and 95th percentile concentration values have been presented.

In simple terms the model divides Darwin Harbour and the adjacent area into a number of cells and then calculates the theoretical concentration of sediments (suspended and settling) in each of these cells. The calculations are then repeated over a number of time steps for each phase of dredging. The median value in a cell is the midpoint of predicted concentrations occurring in that cell over all of the time steps. The 95th percentile value is the concentration which is greater than 95% of all predicted concentrations occurring in that cell.

Contour plots of the median concentrations for a dredge phase join areas where similar median concentrations have been recorded. This represents the most likely concentrations to occur during that particular dredge phase.

Contour plots of the 95th percentile concentrations for a dredge phase join areas where similar 95th percentile concentrations have been recorded. This represents the worst-case concentrations to occur during that particular dredge phase.

The combined effect of light attenuation, sediment load and currents has been considered in assessing the potential impacts of sediment release on marine flora and fauna.

Submission 124-4: Dredging and sedimentation Significant dredging in Darwin Harbour for the shipping channel will potentially impact water quality; Harbour hydrodynamics; corals; other marine wildlife; mangroves and seagrass. There has been no modelling of impacts on the spoil dump from large cyclones. Recommendations: 2) Relocate to Wickham Point or build a long jetty. Select an alternate soil dump site after appropriate modelling and research.

See the INPEX response to comment 110-15 in Section 5.2.2.11 for discussion on impacts of cyclones on the spoil disposal ground.

Alternative spoil disposal grounds were discussed in Section 4.4.6 in Chapter 4 *Project description* of the Draft EIS as well as in Technical Appendix 4 *Studies of the offshore marine environment*, and the process for site selection, including the consultation which took place with key stakeholders, is summarised in this section. The potential impacts associated with the proposed spoil ground location are considered acceptable by INPEX and these risks are considered to be largely insensitive to further changes in the spoil ground location.

Relocation to Wickham Point is not considered as a credible alternative location for the onshore components of the Ichthys Gas Field Development Project. Details on the selection process for the jetty concepts are provided in Section 4.10.2 of this EIS Supplement.

Submission 124-28: Marine communities. Marine habitats for Darwin Harbour are shown in Figure 3-16 (Chapter 3, Section 3.3.6, p. 70). This map shows only a strip of surveyed area, rather than comprehensive habitat mapping as should be required for the EIS to allow accurate assessment of habitats and species likely to be impacted. It appears that only a sub-sample of the Darwin Harbour area was sampled and it is not clear whether some form of extrapolation has been used to infer habitat outside the actual sampling area. The sampled strip is not representative of the very nearshore areas. Recommendation: Conduct a representative habitat sampling and spatial mapping exercise at a large scale to allow adequate assessment of risks to habitat and species. Marine habitats of the nearshore development area and Protected species. Darwin Harbour contains diverse habitats including sponges, seagrass, rocky reefs, mangroves and sponge beds that support a rich collection of marine species, including protected species. Descriptions of nearshore habitats and species ignore important information from local studies and references (e.g. Palmer 201012); impacts are outlined as minimal on the basis of lack of knowledge regarding the reasons species (such as turtles) are present; there are incorrect assertions that no important feeding or breeding areas have been identified for species such as dolphins; and a perceived ability of marine species to move away from any adverse or disruptive activities without disruption to key life habits (e.g. socialising, site fidelity, foraging) (Chapter 3, Sections 3.3.7 & 3.3.8). Six turtle species, dugong, the Australian snubfin dolphin, Indo-Pacific humpback and bottlenose dolphins, sharks, rays, sea snakes, sawfish, crocodiles and a diverse fish fauna are found in Darwin Harbour. Although the distribution, seasonal occurrence, population dynamics and conservation status for many of these species are unknown or little known for Darwin Harbour, their presence and the high diversity of species and habitats identifies this as a significant ecological system. If such a diverse set of species and habitats are present it should be concluded that the area is important to some, if not all aspects of the species lives. Recommendations: Conduct a more professional and thorough review of Darwin Harbour species and habitats and make considered judgements as to the likelihood of serious impacts. Do not use lack of information at the site or similar habitat in adjacent areas as a reason to assume low impacts. Produce a whole-of-Darwin Harbour habitat map to allow for rigorous assessment of the scale of impacts on marine biodiversity both spatially and temporally.

It is acknowledged that Darwin Harbour contains a diverse range of habitats and species, as was acknowledged in Section 3.3.6 in Chapter 3 *Existing natural, social and economic environment* of the Draft EIS. INPEX has conducted additional studies of the benthic environment of Darwin Harbour and collated all available data sets to develop a Harbour-wide comprehensive benthic habitat map (See sections 4.1.1 and 4.1.2 of this EIS Supplement for further details). The map clearly shows areas of high-confidence mapping and areas of inferred habitats. An assessment of impacts to benthic habitats and trophic structures is provided in Section 4.1.3 of this EIS Supplement. Additional information, including vessel-based survey data and a further examination of the Project risks specific to coastal dolphins, is provided in Section 4.1.9. Risks to other protected species, including turtles, are further discussed in Section 4.1.10 and the specific issues of underwater noise and vibration are further examined in Section 4.1.11.

Submission 124-38: Dredging in Darwin Harbour will initially occur over 4 years, with follow up dredging at least every 10 years (Chapter 7, Section 7.3.2, p. 308). The Draft EIS states that "...the key environmental receptors of interest (e.g. mangroves and key coral sites) in East Arm and Darwin Harbour are outside the immediate dredging footprint" (p. 308). Notwithstanding this, Figures 7-18 to 7-23 reveal a series of predictions for suspended sediment concentrations during different stages of the dredging program, many of which show high levels in East Arm, Elizabeth River and Channel Island. Clearly, the time-scale of dredging operations and the spatial scale over which impacts to marine communities will take place is considerable.

Table 7-31 (Chapter 7, Section 7.3.2, p. 327) lists potential impacts from sedimentation, including: reduced growth or death of coral communities; impacts on sponge communities and other soft-sediment biota; impacts on fish eggs and larvae; a reduction in available habitat and food resources for coastal dolphins, marine turtles and dugongs; and reduced growth or death of mangroves. The potential impacts listed occur over many communities and species, and will likely result in a loss of diversity and abundance (Cardinale 2004, Cardinale et al. 2007, Finke and Denno 2004, 2005, Duffy et al. 2005, Byrnes et al. 2006, Jonsson et al. 200718).

These cited studies have found that changed species richness, both within and across trophic levels, influences process rates and that these effects can propagate through food webs. Just the loss of diversity in benthic communities alone will have repercussions for ecosystem function and may cause a reduction in the diversity of fish and other species of importance to top predators such as dolphins. A reduction in food sources combined with disturbance from a range of Project activities (e.g. blasting, dredging, pile driving, increased vessel traffic) will result in a high risk of adverse impact to dolphins and other species.

Management and mitigation measures suggested in Table 7-31 rely heavily on:

- Incorrect statements – for example, the statement that no significant breeding or foraging areas for dolphins and marine turtles are known in the nearshore area; and, key dugong habitats at Channel Island are not predicted to be affected by plumes (despite plume models showing sedimentation in this area for some phases of the Project).
- The premise, consistently stated throughout the Draft EIS, that other similar habitats exist within or near Darwin Harbour.

The text quoted from page 308 in Section 7.3.2 in Chapter 7 *Marine impacts and management* of the Draft EIS is correct, as the term “immediate dredging footprint” refers to the areas of seabed which will be removed by the dredgers.

INPEX recognises the interconnection between the various trophic levels within Darwin Harbour, and that disturbance to one component of the ecosystem invariably influences the others. However, the areas where impacts are predicted to potentially occur (as defined through the conservative modelling of sediment dispersion and accretion described in the Draft EIS’s Technical Appendix 13 *Dredging and spoil disposal modelling*) are small relative to the areas of similar habitat within the Harbour (see Table 4-9 and Table 4-10 in this EIS Supplement).

Following the “consequence” definitions in Table 6-3 in Chapter 6 *Risk assessment methodology* of the Draft EIS, INPEX believes that the appropriate residual-risk rank for impacts upon dolphins, turtles and dugongs is “medium”, rather than “high”. It is considered that there is no potential for impacts on critical habitats or activities, and no threat to the overall viability of populations of these species.

INPEX contends that there are no known breeding or foraging areas in the nearshore development area that could be considered as critical for the survival of populations of these species. To better demonstrate the similarities between the habitats predicted to be at risk of impacts from dredging, and habitats elsewhere in the Harbour, further studies were undertaken during the preparation of this EIS Supplement. The results of these surveys (see Technical Appendix S6 and Section 4.1.2 in this EIS Supplement) support the contention that the habitats and communities at risk of impact are well represented elsewhere in the Harbour.

It should be noted that statement in Table 7-31 of the Draft EIS regarding the dugong habitat at Channel Island being unaffected by plumes refers to the East Arm dredging works, not to the pipeline shore crossing works. It is during the latter works that there is predicted to be a risk of turbid plumes impinging upon the Channel Island rock platform (refer Figure 7-21 and Technical Appendix 13 of the Draft EIS).

Submission 124-44, 124-53: NT Government to consider the imposition of an environmental levy on developers based on environmental risk alternatives and cubic metre of spoil disposed, as per the polluter pays principle and the dredging policy for the Great Barrier Reef Marine Park.

Decisions around policies of this nature are the responsibility of the Northern Territory Government and fall out of the bounds of what INPEX is positioned to respond to in terms of submissions on the Ichthys Project.

Submission 124-45: Dugong foraging habitat includes Channel Island, an area where sediment plume modelling shows high levels of suspended sediment. The Draft EIS states that dugong may avoid Channel Island during the period of dredging activity (Chapter 7, Section 7.3.2, p. 324), yet there is no explanation as to why they would do this, nor any assessment of the potential impacts on the animals of a loss of access to this foraging site for the ‘five week dredging period’. Any increase in the sedimentation disturbance footprint could greatly increase the period over which loss of foraging access occurs, thus increasing the level of impact on this species.

The extent of potential dugong foraging habitat in Darwin Harbour has been estimated by calculating the area of suitable seagrass and macroalgae habitat (see sections 4.1.3 and 4.1.10 of this EIS Supplement). The area of dugong foraging habitat affected by dredge-induced suspended and settled sediment above threshold level is estimated to represent 0.5% of the total foraging habitat available in Darwin Harbour. Furthermore, the period over which these threshold values may be exceeded is relatively brief.

Submission 124-48: Dugongs are difficult to sight and the observation program outlined for marine fauna in Annexe 6 (Chapter 11, p. 539) would not be adequate.

Annexe 6 *Provisional Dredging and Dredge Spoil Disposal Management Plan* to Chapter 11 *Environmental management program* of the Draft EIS addresses several key issues such as sedimentation, elevated levels of total suspended solids, turbidity, coral monitoring, alterations to bathymetry and sedimentation in mangroves. The focus of the plan is not on the management of dugong or other large marine animals.

Dugong management was discussed in the Draft EIS particularly in the following sections:

- Section 7.3.10 *Marine megafauna* in Chapter 7 *Marine impacts and management*
- Annexe 12 *Provisional piledriving and blasting management plan* in Chapter 11.

The main focus of the Provisional Dredging and Dredge Spoil Disposal Management Plan is the management of dredging as it relates to benthic habitats, such as its effects on water quality, sedimentation, mangroves, coral and so on. Section 1.2 of the plan states that the effects of localised seabed disturbance, noise and turbidity are not expected to have a significant negative impact on marine mammals and reptiles. The plan does however address the protection of dugong food sources (in benthic habitats). Since the publication of the Draft EIS in July 2010, considerable additional benthic habitat mapping has been undertaken in the Darwin region by INPEX to identify further areas of seagrass, a key foraging habitat for dugongs. INPEX has also acquired benthic data from other sources.

As discussed in Section 7.3.10 of the Draft EIS, in relation to direct physical impacts of dredging equipment on dugongs, dredging vessels are very slow moving and the dredging equipment does not pose an entrainment risk to dugongs and other marine mammals.

Smaller and faster vessels will minimise their risk of impacts on dugongs by extending the Cetacean PEMP vessel interaction conditions (Annex 4, Chapter 11) to also include dugongs. Specifically, the vessel speeds and approach vectors displayed in Figure 3-1 of the Draft EIS would also apply to dugongs.

Submission 124-50: A study to determine actual habitat use by turtles and dugong should be conducted prior to the development to provide adequate information on which to base risk assessments and effective mitigation of impacts.

The area of potential turtle and dugong foraging habitat within Darwin Harbour has been identified as part the seabed-habitat mapping studies, which are described in Section 4.1.2 of this EIS Supplement. The area of foraging habitat potentially affected has been calculated and is described in Section 4.1.10.

Submission 124-81: Seismic surveys and vessel collisions

These issues are not dealt with adequately in the Draft EIS. There is a considerable body of peer reviewed recent literature on these topics that is not referred to (e.g. Gordon et al. 2002, DFO 2004, Simmonds et al. 2004, Shepherd et al. 2006, Weilgart 2007, Jefferson et al. 200937). As noted below, a comprehensive research program run by independent professional scientists that investigates thoroughly the impacts of these activities on marine species is required. Mere adherence to outdated guidelines, as outlined in the Cetacean Management Plan (Chapter 11, Annexe 4, p. 525), is not adequate for the scale of development proposed, or for the potential risks posed by the development.

Submission 124-89: Incorporate information from key references missing from the Draft EIS on the impacts of noise, including seismic surveys (e.g. footnote 10 references) and vessel strikes/collisions (e.g. Panigada et al. 2006, van Waerebeek et al. 2007, Campbell-Malone et al. 2008, WWF 201038).

As stated in Section 7.2.6 in Chapter 7 *Marine impacts and management* of the Draft EIS, there are no proposals for full-scale three-dimensional seismic surveys for the Ichthys Project. Vertical seismic profiling (VSP) is the only "seismic" operation to be conducted as part of the Project and it has a far lower source level than full two-dimensional or three-dimensional exploration seismic work. Because of the low source level, sound levels rapidly attenuate to below 160 dB re 1 µPa within 100 m of the VSP activity, as discussed in Section 7.2.6 of Chapter 7 of the Draft EIS (and see also Table 7-25).

Extensive research was undertaken during the development of the EPBC Act Policy Statement 2.1 on interaction between offshore seismic exploration and whales (DEWHA 2008a). These guidelines are not outdated and are currently heavily utilised by the Department of Sustainability, Environment, Water, Population and Communities through its ongoing review of petroleum exploration seismic survey proposals.

INPEX is aware of the extensive literature that is available on the topic of underwater noise and has compiled a comprehensive literature review provided in Technical Appendix 15 of the Draft EIS and also in Technical Appendix S7 of this EIS Supplement. However the main chapters of the Draft EIS are not intended to be an all encompassing literature review into every possible environmental impact. Rather, the chapters provide appropriate and relevant information to conduct a robust risk assessment. This risk assessment has been conducted by qualified scientists.

In relation to vessel strikes and collisions, see INPEX's response to comment 85-5 in Section 5.2.2.11.

Submission 124-82: Improve the Draft EIS by providing comprehensive descriptions of the most up to date information on the functioning of marine habitats and the life history and habitat requirements of marine species.

INPEX submits that the information presented in the Draft EIS and the additional data presented in this EIS Supplement including the habitat maps presented in Section 4.1.2, now represent the most up-to-date information that is available to INPEX. It is considered to be at an appropriate level of detail to support the assessment of the risks of environmental impacts that has been undertaken. It should be noted that the additional data presented in this EIS Supplement have not led to any elevation of the consequence rankings applied to any of the potential Project impacts that have been assessed.

Submission 124-85: Impacts on species and habitats in coastal hubs for fly in fly out workers (e.g. due to increased recreational boat use and flight paths over resting wader birds or seabird nesting islands).

In the context of current activity within and around Darwin Harbour from Darwin residents and the large annual tourist influx, it is not anticipated that the additional impact from fly-in, fly-out (FIFO) workers will be significant. The peak workforce is estimated 2000–3000, but the FIFO component will, by definition, be flying home for rest and recreation.

Submission 128-3: Water quality. Darwin Harbour's declared Beneficial Uses under the Water Act NT are defined as the Protection of Aquatic Ecosystem, Recreation and Water Quality. It is possible that this project may impact on many of these parameters.

There is a need to better understand the effects of increased turbidity from construction operations on Phytoplankton in the harbour and the short and long term consequence of these impacts on other marine organisms.

The Draft EIS states that no algal blooms have been recorded in Darwin Harbour. This information is incorrect. Apart from general algae found in this region at specific times of the year, recent water quality issue in the harbour included for the first time an algal bloom consisting of Lyngbya sp on Darwin Beaches in June 2010.

Potential source of hydrocarbon contamination should include the areas associated with the old WW2 storage tanks around Stokes Hill and Fort Hill Wharfs and the now removed storage facility at Stuart Park. These areas seem to have been overlooked in the assessment.

It is unclear what the effects of disturbing sediments containing reported levels of 356 mg/kg N and a mean total P of 315kg/mg will be? This raises further questions that require clarification such as – Will these nutrients be bio-available once disturbed and in suspension and will this initiate further algal blooms in Darwin Harbour?

Also, what is the fate of other contaminates detected in the sediment such as heavy metals and hydrocarbons once they are disturbed and potentially exposed?

Submission 105-1: Dreging will lift all heavy metal pollution out of the mud from wharf loading run off and from sand blasting anti-foaling paint and others at various shipyards in the harbour, causing said pollution to become more active in the marine environment, again.

Have worked at shipyards in Darwin before, those antifoaling paints are nasty. Im afraid the harbour sea floor is loaded with it.

Submission 123-13: The EIS needs to provide a separate assessment for macro algae and for phytoplankton. Both groups are affected differently by dredging and dredge spoil disposal and play different roles within the Darwin Harbour ecosystem. Conceptual Models of the harbour environment would be useful for predicting the effects of the project on these biota.

Submission 123-14: *[Turbid plumes can also release nutrients stored in marine sediments, providing a food source for fish and subsequently attracting predators such as marine mammals and reptiles].*

The use of the word "nutrients" needs to be clarified (dissolved or particulate matter/infauna). No baseline has been conducted to determine infauna composition or nutrient content of sediments; no discussion of the implications to phytoplankton (with the possibility of algal blooms) and bacteria. There is no mention of the possibility of releasing contaminants into the water column and its impacts. Conceptual models would clarify these interactions.

Submission 123-39: Development of a basic conceptual model is an integral part of the assessment process. A conceptual diagram for ecological and human health risk assessment should be developed to illustrate primary and secondary pollutant/stressor sources, release and transport mechanisms, exposure media and ecological and human receptors.

Submission 123-45: Given the recently reported algal blooms in the harbour, some discussion on whether INPEX might contribute to cumulative pressure would be useful.

Submission 123-186: The current EMP does not provide enough information about the biogeochemical properties of dredged sediments. Sediment studies and water quality monitoring need to be undertaken at the proposed dump site using relevant parameters monitored in previous programs. The monitoring program for the dump site should be undertaken prior to, during and post construction to determine the impact that dredged sediments will have on the site and adjacent areas. Additionally, water quality and sediment monitoring will need to be undertaken in the harbour and spoil disposal site during dredging to assess the implications of acid sulfphate soil disturbance or the release of arsenic from underlying geology.

Submission 124-28: Nutrients and phytoplankton . The review of the existing Darwin Harbour environment is deficient, including inaccurate statements such as: "Algal blooms...have not been recorded in Darwin Harbour" (Volume 1, Section 3.3.4, p. 64). No reference has been made to the Darwin Harbour Region Report Cards 200911. Chlorophyll-a measurements in the Blackmore River were found to be up to 10 times higher than other parts of the Harbour (Chapter 3, Section 3.3.4, p. 64). This high productivity could be important for fish and other marine organisms. Recommendation: Undertake further primary productivity studies and broader sampling to investigate the ecological importance of other high primary productivity events or areas. An adaptive management plan should be developed to remove adverse impacts on these events and/or areas to mitigate loss of fish and other marine organisms due to reductions in food availability.

Submission 128-18: The Draft EIS requires further information on the fate and impacts of the contaminates contained in the sediments once disturbed.

Conceptual model

At least two conceptual models for Darwin Harbour have been developed: a trophic model by Martin (2005, in Wolanski et al. 2005) and an estuarine ecohydrology model by Wolanski et al. (2005). Such models can assist the understanding of the connectivity between trophic levels, the ways in which various disturbances may apply pressure to the components of the ecosystem, and the pathways through which impacts at one trophic level can influence other trophic levels.

However, while it is agreed that presentation of the models in the Draft EIS may have enhanced the understanding of those reviewers with a limited scientific background, it should be noted that the impact assessment was undertaken by appropriately qualified personnel with the required level of knowledge of these trophic processes. Hence the absence of these models from the Draft EIS does not affect the veracity of the impact assessment.

Phytoplankton

It is acknowledged that the potential effects of dredging upon phytoplankton in Darwin Harbour could have been addressed in the Draft EIS. Phytoplankton abundance is known to be modulated by the balance between light attenuation (decreasing abundance) and nutrient availability (increasing abundance) (Herzfeld et al. 2006; Sobolev, Moore & Morris 2009).

In considering the potential for INPEX's dredging operations to influence phytoplankton productivity within the Harbour, it must be recognised that, at any point in time during dredging, the proportion of the total Harbour area influenced by turbid plumes will be limited (see figures 40–83 of the Draft EIS's Technical Appendix 13 *Dredging and spoil disposal modelling*). Within the plumes, phytoplankton productivity may be suppressed if light is attenuated to sufficiently low levels, while this may be balanced by increased productivity due to the release of nutrients from the dredged sediments. As the natural nutrient cycling and levels of phytoplankton productivity will continue within the vast areas of the Harbour outside the ephemeral turbid plumes, it is considered inconceivable that any net changes in phytoplankton productivity due to dredging could be sufficiently large to affect the trophic dynamics within the Harbour (e.g. to increase or suppress the productivity of zooplankton or planktivorous fish to the extent that there are effects on higher order predators).

Algal blooms

The recent occurrence of algal blooms in Darwin Harbour is acknowledged. It is noted that in the 2010 Darwin Harbour Region Report Cards (Drewry et al. 2010) algal blooms are described as naturally occurring within the Harbour during most dry seasons. This conflicts with the information presented by WMB (2005), which was the source of the information provided in the Draft EIS.

Contaminants

The historical potential sources of hydrocarbon contamination provided are acknowledged, though it is considered unlikely (given their locations) that they would have contributed to the hydrocarbon levels detected in sediments, as described in Section 3.3.5 and Technical Appendix 9 of the Draft EIS.

An assessment of contaminants in seabed sediments within the areas to be dredged was undertaken in 2008 (refer Section 3.3.5 and Technical Appendix 9 of the Draft EIS). As in previous surveys over the years arsenic was often present at concentrations above guideline criteria levels, though its presence throughout the sediment profile has been taken as an indication that this is a consequence of local geology rather than of anthropogenic contamination. Further testing of samples with elevated arsenic levels demonstrated that only a small proportion of the arsenic would dissolve into bioavailable forms. Chromium and mercury concentrations were elevated above guideline criteria levels in a limited number of samples, but overall concentrations of these metals were sufficiently low that the sediments to be dredged can be considered (under Australian legislation) to be uncontaminated.

Since 2008, there have been incidents of contaminant releases into East Arm, though sampling by AIMS (2010) indicated that elevated metals concentrations in sediments were limited to the berths at East Arm Port. Hence it is considered unlikely that these incidents would have led to contamination of the areas to be dredged for the INPEX Project.

Regarding the fate and impacts of contaminants in the sediments once disturbed, the National Assessment Guidelines for Dredging (DEWHA 2009) provide conservative criteria levels for contaminant concentrations in sediments to be dredged. If contaminant concentrations are below these levels, or if contaminants are demonstrated to have limited bioavailability (cf. arsenic in EIS Technical Appendix 9), then the sediments are deemed to be suitable for unconfined sea disposal as they are considered to not pose a risk of contamination of the receiving environment.

The need for further determination of sediment quality prior to dredging will be considered and discussed with NRETAS during development of the detailed Dredging and Dredge Spoil Disposal Management Plan, which will require approval by NRETAS prior to the commencement of dredging.

Nutrients

In considering INPEX's potential contribution to the input of nutrients into the Harbour from wastewater (sewage), it needs to be recognised that the peak workforce during construction may be in the order of 2000–3000 people, not all of whom would be working on site at the one time. This is an order of magnitude smaller than the present population of Palmerston (approximately 25 000), whose sewage treatment plant outfall is located on the opposite side of East Arm from Blaydin Point. The number of personnel required during the operations phase will be an order of magnitude smaller again (some 300 people, not all of whom would be working at the one time). Given the implementation of the sewage treatment systems and discharge limits described in Section 5.6.3 of the Draft EIS, it is considered reasonable to assume that INPEX's contribution to cumulative pressure will be negligible.

Further discussion on INPEX construction and operations nutrients loads from sewage in comparison with existing point source loads and Darwin Harbour annual load triggers are discussed in Section 4.1.14.

In the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ 2000), it is noted that nutrient release from sediments is influenced by sediment composition, temperature, mixing regime of the water body and oxygen transfer rates. It is also noted that, at the time of preparation of the guidelines, there were no quantitative relationships available to estimate releases; it was deemed essential that such relationships were incorporated into the guidelines "as soon as possible", though there is no evidence that this has been done. Hence there are no firm guidelines against which to assess the measured concentrations of nitrogen and phosphorus in the sediments to be dredged.

The nitrogen and phosphorus concentrations presented in the Draft EIS are similar in magnitude (though generally less than) to those measured in previous Northern Territory Government studies in Darwin Harbour (Padovan 2003). These studies concluded that the nutrient levels present in the sediments did not constitute a significant environmental issue (Warren 2001, not seen, cited in Padovan 2003). Further, Padovan (2001) estimated that 20–50% of the nitrogen and 40–80% of the phosphorus discharged to the Harbour at that time was derived from treated sewage, with the balance coming from catchment runoff.

The mean annual load of nitrogen predicted to be released by dredging for the INPEX Project has been calculated as almost 40 t/a which, when added to the existing loads from diffuse and point sources presented by Skinner, Townsend and Fortune (2009), would result in a total load of approximately 240 t/a. This is well below the trigger target for Darwin Harbour of 1319 t/a of nitrogen for point and diffuse source (Fortune & Maly 2009).

The predicted mean annual load of phosphorus from the INPEX dredging program (approximately 56 t), when added to the existing loads from diffuse and point sources presented by Skinner, Townsend and Fortune (2009), would result in a total load of approximately 85 t/a, also well below the trigger target for Darwin Harbour of 182 t of phosphorus per annum (Fortune & Maly 2009).

These additional inputs of nutrients into Darwin Harbour as a result of dredging will cease at the end of the dredging campaign, at which point the annual nutrient loads should return to pre-dredging levels.

It is recognised that localised nutrient releases from the sediments may occur during dredging, and that these nutrients are likely to be bio-available. This has the potential to lead to some temporary localised (within dredge plumes) increases in planktonic and algal productivity, though this would be balanced by reductions in productivity due to increased light attenuation by the suspended sediments. A net increase in productivity, if it was to occur, could be considered beneficial to the Harbour ecosystem provided it did not lead to algal blooms. However, a measurable increase in productivity is considered highly unlikely as the nutrients released will be dispersed and diluted by tidal currents.

It is noted that in Section 6 of the Executive Summary of the Draft EIS the term "nutrients" is used in a manner which may be construed as including infauna, as the text could be interpreted as indicating that fish would be feeding directly upon the nutrients. It is recognised that the intermediate link provided by plankton should have been described.

Submission 128-5: The blasting at Walker Shoal will result in the loss of habitat which may be significant in the context of Darwin Harbour, especially with this project but also as future developments are anticipated the cumulative effect will also have the potential to diminish habitat. It is difficult to assess how well represented the habitat is at Walker Shoal and in Darwin Harbour due to the lack of available data.

Alternative options to the destruction of Walker Shoal should be pursued along with all potentials for a more suitable location for on the shore development which would allow for an easier traffic route for shipping – one that could be achieved more readily.

A more comprehensive study on the benthic zone of Darwin Harbour should be undertaken to fully understand the impacts of the proposed disturbances on the habitats and biodiversity of the harbour.

An assessment of alternative shipping channel options is included in Section 4.10.1 of this EIS Supplement. Alternative locations for the siting of the onshore development infrastructure within Darwin Harbour has not been considered as the Northern Territory Government offered INPEX the Blaydin Point site zones for industrial development, as their preferred site for development of the onshore components of the Ichthys Gas Field Development Project.

Improved habitat mapping of Darwin Harbour is included in Section 4.1.2 of this EIS Supplement. Further investigations of benthic communities were undertaken during preparation of this EIS Supplement (see Section 4.1.5 and Technical Appendix S6). The Walker Shoal habitat that is proposed to be removed during the construction of the shipping channel is subtidal hard substrate between 5 and 15 m below LAT. Using known and inferred data, this represents 0.07% of the hard substrate between these depths within Darwin Harbour.

Submission 128-17: How long will it take for benthos to recover from disturbance? Discussion and information in this section is based on assumption, not research or contemporary data.

To imply that a particular species or habitat is well represented in the harbour and therefore some loss would be not be considered a problem, is questionable. Particularly in view of the lack of data for Darwin Harbour, along with the potential for more new harbour developments taking the same line of thinking.

Threats to Darwin's Marine Environment and Industries through pest invasions and lack of monitoring require special attention.

Recovery times of benthos from disturbance cannot be accurately predicted as they will vary depending upon the type of benthos and the environmental conditions under which they exist. However, the assumptions made during the risk-assessment process were based upon a plethora of published literature pertaining to the recovery from disturbance of many different types of benthos in tropical locations around the World.

INPEX contends that the notion of "acceptable loss" is fundamental to the environmental impact assessment and management processes. It is inevitable that some loss of individual biota (though not entire populations or species) and some habitat modification or replacement will occur with any development. The purpose of environmental impact assessment and management is to ascertain the proportional loss that is predicted to occur; to assess the implications of those losses to the viability of populations, ecosystem function, etc.; and to manage activities in such a way that these impacts are limited to an acceptable level. The potential for cumulative effects from other developments is discussed in Section 4.13 of this EIS Supplement.

The risks posed from marine pest species, and the proposed management and monitoring thereof, are described in sections 7.2.8 and 7.3.9 of the Draft EIS.

Submission 128-49: Intertidal sediment monitoring is required. Invertebrate species which inhabit these zones should be monitored; sediments should also be sampled for heavy metals and nutrients.

Submission 128-51: Shell fish in the intertidal zone should also be monitored in order to better understand the effects of increased sediment loads on this intertidal habitat. Mangrove community species richness and abundance should also be monitored.

As outlined in Table 11-5 in Chapter 11 *Environmental management program* of the Draft EIS, INPEX has committed to a marine sediments and bio-indicators monitoring program to determine whether construction activities in acid sulfate soils have an effect on pH and heavy-metal availability in marine sediments around the onshore development area and to assess any accumulation of metals and hydrocarbons in selected bio-indicators. These sediments and bio-indicators are likely to be sampled from the intertidal area.

Also as noted in Table 11-5, INPEX has committed to a mangrove health monitoring program to monitor the effects of sedimentation in mangrove intertidal areas. This will include regular assessments of mangrove canopy cover and the development of a leaf defoliation index as indicators of mangrove health. The measurable parameters will be agreed with the Department of Natural Resources, Environment, the Arts and Sport (NRETAS) during the preparation of the final monitoring programs; monitoring of mangrove invertebrate communities will be included in the monitoring programs.

Submission 130-21: We firstly discuss the modelling used and results obtained to simulate the near-shore sedimentation from spoil Site 9 as described Technical Appendices 12 & 13 by HR Wallingford Ltd. The model predicts that the 'fine' sediments from the spoil would be deposited on shoreline locations between Lee Point and the mouth of the Adelaide River. However, the model only considers the action of average tides on the fines in the spoil and the model's bathymetry ends at an imaginary line between Cape Hotham and Melville Island as shown by the red line in Figure 4 next page. In effect, the much increased energy of the higher spring tides is ignored and the model assumes that there is an isthmus connecting Cape Hotham to Melville Island. AMSTECI do not have expertise in such matters but it seems common sense that if the model accurately reproduced the effect of the larger tides and also the effect of the huge volume of water that washes back and forth through Clarence Straight with each tide (currents in the order of 2.5 m/s) then there would be a much higher sediment loads, particularly onto the Class 1 Conservation Reserves of the Vernon Islands.

In order to model the complete proposed dredging and disposal plan to inform the EIS, simplifications were necessarily made with respect to hydrodynamic modelling. The hydrodynamic model simulated a typical, mean spring–neap 15-day cycle (with consideration for seasonality) at different stages of the dredge program. These 15-day cycles were then repeated and sequenced to cover the dredging period.

While tides with the largest range (that tend to occur around the equinox) may transport material further afield than average spring tides, the number of occurrences within the proposed schedule is low. The additional complexity of including such events in the modelling is unwarranted because modelling in this way would intrinsically link the hydrodynamics to a specific period; should the expected date that dredging commences alter, then hydrodynamic predictions and subsequent modelling would become relatively obsolete compared with an approach that uses "mean" spring-neap tidal cycle hydrodynamics to inform the environmental impact assessment.

Importantly the model does not assume an isthmus between Melville Island and Cape Hotham; on the contrary, this is an open (free-surface-driven) boundary, governing the exchange of water in and out of the model domain. INPEX acknowledges that the figures showing model results can be interpreted as suggesting that this boundary is solid.

Submission 130-22: The subject modelling assumes that 50% of the 'fines' from the Site 9 spoil dump are dispersed and the rest of the 'fines' remain trapped within the coarser material in the dump. The modelling predicts that, under the action of average tides and winds, at the end of the dredging for the project, the dispersed fines end up in irregular patches having depths in the range 10 – 20 mm in the locations shown by the red pins in Figure 4. (The size of the pins approximates the size of the sediment patches.)

Scaling from Figure 125 in Appendix 13, the patches vary from being right on the coastline to about 2 km offshore and have a total area of about 15 km2. For an average depth of 20mm, that equates to a volume of 300,000 m3. But, using figures from Appendix 13, 50% of the fines should have a volume equal to 0.5 x 0.33 x 23,900,000 tonne/0.7 tonne/m3 = 5,600,000 m3.

The obvious question is –where is the rest of the 50% of fines?

The estimation of the mass of fines released from the proposed spoil disposal ground is approximately correct; and thus it may be assumed that the calculated volume (0.3 Mm^3) deposited on the shoreline provided by AMSTECI is also correct.

Approximately 4 Mt of fine material has been simulated as being available for dispersion at the offshore disposal ground. The simulation shows that only a small proportion of this material will reach the Northern Territory coastline around the Howard River, Adelaide River and the Blue Holes. This can be explained by the following:

- The hydrodynamic model indicates the presence of a net north-eastward residual current that transports material through the Clarence Straits towards the Van Diemen Gulf and is dispersed widely.
- The colour scale used for the figures showing deposition at the end of dredging (Figure 125 of the Draft EIS's Technical Appendix 13 *Dredging and spoil disposal modelling*) does not highlight deposits of less than 5 mm (which may be considered the realistic estimate that is detectable over a 4-year period).
- A significant proportion of the material is retained in suspension.

Submission 130-23: Appendix 14 [by consultants Asia Pacific Applied Scientists Associated Pty Ltd (APASA)] examined each of the 9 proposed spoil sites and concluded that Site 9 would lead to the least amount of spoil sediment re-entering Darwin Harbour. However, the Executive Summary of Technical Appendix 14 states, in part, that:

"During the wet season, which included the influence of cyclones, including Tropical Cyclone Helen on the current and wave estimates, median stress estimates were indicated to be sufficient to mobilize coarse sand over a wide part of the seabed outside of the Harbour……….The results indicated that finer sediments (silts, clays and fine sands) will be readily mobilized by the strong tidal currents, irrespective of the disposal site (within practical sailing distance of the harbour)……"

This makes it apparent that the major problem with the modelling in Appendices 12 & 13 is that account is only taken of the action of average tides and winds and only on 50% of the 'fines'. Appendix 14 makes it clear that the 83% of the dry mass of the spoil which is finer than coarse sand will sooner or later be re-mobilized and dispersed elsewhere by the action of TCs.

Appendix 14 says in effect, that the offshore disposal ground could be located anywhere around the southern half of Beagle Gulf and an intense TC coming in on an adverse track could still move a large proportion of the spoil back toward, or into, the Darwin Harbour. However, it is apparent that the largest waves and the strongest seabed currents generated by TCs will come from west to east (because of the long reach available through the large, west side opening to Beagle Gulf) and this means that eventually, under the action of perhaps several TCs and the action of normal tidal currents and waves, most of the dredged spoil will end up moving eastward from Site 10 and onto nearshore areas between Lee Point and the mouth of the Adelaide River and the shores and interiors of the Vernon Islands. (The effect of two intense TCs on the western end of North West Vernon Island is shown in Figure 5 and subsequent discussion on the following page.)

It appears to this writer, that unless grab samples show that the seabed material in nearshore areas is coarse sand or larger, the assumption must be that finer spoil material will end up further inshore – much further inshore than indicated in Fig. 125 of Appendix 13 for instance.

Using dry mass and density data from Appendix 13, the total volume of the spoil fines will be about 11,000,000 m3 and the fine to medium sand will have a total volume of about 7,000,000 m3. We can use that total volume of 18,000,000 m3 to make a 'ball-park' estimate of the thickness of spoil material that might end up within the mangroves or on the beaches between Lee Point and the mouth of the Adelaide River and onto the shorelines surrounding the Vernon Islands. The total length of the subject shorelines is approximately 120 km. If the material ended up in a shoreline layer only 200m wide, then the layer would have an average thickness of:

18,000,000/(120,000 x 200) = 0.75m or 750 mm.

Of course, the layer would have neither uniform thickness nor uniform width and the fine to medium sand fraction would probably end up on the beaches with the silt fraction mainly ending up in the mangroves. AMSTECI do not pretend to know what the actual depths of shoreline sedimentation from the spoil will be but it would seem that the Draft EIS understates the scale of the problem by at least an order of magnitude when it states on page 334 that: "Sedimentation rates for most of these areas are in the order of 5 – 20 mm over the three – year time period; equivalent to 3-7 mm of sediment per year."

As stated previously, the modelling conducted by HR Wallingford should be considered long-term rather than event-specific modelling. It is conceivable that a large cyclone event might mobilise and transport more sediment from the offshore disposal ground than months of average tides with "low" or no wave energy.

The APASA report indicates that under tropical cyclones the hydrodynamic conditions are able to mobilise coarse sand over a wide part of the seabed outside Darwin Harbour. Under a tropical cyclone material (sands and fines) will be mobilised from wide areas of the seabed, shoreline and from the offshore disposal site. The areal extent of the disposal area is small compared with the wider offshore area and, as a consequence, resuspension from this zone (possibly at higher rates than elsewhere) will be mixed into the resuspension of material from the wider zone. Pathways of transport for all the mobilised material will be dependent on the timing, intensity and path of the tropical cyclone. While over a very long time scale it can conceptually be argued that much of the potentially mobile material placed at the offshore spoil disposal ground will be reworked and redistributed by tropical cyclones, this will occur over a long time period. During a tropical cyclone, suspended sediment concentrations are likely to be significantly elevated over much of the offshore area because of the composition of the seabed. Over the very long term some of the finer materials placed at the offshore disposal site will be mixed into the wider offshore area and some of these finer materials will also make their way to the longer-term sinks for fine material which may include muddy shorelines. The modelling presented in the Draft EIS does not address the issue of long-term cumulative effects of cyclone redistribution of material from the disposal ground.

Under the typical (non-cyclone) conditions simulated in the sediment transport studies the source for elevated suspended sediment concentrations is the activity at the disposal site. The modelling enables prediction of how fine sediment is redistributed over the medium timescale and these processes lead to the prediction of sedimentation rates in the order of 5–20 mm over the approximately 4-year dredging period. These predictions are of rates above background rates. Background rates of sedimentation or erosion will be influenced by the sequencing of major rainfall and cyclone events.

Importantly the modelling presented indicates that the dispersion of fines from the disposal site over the 4-year period influences an area of the seabed in the region of 450 km^2 whereas the disposal site itself has an area of about 12 km^2. A few years after placement has been completed at the disposal ground the surface properties influencing mobility of sediment of most of the seabed are likely to be similar. The main difference will be the proportion of fines in the surface sediments that may be mobilised during a cyclone. The disposal ground is likely to have a fines content of about 60% on average, whereas that of the wider offshore seabed is likely to be on average lower than this at, an estimated 10–30%. However, if in the longer term the degree of mobilisation of the seabed is similar everywhere, the effect of increased fines being mobilised from the disposal site will be minimal, contributing an estimated 5–15% of the total amount of fines released in the 450-km^2 area. Such an increase would be unlikely to cause a widespread elevation of suspended sediment concentrations during the cyclone compared with that encountered during previous cyclones. It would therefore not be expected that morphological response during the cyclone would be any different to that under most cyclones except at the disposal site itself.

During the 4-year placement period and in the years immediately following placement, before the bed at the disposal site is fully consolidated there is expected to be a greater risk of mobilisation of placed material during a tropical cyclone. Over this period proportionally more fines might be resuspended from the disposal site during a tropical cyclone making a greater contribution to the overall mass released in the offshore area. In this period there is a risk that suspended solids concentrations arising during a tropical cyclone would be higher than that typically experienced, however, as stated earlier the existing material will be mobilised over a wide area and while suspended solids concentrations at the disposal site would be elevated above that in the adjacent offshore area this contribution to overall sediment suspension and movement is unlikely to be significant.

Submission 130-24: How long it would take for that 83% of the spoil dump to be deposited on shore lines would depend on the arrival of intense TCs that push waves from west to east – it could be the year that dredging finishes or it could be twenty years later. But whatever the time interval, it would seem probable that sediment layers of anywhere near the thickness indicated by the ball-park estimate in Section 4.3 would have a devastating effect on the marine life and ecology of the very special stretch of the NT coastline around Gunn Point and the Vernon Islands. The jewels in the crown of that area are the 'blue holes' and they may be protected by the surrounding reefs. However, it would seem that serious damage could be done to:

- the mangroves and marine life that lives and breeds in them;
- the coral reefs and the marine life (including fish, dugong and turtles) that feed from them;
- the rare corals and marine life that inhabit the reef drop-offs around the Gunn Point and Vernon Islands.

We are unconvinced by the assurances given on pages 337 and 338 of the Draft EIS that the impacts from turbidity and sedimentation in the above areas and in Shoal Bay and Adam Bay will be minimal. Further, we are not all that re-assured by the statement on page 329 of the Draft EIS that the 600 tonne or so of arsenic that will be within the spoil "is unlikely (sic) to be toxic in the marine environment, as only very small proportions dissolved into bio-available form." Until such time as more detailed and more realistic studies prove that offshore disposal really does present minimal environmental risk to the Shoal Bay, Gunn Point, Adam Bay and Vernon Island areas, AMSTECI submit:

Recommendation:

1. That the proposal to dispose dredge spoil offshore not proceed – instead onshore disposal be used as recommended under Section 5.3 following.

INPEX contends that it is misleading to consider that the entire volume of material disposed at the spoil ground would be carried ashore during a cyclone. The modelling in Technical Appendix 13 of the Draft EIS shows that, from the time of disposal, the spoil will be progressively spread across a broad area surrounding the spoil ground as a thin (<5 mm) layer. It can be expected that some of the spoil will become incorporated into the existing seafloor sediments, reducing its potential to be resuspended.

It is agreed that mass movement of seabed sediments will almost certainly occur under cyclonic conditions and that shoreline deposition of sediments is inevitable. However, INPEX contends that similar volumes of material will be deposited on the shoreline irrespective of the INPEX dredge spoil. Just because the water depth will be marginally (less than 5 mm) shallower as a result of spoil disposal, it does not follow that an additional 5 mm of seafloor will be suspended and deposited upon the shorelines. That is, cyclone-generated shear stress on the seabed could be expected to suspend the same thickness of sediment, regardless of the minor decrease in water depth.

It is also agreed that, in the event of a cyclone, impacts are likely to occur to mangroves and their associated biota; the coral reefs and the marine life that feed from them; and the marine life of the reef drop-offs (though INPEX is unaware of any coral species on the drop-offs that could be considered "rare"). The extent and severity of impacts will, of course, vary with factors such as the direction of approach, strength and duration of the cyclone. Further, it must be recognised that under cyclonic conditions there will be many sources of physical impact upon the marine life and ecology of Gunn Point, the Vernon Islands and Shoal Bay. These include waves, swells and currents which can lead to the sessile biota over vast tracts of rock pavement being pulverised (either directly by waves, or by rocks and rubble being swept across them), and to their being stripped of living tissue by the abrasive action of suspended sediments. INPEX realises that rock pavement surfaces laid bare by physical cyclone impact will, over time, be colonised again by similar biota, whereas those areas smothered by sediments will instead be colonised by soft-bottom benthic communities.

Hence, while substantial environmental impacts may occur in the event of a cyclone, INPEX contends that the dredge spoil will not cause significant additional impacts. INPEX believes that the modelling outputs presented in Technical Appendix 13 of the Draft EIS are sufficiently conservative for the assessment of a Medium level residual risk to be considered appropriate.

With respect to the comment on the total load of arsenic (600 tonnes, presumably calculated from the average arsenic concentration and the proposed dredging volume) it must be recognised that, globally, sediment quality guidelines are couched in terms of concentrations, not total loads, for metals and metalloids such as arsenic. The rationale is that these contaminants are typically bound within the sediment matrix and are not readily bio-available as discussed in Section 3.3.5 and Technical Appendix 9 of the Draft EIS. In contrast, nutrients (such as nitrogen and phosphorus) are typically less tightly bound and are released more readily into the water column, hence total nutrient loads (e.g. in tonnes per annum) are of greater importance.

5.2.2.12 Monitoring

Submission 1-12: PART I Question 11 What is the pollution monitoring plan for E.Coli and other pollutants?

Submission 16-16, 24-16, 29-15, 89-16, 96-15, 101-17, 102-15, 124-67: Waste water discharge from the development site could impact on water quality, and in turn, marine life.

Submission 120-35: Ongoing monitoring or water quality near the proposed outfall and at other appropriate locations in Darwin Harbour will be critical to the effective management of wastewater discharges from the onshore facility and we note that Inpex is proposing to implement such monitoring. AFANT's view is that this monitoring should become part of a more comprehensive whole-of-harbour monitoring process through the Integrated Monitoring Program proposed by the Darwin Harbour Advisory Committee and now being implemented by the NT Government.

Submission 128-20: Our discharges. The discharge of more contaminated waste water into the harbour cannot be supported. Council requires clarification as to what arrangements have been made to ensure adequate and satisfactory arrangements are being made by INPEX with the Northern Territory Government on this important issue. Ballast water even though collected from the open ocean still has possibility of introducing marine pests that are already in the ballast tanks picked up from elsewhere.

Submission 128-33: Monitoring programs for the receiving environment

Ongoing comprehensive, post and pre condition water quality monitoring programs need to be conducted in conjunction with the development of a suite of suitable triggers and management actions. Recent issues with poor water quality and algal blooms in Darwin Harbour have highlight the short falls of inadequate monitoring regimes and the reliance of only complying with conditions of waste discharge licences in order to appease the requirements of the regulatory body.

There is also a clear need for greater resources to provide adequate information and monitoring in tropical waters.

A Provisional Liquid Discharges, Surface Water Runoff and Drainage Management Plan has been compiled (attached as Annexe 10 to Chapter 11 of the Draft EIS), which will guide the development of a series of more detailed plans during the construction and operations phases of the Project. Key inclusions in this plan relevant to treated wastewater monitoring include the following:

- Wastewater streams will be sampled at appropriate frequencies and selected water-quality parameters will be documented.
- An environment protection licence will be sought for the onshore processing plant from NRETAS under the *Waste Management and Pollution Control Act* (NT). Discharge limits set by this licence will aim to maintain Darwin Harbour water quality and in turn protect marine life and will be met through end of pipe monitoring. End-of-pipe monitoring will likely include monitoring of E. Coli or other faecal coliform indicators.
- A Darwin Harbour Water Quality Monitoring Program will be developed to assess impacts of the Project on water quality in the nearshore development area during the construction and operations phase.

A summary of the Darwin Harbour Water Quality Monitoring Program is provided in Table 11-5 of the Draft EIS. INPEX has also committed to supporting the establishment of a microbial baseline for Darwin Harbour. This work, currently proposed by Charles Darwin University, the Australian Institute of Marine Science and other partner organisations, will provide a microbial baseline in water and sediments that will allow INPEX to monitor changes in microbial communities during construction activities. The program will also develop tools to allow rapid identification of microbes in sediment and water.

INPEX has indicated to the Darwin Harbour Advisory Committee its support for the draft Integrated Monitoring and Research Program (IMRP). Until this program is fully functional, INPEX is committed to collecting, housing and managing all marine monitoring data, including all water-quality data, in formats that allow for these data to contribute to the IMRP.

Submission 85-6: 4) Shipping – The increase of shipping that will be created by the project poses several types of impacts:

iii) Increase in chemical pollution and turbidity

An increase in chemical pollution will be created by the routine activities of the boats and the gas field. In highly industrialised areas, such as the Gulf of St. Lawrence, elevated levels of pollutants have been related to a higher record of tumours in beluga whales (De Guise et al., 1995)

The information and reference are useful. Through its contracting strategy, INPEX will ensure that the environmental management practices adhered to by the operators of Project-related shipping meet relevant international standards. The implementation of these standards, coupled with the nature of the vessels engaged on the Project (i.e. construction and service vessels and product (LNG and condensate) tankers, not bulk minerals carriers), can be expected to minimise the risk of detectable chemical pollution occurring.

Submission 94-3: Further, Inpex must be required from the outset to adequately resource a monitoring regime that engages' and is inclusive of Wunambal Gaambera and Traditional Owner neighbour expertise, in developing initial comprehensive bio-diversity benchmarking and maintaining a robust life-of-project monitoring system.

Emissions and discharges from the construction and operation of INPEX's offshore facilities will not impact upon Wunambal Gaambera country as the facilities are located approximately 200km away. In the unlikely event of a large oil spill there is potential (albeit very low) for Wunambal Gaambera country and adjoining areas to be impacted. To facilitate oil-spill-response planning INPEX will be developing an appropriate scaled Kimberley coastline sensitivity map and developing an appropriate regional scale monitoring program which could be initiated in the event of a large oil spill to assess impacts. INPEX would welcome the participation of Wunambal Gaambera people and neighbouring traditional owners in these endeavours and would indeed add that such involvement is essential to achieving a good outcome.

Submission 107-65:

- It is not clear from Table 11.5 that the mangrove and intertidal zones would be properly monitored, in a way reflecting the ecological importance of these components. This is further complicated because the proposed management methods and risk assessments around which they are based rely upon a cursory description of the ecology as a list of species. The EIS did not appear to provide a summary of typical baseline data including species abundance and diversity measures against which environmental impacts may be adequately monitored.
- In Appendix 8, sampling appeared to favour high-energy sites, with a resultant moderatediversity finding, while sampling of the upper reaches of the mangrove creek systems which would be expected to be the most productive, species-abundant and sensitive, was not carried out.

Contrary to the submission comments the mangrove habitats of Blaydin Point were assessed in detail. Survey methods were selected to incorporate the requirements of NRETAS and developed in consultation with the Museums and Art Gallery of the Northern Territory. The confusion may have arisen because results were presented in the Draft EIS's Technical Appendix 16 *Onshore flora and fauna study*, not in Technical Appendix 8 *Nearshore marine ecology and benthic communities study*.

Since mangrove habitats straddle the interface between onshore and offshore activities a separate mangrove monitoring program will be prepared. This will include interface to (among others) the dredging and dredge spoil disposal management plan and will be subject to approval by the appropriate regulatory authorities prior to the commencement of dredging.

Submission 112-13: The proponent must contribute financially to the development of a monitoring program that would, among other things, track water quality, including sediment load.

Submission 120-29: We recognise that it will be difficult to provide complete certainty in relation to the issues of dredge spoil dispersal and the potential impacts we have raised here. We also recognise that, regardless of the location of the spoil dumping grounds within reasonable proximity to Darwin, spoil material will be easily mobilised. With this in mind we would suggest that a comprehensive monitoring program is implemented in the Howard River, Shoal Bay, Gunn Point and Vernon Islands areas. This monitoring program should commence in advance of any spoil dumping to establish baseline data and should be particularly intensive during the period of dumping.

Submissions 124-42, 16-23, 36-7, 89-23, 96-22, 101-24, 102-22: Utilise latest technologies to track the direction and scale of surface sediment plumes during dredging operations.

INPEX has committed to a dredge-plume discharge monitoring program to monitor suspended sediment elevations (i.e. plumes) at selected coral monitoring locations in East Arm and in waters around the offshore disposal ground. See Table 11-5 in Chapter 11 *Environmental management program* of the Draft EIS as well as Annexe 6 to the same chapter for further detail of this monitoring program. Monitoring plans will be further developed and included in the final dredging and dredge spoil disposal monitoring plan.

Suspended sediment dispersion modelling presented in the Draft EIS indicated that concentrations of suspended sediment and levels of sediment accretion in the areas of Howard River, Shoal Bay, Gunn Point and the Vernon Islands areas are below that at which biological impact may be expected; this is further discussed in sections 4.1.3, 4.1.6 and 4.1.7 of this EIS Supplement. In addition, as discussed in Section 4.1.3, sediment dispersion modelling was undertaken with multiple layers of conservatism.

Aerial surveillance of turbid plumes arising from dredging activities at the pipeline shore crossing will be undertaken to determine movement of the surface suspended sediment plume, with a focus on protecting corals at Channel Island.

In the development of the dredging monitoring plan, consideration will be given to the incorporation of other available proven techniques and technologies to monitor the extent and intensity of surface suspended sediment plumes generated from dredging. This will include consideration of remote-sensing techniques and ADCP (acoustic Doppler current profilers) and LISST (laser in situ scattering and transmissometry) instruments. It should be noted that these technologies are relatively new with limited practical use, including within Darwin Harbour and that techniques and technologies with proven track records are generally preferred to ensure consistent and reliable data collection throughout monitoring programs.

Submission 120-18: We note the discussion on underwater noise and its impacts on fish and other marine life (Draft EIS p.355-362). Piledriving, dredging and blasting for rock removal are likely to be the main sources of noise that could adversely impact fish and, while we note the conclusions that environmental conditions in this area of the harbour are likely to significantly attenuate noise levels, there should be a process in place to monitor any impacts. This monitoring should commence in advance of any dredging, blasting or piledriving to establish baseline data and should continue through the construction phase of the project. It should monitor in sights close to and some distance from the piledriving, dredging and blasting activity to determine if there are any long-range impacts on fish and other animals. We have considered the undertakings given in the Commitments Register (Draft EIS p 638-639) but note that these tend to concentrate more on observation of marine mammals and possible fish kills than on collecting data on fish movements and activity.

Refer to Section 4.1.11 of this EIS Supplement for discussion on noise impacts to fish and other marine fauna from blasting and noise. INPEX is considering implementing a fish monitoring program (as part of the full suite of monitoring programs outlined in Table 11-5 in Chapter 11 *Environmental management program* of the Draft EIS) to detect changes in fish abundance and distribution associated with the Project construction activities within Darwin Harbour. INPEX will be calling on consultants to provide indicative scopes for such a monitoring program and will then determine whether a program that can provide meaningful data (i.e. one that is capable of detecting change in relevant fish species) is feasible. Any such program would likely include the collection of baseline data.

Submission 120-38: Any adverse environmental consequences from the on – and nearshore operations of the Ichthys Project have the potential to significantly impact recreational fishing in and around Darwin Harbour. As noted previously, recreational fishing is an important activity in this area and is significant to a large part of our population.

Because of the particular importance of recreational fishing to the area, AFANT urges Inpex to implement a monitoring process that has a particular focus on the Darwin area's recreational fishery. This monitoring process should be put in place now so that it can provide baseline information prior to construction commencing and then through the construction and operational phases of the project.

INPEX acknowledges the importance of recreational fishing in Darwin Harbour to the people of the Darwin region. Productive recreational fishing supports a healthy tourist industry and can also be an indicator of healthy fish stocks for particular species. INPEX will therefore consider developing a monitoring plan which could be designed to detect negative impacts (beyond natural variation) associated with dredging, blasting, piledriving and other relevant nearshore construction activities, on relevant indicator fish communities and species. The plan could consider monitoring that is specific to recreational fisheries (e.g. intercept surveys or creel surveys) to detect changes in catch per unit effort for the Harbour recreational finfish and mud-crab fisheries. Monitoring would likely include monitoring before, during and following construction activities. Periodic reviews of the program, which would include an assessment of when a closing date for the monitoring should be imposed, would consider any requirement for an extension of fish-related monitoring into operations.

INPEX will consult with appropriate stakeholders such as the Amateur Fishermen's Association of the Northern Territory (AFANT), the Fisheries division of the Department of Resources, and the Department of Natural Resources, Environment, the Arts and Sport (NRETAS) in the development of such monitoring plans.

Submission 122-6: Discharges from the on shore facility (Section 4.5.5 Drainage and Wastewater treatment facility, page 202 +; Section 5.6.3 Darwin Harbour Discharges page 217 +): DHAC understands that INPEX have identified approx 50 m^3/day of sewage effluent discharge as well as much larger volumes of process water to be discharged. While the volume of treated sewage effluent proposed for discharge is relatively small the quality is not good. DHAC seeks clarification of the draft EIS because the text identifies TP <10mg/l and TN <40mg/l but Table 5.7 lists TP = 10mg/l and TN = 40 mg/l. In addition, faecal coliform counts are used as an indicator of quality and, while this may still currently be in water quality guidelines, it is far from an acceptable measure and has little relevance in marine systems. At the very least Enteroccoci should be used, and preferably used along with measures of other indicator pathogens.

Submission 128-34: Table 11-5 Summery of Monitoring Programs Darwin Harbour water quality monitoring program – does not include Bacto sampling. This will need to be done, as it is proposed to discharge sewerage co-mingled with waste water.

The quality of the proposed treated sewage effluent will be at least equivalent to that from other sewage treatment plants that discharge into Darwin Harbour. Nutrient concentrations in the treated sewage will meet the characteristics provided in Table 5.7 of Chapter 5 *Emissions, discharges and wastes* of the Draft EIS (TP less than 10 mg/L and TN less than 40 mg/L).

Measurement parameters relating to faecal coliform at the end of pipe will be agreed with NRETAS and stipulated in an environmental protection licence. INPEX will take further advice from NRETAS to ascertain the optimal parameters for measuring effluent quality in the wastewater outfall.

Submission 124-39: Monitoring programs under Annexe 6, Provisional Dredging and Dredge Spoil Disposal Management Plan (Volume 2, p. 539), are listed in addition to mitigation/management actions noted in Table 7-31 (Chapter 7, Section 7.3.2, p. 327). The only monitoring program with any detail is the "Reactive coral monitoring program" (p. 546 – 549), however it is not clear whether triggers and management response actions will be conducted in collaboration with NRETAS and/or independent scientists, or if information on the state of these marine communities will be provided to the public. It appears that coral monitoring will rely on lethal, rather than sub-lethal triggers due to operational factors, and this needs to be explained and justified in more detail.

Derivation of appropriate physical and biological trigger levels for protection of corals at Channel Island will be developed by expert consultants to INPEX, in conjunction with and for approval by NRETAS. These will be included in the dredging monitoring plan. The monitoring of water quality and coral health to allow assessment against trigger levels will be undertaken by INPEX's expert consultants; the data from this monitoring will be provided on a regular basis to NRETAS (the frequency to be determined during the development of the dredging monitoring plan) and will be provided to the public within the environmental monitoring reports.

As described in Section 4.1.2 in the Annexe 6 *Provisional dredging and dredge spoil management plan* in Chapter 11 *Environmental management program* of the Draft EIS*,* the coral colony surface under each of the 64 points on the 8 x 8 grid will be examined to determine whether it is alive, bleached or dead. To be conservative, if points overlie bleached tissue this will be scored as "dead' for the purposes of the assessment. Note that bleached tissues often regain their colour and return to a healthy condition. Where the colony surface has an algal film or a coating of turf algae, it will be scored as "dead". In this way, *partial* mortality of colonies (i.e. death of some polyps within a colony) will be detected. It should be noted that partial mortality is a common feature of many colonies in the natural environment and is *not* a precursor to mortality of the entire colony. Triggers based upon sublethal effects (e.g. changes in coral colour) will be considered during development of the dredging monitoring plan, taking account of limitations in practicality such as those described by Stoddart et al. (2005).

Submission 123-41: It is expected that monitoring requirements will be included as Licence conditions (under the Water Act) therefore monitoring plans will need to be developed for submission with the licence application.

Submission 124-41: Recommendations: A holistic Harbour wide multidisciplinary study is required to genuinely monitor and mitigate the impacts on marine ecosystems, communities and species, from a Project operating at such a large scale and conducting multiple activities with likely adverse effect,. The study should be developed and conducted by NRETAS and independent scientists with recognised expertise in each of the appropriate fields. The proponent should fund the research, but not determine the science to be conducted. A collaborative framework should be developed between the proponent and the research team to ensure rapid responses, as require, for mitigating adverse impacts.

Submission 86-3: Marine Impacts – the proponent has outlined a strong commitment to monitor receiving environments and this is reflected in the indication of support for the integrated marine monitoring program for Darwin Harbour on page 505 of the draft EIS. Effective monitoring however will be dependant upon good baseline data and the proponent should undertake appropriate detailed baseline surveys including habitat mapping for areas potentially impacted by the Project as part of the integrated program. The scope of these surveys should be established as soon as practicable with the relevant Government agencies.

Submission 123-163: Although much of the detail still remains to be completed, the management plans lack clear measurable outcomes. In setting up a monitoring plan, it is essential to have site-specific, measurable, attainable and realistic objectives. The development of a physical and biological monitoring plan needs to take the following into account: (1) defining site-specific monitoring objectives; (2) identifying components of the monitoring plan; (3) predicting responses and developing testable hypotheses; (4) designing survey and sampling methods; and (5) identifying management options. Baseline study needs to work towards/answer these questions. It is recommended that all baseline studies, monitoring programs and management plans are submitted for peer review before they are put into place to ensure they have clear, measurable and auditable outcomes. Collected data also need to be submitted at regular intervals to allow peer review of management actions.

Submission 9-3: Pro-actively make details of the outcomes of the monitoring programs to assess nearshore marine and terrestrial environmental impacts publicly accessible.

The provisional environmental management plans (EMPs) provided in the Draft EIS are intended to provide core information that will form the basis of construction EMPs (CEMPs) and operations EMPs (OEMPs) required under the *Waste Management and Pollution Control Act* (NT) and the *Water Act* (NT). These will be developed in detail once contracts have been awarded and the construction and operations plan development commences. This EMP structure was developed with input from the Northern Territory's Department of Natural Resources, Environment, the Arts and Sport (NRETAS) and the Commonwealth's Department of the Environment, Water, Heritage and the Arts (DEWHA) (now the Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC)). The purpose of developing the provisional plans at this earlier stage of the Project is to demonstrate INPEX's capacity to manage the environmental risks to an acceptable level. INPEX will be undertaking a comprehensive monitoring program and is at the time of writing preparing to engage appropriate experts to develop monitoring plans that seek to fulfil the criteria provided in this submission comment. Where appropriate, baseline data sets will be collected to allow adequate comparison with preconstruction baseline conditions including natural variation in these conditions. Shorter baseline data sets for other monitoring plans will provide pre-impact conditions and will be supplemented with control sites to allow assessment of changes at impact sites against natural variation at control sites. INPEX and the experts engaged to design and implement the monitoring plans will liaise with NRETAS and other relevant stakeholders during design and implementation. INPEX will report to NRETAS regularly (at a frequency to be agreed and detailed in the CEMPs and OEMPs) and will make results of the monitoring publically available.

A summary of the monitoring committed to is provided in Table 11-5 in Chapter 11 of the Draft EIS. Details of each monitoring program, including methodology, site selection, monitoring frequency, parameters and statistical design will be developed by appropriately qualified expert consultants and where relevant these consultants will liaise with experts from government and academic institutions.

Habitat mapping, for the purposes of impact predictions, has been undertaken and is discussed in Section 4.1.2 of this EIS Supplement. The habitat maps will help guide identification of appropriate monitoring areas for some monitoring programs.

