



**PROJECT SEA DRAGON
STAGE 1 LEGUNE GROW-OUT FACILITY
SUPPLEMENTARY ENVIRONMENTAL IMPACT STATEMENT**

CONTENTS

Acronyms and Abbreviations	iv
1 Introduction	1
1.1 Purpose of this Document.....	1
1.2 Structure of this Document.....	1
1.3 Project Overview	2
1.4 Summary of the Assessment Process	2
2 Summary of Submissions	5
3 Response to Submissions	8
3.1 Warren Keen	8
3.2 Department of Tourism and Culture (Tourism NT).....	9
3.3 Department of Tourism and Culture (Heritage Branch)	11
3.4 Department of Tourism and Culture (Parks and Wildlife)	11
3.5 Department of Tourism and Culture (Arts and Museums)	16
3.6 Department of Housing and Community Development	31
3.7 Power and Water Corporation.....	32
3.8 Department of Chief Minister	33
3.9 Department of Infrastructure, Planning and Logistics.....	34
3.10 Department of Primary Industry and Resources	41
3.11 Department of Health	45
3.12 University of Technology Sydney	48
3.13 Department of Environment and Natural Resources	52
3.14 Commonwealth Department of Environment and Energy	69
3.15 Anonymous Public Comment.....	98
3.16 Department of Treasury and Finance	107
3.17 Department of Trade, Business and Innovation	108
3.18 Northern Land Council	109
3.19 NT EPA	129
3.20 World Wildlife Fund	197
3.21 Environment Centre NT.....	203
4 References.....	208

LIST OF TABLES

Table 1	Number of Submissions Received from Stakeholders	6
Table 2	Number of Comments Received from each Submitter.....	6
Table 3	Fish Species Recorded in the Keep, Ord and Victoria Rivers	21
Table 4	Estuarine and Marine Fish Recored in the Keep, Ord and Victoria River Catchments	25
Table 5	Construction Risk Register - Additonal Traffic Assessment	35
Table 6	Annual Construction Traffic Generation	39
Table 7	Maximum Annual Loads of Nutrients to Alligator Creek	59
Table 8	Existing Annual Concentrations of Nutrients in Alligator Creek	59
Table 9	Total Numbers of Cormorants and Australasian Darter per Month at Legune Station from	
	June to November 2015.....	63
Table 11	Significant Impact Assessment - Largetooth Sawfish	84
Table 12	Area on Legune Occupied by Non-pastoral Activity and Consequences for Stocking	133
Table 13	Farm Pond Inputs.....	139

LIST OF FIGURES

Figure 1	Project Sea Dragon Component Locations	4
Figure 2	Summary of Issues Raised During the Public Comment Period.....	7
Figure 3	Distance Between Keep River National Park and Legune Station	14
Figure 4	Daily Construction Traffic Generation by Vehicle Type	37
Figure 5	Potential Treatment Systems	49
Figure 6	Replicated Dry Season Waterbird Count Coverage - 2015 and 2016	54
Figure 7	Water Released into Alligator Creek (ML/Day).....	71
Figure 8	Freshwater Survey Sites.....	78
Figure 9	Release of Harvest Water Into the Main Discharge Channel.....	93
Figure 10	Climate Statistics, Victoria River Downs	105
Figure 11	Variation in Inundation Extent From the Release of Forsyth Creek Dam	118
Figure 12	Pastoral Operations and Stage 1.....	134
Figure 13	Corrected Grow-out Centre Water Flow Diagram	136
Figure 14	Mean DO Concentration	165
Figure 15	Median DO Concentration	165
Figure 16	Minimum DO Concentration	166
Figure 17	Surface and Bottom DO Concentration, BOD = 50 mg/L	166
Figure 18	Box and Whisker Plots of Additional Nitrogen, Phosphorous and Chlorophyll a	169
Figure 19	Plan Showing Location of Alligator Springs.....	176
Figure 20	Conceptual Hydrogeological Model.....	178
Figure 21	Avifauna Abundance, Richness and Diversity: Event 1	182
Figure 22	Avifauna Abundance, Richness and Diversity: Event 2	183
Figure 23	Avifauna Abundance, Richness and Diversity: Event 3	184
Figure 24	Avifauna Abundance, Richness and Diversity: Event 4	185
Figure 26	Model Reporting Points - Keep River	193

Figure 26 Rapid dilution of model tracer between the mouth of Alligator Creek (I09) and within
 the Keep River (I34) 194

LIST OF APPENDICES

Appendix A	Waterbird Monitoring Program Framework
Appendix B	Avian Predation Submission
Appendix C	2016 Dry Season Waterbird Counts and Review of the 2015 and 2016 Dry Season Survey Programs
Appendix D	Access and Recreational Fishing Policy
Appendix E	Dissolved Oxygen Modelling
Appendix F	Land and Soils
Appendix G	Biosecurity Assessment
Appendix H	Draft Environmental Management Plan
Appendix I	Estimate of Traffic on Keep River Road/Cave Springs Road

ACRONYMS AND ABBREVIATIONS

Acronym or Abbreviation	
µS/cm	microSiemens per centimetre
AAPA	Aboriginal Areas Protection Authority
AGL	above ground level
AHD	Australian Height Datum
ANC	Acid Neutralising Capacity
ANZECC & ARMCANZ	Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand
ARI	average recurrence intervals
ASC	Aquaculture Stewardship Council
ASSMP	Acid Sulfate Soil Management Plan
AWQG	Australian Water Quality Guidelines
CA	consignment authorisation
cm	centimetres
CNG	compressed natural gas
CTMP	Construction Traffic Management Plan
draft EIS	Stage 1 Legume Grow-out Facility Draft Environmental Impact Statement
DEE	Commonwealth Department of the Environment and Energy
DO	dissolved oxygen
DPIR	Northern Territory Department of Primary Industry and Resources
dS/m	deciSiemens per metre
EA Act	Northern Territory <i>Environmental Assessment Act</i>
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EPA	environment protection approval
EPBC Act	Commonwealth <i>Environment Protection and Biodiversity Conservation Act 1999</i>
EPL	environment protection licence
EPZ	Environmental Protection Zone
ESC	erosion and sediment control

Acronym or Abbreviation	
ESCP	Erosion and Sediment Control Plan
FCR	food conversion ratio
GL	gigalitres
ha	hectares
HAT	highest astronomical tide
ILUA	Indigenous Land Use Agreement
km	kilometres
KV	kilovolts
LNG	liquefied natural gas
m	metres
mm	millimetres
m ²	square metres
m ³	cubic metres
m ³ /s	cubic metres per second
MDC	Main Discharge Channel
mg/L	milligrams per litre
MHWS	mean high water springs
ML	megalitres
MNES	matters of national environmental significance
m/s	metres per second
MW	megawatts
NEPM	National Environment Protection Measures
NOI	Notice of Intent
NT	Northern Territory
NT EPA	Northern Territory Environmental Protection Authority
PASS	potential acid sulfate soil
PL	post larvae
ppm	parts per million
ppt	parts per thousand
PV	photovoltaic
SAG	Scientific Advisory Group
Seafarms	Seafarms Group Limited

Acronym or Abbreviation	
SEIS or supplementary EIS	Stage 1 Legume Grow-out Facility Supplementary Environmental Impact Statement
SIMP	Social Impact Management Plan
the Project	Stage 1 Legume Grow-out Facility
TN	total nitrogen
ToR	Terms of Reference for the Preparation of Environmental Impact Statement
TP	total phosphorus
TSS	total suspended solids
WA	Western Australia
WTC	Waste Transport Certificate

1 INTRODUCTION

1.1 PURPOSE OF THIS DOCUMENT

The Stage 1 Legume Grow-out Facility draft Environmental Impact Statement (draft EIS) was available for public review for comment from Saturday 8 October to Friday 2 December 2016. Following the public comment period, on 9 December 2016, the Northern Territory Environmental Protection Authority (NT EPA) directed Project Sea Dragon Pty Ltd (the proponent) to prepare a supplement to the draft EIS. Accordingly, this document has been prepared and is herein referred to as the supplementary EIS or SEIS.

The SEIS summarises and addresses the comments received on the draft EIS during the public comment period. The SEIS also presents the results of ongoing site investigations that have become available since the submission of the draft EIS (for example, Appendix C presents the results of the 2016 dry season waterbird survey program implemented between August and November 2016).

Additionally, the SEIS includes an updated version of the draft Environmental Management Plan (EMP) (see Appendix H). As stated in Section 1.1 of Volume 4, Chapter 3 (draft EMP) of the draft EIS, the draft EMP will be updated to reflect approval requirements upon approval of the Project. In keeping with this commitment, the draft EMP has been amended to incorporate updates that occurred following the lodgement of the draft EIS. These updates are reflected in the responses presented in this SEIS (for example, inclusion of 2 weeds species not previously known and rectification of errors in table numbering - see Sections 0 and 3.19.34 of this document).

The draft EIS and the SEIS, collectively referred to as the EIS, is intended to be the proponents final submission to the NT EPA as part of the environmental approvals process under the Northern Territory *Environmental Assessment Act* (EA Act) and the Australian Governments *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

1.2 STRUCTURE OF THIS DOCUMENT

The SEIS contains the following information:

- Section 1 describes the purpose of the document, a brief Project overview and a summary of the assessment process to date.
- Section 2 provides a summary of the submissions received on the draft EIS during the public comment period.
- Section 3 presents each of the comments received from submitters during the public comment period and corresponding responses from the proponent.
- Section 4 is a summary of references cited.
- Appendices provide additional information referred to in the responses.

1.3 PROJECT OVERVIEW

1.3.1 Project Sea Dragon

The proponent, a wholly owned subsidiary of Seafarms Group Limited (Seafarms) (ASX: SFG), proposes to develop Project Sea Dragon, a large-scale, integrated, land-based prawn aquaculture project in northern Australia. Project Sea Dragon is designed to produce high-quality, year-round reliable volumes for export markets for black tiger prawns (*Penaeus monodon*).

Project Sea Dragon is a staged development of up to 10,000 hectares (ha) of production ponds, comprising a number of facilities across northern Australia (Figure 1), including:

- The Grow-out Facility - proposed to be located at Legume Station in the Northern Territory (NT).
- Quarantine, Founder Stock Facility and Back-up Breeding Centre - located at Exmouth in Western Australia (WA).
- Breeding Program (Core Breeding Centre and Broodstock Maturation Centre) - proposed to be located at Point Ceylon at Bynoe Harbour (NT).
- Hatchery Site - proposed to be located in the Darwin environs (NT).
- A Processing Plant - proposed to be located near Kununurra (WA).
- Export Facilities – proposed to be located at either or both Wyndham (WA) and Darwin (NT).

The Project Sea Dragon Stage 1 Legume Grow-out Facility (herein referred to as the Project) is a component of the larger Project Sea Dragon, and is the first stage of the development of the Grow-out Facility.

1.3.2 Stage 1 Legume Grow-out Facility

The Project Sea Dragon Stage 1 Legume Grow-out Facility is proposed to be located at Legume Station, approximately 106 km north-east of Kununurra on the western border of the Northern Territory. The Project will comprise approximately 1,120 ha of prawn farming capacity and at full production will produce nominally 14,000 tonnes of prawns per annum. Key Project components include:

- Grow-out centre: seawater intake pump station, seawater intake channel, settlement and maintenance pond, main feeder channel, freshwater supply, freshwater channel, grow-out farms, internal farm recycling ponds, main discharge channel, environmental protection zone and outfall.
- Supporting infrastructure: farm roads, farm services, central facilities, accommodation village, Central Service Road and Legume Access Road.

1.4 SUMMARY OF THE ASSESSMENT PROCESS

A Notice of Intent (NOI) for the Project was submitted to the NT EPA on 15 July 2015 for consideration under the EA Act. On 14 September 2015, the NT EPA decided that the Project required assessment under the EA Act at the level of an EIS.

The Project was also referred to the Australian Government under the EPBC Act on 20 July 2015. On 31 August 2015, a delegate of the Commonwealth Minister for the Environment decided that the proposed action was a controlled action and, as such, required assessment and approval under the EPBC Act.