Submission 124-49: Recommendations: Jefferson et al. (2009)20 note the critical importance of conducting surveys to monitor the density and behaviour of animals before, during and after the period of potential disturbance as it is the only way to determine whether the mitigation measures used have been effective. They outline helpful advice on how to construct such a monitoring project. INPEX should use the recommendations in Jefferson et al. 2009 as the basis for its marine fauna mitigation efforts and for research work to be conducted by independent, experienced scientists to ensure that impact mitigation effectiveness is measured.

INPEX has undertaken an extensive review of the literature (including the "grey literature"[11]) pertaining to impacts on, and management controls for, marine mammals in relation to marine construction activities (ERM 2010). Jefferson, Hung and Würsig (2009) provides a useful synthesis of impact assessment and mitigation for a variety of marine construction related activities in Hong Kong over recent times. INPEX will consider recommendations and documented experiences presented in this paper for all relevant activities with regard to management of potential impacts to coastal dolphin species (and dugongs where relevant). Management controls from the above reports will be considered during development of construction-related environmental management plans.

INPEX is committed to implementing a monitoring program to determine the effects of Project construction activities on marine mammals.

11 "Grey literature" is the term used for written materials that cannot be found easily through conventional channels such as publishers, but which are frequently original and usually recent. Examples include technical reports from government agencies or scientific research groups, working papers from research groups or committees, and also ephemera such as PowerPoint presentations.

Submission 124-90: 7. Develop a research program to be conducted over the life of the Project (by independent scientists with experience in marine wildlife surveys in the region, in collaboration with the Traditional owners and Indigenous ranger groups) that will: a) Undertake a toxin/pollutant sampling program for marine species (predators and prey) for the Browse Basin area for the life of the Project, including, but not limited to, species that congregate around the Ichthys Field platform. Sampling should focus on sharks and dolphins as predators and a range of their prey species to investigate levels of pollutants produced by the components of liquid discharge from the Ichthys Field; b) Monitor marine species distribution and toxin levels from liquid discharges around the Ichthys Field site (Browse Basin scale including Scott Reef and associated reef and island complexes) – to commence prior to site construction for initial baseline pollutant levels; c) Monitor distribution, life history and behavior to identify important foraging and breeding areas in the nearshore waters of the Kimberley coast identified in the Draft EIS possible spill trajectories for: significant marine higher order species (Australian snubfin dolphin, Indo-Pacific humpback dolphin, bottlenose dolphin, spinner dolphin, turtles and dugong). This research will leave a legacy to Northern Australia of a much greater knowledge of marine species and will prove invaluable as baseline data if a spill does occur during the life of the Project. d) Investigate the impacts of seismic surveys on marine species through a comprehensive scientific program developed by experienced acousticians and marine species survey scientists and designed under the most recent protocols and recommendations of international acousticians currently working on these issues. e) Include a commitment to make public all data and analyses related to the above projects and ensure that they are not bound by 'commercial in-confidence' agreements.

INPEX has committed to several environmental offset programs and continues to discuss plausible and appropriate offset programs with the Northern Territory and Commonwealth governments (refer to Section 4.9 of this EIS Supplement).

INPEX has committed to participation in a Browse Basin operational and scientific monitoring program. This involves the collaborative participation of operators in the Browse Basin and will result in the acquisition of improved environmental baseline data. The program will ensure collaboration in the assessment and management of oil spills and will improve the scientific knowledge of the effects of spills on environmental receptors.

In addition, INPEX has committed to monitoring the effects of production-drilling discharges for the offshore environment. At this stage routine monitoring of the operational discharges of the offshore facilities is not considered warranted as predicted impacts are minor and localised.

5.2.2.13 Offsets

Submission 1-4: Have the very high economic risks to the NT been considered as there will be only limited long term benefit from the Gas coming onshore. What is the dollar value of the that the NT government will hold in trust like in other EMP's The NT government in their haste to attract INPEX to the NT did not consider opportunities to compensate the community by providing a cheaper electricity production resource at a favourable rate to provide cheaper energy to the NT Electricity grid.

Submission 1-10: Why is INPEX not compensating Territory People by providing cheap gas for electricity production?

The Ichthys Project will deliver many billions of dollars in taxation revenue, fees, charges and levies to the Australian and Northern Territory economy (see Section 10.4 in Chapter 10 *Socio-economic impacts and management* of the Draft EIS). This long-term contribution to the local and national economy will deliver many of the benefits and services that the Australian public expects from its governments.

The Project will not rely on funding or finance from the Northern Territory Government and therefore does not expose the Northern Territory to the "high economic risks" claimed in the comment above.

The Northern Territory's Power and Water Corporation (PWC) manages the power generation and distribution infrastructure in the Territory. The PWC has secured long-term gas supplies from reliable sources close to the Territory coast that meet current and future estimated demand. There are redundancy arrangements in place with alternative gas suppliers in the case of emergencies. INPEX has committed to the supply of gas to PWC in the event of such an emergency.

INPEX's gas is committed to the production of liquefied natural gas (LNG) which will be exported to the international market. INPEX's LNG exports will contribute to a favourable balance of trade with international markets and to the stability of the Australian economy in general.

Submission 8-9, 13-6: Develop measures to compensate for the destruction of habitats, including coastal monsoonal forest and mangroves.

Submission 95-4: Local offsets and mitigation of impacts Over its life, your project will account for 30% of the Territory's greenhouse gas emissions as well as resulting in the clearing of over 400 ha of native vegetation, this is aside from other social, economic and cultural impacts that will inevitably take place. If Inpex is to have such a significant impact on the Territory's natural environment, it is appropriate that there are some measures put in place to offset and mitigate these impacts. I support the creation of new Marine and Terrestrial parks and reserves representing at least 10 times the area impacted by the project (eg. 400ha of native vegetation cleared, 4000ha of equally significant native vegetation protected). These areas should be in close proximity to those impacted and be properly researched, funded and managed to ensure their ongoing integrity and resilience. Inpex should ensure that through supporting secure, Territory-based initiatives, 100% of their GHG emissions are offset over the life and decommissioning of the project. In the face of climate change and pressure to reduce GHG emissions world-wide, the Territory cannot be seen to support a project which will significantly increase levels of GHG emissions without pushing to ensure appropriate steps are taken to offset and reduce them. I thank you for the opportunity to comment on the Draft EIS and sincerely hope that you take all comments from the public and other interest groups into account. I look forward to the supplementary EIS covering all of the points raised and including plans for offsetting and reducing the impacts of the project.

Submission 119-6: Development of an innovative and world-class carbon off-set and biodiversity compensation program in partnership with the NT Government must also be a priority.

Submission 123-187: While there are no savanna burning offset projects currently recognised under the Kyoto Protocol mechanisms, emissions from prescribed burning of savannas, and abatement from improved management, are counted towards Australia's international commitments under the Kyoto Protocol. Although national climate change policy is uncertain, the most recent expression of policy intent with the Carbon Pollution Reduction Scheme stated that CPRS permits would be provided for abatement from the burning of savannas along with a range of other land management activities, subject to the development of robust methodologies. See: http://www.climatechange.gov.au/government/ini tiatives/cprs/~/media/publications/cprs/CPRSImplementation-of-Nov09-changes-pdf.ashx More recently, the Australian Government announced as part of its election platform its intent to introduce the Carbon Farming Initiative. The scheme is intended to facilitate the sale of carbon credits on domestic and international markets by legislating clear rules for the recognition of carbon credits. The Australian Government states that a range of projects could be eligible, including savanna fire management. See: http://alp.org.au/agenda/more---policies/carbonfarming-initiative/

INPEX has commenced dialogue with the Commonwealth's Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) and with the Northern Territory Government to outline a process for the development of an environmental offsets package for any significant residual environmental impacts arising from the Project.

Significant residual impact can only be determined by government after the submission of the Final EIS – that is the Draft EIS and this EIS Supplement. In the interim, INPEX has made a number of voluntary environmental offset commitments which are outlined in Section 4.9 of this EIS Supplement.

Prior to starting the commissioning of the off – and onshore facilities, INPEX will produce a detailed greenhouse gas (GHG) management plan that will provide an updated GHG emission forecast and consolidate plans for technical abatement and offset measures.

Submission 9-4: Promote details of any environmental offset projects that are developed (such as potential support into research to determine marine fauna populations in Darwin harbour etc). Marine based ecotourism operators are likely to have an interest in the results of any such research to add value to the information they provide to visitors whilst on tour.

INPEX has commenced dialogue with the Commonwealth's Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) and with the Northern Territory Government to outline a process for the development of an environmental offsets package for any significant residual environmental impacts which may arise from the Project.

Significant residual impact can only be determined by government after the submission of the "Final EIS", that is, the Draft EIS and this EIS Supplement taken together. In the interim, INPEX has made a number of voluntary environmental offset commitments which are outlined in Section 4.9 of this EIS Supplement.

INPEX is committed to making information collected from research and monitoring activities available to the public including eco-tourism operators.

Submission 9-5:

- Support the development of carbon offset projects within the Northern Territory (for example supporting the growth of renewable energy to help reduce dependence on diesel power generation in remote areas). Tourism businesses are increasingly interested in the opportunity to offset the emissions of their operations, but have a distinct preference toward supporting offset projects that deliver benefits to the NT. Presently there are no such projects that are commercially accessible in the NT.

INPEX has indicated to the Northern Territory Government that it would like to commit to two environmental offset projects in the Northern Territory involving improved fire management practices in the Daly River and Wagait regions (see Section 4.9 for further details). However, INPEX has no intention of making these projects commercially accessible to third parties to offset their own emissions.

Submissions 16-26, 89-28, 96-26, 101-28, 102-26: Development of a world-leading carbon offsetting and biodiversity compensation program in partnership with INPEX. The Gorgon Project in Western Australia, for example, is committing approximately $190 million towards environmental offsets and Net Conservation Benefits2. Recommendations for a Northern Territory program include:

- INPEX offsetting 100% of the GHGE it will create in the Territory, via secure, Territory-based initiatives such as: supporting native bush revegetation and biosequestration programs in the Daly catchment and on the Tiwi Islands; supporting Indigenous fire management as per the West Arnhem Fire Abatement project; financing the development of renewable energy power options for remote communities; purchasing pastoral properties and managing them for carbon and biodiversity outcomes; supporting the partial destocking of over-grazed pastoral properties to encourage native vegetation to regrow; paying farmers, non-government organisations and Traditional Owners to plant native trees on previously cleared land.
- INPEX being a signatory to, and providing financial support for, a Darwin Harbour Integrated Monitoring and Research Plan Agreement that produces annual water quality and biodiversity status reports, and funds land and water management activities by Larrakia Rangers, local government and community groups.
- Designation of new Darwin Harbour National Parks in the West Arm, Middle Arm and Ludmilla Bay areas. This will create an extensive coastal protected areas network alongside Charles Darwin National Park, East Point Reserve and Casuarina Coastal Reserve, in support of the NT Government's Territory Ecolink program and the United Nation's 2010 International Year of Biodiversity.

Submission 109-29: Carbon abatement through Indigenous fire management programs As mentioned in the EIS (Section 9.3, page 417) 'ConocoPhillips, for example, as Operator of the Darwin LNG plant, uses improved fire management practices in savannah as a contribution to managing its CO2 emissions. Similar options are being assessed by INPEX. At this stage, however, fire management offsets are not recognised under the Kyoto Protocol and may therefore not be compliant with Australia's proposed Carbon Pollution Reduction Scheme (CPRS) legislation.' INPEX needs to voluntarily offset its carbon, as in the ConocoPhillips example, regardless of whether it is compliant with the future legislation. The EIS does state (Section 9.11.1, page 430) in relation to these types of projects 'Although these efforts would not be recognised as offsets under the currently proposed CPRS, INPEX sees involvement in such schemes as regionally beneficial both from a social and from an environmental perspective.' This attitude is to be encouraged.

Submission 112-11: The project should not proceed without a commitment from inpex to fully offset 100% of the carbon burden of this project in locally (NT) based offset measures.

Submission 128-35: Environmental offsets: Offsets could include conservation outcomes related to the preservation of the environmental and community values of Darwin Harbour and not protected by the Environment Protection and Biodiversity Act (1999) which is the Australian Government's central piece of Environmental Legislation.

INPEX report they have undertaken extensive biological surveys in Commonwealth waters and along the West Australian Coast Line. A similar level of research has not been undertaken in Darwin Harbour.

Matters of identifying offsets should be undertaken following consultation with all stakeholders, once all the issues associated with the project and its impacts have been assed and understood. The views and concerns of the Darwin Harbour Advisory Committee (DHAC) also need to be fully taken into account in this regard.

Advice as to how INPEX plans to approach offsetting its greenhouse gas emission liabilities in relation to either a Carbon Pollution Reduction Scheme or a Price on Carbon scheme is sought.

INPEX has commenced dialogue with the Commonwealth's Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) and with the Northern Territory Government to outline a process for the development of an environmental offsets package for any significant residual environmental impacts arising from the Project.

Significant residual impact can only be determined by government after the submission of the Final EIS – that is the Draft EIS and this EIS Supplement. In the interim, INPEX has made a number of voluntary environmental offset commitments which are outlined in Section 4.9 of this EIS Supplement.

Prior to starting the commissioning of the off – and onshore facilities, INPEX will produce a detailed greenhouse gas (GHG) management plan that will provide an updated GHG emission forecast and consolidate plans for technical abatement and offset measures.

INPEX believes that the information collected in Darwin Harbour and included in the Draft EIS and this EIS Supplement are adequate to inform the environmental impact assessment process.

INPEX is also committed to improving the scientific knowledge base for Darwin Harbour and has made a number of voluntary commitments in Section 4.9 which will contribute to this.

Submission 23-5: Sea Darwin acknowledges that economic development is important to the future of Darwin. If the IGFDP is to go ahead, Sea Darwin believes that the INPEX should demonstrate their 'corporate citizenship' as a new member of the Darwin community by ensuring that the important natural values that have been identified in their base line survey are supported and maintained with a further 'strategic EIS' for whole of harbour dealing with increase in industrialisation and urbanisation. The location and infrastructure of Darwin is likely to lead to further downstream industry, however neighbouring Bynoe Harbour is not and should be protected for its remaining unique natural status.

Any decision to undertake a strategic EIS for Darwin Harbour is a matter for the Northern Territory Government. Should government initiate such a review, INPEX, will assist with data as appropriate.

Submission 23-6: Sea Darwin considers it likely that the majority of submissions to the EIS are critical of INPEX and the NT government in regard to the likely degradation of the overall harbour environment and coast if the project goes ahead. Sea Darwin is also critical of the proposals that are on the table, and are exceptionally concerned about the impact on the marine habitat and the resultant implications for an eco business. However Management are mindful of economic forces and consider that should the IGFPD proceed, then the following environmental and community 'offsets' should be considered:

1. INPEX should actively assist in the preservation of Bynoe Harbour as a Marine Park;
2. INPEX should financially endorse an educational Darwin Harbour environmental programme for Middle Years and High School students looking at 'sea change' in the harbour comparing the built and industrial development and the surrounding environment. This educational tour is already being conducted for some schools here by Sea Darwin. Should INPEX subsidise this programme it could be available to all school students in Darwin studying the harbour ecosystem;
3. INPEX should adopt the inshore dolphins as the 'INPEX company mascots' and be actively seen to contribute to the inshore dolphin research and preservation, in particular the Australian Snubfin and the Indo Pacific Humpback, both of whom currently have significant presence within Darwin Harbour(Ch 3 80-83) and are iconic animals for the estuary.
4. INPEX should work with the NT Government and stakeholders to develop and regulate management practices on the harbour that support cetacean conservation. This could be scripted with the surveillance programme while blasting and dredging takes place, baselines and post port development surveillance.

INPEX believes that the process for establishing marine and or national parks and reserves is the responsibility of the Northern Territory Government.

INPEX has commenced dialogue with the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) and with the Northern Territory Government to outline a process for the development of an environmental offsets package for any significant residual environmental impacts arising from the Project.

Significant residual impact can only be determined by government after the submission of the Final EIS – that is the Draft EIS and this EIS Supplement. In the interim, INPEX has made a number of voluntary environmental offset commitments which are outlined in Sections 4.9 of this EIS Supplement. The voluntary environmental offsets include the provision of funding to government, or direct complementary research, to improve the understanding of coastal dolphin abundance, distribution and critical resource needs in Darwin Harbour. INPEX will also be trialling a number of innovative approaches for minimising the risk to coastal dolphins and other large marine animals should the Project need to use drill-and-blast methods to remove residual hard rock at Walker Shoal. INPEX has growing confidence that drilling and blasting will not be required to remove hard-rock material (refer to Section 3.3.8 for further information).

Submission 26-2, 27-2, 28-2, 30-2, 38-2, 39-2, 41-4, 44-2, 45-2, 46-2, 47-3, 49-2, 50-2, 52-3, 54-2, 55-6, 56-2, 57-2, 58-5, 60-2, 62-2, 64-3, 65-4, 70-2, 75-3, 76-2, 79-2, 80-3, 88-3, 90-2, 91-2, 92-6, 111-2, 114-2, 115-2, 117-7: Fund the creation of new National Parks around the harbour, and fund a multi-hundred-million dollar carbon fund to offset 100% of the 7 million tonnes of greenhouse gas emissions it will produce

INPEX believes that the process for establishing marine and or national parks and reserves is the responsibility of the Northern Territory Government.

INPEX has commenced dialogue with the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) and with the Northern Territory Government to outline a process for the development of an environmental offsets package for any significant residual environmental impacts arising from the Project.

Significant residual impact can only be determined by government after the submission of the Final EIS – that is the Draft EIS and this EIS Supplement. In the interim, INPEX has made a number of voluntary environmental offset commitments which are outlined in Section 4.9 of this EIS Supplement.

INPEX's approach to greenhouse gas (GHG) offsets is outlined in Chapter 9 Greenhouse gas management of the Draft EIS. INPEX is committed to managing its GHG emissions by actively promoting the reduction of GHG emissions across its operations in a safe, technically and commercially viable manner. INPEX is of the opinion that abatement of GHG emissions is achieved most efficiently and effectively through a well-designed national climate change policy framework that is consistent with global efforts to curb GHG emissions. Climate change is a global issue and should be addressed at the national and global level. Project-specific GHG offset requirements at the local level may impose an unnecessarily high cost burden on the Project when compared with a national market-based scheme with links to international carbon markets. As the Commonwealth Government's policy and legislative landscape is still evolving, INPEX continues to explore all practical GHG management alternatives in order to be well prepared to respond when the legislative process becomes clearer. Further discussion of GHG emissions can be found in Section 4.8 and Table 5-1 in this EIS Supplement.

Submission 87-8: The development of a carbon offsetting and biodiversity compensation program in partnership with INPEX.

Submission 124-63: Recommendation: Establish a Northern Territory Biodiversity Compensation Fund. The Ichthys LNG project will cause significant destruction to sensitive habitats in the Darwin Harbour area, including ??underwater blasting for the shipping channel with likely mortality or exclusion of coastal dolphins, vulnerable and endangered marine turtles, dugong and fish; ??dredging leading to sedimentation of coral reefs, mangroves, creeks and seagrass habitats; ??clearing important vegetation types, namely 66 ha of regionally-significant monsoon vine forest, 83 ha of mangrove communities, 161 ha of savanna woodland and 41 ha of Melaleuca forest/woodland; ??introduction of weeds due to land clearing, road construction and pipeline construction; and, ??wastewater discharge to Darwin Harbour. No amount of biodiversity compensation actions or funding can offset the biodiversity impacts from the Ichthys LNG project. In light of the known and likely impacts arising from the project should it be approved, a Northern Territory Biodiversity Compensation Fund should be established and fully funded by INPEX to invest in a range of measures that will support enhanced biodiversity conservation in Darwin Harbour and its catchment, and elsewhere in the Northern Territory. We note the precedent set by the $190M Net Conservation Benefits Fund and environmental offsets program required as part of the approval for the Gorgon Project in Western Australia, which is in addition to the $1 Bn committed for the proposed geosequestraion initiative. Indicative projects which could receive funding from the Northern Territory Biodiversity Compensation Fund are described in Table 2. The value of these investments are estimated to total $405M over 40 years, but require additional investigation and costings.

INPEX has commenced dialogue with the Commonwealth's Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) and with the Northern Territory Government to outline a process for the development of an environmental offsets package for any significant residual environmental impacts arising from the Project.

Significant residual impact can only be determined by government after the submission of the Final EIS – that is the Draft EIS and this EIS Supplement. In the interim, INPEX has made a number of voluntary environmental offset commitments which are outlined in Section 4.9 of this EIS Supplement.

Prior to starting the commissioning of the off – and onshore facilities, INPEX will produce a detailed GHG management plan that will provide an updated GHG emission forecast and consolidate plans for technical abatement and offset measures. See Section 4.8 of this EIS Supplement.

Submission 89-29: INPEX offsetting 100% of the GHGE it will create in the Territory, via secure, Territory-based initiatives such as: supporting native bush revegetation and biosequestration programs in the Daly catchment and on the Tiwi Islands; supporting Indigenous fire management as per the West Arnhem Fire Abatement project; financing the development of renewable energy power options for remote communities; purchasing pastoral properties and managing them for carbon and biodiversity outcomes; supporting the partial destocking of over-grazed pastoral properties to encourage native vegetation to regrow; paying farmers, non-government organisations and Traditional Owners to plant native trees on previously cleared land.

Submission 109-26: The project provides an opportunity for government to work in conjunction with industry, the community and the environment sector to create a leading carbon offsetting program. This and other opportunities are listed in Part 4 of this submission.

Recommendation

- INPEX should aim to offset 100% of its carbon emissions through locally based projects.

INPEX is of the opinion that abatement of GHG emissions is achieved most efficiently and effectively through a well-designed national climate change policy framework that is consistent with global efforts to curb GHG emissions. Climate change is a global issue and should be addressed at the national and global level. Project-specific GHG offset requirements at the local level may impose an unnecessary high cost burden on the Project when compared with a national market-based scheme with links to international carbon markets.

INPEX has commenced dialogue with the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) and with the Northern Territory Government to outline a process for the development of an environmental offsets package for any significant residual environmental impacts arising from the Project.

Significant residual impact can only be determined by government after the submission of the Final EIS – that is the Draft EIS and this EIS Supplement. In the interim, INPEX has made a number of voluntary environmental offset commitments which are outlined in Section 4.9 of this EIS Supplement.

INPEX has indicated to the Northern Territory Government that it would like to commit to two environmental offset projects in the Northern Territory involving improved fire-management practices in the Daly River and Wagait regions and prior to starting the commissioning of the off – and onshore facilities, INPEX will produce a detailed greenhouse gas management plan that will provide an updated greenhouse gas emission forecast and consolidate plans for technical abatement and offset measures.

Submission 89-30: INPEX being a signatory to, and providing financial support for, a Darwin Harbour Integrated Monitoring and Research Plan Agreement that produces annual water quality and biodiversity status reports, and funds land and water management activities by Larrakia Rangers, local government and community groups.

INPEX has commenced dialogue with the Commonwealth's Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) and with the Northern Territory Government to outline a process for the development of an environmental offsets package for any significant residual environmental impacts arising from the Project.

Significant residual impact can only be determined by government after the submission of the Final EIS – that is the Draft EIS and this EIS Supplement. In the interim, INPEX has made a number of voluntary environmental offset commitments which are outlined in Section 4.9 of this EIS Supplement. The voluntary environmental offsets include participation in and funding of the proposed integrated monitoring and research program for Darwin Harbour.

Submission 89-31: Designation of new Darwin Harbour National Parks in the West Arm, Middle Arm and Ludmilla Bay areas. This will create an extensive coastal protected areas network alongside Charles Darwin National Park, East Point Reserve and Casuarina Coastal Reserve, in support of the NT Government's Territory Ecolink program and the United Nation's 2010 International Year of Biodiversity.

INPEX believes that the process for establishing marine and or national parks and reserves is the responsibility of the Northern Territory Government. INPEX has commenced dialogue with the Commonwealth's Department of Sustainability Environment, Water, Population and Communities (DSEWPaC) and with the Northern Territory Government to outline a process for the development of an environmental offsets package for any significant residual environmental impacts arising from the Project.

Significant residual impact can only be determined by government after the submission of the "Final EIS", that is, the Draft EIS and this EIS Supplement taken together. In the interim, INPEX has made a number of voluntary environmental offset commitments which are outlined in Section 4.9 of this EIS Supplement.

Submission 101-2: New Darwin Harbour national park at Ludmilla Bay. The INPEX project will destroy 66 ha of monsoon vine forest and 83 ha of mangrove communities and further pollute Darwin Harbour. INPEX should therefore give something back to the community through a biodiversity compensation program. The East Point/ Ludmilla Creek area in Darwin has high environmental and cultural values but is at risk due to inappropriate development proposals. The land holders of the area are Darwin City Council, the NT Government and the Gwalwa Daraniki Association Inc, who have a Crown Lease in Perpetuity over 300ha of land known as the Kulaluk Lease. This area is unique in the Darwin region in having large tracts of three ecosystems abutting one another – mangroves, monsoon rainforest and tidal mudflats, each with its own distinctive flora and fauna. The area's main cultural values are the World War 2 heritage at East Point and the granting of land to Aboriginal people as a result of the land rights campaign in the 1970s. This land, which is located on the harbour between the suburbs of Fannie Bay and Coconut Grove, has the potential to be a significant community asset and tourist attraction if developed as a national park (refer attached image). I propose that INPEX provide funding for the development of such a park, including pathways, mangrove boardwalks and a world class visitor centre.

The process for establishing marine and or national parks and reserves is the responsibility of the Northern Territory Government.

INPEX has commenced dialogue with the Commonwealth's Department of Sustainability Environment, Water, Population and Communities (DSEWPaC) and with the Northern Territory Government to outline a process for the development of an environmental offsets package for any significant residual environmental impacts arising from the Project.

Significant residual impact can only be determined by government after the submission of the "Final EIS", that is, the Draft EIS and this EIS Supplement taken together. In the interim, INPEX has made a number of voluntary environmental offset commitments which are outlined in Section 4.9 of this EIS Supplement.

Submission 109-17: Recommendation: Initiatives from Part 4 of this submission should be utilised to compensate for any clearing of the mangrove community and damage due to increased sedimentation.

INPEX has commenced dialogue with the Commonwealth's Department of Sustainability Environment, Water, Population and Communities (DSEWPaC) and with the Northern Territory Government to outline a process for the development of an environmental offsets package for any significant residual environmental impacts arising from the Project.

Significant residual impact can only be determined by government after the submission of the "Final EIS", that is, the Draft EIS and this EIS Supplement taken together. In the interim, INPEX has made a number of voluntary environmental offset commitments which are outlined in Section 4.9 of this EIS Supplement.

Offsetting losses of mangroves within Darwin Harbour caused by the Project may be considered to be an appropriate offset. Practically, however, it may prove difficult to implement as there appears to be a lack of historically impacted locations in the Harbour where mangrove habitat could be reinstated. INPEX has made a commitment in the Draft EIS to rehabilitate any mangrove losses attributable to sedimentation from dredging activities.

Submission 109-21:

- Initiatives from Part 4 of this submission be utilised to compensate for any clearing of the woodland community.

INPEX has commenced dialogue with the Commonwealth's Department of Sustainability Environment, Water, Population and Communities (DSEWPaC) and with the Northern Territory Government to outline a process for the development of an environmental offsets package for any significant residual environmental impacts arising from the Project.

Significant residual impact can only be determined by government after the submission of the "Final EIS", that is, the Draft EIS and this EIS Supplement taken together. In the interim, INPEX has made a number of voluntary environmental offset commitments which are outlined in Section 4.9 of this EIS Supplement.

Eucalyptus tall open forest is the most widespread vegetation community throughout the Darwin Coastal Bioregion and is also well represented in conservation reserves (see submission response 124-62 in Section 5.2.2.20 for a discussion on the use of the terms "Eucalypt woodland" and "open forest"). The extent of clearing of this community proposed within the Draft EIS will not significantly reduce its abundance and distribution at a regional level.

Submission 109-22: Section 3.7.3, page 136 emphasises the importance of Darwin Harbour in relation to the regional tourism industry. The section also emphasises the importance of the tourism industry and states the level of its contribution to the Northern Territory economy is twice national levels.

The visitor experience of the many tourists who come through Darwin is influenced by the natural beauty of Darwin Harbour and its vegetated shoreline. Apart from its value to visitors who actually engage in boating, cruising and fishing activities on the harbour, many people simply enjoy the ambience created by the natural, vegetation lined harbour from the many vantage points both in the CBD and further afield.

The harbour is also well utilised and highly valued by Territorians who sail, fish and socialise on or by the harbour. The experience of all users is becoming diminished as the harbour becomes more industrialised and development replaces the mangroves and other vegetation.

The comment in Section 10.3.11, page 469 in relation to the view from Stokes Hill Wharf (noted as an important tourism location in central Darwin) and other locations that 'The long distance reduces the proportion of the view that would be taken up by the Project' is seriously underestimating the visual impact of the project. The existing LNG plant has had a serious impact on the natural skyline of the harbour, this project is much larger and the effect will be significant.

Recommendation

- Initiatives from Part 4 of this submission be utilised to compensate for loss of amenity to Darwin Harbour users due to vegetation clearing and plant development.

INPEX acknowledges that there will be some loss of visual amenity in Darwin Harbour because of the presence of the onshore gas facilities at Blaydin Point. INPEX believes, however, that vistas from Stokes Hill Wharf will be mitigated to some extent by distance (noting that Blaydin Point is approximately 9 km from Stokes Hill Wharf compared with the 6 km for the Darwin LNG plant) and by the presence of East Arm Wharf. The Draft EIS's Technical Appendix 23 *Visual impact assessment* shows a viewshed analysis for the vista from Stokes Hill Wharf and indicates which areas of the onshore gas plant are expected to be visible from the wharf.

INPEX has commenced dialogue with the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) and with the Northern Territory Government to outline a process for the development of an environmental offsets package for any significant residual environmental impacts arising from the Project.

Significant residual impact can only be determined by government after the submission of the Final EIS – that is the Draft EIS and this EIS Supplement. In the interim, INPEX has made a number of voluntary environmental offset commitments which are outlined in Section 4.9 of this EIS Supplement.

Submission 109-27: There are opportunities for biosequestration on previously cleared land in the Top End of the Northern Territory. Projects implemented under the opportunities listed below could also provide biosequestration opportunities. Direct revegetation or paying land managers to undertake revegetation, manage existing vegetation management and enter into conservation management agreements could achieve this.

It is imperative that investment is in local projects so other benefits (biodiversity and water quality improvement, increased remote employment opportunities) of the biosequestration projects are received by the Northern Territory community (rather than investing in 'down south' projects because they are Kyoto compliant as discussed in Section 9.11.1, page 429 and as implemented in the INPEX trial discussed in Section 9.11.1, page 430).

As an example Greening Australia can provide Vegetation Offsetting incorporating ecological revegetation and restoration, environmental offsetting and biodiverse carbon. In addition Greening Australia's Breathe Easy program is a premium carbon offset product that provides an inspiring solution to global warming. It is more effective than monoculture planting schemes, where only one species is planted, Breathe Easy focuses on mass planting of a mix of species to offer a combination of Carbon Offsets, Landscape Transformation and Nurtured Biodiversity.

INPEX welcomes the suggestions for biosequestration and other carbon abatement opportunities in the Northern Territory provided in the Greening Australia submission.

INPEX is continuing to assess GHG offset opportunities and will produce a detailed GHG management plan that consolidates plans for technical abatement and offset measures prior to starting the commissioning of the off – and onshore facilities for the Ichthys Project.

Submission 109-28: In addition to offsetting their carbon emissions, INPEX needs to offset the area of native vegetation cleared by re-establishing similar habitats in the region. For example under Queensland vegetation management offset legislation major developers have to offset many times the area cleared with land managed for conservation purposed in similar habitats.

INPEX has commenced dialogue with the Commonwealth's Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) and with the Northern Territory Government to outline a process for the development of an environmental offsets package for any significant residual environmental impacts arising from the Project.

Significant residual impact can only be determined by government after the submission of the Final EIS – that is the Draft EIS and this EIS Supplement. In the interim, INPEX has made a number of voluntary environmental offset commitments which are outlined in Section 4.9 of this EIS Supplement.

Submission 109-30: Education and awareness

Investing in education and awareness about conservation will lead to a higher capacity for the community to engage in revegetation and other land management activities. Potential projects include: resourcing community based landcare coordinators; investing in training for community volunteers; and producing publications required for raising awareness and understanding of local natural resource management issues.

INPEX welcomes the suggestions for improving education and awareness in the community on land-care issues.

Submission 117-8: 4. Creating a carbon fund to offset the greenhouse emissions this project would produce. Please consider these points carefully, as they are incredibly important. Our marine life is invaluable.

INPEX's approach to GHG offsets is outlined in Chapter 9: Greenhouse Gas Management of the Draft EIS. INPEX is committed to managing its GHG emissions by actively promoting the reduction of GHG emissions across its operations in a safe, technically and commercially viable manner. INPEX reiterates its position that Ichthys LNG is likely to displace more carbon–intensive fuels in Asia for power generation and manufacturing. INPEX is of the opinion that abatement of GHG emissions is achieved most efficiently and effectively through a well-designed national climate change policy framework that is consistent with global efforts to curb GHG emissions. Climate change is a global issue and should be addressed at the national and global level. Project-specific GHG offset requirements at the local level may impose an unnecessary high cost burden on the Project when compared with a national market-based scheme with links to international carbon markets. As the Commonwealth Government's policy and legislative landscape is still evolving, INPEX continues to explore all practical GHG management alternatives in order to be well prepared to respond when the legislative process becomes clearer.

Submission 119-5: Development of an innovative and world-class carbon off-set and biodiversity compensation program in partnership with the NT Government must also be a priority.

Submission 124-7: Invest $405 M in Northern Territory Biodiversity Compensation Fund to partly compensate for unavoidable destruction.

Submission 124-21: In addition, we propose a series of innovative government policy recommendations that reflect the Conservation Organisations' holistic approach to development assessment and the fact that this Project will ultimately proceed on the basis of a private sector-government sector partnership4. Our major policy recommendation is for the Commonwealth and Northern Territory governments to develop a world-leading carbon offsetting and biodiversity compensation program in partnership with INPEX, in light of the likely, extensive impacts that will result from the Ichythys Project.

INPEX's approach to GHG offsets is outlined in Chapter 9 Greenhouse gas management of the Draft EIS. INPEX is committed to managing its GHG emissions by actively promoting their reduction across its operations in a safe and technically and commercially viable manner. INPEX is of the opinion that abatement of GHG emissions is achieved most efficiently and effectively through a well-designed national climate change policy framework that is consistent with global efforts to curb GHG emissions. Climate change is a global issue and should be addressed at the national and global level. Project-specific GHG offset requirements at the local level may impose an unnecessarily high cost burden on the Ichthys Project when compared with a national market-based scheme with links to international carbon markets. As the Commonwealth Government's policy and legislative landscape is still evolving, INPEX continues to explore all practical GHG management alternatives in order to be well prepared to respond when the legislative process becomes clearer.

However, it should be noted that as recorded in Section 9.11 of Chapter 9 of the Draft EIS, INPEX is currently investigating the various options for offsetting GHG emissions. In Section 9.11.1 it is pointed out that INPEX has already set up a pilot biosequestration assessment project, with an indicative budget of A$4.6 million, to trial plantings of two species of mallee on previously cleared farmland in Western Australia; this project commenced in 2008 and over 1.4 million trees had been planted by the end of 2010.

INPEX has also indicated to the NT Government that it would like to commit to two NT based environmental offset projects involving improved fire management practices in the Daly River and Wagait regions (refer to Section 4.8.5); and prior to starting the commissioning of the off – and onshore facilities, INPEX will produce a detailed GHG management plan that will provide an updated GHG emission forecast and consolidate plans for technical abatement and offset measures.

Submission 123-10: Offsets. It is expected that INPEX will present a detailed, agreed biodiversity offsets package in the supplement and will therefore work through a consultative process with the NT and Australian Governments to establish an agreed package of offsets, in line with the Australian Government's draft offsets policy.

The Northern Territory Government will continue to discuss greenhouse gas offset opportunities with INPEX.

Submission 123-160: The Northern Territory Government will continue to discuss greenhouse gas offsets opportunities with INPEX.

INPEX has commenced dialogue with the Commonwealth Department of Sustainability Environment, Water Populations and Communities (DSEWPaC) and with the Northern Territory Government to outline a process for the development of an environmental offsets package for any significant residual environmental impacts arising from the Project.

Significant residual environmental impact can only be determined by government after the submission of the "Final EIS", that is, the Draft EIS and this EIS Supplement taken together.

In the interim, INPEX has made a number of voluntary environmental offset commitments which are outlined in Section 4.9.

Submission 128-39: Annex 8 – Provisional Greenhouse Gas Management Plan.

The Provisional Plan does not make any firm commitments and has not determined how, if, or what types of offsets it will pursue nor the benefit these offsets will have for Darwin community and the Northern Territory.

INPEX's approach to GHG offsets is outlined in Chapter 9: Greenhouse Gas Management of the Draft EIS. INPEX is committed to managing its GHG emissions by actively promoting the reduction of GHG emissions across its operations in a safe, technically and commercially viable manner. INPEX is of the opinion that abatement of GHG emissions is achieved most efficiently and effectively through a well-designed national climate change policy framework that is consistent with global efforts to curb GHG emissions. However, as long as there is insufficient clarity on climate change legislation in Australia, INPEX cannot commit to large offset investments. INPEX has however indicated to the Northern Territory Government that it would like to commit to two fire-management projects in the Territory (see Section 4.8.5).

Project-specific GHG offset requirements at the local level may impose an unnecessary high cost burden on the Project when compared with a national market-based scheme with links to international carbon markets. As the Commonwealth Government's policy and legislative landscape is still evolving, INPEX continues to explore all practical GHG management alternatives in order to be well prepared to respond when the legislative process becomes clearer.

Prior to starting the commissioning of the off – and onshore facilities, INPEX will produce a detailed GHG management plan that will provide an updated GHG emission forecast and consolidate plans for technical abatement and offset measures.

Submission 124-18: INPEX has made little attempt to clearly identify knowledge gaps for the offshore, nearshore and onshore environments and their associated species, and to relate this to potential impacts. Given the relative lack of knowledge for many of the environments likely to be impacted and the proposed 40 year Project duration, a commitment to making a significant contribution to addressing these knowledge gaps would be a positive improvement to the Draft EIS.

INPEX believes that sufficient environmental information has been provided through the Final EIS to enable a comprehensive assessment of the significance of the Ichthys Project's impacts on the environment. By necessity all environmental impact assessment processes are undertaken with knowledge gaps. It is simply impossible to have comprehensive information on the effects and tolerances of the full range of species and communities which can potentially be affected by a development proposal.

Nevertheless, INPEX is committed to improving the environmental knowledge base both in the Darwin Harbour area and in the offshore development area. A high-level overview of the extensive research conducted in the offshore development area and adjoining Kimberley coastline is presented in Section 11.5 of Chapter 11 Environmental management program of the Draft EIS. This acquisition of this information has cost more than $15 million. See also Table 1-1 in Chapter 1 Introduction for a complete list of studies and surveys undertaken for the environmental impact assessment process before the publication of the Draft EIS.

INPEX has commenced dialogue with the Commonwealth Department of Sustainability Environment, Water, Populations and Communities (DSEWPaC) and with the Northern Territory Government to outline a process for the development of an environmental offsets package for any significant residual environmental impacts arising from the Project.

Significant residual impact can only be determined by government after the submission of the Final EIS – that is the Draft EIS and this EIS Supplement. In the interim, INPEX has made a number of voluntary environmental offset commitments which are outlined in Section 4.9 of this EIS Supplement. These voluntary offset commitments include:

- participation in and funding of the proposed integrated marine monitoring and research program for Darwin Harbour
- provision of funding to government, or direct complementary research, to improve the understanding of coastal dolphin abundance, distribution and critical resource needs in Darwin Harbour. Note that the pilot to this Project commenced in January 2011.

In addition, INPEX is supporting two research projects involving Territory-based and international researchers to improve scientists' basic understanding of fluid mud boundary layers in Darwin Harbour and to develop a microbe inventory and rapid impact assessment tool for the Harbour.

INPEX anticipates being an active member and funder of research in the Northern Territory over the life of the Project.

Submission 124-23: INPEX must commit to a carbon neutral Ichthys Project

INPEX appears to be waiting for legislated emissions trading schemes to be established in Australia before committing to carbon offsets (e.g. Chapter 9, Section 9.3, p. 417; Chapter 11 Annexe 8, p.560). As INPEX has regularly stated that it will be a good corporate citizen and long term part of the Territory community, the Conservation Organisations expect greater leadership and commitments from INPEX to demonstrate their corporate social responsibility and commitment to a safe climate.

We expect INPEX to commit to offsetting 100% of the 7 Mt (av.) of CO2 emissions p.a. released from the Ichthys Project at least until an emissions trading scheme is in place in Australia that is effectively driving steep reductions in emissions in accordance with trajectories to achieve science-based abatement targets.

Further, INPEX appears to propose purchasing carbon offsets that are available only within regulated markets that meet existing emissions abatement targets (e.g p. 57, Executive Summary). By limiting carbon offset opportunities to regulated markets, such as those established under the Kyoto Protocol, these offsets will not be additional to existing legislated targets and hence will not drive significant emission abatement. INPEX should not restrict its carbon offsetting options to simply those available through a range of markets that would enable them to derive a commercial benefit through selling the offsets.

Recommendation:
INPEX should commit to making the Ichthys Project a carbon neutral project. This will at least guarantee that Australia's emissions will not increase in light of the strong likelihood that global emissions will rise through Ichthys LNG being used in addition to coal for electricity generation.

Committing to a carbon neutral Project will mean offsetting 100% of the greenhouse gas emissions produced at least until effective regulatory markets are established nationally and globally to drive emissions abatement, at which time INPEX could slowly and proportionally reduce its investment in offsets as regulated markets gradually drive emissions abatement.

INPEX should not limit the purchase of carbon offsets to only those covered by regulated markets.

Purchasing carbon offsets in the Northern Territory

The draft EIS leaves open the possibility for most or perhaps all carbon offsets to be sourced from overseas. This would also be permitted through a loophole contained in the existing draft Carbon Pollution Reduction Scheme.

Opportunities for achieving a carbon neutral Ichthys LNG Project through investing in carbon offsets in the Northern Territory are outlined in Table 1. Information regarding cost per tonne of abatement for CO2 is presented where available.

Recommendation:
Preferentially purchase secure and independently verified carbon offsets in the Northern Territory, and if this is not possible, within Australia. Given the strong need for additional investment in sustainable landscape management in the Territory, and reflecting the significant environmental damage that the Ichthys LNG Project will cause directly and indirectly in the Territory, the Northern Territory and Australian Government should require the vast majority of carbon offsets to be sourced here.

Such an approach is provided for by the Australian Government's National Carbon Offset Standard7, which covers activities like revegtation, forest management and landscape management. Importantly, the Standard provides explicitly for domestic voluntary offsets that are additional to a business-as-usual approach:

3.2.1 Domestic offset eligibility criteria
In order for domestic offset methodologies and projects to be considered eligible under the Standard they are required to occur within Australia and be:

(a) Additional Greenhouse gas emissions reductions generated by the project must be beyond what would be required to meet regulatory obligations under any Australian laws or regulations or undertaken as part of 'business-as-usual' investment. The level of additional emissions reductions generated by an offset project is the difference between the emissions associated with the project ('project emissions') and emissions under a business-as-usual scenario.

In addition, Indigenous fire abatement projects should be included within the portfolio of carbon offset projects. In contrast to the West Arnhem Land Fire Abatement project in which only avoided emissions methane and nitrous oxide are considered as legitimate greenhouse gas abatement, biosequestration of carbon dioxide within vegetation and the soil should also be considered as a legitimate carbon offset.

Submission 124-25: Fund a Northern Territory Carbon Fund to purchase carbon offsets Precedents exist for requiring significant investments in reducing net emissions by the Australian LNG sector. CononcoPhillips entered into an agreement with the Northern Territory Government and Northern Land Council to fund the West Arnhem Land Fire Abatement project which avoids the release of approximately 140,000 tonnes of methane and nitrous oxide annually by instituting cool season savanna burning by Indigenous traditional owners. This initiative has been successful in illustrating that LNG operators can enter into voluntary offset arrangements with Territory landscape managers, but the amount of avoided emissions represents only a few percent of emissions from the Darwin LNG plant and excludes the significant biosequestration opportunities of storing carbon dioxide in vegetation and soil. More recently, the Gorgon LNG project in Western Australia has proposed to reduce net emissions by 3.5 Mt p.a. of CO2 though geosequestration at a cost of over $1 Bn. This represents a commitment to cut emissions by 40%, or 120 Mt CO2, over the life of the project. Whilst we do not support the proposed methodology for reducing emissions, we consider the proportion (40%) of emissions abatement attached to the Federal Environment Minister's approval of the project as establishing a new minimum acceptable level for carbon offsets by INPEX's Ichthys LNG Project. Recommendation: Establish a Northern Territory Carbon Fund to purchase offsets equivalent to 7 Mt CO2 p.a. over the life of the Ichthys Project, or until such times as effective regulated emissions trading schemes are established in Australia and globally to drive rapid emission reductions. Based on a 40 year project producing 7 Mt p.a. (av) and assuming a carbon price of $25 per tonne of CO2, an estimate of the total value of offsets or carbon credits required to make the Ichthys Project carbon neutral is $7 Bn (40 yrs x $25/tonne x 7 Mt/yr = $7 Bn).

INPEX's approach to greenhouse gas (GHG) offsets is outlined in Chapter 9 *Greenhouse gas management* of the Draft EIS. INPEX is committed to managing its GHG emissions by actively promoting their reduction across its operations in a safe and technically and commercially viable manner. INPEX reiterates its position that Ichthys LNG is likely to displace more carbon–intensive fuels in Asia for power generation and manufacturing. Further information can be found in Section 4.8 of this EIS Supplement.

INPEX is of the opinion that abatement of GHG emissions is achieved most efficiently and effectively through a well-designed national climate change policy framework that is consistent with global efforts to curb GHG emissions. Climate change is a global issue and should be addressed at the national and global level. Project-specific GHG offset requirements at the local level may impose an unnecessarily high cost burden on the Ichthys Project when compared with a national market-based scheme with links to international carbon markets. As the Commonwealth Government's policy and legislative landscape is still evolving, INPEX continues to explore all practical GHG management alternatives in order to be well prepared to respond when the legislative process becomes clearer.

However, it should be noted that as recorded in Section 9.11 of Chapter 9 of the Draft EIS, INPEX is currently investigating the various options for offsetting GHG emissions. In Section 9.11.1 it is pointed out that INPEX has already set up a pilot biosequestration assessment project, with an indicative budget of A$4.6 million, to trial plantings of two species of mallee on previously cleared farmland in Western Australia; this project commenced in 2008 and over 1.4 million trees had been planted by the end of 2010.

INPEX has indicated to the Northern Territory Government that it would like to commit to two savannah fire-management projects; one in the Daly River area and one in the Wagait area in the Northern Territory, south-west of Darwin (see Section 4.8.5 for details).

Prior to starting the commissioning of the off – and onshore facilities, INPEX will produce a detailed GHG management plan that will provide an updated GHG emission forecast and consolidate plans for technical abatement and offset measures.

5.2.2.14 Oil spill

Submission 1-40: What provisions and training will the community receive regarding potential future Spills and Discharges to the Environment ? As we all know accidents DO happen despite the best laid plans. BP Gulf of Mexico 2010

INPEX will maintain teams of personnel appropriately qualified and trained in oil-spill management both at the offshore development area (including drilling rigs, the central processing facility (CPF), the floating production, storage and offtake (FPSO) facility, and associated support vessels and supply bases) and at the onshore gas-processing facility on Blaydin Point. These personnel will provide INPEX with a "first strike" capability, to respond rapidly to spill incidents. If a spill incident should require ongoing management and additional manpower, INPEX will obtain assistance from other oil and gas companies and from the Australian Marine Oil Spill Centre (AMOSC).

INPEX is currently a member of AMOSC and will continue to maintain its membership of this organisation funded by the Australian petroleum industry. AMOSC's primary role is to support petroleum companies in the event of an oil spill in Australian waters. It also has the ability to call upon additional support from international spill-response organisations if required (as was the case with the Montara spill in the Timor Sea in August 2009).

The most likely situation in which the general public would be involved in the response to a spill event would be for a large-scale shoreline clean-up operation. One of the tasks that AMOSC undertakes is to provide highly trained staff to support spill responses, and these staff provide on-the-job training and personal protective equipment (PPE) for both industry personnel and volunteers from the general public who assist with shoreline clean-up operations. An example of AMOSC undertaking this role was in the aftermath of the Moreton Bay oil spill in Queensland in 2009, where AMOSC personnel assisted with the provision of skilled workers to train and oversee volunteers participating in the shoreline clean-up. AMOSC would also provide on-the-job training for personnel assisting with other spill-response activities, such as offshore spill response or nearshore spill containment and recovery from vessels.

Submission 1-48: PART I Question 47 Pollution Prevention and Control – Oil and chemical spills can be highly damaging to the environment and biodiversity, and cause business loss. It is very important for INPEX to have plans to minimise the occurrence and impact of spills. INPEX must have an onsite emergency response base that is able to deal with a wide range of pollution incidents. What are INPEX's detailed plans for an emergency response base at Blaydin Point?

Submission 2-1: In relation to Table 6.1 Accidential hydrocarbon spill the managment control measure of "spill response equipment and procedures will be available" Company should ensure spill model considers major spill events such as Montara/BP Gulf of Mexico during drilling and operational life and nominate where the emergency spill response equipment be located and time to deploy?

Submission 8-5: Finally, I object to the inadequacy of measures to reduce the risk of oil spills. The uncontrolled, 10 week long oil spill from the Montara platform last year shows the risks that oil and gas developments pose to our marine environment. The risks to the Kimberley coast and Timor Sea's marine wildlife have not been properly addressed in the EIS, and pose major concerns. The EIS makes it clear there are huge threats to the Kimberley coastline, Browse Island and Scott Reef from a major oil spill, yet there are no plans in place to deal with a large scale disaster. This is unacceptable.

Submission 8-8: Produce comprehensive modelling of oil spill risk from the proposal and develop a world's-best oil spill contingency plan that effectively protects marine wildlife and sensitive ecosystems from even worst case oil spills.

Submission 13-5: 3. Produce comprehensive modelling of oil spill risk from the proposal and develop a world's-best oil spill contingency plan that effectively protects marine wildlife and sensitive ecosystems from even worst case oil spills.

Submission 40-5: What strategies will be implemented to ensure safety measures to protect the sensitive Kimberley coastline against the risk of an oil spill from the offshore gas field development.

Submission 66-4: As if that's not bad enough, the developers have utterly inadequate safety measures to protect the sensitive Kimberley coastline against the risk of an oil spill from the offshore gas field development.

Submission 78-1: Please reconsider the LNG gas field development project and take some further time to research the effects this will have on the coastal forests as well as the harbour's dugongs, dolphins and turtles. Also to research into safety measures to protect the Kimberly coastline against the risk of oil spill from the offshore gas field development.

Submission 94-1: We note that nine potential spill scenarios were identified and that these spills could 'occur at any position along the offshore pipeline route' (Draft EIS, pp 270). We note that the higher impact scenarios – Scenarios 1 , 3, 4,7 and 8 in the Draft EIS – have lower primary risk gauged as 'remote'or'highly unlikely'. However, we also note that recent events at Deepwater Horizon in the Gulf of Mexico have highlighted that catastrophic impacts can and do occur from these types of scenarios. In the event that these Scenarios eventuated, the Draft EIS modeling indicates that there is potentialfor oil to reach the Kimberley Coast, as well as offshore areas such as Browse Island. The result could be a lasting impact on what is a major marine biodiversity hotspot.

Even though this assessed as a Remote or Highly Unlikely likelihood, the potential catastrophic consequence means that this is a high risk, that should be managed to As Low as Reasonably Possible level.

Submission 94-2: Given that the risk of an accidental hydrocarbon spill is a high risk categorV, we consider that every effort should be made to minimize the potential for such risks. The Montara incident suggests that current practices need review prior to environmental approvals being given for this Project, and a comprehensive regime implemented that better minimises the risks. Resourcing and testing Australia's rapid response system is also vital.

Submission 100-1: Failure to provide spill modelling maps for potential hydrocarbon spill scenario 7 (Subsea well failure during development drilling) and scenario 8 (Subsea well failure during production). The failure to provide spill modelling maps of hydrocarbon spill scenarios 7 and 8 is of serious concern. A revised EIS should be required to be produced that includes full spill scenario modelling during the wet season and dry season. The statement on p 271, Section 7.2.4 that "If a subsea well failure were to occur, spill trajectory modelling would be undertaken at that time for current weather conditions and spill flow rates, to guide response efforts", is unacceptable. Proponents should have carried out all relevant spill modelling and planning and provided it to the community in advance of the development being considered for approval.

Submission 100-2: Inadequate management controls for accidental hydrocarbon spills. The cursory treatment of management control for hydrocarbon spills (p 284-285, Section 7.2.4) is not acceptable, and there is no evidence of the proponents intending to go beyond "industry-standard provisions", despite the remote location and proximity to some of the richest and most intact reefs remaining in the world, as well as proximity to areas of importance for migratory marine species, and important breeding grounds. For example, inclusion of factors such as maintaining a well control manual, should be deemed inadequate detail. The proponent should be required to provide comprehensive details on all aspects of management controls for major offshore spills as part of the EIS, clearly identifying how they intend to exceed industry standard provisions, and instead set new benchmarks for operating in proximity to sensitive habitats such as the Kimberley coast. In its current form, the management controls section is not acceptable. The proponents should be required to substantially revise the management of hydrocarbon spills section of the EIS and resubmit.

Submission 100-3: The Oil Spill Contingency Plan referred to on p 284, Section 7.2.4 should be included in the EIS for community review.

Submission 100-4: Inadequate information on persistence of Ichthys condensate as part of the spill modelling Useful information on the persistence of Ichthys field condensate in surface spills or remaining in the water column as fine droplets from a subsea spill, is included on p 268 and 269, Section 7.2.4. As part of the spill modelling for the full range of scenarios, quantitative estimates of the volume and persistence of Ichthys condensate should be provided as part of the EIS.

Submission 100-11: Slick avoidance behaviour reference and characterisation. The EIS cites a 1983 study on bottlenose dolphins as evidence of slick avoidance behaviour. However, a 2009 study of the Montara Oil spill found a very different behaviour response for impacted marine wildlife, as detailed in the sections below. The sections on response and avoidance need to be reviewed and revised. http://www.montarainquiry.gov.au/downloads/DEWHA/SUBM.3002.0001.0160.pdf. The following is taken from the above document that was submitted to the Montara Inquiry and the page numbers refer to the document found from following the above link:

– P 30 “Importantly, the abundance of certain seabirds (e.g. Common Noddy, Wedge-tailed Shearwater, Streaked Shearwater, Lesser Frigatebird) was frequently high in oil affected waters (especially areas that had a lighter sheen of oil). A comparison of observations along the strip transects (between transects with oil compared to transects without oil) showed that the abundance of these bird species was higher in transects where oil was present (Table 1, Table 6; Figure 8). Figure 21 highlights this pattern for Common Noddy. We observed that this increase in bird activity corresponded with greater activity of larger fish (jumping and schooling) in the oil affected areas and we surmise that the presence of a light oil sheen may attract fish, which then attracts some species of bird. A commonly sighted phenomenon was large groups of Noddies flying around strips of oil and feeding in, and around, these patches of water (Figure 23).”

– P 31 Not all species responded in the same manner and there appeared to be species-specific responses to the oil. Five species were recorded at sea in non-oil affected areas and were not recorded in transects that contained oil records. Species including Brown Booby, Bulwer’s Petrel and Crested Tern were recorded far less often in oil affected waters (Table 1, Table 6). Figure 22 highlights this pattern for the Brown Booby.

– P 33 Cetaceans. We found cetaceans throughout the region, except in transects close to Ashmore Reef. As with the seabirds, we found that there were large numbers of sightings of cetaceans and of individual animals in areas that were affected by oil, especially near the Montara Oil Well. False Killer Whales and Spotted Pantropical Dolphins were found only in oil affected waters.

Reptiles. We found that sea snakes, like cetaceans, were not found close to Ashmore Reef but were frequently encountered in the region of the Montara oil spill. This is unusual as some sea snakes are known to breed at Ashmore Reef at this time of year. Only one species (the Olive Sea Snake) was not recorded in oil affected waters, but it is very possible that they do utilise these waters as many of the unidentified sea snakes were found in oil affected waters. Importantly, when numbers were considered, they were found far more in areas that were affected by oil than areas that were not (Table 4).

Turtles were observed throughout the area and both species that were identified were observed in oil affected areas. There also appeared to be seen more commonly in oil affected waters than non-oil affected waters, but this pattern was far less clear than with cetaceans and sea snakes (Table 5).”

Submission 103-8: No spill modeling has been undertaken for subsea well failure. This should be detailed in the EIS, particularly as flowline ruptures have been identified as having the potential to impact on Scott Reef and surrounding sensitive environments.

Submission 106-15: Lack of oil spill contingency plans

Ichthys field condensate is light oil with low viscosity and relatively low proportion of hydrocarbons and therefore is expected to undergo rapid weathering (evaporation of the 70-80% of the spill volume) within the first day of release. Under certain wind conditions, trajectory modelling indicated there is a chance that persistent hydrocarbons from large spills could reach the shoreline of Browse Is, Seringapatam Reef, Scott Reef and the Kimberley Coast of WA. The likelihood shoreline oil exposure from these scenarios ranges from 4.9 x 10-4 to 4.9 x 10-7 events per annum. Despite the low likelihood of an oil spill, the Montara oil and gas well in the Timor Sea last year showed that it does happen and when it does it takes along time to stop. Thus low likelihood is no reason not to have a properly developed oil spill contingency plan.

However, the EIS states that “Spill modelling has not been included for the longer-term subsea well failure scenarios because of their very low likelihood of occurrence. If a subsea well failure were to occur, spill trajectory modelling would be undertaken at that time for current weather conditions and spill flow rates, to guide response efforts as part of the Projects oil-spill contingency plan’’. This is a sever omission and must be rectified.

The EIS provides maps of the predicted impacts of any smaller leaks from the Ichthys offshore gas project. In the wet season, hydrocarbons from the well head could be expected to reach bird-breeding areas along the coast, and possibly reefs and islands. A larger leak, similar to that from the Montara oil and gas well in the Timor Sea last year, are predicted to reach some point on the shorelines of Browse Island, Scott Reef and the Western Australian Kimberley coast.

The Montara oils spill in the Timor Sea raised issues of the legal jurisdiction of oil rigs and their legal responsibility in an oil spill. Oil rigs are only covered in the international law of the sea when they are mobile. What are the legal jurisdiction of the floating infrastructure of the Ichthys project such as the CPF and FPSO. What is INPEX's responsibility in the case of an oil spill and or environmental accident.

INPEX must acknowledge that an oil leak in this pristine marine environment would be a disaster for the marine wildlife and megafauna of the region by creating a comprehensive oil spill contingency plan. Once the findings from the Montara Inquiry are released, any new learnings should be incorporated into such a plan. An oil spill contingency plan must be developed before the project is approved.

Submission 107-3: Some protocols and procedures for managing environmental risk is based are yet to be written. Some modelling appears to be incomplete (e.g. the spill dispersal model provided in Appendix 10 does not consider serious spills)

Submission 107-31: INPEX states that hydrodynamic modeling of plumes from the gas export pipeline is to be undertaken prior to commissioning but after construction. Modelling of plumes should be undertaken before construction, as alternative system designs might provide maximum protection to the environment. INPEX should explain why they believe that postconstruction modeling provides maximum environmental protection, and should identify further contingencies and actions they will put in place to ensure that plumes from the gas export pipeline have a decreased effect in the future.

Submission 107-34: There is mention of a non-volatile residue from the condensate that resists evaporation. The exact nature, chemical composition and ultimate fate of this material should be described, and contingency plans derived for dealing with it. This level of information is required to fully address all scenarios listed in Table 7-17.

Submission 107-36: Scenarios 7 and 8 in Table 7-17 refer to subsea well failure during development and production, but are not described in the text of the EIS. The argument that there is a low likelihood of occurrence and that modeling would be undertaken at the time it happened (should it occur), should not be used as an excuse to fail to provide modeling information.

Submission 107-40: INPEX states it has developed an Oil Spill Contingency Plan. As this is one of the key areas of risk and environmental concern, it should have been provided with the EIS as it is reasonable to expect it contains information relevant to our concerns raised above. On receipt by the NT Government, it should be released for public comment as it remains a part of the EIS.

Submission 123-90: Modelling for worse-case scenarios need to be conducted for spills, pipeline blowouts and facility blowouts within Darwin Harbour. This should include discussion of potential impacts and management measures.

Submission 124-8: Oil spill risks and potential impacts on biota have been inadequately evaluated through modelling and other processes. Recommendations: 1 – More modelling, better management controls, review likely impacts on marine wildlife & habitats. 2 – Incorporate relevant information and lessons from report from Montara Inquiry.

Submission 124-76: 4.2 Marine Impacts and Management – Risk assessment ratings

The risk assessment ratings provided for impacts in the offshore area in the Draft EIS are: alteration of habitat is low to medium for offshore marine environments noting that any effects would be localised and small in scale (Volume 1, Chapter 7, Section 7.2.1, p. 247); low to medium for liquid discharges (p. 254 – 264); medium or low for risks of harm from spills to the offshore environment (p. 285); and risks for spills to the Kimberley coast nearshore environments are not mentioned. The latter is a serious oversight.

4.2 Marine Impacts and Management

Risk assessment ratings

The risk assessment ratings provided for impacts in the offshore area in the Draft EIS are: alteration of habitat is low to medium for offshore marine environments noting that any effects would be localised and small in scale (Volume 1, Chapter 7, Section 7.2.1, p. 247); low to medium for liquid discharges (p. 254 – 264); medium or low for risks of harm from spills to the offshore environment (p. 285); and risks for spills to the Kimberley coast nearshore environments are not mentioned. The latter is a serious oversight.

Submission 124-79: Spills. A large proportion of nearshore areas on the Kimberley Coast identified in the Draft EIS as likely to be impacted directly in spill trajectory models have also been identified in the Commonwealth Marine Bioregional Planning process as areas for further investigation for marine protected areas. These areas are known key foraging and breeding habitat for Australian snubfin dolphins, Indo-Pacific humpback dolphins, bottlenose dolphins, spinner dolphins, dugongs and turtles (DEWHA 2010, Thiele 2005, Deborah Thiele pers. comm.35). Extensive mangrove habitat and rich and diverse systems built on complexes of island, reef, coral and seagrass habitats are found along these parts of the coast. Shallow tropical ecosystems like these, made up of multiple habitats with high connectivity, have been shown to have much higher biodiversity and are considered critical to maintaining diversity and ecosystem function36.

Submission 124-87: Prepare a detailed plan of action that clearly shows how INPEX will mitigate impacts on marine species and contain any spill in the Ichthys Field or along the pipeline. This contingency plan should be developed to a world-class standard. The current plan primarily refers to 'industry standards' without real detail. Recent spills into the marine environment such as Montara in the NW & Timor Sea (2009) and Gulf of Mexico (2010) have revealed how unprepared the oil and gas industry is for these events, despite adopting 'industry standards'. A detailed plan should include specific information on actions and logistic arrangements in place to ensure a rapid response to spill scenarios that may impact upon reefs and islands and inshore areas (Kimberley Coast; Joseph Bonaparte and the Anson-Beagle Bioregions and at Scott Reef, Seringapatam Reef, Browse Island) in order to protect marine species and habitats. This plan should be made public prior to project approval and reviewed by NRETAS, DEWHA and independent experts for efficacy in reducing impacts.

Submission 127-1: Accidental spills. The EIS acknowledges that there is the potential for oil spills to occur from the offshore infrastructure and the potential that exists for such spills to reach potentially sensitive environmental areas which includes the Kimberley Coast.

Recent adverse outcomes associated with accidents on the PTTEP – West Atlas platform and that which occurred in the Gulf of Mexico have highlighted the vulnerability of the environment to oil spill scenarios and it is therefore vital that there be sufficient capacity to quickly and effectively respond to such events. The pristine environment of the Kimberley would be particularly vulnerable to an oil spill and it is therefore considered an imperative that mitigation measures be put in place that not only meet minimum requirements but exceed that to ensure the integrity of the region is able to be preserved in the event of an oil spill.