The NT EPA also advised that the Project was to be assessed under the assessment bilateral agreement between the Australian and Northern Territory Governments (made under Section 45 of the EPBC Act).

On 6 November 2015, the NT EPA issued the 'Terms of Reference for the Preparation of Environmental Impact Statement' (ToR). The draft EIS was prepared to address the ToR and inform the Northern Territory and Australian Government's approval decision. The draft EIS was submitted to the NT EPA on 29 September 2016.

The draft EIS was available for review for public comment from 8 October 2016 to 2 December 2016. On 9 December 2016 the NT EPA directed the proponent to prepare a supplement to the draft EIS. Accordingly the SEIS was prepared and was submitted to the NT EPA on 7 February 2017.

The NT EPA Environmental Assessment Unit has 35 days from the submission of the SEIS to prepare a draft assessment report and recommendations for consideration by the NT EPA. The assessment report will then be provided by the NT EPA Minister to the responsible Minister (i.e. the Minister of the Department of Primary Industry and Fisheries) for consideration and final determination as to whether or not an approval will be issued, and if so, the conditions that may be applied. Under the bilateral agreement with the Australian government, the NT EPA will also provide the assessment report to Commonwealth Department of the Environment and Energy (DEE) for consideration and approval under the EPBC Act. On receipt of the assessment report the DEE has 30 days to finalise the approval decision.

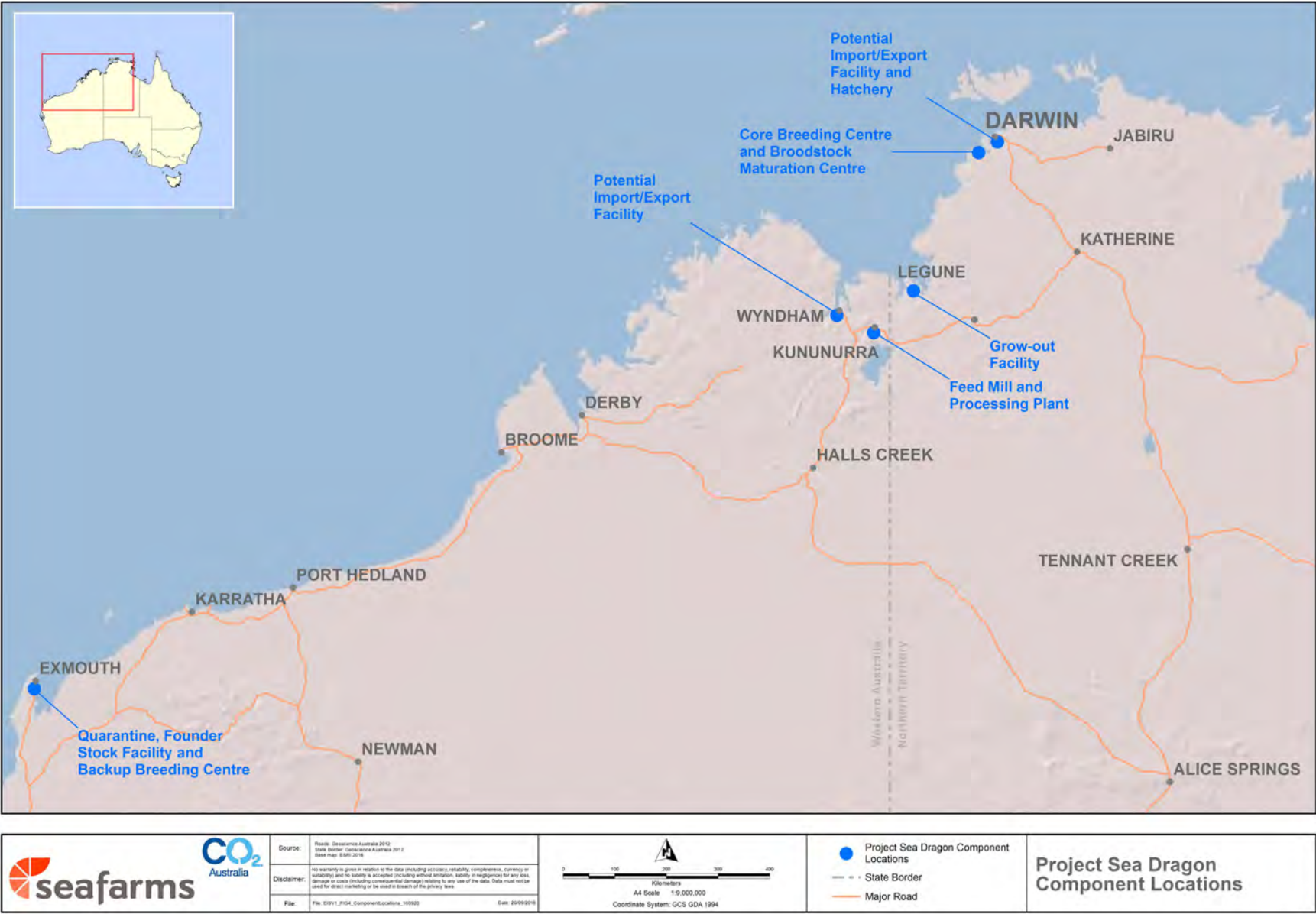


FIGURE 1 PROJECT SEA DRAGON COMPONENT LOCATIONS

2 SUMMARY OF SUBMISSIONS

Following the public comment period the proponent received 18 separate submissions on the draft EIS. As summarised in Table 1, 10 of the 18 submissions received were from Northern Territory Government Departments. Of the 10 submissions from Northern Territory Government Departments, four of the submissions were in support of the Project and required no further response by the proponent. Comments from these four departments included the following:

- Department of Chief Minister - *"The Department of the Chief Minister has a very positive and supportive view of the Project based on the work undertaken by the Proponent around the potential environmental, economic and social impacts of the Project."* (see Section 3.8.1)
- Department of Treasury and Finance - *"The EIA anticipates an increase in the Territory's real gross state product (GSP) by a cumulative total (to 2032) of \$502 million, which is equivalent to about 1.5 per cent of the Territory's GSP. In addition, the modelling projects an increase in the average annual employment for the Territory of around 161 full time equivalent jobs. This is a significant positive impact on the Territory economy. In DTF's view, the Project has the potential to provide significant economic benefits for the Territory and northern Australia."* (see Section 3.16.1)
- Department of Trade, Business and Innovation - *"The Department of Trade, Business and Innovation does not have any major issues in relation to the draft EIS. The economic impact modelling shows the valuable potential socio-economic contributions of this project to the Northern Territory economy."* (see Section 3.17.1)
- Department of Housing and Community Development - *"No comments to provide from the Department of Housing and Community Development's perspective."* (see Section 3.6.1).

Additionally, the Department of Tourism and Culture (Heritage Branch) stated *"Heritage Branch are satisfied for the moment that all heritage and archaeological issues have been adequately addressed in the Draft EIS and have no further comments to add at this point."* (see Section 3.3.1). The Department of Primary Industry and Resources also stated:

- *"The draft EIS as presented comprises a comprehensive set of documents that appear to identify the significant risks posed by this Project."* (see Section 3.10.1)
- *"From the information presented in the draft EIS, and from the water quality presentation to Government agencies by the proponent on Wednesday November 9, my agency considers that the risks posed by water discharge from the farm have been adequately addressed."* (see Section 3.10.2).

In its submission on the draft EIS, Power and Water Corporation also provided no comment and no response was required by the proponent (see Section 3.7.1). The University of Technology Sydney provided support for the draft EIS stating that the proponent "should be commended for their well-presented and considered Environmental Impact Statement which includes a design of the Legume Station Grow-out Facility (Stage 1) based on the Aquaculture Stewardship Council Shrimp Standard and the Environmental Code of Practice for Australia Prawn Farmers. This shows the company's willingness to work co-operatively and collegially with local and international ecologically sustainable aquaculture practices." (see Section 3.12.1).

TABLE 1 NUMBER OF SUBMISSIONS RECEIVED FROM STAKEHOLDERS

Stakeholder	Number of Submissions Received
Northern Territory Government Departments	10
Northern Territory Government Owned Corporation	1
Commonwealth Government Departments	1
Educational Institutions	1
Private Individuals	2
Independent Statutory Authority	1
Non-Government Organisations	1
Community Environment Group	1

Table 2 presents a summary of the number of comments received from each submitter, with a total of 181 comments received. The majority of the comments received were from the NT EPA (55 of 181), followed by the Commonwealth Department of Environment and Energy (28 of 181).

TABLE 2 NUMBER OF COMMENTS RECEIVED FROM EACH SUBMITTER

Submitter	Number of Comments Received
Warren Keen	1
Department of Tourism and Culture (NT)	21
Department of Housing and Community Development (NT)	1
Power and Water Corporation (NT)	1
Department of Chief Minister (NT)	1
Department of Infrastructure, Planning and Logistics (NT)	5
Department of Primary Industry and Resources (NT)	4
Department of Health (NT)	4
University of Technology Sydney	4
Department of Environment and Natural Resources (NT)	16
Department of Environment and Energy (Commonwealth)	28
Private Individual (anonymous)	12
Department of Treasury and Finance (NT)	1
Department of Trade, Business and Innovation (NT)	1
Northern Land Council (independent statutory authority of the Commonwealth)	12
NT EPA	55
World Wildlife Fund	7
Environment Centre NT	7

Figure 2 presents a breakdown of the key issues that were raised during the public comment period. Over fifty percent of the comments received related to the following six matters:

- marine and estuarine water
- marine and estuarine ecology
- terrestrial fauna and avifauna
- geology, geomorphology and soils
- freshwater
- waste management.

In nine of the comments received the submitter expressed support for the draft EIS and/or Project.

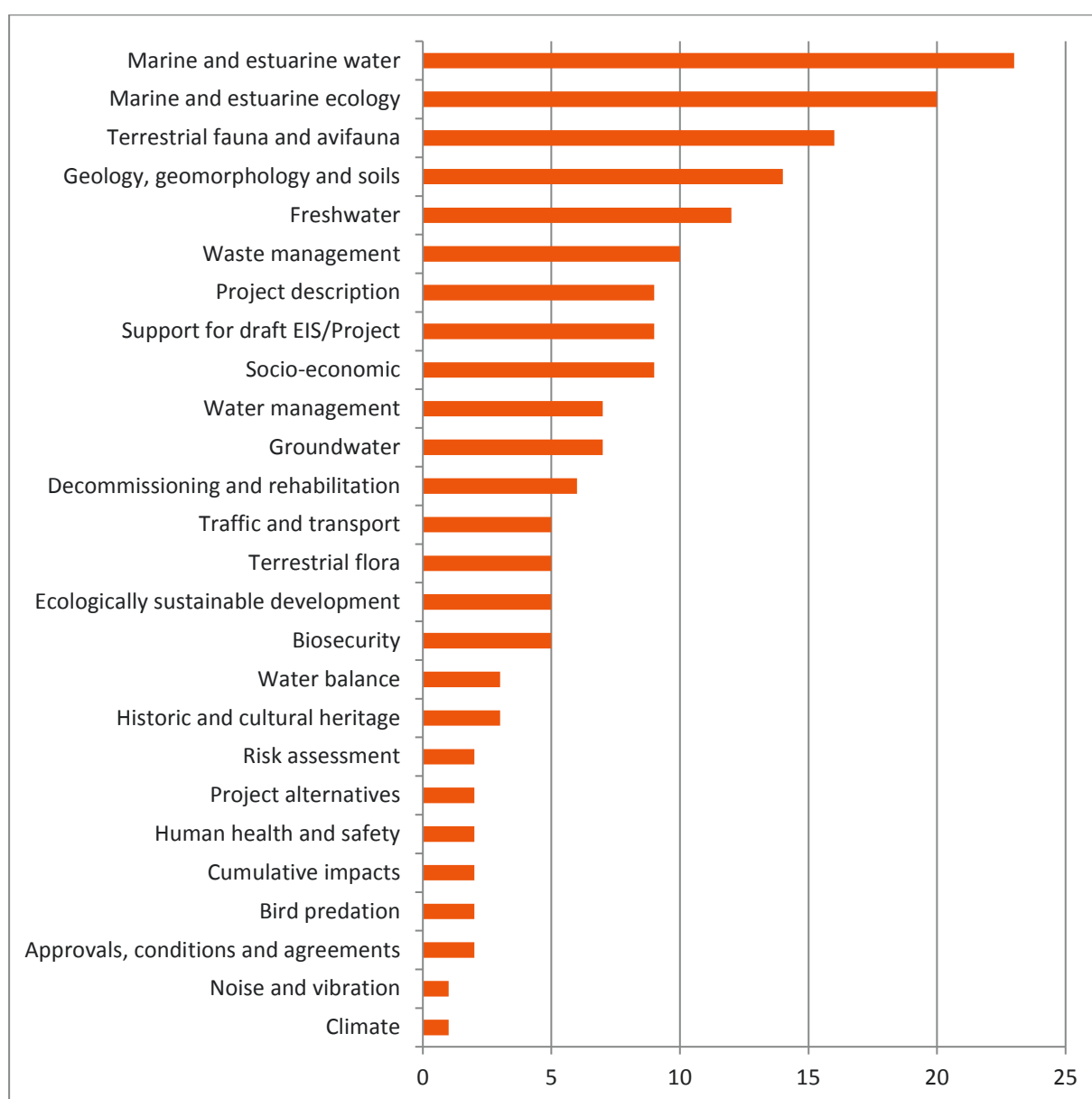


FIGURE 2 SUMMARY OF ISSUES RAISED DURING THE PUBLIC COMMENT PERIOD

3 RESPONSE TO SUBMISSIONS

3.1 WARREN KEEN

3.1.1 Comment 1

Submitter Type	Private Individual	TOR Category or EIS Chapter	-
Date Submission Received	16 October 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