The Council submits that the remote and isolated location of the Browse Gas Basin from the existing ports of Darwin, Broome or those within the Pilbara would diminish the ability of the operators to quickly respond to any major oil spill scenario. The development of Point Torment as a Marine Supply Base would enable Inpex and other future operators in the Browse Basin to store necessary equipment to manage oil spills and also provide a base from which to access the field in the quickest time possible.

The development of a dedicated base at Point Torment with the capacity to respond to major incidents would be considered to supplement the mitigation measures set out within the EIS and assist in addressing some of the environmental concerns of the Kimberley community may hold about the development of the Ichthys Gas Field Development Project.

Submission 128-42: Annex 10 – Provisional Liquid Discharge Surface Water Run off and Drainage Management Plan.

The community would expect a pristine harbour beyond INPEX's 40 years and the life of the project

What contingency plans for major pollution incidents have been developed and what are the worst case scenarios being considered for a catastrophic incident both onshore and off shore?

Submission 129-1: Modelling presented in the EIS documentation (page 270 and Appendix 7) identifies that in the event of an oil spill (condensate) originating from the Ichthys field there is a risk that coastal waters and shorelines will be impacted, and that in particular there is a risk to the Browse Island Nature Reserve (only 30km from the Ichthys field) and to a lesser extent Scott Reef Nature Reserve and the West Kimberley coast and islands. In view of this, and in light of the lessons learnt as a result of the Montara Oil Spill, the management arrangements designed to guard against well blowouts and other accidental spills, as well as contingency planning and scientific monitoring arrangements for marine oil spills are important issues that the OEPA wishes to highlight in the context of the environmental assessment of this project .

Submission 129-2: The project is to involve the drilling of 50 subsea wells in water depths ranging from 235 to 275 meters, over the life of the project (estimated in the EIS to be 40 years). The EIS, Table 7-17 (Chapter 7 page 271) provides an estimate of risk for hydrocarbon spills from a range of project activities, including a spill resulting from subsea well failure during drilling Scenario 7. It is noted that risk is expressed as "Likelihood per annum" except for the drilling activity where risk is expressed "per well". The risk arising from these activities are cumulative and apply over the estimated 40 years production life of the project. The risk of a subsea well failure during production is increased by the fact that up to 50 oil wells are planned for this project.

Submission 129-3: In any event, even on the basis of the risk values provided in the EIS, it follows that there is a risk of a significant marine hydrocarbon spill over the life of this project and recent experience with the Montara oil spill demonstrates that a well blowout may lead to a protracted incident involving continuous release of hydrocarbon over a period of months. Consequently detailed and comprehensive oil spill planning is essential for this project

Submission 129-4: It is noted that scenario 7 and 8, which involve subsea well failure, have not been modelled because of the "very low likelihood of occurrence" [quote from page 271]. These scenarios involve continuous release of hydrocarbons over a period of weeks or months. Scenario 4 (ship collision with the FPSO) represent an oil spill of a magnitude (1000 m3 per day) that potentially is equivalent to the volume of spill from just one day of a significant well blow out. Consequently the scenario 4 probability mapping of the spill trajectory provided on page 276 (Figure 7-9) may also be indicative of the location that could be impacted by a well blowout.

Submission 129-5: The report from the Federal Government Montara Oil Spill Inquiry has not, as yet, been made publicly available. However it is clear from the transcripts of the Inquiry that concern has been expressed about a range of issues including drilling techniques and oil spill response. It is important that the experience gained from the Montara oil spill is applied to the Ichthys project. Any relevant recommendations for improved drilling techniques, safety auditing and oil spill preparedness that are identified in the Montara Report should be applied to this project.

Submission 129-6: Accidental hydrocarbon spills are discussed in Chapter 7, section 7.2.4, (page 266). On page 284 of the EIS it is noted that Inpex has developed an oil spill contingency plan (OSCP) which has been approved by the WA Department of Mines and Petroleum. The EIS notes that the OSCP will be regularly updated. However, Chapter 11 of the EIS (page 497) states that "a Project oil-spill contingency plan (OSCP) will be prepared to insure that INPEX can respond rapidly and effectively to an oil spill in the marine environment." So it is not clear whether an OSCP has been finalised, and details of the plan have not been provided in the EIS. In any event, it is clear that the OSCP will need to be regularly updated and from the perspective of the WA OEPA it is clear that a key focus of the OSCP should be the protection of WA marine and coastal assets, and in particular the nearby, Browse Island Nature Reserve.

Submission 129-7: It is also clear that these updates should incorporate any relevant recommendations coming out of the Montara Inquiry. In particular the OSCP should include pre-arranged provisions for scientific monitoring of a marine oil spill as well as pre-impact baseline monitoring of sites such as Browse Island and other WA locations at risk as identified in the modelling described in Appendix 7.

Submission 129-8: It is also clear that these updates should incorporate any relevant recommendations coming out of the Montara Inquiry. In particular the OSCP should include pre-arranged provisions for scientific monitoring of a marine oil spill as well as pre-impact baseline monitoring of sites such as Browse Island and other WA locations at risk as identified in the modelling described in Appendix 7.

Submission 129-9: Given the remote location of the Ichthys field and the proximity to Browse Island, a vital component of the OSCP, is the plans and arrangements designed to ensure that logistical support is in place to enable the rapid deployment of appropriate and effective equipment. The Montara incident provided experience of an oil spill under the same marine conditions as will apply to the Ichthys field. Capture and containment of surface oil was achieved by the use of booms dragged across the sea surface by paired support vessels. Whether this technique would be effective with a spill from the Ichthys field depends on the nature of the condensate. The effectiveness and appropriateness of dispersants would also depend on the nature of the condensate. These issues need to be addressed in detail by the proponent in order to give assurance that the project can be managed in an environmentally acceptable manner.

Oil-spill modelling, prevention and response comments are addressed in Section 4.2 of this EIS Supplement.

Submission 100-7: Fish population and potentially affected fisheries. This section makes no reference to the potential fish species affected by a hydrocarbon spill, either in the vicinity of the development or in the bays and inlets of the Kimberley coast. Instead it solely talks about laboratory studies and the results of other spills where fish have been affected. It is therefore missing the critical information required by an EIA. This section therefore needs to be rewritten with relevant information included. It would also benefit from reviewing the Gulf of Mexico Deepwater Horizon spill response with regard to fisheries and likely impacts. The entire EIS is lacking good primary base-line data on fish populations and fisheries in the area potentially affected by the spill, including benthic and pelagic populations as well as inter-tidal fish communities. The section on behaviour of condensate in the water column from a subsea incident (such as the Gulf of Mexico), indicates that pelagic and benthic fish communities will be affected. Within the entire EIS, the information on fish populations is inadequate for assessing the impacts of the development. There needs to be a dedicated effort at characterising the fish populations and potentially affected fisheries.

The construction and operation of facilities in the Ichthys Field will pose no significant risk to fish in the Browse Basin or along the Kimberley coastline, except in the unlikely event of a significant oil spill. Information on the toxicity of an oil spill on fish, and the context in which this information needs to be considered (sheltered bay compared with open ocean), is provided in Section 7.2.4 (pages 280–288) in Chapter 7 *Marine impacts and management* of the Draft EIS. This information is adequate and appropriate for evaluating impacts on all fish, regardless of their habitat preferences.

INPEX will prepare, in consultation with other petroleum companies in the Browse Basin, or independently if required, a scientific monitoring program which will be implemented as part of the oil-spill contingency plan. The scientific monitoring program will include provision for monitoring plans to evaluate and determine the extent of any impacts on fish species and populations in the event of a significant oil spill. The scientific monitoring program will incorporate lessons learned from the Montara and Macondo well blow-out incidents (see Section 4.2.2 of this EIS Supplement).

Submission 100-8: Seabirds. This region is extremely important for migratory seabirds, including those listed under a range of international instruments. This section does not adequately describe the regional importance of this region and the species that would be affected through foraging.

In 2010 INPEX commissioned a literature review of seabird distribution and abundance in the vicinity of Ichthys Field infrastructure in the Browse Basin (Surman & Nicholson 2011). The review includes an evaluation of INPEX's seabird survey data collected in the Browse Basin between June and November 2008 (see Section 3.2.8 in Chapter 3 *Existing natural, social and economic environment* of the Draft EIS).

The full literature review is provided in Technical Appendix S3 to this EIS Supplement and a summary of its key findings is presented below.

The Browse Basin is species-rich in terms of seabird diversity at sea, with 39 species having been recorded over numerous surveys. This is comparable to the 39 species recorded during surveys of the eastern Indian Ocean (Dunlop, Surman & Wooller 1995). On a smaller scale within the Browse Basin, Jenner, Jenner and Pirzl (2009) recorded 16 species during their June–July surveys and 16 species during the October–November surveys. Eight of these species were observed during both periods, so that 24 seabird species in all were recorded for the survey area. A similar number of species (range 15–21) were recorded during several surveys undertaken between Broome and Ashmore Reef. From the available literature and survey results, within the proposed sphere of operations of the Ichthys Project it would be expected that approximately 28 seabird species would be encountered regularly.

The seabird species likely to occur in the Browse Basin and in particular in the area of the Ichthys Field are shown in Table 4-21. It provides information on their status (breeding, migratory, regular visitor or vagrant) and the distance to the nearest breeding colony.

Within the North-west Marine Region similar numbers of seabird species have been recorded at other sites. For example, Dunlop, Surman and Wooller (1995) predicted that 18 seabird species could be expected to be observed in areas around the FPSO Jabiru Venture, which is situated further north in the region, while 23 seabird species have been recorded at the Lowendal Group, further south in the region (Surman and Nicholson 2010).

The number of breeding seabird species found on islands within 345 km of the Ichthys Field are comparable to the numbers on breeding islands elsewhere in the North-west Marine Region. Ten seabird species have been recorded nesting on Adele Island (160 km from the Ichthys Field), 13 species on Ashmore Reef (200 km from the Ichthys Field) and 14 species at the Lacepede Group (CCWA 2010; DEC undated; Table 3 in Surman & Nicholson 2011). These numbers compare well with the Lowendal and Montebello groups, where 13 species of seabirds have been recorded breeding (Burbidge et al. 2000; Surman & Nicholson 2010). Two islands in the Browse Basin which have fewer seabird species recorded breeding are Browse Island (30 km) with one species (crested tern), and Scott Reef (167 km) with two species (common noddy and brown booby), which may reflect a lack of frequency of researcher access to record other possible breeding species, and/or lack of suitable habitat in the case of Scott Reef.

Breeding seabirds are dependent upon sources of marine food within their foraging range from the breeding colony and this range differs between species. Browse Island and Scott Reef, two of the closest islands to the Ichthys offshore development area, maintain few breeding species. However the numbers of foraging seabirds in this area would not come from these colonies alone: some of the species that nest on Adele Island, 160 km away, would also forage across these waters.

From data collected from seas adjacent to Christmas Island, Dunlop, Surman and Wooller (2001) found that common noddies and brown boobies foraged within 200–250 km of their breeding colony, while the red-footed booby foraged up to 900 km away. Similarly, lesser frigatebirds and great frigatebirds foraged at least 700 km from their breeding colonies on Christmas Island. Crested terns were observed foraging several hundred kilometres from land, over the continental shelf in the North-west Marine Region (Nicholson 2002). Frigatebirds, boobies and crested terns are all known to have long-distance foraging ranges (Dunlop, Surman & Wooller 2001; Nicholson 2002). The observation of an Abbott's booby during the survey by the Centre for Whale Research (Jenner, Jenner & Pirzl 2008) was not unique—there have been at least six other sightings in the Scott Reef and Browse Basin area—and demonstrates the potential importance of the Browse Basin to the Christmas Island endemic seabird species as well as to seabirds nesting on the Lacepede Group (330 km to the south of the Ichthys offshore development area) and on Adele Island (160 km south) and Ashmore Reef (197 km to the north).

A key risk to populations of seabirds in the Browse Basin would be a significant oil-spill event affecting significant seabird foraging areas or nesting beaches. INPEX's oil-spill response plans will identify all known seabird roosting and breeding habitats as priority areas for protection and clean-up in relation to oil-spill response.

Submission 107-5: In addition, other parts of the overall project (e.g. the accommodation village and product loading jetty for LNG, LPG and condensate export) do not appear to be subject to environmental impact assessment.

The accommondation village was not considered as a part of the Ichthys Project, and is subject to a separate development application with the Northern Territory Government.

The product loading jetties for LNG, LPG and condensate are subject to environmental impact assessment, with most of this information contained in Chapter 7 *Marine impacts and management* of the Draft EIS.

Key aspects of the product loading jetty that have been addressed in Chapter 7 include:

- habitat alteration
- dredging
- piledriving
- light
- discharges
- quarantine.

Submission 107-18: A fuel storage facility for diesel fuel in the hull of the CPF leads to the risk of diesel spillage in the ocean. The volumes of diesel to be stored and contingencies in the event of a spill must be described. The proponent needs to provide evidence of the extent of the risk associated with the loss of diesel fuel as the result of a cyclone and outline contingencies in place to deal with any such event.

Submission 107-19: It is indicated that the FPSO will have the capacity to hold 1,000,000 barrels of condensate (previously described as light oil). This is a significant quantity of material that has potential to lead to a major impact. The level of this risk and contingencies that will be put in place to deal with large scale spillage from the FPSO need to be described.

As discussed on pages 269–271 of Section 7.2.4 of Chapter 7 *Marine impacts and management* of the Draft EIS, Environmental Risk Solutions Pty Ltd (ERS) has conducted a thorough "primary risk" assessment of the potential spill scenarios for the Ichthys Project. This information draws largely from experience in the North Sea where there is a significantly greater volume of shipping traffic, increasing the risk of incidents occurring.

Both the diesel fuel leak scenario for the central processing facility (CPF) and the condensate storage tank leak scenario for the floating production, storage and offtake (FPSO) facility are addressed in Table 7-17 of Chapter 7 of the Draft EIS. Other larger spill scenarios, for example the total loss of all FPSO storage tanks have not been discussed as their risk profiles are $<1 \times 10^{-7}$ and therefore highly unlikely to occur during the 40-year operations phase.

Oil spill contingency plans (OSCPs) will contain appropriate information to ensure that diesel and condensate spills will be reacted to in an appropriate manner, to minimise environmental impact, regardless of the source, size or volume of the spill.

Submission 107-35: The possibility of chronic leaks within the process is not considered in table 7-17 or table 7-37 but should be, irrespective of the level of immediate risk; as low-level chronic leaks might continue unabated over the 40 year operational period should INPEX decide that it is uneconomical to undertake repairs. This might lead to significant impacts, even though the likelihood of this occurring is low. However, it could happen and no contingencies for managing this possibility are apparent in the EIS.

Visual inspections of topside process equipment and facilities will occur routinely throughout the life of the facilities. Any chronic leaks will be identified, reported and appropriate repairs undertaken.

Routine ROV surveys will be conducted to visually inspect and confirm integrity of subsea infrastructure. Any leaks detected through these inspections will be assessed and appropriate repairs undertaken. It is considered unlikely that minor leaks of hydrocarbons from the offshore facilities could lead to significant impacts to the environment.

Submission 107-38: Specific information relating to the potential total loads of condensate, production waters, oils and any associated chemicals in use should be used to assess the potential extent of the impacts for all 8 of the scenarios listed in Table 7-17. Calculations of impact loads should be based upon a range of time periods (i.e. days, weeks and months), as the total length of time expected to affect full repairs does not appear to be provided within the EIS.

Planned or routine discharges and their potential impacts are discussed in Section 7.2.3 of the Draft EIS. The three main discharges from the production facilities in the Ichthys Field are control fluids, hydrotest water and produced water.

As discussed on page 254 of the Draft EIS, control fluids are classified by OSPAR Commissions' Harmonisation Offshore Chemical Notification Format (HOCFM) as Group 5 fluids, of the lowest environmental concern. Because of the low volumes of control fluid releases (4–20 L), and low rates of valve opening (2–5 times per annum), impacts from control fluid discharges will be very localised and not cause any significant impact.

Hydrotest water discharges will only be individual events during the offshore facilities installation and commissioning phase, not a routine discharge during the operational life of the Project. In addition, many of the modules to be installed offshore will be precommissioned in their shipyards overseas, removing the need for hydrotesting in the Ichthys Field. Therefore, the impacts of hydrotest water discharges are localised, short term, and low risk.

Produced-water discharges will be a routine discharge for the operational life of the project. Details of the contents of produced water are contained on in Section 7.2.3 in Chapter 7 *Marine impacts and management* of the Draft EIS. Metals, because of their oxidation status, will form insoluble oxides and sulfides, and hence would not have any significant environmental impact. Most of the MEG in produced water will be recovered on board the FPSO. MEG poses a negligible risk of ecotoxicity, and with the high currents and dilution, would not be expected to have toxic effects on the environment. Similarly, other produced water chemicals are predicted to be rapidly diluted and will not reach sensitive receptors. Modelling of produced water discharges is discussed on page 260 and 261 and displayed in Figure 7-3 of the Draft EIS. The model outputs indicate that the edge of the zone in which acute toxicity impacts could occur is reached at a radius 60m of the discharge point. The edge of the zone at which chronic toxicity effects could occur is reached at a radius of 1.1km from the discharge point. These are a very small mixing/dilution zones in relation to oil discharges.

However, the key concern with oil discharges is the acute impact of oil on the ocean surface. Therefore, the zone of potential acute impacts from toxicity of produced water is insignificant in comparison to the potential impacts of a large accidental hydrocarbon spill.

Table 7-17 of Section 7.2.4 of the Draft EIS is specific to large scale, instantaneous accidental hydrocarbon spill scenarios with zones of effect extending over tens to hundreds of kilometres. It is inappropriate to consider the other aspects of routine Project discharges in the same context as potential impacts from accidental hydrocarbon spills. The frequency, volume, and toxicity of routine discharges are vastly different to the frequency, volume, area of potential impact and toxicity of accidental hydrocarbon spills. Routine discharges from production facilities are highly regulated to ensure they pose minimal risk to the environment and in the context of a significant oil spill, the impacts of routine discharges would be virtually insignificant.

Submission 128-21: Accidental Hydrocarbon Spills. Earthquakes were not taken into consideration as a possible cause of damage to the pipeline even though they are common in northern waters.

What would be the impact of a significant earthquake event on the submarine pipeline and the onshore facilities and are contingency plans in place to deal with such a catastrophic event?

INPEX's engineering design teams have undertaken detailed seismic (earthquake and tsunami) design risk assessments, to determine the appropriate design standards for the offshore and onshore infrastructure. The design standards used will conservatively capture the expected possible ground motions anticipated from great earthquakes (Mw>8) on the Tanimbar, Java and Timor subduction zones, which are estimated to have average recurrence intervals of about 200–300 years, as well as the smaller ground motions from random regional shallow crustal earthquakes in the vicinity of the Blaydin Point site and the Project's offshore infrastructure. The application of conservative design standards will ensure the integrity of Project infrastructure and prevent oil spills from seismic events.

5.2.2.15 Pipeline

Submission 103-2: The EIS states that microtunnelling and HDD techniques for the nearshore crossing are not suitable for a 42" pipeline – please provide justification for this statement.

Horizontal directional drilling is traditionally used on smaller diameter pipelines in harder soil conditions with higher consolidated strength. In the case of the Ichthys pipeline, the combination of reaming length, diameter and soft soil conditions are at the extreme historical limits of successful methodologies and as such, has been considered as a high failure risk.

Micro tunnelling is typically used for large diameter pipelines when the shoreline has high steep cliffs and thereby precludes the use of other construction methodologies. In the case of the Ichthys pipeline, there are no steep cliffs that require tunnelling and therefore more traditional and industry proven construction methodologies such as the proposed trench excavation provide less construction and environmental risk.

Submission 130-26: The potential risks associated with a rupture of the GEP during a TC are discussed in Section 2.1, page 3 above. The scenario presented there was that during the impact from a Cat 5 TC, a large vessel founders and grounds on the GEP or alternatively snares its anchor on the GEP. The diagram of the rock-armouring shown in Fig 4-17 of the Draft EIS is at first reassuring, but no details are given for the design parameters for the trenching and rock-armouring. It is also not explained how that protection will cope with the shifting sand-waves that are known to occur in some areas. Further, it is not clear if the GEP is to have rock-armour protection everywhere within the harbour or just in 'high exposure areas" as inferred on page 12 of Technical Appendix 24.

As was dramatically demonstrated last week by the Singaporean Navy vessel's anchor snaring the Mandorah sub-sea power cable, marking 'Anchoring Prohibited' on Admiralty Charts will not provide fail-safe protection. Further, it is noted that on page 11 of Appendix 8, in relation to a marine biota survey along the route of the Bayu-Undan pipeline, there is the statement:

In sections where the pipeline was suspended over troughs in undulations in the seabed (site DC19), it supported abundant sea fans …..By contrast, the exposed rock-armour positioned where the pipeline passed into the trenched seabed harbored low biotic abundance, ……".

The coordinates of site DC19 is given in Data Table 3 of Appendix 8 as 12° 25.7'S, 130° 46.42'E which puts that bit of suspended pipeline about 1.4 km north-west of West Point. The text above indicates that there are other sections of the Bayu-Undan pipeline which are "suspended over troughs". Are these suspended sections intentional or are they a consequence of shifting sand waves? And how will the proponent's GEP accommodate such suspended sections with its proposed alignment immediately adjacent to the Bayu-Undan pipeline?

Under the Darwin Port Corporation Cyclone Procedures, large vessels (>200 t gross, i.e. rig tenders and larger vessels) are not allowed to remain in Darwin Port during a tropical cyclone so this situation, of a large vessel breaking its moorings in a cyclone, should not arise. However, to guard against the potential risks of a large ship accidentally dropping anchor on to the pipeline or hooking the pipeline with its anchor, a quantitative risk assessment was conducted in July 2009 by Germanischer Lloyd Industrial Services in the United Kingdom based on the current and future shipping activity in Darwin Harbour, and this information was used to assess the need and size of pipeline rock protection.

The pipeline route inside Darwin Harbour, from West Point (near Mandorah) to the pipeline landfall will be trenched to a depth of 3m over most of its length, and over sections of this route which are at risk of vessel grounding or anchor drag (as determined by the QRA) the pipeline will also be protected by a 2m rock berm. The size of the rock berm has been designed to protect the pipeline against a 10 tonne anchor, typically carried by vessels of 60,000 DWT (i.e. a Panamax class bulk carrier).

The areas of sandwaves along the pipeline route have been investigated and those that exist north and north-west of the Cox Peninsula are very slow moving, less than 130 mm/a. Seabed scouring in areas of high current off West Point will be alleviated by the pipeline being trenched, and an assessment of the expected seabed scouring from wave and current activity, particularly during cyclones, will be assessed during follow-on engineering.

Pipeline spans (pipeline suspensions over troughs) are a normal feature of pipelines laid on a seabed where rock or hard substrates occur at or close to the surface of the seabed. The Bayu–Undan pipeline was designed to be fully supported provided the largest allowable spans were not longer than 20 m in length. The area north-west of West Point has hard substrates in parts and the Bayu–Undan pipeline has always had some spans in this area. Sand cover is patchy in this area and it can move, scouring in some areas and building up in others, and for this reason the Government regulators require that pipelines are surveyed at intervals of between 2 and 5 years to confirm their external condition.

In the case of the Ichthys pipeline route, it is intended to be trenched in this area of hard seabed off West Point to protect it against scouring as well as to protect it against the risks identified in the shipping quantitative risk assessment. The extent of the pipeline trenching in this area will be assessed during studies carried out during the detailed engineering phase.

5.2.2.16 Public safety

Submission 1-1: PART I Question 1 Why has INPEX not included any mention of societal risk and worst case incident modeling in their EIS? Can this be provided to the People of the NT so they can make an informed decision about this proposed plant?

Submission 1-2: PART I Question 2 Can INPEX please provide information on legal and planting requirements for building LNG, LPG and condensate plants in other developed nations?

Submission 1-51: PART I Question 50 . What factors, risks and issues do INPEX believe should be taken into consideration when determining what might be unacceptable in terms of societal risk? Societal Risk does not appear to have been adequately outlined in the EIS.

Submission 1-52: PART I Question 51. How has INPEX been required by the NT Government to consider the assessment of societal risk and how will this be used in the control of INPEX's major hazard sites?

Submission 1-53: PART I Question 52. How will societal risk be taken into account by INPEX site operators when considering reasonably practicable on-site control measures? Who will assess and measure the Risks identified by INPEX? Will this be monitored by independent Risk assessors?

Submission 1-54: PART I Question 53. In future LNG Developments where development would raise societal risk levels significantly should consideration be given to sharing the costs of any measures that might counter such an increase in order to enable development to go ahead? How will INPEX meet the increased costs of NT's Emergency Services and other essential community services?

Submission 1-55: PART I Question 54. In the likelihood that the INPEX site development would raise societal risk levels significantly would in not be eminently sensible for the implications of an intended development to be openly debated before future community issues and potential resentment arises. Would it be possible for INPEX to organise an NT referendum on the acceptability of the plant in its current location. Would it be possible to debate the issues raise for a Stateline program.

Submission 1-56: PART I Question 55. As well as INPEX LNG operators taking account of societal risk when considering on site control measures How is societal risk being taken into account by planning authorities when making planning decisions?

Submission 1-58: PART I Question 57 Can INPEX provide a worst case scenario based on two tanks failing which would spread methane and LNG in a 7 mile radius covering Wickham Point, Darwin and Palmerston? Consequential effects of an accident at Blaydin Point and or Wickham Point or vice a versa have not been assessed by the EIS. What assessments have been made for tanker collisions between the two LNG operators and damage to tankers during adverse weather events?

Submission 1-67: PART II Question 6 Why has INPEX not included any mention of societal risk and worst case incident modeling in their EIS? Can this be provided to the People of the NT so they can make an informed decision about the proposed plant operation and safety of tanker movemnets?

The Blaydin Point onshore processing plant will be classified as a major hazard facility (MHF) because it stores large quantities of hydrocarbons on site. Australian legislation sets out clear requirements that these facilities must meet in order for them to operate safely. These requirements are contained within Australian National Standard for Control of Major Hazard Facilities and the National Code of Practice for Control of Major Hazard Facilities which form part of the Northern Territory legislative regime[12].

The Australian regulatory model for managing major hazard facilities (MHFs) is similar to that used in the United Kingdom and Europe. The model was developed following serious industrial accidents at Flixborough in England in 1974 and at Seveso in Italy in 1976. The emphasis is on risk-based approach to land-use planning and zoning to determine the acceptability of an MHF based on existing surrounding land use.

INPEX will be required to develop a safety report which will be submitted to the relevant independent regulatory body (NT WorkSafe) for assessment and review. The safety report will need to demonstrate that all hazards and risks from the plant's operations have been identified, that they will be continuously managed, and that they have been reduced to a level that is "as low as reasonably practicable" ("ALARP"). The Blaydin Point plant can only commence operations after the regulator has endorsed the safety report and is thus satisfied with the demonstrations made therein. Ongoing operations at the processing plant are required to conform to the details noted in the safety report and NT WorkSafe has the power to independently audit those operations for compliance with the accepted safety report. Failure to comply with the requirements of the safety report can or will result in a facility's plant operations being shut down.

Early risk-assessment work has estimated both individual and societal risk generated by the LNG plant. Societal risk has been assessed for acceptability based on the stringent societal risk criteria established by Guidance Note No. 16 published by the Victorian Government (WorkSafe Victoria 2006).

12 From 1 November 2009 the independent statutory agency Safe Work Australia took over the functions formerly performed (until September 2005) by the National Occupational Health and Safety Commission.

These criteria are much more stringent than those used for land-use planning by many other regulatory authorities around the world, including that used in the United Kingdom. The criteria have been established under guidance from the Northern Territory Government. INPEX must comply with these criteria and is not in a position to challenge them. If there are concerns relating to the land-use planning approach these should be raised with the Northern Territory Government along with any request for a referendum on the subject.

The early risk-assessment work was carried out when there was limited plant definition. Risk estimates made at this point have deliberately erred on the side of conservatism to ensure they are not underestimated. Even with this conservatism in place the LNG plant at Blaydin Point meets the stringent societal risk criteria adopted for assessing these projects. This is largely attributable to the separation distance between the plant site and the surrounding populated areas.

The types of incidents that can have an impact on the public and therefore generate (public) societal risk from the Blaydin Point site are major accidents involving the release of LNG or LPG from storage or shipping activities. This risk is well understood and double containment systems are implemented for all large inventories of cryogenic liquids. These ensure that in the unlikely event of leakage from an internal tank, gases are prevented by the secondary tank wall from reaching the external environment.

Note that the risk-assessment work completed for the Project has included scenarios for leakage of LNG and LPG to the external environment. Estimates of how likely it is that such an event could occur are extremely low given the containment barriers that are in place at the plant (the outer tank wall of an LNG or LPG tank consists of thick reinforced concrete). However, these scenarios still form part of the risk- assessment work and the land use planning assessment carried out by the Government. Simultaneous tank failure is not identified as a credible scenario given the high level of protection provided for each tank.

The primary focus for management of process safety on the plant is to ensure that all barriers are put in place to manage safety risks on the site to the required operational standard. Strict systems will be in place to ensure that barriers are maintained to the appropriate level of performance. All site operators will be trained to ensure they understand the importance of these control barriers to their own personal safety, the safety of colleagues on the site and to the safety of the general public.

See Section 4.5.2 for further information on shipping risks in Darwin Harbour. However it should be noted that in the event of severe weather or a cyclone threatening the Darwin region, all LNG and LPG shipping activities would be suspended and the ships will move away from the predicted weather path.

With regard to firefighting and on-site emergency response, the Blaydin Point facility is designed to be self-sufficient. An assessment is however being made of the impact the Ichthys Project could potentially have on community health services in the Darwin area. This will be mainly related to construction-phase risks when there will be a significant expansion of the Project workforce. Measures will be put in place to minimise this impact.

Future LNG developments will not necessarily result in a significant increase in societal risk to the general public since this is highly dependent on where they are located. However, when judging the acceptability of a small increase in societal risk a balance needs to be struck between additional risk and the benefits gained to society as a whole. Where the risks are low and the benefits are significant this needs to be factored into the decision-making process. See Section 10.4 of the Draft EIS for a review of community benefits associated with the development.

Submission 1-3: PART I Question 3 Why is there NO Mention of potential catastrophic risk to human life in relation to the lifetime operation of the plant directly linked to Cyclonic (Category 3-5 cyclones during Spring tides), Seismic events, earthquake movement of pipelines, potential tsunamis effects and potential ignition of LNG Vapour clouds from lightening activity?

INPEX's safety report must document all hazards and risks associated with the operations of its processing plant, including the cyclonic and other events identified in the question. It is necessary that the residual risks from these hazards (after control measures have been implemented) are assessed in order to ensure that the risks are reduced to a level that is "as low as reasonably practicable" ("ALARP").

In general, the design of the facility follows the prescriptions of Australian and international standards.

With respect to wind (including cyclones) and seismic loading, an importance level is assigned to the facilities using the Australian/New Zealand Standard *AS/NZS 1170, Structural design actions series*. The return period for these events is determined based on the design life of the facility and the assigned importance level. This is done in accordance with AS/NZS 1170. The actual magnitude of the "design events" is then determined based on the selected return period and data specific to Darwin. This importance level and the design life of the facility are therefore used to assign a return period for the events.

For wind loads, the associated magnitude of the event is determined for the specific Darwin area from *AS/NZS 1170.2:2002, Structural design actions—Wind actions and AS 4997:2005, Guidelines for the design of maritime structures*.

For seismic loads, the magnitude of the load for the Darwin area is taken from *AS 1170.4:2007, Structural design actions—Earthquake actions in Australia* and Project-specific seismic hazard and tsunami assessments. INPEX's design contractor JKC is well versed in these issues as it has taken part in the design of many LNG import terminals in earthquake-prone Japan. (Note that the earthquake of January 1995 at Kobe in Japan, which killed nearly 6500 people and caused damage estimated at US$131 billion (the most expensive natural disaster of the 20th century), did not affect local LNG import terminals).

The potential for the occurrence of tsunamis has been assessed and accounted for within the Project specific "seismic hazard and tsunami assessment", and facilities will be designed accordingly.

Lightning has been considered and taken into account in the design of Project infrastructure in accordance with *AS/NZS 1768:2007, Lightning protection*. With regard to the possibility of lightning igniting an LNG vapour cloud, there would clearly have to be an LNG vapour cloud to ignite. INPEX believes that by incorporating the necessary lightning protection measures in the design of the gas processing plant at Blaydin Point, lightning strikes should not result in a release of LNG. Given the low likelihood of a gas release caused by other failures (attributable to the engineering barriers incorporated into the design), the chance of a lightning strike occurring at the same time as such a release is extremely low.

Submission 1-9: PART I Question 8 What will the cumulative impact on the shipping channels in Darwin Harbour be from all proposed INPEX LNG facilities and existing users (Conoco Philips, Territory Resources) and how will this be considered with regard to risk of collision, explosion or some form of deliberate harm and can these risk profiles be calculated by INPEX for the NT population to consider on a worst case scenario modelling for the lifetime of the project?

A detailed risk assessment of shipping activities in Darwin Harbour is currently under way. It will examine in detail the risks associated with INPEX's LNG, LPG and condensate tankers in the Harbour, and dialogue is ongoing with the Darwin Ports Corporation and ConocoPhillips at the Darwin LNG plant at Wickham Point.

Worldwide, large LNG vessels have safely completed over 40 000 voyages without major incident (Core Energy Group 2009). These include over 30 years of safe delivery of cargoes through the busy Tokyo Bay in Japan. The design of liquid gas carriers is covered by the International Gas Carrier (IGC) Code published by the International Maritime Organization (IMO) (IMO 1993). The operations of the vessels are covered by guidelines prepared by the Society of International Gas Tanker and Terminal Operators (SIGTTO) and the Oil Companies International Marine Forum (OCIMF).

The LNG vessels have multiple barriers to protect against loss of containment of cargo; these include the outer and inner hulls, double bottom tanks, and secondary and primary containment. There has never been a major or catastrophic loss of containment from such ships. The ships are also regulated under the IMO's International Safety Management (ISM) Code (IMO 2002), and they can be inspected by the Australian Maritime Safety Authority (AMSA). In Darwin Harbour LNG vessel movements, as with those of all shipping in the Harbour, are coordinated by the Darwin Port Corporation (DPC), whose pilots guide each vessel's transits with tug assistance. The vessels are also independently audited by ship classification societies such as Det Norske Veritas and Lloyd's Register. Security aspects of the shipping operation will be covered in a "port security plan", scrutinised by the Northern Territory Government and the DPC. The consequences of a loss of containment incident (which could, for example, be caused by terrorist action) will be reviewed in the shipping quantitative risk assessment (QRA) now under way.

Submission 1-11: PART I Question 10 How does INPEX justify choosing such a low-lying site for their proposed plant?

The site was presented to INPEX by the Northern Territory Government as its preferred location for the onshore component of the Ichthys Project.

Water levels in terms of tides, storm surges and projected rises in sea level as a result of global warming have been included as parameters in the design of the onshore processing plant and associated infrastructure. Therefore INPEX's design of rock berm and other means of preventing inundation of the plant facilities have taken these parameters into account.

It should be noted that INPEX's proposed onshore processing plant for the Ichthys Project at Blaydin Point is an area covered by the Northern Territory Planning Scheme (DLP 2007) and was identified as a "development area" in 2007 in a presentation by the then Department of Planning and Infrastructure (now the Department of Lands and Planning) in May 2007 (DPI 2007).

The Planning Scheme was amended on 12 December 2007 with the stated intent of allowing for the development of further gas based industry on Middle Arm Peninsula (NT Planning Scheme – Amendment No. 37).

Submission 1-13: PART I Question 12 Why has the EIS for the INPEX LNG plant and LNG ships not considered the potential significant terrorist threat to Darwin, Palmerston and the NT. The draft EIS has not impact-assessed the risk of terrorism and possible impacts to the local community?

The potential for and the effects of terrorist targeting of INPEX facilities has been considered extensively through the security risk-assessment process by a third party security consultant. The outcomes of this process have been incorporated into the design process for the onshore processing plant and related facilities and the security design, systems and procedures will be industry-leading. It is not known at this stage whether the Ichthys Project's onshore facilities will be classified by the Attorney-General's Department as national "critical infrastructure". INPEX will have no say in this decision-making.

Submission 1-14: PART I Question 13 The INPEX EIS needs to assess the shipping aspects of the EIS with regard to the SIGTTO standards to determine if the proposed LNG and shipping requirements will be in compliance with these standards. The EIS should assess if the NT Project will meet its duty of care requirements for public safety as detailed in these standards.

All ships nominated for acceptance to load at the Blaydin Point facilities will be vetted to ensure conformance to the recommendations of the Society of International Gas Tanker and Terminal Operators Limited (SIGTTO) and other industry organisation recommendations. INPEX will meet with SIGTTO and will incorporate SIGTTO's guidelines into INPEX's jetty designs and marine operations. Current studies indicate that INPEX will meet internationally accepted safety risk metrics.

Submission 1-15: PART I Question 14 Why are the UK, USA, other developed countries governments and the WA government debating LNG Safety when the NT Government is apparently oblivious to the potential dangers of LNG, LPG, Oil and Condensates? Can the NT government or INPEX confirm that Blaydin Point is the BEST and only site for the INPEX Plant.

Refer to previous response regarding requirements for NT WorkSafe engagement with INPEX's safety report for the Blaydin Point onshore processing plant. The Northern Territory Government is not "oblivious" of safety risks from LNG facilities. This is why there is a safety report process.

Submission 1-16: PART I Question 15 INPEX have proudly announced their partners in the Ichthys Gas Field Development Project are TOTAL who do not have a good safety record in Europe as proved in the UK courts (2009 and 2010) after the Buncefield accident near Hemel Hempstead London. Can INPEX please outline the role that TOTAL will play in the development and long term management of this plant?

Total E&P Australia (Total) holds a 24% stake in the Ichthys Joint Venture. Total is a leading oil & gas multinational with many years' experience in LNG-related operations. Total has played and will continue to play a key role during the detailed-design phase of Ichthys Project and will also provide support during the operations phase.

Submission 1-17: PART I Question 16. What are the HAZOP's outlined for the new construction of the INPEX plant for Phase 1, 2 AND 3 already announced in the light of the existing Conoco Philips plant and existing pipeline. INPEX are reportedly producing LNG, LPG and other Condensates.

All processing elements of the onshore processing plant at Blaydin Point will be subject to a detailed HAZOP (hazard and operability) analysis. Note that a HAZOP analysis is only one type of identification and assessment review among a suite of safety reviews. These can include HAZID (formal hazard identification), Design Reviews, Safety Integrity Level (SIL) assessment, electrical and controls HAZOPs, as well as health risk assessment reviews.

A HAZOP analysis was conducted as part of the front-end engineering design (FEED) phase prior to the production of "issued for design" (IFD) versions of the piping and instrument diagrams (P&IDs). Another HAZOP will be conducted in the detailed design phase prior to the production of the "issued for construction" (IFC) P&IDs.

Submission 1-18: PART I Question 17. Is there any possibility that the INPEX plant will seek to process crude oil if the wells and oil field proves to be a good source for heavier oils?

The Ichthys Project's onshore processing plant at Blaydin Point will not be designed to receive or process any crude oil. The Ichthys gas and condensate field will produce, after processing, liquefied natural gas (LNG), liquefied petroleum gases (LPGs) and condensate; it will not produce crude oil. Most of the condensate, including any heavier hydrocarbon fractions present, will be recovered offshore.

Submission 1-19: PART I Question 18. How will the LPG and condensates be utilised, stored and transported?

The incoming gas stream will be processed at the plant to separate it into the various products (LNG, LPG, and condensate), which will then be stored in tanks prior to export by tankers.

Submission 1-20: PART I Question 19. . How will INPEX prevent LNG, LPG or condensate explosions and safeguard the Darwin, Palmerston and Top End Communities against a catastrophic explosion like at Buncefield over the life of the project.

INPEX and its design contractor, the JKC Joint Venture, are developing a plant design in accordance with recognised First World engineering codes and standards, including, for example, American Petroleum Institute (API) standards, Australian Standards, and National Fire Protection Association (NFPA) standards). JKC is a recognised engineering contractor with extensive experience in the design of similar plants worldwide. Such plants have credible safe operating performance. The designs are regularly reviewed to identify hazards and risks, and steps are proactively taken to eliminate, minimise, or mitigate such risks, in such a way that residual risks are managed to "as low as reasonably practicable" (ALARP) levels. The design includes fire and gas detection systems, emergency shutdown systems, relief and blowdown or flare systems, ignition controls, and full containment LNG tank designs. The plant will be subject to ongoing inspection and maintenance regimes to confirm its ongoing integrity on a "through life" basis. It will be audited by independent INPEX and Total teams, as well as by NT WorkSafe governmental inspectors. The plant will be operated in accordance with its accepted safety report, and its safety management system (SMS).

Submission 1-21: PART I Question 20: Does the EIS and future safety report give the distances to a range of consequence levels of relevance to emergency planners?

The Draft EIS shows contours of individual risk, that is, the risk of death of a hypothetical individual at various locations both on and off site. The contours are derived by identifying all the hazardous scenarios possible, including fires and explosions. The contours are compared against well-recognised criteria enforced by NT WorkSafe, the

Northern Territory body with overall responsibility for occupational safety and health. These criteria show that INPEX's current design meets the recognised safety benchmarks for off-site risk to the public. These safety risks will be more fully explored in the safety report which will be prepared by INPEX for NT WorkSafe's scrutiny. The pertinent parts of the safety report dealing with off-site safety risks and emergency response measures will be provided to stakeholders such as Darwin Port Corporation, the Northern Territory Police, Fire and Emergency Services, the Royal Darwin Hospital, and ConocoPhillips to ensure that all parties are contributing to and informed of the dialogue concerning these important aspects. Detailed emergency response planning will commence following INPEX's final investment decision (FID) to proceed with the Ichthys Project and will be in place prior to the introduction of any hydrocarbons to the onshore processing plant at Blaydin Point.

Submission 1-22: PART I Question 21: What is the risk to the pipeline of unexploded world war II ordinance. Will the sea bed be monitored with a metal detector before disruption ?

Submission 1-23: PART I Question 22 : How will discovery of ordinance be risk assessed during the development and operational phases both to the existing Conoco Philips pipeline and new construction of INPEX pipeline.

Surveys of the gas export pipeline route corridor from the Ichthys Field to Blaydin Point in Darwin Harbour to check for unexploded ordnance (UXO) on the seabed have already commenced. Such items of UXO (e.g. shells or mines) may date back to military action in World War II or may be the result of military training activities in the Northern Australia Exercise Area (NAXA) outside Darwin Harbour.

Several items of UXO have been identified and these have been or will be made safe prior to the gas export pipeline being laid. Thus, the risk to the pipeline from UXO has been or will be managed to ALARP ("as low as reasonably practicable") levels.

Submission 1-24: PART I Question 23. What Links to emergency planning (NTPFES, SES, military and Medical Services, RDH and government) have INPEX put in place to support the community in the event of an accident?

Dialogue has commenced with several of the above-noted stakeholders. Detailed discussions will commence post FID and result in formal Emergency Response plans that will be in place prior to plant start up.

Submission 1-25: PART I Question 24: How have the community uncertainties attached to the risk calculations (explosion risks), effects of category 5 cyclones, earthquakes, lightening strikes been addressed and justified?

The full quantitative risk assessments (QRAs) that have been and will be undertaken prior to the commissioning and start up of the Project's onshore processing plant at Blaydin Point have addressed and will continue to address uncertainties in risk modelling, for example in input data, rule sets, and so on. Data inputs are subjected to sensitivity analysis in order to examine the effect on data outputs from changing the input data. Overly conservative assumptions (i.e. taking worst case scenarios or deliberately overstating risks) and "factors of safety" in design calculations are other methods of ensuring that risk results are credible. These will be more fully discussed in the safety report that INPEX will prepare for NT WorkSafe.

Submission 1-26: PART I Question 25 What confidence do INPEX offer the community when in answer to an audience PART I Question at the launch of the EIS, Sean Kildare offers evacuation and incident management plans for INPEX workers but not the population of the NT directly affected by an incident?

This question is based on a misinterpretation of remarks made at the meeting held in Darwin to launch the Draft EIS for public and government review in July 2010.

Emergency response plans (ERPs) will be developed for site-based emergencies that might affect personnel working at the plant. They will also be developed for emergency scenarios that may extend outside the site boundary and affect members of the general public. These scenarios are considered to be very unlikely owing to the location of the plant and the separation between it and Palmerston–Darwin. Nevertheless, ERPs will be developed for these scenarios in accordance with good industry practice.

Submission 1-27: PART I Question 26: Will the one burns unit at RDH be able to cope with a potential Vapour cloud explosion the size of Buncefield, when many hospitals in the UK found Buncefield a challenge?

Emergency response requirements for the Blaydin Point site and the surrounding community will continue to be assessed between the present and the facility start-up in approximately 2016.

The comment that "many hospitals in the UK found Buncefield a challenge" is gravely misleading. The United Kingdom's Health Protection Agency carried out a comprehensive investigation into the public-health implications of the major conflagration at the Buncefield oil depot near Hemel Hempstead in Hertfordshire in England on 11 December 2005. Its report, *The public health impact of the Buncefield Oil Depot fire*, was published in July 2006 (HPA 2006). The key findings are summarised below:

- One of the main objectives of the study was "to describe the number of attendees with health conditions attributable to the fire and type of presentation".
- The accident and emergency (A&E) services of only two hospitals were involved in the treatment of casualties, Hemel Hempstead and Watford.
- There were no burns injuries recorded in the report.
- Forty members of the public sought medical attention between 11 December and 14 December. Thirty-eight of these people (95%) presented with symptoms. Information on symptoms was not available for the other two. Some people presented with multiple complaints. Injuries were the most common presentation (24/38; 63%) and included lacerations (15/38; 39%), and sprains (7/38; 18%). One person suffered a rib fracture. Eleven people (29%) had respiratory symptoms such as shortness of breath (5/38; 13%), cough or asthma attack (both 3/38; 8%). Two people (5%) suffered from cardiac complaints: one person presented with palpitations and one with angina. Six people suffered from anxiety (16%), five from ringing in the ears (13%), and four presented with vomiting (11%).
- Seventeen people working at, or close to, the oil depot at the time of the explosion attended A&E. All 17 attended Hemel Hempstead Hospital. Sixteen (94%) attended within the first six hours after the initial explosion. Fourteen out of the 16 symptomatic workers presented with injuries including lacerations and sprains. Two workers presented with respiratory complaints (shortness of breath and sore throat) and one person presented with angina pectoris. Some workers also presented with other additional complaints such as anxiety (5 workers) and ringing in the ears (two workers). In total, 5 out of the 17 (29%) oil-depot workers needed further medical follow-up. Two were followed up in A&E for lacerations. Two had sprains and were referred to an orthopaedic surgeon and one was referred to his/her general practitioner for anxiety and lacerations.
- As a result of concerns about the potential health effects related to exposure to the smoke, emergency service workers, mostly police officers, were initially advised by their senior colleagues to attend A&E for a medical check-up. In total 187 emergency service workers attended A&E. Of those emergency service workers who attended A&E, 63 (34%) presented with symptoms, and some of these presented with multiple complaints. The majority of complaints were respiratory complaints (53/63; 84%), such as sore throat (30/63; 48%), cough (12/63; 19%), and shortness of breath (8/63; 13%). The second most commonly reported problem was headache (15/63; 24%). In total, 3 out of 187 (2%) members of the emergency services needed medical follow-up. All three were referred to their general practitioners. One suffered from shortness of breath. Information on diagnosis was not available for the other two

Submission 1-28: PART I Question 27: Will the NT and Federal Government services and RDH be able to cope with a potential tanker incident?

See INPEX's response to comment 1-27 above. Tanker incidents are very low-likelihood events. There will be multiple barriers to a loss of containment in tanker design and operations.

Submission 1-29: PART I Question 28: What will the MAXIMUM daily LNG, LPG, Condensate shipping tanker movements be from INPEX and CONOCO PHILIPS when both plants are at Maximum production and how does this figure sit with International Maritime exclusion zoning taking into account the narrow channel of Darwin Harbour?

As noted in Section 4.4.7 and Table 4-3 of Chapter 4 *Project description* of the Draft EIS, INPEX related tanker traffic numbers will average approximately three LNG vessels per week, one LPG vessel per week, and one condensate vessel per month. ConocoPhillips' numbers are currently approximately one or two LNG vessels per week. This will likely increase to 4-5 LNG vessels per week if the existing Darwin LNG plant is expanded to produce around 10 Mt of LNG per annum.

INPEX, ConocoPhillips and other vessel movements will be coordinated by the Darwin Port Corporation (DPC), using its new vessel traffic service (VTS) system. There will be a dredged channel for INPEX vessels, and this complies with all Permanent International Association of Navigation Congresses (PIANC) and International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) requirements. In addition, ship manoeuvring and berthing simulations have been performed, and these show that is safe for INPEX to move its vessels through the port.

DPC pilots and tug captains will receive extensive simulator training prior to the commencement of operations.

Submission 1-30: PART I Question 29: For 22 Years I have worked directly with the oil industry (BP) and as an elected Member for Purbeck UK (1991-93) was directly involved in the decision making surrounding the expansion and environmental management of BP's Wytch Farm Oil and LPG Field one of the largest onsjore fields in Europe. As Acting Chair of Planning for Purbeck, UK I FULLY supported the great work and safety record of BP. Now I tragically read reports about the colossal oil spill in the Gulf of Mexico. How can NT Politicians not understand the Environmental Protection, International Maritime and WorkSafe Acts. Please can INPEX or the NT government explain to me what my misinterpretation of the Acts may be so that I can understand how the Territory people can be lead to believe that a second LNG Plant is safe in Darwin Harbour?

INPEX is cognisant of the laws, regulations and standards relating to the Ichthys Project, and its current and proposed Darwin-based activities. In the public-safety context, these include the safety report for the Project required to be submitted under Northern Territory law. The safety report will address the requirements of the major hazard facility (MHF) standards prepared by the National Occupational Health and Safety Commission (NOHSC 2002) and administered by NT WorkSafe. This agency and other government bodies are responsible for reviewing safety aspects of the onshore processing plant at Blaydin Point.

Shipping will be regulated by the Darwin Port Corporation (DPC) and the Australian Maritime Safety Authority (AMSA).

Submission 1-31: PART I Question 30. What Australia Building code and safety codes will the new plant be built to? Do Australian Standards represent true build standards for the Cyclonic and Seismic/Tsunami risks in Darwin (Catagory 5)?

The plant will be built to standards which are deemed to effectively satisfy any real or assumed cyclonic and seismic or tsunami risks in Darwin. Current Australian standards are considered suitable for the chosen location. All structures will be designed to comply with Australian standards as a minimum.

Submission 1-32: PART I Question 31. What is the 100 year flood modelling risk zone for Blaydin Point?

The 100-year storm-surge level has been estimated at 4.9 m AHD.

The peak combined sea-level predictions for several locations in Darwin Harbour have been analysed. The closest location at Blaydin Point with available data is East Arm Wharf and therefore these data have been used for design purposes.

Submission 1-33: PART I Question 32. How often will the EIS be reviewed in the light of new global incidents and management of LNG, LPG and condensate protocols?

Environmental impact statements (EISs) are normally produced, reviewed, and approved by government departments (usually with numerous "ministerial conditions") before any construction and operation of project facilities is permitted. EISs are not reviewed after approval and the setting of such conditions.

After government approval is granted to the Ichthys Project, incident and environmental management measures will be dealt with by activity-specific legislation. These legislative instruments set conditions and lay down requirements in addition to those already set within the environmental impact assessment process. Whenever changes to management requirements or undertakings are made, these will be reviewed to ensure that compliance with the EIS conditions is maintained.

Submission 1-45: PART I Question 44 Will there be an LPG pump restage – resizing pump that pumps liquid petroleum gas to tanker loading facility, to make it more energy efficient for both rail and road transportation of LPG?

All LPGs will be exported by ship. INPEX does not plan to export any LPGs either by rail or by road. The Draft EIS reflects this position.

Submission 1-46: PART I Question 45 What has INPEX learned in plant design from the explosions at the Texas City Refinery and the Buncefield oil storage depot?

The lessons learned from the Texas City oil refinery fire and explosion in the US (2005) and from the Buncefield oil storage terminal explosion in the United Kingdom (also 2005) are many and cover design issues, inspection and maintenance issues, as well as corporate safety culture. INPEX has reviewed the findings of the official investigation reports for both these accidents and has incorporated relevant recommendations into the design and safety management systems for the proposed LNG plant at Blaydin Point.

Submission 1-60: How will INPEX protect Territorians Safety over the next fifty years and can we trust that the long term honesty and integrity of the Japanese Company INPEX will maintain the excellent relationships that exist today?

Submission 1-61: What stakeholder roles and responsibilities do the Japanese government have in the Darwin LNG project and are they fully committed to the safety and security of Territorians in the areas of Darwin and Palmerston?

Submission 1-62: Does the energy industry INPEX really have Territorians interests at heart?

Submission 1-64: If INPEX have nothing to hide with regard to the safety of LNG at Blaydin Point can they and/or the NT Government organise a public showing of the DVD "The risk and dangers of LNG" by Tim Riley and Hayden Riley so that we may have a public discussion about this proposal.

Submission 1-75: Why have Timor-Leste, a developing nation, been able to a fair and honest discussion on the Strengths, Weakness, Opportunities and Threats of an LNG Plant when the NT Government has appeared to make a decision without much regard for people safety.

Submission 1-76: Will the INPEX executives and NT Government officials demonstrate their commitment to safety by at least sitting down and addressing the issues highlighted in the DVD produced by lawyer Tim Riley.

INPEX Corporation takes a long-term view to fulfilling its corporate social responsibilities globally. Safety of people and the environment is the primary commitment of INPEX and the company is committed to conducting all activities in a manner that is safe for the community, its employees and the environment. The onshore facility and gas pipeline will be designed and maintained to Australian, international and industry-wide standards and codes of practice. INPEX is required to submit a safety report to NT WorkSafe which will be subject to its independent scrutiny and approval.

The Ichthys Project will provide a number of benefits to the Northern Territory and Australia, including regional and social infrastructure enhancement, community partnerships and sponsorships, local business growth and employment opportunities.

INPEX has conducted a number of community forums in Darwin and Palmerston over the last three years to address community concerns and questions on the Project and will continue to operate in a transparent and accessible manner.

With regard to the Riley DVD "The risks and dangers of LNG", it is INPEX's view that the material contained within the DVD is deliberately misleading and sensationalised. It has been debunked by the LNG industry. INPEX would be happy to provide the facts relating to LNG safety but will not lend any credibility to this film.

Submission 1-63: PART II Question 2 The WA Government struck a deal for 30% of INPEX gas for electricity production. The NT Government has a deal for 0% of gas. INPEX will establish a 2000 people workman village adjacent to one of Rural Darwin's fastest growing Middle and Senior Schools. INPEX will evacuate any workers from their work site in the event of an incident but will make no sensible provisions for Top End Residents. What will INPEX do for Darwin People?

No "deal" was ever finalised between the Western Australian Government and INPEX with respect to the delivery of 30% or any other percentage of LNG gas produced for electricity production. INPEX moved the Ichthys Project to Darwin before submitting a Draft EIS and before obtaining land-use approval for Western Australia's Maret Islands as a potential site for its onshore processing facilities. Discussions with the Northern Territory Government revealed that the Territory's gas needs for electricity are already provided for by gas to be supplied from the ENI Blacktip development. INPEX has agreed to provide the Northern Territory Government with emergency gas should the supply from Blacktip ever be disrupted.

The accommodation village INPEX proposes to build at Howard Springs in Darwin will house the construction workforce during the five years it will take to construct the onshore processing plant at Blaydin Point. When construction is complete and the processing plant commences operations, INPEX will have detailed emergency response plans in place to cover any potentially dangerous incident. These emergency response plans will not be developed for the processing plant alone, but will take into account credible emergency scenarios which may affect the general public.

Submission 1-65: PART II Question 4 What modelling and actual real life scale testing have INPEX performed on the safety of both LNG Tankers and the LNG Plant?

Real-time simulation modelling has been performed to validate the limiting environmental parameters for marine operations and to confirm the size of the required towing support.

The quantitative risk assessments (QRAs) performed by the experienced risk consultancy Germanischer Lloyd Industrial Services UK Ltd (GL) (formerly the research arm of British Gas, the United Kingdom's premier gas utility) have used validated computer models for outflow, dispersion, and explosion modelling. The calibration and validation of these models was based on actual spill tests completed in Europe and the United States of America.

GL has performed full scale explosion modelling (in an offshore module context) at its Spadeadam test site in the United Kingdom, as part of a British North Sea health, safety and environment (HSE) joint industry project (JIP). That experience helped to validate many of the explosion models used by risk consultancies for their oil & gas industry clients. Germanischer Lloyd also provides expert advice to Sandia Corporation (a government-owned contractor-operated organisation managed for the US Department of Energy) in its research on LNG spills.

Submission 1-66: PART II Question 5 Pipeline accidents do and have happened (see below). What provisions have INPEX put in place to ensure the safety of the Top End Community both in the construction and operational phase in relation to both INPEX and Conoco Phillips pipeline? Will it be safe to blast near the Conoco Phillips existing pipeline and how will this risk be effectively?

During the laying of the INPEX gas export pipeline in Darwin Harbour, which will be in the same pipeline corridor as the Bayu–Undan Gas Pipeline, works will only take place after suitable risk-assessment and management activities have been conducted. The new pipeline will be offset from the ConocoPhillips Bayu–Undan pipeline by an 89-m gap (i.e. they will not be immediately adjacent). As the Bayu–Undan pipeline is protected by rock-armour, the anchors of INPEX's lay barges, even if dropped or dragged over it, should not cause any damage to the pipe itself.

INPEX's pipeline will be protected by the approximately 3-m-deep trench in which it will be laid, but also by a rock dumping program similar to that used for the Bayu–Undan pipeline. The new pipeline will be located far from residential areas in order not to present a safety risk during operation.

Submission 1-68: PART II Question 7 How will INPEX protect Territorians Safety over the next fifty years. How will INPEX prevent terrorist activity and assaults on a tanker or the INPEX Plant by boat or plane?

INPEX has established, and will continue to develop, strong relationships with appropriate agencies that can assist us to better understand the changing nature of the threat to the plant, shipping and the public into the future. Through these relationships, by ensuring compliance with regulations, and by leading industry best practice, INPEX will ensure that the risks to the public are minimised and prepared for. INPEX will also develop robust emergency management plans that will focus on prevention, preparation and rapid response. This will ensure that foreseeable incidents are contained and responded to effectively.

Submission 1-69: PART II Question 8 What do all Darwin stakeholders think? Should the Top End Community be willing to permit such a second dangerous industrial enterprise into our residential communities?

The public EIS process, including Community Forums and opportunity for interested parties to comment on the Draft EIS, is intended to ensure that Darwin stakeholders can have a say. INPEX does not accept that either the ConocoPhillips or INPEX facilities are or will be “dangerous industrial enterprises”.

Submission 1-70: PART II Question 9 Should Territorians be forced to live with the dangers of LNG and take such devastating risks of losing our homes, lives and families just so the Japanese energy industry INPEX can pipe its profits through our harbour and close to our residential neighbourhoods onlt to profit Japanese industries?

The INPEX facilities will be designed to ensure safe operations.

Submission 1-71: PART II Question 10 How is INPEX supporting the true Aussie spirit, should we as fairdinkum Aussies stand idly by while INPEX energy consortia try to make us more dependent on foreign fuel?

INPEX does not understand how developing a gas and condensate field will make Australia more dependent on foreign fuel. Reservoir hydrocarbons will provide close to 100% of the energy needed to run the on – and offshore facilities. The relatively small amounts of diesel, natural gas and transport fuels needed by the Project will be purchased at fair price. The Ichthys Project will generate significant employment and tax revenues for the Northern Territory and Commonwealth governments.

Submission 1-72: PART II Question 11 Should Territorians willingly invite major terrorist targets into our peaceful communities?

Based on the information available to INPEX through its own research and its liaison with other agencies, there is nothing to suggest that an LNG plant in the Northern Territory has a high profile as a terrorist target.

Submission 1-73: PART II Question 12 Should we believe the energy industry and INPEX when they say LNG is safe?

INPEX, as part of the energy industry, applies well-proven codes and standards to the design and operation of its activities, and will comply with all regulatory-authority requirements.

There have been around 50 years of safe LNG export and import terminal operations around the world, with between 40 000 and 50 000 LNG ship movements travelling over 210 million kilometres, without a single major LNG release incident (CLNG 2011; Foss 2003).

Submission 1-77: PART III Question 1 What is INPEX’s full, independent and objective view for the potential for significant damage occurring to the LNG Plant. How can an accident (explosions) as outlined below be prevented?

INPEX believe that all accidents are preventable and believes that its rigorous approach to identifying hazards and implementing a range of independent control barriers to prevent accidents from occurring will effectively prevent accidents from occurring.

INPEX’s views, supported by contractor and consultancy assessments, and finally reviewed and approved by government, will be contained in the safety report that INPEX will prepare for NT WorkSafe.

Submission 1-78: PART III Question 2 In the event of a catastrophic plant, pipeline or tanker failure how will INPEX ensure that the neighbouring Conoco Philips will not also be adversely affected? How closely will the INPEX pipeline be located to the Conoco Philips Pipeline and how will INPEX ensure that the Conoco pipeline will not be adversely affected or structurally compromised in the construction (blasting) phase?

The ConocoPhillips Darwin LNG plant will be separated from INPEX's Blaydin Point plant by a distance of about 6 km. No major "cross fenceline" risks will exist between the plants.

As far as the INPEX and Bayu–Undan subsea gas export pipelines in Darwin Harbour are concerned, during the operations phase there is no likelihood that incident with one operation could have an impact on the integrity of the other. At their closest the pipelines are approximately 90 m apart.

Submission 1-79: PART III Question 3 High profile politicians and lawyers in other areas of the world have demonstrated high level opposition to the construction of LNG plants so close to urban areas? What makes Darwin a world exception to normal world opinion and opposition?

The Darwin LNG plant operated by ConocoPhillips at Wickham Point is already operating in Darwin Harbour, approximately the same distance from Darwin and Palmerston as INPEX's Blaydin Point site.

It is not unusual to have LNG terminals sited close to population centres. There are, for example, a significant number of LNG import terminals in Japan close to densely populated urban areas. Other examples of LNG facilities being close to population centres include Boston Harbour in the north-east USA and several facilities in the UK including Milford Haven in south Wales and the Isle of Grain in Kent. The local land-use around Grain LNG is very similar to Blaydin Point, the exception being that Grain LNG imports and store LNG while Blaydin Point will store and export LNG.

Members of government, NGO (non-governmental organisation) groups and the public—including politicians and lawyers—have had the chance to read and comment on INPEX's Draft EIS for the Ichthys Project, and have done so.

Submission 1-82: PART III Question 6 How have elected NT Politicians from Federal, Territory and local Council Representative positions negotiated with INPEX long term (50 year plus) funding so that future Hazard and Risk management committees can monitor the effects of the INPEX LNG Plant on the Top End Community?

This question appears to be intended for politicians not INPEX.

Submission 1-83: PART III Question 7 If INPEX have nothing to hide with regard to the safety of LNG at Blaydin Point can they pay for a Federal and/or NT Government to organise a filmed scientific test demonstrating the safety of an LNG liquid spillage both at sea (simulating a harbour accident) or on land simulating a plant accident under typical Darwin wet and dry season climatic conditions with wind speeds above 100km/hour, huge Sept/Oct bushfire ember ignition sources and in excess of one lightening strike per second over a one hour minimum testing time period.

Such experimental testing is conducted to inform and develop the analysis models used in the assessments made by INPEX and its independent consultants. However, such tests are normally conducted as joint industry projects and not by individual companies; no specific testing is planned for INPEX. There is sufficient information publicly available to specialist consultants and INPEX to develop a clear understanding of the risks associated with potential LNG spills.

Submission 1-85: PART III Question 9 As an ex – Pilot and small boat licence trainer I would like to know how the NT Government intends to manage both maritime safety (Elizabeth river boat ramp) and air safety from NT airfields (especially Batchelor) to exclude potential sabotage or terrorism. Will INPEX pay for increased monitoring (CCTV) at local Territory boat ramps and exposed airfield management?

INPEX will comply with the requirements of the *Maritime Transport and Offshore Facilities Security Act 2003* (Cwlth) in the management of security risks to its operations. INPEX requires that any service providers, in either the maritime or the aviation environment, comply with the relevant legislation to protect their own activities and to support public safety.