I have briefly looked over the Draft Impact statement and I wondered about new research which I read about recently, which indicated that large dams (particularly in the tropics) may be the cause of significant methane production. As methane is perhaps the worst greenhouse gas, I was wondering do you take into account it is unintentional production at this facility and how it might be minimised and/or offset, given that methane is 35 times worse than CO₂?

Proponent Response

As the proposal does not include the construction of any dams, we assume the submitter is referring to a potential for the grow-out ponds to emit methane.

There is no potential for any significant emissions of methane from the grow-out ponds. This is because, in reservoirs (dams), methane is generated by bacteria living in oxygen-starved environments. In reservoirs, thermal stratification occurs and a thermocline forms that divides the water column into a surface layer (epilimnion), and an anoxic bottom layer (hypolimnion). The hypolimnion provides the anoxic conditions under which methane producing bacteria live.

However, there will be no stratification in the grow-out ponds. In prawn farming, aerators are employed to ensure that the pond water is well mixed and stratification does not occur. This is critical to prawn health in maintaining adequate and consistent water quality and oxygen levels throughout the ponds. As such, unlike in reservoirs, there is no anoxic hypolimnion, and hence very limited potential for methane production.

In fact the Project actually has the potential to reduce overall methane emissions from Legume Station. Legume Station is currently managed as a large-scale pastoral operation, carrying up to 32,000 head of cattle on the pastoral lease. As detailed in the Non-Pastoral Use application for Legume Station, which can be found on the NT Government website, the development and operation of the Project will result in a reduction in the amount of cattle on Legume Station. Given that methane emissions from livestock are a major source of methane emissions, the project may result in a net reduction in methane emissions from Legume Station.

3.2 DEPARTMENT OF TOURISM AND CULTURE (TOURISM NT)

3.2.1 Comment 1

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Executive Summary
Date Submission Received	14 November 2016	Submitters Reference to EIS Section (if provided)	Executive Summary (Section 5.1)

Details of the Submission

For the full economic benefit of the project to be realised (see Executive Summary 5.1), the project will need to progress beyond Stage 1 (3 farms, 1489.29ha) to the full scale project (27 farms, 9720ha), possibly strengthening the argument for ongoing development. The degree to which potential impacts on the natural environment, bird-watching and recreational fishing arising from the full project should be considered now is worth some thought.

Proponent Response

This EIS is confined to assessing Stage 1 as per the Notice of Intent, Referral to the Commonwealth Government and the Terms of Reference for the EIS. Matters associated with future stages would be addressed through future environmental assessment processes as required.

3.2.2 Comment 2

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Socio-economic
Date Submission Received	14 November 2016	Submitters Reference to EIS Section (if provided)	Risk Assessment (Volume 1, Chapter 8, Pg 19); Executive Summary (Section 10.1.4, Pg 53); Socio-economic (Volume 3, Chapter 1, Pg 62)

Details of the Submission

Recreational fishing and camping is raised in the EIS however information on access and management is unclear. The risk assessment (Volume 1, Chapter 8, Pg 19) mentions installation of a gate at the entrance to the Legume Station Access Road and access only being permitted to authorised personnel, however, the Executive Summary (under 10.1.4 Mitigation and Management Measures, Pg 53) references engaging Indigenous rangers to monitor and manage impacts of increased public or Project Sea Dragon employees on fishing, camping and cultural areas. The draft EIS provides no detail on resourcing for rangers or how they will be adequately trained and supervised whilst on the project area (responsibility is acknowledged in the Social Impact Assessment, Pg 62).

Proponent Response

An Access and Recreational Fishing Policy has been prepared to consolidate and clarify the access and recreational fishing protocols that were proposed as part of the draft EIS and is included as Appendix D.

3.2.3 Comment 3

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Socio-economic
Date Submission Received	14 November 2016	Submitters Reference to EIS Section (if provided)	Socio-economic (Volume 3, Chapter 1, Pg 74)

Details of the Submission

The Social Impact Assessment, Pg 74, states that a private property Recreational Fishery Access Policy will be established. It is not clear whether access will be available to the NT community and/or tourists transiting between WA and the NT. Tourism NT supports in-principle new areas being opened up for tourism and recreation, however notes this requires effective resourcing and management.

Proponent Response

For reasons of both general project security and biosecurity, access to Legume Station will be restricted to authorised personnel (i.e. Seafarms employees and contractors). Access by the Native Title Holders is being negotiated as part of the Indigenous Land Use Agreement (ILUA)

An Access and Recreational Fishing Policy has been prepared to consolidate and clarify the access and recreational fishing protocols that were proposed as part of the draft EIS for the Project and is included as Appendix D.

3.2.4 Comment 4

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Socio-economic
Date Submission Received	14 November 2016	Submitters Reference to EIS Section (if provided)	Socio-economic (Volume 3, Chapter 1, Pg 23)

Details of the Submission

The EIS mentions possible 'negative construction worker behaviour in town' (Volume 3, Chapter 1, Pg 23) due to the incoming workforce (444 FTE construction jobs and 334 FTE operations) but does not address this risk in the risk assessment and mitigation measures.

Proponent Response

The full context of this statement reads "*Despite the availability of rental properties in Kununurra in 2016, during the construction phase the utilisation of local rentals is likely to be limited to a small number of managers. This assists with transport logistics (i.e. moving workers efficiently to and from the Project site), reduces other pragmatic issues such as access to laundry and sundry 'household' requirements (as these are contained in the workers' camp), and may also assist with controlling any negative construction worker behaviour in the town.*" (Volume 3, Chapter 1, Pg 23). As such, the discussion is really around how the rental of local housing is likely to be limited to a small number of managers, and how this is a mitigating factor as the domiciling of the majority of the work-force off site would likely reduce the likelihood and/or incidence of any negative construction worker behaviour in town. Consequently, "negative construction worker behaviour in town" is seen as a very low risk and will be addressed through standard measures such as human resources policies and codes of behaviour, as well as communications with council and local police.

3.2.5 Comment 5

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Socio-economic
Date Submission Received	14 November 2016	Submitters Reference to EIS Section (if provided)	Socio-economic

Details of the Submission

It is important to ensure there is no conflict of interest with the work CO2 Australia, a subsidiary of the proponent, has done to support this project.

Proponent Response

There is no conflict of interest as the NT EA Act requires the Proponent to prepare and submit the EIS - in this case the Proponent has delegated this responsibility to their subsidiary company, CO2 Australia.

As detailed in Appendix 3 of the draft EIS (EIS Team), consultants from 12 independent, highly experienced and reputable consultancy organisations were contracted to prepare the technical reports that underpin the draft EIS. Furthermore, as can be seen from Appendix 3, the EIS Manager is in fact an independent consultant, although contracted to CO2 Australia.

3.3 DEPARTMENT OF TOURISM AND CULTURE (HERITAGE BRANCH)

3.3.1 Comment 1

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	-
Date Submission Received	11 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

Heritage Branch are satisfied for the moment that all heritage and archaeological issues have been adequately addressed in the Draft EIS and have no further comments to add at this point.

Proponent Response

Noted - no response required.

3.4 DEPARTMENT OF TOURISM AND CULTURE (PARKS AND WILDLIFE)

3.4.1 Comment 1

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Marine and Estuarine Ecology; Terrestrial Fauna and Avifauna
Date Submission Received	17 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

It is recommended that formal procedures / protocols be developed and put into place to ensure minimal disturbance by Project Sea Dragon personal at Turtle Point. The increase in access and disturbance to migratory sea birds and turtles is of concern to the Commission.

It is also recommend that as part of the development of the project, that an ongoing monitoring program be established and implemented assessing impacts on the migratory sea birds and turtles at Turtle Point.

Proponent Response

As is explicitly stated in the impact assessments for migratory and threatened shorebirds that use Turtle Point (see Section 4.2, of Chapter 6, Volume 2) and for the flatback turtles that nest at Turtle Point (see Section 4.2 of Chapter 7, Volume 2), there will be no negative impacts of the project upon flatback turtles, shorebirds, or the habitat they utilise at Turtle Point.

To reiterate, there will be no project activities at Turtle Point and there will be no increase in access or disturbance to Turtle Point as a result of the Project. The shore bird roost site and turtle rookery on Turtle Point is 25 km as the crow flies from the nearest part of the Project footprint, and 35 km by water from the discharge location on Alligator Creek. Furthermore, Turtle Point is an island and a boat or helicopter is required to get there. Other than the possibility of monitoring at Turtle Point, there is absolutely no reason why anyone associated with the project would be required to go to Turtle Point Island.

As specified in the aforementioned impact assessments for shorebirds and turtles, and also in the Marine and Estuarine Water Chapter (Chapter 2, Volume 2), the hydrodynamic modelling of the discharge from the Project has shown that there will be no measureable impacts of the water discharge on Turtle Point. Therefore there will be no direct or indirect impacts to Turtle Point.

As such, there is no need for *"formal procedures / protocols be developed and put into place to ensure minimal disturbance by Project Sea Dragon personal at Turtle Point"*. There will be no *"increase in access and disturbance to migratory sea birds and turtles"*.

Migratory birds will be monitored as part of the Waterbird Monitoring Program that will be developed (see Appendix A). There is no need to monitor turtles at Turtle Point as there is no potential to impact them.

3.4.2 Comment 2

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Marine and Estuarine Water
Date Submission Received	17 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

Sediment, as a result of the construction and operation of the farm may impact upon the water quality and marine environment and the islands.

Proponent Response

As detailed extensively in Volume 2, Chapter 2, apart from a relatively small zone at the discharge outlet which will extend 200 m upstream and downstream of the discharge outlet, there will be no exceedances of the proposed interim site-specific trigger values. The interim site-specific trigger values were calculated in accordance with the requirements of the AWQGs. The aim of the guidelines is to *"provide an authoritative guide for setting water quality objectives required to sustain current or likely future environmental values for natural and semi-natural water resources in Australia and New Zealand"*. Therefore, by definition, where water quality does not exceed the interim site-specific trigger values, there is considered to be a very low risk to the environment, and no management responses are needed. Erosion and sediment control measures to be enacted during construction are outlined in the draft EMP (Appendix H). A commitment has been made in the

draft EIS to implement effective erosion and sediment control (ESC) measures, and an ESC strategy has been outlined in Appendix C1 in the draft EMP (Appendix H).