Submission 1-86: PART III Question 10 How will INPEX plan (scenarios training) for the total evacuation of Darwin, Palmerston and Weddell residences in the event that a credible threat (Cyclone, earthquake, Lightening Strikes, Terrorism, structural collapses, industrial accident) is received for the damage to the INPEX Plant?

INPEX's emergency response plans will be integrated with those of other operators and public-safety agencies to ensure that warning is available for any significant events, and to ensure that risks are minimised. INPEX's current threat modelling does not indicate any threats that will require the evacuation of surrounding population centres.

Submission 1-87: PART III Question 11 According to Arrow Energy's' Queensland project at Gladstone and INPEX EIS LNG has potential hazards identified but these hazards have never been tested under NT conditions especially our huge bushfire ignition risks. All standards discussed are for Europe and climatic conditions are very different. None of these tests can be considered scientifically proven for the Territory. How quickly will LNG Vapourise in NT Climatic (temperature) conditions not the same for Darwin, Gladstone, Perth and Europe. INPEX EIS relies on unproven, untested, unreliable and irrelevant scientific data designed to support LNG Plants in areas with different scientific and climatic conditions to Darwin. Land and Sea temperatures are different to quoted test data for LNG Spillage and Vapourisation

The risk-assessment work carried out for the INPEX plant uses the local conditions in Darwin as the basis for analysis. The tropical climate in Darwin makes gas vaporisation rates faster than those that might be experienced in Europe. Darwin Harbour water temperatures are generally warmer than water temperatures in most of Europe. Cyclonic winds have been allowed for in plant design, and ships are not affected, since they will have left the Harbour before a cyclone might strike.

Submission 1-88: PART III Question 13 How is the above (Pool fire) and following (Vapour Cloud) published scientific information relevant or proved by INPEX EIS under NT Climatic conditions with wind speeds in excess of 100km/hour and multiple cumulonimbus cloud formation conditions and lightening activity a daily occurrence in Darwin Harbour from October – April. What vapour cloud modelling studies has INPEX organised to be performed by licensed or qualified climatologists and meteorologists in support of the INPEX EIS statements?

At the high wind speeds mentioned in the comment, efficient mixing will occur which will mean that vapour clouds will disperse to below their flammable range more quickly than those at low wind speeds. Therefore the lower wind speeds used by INPEX's consultants as part of the modelling will result in an overestimate rather than an underestimate of risk.

Submission 1-89: PART III Question 14 How will small boat river access to the LNG terminal be restricted from the Elizabeth river boat ramp? What warning signs will be erected?

Unauthorised access to the proposed onshore processing plant at Blaydin Point and its associated jetties will be prevented using a range of security measures, including warning signs and modern security controls.

Submission 1-90: PART III Question15 European Directives are mentioned for Australian design specifications of LNG plants, where and what are the Australian design specifications being utilised by INPEX EIS for Australian construction firms and Australian /NT planning departments? Where will all the specialist people who need to safely operate and managed the long term safety of this LNG Plant come from and where will they live over the life time of the plant?

As a minimum, the plant will be built to Australian Standards. Some of the plant staff and specialists will live locally in Darwin and others will commute on a "fly-in, fly-out" (FIFO) basis over the lifetime of the plant. This is normal industry practice.

Submission 1-91: PART III Question 16 Where is INPEX LNG Safety Information Sheet? If one is not available can one be produced as an addition to the EIS taking account of the location of the Plant in Darwin not areas with a different set of climatic conditions?

INPEX has produced a range of "fact sheets" about the Ichthys Project, which are available to the public for downloading at INPEX's web site at <http://www.inpex.com.au/ichthys-draft-environmental-impact-statement/downloads/draft-eis-fact-sheets.aspx>. Among these are fact sheets on "Public safety" and "Liquefied natural gas".

Section 10.3.14 in Chapter 10 *Socio-economic impacts and management* of the Draft EIS discusses public safety issues associated with the Ichthys Project in the Darwin region.

Submission 1-92: PART III Question 17 Can the public or (HELP NT under legal confidentiality clause) please have access to the INPEX security plans and security risk assessment as written MTOFS Act 2003 so that these can be assessed alongside the INPEX EIS?

No. The confidentiality of INPEX security risk assessments and security plans asssists in their effectiveness and it is not common practice for such plans to be made public. INPEX's ship security plans and port facility security plans under the *Maritime Transport and Offshore Facilities Security Act 2003* (Cwlth) will be assessed and authorised by the regulatory authority (the Office of Transport Security) and, where necessary and appropriate, will be shared with other port and shipping users with a defined need to access the plans.

Submission 1-93: PART III Question 18 As outline previously the INPEX EIS has the LNG train plant diagrams drawn in the incorrect geographical coordination so what confidence can the public have when such a fundamental mistake is made in a supposedly comprehensive EIS report. Can INPEX provide for the EIS detailed information on the proposed

- primary containment design and protocols
- secondary containment design and protocols
- safeguard systems design and protocols
- separation distances (safety and security zones) for plant and transportation systems in relation to INPEX and other LNG Plants and facilities in Darwin Area
- Industry standards and regulatory compliance (an assurance from the NT government that NT WorkSafe has Australian qualified/licenced personal with experience in the Oil and Gas industry to safely regulate and monitor this plant construction and operation?

Rotation or orientation of the LNG trains is an optimisation carried out to maximise air cooling, taking into account expected wind directions throughout the year. Train orientation has no impact on public safety outside the plant area or other EIS environmental aspects outside the plant area.

INPEX has the detailed information in various specifications and philosophies. It will be described in detail in the safety report that will be submitted to the relevant independent regulatory bodies for assessment and review as part of the process of obtaining the licence to operate the facilities. This level of detail is not normally provided in an EIS.

Submission 1-94: PART III Question 19 In the event of a Rollover event occurring and causing a need to release gas is there and where will a lightening conductor tower attraction system be positioned in relation to this plant?

Lightning protection is planned and INPEX will incorporate this in the design of the Blaydin Point onshore processing plant and its associated facilities. However, the detailed design of the lightning protection system will be carried out during the Ichthys Project's EPC (engineering, procurement and construction) phase.

Rollover"[13], is a rare but well-understood phenomenon and will be prevented by mechanical circulation of LNG within the tanks.

Submission 1-95: PART III Question 20 The INPEX EIS considers the Environment but what compatibility of LNG facilities with current and projected uses of waterways and adjacent lands have been performed for this proposed project and what assessment of potential risks to the public near the prospective site has been performed? Please can INPEX provide HELP NT and the public with written documentation to support these studies and assessments?

13 The term "rollover" refers to the rapid release of LNG vapour from a storage tank as a result of the stratification of LNG in the tank. This may happen if two separate layers of LNG of different densities are allowed to form, with an older, denser and warmer layer of LNG at the bottom of a storage tank and a newer, lighter and cooler layer of fresh LNG at the top. If the bottom layer continues to heat, its density begins to approach that of the upper layer, allowing rapid mixing to occur. If this occurs suddenly, the top and the bottom layers are said to "roll over" and large amounts of vapour are released from the superheated lower layer as it rises to the surface. As the lower layer has been superheated it gives off large amounts of vapour as it rises, causing a dramatic expansion in vapour pressure and internal tank pressure.

Assessment of risk to the public has been conducted and is contained within internal Project documentation. A summary was included in the EIS and more detailed information will be included in the safety report that will be submitted to the relevant independent regulatory bodies for assessment and review as part of the process of obtaining the licence to operate the facilities.

Submission 1-96: PART IV Question 1 How will INPEX prevent a catastrophic fire like that which occurred in San Francisco today 10th September 2010 killing six people and injuring many?

Submission 1-97: PART IV Question 2 How prepared will Darwin RDH be prepared to cope with such an explosion affecting Darwin and Top End Suburbs?

The San Francisco fire of 10 September 2010 was not caused by an LNG plant. The pipeline that failed ran through a residential suburb (as do many high-pressure pipelines in the United States and Australia), therefore a failure of the pipeline resulted in a major accident involving members of the public. The Ichthys Project's gas export pipeline runs through remote offshore and onshore locations, not residential suburbs, and therefore a similar accident cannot result in the same consequences.

Emergency response planning will include liaising with Royal Darwin Hospital on the possible number and nature of injuries for credible scenarios.

Submission 1-98: PART IV Question 3 Why are Territory Politicians and INPEX executives being blinded and deafened to the dangers of LNG so close to urban areas? HELP NT demands that INPEX provide an accurate independently prepared COMMUNITY RISK ASSESSMENT so Territorians can make an informed decision about this project. Territorians and our POLITICIANS MUST NOT be bought by the promise of money bur needs to consider future generations of Territorians?

The Germanischer Lloyd studies to be summarised in the safety report are independent (see the Draft EIS's Technical Appendix 24 *Onshore and nearshore quantitative risk assessment study*). NT WorkSafe's reviews of them are also independent.

Submission 9-14: • Impediments to harbour access through safety exclusion zones during both the construction and operational stage of the project may affect marine based tourism operators.

Exclusion zones will be in effect around ships and the jetty. The exclusion zone is provisionally set at 500 m from the jetty head and trestle, regardless of whether the jetty is occupied or unoccupied. The exclusion radius is not considered likely to significantly disrupt the activities of tourism operators.

Submission 72-1: The INPEX Ichthys Gas Field Development Project (INPEX Project) proposal to establish a liquified natural gas (LNG) plant on Blaydin Point in Darwin Harbour in the Northern Territory of Australia is a high risk venture in terms of the safety of the residents of Darwin and Palmerston. It is also an environmentally unsound proposition but I will leave other submissions to deal with the environmental factors.

Nowhere else in the world will governments allow the transportation of the hazardous and highly volatile product LNG within such close proximity to large population centres. 270 metre long LNG tankers carrying thousands of cubic metres of LNG at minus 160 degrees centigrade and at 600 times less in volume than its gaseous state is extreme high risk freight and should not be allowed to occur so close to Darwin and Palmerston major population centres.

The following possibilities need to be considered:

1. terrorist action to sink the vessel and or disable the refrigeration capacity of a fully laden LNG tanker in Darwin Harbour
2. shipping incident or accident that would disable the refrigeration capacity of a fully laden LNG tanker in Darwin Harbour
3. machinery and equipment malfunction that would disable the refrigeration capacity of a fully laden LNG tanker in Darwin Harbour
4. Act of God or an extreme natural event that would disable the refrigeration capacity of a fully laden LNG tanker in Darwin Harbour

5. Act of war that would disable the refrigeration capacity of a fully laden LNG tanker in Darwin Harbour
6. any other cause that would disable the refrigeration capacity of a fully laden LNG tanker in Darwin Harbour

Unless and until there has been acurate, publicly available precise modelling of the resulting toxic and highly volatile gas cloud that would form and drift with the wind in the event of one of the above possibilities occuring over the next forty years of daily transportation of LNG through Darwin Harbour the project should proceed no further at this time. Whether the project should proceed at all should be contingent upon the completion of such modelling, public notification of the outcomes from such modelling and acceptance by the residents of Darwin and Palmerston of the results of such modelling.

The movement of LNG cargoes in proximity to population centres is relatively commonplace globally and the LNG industry has an excellent safety record. LNG vessels have a number of redundancy features to minimise the risk of a loss of containment of LNG. ("Redundancy" in this engineering sense means the provision of additional or duplicate equipment or systems that function in the event that an operating part or system should fail.)

LNG carriers are normally not equipped with refrigeration capacity. The cargo tanks are insulated, and boil-off gas created by heat ingress is burned in the ship's engines as fuel. The scenarios described within this submission are unlikely to compromise the entire insulation capacity of the cargo tanks.

The Darwin LNG plant at Wickham Point has been exporting LNG to Japan in tankers since early 2006. The shipping channel is not far from the Darwin central business district and the same channel will be used by the LNG tankers from INPEX's proposed onshore processing plant at Blaydin Point. (The Darwin LNG plant is situated 6 km west of INPEX's proposed Blaydin Point facility.)

See also Section 4.4.2 in this EIS Supplement and INPEX's response to comment 1-79 in Section 5.2.2.16.

Submission 120-37: While the Ichthys Project will only add an additional four vessel movements per week when in its operational phase there will be considerable maritime and other marine traffic during the construction phase (Draft EIS p. 192 and p' 451-453). This in itself may not cause major disruption to the movement of recreational fishing vessels but we note that there will need to be a range of exclusion zones and other safety measures. It needs to be recognised that Darwin's largest-capacity recreational boat launching ramp is in the East Arm basin and that there are other launching facilities upstream including the Palmerston boat ramp in Elizabeth River which is currently undergoing a $4 million plus upgrade. It is not known if the NT Government will include other recreational boating facilities in plans for the Weddell development which is also upstream in the Elizabeth River and Middle Arm.

As far as we know there has been no monitoring of usage rates for these facilities, no monitoring of recreational boat numbers that fish in the East Arm Basin and upstream waters and no projections of likely usage rates of upgraded and possible new facilities. In short, there has been no quantitative analysis of overall boat traffic in the vicinity of, or upstream of, the main nearshore project area.

Inpex should be requesting the NT Government and/or the Darwin Port Corporation to undertake such an analysis so that the movement or potential movement of recreational vessels can be incorporated into the consideration of navigation issues. This should include the placement of navigational aids and warning systems where stand-off or exclusion zones need to be maintained that are relevant to recreational boaters.

Inpex should join with AFANT to urge the NT Government to initiate a detailed and effective safety awareness program (similar to that being conducted on railway crossing safety) for recreational boaters in Darwin to make them aware of navigational rules and aids that will allow them to safely navigate in Darwin Harbour. In AFANT's view this and the traffic analysis exercise referred to above should be government responsibilities as Inpex will be just one of a number large users of this part of Darwin Harbour.

AFANT recognises that there will be a need for some safety restrictions and/or exclusion zones for recreational vessels but we would not support major navigation restrictions such as general speed limits or large exclusion zones unless we have data from a proper quantitative analysis and a meaningful risk assessment.

INPEX agrees that it would be a good idea to work with the Amateur Fishermen's Association of the Northern Territory (AFANT) and the Northern Territory Government to initiate a detailed and effective safety awareness program, and to carefully consider the exclusion zones and safety restrictions needed by INPEX to ensure safety and at the same time minimise disruption to AFANT members and other users of Darwin Harbour.

Submission 123-162: The draft EIS does not outline the major catastrophe risks and possible catastrophe scale for either the offshore or onshore components of the project. It is necessary to understand the extent and duration of unlikely worst-case events. Include discussion of acceptable buffers between event sites and areas of occupation.

Detailed considerations of catastrophe scenarios will be considered in the Ichthys Project's safety reports. These will be submitted to the relevant independent regulatory bodies for assessment and review as part of the process of obtaining the licence to operate the facilities.

Submission 130-1: The risk assessment is given in Technical Appendix 24 of the Draft EIS "Offshore and nearshore quantitative risk assessment study". In the Executive Summary to the appendix it states that the QRA is "preliminary" and that: "This report focuses on off-site safety risks." The QRA was prepared by INPEX and Germanischer Lloyd (GL) Industrial Services. On page 5 of the QRA it states: "The assessment covered the potential major accident hazards from the pipeline and the plant."

AMSTECI disagree with that last statement and consider that the QRA falls well short of the government guideline requirements. The QRA does mention that the pipeline and the jetty are designed to the relevant Australian standards, and that the methodology used in the QRA draws on the generic guidelines given in the Australian standard for risk management. But, the only specification detailed is the NT Worksafe requirement that INPEX's Darwin operations shall be such that the off-site 'individual risk (of fatality) per annum' (IRPA) shall not exceed 1 in 100,000. No details are given of the assumptions used in the risk analyses to meet this requirement nor are the relevant standards, codes and best practice methodologies that minimize risks in the LNG/LPG discussed. Basically, all that the INPEX QRA provides is a table of possible accident scenarios (with no details such as spill volumes, etc) and some charts and maps giving the results of the QRA showing that the NT Worksafe requirement has been met and that there is virtually no risk at all to any populated areas.

The Draft EIS's Technical Appendix 24 *Onshore and nearshore quantitative risk assessment study* is a high-level summary of the comprehensive quantitative risk assessment (QRA) completed for the Ichthys Project's Blaydin Point plant. The detailed aspects of this work are the subject of the safety report, not the Draft EIS.

NT WorkSafe is the regulatory authority that will evaluate this work and the safety report.

Submission 130-2: The 20 pages of the INPEX QRA is in stark contrast to the 128 pages of the 'Hazard and Risk Assessment Report' (HRAP) which Bechtel Corporation and their consultants Quest Consultants Inc. prepared for Phillips Petroleum Australia Pty Ltd as part of the March 2002 Public Environment Report for the 10 MTPA Facility at Wickham Point. The 'Bechtel HRAP' does not include a risk assessment for the feed-gas pipeline but does give most of the details that INPEX were supposed to provide under the government guidelines relating to the processing plant and to LNG ship carriers. (Two points should be noted in making risk comparisons with the INPEX proposal and the current, ConocoPhillips facility at Wickham point. Firstly, although the above mentioned HRAP was for a 10 MTPA facility, the current ConocoPhillips facility is for only 3.2 MTPA of LNG – much smaller than INPEX's proposed production of 8.4 MTPA of LNG plus 1.6 MTPA of LPG. But not only is the current ConocoPhillips plant in Darwin harbour much smaller, it is also potentially much safer because, unlike the INPEX proposal, the potentially more dangerous LPG components (propane and butane) are removed from the gas at the Bayu Undan gas field.)

Detailed considerations of catastrophe scenarios for the Ichthys Project will be developed in the Project's safety report. These will be submitted to the relevant independent regulatory bodies for assessment and review as required by Australian legislation.

Submission 130-3: However both the INPEX QRA and the Bechtel HRAP share a common and glaring omission – neither consider the risks on the facilities from "third party interference" or from "unusual and extreme weather". We let others worry about the possible risks from terrorist or enemy attack and here concentrate only on the risks from TC impacts.

Based on the information available to INPEX through its own research and its liaison with other agencies, there is nothing to suggest that an LNG plant in the Northern Territory has a high profile as a terrorist target.

INPEX's risk assessments include taking into consideration unusual and extreme weather events.

Submission 130-4: Judging from the “risk contours” shown in the figures in Appendix 24, the INPEX QRA probably only allows for the ambient conditions described in the Bechtel HRAP as gas industry standards – that is, during a pipeline or storage tank rupture, ambient winds are not much more than gentle breezes in the range of 2 m/s to 9 m/s.

Wind speeds of 0–12 m/s have been considered. It is a misconception to believe that very high wind speeds create a more conservative result. First, wind speeds greater than this range have a very low frequency of occurrence according to wind rose data for the area and, secondly, at higher wind speeds the gas clouds disperse more easily because of the turbulent mixing. Hence the size of the flammable cloud is less extensive than at lower wind speeds.

Submission 130-5: Given that the NT Worksafe ‘IRPA’ requirement is < 1 in 100,000, the scenario for an event which might lead to say 100 deaths off-site will be a 1 in 10million year event. In the following sections, we consider three worst case scenarios that might correspond to such a low likelihood/ high consequence event when the ambient conditions are the eyewall winds of an intense tropical cyclone:

2.1 Full bore rupture of the Gas Export Pipeline (GEP) in Darwin Harbour at or near its closest approach to Darwin during a period when the maximum winds from a strong Category 5 TC are blowing the released gas plume/fire ball directly toward the populated areas of Cullen Bay or Larrakeyah 2.5 km downwind.

There are many possible causes of such a rupture but perhaps the most likely is if a very large vessel for some reason is unable to get to open sea and grounds on the GEP or drags its anchor and snags the GEP. For this to happen, the GEP would have to be devoid of rock-armouring but this could easily happen due to shifting sand-waves or similar seabed conditions during the TC. An enormous amount of gas would be released – probably more than any ever released during any gas pipeline explosion anywhere to the present day.

Such a full bore rupture of the GEP is examined on page 58 of Technical Appendix 7 of the Draft EIS – but only in relation to the effect of condensate spill in the harbour. (No consideration is given as to what happens to the released gas in Appendix 7; presumably it is assumed that it rises harmlessly into the atmosphere.) In the first paragraph of Scenario 7, page 58 it states: “Due to the gas being highly pressurized the entire contents of the pipeline would escape within 3 hours.” Assuming that the pipeline flow just matches the annual production figures, then in those 3 hours, the amount of feed-gas released would be 3/24 x 1/365 x (8.4 + 1.6) x 106 = 3,400 tonne.

Even if the gas did not ignite from the ship which dragged anchor, most intense TCs in the NT have almost continuous lightning near their radii of maximum winds so the gas would soon ignite either offshore on onshore. The question that needs to be answered is how much of the fireball heat would be swept over the populated areas downwind, and with what consequence?

2.2 Rupture/failure of one or both of the large LNG storage tanks during impact from a strong Cat 5 TC.

Figure 4-2 in the Draft EIS shows that two LNG storage tanks are proposed for the INPEX plant at Blaydin Point. Judging from the 188,000 m3 capacity of the single ConocoPhillips LNG tank for their 3.2 MTPA production, each of the INPEX tanks will be have capacity of about 250,000 m3. Unless the tanks are built like the underground LNG storage tanks around Tokyo Bay with 2 to 3 m thick pre-stressed concrete walls, the Blaydin Point tanks will have some remote chance of a rupture causing a spill of some large proportion of their contents. Such rupture could be caused by a series of fires or vapor cloud explosions (VCE) or boiling liquid expanding vapor explosions (BLEVE). The rupture could be like many accidents where, rather than any one single event, it is a chain reaction of lesser events which lead incrementally to the final catastrophic failure. (Tank failure due to fire or explosion is much more likely than a structural failure due simply to wind loads or wave forces – refer to the Addendum to this submission relating to late advice from INPEX on this subject.)

The normal procedure for the risk assessment of LNG spills is to assume contained pool fires either from tank tops or within dry containment areas under light wind conditions and to then check that the heat from such fires is within safe levels at various distances from the site. But what if there is a large spill from a tank into a containment area that is already filled with either rainwater or seawater and the Cat 5 TC winds are so strong anyway that the LNG is blown out of the containment area onto the wind whipped waters of East Arm? The LNG would quickly vaporize, probably with accompanying rapid phase transition explosions. Large, dispersed vapor clouds could be blown towards populated areas*. LNG vapor is 1½ times heavier than air so the vapor cloud would be swept along close to ground level and its ignition from either lightning or existing fires on land would be inevitable. What would be the consequence of such an event?

2.3 Rupture/failure of the Propane and/or Butane storage tanks during impact from a strong Cat 5 TC.

These tanks will be much smaller but, because of BLEVEs, may be much more prone to fail due to fire or explosion. LPG gas is heavier than air so it too would probably be swept along close to ground level. There would be numerous ignition sources during a TC. What would be the consequences if the LPG gas or fireball was swept over a populated area?

2.4 Rupture/failure of one or more tanks on one of the carrier vessels.

LNG, LPG and condensate carriers have an excellent safety record and probably need not be included in these worst case scenarios provided the vessels serving INPEX's Darwin plant are designed to withstand the winds and extremely high waves from a strong Cat 5 cyclone and there is a strict requirement that they will always put to sea well before any possibility of a TC hit on Darwin Harbour.

* The nearest residential suburb to the proposed LNG/LPG storage tanks is the low density suburb of Marlow Lagoon which has houses within 4 km east of the proposed tank sites. The more densely populated suburbs of Palmerston commence within 5.5 km east of the proposed tank sites and the multi-storey apartments of the Water Front development in the CBD are 9 km north-west of the proposed tank sites.

The NT WorkSafe criterion has been incorrectly interpreted in this question. The criterion for individual risk is based on location-specific risk contours. These contours estimate the likelihood of a fatality (per year) at a specific geographic location based on a hypothetical individual being at the location 100% of the time, being unprotected (i.e. outside and naked) and unable to escape. The contours are not representative of the risks to real persons (the "individual risk (of fatality) per annum" (IRPA)) which are normally much lower because they account for movement and escape. Risk contours are however appropriate as a land-use planning tool since they present the worst-case risk exposure.

The risk measure described in this question relates to societal risk. The likelihood of an accident at the site resulting in 100 or more fatalities is currently estimated at one in 90 million years. This very low likelihood is as a result of the separation between the site and populated locations and the control barriers implemented to prevent major accidents occurring. See INPEX's response to comment 1-1 in Section 5.2.2.16.

2.1—There is a very low likelihood of a full-bore rupture of the gas export pipeline. However, simulation analysis of the gas cloud that would form if such an event should occur shows that it would disperse to below its lower flammability limit (LFL) rapidly and would not reach land. If the failure were to occur during a Category 5 tropical cyclone (the highest category of cyclone) the dispersion distances would be even lower.

The gas export pipeline is protected by trenching and rock-dumping; the rock-armour protecting the pipe is completely stable, even in a cyclonic event. The rock-armour is designed to withstand a 17-t anchor, the largest currently envisaged for use by Project vessels.

On page 58 of the Draft EIS's Technical Appendix 7 *Marine hydrocarbon spill modelling*, it was assumed that the entire contents of the gas export pipeline could be lost within 3 hours in order to be very conservative in estimating condensate spill risks to the waters of Darwin Harbour. In reality, however, even if an extremely low likelihood full-bore rupture were to take place; it would take closer to 10 days to depressure the gas export pipeline completely.

2.2—The LNG and LPG storage tanks at Blaydin Point are full containment tanks, that is, they consist of a metal inner tank and a concrete outer tank. Any leak in the inner tank will flow into the outer tank where it will be contained. It would require a powerful external event to breach both barriers to cause a loss of containment. Such a breach caused by either an accidental or an environmental accident has been assessed in the quantitative risk assessment (QRA) to examine the impact of large consequence low frequency events. Some of these modelled scenarios resulted in very large flammable gas clouds which could potentially affect areas off site. However the frequency of such scenarios was deemed to be so small as not to breach the societal risk criteria specifically set to judge such types of event.

It is important to note that vaporised LNG is lighter than air with its molecular weight approximately half that of dry air.

2.3—See the comment above.

2.4—INPEX operating procedures and DPC procedures both require that all LNG, LPG and condensate tankers depart the Harbour in advance of any cyclone hitting the area.

Submission 130-6: 2.5 Concluding remarks relating to the QRA.

AMSTECI do not have the technical expertise to know if the dreadful scenarios outlined in sections 2,1, 2.2, and 2.3 above are possible – even for an extremely low, annual probability event like 1 in 10 million. We sought advice on the matter from Dr James Fay of MIT who advised that standard plume models show that the distance to the lower flammability limit of a vapor plume varies inversely with the wind speed and this indicates that the danger zone of a burning vapor plume may be much smaller during a TC than from a normal day's wind.

However, AMSTECI note that experimental confirmation of the standard plume models is based on comparatively small releases of gas or LNG conducted under comparatively low ambient wind conditions. Further, it is a very complex subject – for instance Anay Luketa-Hanlin 20053 contains 121 references in a review of experiments and modeling for large-scale LNG spills. The study provides a good summary of the state of knowledge and concludes: "This review has brought out some key areas that require further experimental testing, model development and application. Developing predictive capabilities requires the blending of experimental, numerical, and analytical efforts. With further combined effort on addressing the salient gaps there will be a significant reduction in the uncertainty of current predictive capabilities."

Dr James Fay of the Massachusetts Institute of Technology (MIT) is correct—at higher wind speeds the distance to the lower flammability limit (LFL) for a dispersing cloud reduce as the wind speed increases. In general, however, the models used by INPEX to estimate the consequences of a hydrocarbon release from the LNG plant at Blaydin Point were deliberately designed to be conservative and thus resulted in a overestimate of the risk to the public. And even with this conservatism built into the analysis, the estimated risks from the plant still fall within the acceptable limits of Australian risk criteria. They are therefore considered acceptable as long as they are demonstrated to be as low as reasonably practicable.

Submission 130-7: Given that the proposed facility is probably the largest such plant ever proposed to be constructed so close to a city subject to impact from very intense TCs, AMSTECI have no hesitation in making the following recommendations.

Recommendations:

1. That the NT and Australian Governments require INPEX to engage consultants (such as Sandia National Laboratories) with the necessary skills to estimate the effect on populated, downwind areas if massive ruptures were to occur in the GEP and/or to one or more of the LNG and/or LPG storage tanks coincidently (or subsequently) with impact from the maximum winds from an intense, Category 5 tropical cyclone such as those estimated for TC Monica at landfall (maximum gusts = 99 m/s or one minute sustained wind speeds of 82m/s). The report should be made transparent and available to public comment before any final decisions are made to proceed with the current INPEX proposal.

2. If the Recommendation 1 study indicates that winds from a TC could lead to fatalities at distances of several kilometres downwind, then the design and operating procedures for the GEP, processing plant, and carrier vessels should be based on an extreme, very low likelihood TC event having a probability low enough to be consistent with the IRPA requirements in the government guidelines.

3. In their published response to the Draft EIS, INPEX should detail the sea-worthiness of the carrier vessels during a strong Cat 5 TC and the procedures to be adopted if a TC threatens and one of there carriers is within Darwin Harbour.

INPEX's Ichthys Project facilities in Darwin Harbour will be designed to withstand winds from tropical cyclones. See INPEX's response to comment 130-9 in Section 5.2.2.16.

Submission 130-8: There are several mentions in the Draft EIS that TCs occur in the Darwin region but there is no mention of their intensity. Further, no details are given of the TC event(s) that will determine the design parameters for the gas pipeline and the onshore facilities within Darwin Harbour.

INPEX's Ichthys Project facilities will be designed to withstand winds from tropical cyclones. See INPEX's response to comment 130-9 in Section 5.2.2.16.

Submission 130-9: From consideration of the foregoing, AMSTECI conclude that all components in the INPEX processing plant should be designed for a Return Period of 10,000 y and at least to the wind code's Region D. The design regional gust speed for these 2 conditions = 109 m/s.

(If 109 m/s seems impossibly high, the World Meteorological Organisation has recently announced that TC Olivia in 1996 produced gusts which have set a new world record[11]. They were measured at 113 m/s by an anemometer on Barrow Island, 60 km off the WA coast.)

It is noted that, if they wanted to take a chance with safety, INPEX would probably comply with current regulations relating to structural design for structures by assuming Region C applies and, using the clause in bold under paragraph (b) on the previous page, allow for a Return Period of 2,000 y. This would mean that a regional gust speed = 77 m/s could be used and a few million dollars could be saved. AMSTECI trust that INPEX will comply with their core value of "Safety Number One" and pass up that opportunity.

The designations of cyclone regions and wind actions are currently contained in the Australia and New Zealand Standard *AS/NZS 1170.2:2002, Wind actions* and Australian Standard *AS 4055:2006, Wind loads for housing* (the "Wind Standards"), which are referenced by the Building Code of Australia (BCA) for the determination of wind loads on buildings and other structures.

The onshore processing plant and export facilities at Blaydin Point have been designed in accordance with the relevant Australian standards, including *AS/NZS 1170.2:2002*. Darwin is situated in Wind Region C. INPEX has reviewed the submitter's referenced possible changes to the BCA. It is noted that there are currently no proposals to redraw the boundary of Wind Region D (as shown in Figure 3.1 of *AS/NZS 1170.2* and Figure 2.1 of *AS 4055:2006*) to include Darwin (ABCB 2010).

The design return period is 1 in 500 years for infrastructure of importance level 3 set by the BCA (the greater part of the plant), but with some of importance level 4 (i.e. with a return period of 1 in 1000 years) (for example the product storage tanks) and Wind Region C. Importance level 3 would be 66 m/s × 1.05 safety factor (or 70 m/s × 1.05 for importance level 4). This is considerably lower than the 109 m/s mentioned by the submitter and also the 77 m/s. The risk of wind speeds higher than this value and the impact on tanks and risk have been assessed in the quantitative risk assessment (QRA).

Note that the tanks are designed to withstand blast overpressures in the event of an explosion on site. The design criterion for blast, although for a shorter impulse, is estimated to equate to approximately five times the force of a wind speed of 85 m/s.

Submission 130-10: a) On page 56, under "Oceanography and hydrodynamics" it states:
"Extreme wave conditions were modelled by GHDM using wind data from cyclone Tracy in 1974. Waves with a 'significant wave height' of 4.5m ……were found to occur at the entrance to the Harbour. However, these waves were found to be affected by bathymetry and reduced to a height of around 0.7m in shallower waters in the inner parts of the Harbour (GHDM 1997)."

Comment: Hopefully INPEX will not rely on the GHD findings to determine the significant wave heights to be used for design of the Project facilities. A Cat 5 TC approaching on a critical track could probably produce significant wave heights at Blaydin Point of 3m or more.

The penetration of swell into Darwin Harbour is not a significant factor in the extreme wave climate inside the Harbour. Locally generated waves within the Harbour predominate. Based on a 1-in-500-year cyclonic event the calculated maximum design significant wave height at the Ichthys Project's Blaydin Point in East Arm is 2.7 m with an associated maximum wave height of 4.4 m.

Submission 130-11: b) On page 58, under "Oceanography and hydrodynamics" it states in part:

"Storm tide predictions – which take into account cyclone storm surges together with the effects of frequent breaking waves ('wave set-up') and the influence of astronomical tide – indicate that temporary increases in sea level would occur during cyclone conditions at sites around Middle Arm Peninsula and East Arm (Table 3.3)."

11. Refer: http://wmo.asu.edu/world-maximum-surface-wind-gust

Comment: The Drat EIS attributes the above text and the accompanying Table 3.3 to Hennessy et al 200412. However that report is a compilation of previous research for a statement about climate change. The values in Table 3.3 actually derive from Table 8.1 of VIPAC Ltd (1994)13 – a study carried out for the NT Department of Lands, Housing and Local Government at the time of planning for the East Arm port development.

Storm tide levels and the VIPAC report are discussed later under Section 3.3

INPEX agrees that the levels adopted correspond to the results of the Vipac study (Vipac Engineers & Scientists Ltd 1994).

The comparison with the World Meteorological Organization (WMO) study is noted. However the Vipac results are currently used by the Northern Territory Government for planning in this area.

Furthermore the accuracy of the WMO study is unknown and, taking account of the order of accuracy of such studies, the differences between water levels calculated for events with return periods of less than 500 years may not be significant.

Submission 130-12: c) On page 90, under "Topography and geomorphology" it states in part:

"……Many of the (shore) platforms are covered by relict layers of cemented laterite cobbles transported by waves of high energy. Carbon-14 dating of carbonate cement between the cobbles shows that one sheet was deposited at about 3,700 BP (before present), and the other about the other sheet at about 1,700 BP. Waves generated during devastating tropical cyclones last century had little effect on the cobble sheets, and they were probably transported onshore by tsunamis originating in the Indonesian archipelago prior to last century."

Comment: The Draft EIS gives no reference for this curious passage but it is copied from the Summary from Young and Bryant 199814. The paper gives two locations with the two sheets of 'relict layers'; one at Rapid Creek and the other at Lee Point. Judging from the well sorted appearance of the photographed layers, they were more likely to have resulted from intense TCs than from tsunamis. In any case, the statement linking TCs in last century with features produced thousands of years ago is of course nonsense.

The EIS notes that these cobbles are of recent geological origin (1700 bp and 3700 bp) and that it has been observed that cyclones in the 20th century had no visible effect on these deposits; thus the events which transported them must have involved far greater energy than any process operating in the last century.

Submission 130-13: Recommendation: 4. That INPEX engages a team from Charles Darwin University lead by Prof. Wasson to systematically study beach features such as beach ridges, cheniers, coral rubble ridges and lagoons to estimate the Return Periods of intense TCs affecting the Darwin region.

The Ichthys Project has adopted a 1-in-500 average recurrence interval (ARI) cyclonic event for design based on Australian standards. The prediction of these events can be done with a reasonable degree of confidence based on the data to hand. The study proposed by the submitter is considered excessive for the Project.

Submission 130-14: d) On page 193, under "4.5 Onshore infrastructure" it states in part: "The design of the processing plant layout, has taken the following criteria into consideration: ………..o The plant should be established above the predicted peak combined sea levels (tides together with storm surges) for East Arm Wharf which is the closest location to Blaydin Point with available data (a 6-m AHD (Australian Height Datum) storm surge for a 1-in-1000-year event). Adequate protection should be provided to areas exposed to tidal and storm surge events (eg. using rock-armouring or similar);o The plant should be constructed above a potential rise in sea level of 0.2m as predicted by future climate-change scenarios for the Project's lifetime; "Comment: As discussed under Section 3.3, AMSTECI dispute the validity of using 1,000 y Return Period storm tide levels previously predicted for East Arm Wharf as setting a suitable standard for the Project's facilities. On the other hand, the allowance for sea level rise appears reasonable.

Submission 130-18: h) On page 441, under "Emergency Services" it states:

"In order to effectively plan for major emergency events, such as cyclones and major accidents, INPEX will need to work with these existing emergency services touu 10 ha ensure that they have the capability and capacity to respond.

In addition to this, the onshore facility will need to be built to withstand the climatic conditions experienced in the Darwin region, for example, cyclones and storm surges."

Comment: The questions remain – built to withstand what type of TC and what level of storm surge?

Using the consistent terminology and probabilistic methods adopted by the relevant Australian standards and an "importance level" (function category) of 3, the average recurrence interval (ARI) of the design event is defined in the standards as 500 years. This ARI has been adopted for winds, waves and water levels. The combination of these events is generally carried out in accordance with the recommendations of *AS 4997:2005, Guidelines for the design of maritime structures*. Most of the plant facilities will be at or above 6.5 m AHD. The exceptions are non-critical portions of the flare and operations complexes which have been designed to be above 5.8 m AHD; this corresponds to the height of a 500-year storm surge with an additional contingency of 0.2 m.

INPEX will work with Darwin area emergency services to ensure the capacity to respond to any emergencies.

Submission 130-15: e) On page 203, under "Administration area" it states in part:

"………This area is 2.5 km south of the processing facility on the site access road leading to Blaydin Point. Like the plant pad, the administration area will be designed to be above storm-surge height. It is likely that the administration area pad will not require rock-armouring as it is above Highest Astronomical Tide (HAT) datum and will not be subject to tidal inundation or wave action. ……"

Comment: Presumably, that passage should have said "storm tide height" rather than "storm-surge height". The sentence following is then shown to be wrong because the design storm tide height will be well above HAT and, if the upwind mangroves are stripped to bare poles by prior wind, the administration area could also be subject to some wave action,

Administration buildings and the other buildings which were planned in the process plant site were moved to the south of the process plant site. The rock berm will be provided where wave action is anticipated.

Submission 130-16: f) On page 353, under "Prevention and management of accidental hydrocarbon spills" it states that the gas export pipeline "will be designed to meet the oceanic, climatic and seismic conditions of the area." and that:

"The jetty structure is being designed ……taking cyclones into account; the loading arms, for example, will be designed to allow them to be tied down should a cyclone threaten Darwin,"

Comment: These aspects of the jetty design are also mentioned in Table 12.1 "Key Commitments" – but it is noted that it is the only one of hundreds of key commitments in the 20 pages of the table that relates specifically to TCs. The requirement to tie down the loading arms is obvious – what should also be divulged is the type of TC which will be taken into account in the design of the GEP and the jetty.

The loading arms at the product loading jetty will be tied down during extreme weather conditions. The design will be carried out in accordance with Australian and New Zealand Standard *AS/NZS 1170.2:2002, Structural design actions—Wind actions* and Australian Standard *AS 4997:2005, Guidelines for the design of maritime structures*.

The product loading jetty will be designed as for "importance level 3" as set by the Building Code of Australia (BCA).

Submission 130-17: g) On page 432 under "Impacts of climate change" it states:

"More specific to the NT, the following impacts are predicted:

- a rise in sea level;
- an increase in increase in storm-surge inundations;

The influence of these factors has been or will be incorporated into Project designs. For example, the LNG plant will be built at least 7 m above Highest Astronomical Tide (HAT) to protect against the possibility of gradually increasing seawater levels and storm surges expected over the 40-year life of the facility. This basis assumes a 1-in-1000 – yr storm event, together with a 0.2m allowance for global warming and an additional 0.3m for contingency."

Comments: 7.0m above HAT at Blaydin Point is about 11.2 m AHD. It is clear that the EIS writer has confused the two terms and meant to state that the "plant will be built at or above 7m AHD." The design levels for the plant will be discussed under Section 3.3 following.

An "importance level" of 3 is appropriate for the design of the onshore processing plant. Accordingly, an average recurrence interval (ARI) of 500 years, not 1000 years, has been adopted for design. See also responses to comments 130-14 and 130-18 above.

Submission 130-19: Recommendations – 5. The structural design of INPEX facilities to resist wind forces in Darwin should be designed to Region D standard at least and those facilities that could initiate off-site fatalities if they failed during a cyclone should be designed for a Return Period of 10,000 y.

The statutory requirement for design for wind forces in the Darwin area is the adoption of values for Region C. There are no indications that this requirement will be changed in the foreseeable future.

Submission 130-20: Recommendations: 6. INPEX assist with funding a detailed study by a multidisciplinary team (which would include meteorologists, statisticians and engineers skilled in such studies) to specifically examine cyclonic wind speed recurrence intervals for Darwin to convince themselves, the public and the authorities of the necessity of Recommendation 5 and to determine appropriate storm tide levels, significant wave heights and bed shear stresses for the design of the Project's facilities within Darwin Harbour. Design values for storm tide levels, significant wave heights and bed shear stress levels should be based on a Return Period of at least 10,000 y unless it can be shown that a lesser Return Period would not violate the IRPA requirement given in the government guidelines.

Australian Standards require that the facility be designed for 1-in-250-, 1-in-500-, and 1-in-1000-year events for importance levels 2, 3, and 4. Estimation of design parameters for these average recurrence intervals (ARIs) can be carried out with some confidence using existing data. There is no need for additional studies to estimate design parameters for a 1-in-10 000-year event.

Note that cryogenic tanks at the onshore processing plant which comply with the (US) National Fire Protection Association standard NFPA 59A[14] will be designed for the seismic spectra of a 1-in-2475 year earthquake (a "safe shutdown earthquake").

5.2.2.17 Quarantine

Submission 18-3: How can the EIS suggest that the risk of pest species be medium? Or that marine organisms from Japan may not survive in Australian waters?

"AQIS deems all salt water from ports (or coastal waters) outside Australia's territorial sea to present a "high-risk" of introducing exotic marine pests into Australia".

The fact is that nearly every vessel will carry pest species and it is unrealistic, to consider that ballast water management and anti fouling agents for gas pipelines and hulls will resolve this issue. Moreover, how does this proposal intend to monitor the type of anti fouling agents used for hulls from international vessels?

Submission 53-15: The risk assessment process identified the potential introduction of marine pests by vessels operating on this project as requiring mitigation. Mitigation appears focussed on vessels operating near shore of Darwin. It should be explicit that quarantine requirements are equally pertinent for vessel entering all near shore environments, regardless of where these activities are undertaken. The document states the intent to comply with any pertinent biofouling legislation in force at the time of operations, including the Australian Biofouling Management Requirements currently being developed. In the event that relevant jurisdictional requirements are not in place, the proponent should commit to implementing appropriate risk mitigation. Towards this, the document mentions all vessels will undertake biofouling risk assessment. Each risk assessment must be undertaken, or approved by, the appropriate government authority prior to vessel mobilisation. The document indicates pest detections will be reported to the relevant regulatory authority. Greater detail is required regarding commitment to mitigation/remediation following detection.

Ballast water

The quotation given above can be found as part of a larger statement found on the Australian Quarantine and Inspection Service (AQIS) web site; "*AQIS deems all salt water from ports and coastal waters outside Australia's territorial sea to present a "high-risk" of introducing exotic marine pests into Australia. The discharge of high-risk ballast water from ships is prohibited anywhere inside Australia's territorial sea*".

AQIS is the lead agency for the management of ballast water taken up overseas with the intention of discharge within an Australian port. Part of AQIS's charter is to ensure that foreign ballast water has been managed in accordance with the Australian Ballast Water Management Requirements (AQIS 2008b).

When AQIS states that all saltwater from ports (or coastal waters) is considered high risk, it is referring to waters not exchanged before entering Australian waters. AQIS has a mandatory ballast-water exchange program requiring the exchange of such high-risk water in the open sea. This considerably reduces the risk of contaminated ballast water being discharged in Australian ports.

INPEX has stated that it will meet all AQIS guidelines and requirements, including that of not discharging high-risk ballast water inside the territorial sea. Ballast-water exchange records are required to be maintained. See Annexe 13 *Provisional quarantine management plan* to Chapter 11 *Environment management program* of the Draft EIS.

Introduced marine pests and biofouling

Comment 53-15 about nearshore activity is valid: the focus of the document upon Darwin Harbour is appropriate considering this is where most of the Ichthys Project's nearshore activity will occur. However quarantine management will be applied as appropriate to all Project activities, offshore, onshore and nearshore.

INPEX is familiar with the proposed management procedures for biofouling management and will implement these procedures as they become publicly available, even if they are not yet legal requirements.

14 National Fire Protection Association Standard *NFPA 59A:2009, Standard for the production, storage, and handling of liquefied natural gas (LNG).*

In addition to (or as part of) the final quarantine management plan, an introduced marine pest management plan will be developed for the Project and discussed in detail with the appropriate authorities before it is implemented. This plan will have full information on the marine pest management procedures to be followed. See Annexe 13 *Provisional quarantine management plan* to Chapter 11 *Environment management program* of the Draft EIS.

Through the biofouling risk assessment the anti-fouling agents would be assessed. INPEX will undertake a marine biofouling risk assessment of international vessels engaged in Project activities to assist in the early identification of biofouling risk and the determination of an appropriate management approach. Records of antifouling coats are also required to be maintained by contractor. Biofouling management of all Project-associated vessels will be undertaken in accordance with the relevant regulatory requirements of the time, or in their absence with the National Biofouling Management Guidance (Commonwealth Government 2009). Anticipated regulatory requirements are outlined in a draft overview of proposed Australian biofouling management requirements prepared by the Department of Agriculture, Fisheries and Forestry (DAFF 2008).

In addition to the above guidelines, specific advice is available for operators of oil tankers and gas carriers (the "National biofouling management guidelines for commercial vessels") and operators of heavy-lift vessels and dredgers (including rock-dumping ships) (the "National biofouling management guidance for non-trading vessels").

Incident management and mitigation

Annexe 13 *Provisional quarantine management plan* to Chapter 11 *Environmental management program* of the Draft EIS outlines the incident management and mitigation measures propopsed by INPEX. This plan will be updated and its details will be further developed as the Project progresses through the detailed design and tendering process. This will allow for the appointment of subcontractors and the determination of specific details such as vessel selection before the plans are finalised. The final quarantine management plan will cover quarantine requirements for onshore and offshore activities, and will be prepared in advance of any activities commencing at the Ichthys Field, Blaydin Point or in Darwin Harbour.

Submission 86-18: Marine pest monitoring data collected by the proponent is to be recorded in a format compatible with the survey data being collected by NT Fisheries and Golder Associates in Darwin Harbour.

INPEX will work with the relevant bodies to ensure that its marine pest monitoring data are compatible with the other data being collected and will make such data available to the appropriate bodies.

Submission 107-42: INPEX should make reference to any Australian legislation or regulations prohibiting disposal of ballast into the near shore marine environment. The comment on page 302, that the area where ballast disposal might occur is sufficiently distant from land to reduce the risk to a low level, is not necessarily sound, as this will depend on the nature of the marine pest that might be introduced. For example a foreign krill or plankton species does not need to be close to the land to multiply.

Submission 128-20: Our discharges. The discharge of more contaminated waste water into the harbour cannot be supported. Council requires clarification as to what arrangements have been made to ensure adequate and satisfactory arrangements are being made by INPEX with the Northern Territory Government on this important issue. Ballast water even though collected from the open ocean still has possibility of introducing marine pests that are already in the ballast tanks picked up from elsewhere.

INPEX will comply fully with all Australian Quarantine and Inspection Service (AQIS) ballast-water management requirements. The AQIS strategy is based on preventing marine pest species, which concentrate in disturbed nearshore habitats, from being introduced into Australian coastal environments. It should be noted that AQIS's ballast-water requirements incorporate the results of research by the Bureau of Resource Sciences (BRS) of the Department of Agriculture, Fisheries and Forestry (DAFF), which assessed the risks to coastal areas from ballast water discharged to sea at various distances from the entire Australian coastline, including the Darwin and Beagle Gulf area.

Refer to the responses to 18-3 and 53-15 above for additional commentary on quarantine issues, including ballast water, introduced marine pests and biofouling.

Submission 107-43: The level of risk that could be ascribed to marine pests moving along the subsea infrastructure during the 40 year operational period and into the post-closure period where the infrastructure remains in place, although non-operational, should be discussed in terms of studies undertaken previously. If studies have been undertaken, then the outcomes should be provided and contingencies discussed that might serve to mitigate any potential impacts.

As shown in Figure 3-4 in Section 3.2.1 of the Draft EIS, the predominant currents in NW Australia are directing away from Darwin Harbour. However INPEX recognises that these currents alone will not prevent passage of all species as local conditions may vary and/or run counter to these predominant currents, especially during monsoonal periods in the tropical areas.

The pipeline will not act as a pathway or highway for pests to travel from the CPF/FPSO to Darwin Harbour, as most adults of the IMPs are stationary (e.g. mussels, barnacles, etc.) and therefore do not move any significant distances in the adult phase of their life cycle. Furthermore the subsea architecture at the Ichthys Field is in waters over 200 m deep, so a species would need to be able to distribute, reproduce and survive over the water column and then travel the distance from the field to the Harbour (885 km). The vast majority of benthic species on the national marine pest list have a planktonic distributional larval phase in their life cycle, and it is this phase that presents the greatest risk (in all waters) to introduction and spread of pests. This is the key concern in terms of species extending their ranges if they are distributed into Australian waters, so efforts are focused on prevention of introduction, which is also the focus of regulatory controls around quarantine.

See INPEX's response to comments 18-3 and 53-15 above for more information on quarantine management.

Submission 120-36: Darwin Harbour remains free of marine pests and it is imperative that we keep it that way. We welcome the undertakings given by Inpex to ensure that its construction and operational activities will be conducted to eliminate the risk of it introducing marine pests (Draft EIS p. 302, 341 and 640). Although ballast water exchange requirements may well be an intended element of Inpex's quarantine management plans for ocean-going vessels entering Darwin Harbor, AFANT believes that there should be additional requirements for vessels moving only in Australian waters to exchange ballast at sea before entering the harbour.

As indicated in the Draft EIS, INPEX will comply with all regulatory requirements, including those for marine pests.

The Commonwealth, state and Northern Territory governments are developing a national system for marine pest management to ensure that uniform management procedures are in place throughout Australia; the system will include nationally consistent management measures for the control of "domestic" ballast water. These procedures will be incorporated into the Ichthys Project's marine pest management procedures as they are introduced.

See INPEX's responses to comments 18-3 and 53-15 above for additional commentary on introduced marine pests, ballast water and biofouling management requirements.

5.2.2.18 Socio-economic

Submission 3-2: The images in Appendix 23 are disturbing. It is noted that no images have been produced from the proposed new suburb of Bellamack. Once the tall trees are felled, the view to Blaydin Point will no longer be obscured.

Submission 109-23: If possible screening of development infrastructure with vegetation buffers should be undertaken.

Section 10.3.11 of the Draft EIS describes the methodology for the Visual Impact Assessment undertaken to assess the visual impacts, during day and night conditions.

Fourteen "viewpoints" were selected, in consultation with NRETAS, from locations around Darwin City/Harbour edge and Palmerston. The locations were selected to represent a range of uses or activities including residential, tourist and heritage, business, and light industry. INPEX considers that the viewpoint indicated as "Palmerston planned suburban development" shown in Figure 10-6 in the Draft EIS as similar to a viewpoint along the western side of the proposed future suburb of Bellamack.

Submission 3-3: Future residents of Bellamack and surrounding suburbs should also be made aware of light spill and noise associated with the onshore project (Section 10.3.10).

INPEX does not believe light spill and noise from the Ichthys Project's proposed onshore processing plant at Blaydin Point will impact negatively on future residents in the Palmerston suburb of Bellamack or elsewhere. As noted in the submitter's comment, Section 10.3.10 of Chapter 10 Socio economic impacts and management of the Draft EIS discusses the Project's noise emissions and their likely impact on residential areas in the residential suburbs and urban centres around Darwin. An update on expected noise levels at Palmerston is provided in Section 3.3.5 of this EIS Supplement. During process upset flaring and under certain meteorological conditions, Palmerston may receive noise levels in the order of 45–55 dB(A) three to four times per year for a minutes duration.

Submission 7-25: 1. It is a well known fact that Darwin is short of housing infrastructure at all mediums

It is a well known fact that mining and like activities over inflates the housing and rental markets

It is a well known fact that workers on the previous Gas Project were mainly imported and were unhappy with the temporary accommodation, particularly during the Wet Season.

Submission 7-30: There will be an impact on tourism events & accommodation if the imported project term workers in temporary one room accommodation want family to be able to visit during their contractual period.

Submission 7-31: The affordable short term housing does not help the local resident in the long term.

INPEX has acknowledged in the Draft EIS and during the public consultation initiatives that the local property market (in rentals and sales) is constrained, and has outlined management controls to reduce additional pressures on these markets. As part of the Ichthys Project, INPEX will develop an accommodation village to house construction workers during the onshore development. Additional recreational and support services will be included in the village, thereby reducing the potential strain on the local area products and services.

As part of an overall Project accommodation strategy, additional housing requirements have been identified for other Project personnel (e.g. management and contractors' administrative and ancillary support staff), INPEX will work with local developers to construct additional new accommodation. This overall strategy has been prepared to specifically reduce pressure on existing housing and adding new facilities for the future housing market once the Project is completed.

INPEX has taken into account lessons learned from similar projects. The accommodation village will be designed to be an attractive place to live and will provide recreational and support services and facilities to meet the needs of those staying there, and reduce the potential impact on existing products and services outside the village.

Submission 7-35: Given the detail of the proposed development at Howard Springs consideration should be given to moving this to Weddell to give the city a kick start. It should be an innovative city complete with Solar Power Panels to put back into the already wailing power grid, water tanks & recycling grey water. This would alleviate the additional pressure on roads through Palmerston to the proposed site. In fact move the whole plant to a site on the western side of Cox Peninsula.

Submission 7-36: Move the airport to the Cox Peninsula or at least the RAAF base as well. The development could be a joint venture INPEX, RAAF and both Federal and NT Governments based on similar developments of 2 to 1 private (affordable housing). Put in the bridge and light rail between the peninsulas or make use of the existing railway for a commuter train to link to a new light rail. Would give additional employment to Mandorah and the Aboriginal Community.

Submission 7-37: Sewerage on site should be eco sustainable onsite – Palmerston Sewerage is already under pressure with increased suburbs planned with existing tender plans for work in this area. Investigations should be made for an ecoflow type system.

Submission 7-38: If power impact is minimal then put in solar panels, reduce the diesel to a minimum.

Submission 7-40: 'While the direct impact of the Project on employment in the Northern Territory is minimal, the indirect impact is significant' this meaning that NT companies will need to again put themselves out there with Australia wide companies to vie for trade and by Figure 10-12 this will be for the short term construction period. We have seen projects started from Conco Phillips that have collapsed within a 12-18 month period (eg Petroleum off shoot at East Arm) with little long term money earners for NT companies. "There is the possibility that some local employers – for example in the building, fisheries and government sectors – may lose staff to the Project, particularly if there is a salary competition.' As with many mining towns and cities the ability to get trade workers to do the residential and light commercial work – the companies preferring to do contractual work that is guaranteed and higher salaried. The local will suffer.

INPEX welcomes all comments concerning the proposed Ichthys Project, and these views are noted and published accordingly. However, some of the comments raise issues that INPEX is not a position to respond to or does not have the authority to answer, or that are outside the scope of the environmental assessment process. Where possible, INPEX has responded to the issues raised in the submitters' comments below.

Site selection

The site for the onshore plant was identified for industrial development and proposed as a suitable location for the Project's onshore processing plant by the Northern Territory Government, so consideration of the process of site selection and alternatives is somewhat limited in this context. The Howard Springs site was selected for the accommodation village following extensive consultation with the Northern Territory Government and a site-selection process. the details of which will be provided in the separate approval process INPEX will undertake for the accommodation village.

Power and water supply

Diesel generators will be required in the early construction phases before connection to the headworks for the supply of 22 kV·A overhead power from the nearest connections at Channel Island and Wickham Point. The temporary facilities to be constructed for the peak construction period will include connection to power. Some diesel generation may be maintained on site in the event of power outages or to provide power to isolated workplaces.

It is not clear whether the submitter is referring to the accommodation village or to the Blaydin Point plant site but it has been assumed that it is the plant site. Solar panels are not considered to be a consistent, viable or reliable power supply for the size and scale of the activities to be undertaken at the site during construction and operations. In addition, there will be ample power available from the power generation facility at the onshore processing plant to meet all operational needs.

The PWC and INPEX are in consultation regarding power and water supply; and consideration of any upgrades and/or modifications to infrastructure that may be required. The plant water supply will connect to the existing main in road reserve at Wickham Point Road (connects to Darwin potable water supply, via McMinna Water Treatment and Storage Facility). Water for the village will be also be supplied from Darwin Potable water supply, however it is intended to connect directly to the mains and not to the Whitewood Road aboveground tank.

Sewage treatment

During the early construction period, covering site preparation and bulk earthworks, temporary ablution blocks will be supplied for the on-site personnel. For the peak construction period, a temporary sewage treatment system will be installed. This system will be used during the rest of construction and commissioning. For operations, a combined wastewater and sewage treatment plant will be installed. The water will be treated to a quality that will allow for on-site reuse (e.g. for irrigation and watering or for discharge if it meets the requirements of the waste discharge licence to be issued for the Project by the Northern Territory Government).

Social and economic impacts and benefits (employment/workforce)

The economic effects and benefits of the Project are detailed in Section 10.4 of the Draft EIS, which outlines the positive effects the Project will bring to the economies of Darwin, the Northern Territory and, more broadly, Australia.

INPEX is engaging with local and national businesses through the Australian Industry Participation Plan and Northern Territory Industry Capability Network to encourage and allow participation in opportunities for employment, subcontracting and business engagement in project.

The social impact assessment undertaken from June to September 2008 indicated, in relation to Darwin–Palmerston demographics, that the area is socially well equipped and has a long history of integration with diverse permanent and transitory populations.

Submission 9-2: Develop a series of tourism related fact sheets which consider the following: o Information about where the labour supply will be sourced from, the range of skills needed for the construction phase and the proportion of unskilled labour requirements from the total pool. This will give the industry a sense of the level of skills shortages and upward pressure on wages that might put pressure on the tourism sector, and enable counteractive measures to be considered.

- Potential impediments to harbour access through safety exclusion zones during both the construction and operational stage of the project which may affect marine based tourism operators. (It would also be advisable for Inpex to map the current tourism use of the harbour to determine real versus perceived impacts, and to enable direct engagement with affected operators as the project progresses).
- Potential risks to marine fauna, mangroves, fish stocks etc and the associated mitigation measures and monitoring programs which will be established.
- Potential opportunities for promotion of tourism experiences amongst the Inpex labour force and their families (e.g. Inpex may consider providing a 'Welcome to Darwin' pack that includes information on the range of recreational and tourism opportunities available, or establishing within the local Inpex HR team a staff member who acts as a dedicated tourism liaison to engage with Tourism Top End to support employees with visiting friends and relatives etc.)
- Information about the project which is aimed at visitors (as opposed to tourism industry) to Darwin and the Top End.

Submission 9-6: Potential increase in aviation capacity to support fly-in-fly-out employees may contribute to additional capacity for visitors and complement existing efforts of the Northern Territory Government, as outlined in the Aviation Futures 2015 strategy. Construction and the resulting economic activity from the project will help build the business and corporate travel market and consequently support increased airline services by full service airlines. This would be very welcome.

Submission 9-7: There may be potential tourism application of any additional accommodation developed to support the construction phase of the project and this would be welcome. The project may stimulate investment in commercial tourism accommodation stocks beyond the accommodation village at Howard Springs (e.g. hotels, serviced apartments etc) and the boost in economic development of the Top End provides a strong signal for investor confidence in other sectors.

Submission 9-8: The significant increase in labour to support the project may support a boost in tourism demand over the construction phase, though given the six day roster structure; this is likely to support attractions and experiences that are directly within the Darwin region, rather than supporting regional dispersal of visitors or extended touring products. Visiting friends and relatives of the construction labour market may increase the demand for tourism beyond the Darwin

Submission 9-9: Additional housing stress resulting from the Inpex staff that relocate to Darwin and seek accommodation outside of the proposed Howard Springs accommodation village will place further unwelcome pressure on the availability and affordability of housing for the tourism labour market, particularly in peak visitation periods (April – September) when the industry relies on seasonal workers.

Submission 9-10: Increases in demand for unskilled labour in sectors offering higher wages than tourism, such as mining, have created competition for the tourism industry with many companies unable to recruit enough staff (particularly tour guides and coach drivers). This can have significant impact on the quality and standard of service delivery within the industry. With the Inpex project focussed on sourcing labour from the local pool, this may have the same effect on the tourism industry as recent mining booms have had. The tourism industry has had previous experience of these stresses when the Bechtel plant was built around five years ago and staff turnover in some tourism businesses soared above 300% annually.

Submission 9-11: Competing demand for construction workers between Inpex and tourism developments may drive up construction costs. This could undermine investment in new tourism infrastructure (especially in hotels) during the construction phase of the Blaydin Point plant.

Submission 9-12: Darwin Harbour is significant for its tourism and recreational value. The absence of marine pests, visual amenity, marine fauna and fishing opportunities provide a platform for a range of tourism experiences. The Ichthys project presents risks which span all of these areas, and therefore has the potential to negatively impact the tourism value of the harbour.

Submission 9-13: The project may undermine the clean, green image of the Northern Territory. An anticipated example of this is the very likely negative attention we would receive should the Inpex suggestion to carry out blasting at Walker Shoal with the very real risk of death or injury to a wide range of marine animals.

Submission 93-1: The enormity of this project will have a profound impact on the economic development of the Northern Territory and the city of Darwin.

Submission 93-2: This project will generate many opportunities for Tourism Development but will also create some pressures on the Tourism Industry particularly all industry that interacts with Darwin Harbour.

Submission 93-3: The EIS has limited reference to Tourism collectively, that operates within the Darwin Harbour.

Submission 93-5: Scenic harbour cruises and general leisure Tourism appears to be not identified or addressed in the EIS.

Submission 93-6: Considerable reference to Fishing within Darwin Harbour from a leisure perspective, Tourism is not segmented.

Submission 93-7: Tourism Top End has not received feedback from members that condemn or oppose the development of the Gas Plant in the Darwin Region.

Submission 93-8: Many would like it to be invisible and located in an area that required less construction activity on Darwin Harbour sea bed.

Submission 93-11: 3. The EIS clearly identifies that it will impact on the plant life, wildlife and general ecology within Darwin Harbour substantially during the installation of the shipping channel. The Tourism Industry is voicing that it has concerns that there is insufficient protection of wildlife and plant life and that further consideration must be taken to minimise any impact.

Submission 93-12: Construction and the resulting economic activity from the project will help build the business and corporate travel market and consequently support increased airline services by full service airlines.

Submission 93-13: The project may stimulate investment in commercial tourism accommodation stocks and boost the economic development of the Top End that will generate confident investment in new Tourism Infrastructure.

Submission 93-14: Additional labour force required during construction could deliver positively to the Tourism Sector from temporary workforce and its visiting friends and relatives sector with a focus on regional dispersal.

These submissions raise a number of issues that relate to the tourism industry and tourism operators within the Darwin region. These include the potential for the Project to impact the labour market and therefore place pressure on the ability of the industry to recruit successfully and retain staff; potential impacts on housing availability and affordability; and concerns with impacts on the image of Darwin Harbour especially through the previously proposed blasting program. These issues have been addressed initially in the Draft EIS and furthermore, in response to community comment and design changes, in this EIS Supplement.

INPEX acknowledges all the suggestions put forward in this submission and the issues of concern raised, and will continue to consult with the tourism industry to mitigate potential impacts and develop opportunities for business growth.

Submission 19-4: # (4) If something does go wrong in the Darwin region, if your plant was given the go ahead, then how would Darwin cope with the current lack of medical services?

INPEX undertook consultation with (and reviewed relevant reports published by) Health and Medical services in the greater Darwin region. In particular INPEX contacted the Department of Health and Families who manage Royal Darwin Hospital. DHF indicated that existing emergency services would be able to support a medical emergency in the unlikely event of a medical emergency occurring associated with the Project development. However they also advised that triage services are currently constrained/over capacity, and therefore existing services would be unable to support the additional personnel associated with the construction workforce.