3.4.3 Comment 3

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Socio-economic
Date Submission Received	17 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

The project will see an increase in access to the area, including the number of visitors to Keep River National Park.

Proponent Response

The project will not result in any increase in access to the Keep River National Park.

It is acknowledged that the Keep River National Park is close to Legume Station, however there is no access into the Keep River National Park from the Keep River Plains Road (which runs from the W.A. border to Legume Station). The entrance to the Keep River National Park is located off the Victoria Highway, 3 km from the NT/WA border, 68 km south-east of Kununurra. Legume Station is located 106 km north-east of Kununurra and is therefore around 175 km away and in an opposite direction from Kununurra to the entrance to the Keep River National Park. See Figure 3 below.

Whilst the proponent is aware that an extension to the Keep River National Park is proposed, which would see the National Park abut the boundary of Legume Station, this is still a proposed extension only, and should this proceed, it is unknown whether there will be any road access into the future section of the National Park from the Legume Property Access Road.

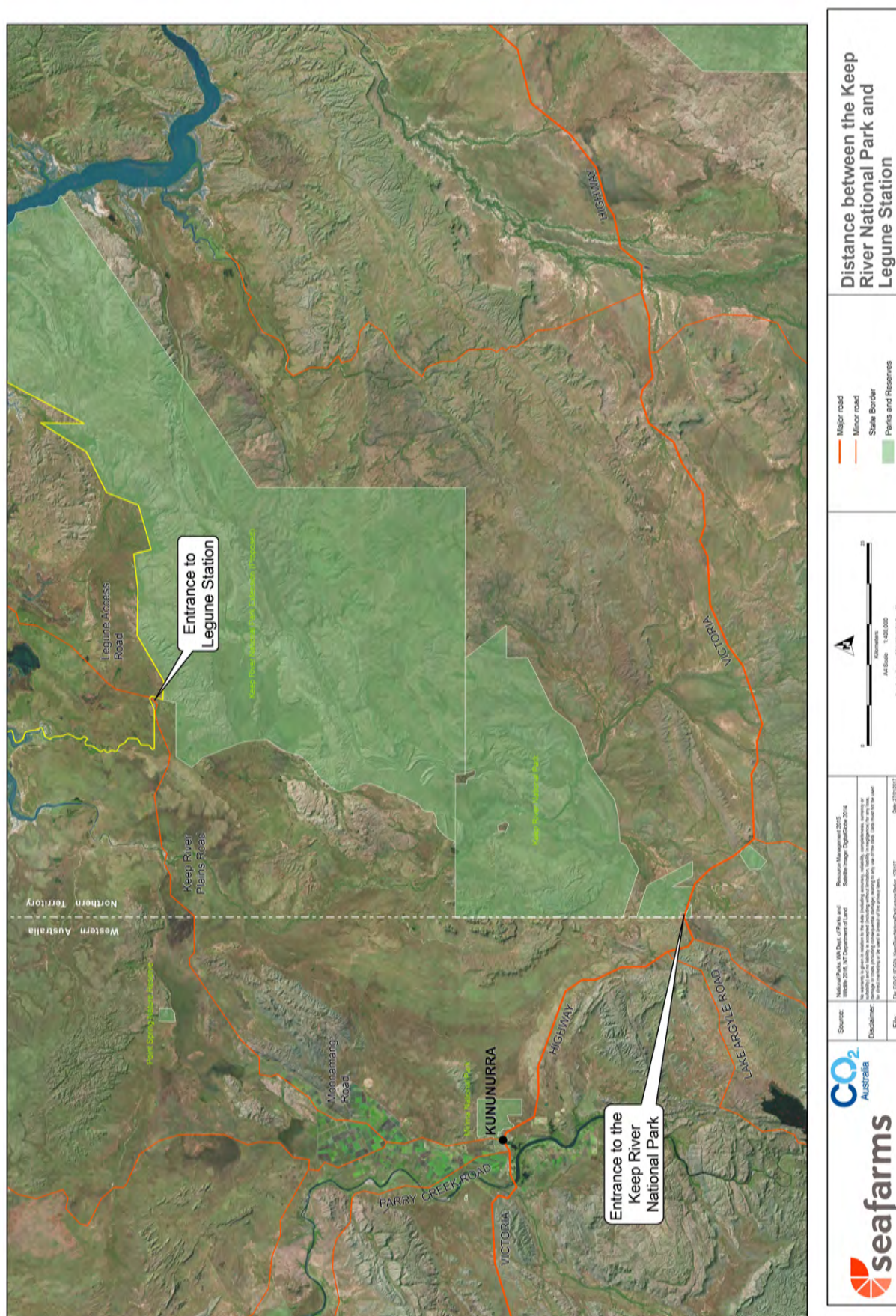


FIGURE 3 DISTANCE BETWEEN KEEP RIVER NATIONAL PARK AND LEGUNE STATION

3.4.4 Comment 4

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Historic and Cultural Heritage
Date Submission Received	17 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

The project is unlikely to impact on the Parks cultural aspects so long as the increase in recreational use of the park is managed.

Proponent Response

The proponent cannot foresee any means by which the Project might facilitate any significant increase in the recreational use of the Keep River National Park. For further information see Comment 3 above (Section 3.4.3).

3.4.5 Comment 5

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Terrestrial Flora
Date Submission Received	17 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

The increased numbers of people and access in the land scape have the potential to cause adverse impacts on the biodiversity values. For example the increased access and vehicle traffic into the area from the Ord Valley which has have a number of weed species of national significance such as parkinsonia and other declared weeds such as rubber bush and neem. It is recommended measures to be put into place to mitigate the spread of weeds such as ensuring vehicles / machinery are cleaned.

Proponent Response

The Proponent agrees and, as detailed in the draft EIS, there have already been commitments to put comprehensive measures in place to control weeds - see Volume 2, Chapter 5 (Terrestrial Flora), and the Environmental Management Plan in Appendix H.

3.4.6 Comment 6

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Marine and Estuarine Ecology
Date Submission Received	17 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

The project aims to avoid dredging, which we would agree with so as to ensure there is no impact on flows and erosion to Turtle Point.

Proponent Response

No dredging is proposed. Furthermore as detailed in the response to Submission 1 (Section 3.4.1) regarding Turtle Point above, the Project will not have any measureable impact on water quality, flows or erosion at Turtle Point.

3.5 DEPARTMENT OF TOURISM AND CULTURE (ARTS AND MUSEUMS)

3.5.1 Comment 1

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Marine and Estuarine Ecology
Date Submission Received	18 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

The assessment of potential impacts from the Operation is based on modelling and very limited field sampling. Monitoring programs will be important to detect any adverse changes to the environment. At present the proponents have suggested a water quality monitoring program, but no benthic or sediment monitoring based on theoretical modelling outcomes (i.e. sufficient dilution is suggested to occur but no real-situation checks have been added).

Proponent Response

Given the challenges of boating in the local environment (crocodiles, no boat ramps, tidal ranges in excess of eight metres, risk of stranding as tides change so quickly, danger of navigating in uncharted waters where the channels change frequently), and the extreme distances required to be covered (i.e. more than 70 km from the proposed intake structure to the proposed discharge location by boat), as well as the considerable costs (each boat based survey costed more than \$120, 000 to implement), the proponent does not consider 36 samples for macroinvertebrates taken over 4 survey events to be "very limited". Data was analysed after each survey event in consultation with the consultant undertaking the shorebird surveys, and there was no reason seen to increase survey effort.

Given the above, and that:

1. the modelling shows conclusively that, apart from a very small initial mixing zone at Alligator Creek, the interim site-specific trigger values for water quality will not be exceeded, and
2. the field assessments for macroinvertebrates and birds show that the macroinvertebrate community is unlikely to be supporting any threatened or otherwise conservation significant species, and
3. the macroinvertebrate habitat to be affected by the discharge is very well represented in the region (i.e. it is not unique in any way) and is very small relative to the amount in the surrounding areas,

it seems an unnecessary cost and risk to personnel to collect such samples. The proponent has, however, committed to a water quality monitoring program, and the collection of data regarding macroinvertebrates will be considered during the formulation of that monitoring program to ensure that there is an adequate data set to inform adaptive management processes. Further, the collection of $\delta^{15}\text{N}$ signatures from mangroves will be considered, as this integrates water quality data over time, and will provide a direct indication of whether the discharge of effluent is impacting estuarine communities.

3.5.2 Comment 2

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Marine and Estuarine Ecology
Date Submission Received	18 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

The benthic fauna at Turtle Point in the vicinity of the Operation supports a 'nationally important habitat for migratory shorebirds'. The reason the birds are there is because of significant populations of their major food items - polychaetes and bivalves. Therefore the statement that 'benthic macroinvertebrate communities have relatively low abundance and diversity' (p 42) ... cannot be referring to Turtle Point or is not capturing the driver of this ecological relationship (e.g. invertebrate abundance). This statement needs to be addressed.

Proponent Response

The submitter asserts that at Turtle Point "the reason the birds are there is because of significant populations of their major food items - polychaetes and bivalves". There is no evidence of this, and the draft EIS does not state this anywhere. The submitter further asserts that the statement that the "*benthic macroinvertebrate communities have relatively low abundance and diversity*" "*cannot be referring to Turtle Point or is not capturing the driver of this ecological relationship*". However, the statement regarding benthic macroinvertebrate communities is indeed referring to Turtle Point and also to the other estuarine habitats that were sampled for macroinvertebrates around Legume Station. The submitter has assumed that invertebrate abundance is the driver of the presence of birds at Turtle Point. As detailed below there is no evidence to support that this is the case.

Large numbers of shorebirds do not necessarily mean that significant populations of invertebrates are present in the immediate surrounds. In this case the data clearly show that the diversity and abundance of macroinvertebrates at Turtle Point are not significantly different to the other areas sampled for macroinvertebrates around Legume Station. In fact, as depicted in Figure 7.2 of Appendix 9 of the draft EIS, the mean abundance of benthic macroinvertebrates per square metre was actually less at Turtle Point than most of the other sites sampled. Further, during the macroinvertebrate surveys at Turtle Point, no significant shorebird feeding activity was observed at low tide.

It is important to understand that all of the shorebird surveys of Turtle Point were undertaken at high tide (i.e. they were scheduled to coincide with the highest point of the highest tide of the month they were conducted in), and this is because the primary purpose of these high tide surveys was to assess the terrestrial roost usage of the site by shorebirds. This is clearly explained in Section 2.3 of Chapter 6, Volume 2 of the draft EIS.

Considerable effort was employed to understand shorebird species, numbers and usage of the site (see both Appendix 15 and Volume 2, Chapter 6). The work undertaken in relation to that indicate that the reason for the comparatively larger numbers of shorebirds at Turtle Point (relative to other areas around Legume Station at high tide) is the availability of high tide roost sites, which, despite concerted effort to locate them, appear to be relatively scarce around Legume Station. Data from aerial count transects along the entire length of the three larger tidal waterways (Forsyth, Bob's and Alligator Creeks) at high tide showed that no significant or notable congregations of birds (at roost) were present along any of the tidal waterways during the survey periods. Despite extensive aerial searches along the Keep River (true right side), across estuarine habitats surrounding the Legume floodplain, along the north coast of Joseph Bonaparte Gulf, and along the Victoria River (true left side), no other significant aggregations of waterbirds (including shorebirds) were detected.

3.5.3 Comment 3

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Marine and Estuarine Ecology
Date Submission Received	18 November 2016	Submitters Reference to EIS Section (if provided)	Marine and Estuarine Ecology (Volume 5, Appendix 9, Pg 109)

Details of the Submission

Data analysis and comparison of data with other studies is generally poor, and the two main conclusions in Vol 5, Appendix 9: Estuarine and Marine Quality and Ecology (and Vol. 2, Chapter 7) are problematic:

1. (p 109) is that “Abundance and taxonomic richness were lower at the intertidal sites than in the subtidal sites. But the proponents have apparently misclassified one of their sites. One of the Turtle Point sites, Site 125, ‘foreshore of turtle creek’ is clearly intertidal if you check Google Maps. The other Turtle Point site (121) is subtidal as they have reported. Both sites are very similar with respect to abundance and species richness, so clearly in this example there is NO effect of elevation. Proponents should reanalyse these data and check their conclusions.

Proponent Response

The proponent has checked with the consultant who undertook the field work, who has confirmed that the invertebrate collection at site 125 was indeed from the subtidal zone (as reported in the draft EIS), and was as close to the point depicted on the map as possible. Furthermore, the eastings and northings for the site given in Table 2.1 of Appendix 9 also show that the site is in the subtidal zone. Google Maps should not be used to attempt verify location accuracy for a map presented at the scale of those depicting the sampling locations in the draft EIS. At this scale the icon used to depict the site location covers an area of around 1 km. As such there is no need to reanalyse any data or check any conclusions.

3.5.4 Comment 4

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Marine and Estuarine Ecology
Date Submission Received	18 November 2016	Submitters Reference to EIS Section (if provided)	Marine and Estuarine Ecology (Volume 5, Appendix 9, Pg 110)

Details of the Submission

2. (P 110.). “The abundance and taxonomic richness of the benthic invertebrate communities were low throughout the area”. Proponents compare their data against Port Curtis (Qld) and Darwin Harbour. Two problems here – firstly they don’t use the same units for comparison (individual per m² and individuals per 3L core) and they don’t provide a figure for mean abundance and richness (it had to be read off Fig. 7.2), and secondly the implication that Port Curtis has higher abundances is incorrect. Fig. 7.2 indicates abundance for subtidal at roughly 100 individuals per m² and for intertidal about 50 individuals per m². Compare this with the range for Port Curtis (60-244 individuals per m²), and one can see it may not be significantly different. Proponents need to standardise abundance and diversity units, better summarise their results, and make comparisons clear; we did not try to compare their data with that reported for Darwin Harbour (as individuals per 3L core!), but is it clearly important in order to gauge the ‘benthic quality’ of the area, and related conclusion regarding ecological values and assumptions used in risk assessment.

Proponent Response

This comment was made in Section 7.4 of the technical report (Appendix 9), which is the summary and discussion section. As such, the comparisons were presented as general comparisons for the purposes of discussing and contextualising the findings, and were not statistical comparisons. They were general comparisons to show what abundances were like in other tropical estuaries as no studies have been conducted in the Project area to provide relevant baseline comparisons. The statistical analyses using data gathered from the field work are clearly explained in the preceding section 7.2.

Both the data from the EIS study and Port Curtis are presented as individuals per m². The mean abundance at Port Curtis ranged from 59.6 (±4) to 244 (±12.5) individuals per m² (Currie & Small 2005). In the EIS study, abundance ranged from 0 to 800 (±538); however, only four sites of 44 across all surveys had a mean greater than 200 individuals per m². In the Darwin study abundance ranged from 600 to 1,404 individuals per m². According to the AWQG, densities over 1,000m² are considered to be high for capitellid worms. That is, the abundance at both Port Curtis and the EIS study were considered to be relatively low.

3.5.5 Comment 5

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Marine and Estuarine Ecology
Date Submission Received	18 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

Having since the project meeting had more time to review the documents, it is clear the fish survey component of field investigations was poor. Basically they set some bait traps (number not specified) with some low angling effort (also not quantified) which is not a very robust way to assess the assemblage in question. This was acknowledged as a limitation due to crocodiles, and diverted by statements saying the overall results should have no bearing on threatened species (e.g. risk assessment based on presumed presence of threatened sawfish and sharks), however this approach of using bait traps as the primary survey method is inconsistent with other survey programs across northern Australia which routinely sample these sorts of lowland habitats. For example NT Fisheries, CDU, MAGNT and private consultants all sample these sorts of habitats regularly. Boat based techniques including electrofishing, gill net or trawl would provide a much better indication and assessment in freshwater areas (we can supply references if required).

This overall leads to a major shortfall in the information available for assessment, failing to set a baseline or potentially identify any local issues of concern.

As an example of the data quality resulting from the approach used is that a meagre 42 fish total were recorded in the survey, when a survey of this nature would however typically return 100s of individuals. Moreover overnight sets of bait traps in northern Australia typically return low results due to crustaceans entering the traps and eating fish, so this is a non-standard operating approach also. Finally in Table 5 of the fish survey captured fishes were not identified to species which again reduces the value of this component; vouchers or images should have been lodged with the regional biodiversity institution to improve the rigour of this data and quality assurance and quality control.

Proponent Response

The fish surveys were purely opportunistic, and not intended to be a major component of the EIS. Instead, a precautionary approach was taken, relying on the literature. Given the limited spatial extent of the main potential impacts of the proposed development (i.e. changes to nutrient levels in receiving waters), the proponent considered it inappropriate to undertake extensive fishing surveys, that, given the scale of the surrounding environment, may have provided inconclusive results. Rather, the proponent took the ecologically conservative approach that rare and threatened species were present, and evaluated the potential impacts accordingly. As most impacts were likely to be mediated through water quality, the focus of the assessments was on collecting a robust water quality data set, so as to best understand the ecological functioning of the waterways, and assess impacts via this understanding (see the conceptual model in Appendix 9). Hence, because of the nature of the potential impacts, extensive fish surveys were considered highly unlikely to significantly change the assessment of impacts.

With respect to the estuarine fisheries, a very large (and very expensive) survey, with significant risks to personnel, would have been required to confirm the presence and abundance of the rare and endangered species. Their absence from survey results could not be interpreted as meaning they did not occur in the estuary. The proponent took the conservative approach of assuming that they were present in the estuary, and evaluated likely impacts based on impacts to water quality. Other potential impacts, such as the potential for impingement of individuals at the intake structure, have been minimised by design.

With respect to freshwater fish, surveys were opportunistic, and not intended or designed to be comprehensive. They were openly acknowledged as being so in the draft EIS. Access to the sites was limited. Again a conservative approach was taken in the assessment of impacts.

There is no "major shortfall in the information available for assessment", as a precautionary approach was taken.

3.5.6 Comment 6

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Marine and Estuarine Ecology
Date Submission Received	18 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

Quote "No aggregations have been recorded in the area potentially impacted by the Project" – no surveys have been undertaken to support this statement. There is a low likelihood that the creeks in question are spawning areas, but as sheltered side branches in proximity to the mouth it is not out of the question.

Proponent Response

The proponent agrees there is a low likelihood that the creeks in question are spawning areas, but as sheltered side branches they may be. The assessment of impacts was undertaken on this basis. Given the low likelihood of spawning areas being present, as agreed by the submitter, no surveys were undertaken. Regardless, it would not alter the outcomes of the impact assessment if spawning areas were present, given the relatively small spatial extent of any potential impacts to water quality, the large area of similar habitat, and the design of structures to minimise impact.

3.5.7 Comment 7

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Marine and Estuarine Ecology
Date Submission Received	18 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

Overall species list was minimal. Why not use an areas search in Atlas of Living Australia to provide a species list for the area?

Proponent Response

The fish tables have been updated to include records from the Atlas of Living Australia, and resulted in the inclusion of a further 17 estuarine species, and 3 freshwater species. Table 3 below replaces Table 7.2 from Appendix 12 of the draft EIS, and Table 4 replaces Table 12.1 from Appendix 9 of the draft EIS.

TABLE 3 FISH SPECIES RECORDED IN THE KEEP, ORD AND VICTORIA RIVERS

Family	Species	Common Name	Catchment (Literature Records with source)		
			Keep River	Ord River	Victoria River
Apogonidae	<i>Glossamia aprion</i>	mouth almighty	x; x2	x	x
Anguillidae	<i>Anguilla bicolor</i>	Indian short-finned eel		x	
Ambassidae	<i>Ambassis agrammus</i>	sailfin glassfish			x
	<i>Ambassis interruptus</i>	long-spined glassfish	x		x
	<i>Ambassis macleayi</i>	Macleay's glassfish	x	x	x
	<i>Ambassis sp.3 (muelleri)</i>	glassfish	x; x2	x	
	<i>Ambassis sp.</i>	glassfish	x	x	x
	<i>Parambassis gulliveri</i>	giant glassfish	x; x2		x
Ariidae	<i>Arius dioctes</i>	—	x		
	<i>Arius graeffei</i>	lesser salmon catfish, blue catfish	x; x2;x3	x	x
	<i>Arius midgeleyi</i>	silver cobbler, shovel-nosed catfish	x; x2	x	x
	<i>Arius sp.</i>	fork-tailed catfish	x		x
	<i>Neotarius leptaspis</i>	triangular shield catfish, salmon catfish	x; x2	x	x
	<i>Plicofollis argyropleuron</i>	long-snouted catfish	x1		
Atherinidae	<i>Craterocephalus stercusmuscarum</i>	fly-specked hardyhead	x; x2	x	x
	<i>Craterocephalus stramineus</i>	strawman, blackmast		x	x
	<i>Craterocephalus sp.</i>	hardyhead		x	
Belonidae	<i>Strongylura krefftii</i>	freshwater longtom	x; x2	x	x
Carcharhinidae	<i>Carcharhinus leucas</i>	bull shark	x1	x	
Clupeidae	<i>Nematalosa erebi</i>	bony bream	x; x2;x3	x	x
Dasyatidae	<i>Himantura dalyensis</i>	freshwater whipray	x1	x	
Eleotridae	<i>Hypseleotris compressa</i>	empire gudgeon	x	x	
	<i>Hypseleotris sp.</i>	golden gudgeon			x
	<i>Mogurnda mogurnda</i>	northern trout gudgeon	x; x2	x	

Family	Species	Common Name	Catchment (Literature Records with source)		
			Keep River	Ord River	Victoria River
	<i>Oxyeleotris lineolatus</i>	sleepy cod		x	
	<i>Oxyeleotris selheimi</i>	giant gudgeon	x; x2	x	x
	<i>Oxyeleotris sp.</i>	gudgeon			x
	<i>Prionobutis microps</i>	smalleye gudgeon	x3		
Elopidae	<i>Elops australis</i>	herring	x1		
	<i>Elops hawaiiensis</i>	giant herring			x
	<i>Elops machnata</i>	Australian giant herring		x	
	<i>Thryssa brevicauda</i>	short-tail thryssa	x; x2; x3		
	<i>Thryssa kammalensis</i>	kammal thryssa	x		
	<i>Thryssa sp.</i>	anchovy	x; x3	x	
Gerrridae	<i>Geres filamentosus</i>	threadfin silver-biddy	x1		
Gobiidae	<i>Acentrogobius sp.</i>	goby	x3		
	<i>Amoya sp.</i>	goby	x2; x3		
	<i>Drombus globiceps</i>	goby	x		
	<i>Glossogobius aureus</i>	golden goby	x; x2; x3		
	<i>Glossogobius giurus</i>	flathead goby		x	
	<i>Glossogobius sp.2</i>	Munro's goby, square blotch goby			x
	<i>Glossogobius sp.</i>	goby	x	x	x
	<i>Oxuderces wirzi</i>	peacock mudskipper	x; x2; x3		
	<i>Periophthalmus argentilineatus</i>	silver-lined mudskipper	x; x2		
	<i>Pseudogobius poecilosoma</i>	–	x		
Hemiramphidae	<i>Arrhamphus sclerolepis</i>	snub-nosed garfish	x	x	x
Kurtidae	<i>Kurtus gulliveri</i>	nurseryfish	x1; x3		
Latidae	<i>Lates calcifer</i>	barramundi	x; x2; x3	x	x
Leiognathidae	<i>Leiognathus equulus</i>	common ponyfish	x; x3	x	x
Lutjanidae	<i>Lutjanus argentimaculatus</i>	mangrove jack	x1		
Megalopidae	<i>Megalops cyprinoides</i>	ox-eye herring	x; x2	x	x