INPEX will provide first aid/medic services for project, and this will include access to a GP between the Village/Project site at Blaydin Point. A new 24/7 afterhours support service is opening to assist general medical/afterhours medical support to Darwin/Palmerston.

INPEX will also undertake ER Planning which will form part of Emergency Response Management Plan (and will include consultation/liaison with ER services such as Police, Fire and Ambulance/Medical services).

Submission 23-1: Sea Darwin is exceptionally disappointed that that the EIS does not acknowledge the presence of eco-tourism on Darwin Harbour, or the impact that the IGFDP will have on this sunrise industry.

Submission 23-7: At a personal business level, Sea Darwin holds grave concerns that should the practices as outlined in the EIS be instituted, it will be the death knell of eco tourism on Darwin Harbour, and consequently result in financial detriment to at least one small business. Sea Darwin hopes that INPEX is mindful of this impact, and acknowledges their responsibility to act ethically in considering the implications for all stakeholders.

Submission 93-4: There is limited reference to the value of Eco Tourism yet there is considerable identification of the significant plant and wildlife with in Darwin Harbour.

The specific issue of eco-tourism in Darwin Harbour has been identified through the public consultation process associated with the publication of the Draft EIS. While tourism in general has been acknowledged this particular segment of the industry requires further consideration.

These issues have been addressed initially in the Draft EIS and furthermore, in response to community comment and design changes, in this EIS Supplement.

INPEX will continue to consult with the tourism industry to identify potential threats to the eco-tourism industry and will continue to develop mitigation strategies to address potential impacts and conversely improve opportunities for business growth.

Submission 23-2: Sea Darwin acknowledges the apparent economic benefit to Darwin, however there is no mention of tourism other than recreational fishing in 'Socio – economic impact' Chapter 10 of the EIS. In addition to Sea Darwin, there is one other 'eco accredited' operator on the harbour plus sunset tour operators. This non fishing component is a significant part of the tourism industry in the Northern Territory, all of whom rely on income from showcasing the pristine state of Darwin Harbour. It is the view of Sea Darwin that any negative impact on the harbour environment from heavy industry will therefore be bad for business, certainly for fishing and those businesses that are showcasing the unspoiled attributes of Darwin Harbour. Sea Darwin strongly believes that harbour tourism, particularly eco-tourism, should be an item on the INPEX commitment register Chapter 12. Sea Darwin considers that INPEX should consult relevant stakeholders to develop a harbour tourism policy relevant to IGFDP, especially concerning construction and the post construction phase of the development.

The concerns of the tourism industry and individual operators concerning the potential impacts of the Ichthys Project were identified through the community consultation process both before and after the release of the Draft EIS. INPEX acknowledges these concerns and will continue to consult with tourism operators as Project design continues to evolve and potential impacts on tourism activities become apparent.

Submission 53-1: There is no mention that the region is of relatively low fishery productivity and that all fisheries are considered fully exploited (Fletcher and Santoro, 2009). Therefore, any additional pressures, including any potential negative effects of the proposed gas line, carries the risks of reducing fishery productivity from current levels. This may result in an increasing need for fishery management in these fisheries.

Submission 53-11: Figure 10-10 is misleading as it does not indicate the offshore fisheries (e.g. NDSF, Mackerel), which occur along in this area. While the effort details can not be shown due to confidentiality reason, the area of the designated fisheries could be shown and it should be noted within the text that the NDSF is a fully exploited fishery. The present map gives the impression that there is no fishing in areas along the pipeline. (Figure 10-10)

Submission 53-12: This does not mention the main risk to commercial fishing, which is potential exclusion from prime fishing grounds and lower catch rates as a result of this and activities during the construction and operational phases. (Table 10-21)

Submission 53-13: General comments on this section (10.3.12): There appears to be an impression that because there is a small number of operators in the offshore fisheries, that there is little fishing activity and these fisheries are of minor importance. This is certainly not the case. The NDSF is fully exploited and DoF manages this fishery through effort quota and a cap on the number of licences issued. This fishery targets high value species and is an important fishery in Western Australia.

Comments 53-1 to 53-3 and 53-7 to 53-14 all relate to commercial fishing and Project activities. They have been separated into broad topics for ease of responding but should be reviewed together for a more comprehensive discussion on potential impacts and management strategies for the Project in relation to commercial fishing activities. The specific sections relating to commercial fishing in the Draft EIS are listed below and should be reviewed in conjunction with the material presented herein:

- Section 3.7.4 in Chapter 3 *Existing natural, social and economic environment*
- sections 10.3.5 and 10.3.12 in Chapter 10 Socio-economic impacts and management.

Commercial fisheries and Draft EIS information sources: The Draft EIS relied on two internal reports (INPEX 2009 and 2010) that collated information on the state of commercial fisheries in the area of the Ichthys Field and the pipeline. During the preparation of these reports various stakeholders were consulted, including the Commonwealth, Northern Territory and Western Australian fisheries departments, and various published reports from these bodies provided the information that allowed an assessment of potential impacts to commercial fishing to be made.

INPEX acknowledges that the submitter's comment is correct in that the region is of relatively low productivity for fishing and that all fisheries are considered fully exploited (Fletcher & Santoro 2010). However, the area of the corridor traversed by the 1.07-m-diameter gas export pipeline is negligible in comparison with the area being managed, which extends from the shoreline out to the 200-nautical-mile limit of Australia's exclusive economic zone. The pipeline corridor will not result in an increasing need for management in these fisheries. Furthermore, once the pipeline is constructed and commissioned, an exclusion zone will not be applied to it and it will be added to marine navigation maps. Rock-armour will only be laid over the pipeline in the nearshore regions to protect it from other activities which may occur in the area. This, however, will be a localised and short-term activity and it will not extend along the total length of the gas export pipeline.

Commercial fishing activities

The Ichthys Field covers waters under Commonwealth jurisdiction (but with Western Australia as the "designated authority") and while the gas export pipeline extends from Western Australian and Commonwealth waters into the Northern Territory at the nearshore end. The discussion on potential impacts to commercial fishing activities focused on those areas that were identified to have overlap with proposed Project activities, and not a review of all fisheries around the North West Shelf and Top End. However some of these data have been provided in this response to provide details on consultation undertaken.

During the preparation of the Draft EIS, the following fisheries activities were identified as overlapping the Ichthys Field and gas export pipeline area of interest:

- Commonwealth fishery – 5 areas were identified
  - the North West Slope Trawl Fishery
  - the Northern Prawn Fishery
  - the Western Tuna and Billfish Fishery
  - the Southern Blue Fin Tuna Fishery
  - the Western Skipjack Fishery.

- Western Australian – 4 areas were identified:
  - the Kimberley Prawn Managed Fishery
  - the Northern Demersal Scalefish Fishery
  - the Mackerel Managed Fishery
  - the Joint Authority Northern Shark Fisheries

In consultation with the Commonwealth fisheries management body, the Australian Fisheries Management Authority (AFMA), it was found that although a number of the fisheries did overlap the Ichthys gas export pipeline route, not all were actually fishing this area. Fisheries including the Western Tuna and Billfish Fishery (WTBF), the Southern Blue Fin Tuna Fishery (SBFTF) and the Western Skipjack Fishery (WSF) fall into this group.

AFMA advised that fishing effort for the WTBF, the SBFTF and the WSF was concentrated between south of latitude 30°S and west of 136°E, well outside the area of interest along the pipeline route (Joshua Fielding, Management Officer, Tuna and International Fisheries, AFMA, pers. comm. 16 December 2010).

The Northern Prawn Fishery and the North West Slope Trawl Fishery were the only fisheries identified as currently utilising areas within the gas export pipeline route (see Figure 5-7 and Figure 5-8 which show two of the identified fishing areas in relation to the Ichthys Field and the gas export pipeline).

The fishing efforts of NPF and NWST fisheries are identified on Figure 10-10 in the Draft EIS. This figure was not provided to indicate the fishing zones or areas in and around the Ichthys Field but to highlight areas of fishing effort, as provided by Northern Territory and Western Australian fisheries representatives or from published information. INPEX recognises that this does not represent all the fisheries present or potentially active in this area. INPEX has endeavoured to consult with relevant industry and government bodies where possible and welcomes the opportunity for ongoing or additional engagement.

The Mackerel Managed Fishery is divided up into three areas. The gas export pipeline area of interest falls within Area 1 of the fishery; this is the in the Kimberley region and extends from 121°E up to the Western Australia – Northern Territory border and out to the exclusive economic zone limit. During the 2008/2009 fishing period, there were only 4 vessels operating within Area 1. Operators of the Fishery are restricted to using either trolling or handline methods to fish (Fletcher & Santoro 2009). Further to this, Western Australia's Department of Fisheries, has advised that the fishery prefers to operate in areas close to the coast (Dr Stephen Newman, Principal Research Scientist, pers.comm. 6 July 2009). In consideration of this, the fishing methods used and the number of vessels operating within Area 1, the fishery is not considered to pose a risk to the gas export pipeline.

In addition to the Mackerel Managed Fishery, the Joint Authority Northern Shark Fishery (JANSF) also has boundaries that overlap the area of interest. This fishery is jointly managed by the Commonwealth and Western Australia. Fishing within the JANSF has been minimal, with only two vessels operating on an opportunistic basis since 2005. Taking into consideration the low fishing effort and the fishing methods used, the JANSF is not considered to pose a risk to the gas export pipeline.

While there are a number of fisheries of varying sizes in the region, available data demonstrate that the Ichthys Field is not a major component of the fisheries. For example, the Northern Demersal Scalefish Fisheries (NDSF) is divided into three areas (see Figure 5-7). The field is located in Zone C of Area 2. Combined catches for Zones A and C in 2009 were 137 t, most of which would have been from Zone A (Fletcher & Santoro 2009). In contrast, the 2009 catch from Zone B was 909 t. Fletcher and Santoro (2010) note that Zone C has historically been lightly fished and is likely to be less productive than Zone B. Thus the area is not a prime fishing ground.

Submission 53-2: The document implies that most of the pipeline will be laid in depths greater than 200m and therefore not impact many of the State's fisheries. However Figure 4.15 (P. 174) shows the depth profile of the pipe and more than 90% (ca. 800 km) will be laid in water depths less than 200m; much of the line will be laid in water depths around 100 m or less (some 700 km+). Depths less than 200m are prime areas for many commercial species. An exclusion zone around subsurface equipment over a pipeline of more than 800 km is potentially a significant amount of area that will be removed from the offshore commercial fisheries. Commercial fish species are not randomly distributed (Lloyd and Puig, 2009). Although the designated area of the NDSF is large, only a small proportion of this designated area is prime habitat for the target species. Thus fishers maybe adversely affected by exclusion zones.

Submission 53-9: The proponent states that longline fishers would need to set their lines 15 km upstream of CPF in order to avoid snagging. This would generate an exclusion area of 25,000 km2, which is not a small area as suggested in the proposal, particularly as fish are not evenly distributed through an area.

Submission 53-10: The proponent states that a “precautionary zone” will be established around subsea equipment. This is effectively an exclusion zone for fishers and the activity of some operators may be impacted.

Explanation on areas that may have restricted access near offshore facilities in the Ichthys Field

Section 10.3.5 of Chapter 10 *Socio-ecomic impacts and management* of the Draft EIS included terminology with regards to areas that may have limitations on entry (i.e. prohibited or restricted entry or activities) in the vicinity of INPEX’s activities in the offshore environment. Based on submitters’ comments and review of the information presented in the Draft EIS clarification of these terms and their application to the Ichthys Field and the gas export pipeline are provided below. It should be noted that this discussion does not include any exclusion or restricted access zones applicable to nearshore or Darwin Harbour areas.

The Draft EIS included the following terms in relation to offshore facilities and vessel entry or activity:

- **Safety exclusion zone:** is a prohibited entry area with a radius of 500 m around a specific facility. It will be put in place around surface and subsurface equipment in the offshore development area, such as drilling rig(s) (temporary during drilling activity), the central processing facility (CPF), FPSO and/or subsea architecture (e.g. wellheads, drill centres). The actual exclusion zones for the FPSO/CPF equates to a combined area of approximately 3.5 km^2. This will be gazetted with under the *Offshore Petroleum and Greenhouse Gas Storage Act*

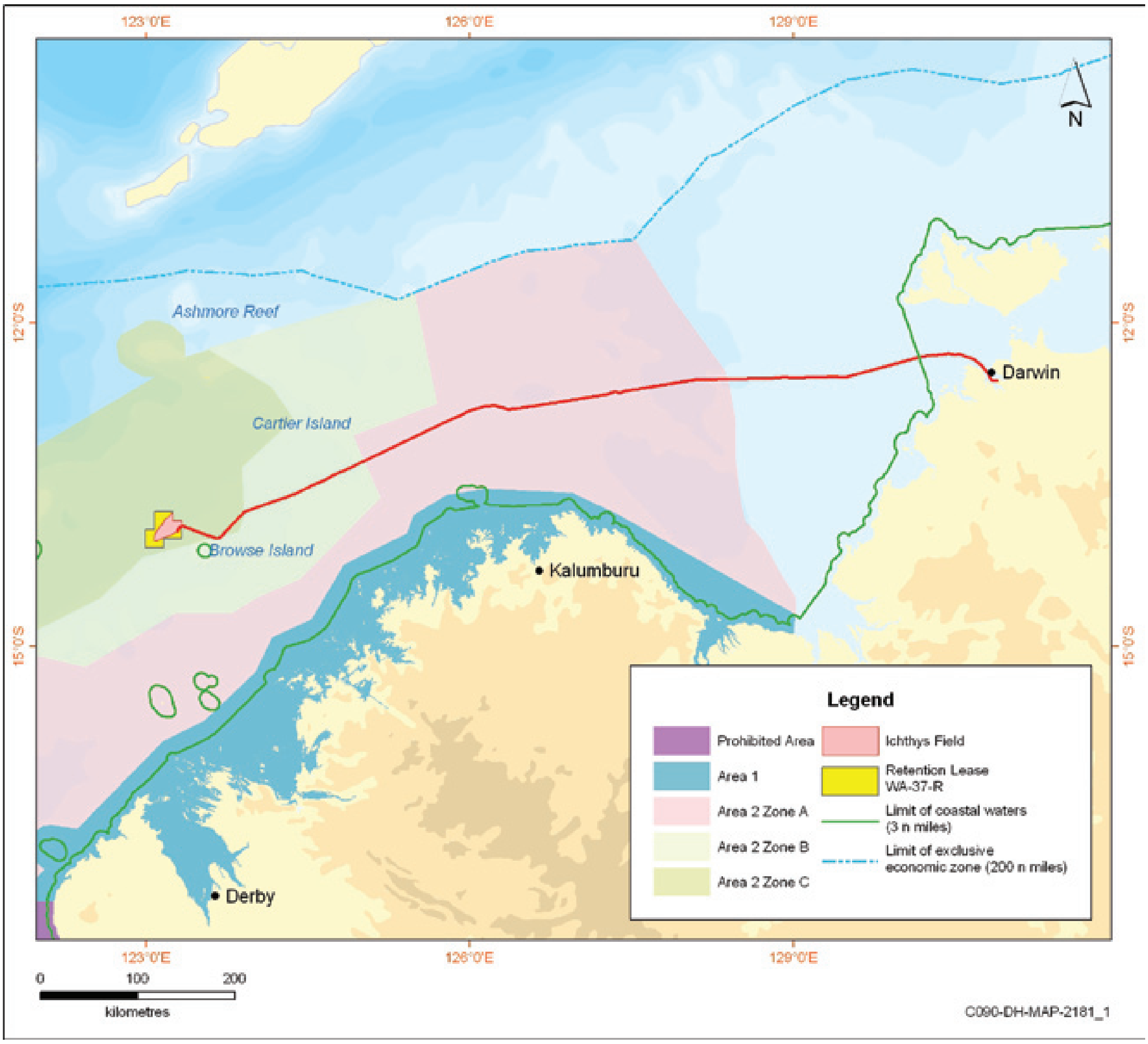

Figure 5-7: NDSF Fishing areas and zones in relation to the Ichthys Field and pipeline route

2006 (Cwlth). This exclusion zone is analogous with other offshore operations and is a standard regulatory and safety requirement to prevent harm to people and the environment or damage to assets through collision with other vessels/activities.

- **Restricted navigation zone:** of 5 nautical miles will be implemented around the offshore facilities in the Ichthys Field throughout the life of the Project. While the 500-m radius exclusion zone around the CPF and FPSO facilities prohibits entry into these areas, the restricted navigation zone places some restrictions on vessel activities (such as dropping or dragging anchors) within that area but does not prohibit entry.
- **Precautionary zone – Construction:** During the construction phase, INPEX will notify mariners of the pipeline installation activities. In Commonwealth waters, during the construction and commissioning periods and following further discussion with relevant authorities, INPEX may apply a **precautionary zone** of 200 m around the pipeline. If applied, within this zone it would be forbidden to drop or drag an anchor or perform an action that could potentially damage the pipeline. The zone will be gazetted and will appear on Australian navigational charts, (under Section 66(5) Threat to pipeline of the *Energy Pipelines Act* (NT).
- **Precautionary Zone – Operations:** INPEX is seeking to obtain regulatory agreement for a precautionary zone to be applied to the gas export pipeline for the **nearshore** sections of the pipeline (this is the section within 3 nautical miles/State jurisdiction waters). This area represents about 34 kms (pipeline length) in the Darwin Harbour area and 55.3 km from the Harbour exit to the Northern Territory – Western Australia boundary or approximately 10% of the total length of the gas export pipeline.

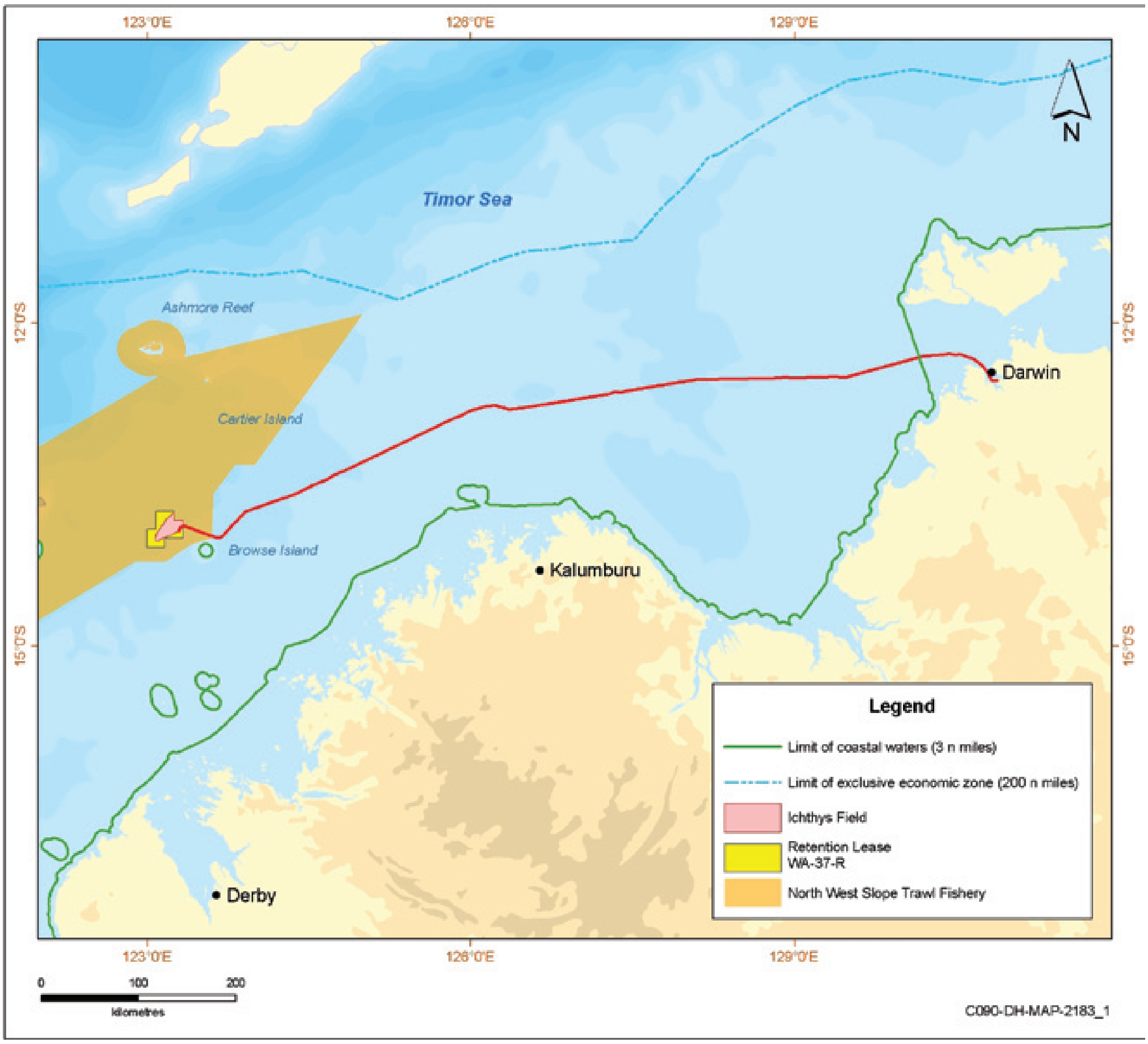

Figure 5-8: Area of the North West Slope Trawl Fishery in relation to the Ichthys Field and pipeline route (adapted from AMFA 2004)

- **Area of avoidance:** The area of avoidance represents an area in which INPEX makes recommendations to avoid certain activities within the Ichthys Field (specifically in the proximity of CPF and subsea equipment) and/or the gas export pipeline. In this instance the area of avoidance would be recommended to longline fisheries. Western Australia's Department of Fisheries annual reporting (2008/2009) indicates that trawling activities are not undertaken in the Ichthys Field. However longline fishing is undertaken in the area around the Ichthys Field. It is not a regulatory or enforceable area but is simply a recommendation that will be made to mariners to avoid the potential of having snags or losses of equipment when operating near or upstream of the platform or FPSO.

Ichthys Field area of avoidance

To clarify, the **"area of avoidance"** identified in the Draft EIS, suggested as 15 km upstream of the CPF and FPSO locations, is a recommendation to longline fishers to avoid potential snagging or snaring of their equipment with subsea equipment. It is not a prohibited or restricted entry area (also known as an exclusion zone) which is an area gazetted into legislation by regulators for safety purposes. The exclusion zone is 500 m from a facility (in this instance this will apply to the FPSO and CPF), which equates to a combined area of approximately 3.5 km^2.

Submission 53-9 mentions a total area of potential exclusion of 25 000 km^2. INPEX, however, cannot determine how this area was calculated; therefore the assumptions and calculations outlined in the Draft EIS are reiterated here.

Longline fishers have a cycle of setting, drifting and recovering their lines. The Draft EIS has made some base assumptions to estimate the recommended area/distance to avoid potential snagging with subsea or surface equipment. These assumptions are around the length of line, time in water drifting, retrieval time and then basic oceanographic conditions, as follows: surface longlines set for 4–5 hours followed by a 10–12-hour retrieval period for a total of 17 hours in the water. Base assumptions on oceanographic conditions are for a current speed of 0.25 m/s for a time period of 17 hours. On the basis of the above parameters and assumptions it was calculated that fishers would need to avoid setting their lines within 15 km upstream of the CPF so that they could complete the cycle of setting, drifting and recovery before reaching the CPF.

Area of Avoidance Calculations (for 15 km upstream recommendation):

1. Formula for calculating Velocity/speed: Velocity (m/s) = Distance (m)/ Time (sec) or **v = d/t**
2. Convert all relevant known number to correct units as used in formula: Convert 17 hours into seconds: 60 minutes in hour and 60 seconds in minute (60 × 60 = 3600) therefore conversion is 17 x 3600 = 61 200 seconds.
3. Velocity is assumed at 0.25 m/s for average current speed
4. Modify formula to calculate distance (velocity and time are known): D = v × t
5. Distance calculation = 0.25 × 61 200= 15 300 m.
6. Convert to kilometres = 15 300/1000 = **15.3 km**

It is possible to estimate this total area by using a further assumption that fishers apply a safety margin of 2 km either side of the drift centreline and 2 km down current past the CPF. On this basis the total area (recommended to be avoided) is calculated to be 68 km^2 (4 km wide by 17 km long) for each facility. When considered cumulatively with the FPSO (and assuming the same avoidance parameters), the total area within which fishers would need to avoid commencing the cycle of setting longlines is 136 km^2; not 25 000 km^2 as stated in the submission.

Submission 53-3: The stability of the pipeline will be achieved via a combination of weighing, trenching and rock dumping (p 174) – thus disturbance to 885 km of benthic habitat will occur, which may impact on fish habitat.

Submission 53-7: This table lists many of the chemical and physical risks associated with the laying of the pipeline. Many of these risks (e.g. turbidity plumes affect fish eggs and larvae; exposure of acid-sulphate soils; reduction in food and habitats) are evaluated as 'medium risks' and several are of concern to the Department, especially given the length of the overall pipeline (885 km). (Table 7-31).

Pipeline stabilisation: Section 7.3.2 of Chapter 7 *Marine impacts and management* of the Draft EIS refers to the nearshore section and shore-crossing section of the gas export pipeline which is in Northern Territory waters, but more specifically in Darwin Harbour, and therefore will not impact on the licence areas controlled by Western Australia's Department of Fisheries. Very little, if any, dredging will be required along the pipeline in the offshore waters.

Most of the pipeline will be laid to self-settle, with only one location outside Darwin Harbour requiring pre – or post-lay trenching and rock-armouring. Most of the route has been surveyed extensively and will be surveyed again prior to pipe-laying commencing to ensure that no obstructions or changes to seabed have occurred that may affect the installation. The Table 7.31 in the Draft EIS referred to in the submission relates specifically to the impacts associated with the pipeline installation in the nearshore and Darwin Harbour area and is not relevant to the offshore marine environment around the central processing facility or along the greater part of the gas export pipeline.

Submission 53-8: The recreational activities section states there is little recreational fishing in offshore regions, however, some important recreational species' are highly mobile (e.g. mackerel, billfish) and thus offshore impacts carry the risk that the movement of these species and availability of these species' inshore may be impacted.

As stated in the submitters comment, these species are highly mobile. However, the area impacted by the proposed development is minor compared to the range of the species. In addition, Fletcher and Santoro (2010), state that mackerel are concentrated in "coastal areas around reefs, shoals and headlands", not in the open areas of the Ichthys Field or the pipeline corridor.

Submission 53-14: Commitments Register: Needs to be updated in relation to comments raised in this review.

Additional information has been provided regarding commercial fishing and potential areas of restricted access around the Ichthys Project's offshore facilities and activities in the response to submitters' comments above, in particular to 53-2, 53-9 and 53-10 and to 53-1, 53-11, 53-12 and 53-13. INPEX considers that the material provided in the Draft EIS and the responses to comments on impacts to commercial fishing in this EIS Supplement accurately describe the offshore activities and potential impacts to the marine environment.

Submission 81-3: 2 Introduction, 2.1 Introduction – Paragraph 1.1

The EIS should state the Ichthys Joint Venturers do not intend to market any hydrocarbon products into Australia and all are, as stated "for export to markets in Japan". The EIS should confirm this is the reason for Inpex's incorporation – namely "To secure the energy future of Japan" and that this Mission has not changed in substance and is, in any event, a directive from the Japanese ministry METI, Inpex's major shareholder. It is notorious fact in the oil and gas industry that the Inpex Chairman and President are required to report to METI within half an hour of being directed to do so no matter what time of the day or night. METI effectively directs Inpex including on matters such as award of contracts (invariably to Japanese companies) and LNG sales (always to Japanese companies).

The introduction to the Draft EIS (Section 1) clearly states that products generated from the Project, namely LNG (liquefied natural gas), LPGs (Liquefied petroleum gases) and condensate are for export to Japan and elsewhere. Information in regard to INPEX Corporation, as Project proponent, is also provided in Section 1.1 as a background to the environmental assessment process. Other aspects of this comment are unsubstantiated and lie outside the scope of an environmental assessment process.

Submission 81-5: Whilst Inpex asserts it has recruited personnel with experience, the fact is every position of authority within Inpex is occupied by a Japanese national with no experience in developing oil and gas projects or any other relevant experience.

The company structure is based on race and nationality.

Australian nationals are recruited into a shell company set up for the sole purpose of employing Australian nationals. Japanese are employed by the parent company. Inpex has an appalling reputation as an employer engaging in wholly inappropriate employment practices.

The EIS should set out how Australian nationals will be recruited, retained and empowered to act in a manner which will ensure safe and efficient construction and operation of the LNG Project.

If this cannot be done, approval should not be given to proceed with this Project unless an experienced operator is appointed. Australia, Western Australia and the NT should not be letting Inpex learn the business at their expense on a field and resource which is world class and at least 50 times larger than Montarra.

Inpex should be required, at a minimum, to comply with immigration laws and appoint Australian nationals to key positions and should send back to Japan those unqualified Japanese who are filling jobs which should be done by qualified Australians. If no satisfactory arrangements can be put in place, Inpex should not be allowed to proceed with the Project.

The Project has engaged and continues to engage a range of highly experienced LNG professionals from around the world as well as including representatives from both Total and INPEX. All engagement – and employment-related matters are conducted in accordance with local regulations and based on merit. Any further details on recruitment are beyond the scope of the environmental impact assessment.

Submission 81-7: 4 Chapter 10 – Socio Economic impacts

EIS should state the amount of Petroleum Resource Rent Tax (PRRT) the Project will pay. Presumably this has been omitted as the answer is zero or very close to zero.

The EIS should contrast PRRT on a Darwin case with PRRT on a Kimberley LNG Hub case.

The same should be done for corporate tax.

Section 10.4.1 in Chapter 10 *Socio-economic impacts and management* of the Draft EIS gives the outcome of detailed economic modelling and provides a meaningful measure of the contribution that the Project will make to the Northern Territory and Australian economies. The scope of the Draft EIS does not require INPEX to provide comparative analyses against other projects that the company is no longer pursuing.

Submission 107-6: The description of impacts and risks would have been more complete had socio-economics and the conservation significance of species been considered in terms of Aboriginal cultural tradition and patterns of natural resource use. This would have been more beneficial to the Larrakia people, who have been recognised as the traditional owners of the Kenbi (Cox Peninsular) area facing Blaydin Point: their cultural knowledge and interpretation of the existing environment should be part of environmental assessment and could add usefully to the development of appropriate management plans.

Submission 107-56: It does not deal with Aboriginal people or their culture as a separate matter, considering them a part of the wider European based cultures now dominating the region. While the management of Aboriginal cultural heritage is a matter between INPEX and the Larrakia people, the NLC has some concerns outlined below.

Submission 107-57: INPEX states that there are three archaeological sites that will be required to be disturbed during construction — all within the road access corridor. An alternative approach is to realign the road corridor to allow these sites to remain. Removal or destruction of an Aboriginal heritage site should be considered a last resort, rather than a matter permissible under law; consequently the rationale why the road corridor cannot be re-aligned to allow the sites to remain should be detailed.

Submission 107-58: Installation of flagging, temporary fencing and signage 5m from an Aboriginal heritage site boundary appears to be too small and arbitrary. The reasoning for this distance should be provided and the distance extended to ensure that adequate space is available for manoeuvring of construction equipment.

Submission 107-59: There is no reason why the value of an Aboriginal heritage site to the local Aboriginal community could not be estimated. Values attributed by newcomers to the area are irrelevant in terms of value of a heritage site to Aboriginal custodians. Valuation of all parts of the cultural landscape (which includes heritage sites) is an important part of baseline studies that are required during the rehabilitation and closure process and should therefore be undertaken as part of the environmental assessment process.

Submission 123-157: "Potential Impacts" (Table 8-6); the discovery/disturbance of unrecorded prescribed archaeological (Aboriginal heritage) sites that are protected under the Heritage Conservation Act. Included under "Management controls/mitigating factors" should be education of all construction workers as to what a site (e.g. a midden) may look like and/an archaeologist and/or Larrakia representative to be present when clearing activities taking place. There is a moderate chance that vegetation clearing will reveal more sites, given the relatively dense vegetation cover in this area and the history of sites being revealed by clearing works previously.

Submission 123-161/123-188: In order to avoid inadvertent disturbance of prescribed archaeological sites and thus breaching of the Heritage Conservation Act, an adequate distance would be 50m, not 10m from the external boundary of an Aboriginal heritage site, that triggers INPEX to flag and fence off that site and provide education and coordinates to contractors prior to works commencing – 10m is an inadequate distance when large machinery is being used. (2 comments were made in relation to content in Ch. 10 and Chapter 11, Annex 9 respectively)

Table 8-6 to which Submission 123-157 refers does not relate to Aboriginal cultural heritage. The relevant table appears to be Table 10-13 in Section 10.3.8 of Chapter 10 *Socio-economic impacts and management*. Therefore Table 10-13 and Section 10.3.8 have been used as the basis from which this comment is answered.

Aboriginal stakeholder engagement

INPEX's Aboriginal and Torres Strait Islander (ATSI) Engagement Policy, adopted in July 2010, commits the company to the goal of working with ATSI peoples and communities wherever its activities occur in Australia, with the aim of building sustainable mutually beneficial relationships. In keeping with this policy, INPEX is engaging with the Larrakia people through the Larrakia Development Corporation (LDC) to ensure that INPEX and the Larrakia people work collaboratively to identify and put in place mutually acceptable initiatives. INPEX has also entered into a memorandum of understanding (MOU) with the LDC that records each party's intentions and expectations in relation to the development of a mutually beneficial relationship for the life of the Ichthys Project in Darwin (see Section 4.6.1 of this EIS Supplement for further details).

INPEX has mechanisms in place for ongoing engagement of this group throughout the Project. Section 10.3.8 of Chapter 10 the Draft EIS summarises the engagement by INPEX with Larrakia representatives through the LDC and the Northern Land Council.

All matters relating to actual or potential Aboriginal heritage sites have been discussed with the LDC. Representatives from the LDC were involved in the Blaydin point archaeological heritage surveys and were integral to the development of the Project's heritage management plan. The heritage management plan covers INPEX's area of interest at Blaydin Point and defines the process that will be used to manage Aboriginal sites.

The heritage management plan identifies where direct involvement of Larrakia representatives is required during the Project's construction phase, for the purpose of managing any other potential heritage or archaeological sites that may be identified during site preparation. The processes to be undertaken in the event that a site is identified have been outlined in the heritage management plan.

Annexe 9 *Provisional heritage management plan* to Chapter 11 *Environmental management program* of the Draft EIS outlines the framework and high-level management strategies for the final heritage management plan which will be developed in consultation with representatives from the Larrakia people and submitted to government for approval prior to issuing for use.

Disturbance to Aboriginal cultural heritage sites

As part of the archaeological and heritage surveys and heritage management plan development process, the significance of identified heritage sites was assessed and each site was assigned a value. Bourke and Guse (2007) discussed the topic of cultural tradition and patterns of natural resource use at Blaydin Point and their report was used as one of the reference sources for the development of INPEX's Blaydin Point heritage management plan.

Management strategies for the avoidance of inadvertent disturbance to significant sites, including buffer distances, fencing and signage, were discussed with representatives of the Larrakia people and agreed to be adequate. Following further advice from the Department of Natural Resources, Environment, the Arts and Sport, INPEX agreed to increase the distance for flagging and fencing of Aboriginal heritage sites to 50 m, or to the greatest extent possible where 50 m may not be achievable.

The Draft EIS also stated that "three sites will be required to be disturbed during construction of the onshore facility: one isolated artefact located close to the pipeline corridor, a shell and stone artefact scatter and a subsurface midden/shell scatter located within the access road corridor". These sites were identified as of low significance and disturbance to the sites was discussed with Larrakia representatives. However, since the Draft EIS was published, optimisation of the onshore design has occurred and alternative approaches assessed with consideration of heritage sites, safety, land availability, vegetation impact, operational impact, and cost.

Through this process, INPEX made a decision to pursue only options that avoided disturbance to the identified Aboriginal heritage sites along the onshore pipeline route and the area of the combined operations complex. Disturbance to the three sites mentioned above is therefore no longer required.

Education in cultural heritage management

The heritage management plan includes a requirement that relevant construction workers receive training in the identification of Aboriginal sites. In addition, INPEX proposes to include information relating to Aboriginal culture and heritage sites in site induction materials, as well as in day-to-day site preparation and clearance activities through toolbox meetings, job hazard analyses etc.

A Larrakia Heritage Management Committee (LHMC) made up of Larrakia representatives and INPEX will be established well in advance of any site works being undertaken at Blaydin Point and will coordinate the compilation of materials to be included in site training and inductions.

INPEX's "Aboriginal heritage management plan: onshore development area and Darwin Harbour" states that the aim of the induction for INPEX Ichthys Project employees and contractors will be as follows:

- to ensure that all employees, contractors, subcontractors, and consultants are aware of their obligations under the *Northern Territory Aboriginal Sacred Sites Act* (NT), the *Heritage Conservation Act* (NT) and other applicable legislation
- to endeavour to ensure that sites are protected and that further impact is minimised
- to make all employees, contractors, subcontractors, and consultants aware of Larrakia traditions and culture as they relate to the Project Area
- to instil in inductees a basic understanding of the Project's heritage management plan, including specific guidelines on issues that may arise from time to time
- to promote a knowledge and understanding of, and respect for, Larrakia and other Aboriginal and Torres Strait Islander tradition and culture
- to foster good relationships between the Larrakia people, other Aboriginal and Torres Strait Islander and non-Aboriginal people in accordance with the heritage management plan.

Submission 107-55: This chapter deals with the potential impacts of the project on the community and their appreciation and use of the environment. While this chapter speaks of impacts on the community, it does not appear to detail the potential health risks presented to people by contact with waterborne residues that might arise during spillage, leakage or equipment failure during operations. Impacts on marine biota and terrestrial species are documented, but the absence of discussion of the potential impacts on human health would seem to be a glaring omission — even if the risk is low.

Routine emissions and discharges from the plant will not pose any health risks to the community. Therefore, assuming the submitter is referring to accidental events such as spills and leaks, the plant site has multiple controls to ensure potentially contaminated water is captured and contained within the process system/site boundary. For example, the LNG train processing area will be contained within enclosed and bunded areas, with closed drain systems so that any water or other runoff is directed to the wastewater treatment plant. At the plant, water will then be directed through the various treatment facilities before discharge. INPEX will monitor the treated wastewater prior to discharge to ensure compliance with discharge limits. There will also be an option to discharge treated wastewater to grounds around the plant for irrigation or infiltration.

In the unlikely event of an incident resulting in a spill that overloads the treatment system or flows direct to the Harbour, INPEX would notify government authorities, who may chose to restrict public access if there was potential for concerns to human health. In such event, INPEX's Emergency Response Plan would be activated and clean-up/containment undertaken. INPEX will be periodically monitoring selected contaminants such as "heavy metals" and hydrocarbons in marine sediments/waters and bio-indicator species in the vicinity of the WWTP outfall and will compare levels against published health and environmental standards. This is likely to include some species that are known to be consumed locally by humans including shellfish such as "long bums" (e.g. *Telescopium* sp. and *Terebralia* spp).

Submission 112-2: I acknowledge the projected impacts on Darwin's economy. I don't accept the conventional wisdom that such a huge lurch in economic activity is welcome. I actually doubt that our city is really ready for such a period of massive short-term growth. The challenge for our city, as for the planet, is to learn how to engineer a new economics that is based on sustainability, not unconstrained growth. I worry that this surge of unprecedented economic activity will lose us much that we value of our home, while taking us towards a future that few of us have considered, let alone consented. I note that much of the employment generated by this project will be for workers from elsewhere, while local people will be confronted with a range of negative social and local economic impacts, such as increased housing stress, constriction of the labor market and trade sectors (as experienced during the Wickham Pt construction) and dramatically altered demographics.

Submission 19-6: We did not discuss the potential problems associated with a WORK FORCE that is uncouth and needing supervision after hours because that is a problem already associated with Darwin and its lack of policing and governance. Nor did we enter into the problems of housing and the impact on the market prices as that is also an existing problem that should be addressed by this lazy government.

Submission 7-28: There is no benefit to the local resident, other than labouring jobs for a short term contract

Submission 7-29: The shortage of work in other states will encourage interstate and visa workers for the short term and in turn increase the pressure for more affordable housing.

INPEX welcomes all comment in regard to the proposed Project, and these views are noted and published accordingly. However, some of the comments raise issues that INPEX is not a position to respond to or does not have the authority to answer, or that are outside the scope of the environmental assessment process. Where possible, INPEX has responded to the issues raised in these submitters' comments below.

INPEX's preference is to utilise suitable local workers subject to their level of skills, qualifications and experience. However there will be a need to supplement the workforce with recruitment from skilled and unskilled labour pools, regionally, nationally and even internationally as necessary. The bulk of the construction workforce will be housed at the accommodation village.

INPEX and its contractors will have in place policies and steps regarding workforce behaviour expectations and management. The facilities at the village will be designed to provide an environment that is comfortable and meets the needs of the personnel.

Personnel working at sites associated with the Project will be required to adhere to the Project's policies and procedures, including codes of conduct and participation in workplace drug and alcohol testing.

It has been recognised that some other workplaces and industries may be affected by labour requirements and opportunities. To assist in this area the Northern Territory Government is planning to increase training and development to backfill potential gaps in other trade and industries.

INPEX is engaging with the Northern Territory Government on the labour demands for the Project, including the training of local people and Aboriginal peoples for working on the Project and in the community in the longer term.

Submission 118-1: Transport of equipment and materials. There needs to be clarification of the routes that will be used for the transport of equipment and materials. Obviously materials such as rock, sand, cement and asphalt will have to be transported to Blaydin Point. Rock will also have to be transported to the East Arm Port. The routes shown on the maps shown as Fig 10.1 and 10.2 show the wrong direction to Mt Bundy and include Lambrick Avenue which is closed to doubles and triples. Traffic to Blaydin Point would have to go via Jenkins Road near Noonamah. Traffic to the Port would go via the Stuart Highway, the new Tiger Brennan and Berrimah Road. The construction of the worker's accommodation village will also have an effect on local roads.

Submission 7-39: "Figure 10-1 Assigned traffic routes. The completion of the Tiger Brennan Drive to Palmerston will have nil effect on the number of cars utilising Wishart Road to access work destinations in the industrial areas of Berrimah, TDZ, East Arm or the new industrial area being built on Wishart Road. There is no direct road onto Tiger Brennan Road from Palmerston so people entering onto Elrundie Road from their suburb continue on Wishart to Berrimah Road – many that work in the northern suburbs also utilise this track to Vanderlin to avoid the bottle neck at the CBD Roystonea lights & Stuart H/Way. Further work at the CDU residential area effectively making Yarrawonga Road a cross road and the additional lights on University Ave/Chan Wah Terrace makes the CBD a further bottle neck. The exit road out of Durack onto Wishart is currently a dangerous T junction both morning and night and abuts the railway line with boom gates. The road is also utilised by cattle transporting prime mover + 2 trailers.

The timing of traffic volumes commencing at 7.15am are probably not early enough. Trades persons usually commence work at 7am so they would have already travelled through. Hospital staff shifts commence 6am, 7am and 8am so inbound traffic would be missed. University staff & Govt workers commence 8am in Casuarina so many would also be through this period. Government workers travelling into Darwin would also be mostly through even if they add to the traffic at the Berrimah/Tiger Brennan intersection – they still have to find car parking on arrival to their destination. In addition schools commence 8am so there are many school buses and parents having to drop children off prior to going to work. This is probably the reflection of the difference between a.m. and p.m in Table 10-5. The prime movers + trailers and buses turning right onto the Stuart Highway from Berrimah Road in the morning between 6.30am and 7.15am can hold traffic up for a couple of sets of lights – particularly if turning right from Stuart H/way into Berrimah or Vanderlin Roads."

Submission 86-6: The proponent should review its proposal to use B Doubles to move equipment and materials to and from site. There are currently approximately 6 B – Double configurations registered in the Territory. Innovative road train configurations that have been used by other projects have reduced trip requirements by up to 50% compared to the B-Double configuration.

Submission 86-7: Jenkins Road is proposed to be upgraded to sealed standard prior to project movements from the quarry commencing. Therefore, Jenkins Road should be examined as an alternative route to Lambrick Avenue for the movement of rock from the quarry to Blaydin Point.

Submission 86-8: The EIS indicates that the Lambrick Avenue – Stuart Highway intersection is at saturation . The proponent should examine whether offsetting the time of construction (personnel) movements from non-project related peak periods will mitigate the identified issues at this intersection.

Submission 128-48:

- Transport: Council is aware that Inpex may be planning to provide accommodation for its workforce in Howard Springs.

Council requests an account of how Inpex will provide or facilitate transport for its workforce from Howard Springs to the project site in consideration of traffic congestion and any other traffic management issues.

It is acknowledged that the routes shown in the Draft EIS Figures10.1 and 10.2 show the wrong direction to/from Mount Bundey. INPEX is undertaking additional studies into rock supply options in the Northern Territory (around Darwin region) and viable transportation alternatives. Transport options and road routes presented in the Draft EIS are therefore under review and final routes are still to be finalised.

Additional information on rock supply, Project traffic estimates and transport options (including road and route selection) is provided in Section 3.3.3 of this document. INPEX continues to investigate transport options to reduce potential traffic loads on existing roads, potential development options and alternative transport options. INPEX is in regular dialogue with Northern Territory Roads regarding the selection of suitable transport options and routes.

Submission 118-3: Workers' Accommodation The workers' accommodation at Howard Springs will certainly have an impact on the surrounding residential and retail area. Some of these affects are mentioned in the Socio-Economic Impacts section of the EIS but I believe there needs to be a more fulsome study done. For instance what will be the effect on the local roads due to the increase in traffic travelling to and from the accommodation village? Should there be an upgrade of Howard Springs Road between Whitewood Road and the Stuart Highway? Will there be sufficient water storage in the Whitewood Road water tank to supply the accommodation village without effecting local supplies and pressure? While I realise that matters relating to the accommodation village may be dealt with at the planning application stage later on, the issue is mentioned in the EIS and deserves some comment.

Detailed design of the proposed accommodation village for the Ichthys Project's construction workforce at Howard Springs is yet to be undertaken and is scheduled for later in 2011. When more information and data are available, a more detailed assessment of the impacts of the accommodation village will be possible and will be addressed in the planning application.

The most recent information regarding traffic volumes and routes is provided in Section 3.3.3. In the interim, the traffic modelling and impacts presented in the Draft EIS take into account the best available information at the time of publication (July 2010). INPEX is committed to remodelling all traffic impacts at a later date when more detailed traffic data become available. The outcomes of such modelling will provide specific answers to the questions raised in this submission and will facilitate informed discussions regarding the perceived need for road infrastructure upgrades or construction.

INPEX is in ongoing dialogue with the Northern Territory's Power and Water Corporation (PWC) regarding water supply to the accommodation village. Both INPEX and the PWC are aware of a potential for the workforce in the accommodation village to impact on local water supplies and water pressure and are working towards a solution that would remove any impact on existing water users in the vicinity of the proposed new village.

Submission 120-1: We recognise and acknowledge the potential economic contribution that the Ichthys Project can make to Australia, the Northern Territory and Darwin but, at the end of the day, it is not going to be possible to manage a project of this magnitude without any impacts and it will be the people of Darwin who will be most affected by the development. Recognising this, we believe that it is a serious responsibility for both Inpex and the Northern Territory Government to ensure that, wherever possible, there are local benefits.

Submission 120-2: We note that Inpex has already made some local contributions including its significant support for Larrakia Trade Training Centre. We would expect that Inpex will continue to contribute in similar ways for the life of this project but there should be even more emphasis on local benefits. For example, Darwin should definitely be the service centre for as much of the gas field and pipeline development and operation as possible. It would be ironic if the major processing facility with its associated impacts is located in Darwin but the benefits to flow from a service base were to go to another community in Australia or even overseas. Similarly, if there are to be environmental and/or other offsets (such as carbon offsets for example) every effort should be made to ensure that these are established in Darwin or the Northern Territory where much of the activity to be offset is actually taking place. There needs to be more certainty about some of these issues and they should be addressed in the supplementary EIS.

Chapter 10 *Socio-economic impacts and management* of the Draft EIS described the socio-economic impacts and benefits flowing from the Project.

Furthermore, INPEX is proactively engaging with local and national businesses through the Australian Industry Participation Plan and Industry Capability Network to encourage and provide opportunities for employment, subcontracting and business engagement in the Project.

The social impact assessment undertaken from June to September 2008 indicated, in relation to Darwin–Palmerston demographics, that the area is socially well equipped and has a long history of integration with diverse permanent and transitory populations. INPEX will continue to work with stakeholders within the Darwin region to facilitate opportunities for the involvement of local businesses in Project activities.

In relation to environmental and greenhouse gas offsets associated with the Ichthys Project (see sections 4.8 and 4.9 for more detailed discussion regarding offsets), INPEX is engaged in ongoing dialogue with both the Northern Territory and Commonwealth regulators to develop an appropriate offsets package.

Submission 120-3: The view of AFANT is, as it was in 2007, that any development in or near Darwin Harbour must be carried out in such a way that it will not have detrimental impacts on our lifestyle or on recreational fishing. Central to this is that any adverse impacts on fish or the environments that they depend on must be eliminated or maintained within acceptable limits. We believe that this can be done for the Ichthys Project.

Submission 120-4: The significance of the east Arm area to recreational fishing should also be recognised.

The significance of the East Arm area (including Lightning Creek and Cossack Creeks ("Catalina Creeks 1 & 2")) to recreational fishing has been recognised by INPEX in the Draft EIS and during the stakeholder consultation and Project planning processes.

INPEX has designed the Project to minimise the impacts on the environmental and social values of Darwin Harbour. For example, INPEX has developed a best-practice dredging method which will significantly reduce the environmental impacts associated with dredging at an additional cost to INPEX of around $200 million. INPEX has also committed to removing Walker Shoal through methods which avoid blasting (see Section 3.3.8 of this EIS Supplement).

INPEX acknowledges the recreational values of Darwin Harbour in one of the Project fact sheets ("Recreational use of Darwin Harbour').

Submission 128-45:

- Work force influx management

Council requests a qualitative and quantitative assessment of the social planning impacts of significant numbers and demographic types of workers recruited by Inpex from elsewhere in terms of:

- social mix
- likelihood of enhanced or compromised social cohesion as a result of the introduction of the project's workforce
- potential impact of a rotating (fly in/out) cohort of workers
- proposed strategies for the management of work force influxes

Submission 128-46:

- Impact on housing stress

In view of the acute lack of affordable housing in Darwin, Council requests an assessment of the potential impact of the project upon the municipality in affordable housing terms.

Submission 128-47:

- Economic benefits to Darwin and the region

Council requests an assessment of the forecasted economic benefits, or otherwise, to Darwin as a result of the project.

INPEX has undertaken a social impact assessment and economic modelling and forecasting to attempt to identify the impacts from, in particular, the increase in the construction workforce and forecast economic benefits to the Northern Territory and Australia. Some of the material collected is confidential or commercially sensitive and therefore the reports were not reproduced in their entirety in the technical appendices of the Draft EIS. However a summary of the results was provided in Section 3.6.8 in Chapter 3 *Existing natural, social and economic environment* and in particularly Section 10.3.2 in Chapter 10 *Socio-economic impacts and management*.

Further information is contained in the response to comment 7-25 in Section 5.2.2.18 in this EIS Supplement for commentary on housing and accommodation plans for the Project.

The social impact assessment was undertaken during June to September 2008. The stakeholder groups that INPEX engaged with included businesses and community groups as well as local, state and Commonwealth government departments. In addition to the public meetings and interviews with various stakeholders, INPEX prepared, and continues to prepare, fact sheets, question-and-answer information, and media notices to provide ongoing updates.

The company intends to maintain ongoing engagement with stakeholders.

INPEX also supports community programs and sponsorship, including support for the development of Larrakia Trade Training Centre. INPEX has also developed its supplier relationship program (through the Australian Industry Participation Plan (AIPP) and the Northern Territory Industry Capability Network (NTICN)) to provide a mechanism to allow potential suppliers access to contracting and procurement opportunities.

5.2.2.19 Stakeholder consultation

Submission 7-27: Why hasn't the Darwin Harbour Use Committee been given the "legs" promised to ensure stakeholder issues were addressed – the Northern Territory Government has endorsed the strategy for the Darwin Harbour use (June 2010) but ignores the proposals!?

In responding to this comment, INPEX assumes that the "Darwin Harbour Use Committee" refers to the Darwin Harbour Advisory Committee (DHAC).

INPEX is not in a position to answer the issues raised in this comment, as they appear to be directed at the Northern Territory Government. INPEX recommends that the submitter raise these issues with the relevant government departments.

Submission 86-5: Social and Economic Impact – the comprehensive early engagement with the community, development of community and business support programs, and the information provided by the proponent in Chapters 2, 3 and 10 of the EIS is acknowledged. The Ichthys Project will have a significant impact on Darwin and the region throughout its life. The nature of this impact will change with time as the project matures and develops. It will be important to maintain engagement with the community, business and government through the life of the project to ensure that the measures proposed by the proponent to manage social and economic impacts (particularly impacts on labour markets, local businesses, housing and social outcomes) are effective and can be adapted to ensure the potential benefits of the project can continue to be delivered over time.

INPEX is committed to ongoing engagement with all relevant stakeholders throughout all phases of the Ichthys Project. At this early stage in the Project, consultation with stakeholders has been extensive and open through numerous community forums, meetings and public communications. INPEX will continue to listen to the concerns and issues of the community, business, and government and has developed plans to address some of those issues that relate to socio-economic impacts listed here.

Submission 97-1: The LDC considers the nearshore and onshore management controls and risk reduction strategies outlined by the draft EIS (Section 6 Marine Impacts and management pages 33 – 46 and Section 7 Terrestrial Impacts and Management pages 47 – 53) to be acceptable and representative of the discussions held based on the details supplied at the time and are reflective outcomes of consultation with the LDC.

The LDC expects:

- INPEX to continue to consult the Larrakia community and seek advice on the correct procedures to be undertaken to gain access to and protect all the known Larrakia archaeological sites.
- INPEX is to adhere to the management controls and mitigation plans outlined in the draft EIS and continue to inform and seek advice from the LDC and also its Advisory Committee when invited to do so by the LDC Board.
- INPEX to regularly inform the LDC of any exclusion zones and other issues impacting Darwin Harbour access during construction.
- INPEX to regularly inform the LDC and of the results of the marine and terrestrial monitoring programs INPEX has proposed to assess the affects of development activities on the environmental health of the Harbour and the Blaydin Point construction area.
- INPEX to fully investigate the viability of alternative techniques to drilling and blasting, as outlined in the draft EIS, to further reduce the risk of injury or death to flora and fauna cause by hard rock removal, and to consider that any blasting be done at extreme low tide so as minimise any impact on marine life.
- INPEX to openly and actively consult the LDC on any further developments in the approved management controls throughout the various stages of the Project.

INPEX acknowledges the considered views of the LDC in regard to the Draft EIS and will to continue to engage with the LDC in a constructive and proactive manner in regard to all heritage, Darwin Harbour access, and environmental monitoring issues as the Project continues to develop.

Furthermore, INPEX notes the LDC reference to the removal of Walker Shoal and refers to Section 3.3.8 of this EIS Supplement which provides the most recent information in regard to rock removal methods.

Submission 97-2: The LDC looks forward to fostering a mutually beneficial relationship with INPEX, which will see the socio-economic opportunities of the Ichthys Gas Field Project maximised for the Larrakia people.

The LDC expects

- INPEX to act according to the spirit of the MoU to actively encourage and facilitate the participation of the Larrakia people and the Larrakia businesses in the Ichthys Gas Field Project
- INPEX to undertake regular and timely communication with the LDC to inform the Corporation of appropriate employment and business opportunities for Larrakia people and Larrakia business to participate in the Project.
- INPEX to consult with the LDC on a regular and ongoing basis with respect to an aboriginal employment and training plan having regard to the skills and level of participation of Larrakia and other Aboriginal people in the Ichthys Gas Field Project

INPEX recognises the importance of this Project in providing socio-economic opportunities for the people of the Northern Territory, including the Larrakia people. A detailed description of INPEX's approach to the engagement of Larrakia people is provided Section 4.6.1 of this EIS Supplement. This describes agreed initiatives, progress to date with participation plans, and future opportunities as the Project moves towards FID (final investment decision).

Submission 124-74: Stakeholder consultation

INPEX has undertaken limited consultation with relevant Aboriginal organisations, engaging with the Northern Land Council and Larrakia Development Corporation, but not the Larrakia Nation Aboriginal Corporation (LNAC) (p. 21, Volume 1).

Recommendation: Efforts should be made to effectively consult with the LNAC, the peak representative body of the Larrakia peoples. The LNAC's Men's and Women's Ranger Programs, in particular, are important for biodiversity conservation efforts in the Darwin Harbour region.

INPEX has undertaken extensive consultation with a wide range of Aboriginal groups, including those mentioned in this submission. In regard to the Larrakia Nation Aboriginal Corporation (LNAC), INPEX has met with representatives of the LNAC on particular occasions and has noted the attendance and participation of LNAC representatives at various community forums.

INPEX is open to further consultations with the LNAC, although it understands that current administrative issues within that organisation may have limited its ability to engage more completely with INPEX at this time.

INPEX is aware of the LNAC ranger programs and will consider using these resources as the Ichthys Project progresses.

Submission 128-44: Status of Traditional Owner (Larrakia) – Inpex negotiations

Council requests an apprising of the nature, scope and status of the negotiations between Inpex and Larrakia peoples in terms of:

- arrangements for compensation, if any
- the breadth and nature of engagement with Larrakia people and organisations
- the engagement of Larrakia peoples in land use issues to ensure particular site protection and mitigation strategies for land degradation
- employment and economic development prospects for Larrakia people as a result of the project

INPEX has a strong and ongoing relationship with the Larrakia people and respects their history as the traditional occupiers and owners of the Darwin region and the legacy of their culture as it survives today.

INPEX has also entered into a memorandum of understanding (MOU) with the Larrakia people; a copy of the MOU is presented below.

INPEX has also engaged with the Larrakia people and the Northern Territory Government on cultural and archaeological heritage matters and has drafted heritage management plans to the satisfaction of both the Larrakia and the government.

In terms of benefits to the Larrakia people, in 2010 INPEX and its joint venture partner Total contributed $3 million for the construction of a trade training school in the East Arm Industrial area to facilitate the training and achievement of industrial trade qualifications for Larrakia, other Aboriginal and non-Aboriginal trainees. The Trade School's construction is complete and has commenced training students.

INPEX has also reached agreement with the Larrakia on a package of other benefits to be managed and delivered through the Larrakia's commercial business, the Larrakia Development Corporation, over the life of the Project.

In December 2009 INPEX signed an Industry Participation Plan (IPP) agreement with the Northern Territory Government to crystallise its commitments to local (Territory) business participation in the Project. The IPP also captures Aboriginal and Torres Strait Islander employment and training commitments.

In regard to land use issue and mitigation strategies, these issues have been addressed in various sections of the Draft EIS, most particularly sections 8.2 and 10.3.8.

5.2.2.20 Terrestrial impacts and vegetation-clearing

Submission 5-1: Regarding the shipping. I have heard occasionally ships passing our Deckchair Cinema, or moored nearby the Deckchair, that are only minor. However the LNG ships they will use are supertankers, and the eis has no mention of volume of noise from these. What do you expect this noise level to be and the expected impact. If it shows any possible impacts, then a mitigation could be that there be no shipping in the evening. We open at 6:30pm, closing around 9:30 Sunday to Thursday and around 11:30 Friday and Saturday evenings. We feel it is worth raising now to ensure that Inpex, the government and the Port Corporation are aware of the possible future impacts to a well loved community event. Our attendance figures bear this out with between 40-45,000 patrons visiting between mid April and mid November each year.

INPEX does not expect any of the ships sailing to and from Blaydin Point to generate significant noise. The ships will travel in a shipping channel no closer than about 2 km from shore, close to where LNG ships visiting the ConocoPhillips Darwin LNG plant at Wickham Point currently travel. INPEX does not expect that restrictions to shipping times will be required.

Submission 5-2: Regarding the Operation. There may be some noise impacts on operation of the Deckchair Cinema during the Dry season when south easterlies are blowing. This could arise from background noise from operation of the plant itself in addition to shipping noise. The EIS has noise pollution modelling in Appendix 20, and has noise contour lines of areas around the Harbour that would be impacted. But they have taken the worse case scenario which for them is north easterly winds pushing noise onto nearby Palmerston. There is no modelling on what impacts south easterlies would have during the Dry season on the city area. There is no modelling of noise at any time of year from the LNG tankers either. These tankers would start at 4 per week, and increase as production increases. There is no upper limit of shipping presented, but they could be one or two a day. I don't know whether navigation through the Harbour is limited by high tides, but the issues for the Deckchair Cinema is whether or not they pass at night, and what the passage duration would be, and what the noise levels would be of the LNG tanker and the four tugs. This noise should be modelled for Dry season scenarios in addition to that produced by the new plant. If impacts are unacceptable, perhaps a way to mitigate that is to have no shipping traffic in the evening during the Dry season (mid April to mid November).

Submission 5-3: Noise issues and cinema operation: There are standards for operation of cinemas with regards to allowable background noise – and this is provided by SMPTE as Noise Criterion levels, rather than as dB levels, but I think they are the same. Some internet searches provided the following: Noise Criteria (NC) are noise level guidelines applicable to cinema and home cinema. For this application, it is a measure of a room's ambient noise level at various frequencies. For example, in order for a theatre to be THX certified, it must have an ambient sound level of NC-30 or less. This helps to retain the dynamic range of the system.[9]

- NC 40: Significant but not a dooming level of ambient noise; the highest "acceptable" ambient noise level. 40 decibels is the lower sound pressure level of normal talking; 60 being the highest.
- NC 30: A good NC level; necessary for THX certification in cinemas.
- NC 20: An excellent NC level; difficult to attain in large rooms and sought after for dedicated home cinema systems. For example; for a home cinema to be THX certified, it has to have a rating of NC 22. [10]
- NC 10: Virtually impossible noise criteria; 10 decibels is associated with the sound level of calm breathing.

INPEX does not expect processing-plant or ship noise to be a concern for Darwin's Deckchair Cinema. The onshore processing plant noise-modelling contours assume winds coming from all directions, not just north-easterlies.

In this respect they are conservative in that they assume worst-case noise levels in all directions, including winds from the south-east. Noise impacts from passing Ichthys Project product tankers on both Palmerston and Darwin are expected to be even lower than the impacts from the processing-plant operations at Blaydin Point.

The noise modelling shown in figures 10-4 and 10-5 (and tabulated in Table 10-15) of Chapter 10 *Socio-economic impacts and management* of the Draft EIS show that the noise impact in Darwin from the Blaydin Point plant will be in the 25–35 dB(A) range (worst-case scenario).

Section 3 *Ambient noise* of the Draft EIS's Technical Appendix 20 *Onshore airborne noise study* shows that existing noise levels at various locations around Darwin and Palmerston already exceed the 25–35 dB(A) range at most times, day and night. This means that noise levels at the Deckchair Cinema will likely be affected more by natural and other pre-existing sources (e.g. wind or traffic noise) than by the Blaydin Point plant or passing ships.

Submission 7-3: Flora field surveys have only been conducted in the 'Dry Season' when accessible and it is a well known fact that there is a large difference in vegetation type with some genera only 'appearing' during the Wet Season (example: yams). It is also very difficult to identify general species without fruit or flower which is mostly prevalent in the lead up to and during the Wet Season.

Submission 7-4: There still appears to be a reliance on desktop survey of similar sites which is an incorrect assumption. Each habitat has similarities but they are not identical nor have the same interactions. Many desktop surveys are published <2009 using data up to 5 years or more old.

Submission 7-5: The change of flora will also reflect a change of fauna.

Submission 7-6: The increase in tides and rain during the Wet season will also alter the coast and inter-tidal zones – a process that has slowly evolved for habitat survival. – and also reflect on the fauna use.

Submission 7-7: Fauna field surveys have only been conducted in the Dry Season when accessible.

Submission 7-8: There still appears to be a reliance on desktop survey of similar sites which is an incorrect assumption. There are similar sites that do not attract the same species – therefore some described vegetation habitats maybe classed as common but the fauna that inhabits them maybe localized to a particular habitat.1

Submission 7-9: Fauna utilizes the flora habitats in different ways during the Dry and Wet. Feeding and nesting sites are often different for different genera. Some may only visit the area on an annual basis for a short period of time to nest.

Ichthys PROJECT

MEMORANDUM OF UNDERSTANDING

BETWEEN

THE LARRAKIA DEVELOPMENT CORPORATION PTY LTD (LDC)

AND

INPEX BROWSE LTD ON BEHALF OF THE ICHTHYS JOINT VENTURE (INPEX),

COMPRISING INPEX BROWSE LTD. AND TOTAL E&P AUSTRALIA

INPEX and the LDC have entered into this Memorandum of Understanding (MoU) to record their intentions and expectations in relation to the development of a mutually beneficial relationship for the life of the Ichthys LNG Project (the Project).

The Larrakia Development Corporation, as agent for all Larrakia people, is committed to building the Larrakia Development Corporation as a major business within the Northern Territory – to enable the LDC to improve the lives of all Larrakia.

INPEX recognises the Larrakia people as the traditional owners of Darwin and acknowledges their aspirations in securing their economic future for all Larrakia.

OBJECTIVES

Even though this MoU is not legally binding, both parties seek to build a professional and long term relationship based on openness, honesty, respect and mutual opportunity with the aim of delivering commercial integrity and economic benefit for both parties.

Both parties agree that the primary relationship is between INPEX and the LDC on behalf of all Larrakia and expect to build this relationship in a way that generates opportunities for the Larrakia people, other Aboriginal people and the local community as appropriate.

The parties agree to work together to:-

a) ensure heritage and environmental values are managed appropriately and collaboratively
b) ensure that INPEX obtains approvals for the Project in a timely manner
c) publicly support the business objectives of the Project
d) enable opportunities for participation in the Project by established and new Larrakia businesses
e) conduct pre-employment training and training of Larrakia people involved with the Project
f) actively seek ways to maximise employment opportunities for Larrakia people on the Project
g) develop and deliver a community benefits package for the benefit of all Larrakia people, other Aboriginal people and the local community.

SEIYA ITO
Managing Director
INPEX Browse Ltd

In the presence of

THE HON PAUL HENDERSON MLA
Chief Minister
Government of the Northern Territory

KOOLPINYAH BARNES
Chairman
Larrakia Development Corporation

4 November 2009

INPEX   Northern Territory Government   LARRAKIA DEVELOPMENT CORPORATION

Submission 7-11: The assumption that the removal of vine thickets will not affect frugivorous birds as there are sufficient 'Carpenteria Palm' planted in urban areas that these brids can utilise is an obviously an assumption made with no knowledge of frugivorous birds & in particular the Rose-crown fruit-dove which is an extremely shy bird and one listed on most international birding lists to see.

Submission 7-14: Table 8-6 clearly indicates significant loss of habitat and localised reduction in biodiversity. This would mean that the cyclic flowering and fruiting of plants species that retains all year round sustenance for frugivorous birds and others will be lost.

Rainforests in the Northern Territory occur as small patches, and the frugivorous birds that depend on them are thought to move among the patches. I attached radio-transmitters to 41 birds of four species captured in several locations near Darwin. I recorded 55 interpatch flights, and estimated flight rates as between once per day and five days for figbirds and pied imperial-pigeons. The flight rates for rose-crowned fruit-doves and yellow orioles were much lower, but no reliable estimate could be made. The median flight distance was 2.5 km but one in five flights were more than 10 km. In addition, one pigeon flew 220 km in preparation for migration from Australia. Birds often undertook exploratory flights, returning to the original patch. Birds of one species captured together usually flew to different locations. When birds left a patch, it was usually to a distant patch, rather than a near neighbour. These movement patterns demonstrate that frugivorous birds use the rainforest network in a complex way. The birds depend on a network of rainforest patches and the pigeons and figbirds probably disperse large quantities of seeds among the patches. The conservation of rainforest ecosystems in northern Australia will depend on the protection of the current configuration of patches rather than a representative set of patches.

The rose-crowned Fruit-Dove (Ptilinopus regina) has a conservation status in NSW of vulnerable already with significant guidelines to retain and maintain habitat. Ptilinopus regina.

Submission 7-15: Birds Vulnerable. 1. Include protection of population's habitat and ecological requirements in statutory planning in relevant shires. (High priority)

Submission 7-16: Prepare Habitat Management Guidelines for fruit-doves, including exclusion of stock, weed removal, and exclusion of fire from rainforest and rainforest remnants, habitat restoration and corridor planning. (High priority)

See all priority actions for this species.

Habitat and ecology

- Rose-crowned Fruit-doves occur mainly in sub-tropical and dry rainforest and occasionally in moist eucalypt forest and swamp forest, where fruit is plentiful.
- They are shy pigeons, not easy to see amongst the foliage, and are more often heard than seen.
- They feed entirely on fruit from vines, shrubs, large trees and palms, and are thought to be locally nomadic as they follow the ripening of fruits.
- Some populations are migratory in response to food availability – numbers in north-east NSW increase during spring and summer then decline in April or May.

Submission 109-6: The Northern Territory Government(4) states 'Any further fragmentation of the rainforest estate from land clearing is a threat. As patches become more isolated, it will be less energy efficient for birds to move to them and therefore seed movement will decrease. Reduced seed movement will result in less regeneration and possibly to localised extinction. Reduction in the rainforest estate is a major threat to dependant frugivorous birds.' They recommend that 'development should be excluded from areas where rainforest patches are present' and state we can make a difference by 'Retaining all rainforest patches'. Appendix 16, page 40, comments 'Reduction in MVF area has been predicted to result in regional declines in populations of frugivorous birds'.

This would appear to be contradictory to the EIS claim (Section 8.3.2, page 391) '...removal of the monsoon vine forest from Blaydin Point is likely to be the most significant alteration of habitat at the onshore development area as this plant community provides food resources to specialised frugivorous birds. However, monsoon vine forest occurs in other areas around Darwin Harbour ... and throughout the Darwin Coastal Bioregion, and removal of this habitat does not represent a critical loss at a regional scale ...'

The statement in the EIS (Section 8.3.1, page 387) ‘Extensive plantings of tropical fruit bearing trees (e.g. the palm Carpentaria acuminata) in suburbs of Darwin and Palmerston and the surrounding rural areas are capable of supporting some of the frugivorous bird species that inhabit monsoon vine forest’ appears to be an extraordinary habitat option for fauna living in large intact sections of ecologically diverse native monsoon vine forest.

INPEX commissioned GHD Pty Ltd to undertake wet – and dry-season flora and fauna surveys at Blaydin Point. The results of these surveys, which included intertidal and mangrove invertebrates, are contained in the Draft EIS’s Technical Appendix 16 *Onshore flora and fauna study*. These surveys were undertaken in 2007 and 2008. A separate survey of biting insects at Blaydin Point was carried out by the Medical Entomology Section of the Department of Health and Families and was attached to the Draft EIS as Technical Appendix 21 *Biting insect survey of Blaydin Point, Darwin*.

Following the publication of the Draft EIS, INPEX noted that a page had been accidentally omitted during the printing of Technical Appendix 16; this page carried the information on the methodology of the fauna and flora surveys. Details of the methodology are reproduced here, and a copy of the missing page has been provided as Figure 5-9 at the rear of this section (p. 488) in this EIS Supplement.

Technical Appendix 16 includes the following information on survey methodology:

- details of the flora and fauna of the general area and region of the study site
- details of species and ecological communities listed as threatened under the *Territory Parks and Wildlife Conservation Act* (NT)
- details of “matters of national environmental significance” under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth)
- an assessment of the local, regional and national significance of the habitats, and flora and fauna of the study site
- an evaluation of the habitat characteristics likely to be of importance in the maintenance of the area’s biodiversity.

Desktop surveys were undertaken before the commencement of the field surveys, as is standard practice, to search the records of the Northern Territory (from the Department of Natural Resources, Environment, the Arts and Sport, the Northern Territory Herbarium and the Parks and Wildlife Service’s Northern Territory Fauna Atlas) and the Commonwealth (from the EPBC database) to identify records for plant and animal species recorded in the Blaydin Point and Middle Arm areas and to identify any protected or listed species. GHD and INPEX did not rely solely on desktop surveys but used the information as background material for the field surveys that were undertaken.

The survey methods were based on the Northern Territory Biodiversity Conservation Unit guidelines for sampling fauna.

Survey sites were selected on the basis that they represented:

- major vegetation communities within the Project area
- conservation-significant communities or potential habitat for conservation-significant species
- the proposed areas of impact.

Mapping was undertaken using publicly available information and surveys and site visits by INPEX personnel were undertaken on the onshore site to ground-truth this information and update vegetation community delineations and descriptions.

Discussions on the effects of surface-water and groundwater flow alterations and impacts on communities are covered in the Draft EIS in Section 8.2.3 of Chapter 8 *Terrestrial impacts and management* and in Technical Appendix 16, which included a discussion on changes to coastal and intertidal zones during the wet season, and Technical Appendix 18 of the Draft EIS.

The comments above on the need to provide regional ecological and habitat protection for the rose-crowned fruit-dove (*Ptilinopus regina*) and/or to develop regional habitat or flora and fauna management plans are outside the jurisdiction of INPEX. This is rather a matter to be raised with the relevant government departments.

With regard to the comments on frugivorous birds, and in particular the rose-crowned fruit-dove, INPEX acknowledges the statement about the conservation status of the species in New South Wales. In the Northern Territory, however, its status is “secure”, as it is in Western Australia and Queensland. The rose-crowned fruit-dove is widely distributed and common in eastern and northern Australia, and also in the Lesser Sunda and Maluku islands of Indonesia.

It has been categorised as of “least concern” on the IUCN Red List. It is noted as being partly migratory and partly resident, suggesting some movement over the seasons and for feeding. It was recorded five times in the fauna studies undertaken across the Blaydin Point – Middle Arm area. Recognised threats to the species for the most part relate specifically to reduction of habitat and introduced species competing for resources. This was recognised by INPEX in the Draft EIS, in particular in Technical Appendix 16 which states:

> Reduction in MVF [monsoon vine forest] area has been predicted to result in regional declines in populations of frugivorous birds … For example, a 50% reduction in the area of MVF in the Darwin area has been predicted to cause an 83% reduction in the regional population of rose-crowned fruit-dove. Predictions of this sort are backed up by observations of declines in frugivorous birds as an apparent consequence of loss of rainforest habitat … Loss of seed dispersal mechanisms may be a critical factor in determining the long-term conservation status of MVF plant species.

The Draft EIS’s Technical Appendix 16 also made the following statement with reference to monsoon vine forest and frugivorous birds:

> The area of rainforest on Blaydin Point and the adjacent area near Wickham Point are a relatively small fraction of the MVF within the 50 kilometres radius area (NRETAS Rainforest Database). The significance of any possible decline in frugivorous birds resulting from loss of the Blaydin Point MVF is difficult to evaluate. This is because of the past history of MVF loss in the Darwin region. Panton (1993) found that approximately 60% of the MVF in the Darwin region had been lost since the end of the World War II. This occurred as a result of a combination of the effects of clearing, fire and weed intrusion. The area of Panton’s study was less than that enclosed by a 50 km radius around Blaydin Point.
>
> Loss of the Blaydin Point MVF would not result in an observable impact on frugivorous birds, if assessed according to the existing patterns of MVF abundance and distribution in the area of 50 km radius around Blaydin Point (Bach and Price 1999). The level of impact from loss of the Blaydin Point MVF in association with losses since World War II is not easily assessed in the absence of more detailed information on the data included in Panton’s (1993) study, and an assessment of MVF distribution and abundance in the area within 50 km of Blaydin Point now, and at the end of World War II.

INPEX acknowledges that remaining existing patches of monsoon vine forest and fruit-bearing trees in the residential areas of Darwin or Palmerston will not provide alternative habitat for all frugivorous birds relocating from Blaydin Point. While some birds may be able to relocate to other areas, it is very likely that many suitable trees may already be fully utilised. However it should also be noted that there is some inherent level of change and mobility across habitat areas as the field studies showed significant differences in individual bird numbers and species diversity between the wet and dry seasons. Based on the comments from the submitters it would appear this mobility and dispersal across multiple habitats was also observed during the tagging and tracking undertaken.

None of the species identified at Blaydin Point are threatened with extinction, critically endangered or unique to the site.

Submission 7-12: Figure 8-1 clearly shows that a significant portion of vine thicket will be removed from Blaydin Point and the Wickham Point area is already significantly demised and misleadingly shown as still in existence as is the East Arm Point. This will remove corridors in general (of all habitats) from Middle Arm totally.

INPEX acknowledges that Figure 8-1 in Chapter 8 *Terrestrial impacts and management* of the Draft EIS does show a small number of patches of monsoon vine forest that no longer exist.

The data for Figure 8-1 were sourced from a vegetation data set provided by the Department of Natural Resources, Environment, the Arts and Sport (NRETAS) that was not properly evaluated against current aerial photography or through site visits to validate its currency.

For areas specific to the onshore development area (e.g. the pipeline route, the borrow area, the product loading jetty and module offloading facility access areas, the access corridors and the processing-plant pad) vegetation communities were identified using publicly available vegetation mapping (Brock 1995; Brocklehurst & Edmeades 1996; NRETAS data sets) and aerial photography. Verification of this preliminary mapping was undertaken through field surveys conducted by INPEX’s consultant GHD Pty Ltd in October 2007 and May 2008 and has been further refined during INPEX personnel site visits. This ground-truthing activity was restricted to the proposed onshore Project activity areas and did not cover all of Middle Arm Peninsula or the rest of the Darwin region.

Note that INPEX has indicated to the Northern Territory Government that it would like to commit to two environmental offset projects in the Northern Territory involving improved fire management practices; one each in the Daly River and Wagait regions. As there are remnant monsoon vine forest patches in these areas, it is possible that the Project could be designed to incorporate fire-protection mechanisms for some of the monsoon vine forest patches.

INPEX has estimated the reduction in monsoon vine forest on Middle Arm from more recent imagery and NRETAS has indicated it is in the process of updating its vegetation data. Despite the removal of a number of patches, primarily attributable to development, there are still a number of patches remaining in the vicinity of Darwin Harbour and monsoon vine forest occurs extensively in the Darwin Coastal Bioregion. There is a larger patch of monsoon vine forest remaining at Wickham Point but this is not in close proximity to the Blaydin Point patch.

It may be misleading for the submitters to assume there are or were links or corridors between the monsoon vine forest patches, past and present, at Middle Arm. The Blaydin Point patch is contained within other woodlands (Melaleuca, Mixed species and Eucalypts), and is isolated from the other monsoon vine forest in the vicinity and/or Middle Arm.

It should also be noted that the monsoon vine forest and forest and woodland areas at Blaydin Point are not pristine undisturbed environment. Blaydin Point has tracks into most areas, and public access has been freely available. Recreational uses include fishing, hunting and camping activities. Field studies have indicated the presence of introduced plants and animals including weeds and pests.

The following data sources were used in the preparation of the Draft EIS and GHD field studies for the mapping of the terrestrial environment and vegetation communities:

- Commonwealth – Darwin Coastal Bioregion, based on National Vegetation Information System based on previous data collections and surveys and assessment programs such as Australian Native Vegetation Assessment 2001
- Northern Territory: NRETAS vegetation mapping data (data set from 1990), and records from the Northern Territory Herbarium and the Parks and Wildlife Service's Northern Territory Fauna Atlas.
- GHD Field Studies (2007 and 2008) utilised
  - 1:25 000 Remnant Vegetation Survey – Litchfield Shire Municipality (Brock 1995)
  - 1:25,000 Mangrove Mapping Darwin Harbour (Brocklehurst & Edmeades 1996)
  - Aerial photography (provided by INPEX).

Verification of data for GHD studies was conducted as described in Section 4.1 of the Draft EIS's Technical Appendix 16 *Onshore flora and fauna study* and the NRETAS 1:25 000 Remnant Vegetation Survey updated to better delineate and describe the communities identified during the field survey. The vegetation groups surveyed were mostly consistent with the preliminary mapping, including corrections made to the existing mapping. These communities have been classified and renamed according to NVIS nomenclatural rules as far as possible.

Submission 16-15, 24-15, 29-14, 89-15, 96-14, 101-16, 102-14: Increased vehicle traffic, ground disturbance and land clearing at Blaydin Point will increase the risk of weed introductions.

Submission 7-13: Not only is the increase of weed invasion to this particular area evident but also throughout the vehicular distance travel of all machinery, equipment and soil filling transportation. The minimal public access by passenger vehicles to the area does not cause the same risks that are known with earth moving equipment & note in the "management of introduced species" that appropriate plans are in place. It is noted that 'topsoil containing high densities of weed seeds will not be used in rehabilitation but this should also be the case for any reclamation and filling as it is known that seed banks can remain dormant for long periods of time and during rehabilitation these could rise to the surface.

Submission 109-24: The introduction and spread of weeds pose a serious risk to native vegetation adjacent to the project site, especially along the pipeline and access corridors. Section 3.4.10, page 108 states that weeds in the project area 'are mainly found along roads and tracks, as vehicles are important vectors for weed spread' and that 'Other key weed infestations are in areas of previous land clearing and soil disturbance' and 'The weed species of most concern to the local vegetation communities are mission grass, gamba grass and hyptis because of their potential to spread rapidly and to alter the ecology of the natural vegetation. Mission grass and gamba grass form dense thickets that can support excessive fire frequencies and intensities that alter the vegetation structure of the northern savannahs, including the tree layer'.

Submission 124-55: Aside from the direct impact of land clearing on biodiversity there will be indirect impacts too. Increased vehicle traffic, ground disturbance and land clearing at Blaydin Point will increase the risk of weed introductions. Indeed, declared weeds (i.e. gamba grass, mission grass, hyptis and lantana) are already established in the Project area (Volume 2, Section 8.3.4, p. 394).

Submission 109-21: Initiatives from Part 4 of this submission be utilised to compensate for any clearing of the woodland community.

The submitter (109-24) refers to part of a sentence in the Draft EIS relating to weed coverage in the onshore development area, which in full reads "overall, weeds in the onshore development area are not abundant and are mainly found along roads and tracks, as vehicles are important vectors for weed spread" (see page 108 of Section 3.4.10 in Chapter 3 *Existing natural, social and economic environment*).

During field surveys the locations of weeds were noted. A number of weed species both "declared" and "environmental" currently exist at the Blaydin Point site. Most of these were in areas that had been historically used or cleared for industrial and recreational activities.

Annual weed surveys have been undertaken over the last three years and management and control options have been identified. Spraying programs have already been conducted on the site and future weed-control programs are planned.

INPEX has inherited the current condition of Blaydin Point and has incorporated the historical situation into its own management controls to coordinate its own disturbance activities (e.g. access for geotechnical survey activities) in a way which will control existing infestations and prevent the introduction of new weed species.

Where opportunities arise to work with government and industry, INPEX will fully engage as appropriate. INPEX engages regularly with the Department of Natural Resources, Environment, the Arts and Sport (NRETAS) concerning potential weed risks and appropriate management options and also works with members of the NT Gamba grass working group.

Annexe 13 *Provisional quarantine management plan* and Annexe 15 *Provisional vegetation clearing, earthworks and rehabilitation management plan* to Chapter 11 *Environmental management program* of the Draft EIS include actions and controls directly relating to the management and control of weeds.

During the operations phase of the Ichthys Project a weed management program will be put in place to manage listed weeds occurring in the onshore development area, for example along roadsides, cleared areas, firebreaks and easements.

Submission 84-7: Could Inpex please provide an exact figure as to how many hectares of mangrove and bush would need to be cleared for the project? The impact of mangrove and monsoon vine forest clearing also needs to be clearly established through studies by independent bodies on fauna and flora likely to be affected and their conservation status.

See Section 4.4 of the Draft EIS for information on the revised vegetation-clearing calculations for the onshore development. The vegetation clearing estimates have been revised based on corrections to Table 8.5 (in Draft EIS) and changes to plant layout that have had minor impacts on overall vegetation clearing counts.

INPEX has undertaken site-specific flora and fauna studies during wet and dry seasons at Blaydin Point. These data are provided in Chapter 3 and Technical Appendix 16 of the Draft EIS. As mentioned, there have been some changes to clearing estimates that are covered in Section 4.4. The overall environmental impact of clearing mangrove and monsoon vine forest communities on Middle Arm has been provided in a regional context, which shows that overall, clearing of the communities represents less than 1% of their respective areas within the Darwin Coastal Bioregion.

Submission 95-3: Destruction of Cycas armstrongii. Cycas armstrongii is a protected species and listed as Vulnerable in the NT and every effort should be made to salvage plants from woodland areas that are marked for clearing. These species are an iconic local plant, close to the hearts of many Territorians and should be given the respect and value that they deserve.

Submission 109-20: 2. Section 3.4.9, page 107 states 'The cycad Cycas armstrongii is listed as vulnerable under the TPWC Act, and was recorded in the field survey of the onshore development area. This species is endemic to the Northern Territory' and 'Cycas armstrongii was observed in the study area throughout the Eucalyptus miniata – E. tetrodonta woodland community.' Whilst Cycas armstrongii is 'locally abundant', it is one of the Territory's most iconic and ancient plants and is a highly valued species within the local community. This plant's listing as 'vulnerable' under the Territory Parks and Wildlife Conservation Act reflects its poor representation in conservation reserves and the current threats to its extent which include:

- Clearing for urban, industrial, agricultural, forestry and horticultural development; and
- More intense fire regimes due to the proliferation of introduced exotic grasses such as gamba grass (Andropogon gayanus) and mission grass (Pennisetum polystachion). These species have the potential to expand across the full extent of Cycas armstrongii(6).

Greening Australia strongly recommends the salvaging of cycads in areas to be cleared as part of the on-shore development. There have been several successful examples of mature cycads being salvaged from development sites and either planted immediately into revegetation or landscaping in other areas or stored in a nursery situation until needed. Successful salvaging operations have previously been undertaken for the Wickham Point Interconnect Gas pipeline, with plants subsequently being used in environmental and landscaping projects in the local area.

Opportunities exist for provision of cycads to worthwhile community revegetation and landscaping projects. Alternatively there is a commercial market in the landscaping industry for mature cycads. Sound technical advice should be sought in relation to salvaging and storage methodology to ensure survival of the cycads.

Recommendations

- The workers camp be developed in a manner that retains the maximum amount of native vegetation and results in a facility that is attractive and sustainable with landscaping incorporating local native plants.
- Salvaging of all cycads be mandatory for the plant site, the workers camp site and all pipeline and access corridors.

INPEX is aware of the conservation status of cycads and the Northern Territory Land Clearing Guidelines. Opportunities to reuse cycads from the clearing activities at the onshore development and accommodation village sites will be investigated during detailed design. If the vegetation can not be used onsite opportunities to salvage these plants for use by third parties (subject to appropriate HSE consideration and regulatory approvals) will be sought.

Submission 106-8: Light pollution. As nearby Browse Basin has a green turtle rookery, it is important that the lighting on the seas structures complies with the Western Australian Environmental Protection Authority's Environmental Assessment Guidelines No 5, Environmental Assessment Guidelines for Protecting Marine Turtles from Light Impacts.

The Ichthys Project's Draft EIS fully considered the effect of light on marine turtles. INPEX has, however, taken note of the new guidelines published by Western Australia's Environmental Protection Authority (EPA) in November 2010 (subsequent to the publication of the Draft EIS)—*Environmental Assessment Guidelines No. 5: environmental assessment guideline for protecting marine turtles from light impacts* (EPA 2010). This guideline states (page 14) that with regard to minimising the effect of light on turtle rookeries, "the starting point for design should be to locate developments sufficiently far from the coast to ensure that lights (or light glow) are not visible from nesting beaches or the adjacent sea."

The highest points of the central processing facility (CPF) and the floating production, storage and offtake (FPSO) facility at the Ichthys Field, excluding their flare towers, are approximately 60 m above sea level and would theoretically be visible to an observer 2 m above sea level (roughly the height of a turtle hatchling emerging from a nest above high-water mark) from a distance of approximately 27 km. As the proposed Ichthys facilities are located approximately 30 km from known turtle-nesting beaches on Browse Island, the light from the deck facilities is not expected to be visible to turtles on the island.

Both the CPF and the FPSO will have a safety flare for venting of gas during process upsets or emergency situations. The flares are integral to the safe design of the facilities. The flares would be visible for a distance of approximately 50 km during process-upset flaring. This means that nesting turtles and turtle hatchlings on west-facing beaches of Browse Island would have a direct line of sight to the flare tip. It is possible that indirect light from normal operational lighting may also be visible at night from Browse Island, appearing as a faint glow on the horizon.

The potential effect of direct light from the flare tip or glow from deck facilities is mitigated by the reduction in intensity of light, which diminishes with the square of the distance (i.e. light is reduced to one-hundredth of the initial intensity after 10 m, one ten-thousanth after 100 m, etc.) and by the spectral range of the emitted light. Gas flares emit measurable light energy over the whole range of visible and near-infrared wavelengths, with peak intensities in the spectral range from 750 to 900 nm (Hick 1995) while the most disruptive wavelengths to turtles are in the range of 300 to 500 nm (Tuxbury & Salmon 2005; Witherington 1992). Therefore the glow that may be visible at Browse Island is considered to be too low and primarily of the wrong spectral range to cause any disturbance to turtles. It should also be noted that while turtle hatchlings primarily use light cues to orient to water, once in the water they rely on sea-wave and magnetic cues for orientation (Witherington & Martin 1996).

Submission 107-51: The rationale behind the decision not to use fuel reduction burning as a means of mitigating fire risks should be explained. Fuel reduction burning following the first rains and at the end of the wet season is a traditional Aboriginal land management practice, a culturally acceptable land management practice in the Northern Territory, which serves also as an effective weed management technique.

During operations it would not be considered appropriate to allow (a potentially uncontrolled) source of fire in proximity of a hydrocarbon processing plant. Therefore operations phase weed management and control will primarily involve management spraying for those areas vegetated following the construction of the plant, pipeline and access roads.

INPEX is looking at an option to use of fire on areas known to have extensive weed infestations prior to vegetation clearing, to attempt to kill the weeds, plants and seeds prior to site earthworks. This will prevent/ensure weeds are not transmitted in materials/soil moved around the site.

See the Section 4.9 of this EIS Supplement for a discussion on two fire-management projects that INPEX has indicated it would like to commit to.

Submission 109-4: Appendix 16, page 51 admits ‘The ecological and conservation significance of the monsoon vine forest of the area is difficult to assess’. Section 8.3.2, page 392 claims ‘Most animals present at the start of land clearing activities should be able to move to adjoining habitat on Middle Arm Peninsula or elsewhere in the vicinity. ‘ Given there is no adjoining monsoon forest this option may not be a possibility for the lesser mobile species.

Submission 124-61: The Draft EIS also makes the bold, unjustified assumption that: “Most animals present at the start of landclearing activities should be able to move to adjoining habitat...” (Volume 2, Section 8.3.2, p. 392). Unfortunately there is no adjoining patch of monsoon vine forest next to the patch that INPEX is proposing to clear, with the nearest patches on Middle Arm Peninsula occurring 3 to 5 km away (Figure 8-1, p. 388). In addition, there is no guarantee that these other patches of monsoon vine forest will be of similar quality to the one that is to be cleared. INPEX also states that “Major clearing activities will be undertaken in a manner that maximises the opportunities for animal life to move into remaining vegetation in the vicinity”. They do not, however, provide any further details about what this means in terms of land clearing machinery and methods, and present no evidence to demonstrate that this is actually feasible.

The GHD report (Technical appendix 16 of the Draft EIS) noted a difference between species numbers and diversity between wet and dry seasons. It could be concluded that some of the fauna (birds and larger mammals in particular) recorded in the field studies have a level of mobility and/or are transitory in their occupation of the woodland/forest areas. While this is not the case for all fauna species, especially the smaller ones (with limited mobility or home range) clearly some fauna will be able to relocate to other habitat.

While efforts will be made to encourage faunal relocation through staged clearing activities, INPEX does acknowledge that not all individuals or faunal species will be able to relocate prior to vegetation clearing. Details of final areas and methodology for land clearing will be provided in an Environmental Management Plan to be provided to NRETAS for feedback and ultimately approval.

See also INPEX's response to comment 7-3 (and others) for additional information on monsoon vine forest and vegetation-clearing.

Submission 109-5: Section 4.3.2, page 176 states that the pipeline will create a corridor 20 to 25 metres wide through mangroves to the south of Wickham Point Road. This corridor then crosses and appears to divide a second large monsoon forest patch and an area of Melaleuca woodland. The effect of the corridor will be to dissect the forest, disturb the connectivity of the monsoon forest patch and provide greater exposure to the risk of weed invasion and fire. Effectively two smaller patches will be created, less ecologically important, and more vulnerable, than the original patch.

The proposed onshore section of the gas export pipeline crosses the intertidal and shoreline area on the western side of Middle Arm Peninsula, just to the south of the ConocoPhillips Darwin LNG plant and north of Channel Island (see plant layout in Figure 3-1). The pipeline will follow a route that is a nearly straight line (in a west–east direction) as it crosses through three mangrove communities (Sonneratia Woodland, Shoreline Forest and Avicennia/Ceriops Forest) for approximately 400 m, then a patch of salt flats for approximately 300 m until it intersects with the existing Channel Island Road. At this point, which appears on the vegetation maps to be in the middle of the monsoon vine forest patch, the pipeline then follows the existing road route until it reaches the junction of the proposed site access road into the onshore plant. What may not be obvious from the maps provided is that the area of Melaleuca woodland and monsoon vine forest patches identified in the submission are actually already dissected by Wickham Point Road and utility corridors.

In terms of land requirements for the installation of the pipeline shore crossing and onshore sections of the gas export pipeline, areas for laydown during construction and a winch pad for pulling the pipeline ashore will also be required. An additional area is also required for the beach valve. These areas are provided for on the plant layout figures and are included in the clearing estimates.

The winch pad (for pulling the pipeline ashore) and beach valve are required to be sited above HAT (Highest Astronomical Tide), with additional elevation for storm-surge protection. Therefore, regardless of the pipeline's alignment, some disturbance of the vine thicket will be required.

The laydown area will also be required for commissioning activities, and is located adjacent to the pipeline beach valve. These commissioning activities include hydrotesting and dewatering, as discussed in Section 4.3.3 and Figure 4-18 of the Draft EIS. Therefore, based on these additional infrastructure requirements and associated disturbances, it is logical to continue to utilise these temporary disturbance areas for the pipeline commissioning.

It should be noted that most of the disturbed areas will be rehabilitated. Based on INPEX's experience with rehabilitation in these areas, INPEX anticipates that with appropriate vegetation rehabilitation techniques, regeneration of the vegetation will occur.

Submission 109-1: 3. Section 3.4.9, page 103 indicates that plant survey work for the project produced 109 new records for the Middle Arm Peninsula and its surrounds. This indicates the data deficient nature of information relating to vegetation in this area. The potential is that the vegetation is even more significant than currently thought. The precautionary principle should prevail in any decision making.

Submission 123-78: There is a large number of plant species listed as Near Threatened or Data Deficient under the TPWCA. However the draft EIS or Appendix 16 has not listed the occurrence of these species. Many of these species have restricted range and the proposed development may impact these species.

The desktop research undertaken prior to the field studies included searching the database of the Northern Territory's Department of Natural Resources, Environment, the Arts and Sport (NRETAS) and the Commonwealth's Department of Sustainability, Environment, Water, Population and Communities. The following comments relate to the results of this search and relationship to field surveys. The report by INPEX's consultant GHD Pty Ltd (included in the Draft EIS as Technical Appendix 16 *Onshore flora and fauna study*) states in Section 2.2 that there were no plant species listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) and that only one was recorded that was listed under the *Territory Parks and Wildlife Conservation Act* (NT) (TPWC Act), namely the cycad *Cycas armstrongii*, which is classed as "vulnerable".

Section 2.2 of Technical Appendix 16 notes that the Northern Territory Herbarium records contain 421 records of plants in the Blaydin Point area, which included a 2-km buffer area. These are listed in the report's Appendix A. Search results indicated the presence of 226 plant species.

INPEX's environment team has undertaken another review of the species listed under the TPWC Act and can confirm that no species identified at Blaydin Point appear on the "near threatened" list under the TPWC Act. It should be noted that NRETAS does not consider "data deficient" as a category of threat (i.e. threat to extinction/endangerment).

The GHD report indicated, from their research, the numbers of Northern Territory Fauna Atlas records of frogs, reptiles and mammals are low and likely to under-represent the past and possibly current diversity of these groups in the Project area. This may be due to several factors, including the inability to detect some animal species at particular times of the year (e.g. species that are not active during the dry season), species that are naturally relatively rare, or under-sampling for these particular groups. The number of Northern Territory Fauna Atlas records of birds is likely to be sufficient to provide a reasonably accurate representation of the area's species richness.

The field studies undertaken for the EIS represent standard best practice for flora and fauna assessments. A desktop study is normally undertaken prior to undertaking a field investigation to identify what species may or may not be present or expected to be found in the area. The NRETAS database represents data collected from a number of local and regional studies undertaken in the Northern Territory. The study by GHD for the Draft EIS's Technical Appendix 16 is specific to the Blaydin Point area: in addition to finding 109 new records, GHD discovered that some plant and animal species not found in previous investigations were found in these field studies. Some difference is to be expected.

This cannot all be attributed to data deficiency but may reflect changes to the land use ecosystem and species composition at the site and possibly the level of detail undertaken in earlier studies (e.g. fewer transects or quadrants and survey sites). For instance, as stated in Section 6.1.2 of Technical Appendix 16 of the Draft EIS, two areas of monsoon vine forest were not mapped prior to the investigations. Prior to the survey, vegetation mapping suggested one was an open *Eucalyptus tetrodonta* and *E. miniata* woodland to low woodland, and the other a *Melaleuca leucadendra*, *M. cajuputi*, *M. viridiflora* open to closed forest freshwater swamp with occasional *Acacia auriculiformis* (Brock 1995). Field surveys demonstrated that these areas are monsoon vine forest.

Submission 109-4: Appendix 16, page 51 admits 'The ecological and conservation significance of the monsoon vine forest of the area is difficult to assess'. Section 8.3.2, page 392 claims 'Most animals present at the start of land clearing activities should be able to move to adjoining habitat on Middle Arm Peninsula or elsewhere in the vicinity. ' Given there is no adjoining monsoon forest this option may not be a possibility for the lesser mobile species.

Submission 124-61: The Draft EIS also makes the bold, unjustified assumption that: "Most animals present at the start of landclearing activities should be able to move to adjoining habitat..." (Volume 2, Section 8.3.2, p. 392). Unfortunately there is no adjoining patch of monsoon vine forest next to the patch that INPEX is proposing to clear, with the nearest patches on Middle Arm Peninsula occurring 3 to 5 km away (Figure 8-1, p. 388). In addition, there is no guarantee that these other patches of monsoon vine forest will be of similar quality to the one that is to be cleared. INPEX also states that "Major clearing activities will be undertaken in a manner that maximises the opportunities for animal life to move into remaining vegetation in the vicinity". They do not, however, provide any further details about what this means in terms of land clearing machinery and methods, and present no evidence to demonstrate that this is actually feasible.

The GHD report (Technical Appendix 16 of the Draft EIS) noted a difference between species numbers and diversity between wet and dry seasons. It could be concluded that some of the fauna (birds and larger mammals in particular) recorded in the field studies have a level of mobility and/or are transitory in their occupation of the woodland/forest areas. While this is not the case for all fauna species, especially the smaller ones (with limited mobility or home range) clearly some fauna will be able to relocate to other habitat.

While efforts will be made to encourage faunal relocation through staged clearing activities, INPEX does acknowledge that not all individuals or faunal species will be able to relocate prior to vegetation clearing. Details of final areas and methodology for land clearing will be provided in an Environmental Management Plan to be provided to NRETAS for feedback and ultimately approval.

See also INPEX's response to comment 7-3 in Section 5.2.2.20 for additional information on monsoon vine forest and vegetation-clearing.

Submission 109-10: As mentioned in Section 8.2.1, page 380, soil erosion from clearing for the onshore development has the potential to create a further sedimentation risk for the mangroves.

Submission 109-13: The Northern Territory Government (3) states that to conserve mangroves we should 'Limit disturbance and development in coastal areas' and that we can make a difference by 'Reducing the amount of sedimentation entering waterways and coastal areas by controlling erosion'.

Submission 109-16: Recommendation: Every available measure should be utilised to reduce sediment affecting this important plant community.

The statement in the submission relating to the potential for further sedimentation risk to mangroves, omitted "unless properly managed". Section 8.2.1 in Chapter 8 *Terrestrial impacts and management* of the Draft EIS states that "unless managed properly, soil erosion from clearing at the onshore development area could create a sedimentation risk to mangroves at the pipeline shore crossing, the onshore pipeline route and around the boundaries of the processing plant on Blaydin Point".

Environmental management plans form part of the process INPEX will use to ensure that environmental impacts are minimised and/or managed appropriately. INPEX identifies the types of management actions to be undertaken to minimise identified impacts in the provisional environmental management plans in Chapter 11 *Environmental management program* of the Draft EIS.

INPEX prepared these provisional plans for inclusion in the Draft EIS in order to outline the high-level management actions that will form the basis of final (and more detailed) plans to be approved by the regulatory authorities. They were prepared to provide an initial outline of the Project's management program and will serve as a framework for the development of the final management plans which will have to be approved by the relevant regulatory authorities.

Details relevant to these submissions may be found in Annexe 10 *Provisional liquid discharges, surface water runoff and drainage management plan* and Annexe 15 *Provisional vegetation clearing, earthworks and rehabilitation management plan* to Chapter 11 *Environmental management program* of the Draft EIS.

These two plans provide an outline of the management controls and strategies to manage soil erosion risks and dust emissions. The key management controls in sections 3.5 and 4 of Annexe 10 for instance include the following:

- Large-scale vegetation clearing and earthworks will preferentially be undertaken in dry-season conditions.
- Erosion protection infrastructure (e.g. silt-fencing, contouring and sediment ponds) will be installed to ensure that sediment is contained within site boundaries as far as is practicable.
- If soil erosion is evident, exposed surfaces at the affected area(s) will be stabilised with mulched vegetation, dust suppressants or slope-stabilisation products.
- A mangrove health monitoring program will be developed to determine if Project activities in the onshore development area adversely impact on mangrove health.

Submission 109-11: Other impacts relate to the vegetation remaining post development. Section 8.2.3, page 384 refers to the sealed surfaces throughout the plant which will impact on the amount and intensity of run-off, as well as the inability of freshwater from rainfall to infiltrate and recharge the groundwater aquifer. The impacts could vary from mangroves suffering due to increased freshwater run-off through to saline intrusion into the aquifer and resultant impacts on groundwater dependent ecosystems.

Submission 124-68: Vegetation clearing and the sealing of surfaces on Blaydin Point may reduce groundwater recharge, and in turn, lead to saltwater intrusion and impacts on groundwater-dependent ecosystems and built infrastructure. The Draft EIS refers to maintaining "sufficient unsealed areas" in order to allow for natural infiltration (p. 384, Volume 2), however, it does not explain what "sufficient unsealed areas" actually means.

Submission 124-70: Develop or detail an understanding of Blaydin Point's hydrogeology, to demonstrate an ability to appropriately designate sealed and unsealed areas on-site, and in turn, ensure sufficient recharge of the groundwater aquifer.

To provide an indication of the amount of surface area available for direct ground infiltration compared with those areas of the plant that will have impermeable surface coverage, a review of the paving and drainage plans for the site was undertaken. This indicated that about half of the operational processing plant area will have an permeable surface that will allow for natural infiltration of rainfall.

The rest of the Blaydin Point development area will retain a permeable surface to allow for natural infiltration.

The hinterland mangroves and monsoon vine forest (potential groundwater-dependent communities) will be removed during the site preparation works. There will therefore be fewer groundwater-dependent plant species. Fringing mangroves are not dependent on groundwater. INPEX will undertake a mangrove health monitoring program as part of its environmental management program and will monitor groundwater elevation and salinity at monitoring bores at numerous locations around the Blaydin Point site.

Monitoring of the groundwater wells will allow INPEX to identify and assess potential changes to water levels and salinity and, should there be any impacts to fringing mangrove health as a result of groundwater changes, to initiate appropriate actions.

See also the Draft EIS's Technical Appendix 18 *Hydrology and hydrogeology of Blaydin Point, Darwin*.

Submission 112-5: Clearing and degradation of sensitive and high value vegetation communities

I'm very concerned at the effortless way the proponent shrugs off the destruction and degradation of high conservation value vegetation communities for this project. Once again, given that the draft has been compiled in consultation with both governments, the lack of regard for mangrove and monsoon vine forest communities evokes broader concern at the status and level of protection in place for remaining stands of high conservation value coastal vegetation communities.

We are told in section 3.6.3, "Land tenure", that: "Middle Arm Peninsula was identified as a site for future industrial development by the Northern Territory Government and is classified as such under the Northern Territory Planning Scheme." But this is not the full story. Clause 9.1.2 of the Planning Scheme was added in 2003, as a sweetener in the face of widespread organised community opposition to the construction of the Wickham Pt gas plant on Middle Arm. The new clause had the stated purpose of limiting the nature of indsutrial development on Middle Arm, and specifically disallowed further LNG processing on Middle Arm. The clause remained in place until it was removed, to make way for the Inpex project, in November 2007.

We are also told that "Most of the mangrove tracts surrounding Darwin Harbour are zoned for "conservation" under the Northern Territory Planning Scheme (DPI 2008), recognising the biodiversity value of this vegetation community." but such zoning was meaningless when the NT government decided to revoke clause 9.1.2. This, and other recent inappropriate proposals to sacrifice our precious mangroves (such as the East Point 'Arafura Marina' canal estate debacle) demonstrate that our precious mangrove communities in fact do not enjoy the level of protection and active management for conservation values that they deserve.

Territorians are concerned that 'Conservation' zoning means 'saved … for next time'. That community expectations are being managed, rather than addressed. That this government is not being candid with us about their real plans for the future development of Darwin. That this government does not share our respect for our living Harbour. I believe our mangroves and other high conservation value coastal communities deserve a higher level of protection other beyond mere zoning.

The Northern Territory Government Planning Scheme defines mangrove as 'sensitive and significant' vegetation communities which should not be cleared at all. Rightly so : mangrove environments have great intrinsic value and are extremely important habitat for a diverse range of land and marine animals. Mangroves also provide numerous free ecological services, including their capacity to filter stormwater of pollution and sedimentation, and offer essential feeding, breeding and nursery habitat for many fish and other marine species, contributing greatly to the overall health of our harbour.

Yet the draft statement does a poor job of identifying the values of our remaining mangroves, and describes plans to smother around 80 hectares of mangrove (and degrade a further area through sedimentation from dredging) as 'insignificant'. We are told the area of mangroves to be buried alive under truckloads of fill "represents less than 0.3% of that vegetation type found in the Darwin Harbour region, and is an insignificant portion of the vegetation type in the overall context of the Darwin Coastal Bioregion."

But this is a warped depiction that fails to adequately value our Harbour's natural heritage. While mangrove communities are common in the harbour, at a global level, mangroves are now one of the most threatened tropical ecosystems—more threatened than rainforests and coral reefs. Many of our regional neighbours are scrambling to regenerate their own lost mangrove heritage. It is entirely inappropriate to dismiss the planned loss of mangroves by ignoring their precious status at a global level.

Inpex's failure to acknowledge natural values is even more stark in the case of around 66 ha of regionally-significant monsoon vine forest destined to be cleared – including what has been described as one of the best patches of monsoon vine forest on the Harbour foreshore. The draft statement belittles this impact with the assurance that: "Other monsoon vine forest habitats exist within the region". This careless attitude towards high value coastal vegetation does not bode well for the management of these values in the face of likely impacts such as ongoing dredging.

INPEX can not comment on the submitter's views on government policies and/or the NT Planning Scheme; these are the responsibility of the Northern Territory Goverment.

INPEX does not propose to smother or bury alive 80 ha mangroves under truckloads of fill. See the Draft EIS Chapter 7 *Marine impacts and management* (Section 7.3.2 pages 320-321) which describes levels of modelled sedimentation within intertidal areas and the attendant risk to mangrove communities. Model outputs show approximately 30 ha of intertidal mangrove area are predicted to experience sedimentation levels of 50 mm or above. Two hectares are predicted to experience sedimentation at or above 100 mm. As discussed in the Draft EIS, a literature review of mangrove sedimentation thresholds indicated that at or above sedimentation levels of 50 mm mangrove health may be impacted; while sedimentation levels at or above 100 mm may result in mangrove mortality.

Submission 118-2: Clearing of the monsoon vine forest. There is a 100m corridor shown to the east of the LNG Plant on Blaydin Point. This corridor is for a future road across East Arm and years away from construction, therefore the monsoon vine forest should be retained, not cleared. Monsoon vine forest is a special eco type and should be retained where possible

Submission 16-24, 36-9, 89-25, 96-24, 101-26, 102-24: Minimise the onshore development footprint – speculative land clearing for potential future development should not be permitted.

With respect to vegetation clearing required for the terrestrial footprint of the onshore development INPEX has committed to the following:

- The vegetation-clearing footprint for the onshore development area will be minimised during the design of the onshore facilities, subject to constructibility and safety operating requirements.
- During construction a number of large areas will be required for laydown to cater for a range of temporary facilities, construction materials and equipment.
- Construction laydown areas are required to be as close to the construction site as possible. Temporary facilities may also be located on areas which will be used later for permanent facilities.
- Temporarily disturbed areas such as those in the vicinity of the pipeline shore crossing and onshore pipeline route will be reinstated and rehabilitated, as will any areas around the plant that do not need to remain cleared.

INPEX will not be undertaking speculative land clearing for future development – the terrestrial footprint and vegetation clearing estimates provided in the Draft EIS (and revised figures in the Supplement) relate specifically to the onshore development described in the EIS. The third party 100-m-wide access corridor, as described in the Draft EIS, is to provide for third party access to Darwin Harbour and Middle Arm should safety and operational issues allow. Middle Arm Peninsula was identified as a site for future industrial development by the Northern Territory Government and is classified as such under the Northern Territory Planning Scheme.

Submission 123-112: Information provided [with regards to acid sulphate soils disturbance] does not include the indirect affects on coastal dolphins due to loss of food supply (Jefferson et al. 2009) and potentially damage to coastal dolphin skin and eyes.

Submission 123-186: The current EMP does not provide enough information about the biogeochemical properties of dredged sediments. Sediment studies and water quality monitoring need to be undertaken at the proposed dump site using relevant parameters monitored in previous programs. The monitoring program for the dump site should be undertaken prior to, during and post construction to determine the impact that dredged sediments will have on the site and adjacent areas. Additionally, water quality and sediment monitoring will need to be undertaken in the harbour and spoil disposal site during dredging to assess the implications of acid sulphate soil disturbance or the release of arsenic from underlying geology.

Submission 128-19: Acid Sulphate Soils may not remain submerged in the tidal zone as suggested but can be expected to be exposed to the atmosphere at low tide. This would then increase the likelihood of generating acid leachate and mobilising heavy metals contained in the sediments.

Food Web

Food web effects were considered during the assessment of potential impacts arising from disturbance of acid sulfate soils. However, the consequences were assessed to be no higher than 'minor' (as defined in Draft EIS Table 6-3) across any of the biodiversity and ecological processes and environmental qualities considered.

Monitoring of spoil ground

Biological monitoring and physico-chemical monitoring of sediments at the spoil disposal ground will be undertaken prior to commencement of dredging and for a period of time after dredging has finished. The proposed program will be defined in the final dredging and dredge spoil disposal management plan.

Intertidal exposure of acid sulfate soils

During construction of the shipping channel and trenching for the pipeline, sediment will be dispersed into the water column. Some of this suspended material is predicted to reach shoreline mangrove areas (refer to Section 7.3.2 in Chapter 7 *Marine impacts and management* of the Draft EIS). The suspended sediment may potentially contain iron sulfides which, in the presence of oxygen, can lead to the production of acid sulfate forms.

The marine waters of Darwin Harbour contain oxygen. However, because it is in low concentrations (in comparison with air) only a very small portion of iron sulfides would oxidise. It is generally accepted that acid sulfate soils only become a problem when they are disturbed *and* exposed to air (DIP 2002).

The effect of any residual potential acidity of sediments deposited on the mangrove habitat will depend on the rate of deposition and the concentration of oxidisable sulfur in the sediments. In thin layers deposited at a rate of one millimetre or less on each tidal cycle, as predicted to occur, the sediment will be exposed to oxygen from the atmosphere during low-tide periods, resulting in the oxidation of sulfides and the release of acid. The environmental effect of this is however ameliorated by two factors: firstly, the acid-neutralising potential of the sediments themselves and, secondly, because the sea water also contains carbonates and bicarbonates which act to neutralise acidity. These two factors are explained further as follows:

- The acid-neutralising capacity of the seabed soils was considered in Section 3.2.6 of the Draft EIS's Technical Appendix 9 *Nearshore marine water quality and sediment study*. For almost all samples the oxidisable sulfur content of the samples was less than the acid-neutralising capacity (measured as percentage sulfur equivalent), meaning that there would be no net change in pH.
- Sea water contains carbonates and bicarbonate ions which provide a buffering capacity to resist changes in pH. The degree of buffering is determined predominantly by the alkalinity of the sea water. In circumstances where there is limited exchange of pooled water, or pore water, across the deposited sediments then conditions may occur where the buffer capacity is overwhelmed leading to the pH of pooled or pore waters dropping.

A fall in pH of pooled water could result in mobilisation of some heavy metals, such as arsenic and aluminium, and, on the incoming tide, leaching of acidic water and bioavailable metal ions into adjacent shorelines. However for the reasons outline above it is considered that the potential for this to occur is low. It should be noted that the underlying layers in mangrove sediments (in some cases only a few millimetres below the surface) are anoxic and the presence of organic matter in the form of mangrove leaves, algae, seagrass leaves or other organic detritus gives rise to potential acidity, identifiable in the field by the "rotten egg" odour of hydrogen sulfide when the sediment is disturbed. Reworking of the sediments by mangrove fauna (e.g. burrowing crabs, mud lobsters, etc.) brings anoxic sediment to the surface on each tidal cycle giving rise to a similar effect as in thin layer deposition and with no obvious effects to the mangrove communities.

A monitoring program will be in place to measure (among other parameters) the pH of water draining from mangrove areas, during dredging operations (refer to Annexe 6 Chapter 11 of the Draft EIS).

Submission 123-165: The Draft EIS indicates that detailed Acid Sulfate Soil (ASS) documentation will be developed for the construction phase and that the URS soil study will be supplemented with detailed geotechnical studies including tests for Potential Acid Sulfate Soils (PASS). Of particular concern is the large quantity of (PASS) to be disturbed, more than 1.5million tonnes (Draft EIS; p383).

Sampling by the proponent supports published NRETAS information that shows that some of this material is potentially highly acidic and disturbance will pose a significant environmental risk. A separate ASS Management Plan needs to be developed to the satisfaction of NRETAS prior to the commencement of detailed geotechnical investigations.

In addition to those stated in the Draft EIS and other supporting documentation, NRETAS requires the following issues to be addressed by the ASS Management Plan:

- Safe storage and transport of large quantities of lime (in excess of 15000 tonnes) for PASS neutralisation.
- Table 9, URS report (2009) "Icthys Gas Field Development Project: onshore topography, geology, geomorphology ad soils study" shows the liming rate to achieve neutralisation ranges from 2.2 to 140 (average 30.1) kg pure $CaCO_3$/tonne of PASS material. The neutralisation of the 10,800 tonnes (7200 m^3) of highly acidic mangrove soils requiring up to 420 kg aglime/tonne would need some 4500 tonnes of aglime. Based on the lowest rate of 6.6 kg aglime/tonne, neutralising 1.5m tonnes of lowest acidity PASS would require 9900 tonnes of aglime. Using the median liming rate of 17 kg aglime/tonne this rises to 25500 tonnes of aglime.
- If neutralisation of PASS is proposed the proponent needs to a) demonstrate the effectiveness of the method(s) used to mix/incorporate lime with the large quantities of PASS material to be disturbed by excavation activities; and b) include a program of ongoing monitoring into the continued effectiveness of this process.
- Clear definition of an ASS "incident" which recognises that incidents can arise outside the nominated monitoring cycle – such as encountering PASS when none were expected,
- Demonstrate that staff will be trained to recognise an ASS incident outside any monitoring program.
- Results of the detailed geotechnical investigations need to be included and specifically addressed.
- An ASS management plan needs to include management of PASS material during transportation, for example how to respond to and manage ASS issues following an accident involving a vessel or vehicle transporting PASS material either on and off site whether or not a spill results.
- Offsite PASS storage or disposal areas require site specific ASS management plans that are integrated with the project ASS plan.
- The ASS Management Plan must be clearly integrated with other interrelated management plans such as the
  - Transport Management Plan – accidents/spills involving vehicles or vessels transporting PASS material, wash down area, leakage material on route;
  - Waste (Hazardous) Management Plan – acidic leachate; and the
  - Dredging and Dredge Spoil Disposal Management Plan.
- ASS monitoring to include areas outside the development footprint – for example placing large quantities of fill onto ASS soil can result in a mud wave that causes PASS material to be exposed to oxidation.
- Clear timetable for the periodic review of the project ASS Management Plan, site specific ASS management plans and related management plans in consultation with NRETAS.
- Include a framework for reporting all ASS incidents and the results of monitoring programs for review by NRETAS.

The Northern Territory recommends the guidelines developed by the Queensland Acid Sulfate Soils Investigation Team (QASSIT). ttp://www.nrw.qld.gov.au/land/ass.

The ASS management plan must demonstrate that disturbance of ASS will be managed to avoid environmental harm. NRETAS requires the proponent to:

- Undertake sampling in accordance with the "Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils (ASS)" (QASSIT, 1998).
- Laboratory analysis is to be undertaken in accordance with the "Acid Sulfate Soils Laboratory Methods Guidelines" (QASSIT, 2004), either S-POCAS (Suspension-Peroxide Oxidation Combined Acidity and Sulfate) or CRS (Chromium Reducible Sulfur). Some of these Laboratory methods are included in Australian Standard AS4969 released in June 2008.
- Prepare an ASS management plan based upon the "Queensland Acid Sulfate Soil Technical Manual – Soil Management Guidelines" (QASSIT, 2002).

An ASS Management Plan was developed to the satisfaction of NRETAS prior to the commencement of detailed geotechnical investigations, the approval of which was separate from the EIS approval process. Prior to commencement of Project construction, a detailed Acid Sulfate Soils Management Plan will be developed and submitted for approval. This plan will address the issues raised in this submission (most of which are addressed in Chapter 11, Annex 1 of the Draft EIS) and will be prepared in close consultation with NRETAS ASS specialists.

See also INPEX's responses to comments a)124-56/124-58/ 107-49/ 128-25 and 128-36 for additional information on acid sulfate soils management in Section 5.2.2.20 and b) 123-12/ 123-186 and 128-19 for acid sulfate soils management in Section 5.2.2.11.

Submission 124-56: Soil erosion from large-scale earthworks along with acid sulfate soil disturbance could also impact on native biodiversity if risks are not managed appropriately. The Draft EIS is deficient in not making reference to the latest acid sulfate soils report for the Darwin region. This report highlights extremely high potential acidity levels in the mangrove soils of Darwin Harbour22. Potential levels of acidity are some of the highest, if not the highest, recorded in Australia. In certain areas, only small volumes of soil need to be disturbed for vast amounts of acid and heavy metals to be released into the waters and marine environment.

Submission 124-58: Review the latest acid sulfate soils report for the Darwin region, given that it provides baseline information and a scientific basis for the preparation of Territory-specific acid sulfate soil management plans.

Submission 107-49: INPEX indicates that an Acid Sulfate Soils plan is in preparation but cannot be completed until further geochemical testing is completed. This testing should have been completed and the information reported prior to the EIS being issued. A more detailed and therefore more meaningful discussion of the likely risk from ASS could then have been provided, along with a detailed plan made available for public comment as part of the EIS process.

Submission 128-25: It should be noted that Darwin City Council does not accept Acid Sulphate Soil as waste, until it has been remediated.

Submission 128-36: Annex 1 – Provisional Acid Sulphate Soil Management Plan

Shoal Bay Landfill may not be able not accept Acid Sulphate Soils – How will INPEX dispose of this waste? If the plan is to remediate the soil prior to disposal where will this occur and how will it be managed?

The above comments cover a number of different categories in relation to identification and management of acid sulfate soils. These have been broken down and responded under the following subheadings – EMPs, Knowledge of ASS/PASS at Blaydin Point and proposed Management strategies for the management of ASS/PASS if/when located during site works.

Environmental Management Plans

INPEX proactively developed Provisional EMPs to be included in the EIS to provide framework and outline of the key environmental impacts and associated management controls. These were not intended to be the final plans that will be submitted to the regulatory authorities for approval. The final plans will be developed with the appropriate contractors associated with the works program and as detailed design progresses. This allows INPEX to develop works plans and strategies that minimise potential negative impacts with contractors who have direct and experience to the different activities, and allow for INPEX to incorporate their experience and methodologies, while negotiating the final plans with relevant government authorities, rather than submit an early plan that does not incorporate the actual parties that may be engaging in site activities. All EMPs will be submitted to the relevant Northern Territory Government departments in draft form for review and to reach agreement with the government in terms of activities and management controls that will minimise environmental impact. The approved EMPs will be publicly available.

Knowledge of ASS/PASS at Blaydin Point

INPEX acknowledges the comments made by submitter 124 in comments (number) 56 and 58 with regard to the Darwin Region Acid Sulfate Soils report. INPEX engaged URS to undertake desktop and field studies to prepare a report on the Topography, Geology, Geomorphology and Soils specific to Blaydin Point, so that INPEX can evaluate the site specific risks and develop site specific management plans. This report was included as Technical Appendix 17 of the Draft EIS. A review of the Darwin Region Acid Sulfate Soils report has been conducted and INPEX's reported ASS results (provided in Technical Appendix 17 of the Draft EIS) are generally consistent with the findings of the Darwin Region Acid Sulfate Soils report.

In addition to this study, INPEX's Onshore Engineering team have undertaken specific geotechnical investigations (Phase 1 and 2) at Blaydin Point, which in addition to the specific geotechnical tests (e.g. soil resistivity, groundwater monitoring, seismic data, etc) provide information on presence of ASS at various locations around the proposed onshore plant site.

Prior to construction commencing a further detailed ASS testing program will be undertaken in accordance with the relevant Queensland ASS soil testing guidelines, as discussed in the Provisional Acid Sulfate Soils Management Plan (Chapter 11, Annex 1 of the Draft EIS).

Appropriate environmental and engineering data sets on ASS (including the future ASS testing to be undertaken prior to construction) will be incorporated into the final management plans.

Management strategies and controls for ASS/PASS

A wide range of management strategies have been identified to treat ASS, as discussed in Section 8.2 and in Annexe 1 *Provisional acid sulfate soils management plan* to Chapter 11 *Environmental management program* of the Draft EIS.

These management options are based on widely understood best practice management measures described in the Queensland Acid Sulfate Soil Technical Manual (Dear et al. 2002), which is the benchmark standard utilised for management of ASS in both Queensland and the Northern Territory.

If soils containing ASS/PASS are required to be removed from the area/site of works then onsite treatment will occur. The 'Borrow Pit' just south of Blaydin Point is a proposed ASS treatment and disposal area.

Offsite disposal (e.g. to a landfill or other disposal location) will be enacted as a final resort and only once appropriate neutralisation or other appropriate treatment has occurred. Relevant regulatory approvals will be obtained and stipulated management controls complied with, (e.g. soil chemistry testing regimes to ensure appropriate neutralisation has occurred if required), prior to disposal.

Submission 124-57: Recommendations: Develop plans to work with neighbouring landholders/land-users in the eradication of existing weeds and in the prevention of new weed species introductions in the project region. Joint weed management efforts will be far more effective than any weed management activities that occur in isolation.

INPEX is a member of the NT Gamba Grass Working Group and engages regularly with the Northern Territory Government in connection with potential weed risks and appropriate management options.

During field surveys locations of weeds were noted. Most of these were in areas that had been historically used or cleared for commercial and/or recreational activities (e.g. during Darwin LNG construction, access to the borrow/fill pits and access to Blaydin Point for recreational activities) that INPEX has inherited at the Blaydin Point site.

INPEX has undertaken field surveys and an ongoing spraying program to control the existing weeds and prevent introduction and spread of weeds during any INPEX onsite activities (e.g. geotechnical studies).

Where opportunities arise to work with government and industry INPEX will fully engage as appropriate.

Submission 124-60: INPEX also downplay the affect that land clearing activities will have on regional biodiversity, stating that "...monsoon vine forest occurs in other areas around Darwin Harbour...and removal of [monsoon vine forest] does not represent a critical loss at a regional scale" (Volume 2, Section 8.3.2, p. 391) and "...[eucalyptus] woodland occurs in large areas elsewhere on Middle Arm Peninsula and throughout the Darwin region and clearing at Blaydin Point will not represent a major reduction in availability of this habitat type" (Volume 2, Section 8.3.2, p. 391). These statements may be correct in relation to vegetation coverage, however in assessing biodiversity value it is important to not only consider the extent of vegetation, but also:

- The quality of the vegetation, particularly in comparison to other similar patches, taking into account factors such as species diversity, fire history etc. (Note that the patch of monsoon vine forest on Blaydin Point has been relatively protected from fire damage, Volume 2, Annexe 15, p.614);
- The isolation of a particular vegetation community patch, and hence, its local conservation significance;

The relative habitat and productivity values of different vegetation communities (e.g. "Monsoon vine forest in the Darwin Coastal Bioregion is considered to have a higher conservation value than most other vegetation types found in the onshore Project area", Volume 2, Section 8.3.1, p. 387; and "...mangroves act as primary producers providing habitat and resources to marine biota", Volume 2, Section 8.3.1, p. 389).

Submission 16-12, 24-12, 29-11, 89-12, 96-11, 101-13, 102-11: Mangroves and monsoon vine forest are considered sensitive or significant vegetation communities in the NT Government's Land Clearing Guidelines 2010. It is recommended that clearing of these communities be avoided.

Submission 123-77: To clarify, under the NT Land Clearing Guidelines, both monsoon vines forest and mangrove communities are classified as "significant vegetation".

Submission 124-54: Land clearing and land development at Blaydin Point. Mangroves and monsoon vine forest are considered sensitive or significant vegetation communities in the NT Government's Land Clearing Guidelines 2010. The Guidelines recommend that clearing of these communities be avoided. In spite of this, INPEX is proposing to clear 66 ha of monsoon vine forest and 83 ha of mangrove communities, (and there is the potential for more mangroves to be affected by sedimentation from the proposed dredging program). Additional land clearing – 161 ha of eucalyptus woodland and 41 ha of melaleuca communities – will lead to a total land clearing area of approximately 350 ha.

Recommendation: Minimise the onshore development footprint and reduce the size of the area of land to be cleared – speculative land clearing for potential future development should not be permitted.

Submission 16-13, 24-13, 29-12, 89-13, 96-12, 101-14, 102-12: 66 ha of regionally-significant monsoon vine forest to be cleared – one of the best patches of monsoon vine forest on the Harbour foreshore

Submission 40-4: 4 plans to clear sensitive coastal forests including 66 hectares of monsoonal rainforest and 83 hectares of mangrove forests to build the plant itself – coastal areas are under threat with sea level rises expected and their vegetation is essential for the health of a region.

Submission 66-3: 3. I also object to the plans to clear sensitive coastal forests including 66 hectares of monsoonal rainforest and 83 hectares of mangrove forests to build the plant itself.

Submission 124-6: Land clearing on Middle Arm Land clearing will destroy approximately 350 hectares of vegetation on Middle Arm: 66 ha of monsoon vine forest, 161 ha of eucalyptus woodland, 41 ha of Melaleuca vegetation, and 83 ha of mangroves. Recommendations: Reduce area of clearing.

Submission 12-3: I am also deeply concerned that your desire to clear and develop sensitive and significant native tropical vegetation in already diminishing environmentally-healthy coastal areas of Australia.

Tropical coastal rainforests and woodlands are the powerhouse of the world. They are far more valuable remaining relatively undisturbed by human over-consumption and unsustainable development.

Submission 104-2: Flying over Darwin it is apparent that the harbour side vegetation is being progressively cleared. The proposed Inpex site and supporting infrastructure will result in the destruction of important mangrove and forest ecosystems. These resources are not infinite or easily re-established . We do not yet know their full value as many smaller organisms and their relationship to the broader health of the Harbour are still being discovered. Furthermore the mangroves are an important buffer for storm surge and cyclones, events which are becoming more likely with increased global warming due to greenhouse gas emissions. We would like Inpex to find ways to preserve more of this valuable habitat.