Family	Species	Common Name	Catchment (Literature Records with source)		
			Keep River	Ord River	Victoria River
Melanotaeniidae	<i>Melanotaenia australis</i>	western rainbowfish	x	x	x
	<i>Melanotaenia exquisita</i>	exquisite rainbowfish	x		x
	<i>Melanotaenia nigrans</i>	black-banded rainbowfish	x; x2		
	<i>Melanotaenia splendida. australis</i>	western rainbowfish	x; x2	x	
	<i>Melanotaenia sp.</i>	rainbowfish	x		x
Mugilidae	<i>Liza alata</i>	diamond mullet	x; x2; x3	x	x
	<i>Liza ordensis</i>	mullet	x; x3		
	<i>Liza tade</i>	flathead mullet	x; x2		x
	<i>Mugil cephalus</i>	sea mullet	x1	x	
	<i>Rhinomugil nasutus</i>	pop-eye mullet	x; x2; x3		x
Osteoglossidae	<i>Scleropages jardinii</i>	gulf saratoga			x
Plotosidae	<i>Anodontiglanis dahli</i>	toothless catfish	x; x2		x
	<i>Neosilurus ater</i>	black catfish, butter jew, narrow-fronted tandan	x; x2	x	x
	<i>Neosilurus hyrtlii</i>	Hyrtl's tandan	x; x2	x	x
	<i>Neosilurus pseudospinosus</i>	false-spined catfish		x	x
	<i>Plotosidae sp.1</i>	eel-tailed catfish		x	
	<i>Plotosidae sp.2</i>	eel-tailed catfish		x	
	<i>Porochilus rendahli</i>	Rendahli's catfish	x; x2		
Pomadasys	<i>Pomadasis kaakan</i>	barred javelinfish	x1		
Polynemidae	<i>Eleutheronema tetradactylum</i>	blue threadfin	x1; x2; x3		
	<i>Polydactylus macrochir</i>	giant threadfin	x1; x3		
Pristidae	<i>Pristis pristis</i>	largetooth sawfish	x; x1; x2		x
	<i>Pristis clavata</i>	dwarf sawfish	x; x2		
Scatophagidae	<i>Scatophagus argus</i>	spotted scat	x	x	
Sciaenidae	<i>Johnius borneensis</i>	river jewfish	x3		
	<i>Johnius novaeguineae</i>	paperhead jewfish	x3		

Family	Species	Common Name	Catchment (Literature Records with source)		
			Keep River	Ord River	Victoria River
	<i>Nibea soldado</i>	soldier croaker	x1		
	<i>Nibea squamosa</i>	scaly croaker	x; x3	x	x
Sillaganidae	<i>Sillago lutea</i>	mud sillago	x; x3		
Soleidae	–	unidentified specimen			
Sparidae	<i>Acanthopagrus sp.</i>	bream	x3		
Terapontidae	<i>Amniataba percooides</i>	barred grunter	x; x2	x	x
	<i>Hephaestus jenkinsi</i>	Jenkin's grunter, western sooty grunter	x; x2	x	x
	<i>Leiopotherapon unicolor</i>	spangled perch	x; x2	x	x
	<i>Scortum neili</i>	Neil's grunter			x
	<i>Syncomistes butleri</i>	Butler's grunter	x	x	x
	<i>Syncomistes rastellus</i>	Drysdale grunter		x	x
	<i>Syncomistes trigonicus</i>	long-nose grunter		x	
	<i>Terapon jarbua</i>	crescent perch	x; x2; x3		
Tetraodontidae	<i>Marilyna meraukens</i>	merauke toadfish	x; x3	x	
Toxotidae	<i>Toxotes chatareus</i>	seven-spot archerfish	x; x2	x	x

x: Species recorded by TropWater (accessed March 2016) and Wetland Research and Management (2014)

x1: Species only recorded by Wetland Research and Management (2014)

x2: Species recorded by Larson (1999)

x3: Species recorded by Atlas of Living Australia (accessed 2016)

X: confirmed sighting

(X): unconfirmed sighting

TABLE 4 ESTUARINE AND MARINE FISH RECORDED IN THE KEEP, ORD AND VICTORIA RIVER CATCHMENTS

Family	Species	Common Name	Catchment (Literature Records with source)		
			Keep River	Ord River	Victoria River
Apistidae	<i>Cheroscorpaena tridactyla</i>	humpback waspfish	x3		
Anguillidae	<i>Anguilla bicolor</i>	Indian short-finned eel		x	
Ambassidae	<i>Ambassis agrammus</i>	sailfin glassfish			x
	<i>Ambassis interruptus</i>	long-spined glassfish	x		x
	<i>Ambassis macleayi</i>	Macleay's glassfish	x	x	x
	<i>Ambassis sp.3 (muelleri)</i>	glassfish	x; x2	x	
	<i>Ambassis sp.</i>	glassfish	x	x	x
	<i>Parambassis gulliveri</i>	giant glassfish	x; x2		x
Ariidae	<i>Arius dioctes</i>	—	x		
	<i>Arius graeffei</i>	lesser salmon catfish, blue catfish	x; x2;x3	x	x
	<i>Arius midgeleyi</i>	silver cobbler, shovel-nosed catfish	x; x2	x	x
	<i>Arius sp.</i>	fork-tailed catfish	x		x
	<i>Nemapteryx armiger</i>	copper catfish	x3		
	<i>Neoarius leptaspis</i>	triangular shield catfish, salmon catfish	x; x2	x	x
	<i>Plicofollis argyropleuron</i>	long-snouted catfish	x1		
Atherinidae	<i>Craterocephalus stercusmuscarum</i>	fly-specked hardyhead	x; x2	x	x
	<i>Craterocephalus stramineus</i>	strawman, blackmast		x	x
Belonidae	<i>Strongylura krefftii</i>	freshwater longtom	x; x2	x	x
Carangidae	<i>Scomberoides commersonianus</i>	giant queenfish	x1		
Carcharhinidae	<i>Carcharhinus leucas</i>	bull shark	x1	x	
Clupeidae	<i>Nematalosa erebi</i>	bony bream	x; x2;x3	x	x
	<i>Nematalosa vlaminghi</i>	Perth herring	x1		
Cynoglossidae	<i>Paraplagusia bilineata</i>	lemon tongue Sole	x3		
	<i>Paraplagusia longirostris</i>	long-snouted tongue sole	x3		

Family	Species	Common Name	Catchment (Literature Records with source)		
			Keep River	Ord River	Victoria River
	<i>Cynoglossus maculipinnis</i>	spotfin tongue sole	x3		
Dasyatidae	<i>Himantura dalyensis</i>	freshwater whipray	x1	x	
	<i>Himantura uarnak</i>	reticulate whipray			
Eleotridae	<i>Hypseleotris compressa</i>	empire gudgeon	x	x	
	<i>Hypseleotris sp.</i>	golden gudgeon			x
	<i>Mogurnda mogurnda</i>	northern trout gudgeon	x; x2	x	
	<i>Oxyeleotris selheimi</i>	giant gudgeon	x; x2	x	x
	<i>Oxyeleotris sp.</i>	gudgeon			x
Elopidae	<i>Elops australis</i>	herring	x1		
	<i>Elops hawaiiensis</i>	giant herring			x
	<i>Elops machnata</i>	Australian giant herring		x	
Engraulidae	<i>Papuengraulis micropinna</i>	bareback anchovy	x3		
	<i>Thryssa kammalensis</i>	kammal thryssa	x		
	<i>Thryssa sp.</i>	anchovy	x; x3	x	
Gerridae	<i>Geres filamentosus</i>	threadfin silver-biddy	x1		
Gobiidae	<i>Acentrogobius sp.</i>	goby	x3		
	<i>Apocryptodon sp.</i>	goby	x3		
	<i>Boleophthalmus sp.</i>	goby	x3		
	<i>Drombus globiceps</i>	goby	x		
	<i>Glossogobius aureus</i>	golden goby	x; x2; x3		
	<i>Glossogobius sp.2</i>	Munro's goby, square blotch goby			x
	<i>Glossogobius sp.</i>	goby	x	x	x
	<i>Gobiopterus</i>	goby	x3		
	<i>Pseudogobius poecilosoma</i>	–	x		
	–	mudskipper	(x)		
	<i>Silhouettea evanida</i>	vanishing silhouette goby	x3		
Hemiramphidae	<i>Arrhamphus sclerolepis</i>	snub-nosed garfish	x	x	x

Family	Species	Common Name	Catchment (Literature Records with source)		
			Keep River	Ord River	Victoria River
Kurtidae	<i>Kurtus gulliveri</i>	nurseryfish	x1; x3		
Latidae	<i>Lates calcifer</i>	barramundi	x; x2; x3	x	x
Leiognathidae	<i>Leiognathus equulus</i>	common ponyfish	x; x3	x	x
Lutjanidae	<i>Lutjanus argentimaculatus</i>	mangrove jack	x1		
Megalopidae	<i>Megalops cyprinoides</i>	ox-eye herring	x; x2	x	x
Mugilidae	<i>Liza alata</i>	diamond mullet	x; x2; x3	x	x
	<i>Liza ordensis</i>	mullet	x; x3		
	<i>Liza parmata</i>	mullet	x3		
	<i>Liza melinoptera</i>	Otomebora mullet	x3		
	<i>Liza sp.</i>	mullet			x
	<i>Liza tade</i>	flathead mullet	x; x2		x
	<i>Mugil cephalus</i>	sea mullet	x1	x	
	<i>Rhinomugil nasutus</i>	pop-eye mullet	x; x2; x3		x
Osteoglossidae	<i>Scleropages jardinii</i>	gulf saratoga			x
Plotosidae	<i>Anodontiglanis dahli</i>	toothless catfish	x; x2		x
	<i>Neosilurus ater</i>	black catfish, butter jew, narrow-fronted tandan	x; x2	x	x
	<i>Neosilurus hyrtlai</i>	Hyrtl's tandan	x; x2	x	x
	<i>Neosilurus pseudospinosus</i>	false-spined catfish		x	x
	<i>Neosilurus sp.</i>	false-spined catfish			x
	<i>Porochilus rendahli</i>	Rendahli's catfish	x; x2		
Pomadasys	<i>Pomadasys kaakan</i>	barred javelinfish	x1		
Polynemidae	<i>Eleutheronema tetradactylum</i>	blue threadfin	x1; x2; x3		
	<i>Parapolynemus verekeri</i>	streamer threadfin	x3		
	<i>Polydactylus macrochir</i>	giant threadfin	x1; x3		
	<i>Polydactylus nigripinnis</i>	blackfin threadfin	x3		
Pristidae	<i>Pristis pristis</i>	largetooth sawfish	x; x1; x2		x

Family	Species	Common Name	Catchment (Literature Records with source)		
			Keep River	Ord River	Victoria River
	<i>Pristis clavata</i>	dwarf sawfish	x; x2		
Scatophagidae	<i>Scatophagus argus</i>	spotted scat	x	x	
Sciaenidae	<i>Johnius borneensis</i>	river jewfish	x3		
	<i>Johnius novaeguineae</i>	paperhead jewfish	x3		
	<i>Nibea soldado</i>	soldier croaker	x1		
	<i>Nibea squamosa</i>	scaly croaker	x; x3	x	x
Sillaganidae	<i>Sillago lutea</i>	mud sillago	x; x3		
Soleidae	<i>Rendahlia jaubertensis</i>	Jaubert sole	x3		
Sparidae	<i>Acanthopagrus sp.</i>	bream	x3		
	<i>Acanthopagrus latus</i>	western yellowfin bream	X		
Terapontidae	<i>Amniataba percoides</i>	barred grunter	x; x2	x	x
	<i>Hephaestus jenkinsi</i>	Jenkin's grunter, western sooty grunter	x; x2	x	x
	<i>Leiopotherapon unicolor</i>	spangled perch	x; x2	x	x
	<i>Syncomistes butleri</i>	Butler's grunter	x	x	x
	<i>Syncomistes rastellus</i>	Drysdale grunter		x	x
	<i>Terapon jarbua</i>	crescent perch	x; x2; x3		
Tetraodontidae	<i>Chelonodon patoca</i>	milk-spotted toadfish	X		
	<i>Marilyna meraukens</i>	merauke toadfish	x; x3	x	
Toxotidae	<i>Toxotes chatareus</i>	seven-spot archerfish	x; x2	x	x

x: Species recorded by TropWater (accessed March 2016) and WRM (2014)

x1: Species only recorded by WRM (2014)

x2: Species recorded by Larson (1999)

x3: Species recorded by Atlas of Living Australia (accessed 2016)

X: confirmed sighting

(X): unconfirmed sighting

3.5.8 Comment 8

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Biosecurity
Date Submission Received	18 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

Has the proponent considered the natural high genetic stock structure of the Tiger Prawn in terms of broodstock source and the risk to genetic diversity of the receiving environment due to potential escapes?