Submission 109-1: 1.Section 8.3.1, page 386 states that approximately 352 hectares of vegetation will be cleared for the onshore development. An additional approximately 70 hectares of woodland is likely to be cleared for the workers camp near Howard Springs (not covered in this EIS) meaning over 400 hectares is likely to be cleared for the project.

2. The EIS does not place sufficient emphasis on the conservation values of the vegetation to be impacted.

66 hectares of monsoon vine forest and 83 hectares of mangrove communities are to be cleared for the onshore development (Section 8.3.1, page 387). Both these communities are determined to be sensitive or significant communities in the NT Government's Land Clearing Guidelines and the guidelines recommend 'that the clearing of these communities should be avoided' (2).

Submission 109-3: Monsoon forests (commonly referred to as rainforests) are determined to be sensitive or significant communities in the NT Government's Land Clearing Guidelines(2). 13% (604 species) of the Territory flora species occur in monsoon forests, they are highly diverse and significant vegetation communities. 'Patch size ranges between 1 hectare and 4000 hectare in area and they have a median size of 3.6 ha'.(4) The monsoon vine forest community proposed to be cleared is one of the largest and most intact on the Darwin Harbour foreshore. The area of monsoon vine forest on Blaydin Point represents about 4% of the total extent of the vegetation type found around Darwin Harbour and an estimated 1% of mapped monsoon vine forest in the Darwin Coastal Bioregion. The 65 hectare patch to be cleared is significantly larger than the regional median, indicating its importance in the regional landscape. It is likely to act as a significant refuge for both flora and fauna in the region.

Submission 109-7: Recommendation: Clearing and dissection of the monsoon forest communities should be avoided and the development diverted around them.

Submission 109-8: 'The mangrove communities of Darwin Harbour are amongst the most diverse in Australia, making them a significant natural resource locally and globally…Mangroves support highly specialised animals, including many species which occur nowhere else'(3). 14 bird species living in the mangroves of Darwin Harbour are entirely restricted to mangrove environments. Mangroves play a vital role in protecting the coastline from erosion and storms and reducing siltation of waterways. Their large amounts of organic matter and nutrients support flora and fauna within the mangroves and in adjacent habitats. They are important nursery habitat and spawning grounds for many fish and crutacean species.(1) They are also a significant carbon sink.

Section 8.3.1, page 387 states the majority of mangrove areas around Blaydin Point and throughout Darwin Harbour 'are zoned for "conservation" under the Northern Territory Planning Scheme ... in recognition of the high level of biodiversity contained in these vegetation communities.' Mangroves are determined to be sensitive or significant communities in the NT Government's Land Clearing Guidelines(2).

The mangroves of Darwin Harbour are already impacted by clearing and development pressure. By 2004, 400 hectares or 1.5% of the total mangrove area had been cleared(1). The 83 hectares to be cleared for this project represents a significant increase in mangrove community reduction in the harbour.

Submission 109-19: 1. The EIS (Section 8.3.1, page 387) claims that 161 hectares of Eucalyptus woodland will be cleared for the onshore operations. In addition, Section 4.5.7, page 207 indicates in the vicinity of 70 hectares of woodland is to be cleared for the workers camp on the Howard Springs road. This is subject to a different approval process and not included in this EIS. However it is crucial to include this information in the assess19ment of the impact of the project on native vegetation – it is likely that over 200 hectares of woodland is to be removed.

There is an opportunity to retain as much woodland as possible in the development of the worker's camp. An ecofriendly complex with cabins nested in amongst healthy retained vegetation will leave behind an attractive, sustainable resource for the local community (to be utilised for low cost housing, tourism or retirement village etc. at the completion of the project). There are examples of such developments elsewhere in the Top End.

Recommendations

link with 1.The workers camp be developed in a manner that retains the maximum amount of native vegetation and results in a facility that is attractive and sustainable with landscaping incorporating local native plants.

link with 2.Salvaging of all cycads be mandatory for the plant site, the workers camp site and all pipeline and access corridors.

3.Initiatives from Part 4 of this submission be utilised to compensate for any clearing of the woodland community.

Submission 109-15: Recommendation: Clearing of mangroves should be kept to an absolute minimum.

Submission 117-2: The gas plant would see hundreds of hectares of rainforest, mangroves and woodland cleared.

Submission 119-4: On-shore development and impacts on significant vegetation including rainforest and mangrove communities should be minimised and monitored.

Submission 84-7: Could Inpex please provide an exact figure as to how many hectares of mangrove and bush would need to be cleared for the project? The impact of mangrove and monsoon vine forest clearing also needs to be clearly established through studies by independent bodies on fauna and flora likely to be affected and their conservation status.

Submission 95-2: Destruction of Mangrove and Monsoon Vine Forest communities. Described in the NT Government's Land Clearing Guidelines as sensitive or significant communities in the NT, Mangrove and Monsoon Vine forests are home to a large number of the NT's native plant and animal species. The EIS states that 83 ha of mangroves and 66 ha of monsoon vine forest will be cleared representing 0.3% and 4% respectively. I do not support the clearing and fragmentation of these areas and wish to see alternative plans that exclude the need for disturbance of these important vegetation types.

Submission 123-155: Based on spatial data of rainforest vegetation in the NT (i.e. same data as used in the draft EIS), the Blaydin Point MVF is significant: within 5 km radius the patch represents 20% of MVF and is ranked the second largest patch; within 10 km radius represents 11% of dry MVF and is ranked the second largest dry MVF patch; within 20 km radius represents 4% of dry MVF and is ranked the tenth largest patch; within 50 km radius represents 1% of dry MVF and is ranked the 27th largest patch.

Submission 128-23: Vegetation Clearing. The clearing of 4% of Monsoon Vine Forest is significant particularly in view of its Biodiversity values and the cumulative effects of further clearing for other developments which will occur in the harbour.

Estimates for vegetation-clearing have changed since the publication of the Draft EIS. See Section 4.4 of this EIS Supplement for updated estimates of vegetation-clearing to take into account changes to plant design and layout. The corrected area estimates for communities to be cleared are provided in Table 4-23 of Section 4.4.

The submitters' comments and concerns are duly noted. However construction and engineering constraints prevent any significant reductions in the size of the onshore development area, because of the requirements for large areas for construction laydown and to allow for a permanent design that maintains safe distances between hazardous and non-hazardous areas.

The Northern Territory Land Clearing Guidelines 2010 states “Mangroves, rainforest and monsoon vine thickets are found in coastal areas and are considered sensitive or significant vegetation. It is recommended that the clearing of these communities should be avoided. Applicants must demonstrate how the extent to be cleared has been minimised”.

With regard to this, INPEX notes the following:

- The vegetation-clearing footprint for the onshore development area will be minimised during the design of the onshore facilities, subject to constructibility and safety operating requirements.
- During construction a number of large areas will be required for laydown to cater for a range of temporary facilities, construction materials and equipment. these construction laydown areas are required to be as close to the construction site as possible.
- Temporarily disturbed areas such as those in the vicinity of the pipeline shore crossing and onshore pipeline route will be reinstated and rehabilitated, as will any areas around the processing plant that do not need to remain cleared.

INPEX is not clearing areas for future development or that are not required for the construction, commissioning and operation of the facilities and infrastructure at Blaydin Point.

The total land footprint (this includes any mangrove or intertidal area to be cleared or reclaimed for the establishment of the onshore facilities such as the module offloading facility and jetty) is about 413 ha. This includes the onshore section of the gas export pipeline, access corridors (including roads), the combined operations complex, the borrow-pit areas and the onshore plant.

The proposed disturbance of mangrove vegetation communities at the onshore development area (82 ha in total) represents less than 0.3% of that vegetation type found in the Darwin Harbour region, and is an insignificant portion of the vegetation type in the overall context of the Darwin Coastal Bioregion. Clearing is not expected to significantly impact the vegetation type at a regional scale.

The area of monsoon vine forest to be cleared on Blaydin Point (approximately 61 ha) represents an estimated 1% of mapped monsoon vine forest in the Darwin Coastal Bioregion.

When using the terms “significance” and “significant” INPEX is not suggesting a value judgment in terms of the importance of the vegetation assigned to these areas, as indicated by a number of submitters. The term is used in relation to the discussion on overall area of clearing in comparison to overall vegetation in the Darwin Coastal Bioregion. INPEX is not indicating in the EIS that the vegetation communities (in particular the mangroves and monsoon vine forest) are any better/worse or more/less important than other communities in the Darwin coastal area.

The potential impacts of the proposed accommodation village at Howard Springs, including vegetation clearing, will be addressed in a separate approval process, as stated in the Draft EIS. Opportunities to minimise vegetation clearing and salvaging some species, such as the cycads, will be investigated with the design and construction contractor and incorporated into the plans for the village.

Submission 124-62: There are inconsistencies in the sections of the Draft EIS that address with terrestrial flora and fauna. For example, paragraph 1, p. 102 (Volume 1) states that the “most widespread vegetation community in the region is eucalypt woodland” but Table 3-11 on p. 102 indicates eucalyptus open forest, rather than eucalyptus woodlands, being most widespread.

With 161 ha of eucalyptus woodland to be cleared for the development, clarification of this matter is important, especially given eucalyptus woodlands only covered 4 300 ha of the Darwin Coastal Bioregion in 1997, as opposed to eucalyptus open forest covering 1 157 372 ha (data from Table 3-11). There are also discrepancies in the stated survey dates in the Draft EIS, (see pp. 8, 103 and 109), which need to be corrected to provide an accurate record of survey efforts.

See Section 4.4 of this EIS Supplement for updated vegetation mapping and clearing estimates.

As the submitter correctly points out the most abundant community, based on information provided in Table 3-11 in the Darwin Coastal bioregion is Eucalyptus Open Forest, not Eucalypt woodlands.

The Australian Natural Resource Atlas (ANRA) web site states that “inland from the coast the dominant vegetation type is eucalypt tall open forest, typically dominated by Darwin woollybutt (*Eucalyptus tetrodonta)* and Darwin stringyback (*E. miniata*)”.

This is reflected in Table 3-11 in the Draft EIS showing Open Forest as the most widespread community in the Darwin Coastal Bioregion.

For the most part GHD applied the National Vegetation Information System (NVIS) framework and nomenclature when classifying the vegetation at Blaydin Point and Middle Arm. Furthermore the NVIS stated that the tall open forest is mostly found inland from the coast. That being said, the use of the term eucalypt woodlands was applied to the eucalypt communities found at Blaydin Point, which are dominated by *E. tetrodonta* and *E. miniata* but that also contains other species and a grass/cycad understorey in most areas (and therefore may represent communities that could be classified as more than one vegetation community rather than a specific vegetation subgroup).

To elaborate the term “eucalypt woodland” is loosely applied to a number of eucalypt vegetation communities, for instance, the NVIS which identifies and describes major Australian native vegetation communities, suggest that on the basis of dominant species and understorey more than more classification can be applied. These are as follows:

- Eucalypt woodland (MVG 5)
- Tropical Eucalypt woodland (MVG 12)
- Eucalypt Open Forest (MVG 3)

The NVIS MVG 5 Eucalypt woodland is the largest distribution of woodland type in Australia and occurs in all states and territories; NVIS identifies several major groupings of Eucalypt woodlands (MVG 5) that are commonly recognised, of which northern/tropical climates (dominated by *Eucalyptus tetrodonta* and *E. miniata)* are commonly recognised within the MVG (12) Tropical Eucalypt woodlands (with grass understoreys). However MVG 3 Eucalypt Open Forests also states that Northern eucalypt open forests are dominated by *Eucalyptus tetrodonta* and *E. miniata* with understorey of woody shrubs and grasslands (including cycads). Both of these descriptions align with the dominant species in the Eucalypt vegetation communities at the site. At Blaydin Point the eucalypt communities present are dominated by *Eucalyptus tetrodonta* and *E. Miniata* with a grass and shrub understorey including cycads.

In the description accompanying Table 3-11 in the Draft EIS, “Woodland” is characterised by fairly sparse foliage cover (less than 30%) with an understorey of perennial and annual grasses. This vegetation type occurs on the upper slopes and is dominated by stringybark (*Eucalyptus tetrodonta*) and woollybutt (*E. miniata*). Common understorey species include the cycad *Cycas armstrongii*, the sand palm *Livistona humilis* and the pandanus *Pandanus spiralis*, with a perennial grass layer of *Sorghum* species’. ANRA/NVIS describe the Eucalypt Open Forests as varying from 10–30 m in height, dominated by several species of eucalypts occurring in associated with each other. The open forests allow more light to penetrate the canopy. One of the primary differences may be proximity to coastal areas, with MVG 5 Eucalypt woodlands described as primarily an inland vegetation group that forms a transitional zone before higher rainfall forested margins and hummock grasslands/shrublands of the arid interior, while MVG 3 Eucalypt Open Forests are described as usually occurring in monsoonal, tropical/subtropical and temperate regions of Australia and within 200 km of the coast or major water courses.

INPEX considers the eucalypt community at Blaydin Point is representative of the widespread Open Forest classification, and not a threatened or unique ecological community.

With regard to the comments on discrepancies regarding Draft EIS GHD survey dates, as listed below, the summary of studies undertaken by INPEX and provided in Chapter 1 is reflected of the period or work or engagement of GHD by INPEX, while the references on page 103 and 109 are referring to actual field studies.

- Page 8 Chapter 1 states: GHD Terrestrial Ecology (Native Flora/Fauna; Introduced Species and Pests/Weeds) November 2007 – June 2008
- Section 3.4.8 Vegetation Communities (onshore Development Area) – Page 103 chapter 3 states: Vegetation communities were identified in the onshore development area using publicly available vegetation mapping (Brock 1995; Brocklehurst & Edmeades 1996) and aerial photography. Verification of this preliminary mapping was undertaken through field surveys conducted by GHD in October 2007 and May 2008. A total of 17 quadrats, each 50 m × 50 m, were surveyed throughout the onshore development area to record plant species and vegetation community structure (e.g. landscape position, canopy cover, ground cover, and stand basal area).
- Page 109 Chapter 3 states: As described in Section 3.4.8, plant surveys were conducted in the onshore development area by GHD in October 2007 and May 2008, representing dry-season and wet-season vegetation conditions respectively (see Technical Appendix 16). Seventeen quadrats of 50 m × 50 m were included in the survey, which recorded all plant species and their distribution within each quadrat.

GHD

3. Methods

3.1 Overview

Surveys were undertaken during the late dry season of 2007 (25 October to 3 November) and the late wet season in 2008 (27 April to 8 May). Fauna survey methods were based on protocols now standard for sampling fauna in the Top End of the Northern Territory (e.g. Woinarski *et al.*, 2004). Flora survey methods were based on NRETAS' flora and vegetation survey methodology (Brocklehurst *et al.*, 2007). Methods were discussed with and agreed to by NRETAS staff.

Survey sites were selected on the basis that they represented:

- Major vegetation communities within the project area;
- Conservation significant communities or potential habitat for conservation significant species; and
- Proposed areas of impact.

Table 1 identifies plots and their locations on Blaydin Point. Figure 4 shows the flora and fauna survey locations.

Sampling of plants and animals was based on 50 x 50 m quadrats in each of the sites of interest.

Table 1 Flora and Fauna Sites

Site No	Habitat	Easting	Northing	Flora / Fauna
1	Avicennia/Ceriops Closed Forest	708025	8615675	Flora and Fauna
2	*Eucalyptus miniata/E. tetrodonta* Woodland	708525	8615575	Flora and Fauna
3	*Eucalyptus miniata/E. tetrodonta* Woodland	708825	8614925	Flora and Fauna
4	Mixed Species Low Open Forest	707975	8615375	Flora and Fauna
5	Ceriops Closed Forest	708475	8615025	Flora and Fauna
6	Monsoon Vine Forest	709225	8614475	Flora and Fauna
7	Sparse Samphire Shrubland	708875	8613775	Flora and Fauna
8	Mixed Species Low Open Woodland	708475	8613375	Flora and Fauna
9	*Eucalyptus miniata/E. tetrodonta* Woodland	707775	8612130	Flora and Fauna
9A*	Seasonal Waterbody (borrow scrape)	707858	8612128	Fauna
10	Mixed Species Low Open Woodland	707125	8612025	Flora and Fauna

43/21287/27179 **Ichthys Gas Field Development Project: onshore flora and fauna study.** 11
Final Report. Prepared by GHD Pty Ltd. Prepared for INPEX Browse, Ltd. Inpex document number: C036-AH-REP-0028

Figure 5-9: Draft EIS Technical Appendix 16 – GHD Flora & Fauna Studies – Missing Page

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7 Glossary

7 GLOSSARY

AAM	See **active acoustic monitoring** below.
AAPA	See **Aboriginal Areas Protection Authority** below.
AASS(s)	See **actual acid sulfate soil(s)** below.
abiotic	Non-living; devoid of life.
Aboriginal Areas Protection Authority	Abbreviated as **AAPA**. A statutory authority established under the *Northern Territory Aboriginal Sacred Sites Act* (NT) to administer sacred-site protection in the Northern Territory. The Administrator of the Northern Territory appoints members to the Authority, which administers the Act at arm's length from the day-to-day operations of the Northern Territory Government.
Aboriginal cultural heritage	The unique and irreplaceable legacy of the ancient, diverse and complex cultures of the original inhabitants of continental Australia. It encompasses cultural heritage as commonly understood, but is particularly notable for its emphasis on the particular affinity that Aboriginal people have with the land, and the importance they place on social values and traditions, customs and practices, aesthetic and spiritual beliefs, artistic expression and language.
acid gas removal unit	Abbreviated as **AGRU**. Before raw natural gas can be processed and liquefied it has to be cleansed of impurities. Two of these are the "acid" gases carbon dioxide (CO_2) and hydrogen sulfide (H_2S). The CO_2 has to be removed from the gas stream to prevent it from freezing in the liquefaction process and blocking the main cryogenic heat exchanger and other equipment. The H_2S is removed from the gas stream to meet buyers' specifications for the final gas products. The Ichthys Project's AGRU removes the acid gases from the hydrocarbon gas stream using activated methyldiethanolamine. See **activated methyldiethanolamine** below.
acid sulfate soil(s)	Abbreviated as **ASS(s)**. Naturally occurring soft sediments and soils containing sulfides of iron, principally iron disulfide (FeS_2) but also iron monosulfide (FeS). The exposure of the sulfides in such soils to oxygen by drainage or excavation leads to their oxidation and to the generation of sulfuric acid. This in its turn reacts with other soil constituents to liberate naturally occurring heavy metals, such as aluminium, manganese, copper and arsenic, into soil and drainage waters. These substances are toxic in varying degrees to plants, fish, etc. See **actual acid sulfate soil(s)** and **potential acid sulfate soil(s)** below.
activated methyldiethanolamine	Abbreviated as **aMDEA**. An aqueous solution of methyldiethanolamine (MDEA) to which an activator has been added to accelerate the rate of absorption of carbon dioxide (CO_2) by the MDEA. The activator may be any of several organic compounds. See **MDEA** and **methyldiethanolamine** below.
active acoustic monitoring	Abbreviated as **AAM**. In (especially) marine mammal monitoring, this term refers to a technique in which observers generate sounds underwater and listen for echoes from nearby objects such as cetaceans, turtles and fish. Observers use one or more sonar systems that actively emit sound and measure the returning noise signal to locate objects. Unlike passive acoustic monitoring (PAM), which can only detect animals when they vocalise, AAM can detect non-vocalising animals. See **PAM** and **passive acoustic monitoring** below.

actual acid sulfate soil(s)	Abbreviated as **AASS(s)**. Acid sulfate soils which have been subjected to disturbance and exposed to air. This exposure has therefore already resulted in the oxidation of some of the sulfides and the generation of liquid and leachable sulfuric acid. This acid moving through the soil has the potential to liberate naturally occurring heavy metals such as aluminium, manganese, copper and arsenic, which can cause secondary contamination of soils and water. These substances are toxic in varying degrees to plants, fish, etc. See **acid sulfate soil(s)** above and **potential acid sulfate soil(s)** below.
adsorption	The adhesion of molecules of a gas, liquid or dissolved substance as an ultrathin layer on the surface of (usually) solids.
aeolianite	A sedimentary rock formed from windblown sand that has been cemented by carbonates. See **calcarenite** below.
AGRU	See **acid gas removal unit** above.
airgun	A source of energy used to acquire seismic data in the marine environment. The airgun releases highly compressed air to produce an explosive blast into the water surrounding the gun. The shock waves are reflected and refracted by the subsurface layers of sediments and rocks and the returning signals are received by hydrophones.
airshed	A definable geographical area within which the movement of air containing gaseous emissions from industry, agriculture, bushfires, etc., takes place. An airshed will often be separated from other airsheds by local topographical and sometimes meteorological constraints.
ALARP	An acronym for the words "**a**s **l**ow **a**s **r**easonably **p**racticable". This is a term used in the field of risk management and describes a process where the benefits of taking an action to minimise risk are evaluated with consideration of the practicality and costs of taking (or not taking) that action.
alkane	Any of a series of saturated hydrocarbons having the general formula C_nH_{2n+2}. The first five alkanes in the series are methane (CH_4), ethane (C_2H_6), propane (C_3H_8), butane (C_4H_{10}) and pentane (C_5H_{12}).
aMDEA	See **activated methyldiethanolamine** above.
anastomosing	Branching and recombining in a reticulated pattern, as in the channels in river deltas, the reticulation of veins in a leaf, or the cross-connections of arteries.
anoxic	Lacking (or deficient in) oxygen.
anthropogenic	Created or caused by man, or originating from human activity.
aspect	See **environmental aspect** below.
asphaltene	Asphaltenes constitute the heaviest component of crude oil. They are characterised by high molecular weight, often exist in solid form at room temperature, and are relatively non-volatile. Condensates contain very low levels of asphaltenes. See **condensate** below.
ASS(s)	See **acid sulfate soil(s)** above.

Australian emissions unit	The term used in Australian climate-change legislation to refer to a carbon pollution permit. See **carbon pollution permit** below.
avifauna	All of the bird species of a given region, taken collectively.
barotropic	Of tidal currents, flows induced by the horizontal forces resulting from a slope in the water surface.
bathymetry	The measurement of the depth of water in oceans and other large waterbodies.
benthic zone	The lowest levels in a body of water such as a sea or a lake, including the upper subsurface layers of the sediment. See **littoral zone**, **sublittoral zone** and **supralittoral zone** below.
benthos	The organisms attached to, or living on, in or near the seabed (or riverbed or lake floor).
billion	A thousand million (10^9 or 1 000 000 000). In the International System of Units (the SI) the prefix "giga-" (symbol G) indicates the value 10^9.
bioaccumulation	The increase in concentration of a usually toxic substance (e.g. a heavy metal such as lead or mercury or a pesticide such as DDT) in the tissues of a plant or an animal at a particular level in a biological food chain. Such toxins accumulate because they are absorbed at a faster rate than they can be excreted or broken down. Compare with **biomagnification** below.
bioavailability	In ecology, this term is used to describe the degree to which a substance existing or released into a particular environment is actually available for uptake by a living organism or organisms, for example a toxic metal or chemical in an aquatic ecosystem. Potentially toxic elements or substances may be unavailable for biological uptake because they are present in a form that organisms cannot absorb.
biochemical oxygen demand	Abbreviated as **BOD**. A measure of water pollution representing the content of biochemically degradable organic substances in water or effluent. It is typically measured as the mass of oxygen in milligrams per litre of water absorbed by a sample kept at 20 °C for five days. The oxygen is used by micro-organisms which break down organic materials into carbon dioxide and water.
bioclastic	Descriptive of sediments or rocks composed of broken fragments of organic skeletal matter; for example bioclastic limestones are composed largely of shell fragments.
bioconcentration	The accumulation of waterborne chemicals by aquatic animals through non-dietary routes. By contrast, "bioaccumulation" is the accumulation of chemicals (by aquatic and other animals) through any route of exposure.
biodiversity	This term was defined by the United Nations Earth Summit in Rio de Janeiro in 1992 as "the variability among living organisms from all sources, including … terrestrial, marine, and other aquatic ecosystems, and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems".

biofouling	The unwanted build-up of organisms on man-made structures. In the marine environment this occurs especially on the submerged portions of ships' hulls, oil and gas platforms, jetties, etc. It also applies to similar growths on filters, inside pipelines, and on other items of equipment used, for example, in the wastewater treatment industry.
biogenic	Produced by living organisms or biological processes.
biohermic	Descriptive of a moundlike mass of rock built by sedentary organisms such as colonial corals or calcareous algae.
bio-indicator	An organism (which may be a plant, an animal or a bacterium) used to monitor the health of, or changes in, a particular environment or ecosystem. Examples include invertebrates used to assess any accumulation of metals or petroleum hydrocarbons that may result from drainage flows into the sea from an industrial operation.
biomagnification	The name given to the increase in concentration of a usually toxic substance (such as a heavy metal like lead or mercury or a pesticide like DDT) in the tissues of animals at higher levels in the biological food chain. The predators at the top of the food chain (e.g. man, dolphins and eagles) ingest and store in their tissues the bioaccumulated toxins of all the levels below them. Compare with **bioaccumulation** above.
bioregion	A biogeographical region characterised by a distinctive fauna and flora and made up of a group of interacting and related ecosystems. Terrestrial bioregions are defined in terms of their climate, geology, landforms and vegetation; marine bioregions are defined in terms of their plants, animals and ocean conditions.
biosequestration	The process of converting a chemical compound through biological processes to a chemically or physically isolated or inert form. The term is most commonly used to refer to the "locking", through photosynthesis, of the carbon in atmospheric carbon dioxide (CO_2) into plant biomass (usually trees) to offset the effect of the CO_2 and other greenhouse gases released by such activities as the development of natural gas fields, the burning of fossil fuels, etc.
biota	The collective term for the animal and plant life of a given region.
biotic	Relating to life or to living things.
biotone	An ecological term for a transition zone between two or more bioregions where the assemblages of species and communities are mixtures of those from the contributing bioregions.
bioturbation	In oceanography, the mixing of benthic sediments by the burrowing, feeding or other activity of living organisms such as annelid worms or bivalves.
BOD	See **biochemical oxygen demand** above.
bombora	An Australian word (from an Aboriginal language) for a coral reef or rock just under the sea's surface over which waves swell (in calm conditions) or break (in rough conditions).

BP	The letters meaning "before present" used by geologists, archaeologists, palaeontologists, etc., in association with an approximate year to specify when an event occurred in the distant past (usually in the order of thousands of years before the present, e.g. "8500 bp"). Because the "present" time changes, the year ad 1950 has been arbitrarily chosen as being the "present" for the purposes of the time scale.
British thermal unit	This unit (symbol **Btu**) is a measure of the energy required to raise the temperature of one pound of water by one degree Fahrenheit. Although no longer officially used in Britain or Australia, the British thermal unit is still widely used in the USA, as well as in the oil & gas industry worldwide where it appears along with its SI equivalent unit, the joule. (1 British thermal unit = 1.055×10^3 joules.) See **quad** below.
BTEX	The acronym (pronounced "bee-tex") for the low-boiling-point aromatic hydrocarbon compounds benzene (C_6H_6), toluene ($C_6H_5CH_3$), ethylbenzene ($C_6H_5CH_2CH_3$), and xylenes ($C_6H_4(CH_3)_2$). (The word "xylenes" is plural as there are three xylene isomers.) The BTEX compounds form a subset of the chemicals called "volatile organic compounds" (VOCs). They are some of the most commonly encountered VOCs and are, for example, normal components of petrol. The BTEX hydrocarbons are lumped together because they have similar properties and are toxic to humans and to the environment in general, particularly when they contaminate soil and groundwater. See **volatile organic compound(s)** below.
Btu	See **British thermal unit** above.
butane	An alkane hydrocarbon with the chemical formula C_4H_{10}. It is a major constituent (with propane) of liquefied petroleum gas. See **ethane**, **isopentane**, **liquefied petroleum gas**, **methane**, **pentane** and **propane** below.
bycatch	The non-target species caught incidental to commercial fishing operations, including both saleable and non-saleable fish and other animals.
calcarenite	A sedimentary rock formed from sand, shell fragments and other carbonate material. See **aeolianite** above.
carbon (dioxide) capture and storage	Abbreviated as **CCS**. An approach to carbon dioxide (CO_2) abatement in which the greenhouse gas CO_2 is captured from industrial processes (such as power generation and gas-field development projects) and injected deep underground for long-term storage in secure geological formations. The process is also called "geosequestration". See **geosequestration** below.
carbon dioxide equivalent	Abbreviated as **CO_2-e**. A measure, using carbon dioxide (CO_2) as the standard, with a value of 1, used to compare the global warming potentials of the different greenhouse gases. For example, if the global warming potential for methane over 100 years is taken as 21, this means that the emission of 1 Mt of methane may be expressed as the emission of 21 Mt of carbon dioxide equivalents. See **methane** below.

carbon footprint	A measure of the total amount of greenhouse gas emissions (measured in carbon dioxide equivalents) that is directly and indirectly caused by an activity or is accumulated over the lifespan of a product.
carbon intensive	Descriptive of fuels, industries, economies, etc., whose emissions of greenhouse gases (measured in carbon dioxide equivalents) are relatively high in comparison with those of other fuels, industries, or economies.
carbon pollution permit	Australia's proposed domestic unit of compliance with an emissions trading scheme. It has been proposed that each permit should correspond to one tonne of carbon dioxide equivalents. In proposed Australian legislation a "carbon pollution permit" is referred to as an "Australian emissions unit". See **carbon dioxide equivalent** above.
Carbon Pollution Reduction Scheme	Abbreviated as **CPRS**. The name used for the Australian Government's emissions trading scheme (or ETS), proposed to be established as part of a framework for meeting the climate-change challenge. See **emissions trading scheme** below.
carbon sink	Any natural or man-made system that takes up and stores large quantities of carbon dioxide from the atmosphere, especially forests and the oceans.
carbon tax	A tax imposed by a government on industry-generated emissions of carbon dioxide (CO_2) and possibly other greenhouse gases. Its intention is to discourage the use of fossil fuels and thereby reduce CO_2 emissions which are believed to contribute to the phenomenon of global warming.
cay	A small low-lying island or island-like bank or reef of sand, coral, etc.
CCS	See **carbon (dioxide) capture and storage** above.
cetacean	Any whale, dolphin or porpoise of the largely marine mammalian order Cetacea.
cfu	See **colony-forming unit** below.
"charismatic megafauna"	Large well-known animals, such as whales, tigers, elephants and eagles, which possess wide popular appeal and can therefore be used by environmentalists in publicity campaigns to raise conservation awareness and funds. As these "charismatic" species are generally key or apex species, any conservation gains made for them are likely to cascade down to all of the plants and animals of the ecosystems in which they live.
chenier	A sandy or shelly beach ridge on a mudflat area, caused by wave-induced sorting of the mudflat sediments to concentrate coarser material in ridges.
chlorophyll-*a*	The primary photosynthetic pigment in all plants that carry out photosynthesis.
clade	A group of organisms which includes the most recent common ancestor of all of its members and all of the descendants of that most recent common ancestor.
colluvium	Unsorted and unconsolidated rock etc. material at the base of a cliff or slope, deposited there by gravity. The adjective is "colluvial".

7 Glossary

colony-forming unit	Abbreviated as **cfu**. A unit used in microbiology as a measure of the viable micro-organisms (typically bacteria) present in a water sample and commonly used to gauge the level of contamination of water. It is typically measured as the number of colony-forming units present in one hundred millilitres of water (cfu/100 mL).
combustion greenhouse gas	"Combustion greenhouse gases", as opposed to "reservoir greenhouse gas" in the context of liquefied natural gas (LNG) production, are the greenhouse gases created by burning any type of carbon-containing fuel in the LNG production process. They are produced, for example, by the gas turbines used for compression and power generation, as well as by incinerators, hot-oil furnaces, and flares.
condensate	In the oil & gas industry, condensate is the name given to the mixture of heavier hydrocarbons which is present in hydrocarbon-containing reservoirs. Condensate is ultimately marketed, after fractionation, in liquid form at normal atmospheric temperature and pressure.
contingent gas resources	In the resources industry, contingent gas resources are those which are potentially recoverable from known accumulations, but only if a number of contingent circumstances are overcome; these may be economic, legal, environmental, political, and regulatory matters, or a lack of markets.
coralgal	Descriptive of a marine reef substrate consisting of fragments of coral and other calcareous organisms bound together with algal growths.
coralline algae	Coralline algae are red algae of the marine order Corallinales, characterised by having calcareous deposits within their cell walls. They are typically encrusting and rocklike and play an important role in the ecology of coral reefs.
corymbose	Descriptive of corals, especially of the genus *Acropora*, which have horizontal branches and short-to-medium vertical branchlets that terminate in a flat top.
CO_2	The chemical formula for carbon dioxide.
CO_2-e	See **carbon dioxide equivalent** above.
CPRS	See **Carbon Pollution Reduction Scheme** above.
cryogenic	Of or relating to very low temperatures.
cuirasse	In geology, the name sometimes given to the weathered rock "crust" or "iron crust" on the surface of a soil in tropical regions. It is also called a "lateritic duricrust". See **duricrust** below.
cultural heritage	The cultural legacy of a group or society that is inherited from past generations, nurtured in the present and held in trust for the benefit of future generations. Its tangible components include both movable and immovable objects of archaeological, architectural, artistic, environmental, ethnographic, geological, historical and palaeontological importance. Its intangible components include social values and traditions, customs and practices, aesthetic and spiritual beliefs, artistic expression, language and other aspects of human activity.

Darwin Coastal Bioregion	One of the 85 terrestrial bioregions (= biogeographical regions) into which Australia has been divided. It covers an area of 28 000 km^2 and includes most of the western coastline of the Northern Territory. The major population centres in the bioregion are Darwin and Palmerston and it extends from Wadeye in the south through Peppimenarti to Oenpelli and Murganella in the north.
Darwin Harbour region	The "Darwin Harbour region" was defined by the Darwin Harbour Advisory Committee in 2003 for its *Darwin Harbour regional plan of management* as an area covering Port Darwin, Shoal Bay and their catchments. It covers 3227 km^2 and extends from Charles Point to Gunn Point, including the estuarine areas and tributaries of Woods Inlet, West Arm, Middle Arm, East Arm, the Howard River and all of the land that drains into these waterways. The total area of land within the Darwin Harbour region as thus defined is 2417 km^2. Six local governments are contained within the region: Darwin City Council, Palmerston City Council, Litchfield Council, Cox Peninsula Community Government Council, Belyuen Community Government Council, and Coomalie Community Government Council.
dB(A)	The symbol used in acoustics for the decibel (using the "A" weighting), a measure of perceived loudness. Statistical sound level descriptors, such as $L_{A\,1}$, $L_{A\,10}$, and $L_{A\,90}$ are used to represent noise levels in A-weighted decibels that are exceeded 1%, 10% and 90% of the time. See $\mathbf{L}_{A\,10}$ and $\mathbf{L}_{A\,90}$ below.
decibel	See **dB(A)** above.
delphinid	Any member of the dolphin family Delphinidae, including dolphins, pilot whales, killer whales and the melon-headed whale.
demersal	Descriptive of a fish etc. living near the sea bottom.
depauperate	Descriptive of a fauna, flora or ecosystem, especially on islands, which is lacking the species richness of similar environments or habitats elsewhere. The term is commonly applied to "islands" of natural vegetation in an agricultural landscape as these will inevitably decline in species richness over time.
design life	The period for which a structure or a structural element remains fit for use for its intended purpose with appropriate maintenance. [With acknowledgments to Australian Standard *AS 4997:2005, Guidelines for the design of maritime structures*.]
detailed design	In engineering, the process of refining and expanding the preliminary design of a structure or component of a structure to the extent that the design is sufficiently complete to allow construction etc. to commence.
detritivore	An animal that subsists entirely or predominantly on dead organic material, especially plant detritus.
differential global positioning system	Abbreviated as **dGPS**. An enhanced global positioning system whose accuracy has been improved through the use of a network of fixed, ground-based reference stations with precisely known locations. Each station calculates its location based on GPS satellite signals and compares this location with its true position. Any difference (that is, any inaccuracy contained in the signal from the global navigation satellite system) is broadcast to the dGPS user to correct the information received from the satellite system. See **global positioning system** below.

digitate	Of corals, having short unbranched branches like the fingers of a hand.
dolphin	For the man-made mooring dolphins used in ports and marine terminals, see **mooring dolphin** below.
dry season (Darwin)	Darwin's climate is influenced by the tropical monsoon and thus has two distinct seasons—a wet season and a dry season. The dry season extends from May until October and the wet season from November until April. The dry season is mostly rain-free and day temperatures range from 16 to 32 °C (averaging about 25 °C). See **wet season (Darwin)** below.
duricrust	In geology, the weathered hard rock "crust" formed on the surface of a soil or in the upper horizons of a soil in a semi-arid climate. The duricrust is "cemented" by the precipitation of minerals such as iron oxides and oxyhydroxides by the evaporation of groundwater saturated with dissolved salts etc. See **cuirasse** above.
EC_{10}	The notation EC_{10} stands for "effect concentration 10%" or the concentration of a substance that results in 10% less growth, fecundity, germination, etc., in a population. In ecology it is used as a measure of a substance's ecotoxicity but, unlike the LC_{10} which measures lethality, the EC_{10} value measures sublethality—it demonstrates the adverse effects of a substance on a test organism, such as changes in its behaviour or physiology. See **EC_{50}**, **IC_{50}**, **LC_{50}** and **LD_{50}** below.
EC_{50}	The notation EC_{50} stands for "effect concentration 50%". See **EC_{10}** above and **IC_{50}**, **LC_{50}** and **LD_{50}** below.
ecotourism	In the strict sense ecotourism is a specialised form of tourism aimed at ecologically and environmentally aware people. It usually has a strong educational focus and often involves travel to wilderness areas or areas with special environmental or wildlife values with a view to drawing attention to their fragility. The term has been watered down, however, and now includes any commercial tourism operations in wilderness and semi-wilderness areas.
ecotoxicology	The study of the adverse effects of chemical or physical agents on ecosystems and on all or any of the animal and plant species living in them. These adverse effects may be lethal (causing death) or sublethal (having negative effects on growth, development, fertility, genetic constitution, etc.). Ecotoxicity tests may be carried out at the request of regulatory authorities, typically using well-studied "indicator" species.
EEZ	See **exclusive economic zone** below.
effect concentration 10%	See **EC_{10}** above.
EIS	See **environmental impact statement** below.
emissions trading scheme	Abbreviated as **ETS**. The name applied to a government approach to reducing pollutant production, especially of greenhouse gases but also of pollutants such as sulfur dioxide, through which economic incentives to achieve reductions are offered to industry. In Australia, the Commonwealth Government's ETS, the Carbon Pollution Reduction

Scheme, proposes to achieve CO_2-e reduction through a “cap and trade” process whereby the government sets a limit or “cap” on the total emissions allowable from the activities or sectors covered under the scheme by setting a limit on the number of permits it releases. An industry needs to produce a “credit” or “permit” or “offset” for every tonne of gas it emits. This creates a market where some industries that cannot avoid reducing their CO_2-e production to below the cap are allowed to buy or trade “carbon credits” from another business that is emitting below its own cap.

See **carbon dioxide equivalent**, **Carbon Pollution Reduction Scheme** and **CO_2-e** above.

endemic	Of plants or animals, native to and restricted to a specified geographical region.
endemicity	In biodiversity science, a measure of the extent to which the plants or animals (or both) of a particular region are endemic to it. It may be applied to the whole fauna or flora of the region or to a specified taxonomic group. It is often expressed as a percentage.
enhanced greenhouse effect	The name given to the imbalance created in the natural greenhouse effect—the historical equilibrium between incoming solar radiation and outgoing emissions of heat energy from the earth—by the increase in greenhouse gas emissions from human actions such as burning fossil fuels, intensive agriculture and land clearing. The “enhanced greenhouse effect” is believed to be the cause of global warming. See **greenhouse effect** below.
ENVID	This is the acronym for “environmental (impact) identification”. An ENVID process is a risk assessment process that investigates the likelihood of an accidental or unplanned event which could cause adverse impacts to air, land, water or living organisms in the natural (or urban etc.) environment.
environment	The Northern Territory Government defines the term “environment” in the *Environmental Assessment Act* (NT) as follows:

> “environment” means all aspects of the surroundings of man including the physical, biological, economic, cultural and social aspects

The Commonwealth Government defines the term “environment” in the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth) as follows:

> ***environment*** includes:
>
> (a) ecosystems and their constituent parts, including people and communities; and
>
> (b) natural and physical resources; and
>
> (c) the qualities and characteristics of locations, places and areas; and
>
> (d) the social, economic and cultural aspects of a thing mentioned in paragraph (a), (b) or (c).

These definitions are adhered to in the *Ichthys Gas Field Development Project: draft environmental impact statement*.

environmental aspect	In environmental management in Australia an “environmental aspect” is an element or activity of a project or operation that may result in an impact upon the environment, for example gas emissions, light emissions, the production of waste material, and vegetation-clearing.
environmental impact	In environmental management in Australia an “environmental impact” is any change to the environment, whether adverse or beneficial, wholly or partly resulting from an organisation’s environmental aspects. See **environmental aspect** above.
environmental (impact) identification	See **ENVID** above.
environmental impact statement	Abbreviated as **EIS**. An environmental impact statement is a comprehensive report, based on detailed studies, that discloses the possible, probable and certain environmental consequences of a proposed development or project and outlines the measures that would be implemented to mitigate them. It is required by law in Australia and is prepared by or for a project proponent for submission to government as part of a formal review process. The EIS is also made available to the general public for comment. The final EIS forms the basis for a decision by the regulatory authorities as to whether a project may proceed and, if so, under what conditions.
environmental indicator	A significant physical, chemical, biological, social or economic variable which can be measured in a defined way for environmental management purposes.
environmental risk analysis	The systematic process undertaken to understand the nature of and to deduce the level of environmental risk.
environmental risk assessment	The overall process of environmental risk identification, analysis and evaluation.
environmental risk evaluation	The process of comparing the level of risk against a set of risk criteria.
environmental risk identification	The process of determining what might happen to have an impact on the environment as the result of the implementation of a project etc., and where, when, why and how this could happen.
epibenthic	Of an organism, living at the surface of a seabed or lake floor.
epibenthos	The community of plant and animal organisms living at the surface of a seabed or lake floor.
epifauna	The animal life inhabiting the surface of a usually hard ocean substrate, a man-made subsea structure, or another organism.
ethane	An alkane hydrocarbon with the chemical formula C_2H_6. It is present in liquefied natural gas at anything from 1% to 10% by volume (methane being the main constituent at 83% to 99%) and is a valuable feedstock for the petrochemical industry. See **butane** above and **isopentane**, **liquefied natural gas**, **methane**, **pentane** and **propane** below.
ETS	See **emissions trading scheme** above.

exclusive economic zone	Abbreviated as **EEZ**. Australia's exclusive economic zone was declared in relation to Australia and its external territories under the *Seas and Submerged Lands Act 1973* (Cwlth). It commences at the outer limit of the territorial sea (12 nautical miles from the territorial sea baselines established under the Act) and extends generally to 200 nautical miles from the baselines. In its exclusive economic zone, Australia has sovereign rights to explore and exploit, conserve and manage the natural resources of the waters, seabed and subsoil.
fauna	All of the animals of a given region, taken collectively.
FEED	See **front-end engineering design** below.
ferruginous	Containing iron or iron compounds.
FID	See **final investment decision** below.
final investment decision	Abbreviated as **FID**. The commitment by a company, a joint venture, etc., to make funds available to proceed with the execution phase of a project based on a robust concept definition and a budget developed during the front-end engineering design phase.
flaring	The controlled burning off of hydrocarbon streams through flare stacks at an oil or gas facility such as an offshore processing facility or an LNG or LPG processing plant. Flaring is primarily carried out for safety reasons. The hydrocarbon streams flared will typically consist largely of natural gas but may also include higher alkanes.
floating production, storage and offtake (facility or vessel)	Abbreviated as **FPSO**. A converted tanker or barge or specially designed fixed facility in the ocean. Its purpose is to receive hydrocarbons from an oil or gas platform, to carry out a degree of processing, and to act as a storage vessel for liquid hydrocarbons before these products are offloaded into export tankers. The FPSO planned for the Ichthys Project will store condensate and monoethylene glycol (MEG) and will have a condensate storage capacity of more than 1 000 000 barrels. See **monoethylene glycol** below.
foliose	Of corals, having a flattened, leaflike growth form that may be folded and convoluted, often forming whorls.
formation water	Saline water trapped under natural gas and oil deposits and the surrounding rock formations. See **produced formation water** and **produced water** below.
4-D seismic technology	Time-lapse or 4-D seismic technology involves the acquisition, processing and interpretation of seismic data obtained from seismic surveys repeated at intervals over a producing oil or gas field. The technique analyses differences in successive data sets in order to determine the changes occurring in the reservoir as a result of hydrocarbon abstraction or the injection of water or gas into the reservoir.
FPSO	The abbreviation used for a "floating production, storage and offtake" facility or vessel. See **floating production, storage and offtake (facility or vessel)** above.

front-end engineering design	Abbreviated as **FEED**. The phase of an industrial plant construction project etc. where a single concept is defined in sufficient detail to allow a company to make its final investment decision (FID) prior to the project entering the execution phase. It entails undertaking a number of studies to provide a robust design where risks are well understood and the potential for (expensive) change following FID is minimised. These include technical studies; health, safety and environment studies; and operability, maintainability and availability studies.
frugivore	An animal that subsists entirely or predominantly on fruit.
frugivorous	Feeding on fruit.
fuel oil	Heavy distillates obtained from the refining of petroleum, used as fuels for engines to produce power or in boilers to produce heat. They have different grades from No. 1 to No. 6. Fuel oil graded No. 2, for example, with alkanes in the C_{14}–C_{20} carbon-chain range, is the diesel that trucks and some cars use and it is also used as heating oil. The heavy and viscous so-called "bunker oil" used to power ships is usually taken as being No. 6 and has carbon-chain lengths in the range C_{20}–C_{70}.
fugitive emissions	In the oil & gas industry, the term used to describe all gaseous emissions that result from leaks, including those from pump seals, pipe flanges and valve stems, and from accidents and equipment failures such as pipeline breaks.
gabbro	A dark volcanic rock of crystalline structure.
gas export pipeline	The name applied to the subsea pipeline which will carry natural gas and LPGs from the Ichthys Field in the Browse Basin to the Blaydin Point processing facilities in Darwin Harbour. It will have an outside diameter of approximately 42 inches (*c*.1.07 m) and an approximate length of 885 km (only 6 km of which will be onshore).
geographic information system	Abbreviated as **GIS**. A suite of computer applications widely used by planners to create multi-layered maps which permit the manipulation, analysis, and modelling of a wide range of spatially referenced data.
geosequestration	The process of capturing carbon dioxide, one of the most important greenhouse gases, from natural gas reservoirs and industrial sources such as power stations, and injecting it deep underground for long-term storage in secure geological formations. The technique is also called "carbon (dioxide) capture and storage". See **carbon (dioxide) capture and storage** above.
GHG(s)	See **greenhouse gas(es)** below.
GHG intensive	Descriptive of fuels, materials, processes, techniques, etc., with a direct or indirect capacity to produce undesirable quantities of greenhouse gases (GHGs).
GIS	See **geographic information system** above.
global positioning system	Abbreviated as **GPS**. Any worldwide navigational and surveying system based on radio signals transmitted from an array of orbiting satellites to hand-held or vehicle-mounted receivers. See **differential global positioning system** above.
global warming	The gradual increase in the earth's surface temperature caused by the enhanced greenhouse effect. See **enhanced greenhouse effect** above and **greenhouse effect** below.

global warming potential	Abbreviated as **GWP**. A measure of how much a given mass of a greenhouse gas is estimated to contribute to global warming. It is a relative scale which compares the global warming potential of the gas in question with that of an equivalent mass of carbon dioxide (which has been assigned the point-of-reference global warming potential of 1). See **methane** and **nitrous oxide** below.
GPS	See **global positioning system** above.
gravid	Pregnant. The term is usually used in relation to non-human animals, particularly reptiles and arthropods.
greenhouse effect	The natural warming process of the earth caused by the trapping of solar energy in the lower levels of the earth's atmosphere by greenhouse gases, principally carbon dioxide, methane and water vapour. In recent years, however, the necessary equilibrium between incoming solar radiation and outgoing emissions of heat energy from the earth has been affected by the increase in greenhouse gas emissions from human actions such as burning fossil fuels, intensive agriculture and land clearing. This is called the "enhanced greenhouse effect" and is believed to be the cause of global warming. See **enhanced greenhouse effect** above.
greenhouse gas(es)	Abbreviated as **GHG(s)**. Any of a number of gases found in the atmosphere which contribute to the greenhouse effect. The gases principally responsible for the greenhouse effect are defined in the *National Greenhouse and Energy Reporting Act 2007* (Cwlth) as carbon dioxide, methane, nitrous oxide and sulfur hexafluoride, together with certain specified hydrofluorocarbons and perfluorocarbons. See **carbon dioxide equivalent** and **greenhouse effect** above.
grey water	Non-industrial wastewater resulting from domestic activities in kitchens, showers, baths and laundries.
GWP	See **global warming potential** above.
HAT	See **Highest Astronomical Tide** below.
hazard	In industry, a hazard is any operation that could possibly cause a release of toxic, flammable or explosive chemicals or any action or situation that could result in injury to personnel or harm to the environment.
hazard and operability (analysis)	See **HAZOP** below.
hazard identification	See **HAZID** below.
HAZID	Acronym for "hazard identification". A HAZID process is a high-level process of hazard identification that addresses the overall project, not only the process equipment.
HAZOP	Acronym for "hazard and operability" (analysis). A HAZOP analysis is a systematic methodology used to examine facilities or processes to identify actual or potentially hazardous operations and procedures with a view to eliminating or mitigating them.
herpetofauna	All of the reptile and amphibian species of a given region, taken collectively.

Highest Astronomical Tide	Abbreviated as **HAT**. Highest Astronomical Tide is the highest level to which sea level can be predicted to rise under normal meteorological conditions.
hub	See **LNG hub** below.
hydrocarbon	Any compound consisting of hydrogen and carbon. The light hydrocarbons with low molecular weights are gases under room temperature and pressure (e.g. methane (CH_4)) and the heavy hydrocarbons with higher molecular weights are liquids (e.g. pentane (C_5H_{12}) and benzene (C_6H_6)) or solids (e.g. eicosane ($C_{20}H_{42}$), a constituent of candle wax). See **methane** and **pentane** below.
hydrogeology	The branch of geology that deals with the occurrence, distribution, movements and effects of groundwater.
hypothermia	The condition of having an abnormally low body temperature.
ichthyofauna	All of the fish species of a given region, taken collectively.
Ichthys Field	The Ichthys Field is the name given to the gas and condensate field discovered by INPEX in petroleum exploration area WA-285-P in the Brewster Member and the Plover Formation in the Browse Basin. *Ichthys* is the classical Greek word for "fish"—the modern word is *psari*. The Latin equivalent is *piscis*. It appears as an element in the (compound) scientific names of many fish. Examples include several fossil fish genera of the class Placodermi which flourished in the Late Devonian period some 360 to 400 million years ago. Three such genera are *Dinichthys*, *Gorgonichthys* and *Titanichthys*, after which three of the Ichthys Field's wells are named. The names for the wells were chosen by Shinsuke Ban (then the General Manager of INPEX's Perth office) in 2000 because of his interest in fossils, in particular those of the Devonian placoderms. The name "Ichthys" was chosen for the gas field because it was the common element in the names *Dinichthys*, *Titanichthys*, and *Gorgonichthys*.
igneous	In geology, descriptive of rock that has been solidified from molten rock material (magma) generated deep within the earth. It may solidify on the surface of the earth by volcanic action or under the surface of the earth by magmatic action. See **metamorphic** and **sedimentary** below.
IC_{50}	The notation IC_{50} stands for "inhibition concentration 50%". The IC_{50} value is the concentration of a substance that causes an inhibition of growth of 50% in a population of a target species when compared with controls. See **EC_{10}** and **EC_{50}** above and **LC_{50}** and **LD_{50}** below.
individual risk per annum	Abbreviated as **IRPA**. In risk management, this term is an expression of the annual likelihood of a fatality as a result of an activity or operation.
Indonesian Throughflow	A major ocean current which transports warm low-salinity water from the western Pacific into the high-salinity waters of the eastern Indian Ocean through the Indonesian archipelago. Flowing between the southern extremity of the Asian mainland and Australia, the Throughflow is one of the primary links or "choke points" in the global exchange of water and heat between the major ocean basins.

infauna	The animal life inhabiting the sediments of a river, lake, sea, or ocean, usually in burrows or in the interstices between the sediment particles.
infraspecific taxon	Any taxon below species level. In botany there are five ranks (taxa) below species level (subspecies, variety, subvariety, form and subform) while in zoology there is only the subspecies.
inhibition concentration 50%	See **IC_{50}** above.
inter-nesting period	Of marine turtle nesting, the period of time that elapses between the laying of the first and the laying of the last clutch of eggs by a female in one nesting season.
inter-nesting area	Of marine turtle nesting, the seas adjacent to a nesting beach where a gravid female will spend the time between the laying of successive clutches in one breeding season.
intertidal zone	See **littoral zone** below.
introduced species	An animal, plant or other organism present (either established or not) in any given ecosystem, which is not native to that ecosystem and has arrived there usually as a result of human activities.
invasive species	Defined by the International Union for Conservation of Nature and Natural Resources (IUCN) as "organisms (usually transported by humans) which successfully establish themselves in, and then overcome, otherwise intact pre-existing native ecosystems".
IRPA	See **individual risk per annum** above.
isobath	A contour line on a map connecting points of the same depth below the surface of a waterbody.
isopentane	Pentane (C_5H_{12}) has three isomers: the straight-chain isomer "pentane"; the single-branched isomer "isopentane"; and the double-branched isomer "neopentane". See **pentane** below.
JHA	See **job hazard analysis** below.
job hazard analysis	Abbreviated as **JHA**. A routine workplace requirement to assess the hazards and potential hazards associated with a job, and which identifies the measures to be taken to eliminate or mitigate causes of such hazards before the job is carried out. It is sometimes called "job safety analysis" (JSA).
Kjeldahl nitrogen	See **total Kjeldahl nitrogen** below.
Kyoto Protocol	An agreement made under the United Nations Framework Convention on Climate Change (UNFCCC). Countries that ratify the protocol commit to reduce their emissions of CO_2 and other GHGs or to engage in activities such as emissions trading if they maintain or increase emissions of these gases. The protocol was adopted in Kyoto, Japan on 11 December 1997 and entered into force on 16 February 2005. As of November 2009, 187 states had signed and ratified the protocol.
landform	A naturally formed feature of the earth's surface such as a hill, a plateau or a cliff.

L_{AE}	The symbol for “sound exposure level”. See **sound exposure level** below.
$L_{A\ max}$	The maximum noise level in A-weighted decibels (dB(A)), measured as an $L_{A\ Slow}$ value.
$L_{A\ Slow}$	The reading in decibels (dB) obtained using the “A” frequency-weighting characteristic and the “S” (Slow) time-weighting characteristic as specified in Australian Standard *AS 1259.1:1990, Sound level meters. Part 1: Non-integrating*.
$L_{A\ 10}$	The noise level in A-weighted decibels (dB(A)) which, measured as an $L_{A\ Slow}$ value, is exceeded for more than 10% of a specified period.
$L_{A\ 90}$	The noise level in A-weighted decibels (dB(A)) which, measured as an $L_{A\ Slow}$ value, is exceeded for more than 90% of a specified period.
LAT	See **Lowest Astronomical Tide** below.
laterite	Laterite is a residual rock or hard claylike crust formed in hot and wet tropical and subtropical areas by the weathering of pre-existing rocks through the action of rainwater. It is characteristically enriched in iron and aluminium compounds as they are less soluble in water than the sodium, potassium, calcium and magnesium minerals, which are leached out.
LC_{50}	The notation LC_{50} stands for “lethal concentration 50%”. It is the concentration of a chemical in air or water that will kill 50% of a group of a specific test animal species exposed to it in a given time, for example 4 hours or 24 hours. The LC_{50} is a measure of the short-term poisoning potential of a substance. See **EC_{10}**, **EC_{50}** and **IC_{50}** above and **LD_{50}** and **LT_{50}** below.
LD_{50}	The notation LD_{50} stands for “lethal dose 50%” and is the amount of a material, given all at once, which will kill 50% of a group of test animals (typically laboratory mice or rats) in a given time. The LD_{50} is a measure of the short-term poisoning potential of a substance. See **EC_{10}**, **EC_{50}**, **IC_{50}** and **LC_{50}** above and **LT_{50}** below.
lenticel	A blister-like or lens-shaped pore on the stem of a woody plant containing loosely aggregated cells which provide a pathway for the exchange of gases between the plant and the surrounding air. See **pneumatophore** below.
lethal concentration 50%	See **LC_{50}** above.
lethal dose 50%	See **LD_{50}** above.
lethal time 50%	See **LT_{50}** below.
LFL	See **lower flammability limit** below.
liquefied natural gas	Abbreviated as **LNG**. Liquefied natural gas is natural gas that has been converted to liquid form by cooling to under –160 °C. It contains only the lightest gaseous hydrocarbons of the alkane series, predominantly methane (CH_4), but also ethane (C_2H_6), a small amount of propane (C_3H_8), and a very small amount of butane (C_4H_{10}). See **liquefied petroleum gas** below.

liquefied petroleum gas	Abbreviated as **LPG**. The generic name for mixtures of the gaseous hydrocarbons of the alkane series, slightly heavier than LNG hydrocarbons, which are converted to liquid form by slight cooling and/or compression. LPG is usually predominantly propane (C_3H_8) and butane (C_4H_{10}), but may contain small quantities of pentane (C_5H_{12}) and other hydrocarbons. See **butane, ethane** and **liquefied natural gas** above and **pentane** and **propane** below.
littoral zone	In marine biology the littoral zone is taken as extending from the high-water mark of the seashore to the low-water mark. It is also called the intertidal zone. See **benthic zone** above and **sublittoral zone** and **supralittoral zone** below.
LNG	See **liquefied natural gas** above.
LNG hub	As more natural gas (and condensate) fields are discovered off the Australian coast, particularly in Western Australia and the Northern Territory, there is a risk that there may be an unnecessary proliferation of project-specific onshore gas-processing plants. This could lead to unnecessary duplication of infrastructure and unnecessary damage to environmental, cultural and scenic values. This has led to governments developing the "hub" concept, whereby several gas-processing plants would be brought together at one location to minimise the overall level of environmental, cultural and scenic impact.
LNG train	An LNG train is the processing unit that carries out the purifying and liquefying of natural gas for transport to domestic and international markets. The facility is popularly known as a "train", as on an engineer's process flow diagram the major steps in the liquefaction process are represented by rectangular blocks coupled in a row, fancifully resembling a series of railway carriages. A train typically consists of a mercury removal unit; an acid gas removal unit (to remove carbon dioxide and hydrogen sulfide which are dangerous to the liquefaction process); a dehydration unit; a liquefied petroleum gas recovery unit; and a gas liquefaction unit with its associated refrigerant compressors, gas turbines, etc.
LOEC	See **lowest-observable-effect concentration** below.
London Convention	The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972. This was drafted in London and is known as the "London Convention" for short. It is one of the first global conventions to protect the marine environment from human activities and it has been in force since 1975. In 1996 a special meeting of the contracting parties adopted the "1996 Protocol" to further modernise the 1972 Convention and eventually replace it. The Protocol entered into force on 24 March 2006 and had 36 State Parties as of November 2008. The London Convention is still in force and has 85 State Parties. The purpose of the London Convention 1972 is to control all sources of marine pollution and to prevent pollution of the sea through regulation of the dumping of waste materials into the sea. See **MARPOL 73/78** below.

low-carbon economy	An economy which produces low quantities of greenhouse gases (especially carbon dioxide) either naturally or because of a conscious political and social effort to use technologies that produce and use energy and materials with minimal emissions of greenhouse gases. The economic viability of such an economy may depend on legislative enforcement through the imposition of a "carbon tax" or an "emissions trading scheme". See **carbon tax** and **emissions trading scheme** above.
lower flammability limit	Abbreviated as **LFL**. The lowest percentage (or concentration) of a gas or a vapour in air capable of producing a flash of fire in the presence of an ignition source. At a concentration in air below the LFL there is not enough fuel to continue an explosion.
Lowest Astronomical Tide	Abbreviated as **LAT**. Lowest Astronomical Tide is the lowest level to which sea level can be predicted to fall under normal meteorological conditions. It is the datum used on Australia's hydrographic charts and is the zero value from which all tides and depths are measured.
lowest-observable-effect concentration	Abbreviated as **LOEC**. The lowest concentration used in a toxicity test on a test sample of a species that causes an effect significantly different from that observed in the control sample. See **no-observable-effect concentration** below.
LPG	See **liquefied petroleum gas** above.
LT_{50}	The notation LT_{50} stands for "lethal time 50%" or "median lethal time" and is the time required for 50% of a group of test animals to be killed following exposure to a given concentration of a toxic substance in air or water. It is complementary to the LC_{50} measure. See **EC_{10}**, **EC_{50}**, **IC_{50}** and **LC_{50}** above and **LD_{50}** below.
lunate	Crescent-shaped.
Mackay dispersant performance test	The Mackay dispersant performance test is used to determine: • how well various chemical dispersants work on various types of oil under given energy conditions, water salinities and temperatures • the relative performance of different chemical dispersants under the same conditions. In the Mackay test a circulating air current imparts energy to the water surface in the test chamber. This method of generating turbulence is believed to simulate ocean conditions more accurately than do shaking, stirring or pumping methods. This method does not attempt to simulate subsurface ocean hydrodynamics. The focus is on approximating the mixing at the surface, since this is where oil dispersal occurs. Source: AMSA (2011b).
macroalga	Any seaweed visible to the naked eye.
macrobiota	The living organisms (plants and animals) of a region that are macroscopic, that is, large enough to be seen with the naked eye. Compare with **microbiota** below.
macrophyte	A plant large enough to be seen by the naked eye. Most marine macrophytes are macroalgae, but the term also includes seagrasses which are flowering plants and not algae.

macrotidal — Descriptive of a sea or estuary experiencing large tidal ranges, usually taken to be 4 metres and above.

Compare with **mesotidal** and **microtidal** below.

mangal — See **mangrove** below.

mangrove — An intertidal salt-marsh community in the tropics and subtropics dominated by specialised trees and shrubs which have developed physiological adaptations to withstand fluctuating salinity levels and water levels together with a lack of oxygen in the mud substrate. The word may be used to describe individual species or groups of species, or it may be taken as a collective noun describing the mangrove community or ecosystem. The name "mangal" is sometimes applied to the mangrove forest community.

marine pests — Marine pests in Australia are marine plants or animals that are not native to Australia and which have been translocated to Australian waters by various vectors. Commercial vessels, for example, may discharge ballast water containing pest species from foreign waters; the biofouling organisms growing on the hulls and piping systems of commercial and recreational vessels may include pest species; commercial aquaculture operations may lead to the accidental introduction of pest species; and the aquarium industry may unknowingly or carelessly import pest species.

Marine pests may have a significant impact on human health, fisheries and aquaculture, shipping and ports, tourism, environmental values, biodiversity and ecosystem health. They can be very expensive to eradicate.

MARPOL 73/78 — The abbreviated name of the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto. It entered into force on 2 October 1983. "MARPOL" is short for "marine pollution" and 73/78 denotes the years 1973 and 1978.

The Convention covers all the technical aspects of pollution from ships, except the dumping of wastes by ships and pollution arising from exploration and exploitation of seabed mineral resources. The dumping of wastes by ships is covered by the London Convention.

See **London Convention** above.

matters of national environmental significance — Eight "matters of national environmental significance" are specially protected under national environment law and are listed in the *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth). They are as follows:

- listed threatened species and ecological communities
- migratory species protected under international agreements
- Ramsar wetlands of international importance
- the Commonwealth marine environment
- World Heritage properties
- National Heritage places
- the Great Barrier Reef Marine Park
- nuclear actions.

See **Ramsar wetland** below.