Proponent Response

Yes, the proponent has considered the matters raised in the submission.

As detailed in the risk assessment (Chapter 8 of Volume 1), the risk of changes to aquatic ecological values as a result of the escape of prawn stock was evaluated as being very low.

The grow-out facility will be stocked with black tiger prawns (*Penaeus monodon*) which are native to the Joseph Bonaparte Gulf. The founder stock which will be used to establish the breeding program for the Project will be sourced from wild populations of black tiger prawns from the waters around the Northern Territory and Western Australia. Hence should there be escapes from the facility, the risk of 'genetic pollution' to wild stock is essentially zero since no 'new' genes will be introduced to the environment, because there is no source of new (or introduced) genes. The risk of changing the structure of genetically identifiable sub-populations is also exceedingly small, not only because the numbers of escapes (if any) would be too low to change gene frequencies at the population level, but also because domesticated populations of animals typically have a compromised survival rate within the environment compared with wild stock, and thus ability to survive to achieve inter-breeding is unlikely.

In any case the following additional measures have been designed into the facility to reduce the risk of escapes:

- All pond outlets will be screened with a mesh of a suitable size to prevent prawns escaping.
- A cage screened with a mesh of a suitable size will be inserted inside the monk (the outlet structure) during harvesting.
- A bird predation management strategy will be implemented to prevent birds preying on prawns and potentially removing prawns from the grow-out ponds (notwithstanding that the probability of a prawn being viable after being preyed upon by a bird would be vanishingly remote).

In terms of the risk methodology employed in the draft EIS, the risk of 'prawn escapes leading to genetic pollution' is classed as 'very low'.

3.5.9 Comment 9

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Marine and Estuarine Ecology
Date Submission Received	18 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

Implement a benthic/sediment monitoring program at sites downstream of the outfall, especially at Turtle Point. Please consider involving MAGNT staff, who have a broad knowledge of benthic fauna in the area, and important reference collections, including animals from a survey of Keep River. The Proponent may consider downplaying the role of the fish survey in forming any conclusions in the EIS, and acknowledge that if fish surveys are required in relation to this project in the future that they will be more thorough.

Proponent Response

As mentioned in the response to a preceding comment (Comment 1 of Department of Tourism and Culture (Parks and Wildlife) - Section 3.4.1) there will be no impact upon Turtle Point and as such the proponent sees no logical reason to monitor macroinvertebrates in area 35 km (by water) from the discharge location, especially given the risks outlined earlier of working in that environment.

As also mentioned in response to Comment 1 of Department of Tourism and Culture (Parks and Wildlife), the proponent has committed to a water quality monitoring program and the collection of data regarding macroinvertebrates (closer to the discharge outlet, e.g. in Alligator Creek) and $\delta^{15}\text{N}$ signatures from mangroves will be considered during the formulation of that monitoring program.

See the response to the queries from the Department of Tourism and Culture (Arts and Museums) in Section 3.5 on fish survey methodology and effort.

3.6 DEPARTMENT OF HOUSING AND COMMUNITY DEVELOPMENT

3.6.1 Comment 1

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	-
Date Submission Received	20 October 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

I have no comments to provide from the Department of Housing and Community Development's perspective.

Proponent Response

Noted - no response required.

3.7 POWER AND WATER CORPORATION

3.7.1 Comment 1

Submitter Type	Northern Territory Government Owned Corporation	TOR Category or EIS Chapter	-
Date Submission Received	1 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

No comments from PWC.

Proponent Response

Noted - no response required.

3.8 DEPARTMENT OF CHIEF MINISTER

3.8.1 Comment 1

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Socio-economic
Date Submission Received	18 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

The Department of the Chief Minister has a very positive and supportive view of the project based on the work undertaken by the Proponent around the potential environmental, economic and social impacts of the project. A highly credentialed consultant was engaged to model the potential economic impacts and they used an appropriate technique to do so. The modelling suggests that the project could deliver significant economic and social benefits, based on assumptions which are conservative in some respects. Hence, the potential benefits may be understated and this should be kept in mind when assessing potential risks attributed to the Project. The Proponent has also taken a conservative approach in their risk assessment and this may overstate the residual risks in many areas. Requirements imposed on the project should recognise the conservative approach adopted by the Proponent in their risk assessment. No additional analysis of the potential economic impact is necessary at this stage because the economic analysis provided is rigorous, thorough and comprehensive, and undertaken by a highly skilled specialist.

The Proponent has demonstrated that they have engaged with key stakeholder groups to discuss the project, potential community effects, and workforce opportunities. The Proponent has been attentive to the opportunity to work with traditional owners and this is to be encouraged. The Project EIS includes an outline of a social impact management plan (SIMP), and best practice suggests this should be finalised before a final investment decision is made, but then refined as the project progresses through its various stages. The Department of the Chief Minister welcomes the opportunity to work with the Proponent to finalise and implement an effective SIMP.

Proponent Response

The proponent has discussed the development of the Social Impact Management Plan (SIMP) further with the Department of the Chief Minister and it has been agreed that the process and timing for finalisation of the SIMP will be included in the Project Development Agreement which will be finalised with the Northern Territory Government prior to financial investment decision.

3.9 DEPARTMENT OF INFRASTRUCTURE, PLANNING AND LOGISTICS

3.9.1 Comment 1

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Traffic and Transport
Date Submission Received	18 November 2016	Submitters Reference to EIS Section (if provided)	Volume 5, Appendix 23, Section 4.1.1

Details of the Submission

The proponent states “The new roads will not be ready in time for the start of the Project's construction phase. The Construction Traffic Management plan (discussed further later in this report) will need to demonstrate how access to the site will be achieved using the existing network and/or purpose built construction access tracks”.

This risk has not been addressed in the document. The risks identified, and the traffic management proposals are all based on the premise that the Legume Property Access Road will be upgraded. Nowhere in the document is the risk of the capacity of the existing road being able to adequately cater for the construction activities identified.

The proponent needs to ascertain if the existing pavement and road structure is able to withstand the proposed impacts.

Proponent Response

The upgrade of relevant sections of Moonamang Road and the Keep River Plains Road by the Western Australian and Northern Territory Governments will not be finalised prior to the commencement of construction in mid-2017. Accordingly, Project construction traffic will utilise the existing Moonamang and Keep River Plains Roads. There are a number of potential risks associated with the use of the existing roads by construction traffic. An additional risk assessment has been undertaken to assess these risks and is presented below in Table 5. The risk assessment identified three risks associated with the use of the existing roads during construction:

- An increase in dust emissions results in a reduction of air quality at potentially sensitive receptors.
- Increased traffic results in impacts to the road network affecting existing pavement and road structure.
- Increased traffic movements lead to an increase in vehicle incidents.

Relevant control strategies, including the preparation of a Construction Traffic Management Plan, were also developed and are presented in Table 5 for each risk identified. The Construction Traffic Management Plan will be finalised following project approval.

TABLE 5 CONSTRUCTION RISK REGISTER - ADDITIONAL TRAFFIC ASSESSMENT

Source of Impact	Consequence Aspect	Risk	Initial Risk Rating			Control Strategies	Residual Risk Rating			Evaluation Rationale
			Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level	
Increased traffic volumes on unsealed sections of the Moonamang and Keep River Plains Roads during Project construction (i.e. prior to the road upgrades).	Air Quality	An increase in dust emissions results in a reduction of air quality at potentially sensitive receptors.	2	2	L	- A Construction Traffic Management Plan (CTMP) will be prepared and implemented. - A communications plan will be developed as part of the CTMP to ensure: - public notification of the timeframes for construction, including mobilisation and demobilisation. - communication protocols are in place between the proponent, WA and NT Governments to coordinate the concurrent road upgrades and the use of the roads by construction vehicles. - observations from drivers are communicated to the WA and NT government on the state of external roads. - liaison with the WA and NT Governments to maintain trafficability on these roads. - Speed limits and road rules will be enforced for all vehicles on unsealed roads, including installation of additional signage if required. - Total vehicle travel will be reduced where practicable, by developing logistics to reduce overall travel distance / time on-site, and for workers travelling to and from the site.	1	1	VL	- There are only two sensitive receptors located along the Keep River Plains Road - the Marralum community and Spirit Hills Station. Marralum community is typically uninhabited during the week when the majority of the construction traffic will be generated. - Dusty conditions already exist on the unsealed sections of Moonamang Road and the Keep River Plains Road. - Given construction occurs only during the dry season any impacts from dust will be short term. - Existing peak daily traffic on the Moonamang Road and Keep River Plains Road is estimated to be 40 - 45 vehicles per day (Appendix I, GHD 2016a). - Average daily traffic generation during peak construction period is 30 vehicles per day (Figure 4). The projected increase in traffic movements during the construction of the Project will be managed in accordance with the CTMP.
	Land	Increased traffic results in impacts to the road network affecting existing pavement and road structure.	3	1	L	- A CTMP will be prepared and implemented. - The CTMP will outline the requirements for heavy vehicles. - The CTMP will outline processes for monitoring road pavement condition and signs of road failure of external haulage routes and undertaking pre-emptive repair works to impacts to the road network. - A communications plan will be developed as part of the CTMP to ensure: - public notification of the timeframes for construction, including mobilisation and demobilisation. - communication protocols are in place between the proponent, WA and NT Governments to coordinate the concurrent road upgrades and the use of the roads by construction vehicles. - observations from drivers are communicated to the WA and NT	2	1	VL	- The existing Moonamang and Keep River Plains Roads are currently utilised by road trains, which are comparable to heaviest vehicles proposed to be used during construction of the Project. - Existing peak daily traffic on the Moonamang Road and Keep River Plains Road is estimated to be 40 - 45 vehicles per day (GHD 2016a). - Average daily traffic generation during peak construction period is 30 vehicles per day (Figure 4). The projected increase in traffic movements during

Source of Impact	Consequence Aspect	Risk	Initial Risk Rating			Control Strategies	Residual Risk Rating			Evaluation Rationale
			Likelihood	Consequence	Risk Level		Likelihood	Consequence	Risk Level	
						government on the state of external roads. liaison with the WA and NT Governments to maintain trafficability on these roads.				the construction of the Project will be managed in accordance with the CTMP.
	Human Health and Safety	Increased traffic movements lead to an increase in vehicle incidents.	3	5	H	A CTMP will be prepared and implemented. A communications plan will be developed as part of the CTMP to ensure: - public notification of the timeframes for construction, including mobilisation and demobilisation. - communication protocols are in place between the proponent, WA and NT Governments to coordinate the concurrent road upgrades and the use of the roads by construction vehicles. - observations from drivers are communicated to the WA and NT government on the state of external roads. - liaison with the WA and NT Governments to maintain trafficability on these roads. The CTMP will outline processes for monitoring roads for signs of failure and undertaking pre-emptive repair works to avoid accidents or delays. The CTMP will outline procedures for controlling traffic including in an emergency. The CTMP will outline processes for recording all off-site accidents involving Project drivers, employees and/or vehicles in the incidents-complaints register. Reporting of near misses will be encouraged. Speed limits and road rules will be enforced for all vehicles on unsealed roads, including installation of additional signage if required. Personnel operating vehicles will not be under the influence of alcohol or other drugs. Establish, implement and monitor a Driver Safety and Fatigue Management Policy for all employees and contractors. Personnel will be appropriately licenced. Vehicle inspection checks and services required to be undertaken at regular (appropriate) intervals. All Project personnel to complete a site and safety induction prior to commencement of work.	2	5	M	Existing peak daily traffic on the Moonamang Road and Keep River Plains Road is estimated to be 40 - 45 vehicles per day (Appendix I, GHD 2016a). Average daily traffic generation during peak construction period is 30 vehicles per day (Figure 4). The projected increase in traffic movements during the construction of the Project will be managed in accordance with the CTMP.