MDEA	See **methyldiethanolamine** below.
MEG	See **monoethylene glycol** below.
megafauna	Large animals. In a marine context the term includes animals such as whales and dolphins, dugongs and whale sharks. See **charismatic megafauna** above.
megaripples	High, ripple-like sand waves formed on the seabed, ranging in height from tens of centimetres to several metres. See **sand wave** below.
meiofauna	Small invertebrate animals that can pass through a 1-mm mesh but are retained by a 0.1-mm mesh.
mesocosm	In the context of toxicological studies of marine organisms, a mesocosm is an enclosed experimental ecosystem in which the fate and effects of, for example, oil on individual organisms or populations can be studied and evaluated.
meso-scale bioregion	The Integrated Marine and Coastal Regionalisation of Australia (IMCRA) framework for classifying Australia's marine environment has defined 41 "provincial" bioregions and 60 "meso-scale" bioregions. The meso-scale (= intermediate scale) bioregions may be hundreds to one or two thousand kilometres wide. The IMCRA program operates under the auspices of the Commonwealth's Department of Sustainability, Environment, Water, Population and Communities.
mesotidal	Descriptive of a sea or estuary experiencing a moderate tidal range, usually taken to be between 2 and 4 metres. Compare with **macrotidal** above and **microtidal** below.
metamorphic	In geology, descriptive of rock that has undergone partial or complete recrystallisation by natural agencies such as heat and pressure. See **igneous** above and **sedimentary** below.
methane	A colourless, odourless gas with the chemical formula CH_4. It is the simplest alkane and the principal component of natural gas. It is the main constituent of liquefied natural gas, at usually 83–99% by volume. According to the Second Assessment Report of the United Nations Intergovernmental Panel on Climate Change (1995), whose figures have been adopted by the Commonwealth Government's Department of Climate Change, weight for weight methane has the capacity to cause 21 times more global warming than carbon dioxide (CO_2), calculated over a time horizon of 100 years. Not including water vapour, after carbon dioxide it is the second-largest greenhouse gas contributor to global warming both by volume and on a carbon-dioxide-equivalent basis. See **butane**, **carbon dioxide equivalent**, **ethane**, **isopentane** and **liquefied natural gas** above and **pentane** and **propane** below.
methyldiethanolamine	Abbreviated as **MDEA**. A compound which absorbs the acid gases carbon dioxide (CO_2) and hydrogen sulfide (H_2S) at lower temperatures and releases them at higher temperatures. In the form of activated methyldiethanolamine (aMDEA), it is used to separate CO_2 and H_2S from natural gas streams. See **activated methyldiethanolamine** above.

metocean conditions	Meteorological and oceanographic conditions. The word "metocean" is a compressed adjective derived from the first syllables of "**met**eorological" and "**ocean**ographic".
microbiota	The living organisms (plants and animals) of a region region that are microscopic, that is, too small to be seen with the naked eye. Compare with **macrobiota** above.
microtidal	Descriptive of a sea or estuary experiencing a low mean tidal range, usually taken to be less than 2 metres. Compare with **macrotidal** and **mesotidal** above.
monoethylene glycol	Abbreviated as **MEG**. Monoethylene glycol is used to prevent hydrate formation in subsea pipelines. Gas produced at the wellhead contains water which, under conditions of high pressure and low temperatures, can react with methane or ethane to form solid methane or ethane hydrate. This material can block pipelines and its formation must therefore be prevented to allow gas to flow. The MEG will be injected into the reservoir fluids flowing out of the Ichthys Field wellheads. After the reservoir fluids have been separated into liquid and gas streams on the central processing facility, the MEG will pass in the liquid stream of condensate and water to a regeneration unit where it will be recovered and returned to the wellheads for reuse. See **triethylene glycol** below.
Montreal Protocol	The Montreal Protocol on Substances that Deplete the Ozone Layer is an international agreement signed in 1987 and subsequently amended on several occasions, most recently in 1999. It establishes in participating countries a schedule for phasing out release to the earth's atmosphere of chlorofluorocarbons and other substances with ozone-depleting potential.
mooring dolphin	An independent maritime structure at a port or maritime terminal that is not connected to the shore. It is fixed to the seabed and extends above water level as a platform or similar structure to provide a mooring point for ships. It permits tying mooring lines at favourable angles without having to extend an entire pier or wharf structure. Adjacent mooring dolphins are generally connected by pedestrian walkways.
native species	In the context of the Ichthys Project, a plant or animal species (or subspecies etc.) that is considered to be indigenous to the offshore, nearshore or onshore Project areas.
natural gas	A mixture of hydrocarbon gases formed underground by the decomposition of organic materials from the decay of plants and animals. It commonly occurs in association with crude oil, but many gas (or gas and condensate) reservoirs have little or no oil. The main component of natural gas is methane, but there will also be other alkanes such as ethane, propane, butane and pentane as well as a range of heavier hydrocarbons. Possible contaminants include water, carbon dioxide, hydrogen sulfide, nitrogen and mercury.
naturally occurring radioactive material(s)	Abbreviated as **NORM(s)**. Naturally occurring radioactive materials occur in trace amounts in most of the earth's crust and all humans are exposed to low levels of radiation from this source. Certain minerals and other resources such as natural gas reservoirs contain radioactive substances and these may be concentrated in scale deposits in pipelines, processing vessels, etc., if not managed properly.

neap tide
The tide with the least difference between high and low water, occurring just after the first and third quarters of the moon.

See **spring tide** below.

nephelometric turbidity unit
Abbreviated as **NTU**. A unit used to measure the degree of turbidity in water. It is measured by an instrument, a nephelometer (from Greek *nephele* "cloud" + English *meter* = "measuring device"), which quantifies how much light is scattered by suspended particles.

nitrogen oxides
Any of six gaseous oxides of nitrogen, three of which (N_2O_3, N_2O_4 and N_2O_5) are rare and unstable and may be discounted here. The two mononitrogen oxides, nitrogen monoxide (nitric oxide) (NO) and nitrogen dioxide (NO_2), are produced during combustion, especially at high temperatures. They are environmental pollutants which are harmful to human health. They are together known as NO_x and are not greenhouse gases.

Nitrous oxide (N_2O) is a dinitrogen oxide and is an important greenhouse gas. It is not a NO_x.

See **NO_x** below.

nitrous oxide
Nitrous oxide (N_2O) is a colourless non-flammable gas. It is the third-largest greenhouse gas contributor to global warming. According to the Second Assessment Report of the United Nations Intergovernmental Panel on Climate Change (1995), whose figures have been adopted by the Commonwealth Government's Department of Climate Change, weight for weight nitrous oxide has the capacity to cause 310 times more global warming than carbon dioxide (CO_2), calculated over a time horizon of 100 years.

NOEC
See **no-observable-effect concentration** below.

no-observable-effect concentration
Abbreviated as **NOEC**. "No-observable-effect concentration" is the highest concentration of a substance used in a toxicity test on a sample of a particular test species that causes an effect that is not significantly different from that observed in the control sample.

See **lowest-observable-effect concentration** above.

NORM(s)
See **naturally occurring radioactive material(s)** above.

normal cubic metre
A normal cubic metre (symbol Nm^3) is a quantity of any gas that, under "normal" conditions of temperature and pressure, occupies a volume of one cubic metre. The "normal" (or "standard") conditions must be defined, however, as there are a number of different measures in common use. It is usually defined as being measured at 0 °C and 1 atmosphere of pressure.

NO_x
The generic symbol or formula for the two mononitrogen oxides, NO (nitric oxide) and NO_2 (nitrogen dioxide). (By convention, the "x" is subscripted and italicised.)

See **nitrogen oxides** above.

NTU
See **nephelometric turbidity unit** above.

octanol–water partition coefficient	Abbreviated as **P_{ow}**. This coefficient is the ratio of the concentration of a chemical in octanol and in water at equilibrium and at a specified temperature. Octanol is an organic solvent that is used as a surrogate for natural organic matter. This coefficient is used in many environmental studies to help determine the fate of chemicals in the environment, for example in predicting the extent to which a contaminant will bioaccumulate in fish.
odontocete	Any (usually) marine mammal of the suborder Odontoceti, the toothed whales. Odontocetes include dolphins, the orca or "killer whale", porpoises, beaked whales, pilot whales, bottlenose whales and the sperm whale. Most species live in the marine environment but several live in fresh water. The baleen whales such as the humpback and southern right whales make up the suborder Mysticeti.
Operator	INPEX Browse, Ltd. and Total E&P Australia are in joint venture for the development of the Ichthys gas and condensate field in the Browse Basin. INPEX Browse, Ltd., however, is the Joint Venturer designated as the Operator of the Ichthys Gas Field Development Project and, as such, is responsible for managing the operation for and on behalf of the Joint Venturers in accordance with the terms of the two companies' joint operating agreement.
organotin	Compounds containing at least one bond between tin and carbon. They are often highly poisonous, especially to marine life. See **tributyltin** below.
PAH(s)	See **polycyclic aromatic hydrocarbon(s)** below.
palaeodrainage	Drainage systems of past geological ages, whose direction and structure can be inferred from geological analysis.
PAM	See **passive acoustic monitoring** below.
parasite	Any organism which is intimately associated with another organism (the host) and metabolically dependent upon the host for the completion of the whole, or part, of its life cycle. The activities of the parasite are typically detrimental to the host to a greater or lesser degree.
particulate matter	Abbreviated as **PM**. A term used to describe a complex group of air pollutants that are collectively regarded as a health hazard. These pollutants are a mixture of fine airborne solid particles and liquid droplets (aerosols) and include, for example, smoke, soot, dust particles, pollen, and a variety of chemical compounds. Particulate matter is usually categorised as PM_{10} and $PM_{2.5}$. The fraction of suspended particles whose diameter is less than 10 micrometres (10 μm or 10 millionths of a metre) is PM_{10}; these particles can enter the main passages in the lungs. Smaller particles, designated $PM_{2.5}$ (less than 2.5 μm in diameter), can enter the fine tubules deep in the lungs.
passive acoustic monitoring	Abbreviated as **PAM**. In (especially) marine mammal monitoring, this term refers to a technique in which observers listen passively to sounds generated underwater, such as the vocalisations of cetaceans. PAM relies on the ability of the monitoring system firstly to detect animal vocalisations and secondly to recognise the vocalisations. By contrast, active acoustic monitoring (AAM) actively generates underwater sound and measures the returning echo to locate objects. See **AAM** and **active acoustic monitoring** above.

PASS(s)	See **potential acid sulfate soil(s)** below.
pathway	In biological quarantine terminology, a pathway is a means, method or route that can provide an alien organism with the opportunity to move across a declared quarantine border.
pelagic	Relating to the open sea. Of fish and other organisms, living and feeding in the open sea but not in close association with the seabed.
peneplain	An extensive area of land that has been levelled to a flat or gently undulating plain by long-term erosion.
pentane	An alkane hydrocarbon with the chemical formula C_5H_{12}. It is a liquid at normal temperature and pressure and is a minor constituent of liquefied petroleum gas (LPG) and a more significant constituent of condensate. See **butane**, **ethane**, **isopentane**, **liquefied petroleum gas** and **methane** above, and **propane** below.
permanent threshold shift	Abbreviated as **PTS**. In acoustics, the irreversible hearing loss that results from exposure to intense impulse or continuous sound, as opposed to the reversible "temporary threshold shift" that also results from somewhat or significantly less exposure.
P_{50} resources	In the terminology of the oil & gas industry, P_{50} resources (often called "proved plus probable") are a median estimate of the resources expected to be extracted from a hydrocarbon field. A P_{50} estimate refers to a value which has a 50% probability of being exceeded.
pH	The standard measure of acidity and alkalinity (from German *Potenz* = power, and H, the symbol for hydrogen). It is a logarithmic index for the hydrogen ion concentration in an aqueous solution.
photic zone	The upper layer of the ocean water column penetrated by light.
phytoplankton	The plant-life component of plankton. See **plankton** and **zooplankton** below.
pig	In the oil & gas industry, a pig is a device sent through an active pipeline either to inspect the condition of the interior of the pipe or to scrape off rust or other foreign matter. It is propelled by the pressure of the fluid behind it.
plankton	The mostly microscopic plants and animals which drift in the upper layers of seas, lakes, and other waterbodies. Although some species can propel themselves feebly, they are moved more or less passively by currents, wind or waves. See **phytoplankton** above and **zooplankton** below.
PM	See **particulate matter** above.
PM_{10}	Particulate matter smaller than 10 micrometres (10 μm) in diameter. See **particulate matter** above.
$PM_{2.5}$	Particulate matter smaller than 2.5 micrometres (2.5 μm) in diameter. See **particulate matter** above.

pneumatophore	Pneumatophores are specialised aerial roots developed by many of the mangrove species which inhabit tidal swamps and estuarine mudbanks. The subterranean roots grow in waterlogged, saline, anaerobic soils and cannot obtain enough oxygen to function. The pneumatophores allow atmospheric oxygen to enter through their lenticels and reach the submerged roots by diffusion. See **lenticel** above.
polycyclic aromatic hydrocarbon(s)	Abbreviated as **PAH(s)**. Polycyclic aromatic hydrocarbons (also called polynuclear aromatic hydrocarbons) are a complex class of hydrocarbon compounds with two or more fused benzene rings. They can be released into the atmosphere through incomplete combustion of organic matter and are environmental contaminants. Some are known to be carcinogens.
P_{ow}	See **octanol–water partition coefficient** above.
potential acid sulfate soil(s)	Abbreviated as **PASS(s)**. Potential acid sulfate soils are soils which contain iron sulfides or sulfidic materials which are in an anaerobic environment and have therefore not been exposed to air and oxidised. The pH of such a soil in its undisturbed state can be 4 or higher and may even be neutral (pH 7) or slightly alkaline. However, if disturbed, exposed to air and oxidised, PASSs pose a considerable environmental risk as they will become acidic ("actual acid sulfate soils") and leach sulfuric acid. Disturbances that can result in the oxidisation of PASSs include the lowering of natural water tables and the excavation of soils that were previously below natural groundwater levels. See **acid sulfate soil(s)** and **actual acid sulfate soil(s)** above.
ppmv	Parts per million by volume. In atmospheric chemistry, the unit "ppmv" is a measure of the volume of a gaseous component per million volumes of total gas.
ppt	The abbreviation for both parts per thousand and parts per trillion. It is used in the *Ichthys Gas Field Development Project: draft environmental impact statement* in the meaning "parts per thousand" in salinity measurements.
produced formation water	The saline formation water produced during the extraction and processing of oil and gas from underground reservoirs. See **formation water** above and **produced water** below.
produced water	Water is always produced during the extraction and processing of gas from a natural gas field. It has two sources: one is the saline "produced formation water" found as a liquid in the geological formation below the gas, and the other is the water vapour commingled with the gas which is condensed out during the processing phase. "Produced water" is the combination of produced formation water and the condensed water. The produced water that is normally discharged from offshore oil and gas facilities contains dissolved compounds from the geological formation (such as organic acids, salts and hydrocarbons of low molecular weight) and finely dispersed oils and production chemicals. See **formation water** and **produced formation water** above.
propane	An alkane hydrocarbon with the chemical formula C_3H_8. Propane and butane are the major constituents of liquefied petroleum gas. See **butane**, **ethane**, **isopentane**, **methane**, **liquefied natural gas** and **pentane** above.

PTS	See **permanent threshold shift** above.
pulverulent	In soil studies, descriptive of soils composed of fine particles which are powdery and dusty when dry and disturbed.
quad	A unit used in discussing large amounts of energy, equal to a quadrillion (10^{15}) British thermal units (symbol Btu). In the International System of Units (SI), energy is measured in joules (symbol J). The United States, however, uses the Btu and the US Department of Energy employs the term "quad" in calculating and reporting national and international energy budgets. For convenience, large-scale energy use is therefore measured in quadrillions (or quads) of Btu. A quad is equal to 1.055×10^{18} joules or 1.055 exajoules (1.055 EJ). See **British thermal unit** above.
quadrillion	One thousand million million (10^{15} or 1 000 000 000 000 000). In the International System of Units (the SI) the prefix "peta-" (symbol P) indicates the value 10^{15}. See **quad** above.
quarantine	A system of regulatory measures put in place by governments to prevent or control the introduction, establishment or spread of plants and animals, or of pathogenic fungi, viruses, bacteria or protozoa, that could cause damage to natural ecosystems, agriculture, human health, etc. In the context of the Ichthys Project, the quarantine measures put in place are to prevent or control the introduction of any living organism not native to any part of the terrestrial or marine environment in which the Project operates.
quarantine waste	In the context of the Ichthys Project, quarantine waste means materials or goods of quarantine concern as determined by the Australian Quarantine and Inspection Service (AQIS) and which are subject to and/or identified under the *Quarantine Act 1908* (Cwlth) and associated legislative instruments. It includes material used to pack and stabilise imported goods; galley food and other waste from overseas vessels; human, animal or plant waste brought into Australia; refuse or sweepings from the hold of an overseas vessel; and any other waste or other material that has come into contact with the quarantine wastes listed above.
Ramsar wetland	A wetland (or site) designated for inclusion on the Ramsar List of Wetlands of International Importance. The Ramsar Convention (the "Convention on Wetlands of International Importance, especially as Waterfowl Habitat") was signed in Ramsar in Iran in 1971 and came into force in 1975. It is an intergovernmental treaty which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. There are presently 159 contracting parties to the convention. Australia signed the convention in 1971. Wetlands included in the list acquire a new status at the national level and are recognised by the international community as being of significant value for humanity as a whole. Contracting parties are committed to ensuring the maintenance of the ecological character of each Ramsar site under their control.

receptor	In environmental management and ecology, receptors are living organisms, the habitats or ecosystems which support such organisms, or natural resources which could be adversely affected by any form of environmental contamination (e.g. toxins, sewage, dust, light or noise).
relevé	A simple quantitative sampling technique in which a visual description is made of the vegetation of an area, including characteristics such as species found, cover, density, etc. It allows large areas to be classified and mapped in a limited amount of time. The name is also applied to the sampling site itself.
reservoir CO_2	A term used in the oil & gas industry to describe the carbon dioxide (CO_2) naturally present in a natural gas formation and which is typically vented to the atmosphere when the gas is extracted from the reservoir and processed. It is also called “native CO_2”.
residual (environmental) risk	In environmental risk management, the level of risk remaining after the implementation of risk-control strategies.
rhizobenthic	Descriptive of seaweeds etc. which are rooted in the substrate of the seabed.
ria	A drowned river valley, usually long and narrow, formed as a result of a rise in sea level relative to the land, either by an actual rise in global sea level or by the land sinking. A “ria coast” is a deeply indented coastline with numerous rias.
rollover	The term “rollover” refers to the rapid release of LNG vapour from a storage tank as a result of the stratification of LNG in the tank. This may happen if two separate layers of LNG of different densities are allowed to form, with an older, denser and warmer layer of LNG at the bottom of a storage tank and a newer, lighter and cooler layer of fresh LNG at the top. If the bottom layer continues to heat, its density begins to approach that of the upper layer, allowing rapid mixing to occur. If this occurs suddenly, the top and the bottom layers are said to “roll over” and large amounts of vapour are released from the superheated lower layer as it rises to the surface. As the lower layer has been superheated it gives off large amounts of vapour as it rises, causing a dramatic expansion in vapour pressure and internal tank pressure.
salp	A free-swimming marine invertebrate with a transparent barrel-shaped body. Salps are tunicates related to the sea squirts.
sand wave	The term used for wave-like bed forms in sand on the seabed. These can vary in height from a few centimetres (sand ripples) to several metres (megaripples). See **megaripples** above.
SBM	See **synthetic-based mud** below.
sedimentary	In geology, descriptive of rock that has been formed by the consolidation of sediment carried by water, ice or wind and deposited on land or under water, for example sandstone. See **igneous** and **metamorphic** above.
SEL	See **sound exposure level** below.

semidiurnal	Descriptive of tides having cycles of approximately 12 hours. The predominant type of tide throughout the world is semidiurnal, with two high waters and two low waters each day.
semi-hispidose	Literally “half-bristly”. Of corals, having numerous short side branchlets projecting outwards from the main branch.
septage	The liquid, sludge and solid material pumped from a septic tank, cesspool, or other primary treatment source.
sheetflow	Water flow that occurs overland in places where there are no defined channels. The floodwater may spread out over a large area at a relatively uniform depth.
SI	The international abbreviation for the French words *Système International* from *Le Système International d’Unités*, known in English as the International System of Units. The SI is the internationally recognised system of measurement.
slug catcher	A large vessel placed at the outlet of a gas pipeline before the gas enters the processing facilities at an off- or onshore hydrocarbon processing plant. A “slug” is a mass of liquid (condensate, water, etc.) travelling through the pipeline along with the gas. The slugs (along with any other liquids arriving continuously at the onshore processing plant through the pipeline) are captured in the slug catcher and removed before they can overload the downstream receiving equipment at the plant. The slug catcher essentially acts as a large gas–liquid separator ahead of facilities that will separately process the gas and the liquids.
sound exposure level	Abbreviated as **SEL**. The total noise energy produced from a single noise event. Its symbol is L_{AE}.
sound pressure level	Abbreviated as **SPL**. In acoustics, a logarithmic measure of the root mean square sound pressure of a sound relative to a reference value.
SO_x	The generic symbol for the oxides of sulfur. (By convention, the “x” is subscripted and italicised.) See **sulfur oxides** below.
SPL	See **sound pressure level** above.
spring tide	The tide with the greatest difference between high and low water, occurring just after the new moon and full moon. See **neap tide** above.
squat	The apparent increase in the draught of a ship caused by pressure changes in the surrounding waters resulting from the movement of the ship through the water.
stakeholder	Any organisation, government agency, group or person that has an interest in, or may be affected by, a project or by the activities or decisions of an organisation.
“step back 5 × 5”	A workplace safety mantra which encourages workers to figuratively step back five paces and pause for five minutes to reflect upon likely hazards before embarking on an activity.
stochastic	Occurring in a random pattern.

subarborescent	Of corals, tending to be treelike in form.
sublittoral zone	The area of shallow water on a seashore immediately below the littoral (or intertidal) zone. It is permanently under water. See **benthic zone** and **littoral zone** above and **supralittoral zone** below.
Suezmax	A naval architecture term for the largest ships capable of passing through the Suez Canal fully loaded. It is almost exclusively used in reference to tankers.
sulfur oxides	Abbreviated as **SO_x**. Gaseous sulfur oxides are produced by the combustion of coal, oil, gas and metal-containing ores. Sulfur oxide emissions consist principally of the stable sulfur dioxide (SO_2), but include the unstable or short-lived sulfur monoxide (SO) and sulfur trioxide (SO_3). Anthropogenic emissions are caused by fossil-fuel combustion, smelting, etc. Sulfur oxides in the atmosphere are harmful to human health when in high concentrations and are considered to be environmental pollutants.
supralittoral zone	The area of a seashore immediately above the level of a spring high tide that is subject to splash by sea water but is not submerged. See **benthic zone**, **littoral zone** and **sublittoral zone** above.
supratidal	Of or relating to the coastal zone (often salt flats or sand dunes) above the high-tide mark.
synthetic-based mud	Abbreviated as **SBM**. A fluid used to facilitate the drilling of boreholes into rock. The mud is formulated using a variety of synthetic organic base fluids and has most of the performance properties of oil-based muds but without the adverse environmental effects caused by the use of diesel and mineral-oil muds. Synthetic-based muds are generally used deeper in the wells than the water-based muds in formations where the material being drilled swells if water-based muds are used. See **WBM** and **water-based mud** below.
tabular	Of corals, having a tiered, table-like growth form consisting of horizontal flattened plates.
TBT	See **tributyltin** below.
TEG	See **triethylene glycol** below.
temporary threshold shift	Abbreviated as **TTS**. In acoustics, the reversible hearing loss that results from exposure to intense impulse or continuous sound, as opposed to the irreversible “permanent threshold shift” that may result from more intense exposure.
terrigenous	Descriptive of marine rock material, sediments, etc., derived from the land. (From Latin *terrigenus* “earth-born”.)
thermocline	A temperature gradient, especially an abrupt one in a body of water.
tidal excursion	The net horizontal distance covered by a water molecule or particle during one complete tidal cycle of flood and ebb.
Tiwi Islands	The Tiwi Islands are approximately 80 km north of Darwin at the junction of the Arafura Sea and the Timor Sea. There are three islands in the group—Melville Island, Bathurst Island and Buchanan Island. The first two are large, with a total area of 8320 km^2, while Buchanan Island in Shoal Bay in the south is only 170 ha in extent.

TKN	See **total Kjeldahl nitrogen** below.
Top End	The colloquial expression "the Top End" is used to distinguish the tropical and monsoonal northern quarter of the Northern Territory from the semi-arid and arid southern three-quarters. No southern boundary line has been officially defined for the Top End. For the purposes of the environmental impact statement for the Ichthys Gas Field Development Project, the Top End may be taken as being the whole of the Darwin – Arnhem Land peninsula south to a line joining the points where the eastern border of Western Australia and the western border of Queensland meet the sea in the Joseph Bonaparte Gulf and the Gulf of Carpentaria respectively.
total Kjeldahl nitrogen	Abbreviated as **TKN**. A quantification of total organic nitrogen and ammonia nitrogen present in water, used in environmental science in particular to determine the level of nitrogen pollution. It differs from the measure of total nitrogen (TN) in that it does not include the oxidised forms of nitrogen existing as nitrates and nitrites.
train	In the oil & gas industry a "train" is a "gas liquefaction train" or "liquefied natural gas train". See **LNG train** above.
tributyltin	Abbreviated as **TBT**. Tributyltin compounds are biocides and were used especially in marine antifouling paints to protect the hulls of boats and ships against the growth of marine organisms. They are now recognised as environmental pollutants and as of 1 January 2008 there is a complete prohibition on the presence of TBT paints on ships worldwide.
triethylene glycol	Abbreviated as **TEG**. Triethylene glycol has a strong affinity for water and is used in the oil & gas industry to dehydrate natural gas. It will be used on the central processing facility at the Ichthys Field to remove the water from the gas stream before the gas is sent through the gas export pipeline to the LNG plant in Darwin. See **monoethylene glycol** above.
trillion	A million million (10^{12} or 1 000 000 000 000). In the International System of Units (the SI) the prefix "tera-" (symbol T) indicates the value 10^{12}.
TTS	See **temporary threshold shift** above.
tubicolous	Living in tubes. Descriptive, for example, of those species of polychaete worm which construct "cemented" tubular burrows in seabed sediments.
tunicate	Any of various small marine animals of the subphylum Tunicata usually having a cylindrical or globular body enclosed in a tough outer covering. The adults are often colonial and affixed to rocks etc., but some are free-swimming. See **salp** above.
turbidity	The cloudiness in a liquid caused by the presence of finely divided suspended particles.
ultraviolet A	Abbreviated as **UV-A**. Ultraviolet radiation in the 320–400 nm band.

umbilical	In the oil & gas industry an umbilical is an assembly of hydraulic hoses which can also include electrical cables or optic fibres, used to control subsea structures from a platform or a vessel.
UV-A	See **ultraviolet A** above.
vacant Crown land	In the Northern Territory the expression “vacant Crown land” is the name used for Crown land currently not being used and not reserved for any specific future purpose.
viewshed	The area of a landscape that is visible from a given vantage point. The viewshed concept is used in urban and industrial planning and landscape architecture to assist planners to mitigate the impacts of developments.
VOCs	See **volatile organic compound(s)** below.
volatile organic compound(s)	Abbreviated as **VOC(s)**. Volatile organic compounds are organic chemical compounds that have a high enough vapour pressure under normal conditions to significantly vaporise and enter the atmosphere. It may contain hydrogen, oxygen, nitrogen and other elements. Methane (CH_4) is not generally included as a VOC. Volatile organic compounds react with nitrogen oxides in sunlight to form ground-level ozone and thus contribute to smog. Some VOCs, such as benzene (C_6H_6), have been identified as potential carcinogens. See **BTEX** above.
vug	A small hollow or cavity in rock, often lined with crystals whose mineral composition is different from that of the surrounding rock.
water-based mud	Abbreviated as **WBM**. A fluid used to facilitate the drilling of boreholes into rock. It consists of a blend of water with clay (bentonite) and other additives. The water-based muds are generally used higher in the wells than the synthetic-based muds. See **SBM** and **synthetic-based mud** above.
WBM	See **water-based mud** above.
wet season (Darwin)	Darwin’s climate is influenced by the tropical monsoon and thus has two distinct seasons—a wet season and a dry season. The dry season extends from May until October and the wet season from November until April. Most rain falls in the period from December to March and “the Wet” is characterised by high humidity and high-intensity electrical storms. Wet-season temperatures range from 25 to 36 °C and the average annual rainfall is over 1700 mm (*c*.67 inches). See **dry season (Darwin)** above.
zone of visual influence	Abbreviated as **ZVI**. The zone within which a human can both see and define an object. The term is used by landscape architects and environmental planners especially in the preparation of visual impact assessments made as part of the approvals process for industrial developments. The ZVI has been defined to demonstrate what a person sees without assistance and is subject to factors such as air quality, illumination and light reflectivity.
zooplankton	The animal-life component of plankton. See **phytoplankton** and **plankton** above.
ZVI	See **zone of visual influence** above.

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8 Abbreviations

8 ABBREVIATIONS

Abbreviations and acronyms

A&E (department)	accident and emergency (department)
AAM	active acoustic monitoring (see *Glossary*)
AAPA	Aboriginal Areas Protection Authority (see *Glossary*)
AASS(s)	actual acid sulfate soil(s) (see *Glossary*)
ABARE	Australian Bureau of Agricultural and Resource Economics
ABS	Australian Bureau of Statistics
ACC	American Chemistry Council
ADCP	acoustic Doppler current profiler
ADF	Australian Defence Force
ADWG	Australian Drinking Water Guidelines
AER	Australian Energy Regulator
AFANT	Amateur Fishermen's Association of the Northern Territory
AFMA	Australian Fisheries Management Authority
AGL	above ground level
AGM	annual general meeting
AGRU	acid gas removal unit (see *Glossary*)
AHD	Australian Height Datum
AIMS	Australian Institute of Marine Science
ALARP	as low as reasonably practicable (see *Glossary*)
aMDEA	activated methyldiethanolamine (see *Glossary*)
AMOSC	Australian Marine Oil Spill Centre
AMSA	Australian Maritime Safety Authority
AMSTECI	Association for Mitigation Studies for Top End Cyclones Inc.
ANRA	Australian Natural Resources Atlas
ANZECC	Australian and New Zealand Environment and Conservation Council
APASA	Asia-Pacific Applied Science Associates, Australian-based representatives of the international ASA group, specialist providers of marine modelling services for environmental and engineering assessment
API	American Petroleum Institute
APIN	Army Presence in the North (Project)
APPEA	Australian Petroleum Production & Exploration Association Limited
AQIS	Australian Quarantine and Inspection Service
ARI	average recurrence interval
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
AS	Australian standard
AS/NZS	(joint) Australian and New Zealand standard
AS/NZS ISO	(joint) Australian, New Zealand and International Organization for Standardization standard
ASS(s)	acid sulfate soil(s) (see *Glossary*)
ATSI	Aboriginal and Torres Strait Islander
AVTAS	AIMS Video Transect Analysis System (see AIMS above)
BCA	Building Code of Australia
BCF	bioconcentration factor
BEF	buoyancy enhancement factor
BHD	backhoe dredger
BMSL	below mean sea level
BOD	biochemical oxygen demand
BOG	boil-off gas
BOM	Bureau of Meteorology

BOP	blow-out preventer
BP	before present (see *Glossary*)
BRS	Bureau of Resource Sciences
BTEX	benzene, toluene, ethylbenzene and xylenes (see *Glossary*)
c.	*circa* (Latin = “about”, “approximately”)
CASA	Civil Aviation Safety Authority
CBD	central business district
CCGT	combined-cycle gas turbine
CCPP	combined-cycle power plant
CCS	carbon (dioxide) capture and storage (see *Glossary*)
CDM	clean development mechanism
CD-ROM	compact disc read-only memory
CDU	Charles Darwin University
CEMP	construction environmental management plan
CEO	chief executive officer
CER	certified emission reduction
cfu	colony-forming unit (see *Glossary*)
CF_x	perfluorocarbons
CHiSP	high-resolution continuous seismic profiling
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CMS	Convention on the Conservation of Migratory Species of Wild Animals (signed at Bonn in Germany in 1979 and also known as the “Bonn Convention”)
CO2CRC	Cooperative Research Centre for Greenhouse Gas Technologies
CPCe	Coral Point Count with Excel extensions (a Visual Basic program for the determination of coral cover)
CPF	central processing facility
CPI	corrugated plate interceptor
CPRS	Carbon Pollution Reduction Scheme (see *Glossary*)
CRC	Cooperative Research Centre
CSD	cutter-suction dredger
CSIRO	Commonwealth Scientific and Industrial Research Organisation
Cwlth	Commonwealth
CWR	Centre for Whale Research (Western Australia) Inc.
DAF	dissolved air flotation
DAFF	(Commonwealth) Department of Agriculture, Fisheries and Forestry
DBE	(Northern Territory) Department of Business and Employment, formerly the Department of Business, Economic and Regional Development
DBERD	(Northern Territory) Department of Business, Economic and Regional Development, now the Department of Business and Employment
DCC	(Commonwealth) Department of Climate Change, now the Department of Climate Change and Energy Efficiency
DCM	(Northern Territory) Department of the Chief Minister
DEC	(Western Australia) Department of Environment and Conservation
DECC	(New South Wales) Department of Environment and Climate Change
DEET	(Northern Territory) Department of Employment, Education and Training, now the Department of Education and Training
DEFRA	(United Kingdom) Department for Environment, Food and Rural Affairs
DEH	(Commonwealth) Department of the Environment and Heritage, now the Department of Sustainability, Environment, Water, Population and Communities
DET	(Northern Territory) Department of Education and Training, formerly the Department of Employment, Education and Training

DEW	(Commonwealth) Department of the Environment and Water Resources, now the Department of Sustainability, Environment, Water, Population and Communities
DEWHA	(Commonwealth) Department of the Environment, Water, Heritage and the Arts, formerly the Department of the Environment and Heritage and the Department of the Environment and Water Resources; now the Department of Sustainability, Environment, Water, Population and Communities
dGPS	differential global positioning system
DHA	Defence Housing Australia
DHAC	Darwin Harbour Advisory Committee
DHCS	(Northern Territory) Department of Health and Community Services, now the Department of Health and Families
DHF	(Northern Territory) Department of Health and Families, formerly the Department of Health and Community Services
DIPE	(Northern Territory) Department of Infrastructure, Planning and Environment, now (for environmental matters) the Department of Natural Resources, Environment, the Arts and Sport
DITR	(Commonwealth) Department of Industry, Tourism and Resources, now (for resources matters) the Department of Resources, Energy and Tourism
DITRDLG	(Commonwealth) Department of Infrastructure, Transport, Regional Development and Local Government
DLP	(Northern Territory) Department of Lands and Planning
DNA	deoxyribonucleic acid
DoR	(Northern Territory) Department of Resources, formerly the Department of Regional Development, Primary Industry, Fisheries and Resources
DoS	degree of saturation
DPC	Darwin Port Corporation
DPI	(Northern Territory) Department of Planning and Infrastructure, now the Department of Lands and Planning and the Department of Construction and Infrastructure
DRDPIFR	(Northern Territory) Department of Regional Development, Primary Industry, Fisheries and Resources, now the Department of Resources
DRET	(Commonwealth) Department of Resources, Energy and Tourism
DSEWPaC	(Commonwealth) Department of Sustainability, Environment, Water, Population and Communities
DVD	digital video (or versatile) disc
EA Act	*Environment Assessment Act* (NT)
EC_{10}	effect concentration 10% (see *Glossary*)
EC_{50}	effect concentration 50% (see *Glossary*)
ECNT	Environment Centre Northern Territory
EEZ	exclusive economic zone (see *Glossary*)
EGS	Earth Sciences and Surveying, an international group of companies engaged, *inter alia*, in providing earth science and oceanographic services
EHA Division	Environment, Heritage and the Arts Division (of the Northern Territory's Department of Natural Resources, Environment, the Arts and Sport); now the Environment and Heritage Division
EIS	environmental impact statement (see *Glossary*)
EITE	emissions-intensive trade-exposed
EMP	environmental management plan
ENSO	El Niño Southern Oscillation
ENVID	environmental (impact) identification (see *Glossary*)
EPA	(Northern Territory) Environment Protection Authority
EPA	(Western Australia) Environmental Protection Authority
EPA (US)	(United States) Environmental Protection Agency

EPA	(Western Australia) Environmental Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cwlth)
EPC	engineering, procurement and construction
ERMP	environmental review and management program
ERP	emergency response plan
ERS	Environmental Risk Solutions Pty Ltd, an Australian health, safety and environmental consulting and training firm
ERU	emission reduction unit
ETS	emissions trading scheme (see *Glossary*)
EUA	European Union allowance
EU ETS II	European Union Emissions Trading Scheme Phase II
FEED	front-end engineering design (see *Glossary*)
FID	final investment decision (see *Glossary*)
FPSO	floating production, storage and offtake (vessel or facility) (see *Glossary*)
GBRMPA	Great Barrier Reef Marine Park Authority
GD	grab (or clamshell) dredger
GDP	gross domestic product
GE	General Electric
GHD	an international consultancy, GHD Pty Ltd (formerly known as Gutteridge Haskins & Davey Pty Ltd), offering a range of services in the fields of water, energy, resources, the environment, etc.
GHGs	greenhouse gas(es) (see *Glossary*)
GIS	geographic information system (see *Glossary*)
GL	Germanischer Lloyd Industrial Services UK Ltd
GPS	global positioning system (see *Glossary*)
GSP	gross state product
GVA	gross value added
GWP	global warming potential (see *Glossary*)
HAT	Highest Astronomical Tide (see *Glossary*)
HAZID	hazard identification (see *Glossary*)
HAZOP	hazard and operability (analysis) (see *Glossary*)
HB	hopper barge
HCFC(s)	hydrochlorofluorocarbon(s)
HFC(s)	hydrofluorocarbon(s)
HOCNF	Harmonised Offshore Chemical Notification Format
HRW	HR Wallingford Limited, a British-based international consultancy offering services in engineering and environmental hydraulics, and in the management of the water environment
HSE	health, safety and environment
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities
IC_{50}	inhibition concentration 50% (see *Glossary*)
ICN	Industry Capability Network
IFC	issued for construction
IFD	issued for design
IGC Code	International Gas Carrier Code
IMCRA	Integrated Marine and Coastal Regionalisation of Australia (IMCRA v. 4.0, 2006)
IMCRA	Interim Marine and Coastal Regionalisation of Australia (IMCRA v. 3.3, 1998)
IMDG Code	International Maritime Dangerous Goods Code
IMO	International Maritime Organization
IMRP	Integrated Monitoring and Research Program
IMS	Integrated Managed Services Pty Ltd, a Western Australian company offering people

	management services to heavy engineering construction projects
IO	internal olefin
IPCC	Intergovernmental Panel on Climate Change
IPCS	International Programme on Chemical Safety
IPP	Industry Participation Plan
IRPA	individual risk per annum (see *Glossary*)
ISM Code	International Safety Management Code
ISO	International Organization for Standardization
ISQG(s)	interim sediment quality guideline(s)
IUCN	International Union for Conservation of Nature and Natural Resources
JHA	job hazard analysis (see *Glossary*)
JI	joint implementation
JIP	joint industry project
JPDA	Joint Petroleum Development Area
KP	kilometre point (measures in kilometres along the gas export pipeline, starting at the Ichthys Field and ending at the pipeline shore crossing on Middle Arm Peninsula in Darwin Harbour)
KPI	key performance indicator
$L_{A\ 10}$	An $L_{A\ 10}$ noise level is the noise level in A-weighted decibels (dB(A)) which, measured as an $L_{A\ Slow}$ value, is exceeded for more than 10% of a specified period.
$L_{A\ 90}$	An $L_{A\ 90}$ noise level is the noise level in A-weighted decibels (dB(A)) which, measured as an $L_{A\ Slow}$ value, is exceeded for more than 90% of a specified period
LAC	light attenuation coefficient
LAT	Lowest Astronomical Tide (see *Glossary*)
LC_{50}	lethal concentration 50% (see *Glossary*)
LD_{50}	lethal dose 50% (see *Glossary*)
LDC	Larrakia Development Corporation
LETDF	Low Emissions Technology Demonstration Fund
LFL	lower flammability limit
LHMC	Larrakia Heritage Management Committee
LLR	lower limits of reporting
LNG	liquefied natural gas (see *Glossary*)
LOEC	lowest-observable-effect concentration (see *Glossary*)
LPG(s)	liquefied petroleum gas(es) (see *Glossary*)
LSR	location-specific risk
LT_{50}	lethal time 50% (see *Glossary*)
MARPOL 73/78	International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78)
MCMPR	Ministerial Council on Mineral and Petroleum Resources
MEG	monoethylene glycol (see *Glossary*)
MHF	major hazard facility
MMO	marine mammal observer
MMPE	Monterey–Miami Parabolic Equation (a modelling program for underwater acoustics)
MMRF	Monash Multi-Regional Forecasting (a modelling program for simulating the regional and national economic impacts of an Australian project etc.)
MODU	mobile offshore drilling unit
MOF	module offloading facility
MOU	memorandum of understanding
M_s	the notation for values of surface-wave magnitude (a magnitude scale for earthquakes)
M_w	the notation for earthquake magnitude based on the seismic moment
MSDS(s)	material safety data sheet(s)
mtDNA	mitochondrial DNA

MW	molecular weight
n.a.	not applicable; not available
NATA	National Association of Testing Authorities, Australia
NAXA	Northern Australia Exercise Area
NEPC	National Environment Protection Council
NEPM(s)	national environment protection measure(s)
NFPA	National Fire Protection Association
NGERS	National Greenhouse and Energy Reporting System
NHMRC	National Health and Medical Research Council
NIMPCG	National Introduced Marine Pests Coordination Group
NLC	Northern Land Council
NODGDM	National Ocean Disposal Guidelines for Dredged Material
NOEC	no-observable-effect concentration (see *Glossary*)
NOHSC	National Occupational Health and Safety Commission
NOI	notice of intent
NORM(s)	naturally occurring radioactive material(s) (see *Glossary*)
NPV	net present value
NRETA	(Northern Territory) Department of Natural Resources, Environment and the Arts, now the Department of Natural Resources, Environment, the Arts and Sport
NRETAS	(Northern Territory) Department of Natural Resources, Environment, the Arts and Sport, formerly the Department of Natural Resources, Environment and the Arts
NRMMC	Natural Resource Management Ministerial Council
NT	Northern Territory
NTICN	Northern Territory Industry Capability Network
NTU	nephelometric turbidity unit (see *Glossary*)
OCIMF	Oil Companies International Marine Forum
ODS(s)	ozone-depleting substance(s)
OEMP	operations environmental management plan
OPF	organic-phase drilling fluid
OPGGS(Environment) Regulations	Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations 2009 (Cwlth)
OSCP	oil-spill contingency plan
OSMP	operational and scientific monitoring program
OSPAR	Oslo and Paris (Commission or Convention)
PAH(s)	polycyclic aromatic hydrocarbon(s)
PAM	passive acoustic monitoring (see *Glossary*)
P&ID(s)	piping & instrumentation diagram(s)
PAR	photosynthetically active radiation
PASS(s)	potential acid sulfate soil(s) (see *Glossary*)
PBB	polybrominated biphenyl
PCB	polychlorinated biphenyl
PCN	polychlorinated naphthalene
PCT	polychlorinated terphenyl
PDA	Project Development Agreement
PFC(s)	perfluorocarbon(s)
pH	logarithmic index for the hydrogen ion concentration in an aqueous solution as a measure of acidity or alkalinity (see *Glossary*)
PIANC	Permanent International Association of Navigation Congresses
PLan	Planning Action Network Inc.
PLJ	product loading jetty
PM	particulate matter (see *Glossary*)

PM_{10}	(air-polluting) particulate matter with diameters less than 10 µm
$PM_{2.5}$	(air-polluting) particulate matter with diameters less than 2.5 µm
PMBH	polyhexamethylene biguanide hydrochloride
P_{ow}	octanol–water partition coefficient (see *Glossary*)
ppb	parts per billion
PPE	personal protective equipment
ppm	parts per million
ppmv	parts per million by volume
ppt	parts per thousand (see *Glossary*)
PSD (analysis)	particle size distribution (analysis)
psi	pound(s) per square inch
P(SL)(MoE) Regulations	Petroleum (Submerged Lands) (Management of Environment) Regulations 1999 (Cwlth)
PTS	permanent threshold shift
PVC	polyvinyl chloride
PWC	Power and Water Corporation (of the Northern Territory)
PWSNT	Parks and Wildlife Service of the Northern Territory
QAP	quarantine-approved premises
QRA	quantitative risk assessment
rms	root mean square
RMU	removal unit
RO	reverse osmosis
ROV	remotely operated vehicle
RPS	RPS Environmental Pty Ltd, an international consultancy providing, *inter alia*, environmental management services
SBM(s)	synthetic-based mud(s) (see *Glossary*)
SD	statistical division (of the Australian Bureau of Statistics)
SDP	self-elevating drilling platform
SEA SERPENT (project)	South East Asia Scientific and Environmental ROV Partnership using Existing iNdustrial Technology (project)
SEL	sound exposure level
SIGTTO	Society of International Gas Tanker and Terminal Operators Limited
SIL	safety integrity level
SKM	Sinclair Knight Merz Pty Limited, an international engineering, sciences and project delivery company
SMCA	*Sunken Military Craft Act* (US)
SMS	safety management system
sp.	species (singular)
SPL	sound pressure level
SPOCAS	suspension peroxide oxidation combined acidity and sulfate
spp.	species (plural)
SS	suspended solids
SSC	suspended-sediment concentration
SSD	statistical subdivision (of the Australian Bureau of Statistics)
SSE	safe shutdown earthquake
SVT	SVT Engineering Consultants, a Perth-based consultancy specialising in acoustics, vibration and corrosion
TAPM	The Air Pollution Model (a CSIRO modelling program for the prediction of air quality)
TBM	tunnel-boring machine
TBT	tributyltin (see *Glossary*)
TDS	total dissolved solids
TED(s)	turtle excluder device(s)

TEG	triethylene glycol (see *Glossary*)
TKN	total Kjeldahl nitrogen (see *Glossary*)
TOC	total organic carbon
TOPROC	Top End Regional Organisation of Councils
TPH(s)	total petroleum hydrocarbon(s)
TPWC Act	*Territory Parks and Wildlife Conservation Act* (NT)
TSHD	trailing suction hopper dredger
TSS	total suspended solids
TTS	temporary threshold shift (see *Glossary*)
UCL	upper confidence level
UCS	unconfined compressive strength
UNCLOS	United Nations Convention on the Law of the Sea
UNFCCC	United Nations Framework Convention on Climate Change
URS	URS Australia Pty Ltd, the Australian arm of an international multidisciplinary engineering design and environmental services consultancy, and formerly known in Australia as Dames & Moore
US EPA	(United States) Environmental Protection Agency
VER	voluntary emission reduction
VET	vocational education and training
VOC(s)	volatile organic compound(s) (see *Glossary*)
VSP	vertical seismic profiling
VTS (system)	vessel traffic service (system)
WBM	water-based mud (see *Glossary*)
WHO	World Health Organization
WHRU	waste heat recovery unit
w/w	weight per weight
WWTP	wastewater treatment plant
YMCA	Young Men's Christian Association

Chemical symbols and formulae

$BaSO_4$	barium sulfate (barite)
C_5 (etc.)	(in carbon chain notation) a carbon compound with five carbon atoms, usually in a chain
$CaCO_3$	calcium carbonate
CH_4	methane
C_2H_6	ethane
C_3H_8	propane
$(C_4H_9)_3Sn$ group	the chemical group forming the basis of tributyltin compounds (TBTs)
C_4H_{10}	butane
C_5H_{12}	pentane
$C_{11}H_{19}N_5S$	Irgarol® 1051 (a triazine)
Co	cobalt
CO	carbon monoxide
CO_2	carbon dioxide
CO_2-e	carbon dioxide equivalent (see *Glossary*)
Cu	copper
Cu^{2+}	copper(II) cation
Fe	iron
Fe_2O_3	iron(III) oxide (haematite)
FeS	iron monosulfide (ferrous sulfide)
FeS_2	iron disulfide (ferric sulfide)
Hg	mercury

HNO_3	nitric acid
H_2S	hydrogen sulfide
H_2SO_4	sulfuric acid
Mn	manganese
N	nitrogen
NH_4^+	ammonium (ion)
NO	nitric oxide
N_2O	nitrous oxide
NO_2	nitrogen dioxide
NO_3^-	nitrate (ion)
NO_2^-	nitrite (ion)
NO_x	nitrogen oxides (see *Glossary*)
O_3	ozone
PO_4^{3-}	orthophosphate (ion)
SF_6	sulfur hexafluoride
Sn	tin
SO_2	sulfur dioxide
SO_x	sulfur oxides (see *Glossary*)
$SrSO_4$	strontium sulfate

Abbreviations and symbols for units of measurement

The units of measurement used in the *Ichthys Gas Field Development Project: draft environmental impact statement* and the *Ichthys Gas Field Development Project: supplement to the draft environmental impact statement* are, in the main, those recommended by the International System of Units (SI). They also, however, include the following:

- non-SI units that are based on the SI and are retained because of their practical importance (e.g. hectare, litre and tonne)
- non-SI units that are recognised as having to be retained because of their practical importance (e.g. day, hour, minute and degree Celsius)
- various other non-SI units or specialist units in combination with SI units (e.g. decibel and parts per million)
- non-SI units widely used in the oil & gas industry (e.g. British thermal unit and million barrels).

a	year (from Latin *annus* = year)
bbl	barrel(s)
bbl/d	barrel(s) per day
Bq	becquerel(s)
Bq/L	becquerel(s) per litre
Btu	British thermal unit (see *Glossary*)
c	centi- (SI prefix = 0.01, or 10^{-2}, or one-hundredth)
°C	degree(s) Celsius
cfu/100 mL	colony-forming unit(s) per 100 millilitres (see *Glossary*)
cm	centimetre(s)
cP	centipoise
d	day
dB	decibel
dB(A)	decibel ("A" weighting) (see *Glossary*)
dB re 1 µPa	sound pressure level with reference to one micropascal
dB re 1 µPa at 1 m	sound pressure level with reference to one micropascal at the standard reference distance of one metre from the acoustic centre of the source
dB re 1 µPa rms	sound pressure level with reference to one micropascal root mean square
G	giga- (SI prefix = 1 000 000 000, or 10^9, or one thousand million)
GJ	gigajoule(s)

GL	gigalitre(s)
GL/s	gigalitre(s) per second
Gm^3	cubic gigametre(s) (or thousand million cubic metres)
GW	gigawatt(s)
GW·h	gigawatt hour(s)
GW·h/a	gigawatt hour(s) per annum
g	gram(s)
g/L	gram(s) per litre
g/m^2	gram(s) per square metre
h	hour(s)
ha	hectare(s)
hp	horsepower
Hz	hertz
k (prefix)	kilo- (SI prefix = 1000, or 10^3, or one thousand)
kg	kilogram(s)
kg/d	kilogram(s) per day
$kg/ha{\cdot}a^{-1}$	kilogram(s) per hectare per annum
kg/m^3	kilogram(s) per cubic metre
kg/t	kilogram(s) per tonne
kHz	kilohertz
km	kilometre(s)
km/h	kilometre(s) per hour
km^2	square kilometre(s)
kV·A	kilovolt ampere(s)
L	litre(s)
lm	lumen(s)
lm/m^2	lumen(s) per square metre
lx	lux
M (prefix)	mega- (SI prefix = 1 000 000, or 10^6, or one million)
ML	megalitre(s)
ML/a	megalitre(s) per annum
Mm^3	cubic megametre(s) (or million cubic metres)
Mt	megatonne(s)
Mt/a	megatonne(s) per annum
MW	megawatt(s)
m	metre(s)
m^2	square metre(s)
m^3	cubic metre(s)
m^3/a	cubic metre(s) per annum
m^3/d	cubic metre(s) per day
m^3/h	cubic metre(s) per hour
m/s	metre(s) per second
m^3/s	cubic metre(s) per second
m (prefix)	milli- (SI prefix = 0.001, or 10^{-3}, or one-thousandth)
mg	milligram(s)
$mg/cm^2{\cdot}d^{-1}$	milligram(s) per square centimetre per day
mg/g	milligram(s) per gram
mg/kg	milligram(s) per kilogram
mg/L	milligram(s) per litre
mg/m^2	milligram(s) per square metre

mg/Nm^3	milligram(s) per normal cubic metre
mL	millilitre(s)
mm	millimetre(s)
mm/a	millimetre(s) per annum
mm/h	millimetre(s) per hour
mol	mole
µ	micro- (SI prefix = 0.000 001, or 10^{-6}, or one-millionth)
µg	microgram(s)
µg/cm^2·d^{-1}	microgram(s) per square centimetre per day
µg/L	microgram(s) per litre
µg/m^3	microgram(s) per cubic metre
µg/Nm^3	microgram(s) per normal cubic metre
µm	micrometre(s)
µPa	micropascal(s)
MMbbl	million barrels
MMscfd	million standard cubic feet per day
mol	mole(s)
n	nano- (SI prefix = 0.000 001, or 10^{-9}, or one thousand-millionth)
ng	nanogram(s)
ng/g	nanogram(s) per gram
nm	nanometre(s)
N/m^2	newton(s) per square metre
Nm^3	normal cubic metre (the volume of gas under standard conditions)
NTU	nephelometric turbidity unit (see *Glossary*)
P	peta- (SI prefix = 1 000 000 000 000 000, or 10^{15}, or one thousand million million)
PJ	petajoule(s)
Pa	pascal(s)
ppb	parts per billion
ppm	parts per million
ppmv	parts per million by volume
ppt	parts per thousand (see *Glossary*)
psi	pound(s) per square inch
s	second(s)
t	tonne(s)
t/a	tonne(s) per annum
tcf	trillion cubic feet

9 Contributors

9 CONTRIBUTORS

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Annexure 1: List of Public Submissions

ANNEXURE 1: LIST OF EIS PUBLIC SUBMISSIONS

A.1 Petition submissions

Organisation	Submission number	Supplement page number reference
Australian Marine Conservation Society	8	177, 278, 282, 393, 406

A.2 Organisation submissions

Organisation	Name	Submission number	Supplement page number reference
Amateur Fishermen's Association NT	Chris Makepeace	120	181, 182, 198, 217, 218, 240, 267, 280, 312, 317, 319, 320, 321, 322, 326, 327, 386, 388, 389, 443, 460, 461
AMSTECI	Mike Nicholls	130	181, 183, 184, 186, 382, 383, 385, 415, 433, 434, 436, 437, 438, 439, 440
Atmospheric Solutions	Robert Kennedy	103	208, 209, 210, 255, 256, 257, 408, 415
CAT Travel (Darwin)	Duncan Dean	72	431
Charles Darwin University	Donald Franklin	99	234
Climate Action Darwin	Michael Cauce	102	176, 177, 235, 249, 253, 261, 267, 270, 279, 282, 285, 287, 293, 341, 386, 388, 394, 470, 478, 483
Darwin City Council	Pam Robinson	128	175, 176, 189, 193, 204, 206, 208, 220, 221, 222, 239, 246, 259, 261, 281, 290, 292, 350, 377, 378, 381, 382, 386, 389, 395, 402, 410, 415, 442, 459, 461, 463, 479, 481, 485
Darwin Film Society	Jeff Coulter	5	464, 465
Darwin Harbour Advisory Committee	Bill Stuchbery	122	181, 182, 218, 267, 284, 389
Department of the Chief Minister	Maria Duchateau	86	176, 179, 189, 207, 214, 222, 237, 247, 298, 299, 390, 442, 459, 462
Environment Centre NT	Stuart Blanch	124	177, 178, 183, 199, 200, 201, 207, 208, 239, 245, 246, 251, 255, 258, 263, 264, 267, 274, 281, 292, 297, 300, 302, 305, 307, 310, 312, 317, 320, 373, 374, 375, 376, 377, 378, 386, 388, 390, 391, 392, 397, 401, 403, 405, 409, 410, 463, 471, 473, 475, 476, 481, 482, 483, 486
Environmental Recycles NT	Greg Chapman	42	230, 262
Greening Australia NT	Mike Clark	109	198, 207, 250, 286, 311, 395, 397, 399, 400, 401, 443, 467, 470, 471, 472, 473, 474, 475, 476, 484, 485
HELP NT	Carolyn Reynolds	1	176, 202, 203, 204, 214, 223, 224, 227, 247, 248, 386, 392, 406, 416, 417, 418, 419, 420, 421, 422, 423, 424, 425, 426, 427, 428, 429, 430, 431
La Laguna University	Natacha Aguilar Soto	85	266, 287, 288, 297, 387

Organisation	Name	Submission number	Supplement page number reference
Larrakia Development Corporation	Greg Constantine	97	462, 463
Northern Land Council	John Hughes	107	190, 191, 192, 193, 194, 195, 196, 197, 212, 213, 214, 216, 217, 219, 239, 258, 267, 276, 305, 309, 310, 311, 387, 409, 413, 414, 442, 443, 455, 457, 473, 481
NRETAS	Jim Grant	123	172, 173, 174, 175, 182, 187, 198, 219, 220, 241, 242, 243, 244, 258, 260, 267, 269, 270, 271, 272, 273, 274, 276, 277, 290, 291, 298, 299, 300, 322, 328, 330, 331, 333, 335, 336, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 352, 353, 354, 355, 356, 357, 358, 359, 360, 362, 363, 364, 365, 367, 368, 369, 370, 371, 372, 373, 378, 390, 393, 402, 409, 433, 455, 456, 474, 479, 480, 481, 483, 485
Sea Darwin	Jim Smith	23	283, 395, 396, 448
Shire of Derby/West Kimberley	Shane Burge	127	246, 410
The Wilderness Society	Jill StJohn	106	190, 204, 210, 211, 238, 249, 301, 302, 308, 336, 408, 472
Tourism Top End	Tony Clementson	93	177, 283, 447, 448
Western Australia's Department of Fisheries	Julie Lloyd	53	294, 295, 296, 441, 448, 449, 450 ,451, 453, 454
Western Australia EPA	Dr Ray Masini	129	410, 411
Wunambal Gaambera Aboriginal Corporation	Lillian Karadada	94	237, 387, 407
WWF-Australia	Gilly Llewellyn	100	180, 254, 271, 280, 284, 286, 289, 290, 297, 301, 304, 305, 306, 307, 407, 412

A.3 Individual submissions

Name	Submission number	Supplement page number reference
Alana Corr	14	283
Amanda McLennan	88	176, 178, 266, 396
Andrew Raith	74	177, 283, 296
Angela Roodhouse	10	229
Angela Snow	59	229
Brendan Anderson	21	229
Brendan Dowling	116	240, 280, 290
Brian Cotgrove	61	229
Brigid Oulsnam	101	176, 177, 181, 235, 249, 253, 261, 267, 270, 279, 282, 285, 287, 293, 341, 386, 388, 394, 399, 470, 478, 483
Bruce Williamson	81	235, 236, 255, 454, 455
Catherine Martel	84	176, 206, 233, 237, 249, 279, 296, 471, 485

Name	Submission number	Supplement page number reference
Catherine Orme	95	266, 393, 472, 485
Cheryl Billing Smith	71	266, 279, 296
Christine Cox	29	235, 249, 253, 270, 279, 282, 285, 386, 470, 483
Cliff Walton	4	265
Clive Pearce	35	230
Cristina Reyes	18	186, 205, 235, 265, 293, 294, 441
Cynthia Miall	69	232
Deborah Hall	104	206, 237, 249, 484
Deborah Mills	44	176, 178, 396
Derek Archer	108	267
Derek McCarthy	63	232
Diana Rickard	12	229, 265, 282, 484
Diane Kastel	114	176, 178, 396
Duncan Carson	13	176, 177, 265, 283, 393, 406
Elizabeth Thornton	31	230
Francine Bartlett	40	265, 279, 283, 406, 483
Georgia Phillips	27	176, 178, 396
Gerry Wood	118	207, 458, 460, 478
Glenn Osboldstone	36	176, 177, 207, 261, 287, 341, 388, 478
Grahame Hubbard	60	176, 178, 396
Greg Harrison	2	406
Heather Moorcroft	87	233, 249, 279, 293, 299, 397
Heather Ryan	7	205, 207, 224, 227, 228, 229, 278, 281, 281, 282, 444, 445, 459, 465, 467, 469, 470
Helen Lindstrom	32	230, 280, 283
Helena Bond	65	241, 296, 396
Ian Kitney	77	233
Jaemie Page	96	177, 247, 261, 253, 267, 270, 279, 282, 285, 287, 293, 341, 386, 388, 394, 471, 480, 485
James Treloar	64	176, 178, 232, 266, 396,
Jane Herrador	39	176, 178, 396
Jane Paterson	68	232
Jennie Renfree	111	177, 396
Jodi Kirkby	121	234
John Hart	48	230
John Roodenrys	110	177, 240, 257, 262, 269, 280, 284, 312, 313, 314, 315, 317
Judith Flynn	43	230
Judy De Groot	79	176, 178, 396
Julie Weston	62	176, 178, 396
Justin Tutty	112	234, 250, 254, 263, 267, 318, 387, 395, 458, 477
Ken Hooke	70	176, 178, 396
Keren Parnell	117	177, 255, 265, 284, 396, 401, 485
Kitri Cardwell	52	176, 178, 266, 396

Name	Submission number	Supplement page number reference
Kree Eyre	75	176, 178, 323, 265, 396
Kris Garrein	33	230
Kylie Ellis	82	233
Laura Smith	73	232
Lindsay Mugglestone	56	176, 178, 396
Louise Harrison	119	287, 290, 318, 393, 401, 485
Lyn Higgs	45	176, 178, 396
Magdalena Szaszorowska	58	176, 178, 230, 265, 396
Margie West	126	178, 234
Maria Papadopoulou	41	176, 178, 230, 265, 396
Mark Gregson	28	176, 178, 396
Mark Jones	125	265
Marnie Cooper	49	176, 178, 396
Megan Clementi	115	176, 178, 396
Megan Lawrence	67	176, 266
Meredith Tyburczy	51	231
MF McAuliffe	16	176, 177, 235, 249, 253, 261, 270, 279, 282, 285, 287, 293, 341, 386, 388, 394, 470, 478, 483
Michael Webb	83	179, 233
Mick Guinea	98	179, 300, 301
Mirjam Kaestli	11	265, 274
Morgana Robb	47	176, 178, 265, 396
Morris Pizzutto	20	176, 177, 178, 279, 270
Nicolas Mialaret	66	279, 283, 406, 483
Pam Nunn	3	172, 443, 444
Patrick Barrie	50	176, 178, 266, 396
Rachel Bury	30	176, 178, 229, 396
Raphael Kunzli	76	176, 178, 396
Rebecca Savage	57	176, 178, 396
Rick Murray	9	248, 265, 268, 390, 394, 431, 446, 447
Robert Rutkowski	55	176, 178, 230, 231, 265, 396
Roberta and Ed Dixon-Valk	24	294, 235, 249, 253, 270, 279, 282, 285, 386, 470, 483
Robin Ellis	92	176, 177, 178, 234, 249, 396
Rose Kubatov	22	229
Roy Beames	6	268, 271, 276, 278
S Sankar	80	178, 265, 396
Sam Ryan	54	176, 396
Sean Corrigan	38	176, 178, 230, 396
Sophie Chapman	17	279
Steve and Donna Mahony	19	229, 265, 294, 318, 447, 458
Sue Mornane	113	234
Sue Pratt	91	176, 396
Susan Lloyd	37	230, 265
Suzanne Rosenberg	90	176, 178, 396
Tanya Roddan	46	176, 178, 396

Name	Submission number	Supplement page number reference
Teja Lipold	78	407
Terry Lustig	25	229
Tida Nou	89	176, 177, 207, 235, 249, 253, 261, 270, 279, 282, 285, 287, 293, 300, 341, 386, 388, 394, 397, 398, 470, 480, 483
Tiffany Theden	15	229
Tina Sykes	26	176, 178, 396
Warren Clancy	105	378
Wendy Sykes	34	230

Annexure 2: Draft EIS Public Submissions

ANNEXURE 2: DRAFT EIS PUBLIC SUBMISSIONS

This Annexure contains the original public submissions received by INPEX as part of the public review of the Draft EIS.

Public submissions received are extensive in size and are therefore provided with this document on the CD (located in the sleeve on the rear cover).

Submissions are also accessible on the INPEX web site at <www.inpex.com.au>.