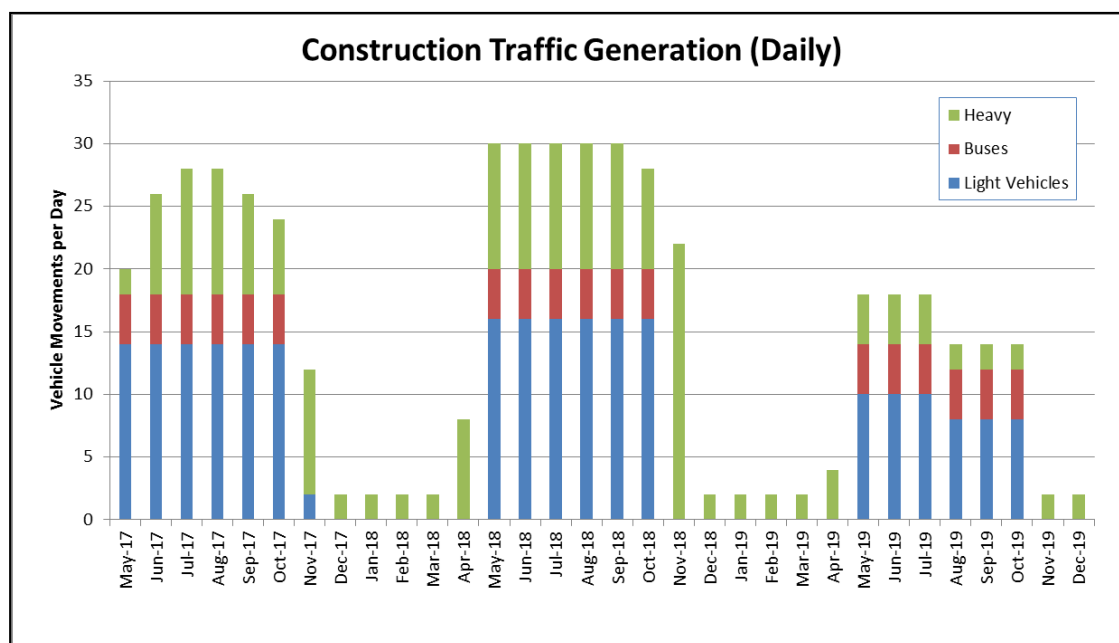


FIGURE 4 DAILY CONSTRUCTION TRAFFIC GENERATION BY VEHICLE TYPE

3.9.2 Comment 2

Submitter Type	State Government	TOR Category or EIS Chapter	Traffic and Transport
Date Submission Received	18 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

Local traffic users on the Legume Property Access have also not been considered from a traffic management perspective and have not been included in the Traffic component of the report. This information is required to adequately assess and mitigate the risk to local traffic users and the road infrastructure.

Proponent Response

Local traffic users primarily include those utilising the Moonamang Road and Keep River Plains Road and are associated with Legume Station, Marralum Community, Spirit Hills Station, recreational fishers, Traditional Owners and government agency staff. Existing peak daily traffic on the Moonamang Road and Keep River Plains Road is estimated to be 40 - 45 vehicles per day (GHD 2016a).

The risk assessment presented in Volume 1, Chapter 8 (Risk Assessment) identified a number of risks to traffic users and road infrastructure, including risks posed to local users.

A separate risk assessment was also undertaken for the socio-economic impact assessment and risks to local traffic users were addressed as part of this assessment (Volume 3, Chapter 1, Section 5).

An additional risk assessment was also undertaken to assess the potential risks associated with the use of the existing roads by construction traffic. This risk assessment and associated control strategies are presented in Table 5 above.

In summary, risks to traffic users and road infrastructure during construction are identified as:

- Extra heavy vehicle movements resulting in increased risk to other road users (which may include death).

- Extra heavy vehicle movements result in degradation of local and main roads and bridges.
- Increased traffic movements lead to an increase in vehicle incidents.
- Increased traffic results in increased dust emissions from unsealed roads.
- Increased traffic results in soil compaction, rutting and soil erosion outside of designated traffic areas.
- An increase in dust emissions results in a reduction of air quality at potentially sensitive receptors.
- Increased traffic results in impacts to the road network affecting existing pavement and road structure.

In summary, risks to traffic users and road infrastructure during operation are identified as:

- Sealed road extension to Legume Station results in increased public traffic to Keep River area, and potential for subsequent increase in traffic incidents.
- Extra heavy vehicle movements resulting in increased risk to other road users (which may include death).
- Extra heavy vehicle movements result in degradation of local and main roads and bridges.
- Increased traffic movements lead to an increase in vehicle incidents.

The impacts on local traffic will be managed through the implementation of the control strategies identified through the risk assessments, including the development and implementation of Construction and Operation Traffic Management Plans

3.9.3 Comment 3

Submitter Type	State Government	TOR Category or EIS Chapter	Traffic and Transport
Date Submission Received	18 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

The proponent needs to identify processes to ensure the effective coordination between themselves and the WA and NT Governments during construction phase.

Proponent Response

The proponent is committed to ensuring effective coordination with the Western Australian and Northern Territory Governments during the Project's construction phase. As part of achieving Major Project status, the Northern Territory government and the Proponent signed a non-binding Project Facilitation Agreement. As is common practice, the parties are working towards a Project Development Agreement.

The proponent will also prepare a Construction Traffic Management Plan which will include a communications plan to ensure:

- public notification of the timeframes for construction, including mobilisation and demobilisation.
- communication protocols are in place between the proponent, WA and NT Governments to coordinate the concurrent road upgrades and the use of the roads by construction vehicles.
- observations from drivers are communicated to the WA and NT government on the state of external roads.
- liaison with the WA and NT Governments to maintain trafficability on these roads.

3.9.4 Comment 4

Submitter Type	State Government	TOR Category or EIS Chapter	Traffic and Transport
Date Submission Received	18 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

It is noted that the breakdown of annual operational traffic for the operation phase is adequately comprehensive, which would be useful to repeat for the construction phase section of the traffic assessment.

Proponent Response

As stated in Volume 3, Appendix 5, Page 8 of the draft EIS, *"unlike operational traffic, construction traffic does not have a consistent composition and directional pattern"* (GHD 2016b). For this reason the construction data has been presented in the draft EIS based on total vehicle movements. Notwithstanding,

Table 6 presents the draft EIS traffic data for each construction year by vehicle type. It is important to note that these are indicative numbers only and numbers continue to be changed and refined as Project planning progresses.

TABLE 6 ANNUAL CONSTRUCTION TRAFFIC GENERATION

Vehicle Type	2017	2018	2019	Total
10t Trucks	40	60	0	100
20 T Trucks	288	512	80	880
26 Seater Bus	240	360	360	960
53 Seater Bus	70	96	96	262
Double Semi-Trailer	0	40	0	40
Dump Truck	8	0	0	8
Light Vehicles	1,760	1,740	2,310	5,810
Low-Loader	226	560	2	788
Semi-Trailer	548	818	248	1,614
Triple Train	96	184	128	408
Total	3,276	4,370	3,224	10,870

3.9.5 Comment 5

Submitter Type	State Government	TOR Category or EIS Chapter	Traffic and Transport
Date Submission Received	18 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

I also note that the proponent consistently refers to the "Cave Springs Road" as part of the Legume Property Access Road. This is factually incorrect.

The submission noted that the road from the WA border east to Legume Station is known as “Legume Property Access Road”.

Proponent Response

Following a meeting with the Department of Infrastructure, Planning and Logistics on 29 November 2016, it was confirmed that the correct name of the road referred to in the draft EIS as Cave Springs Road is the Keep River Plains Road.

3.10 DEPARTMENT OF PRIMARY INDUSTRY AND RESOURCES

3.10.1 Comment 1

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	-
Date Submission Received	18 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

The draft EIS as presented comprises a comprehensive set of documents that appear to identify the significant risks posed by this project.

Proponent Response

Noted - no response required.

3.10.2 Comment 2

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Marine and Estuarine Water
Date Submission Received	18 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

From the information presented in the draft EIS, and from the water quality presentation to Government agencies by the proponent on Wednesday November 9, my agency considers that the risks posed by water discharge from the farm have been adequately addressed. The proponent's waste discharge modelling shows rapid disbursement of the effluent water within the creek system. When this is coupled with the timing of release to coincide with ebb tides to facilitate downstream movement of the discharge water, and prevent upstream nitrification, it can be concluded that accumulation of nutrients in the creek and river system is unlikely.

In addition, the company (Seafarms) has extensive experience operating a prawn farm in the vicinity of the Great Barrier Reef and has demonstrated the ability to effectively manage water quality in this sensitive location. The Legume farm, which includes an extensive bio remedial waste water treatment system in its design farm (which its Queensland farm does not have), is expected to operate with minimal risks to local water quality.

Proponent Response

Noted - no response required.

3.10.3 Comment 3

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Biosecurity
Date Submission Received	18 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

The terms of reference for this EIS required an assessment of the risks to the surrounding environment posed by the escape of prawn stock and the transmission of pathogens and/or disease from the project's facilities.

The information supplied in the draft EIS notes the obvious point that if juvenile prawn stock is free of a particular disease agent prior to release into the growing ponds then there is no possibility of that agent being released into the environment.

It should be noted that the original breeding prawns (prior to entry into the proponent's breeding and maturation facilities) will all come from waters adjacent to the Northern Territory. The disease status of these stocks has been well documented over recent years as this region has become the primary source of breeding stock for the Australian industry. In addition, the proponent is engaging in a rigorous disease testing and breeding program with the aim of producing disease-free stock. This process is to be coupled with stringent biosecurity protocols between and within all the sites associated with this project.

DPIR notes that the biosecurity chapter of the report contains an incomplete section which references additional information to be supplied by the proponent to explain the management actions to be taken to minimise the escape of farmed prawns into the environment. This section needs to be completed.

Additionally, the biosecurity chapter makes reference to a comprehensive biosecurity plan. This plan was not included in the draft EIS. DPIR offers to work with the proponent, at the appropriate time, to develop a biosecurity plan that meets the farms operational needs and that provides assurance to Government that biosecurity management is being adequately addressed. This will include reporting instances of high or escalating prawn mortality to the Director of Fisheries in accordance with statutory requirements of the Territory's Fisheries legislation.

DPIR advises that the supply to the farm of disease-free stock, coupled with the use of founder stock from Territory Waters addresses a significant proportion of the disease risk of the proposed farm. Additional risks can be managed by the (still to be developed) comprehensive biosecurity plan.

Proponent Response

An early version of the biosecurity report (Appendix 16 – Biosecurity Assessment) was inadvertently included with the draft EIS. The incomplete section of the biosecurity appendix has been completed and the updated version is provided in Appendix G. It should also be noted that the information that was missing from Appendix 16 of the draft EIS was detailed in the EIS at Section 4.1.6 of Volume 2, Chapter 7 (Marine and Estuarine Ecology).

A draft comprehensive biosecurity plan has been developed by the proponent - it has not been finalised. The proponent notes the Department of Primary Industry and Resources (DPIR) offer to consult with them in regards to the biosecurity plan. Since the submission of the draft EIS and receipt of comments the proponent has met with DPIR and has accepted DPIR's offer. The proponent notes that due to regulatory and other requirements the biosecurity plan is not normally finalised until after the facility is constructed and is a state of operational readiness.

Finalisation of the biosecurity plan depends in part on final (detailed) engineering design, as well as any additional obligations that may arise prior to commencement of operations. The biosecurity plan is not a static document but evolves in concert with operations as a result of continuous improvements that include refinement and development of Standard Operating Procedures, reassessments of biosecurity risks and incorporation of new knowledge.

3.10.4 Comment 4

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Project Description
Date Submission Received	18 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

Whilst the project is unlikely to impact on any mining or petroleum developments, it is noted that the proponent proposes to build up to 6 MW power generation capacity to be supplied with diesel. Consideration should be given to compressed natural gas (CNG) which can be trucked from Middle Arm (a CNG project is currently under consideration at Middle Arm to supply CNG to ERA). This will reduce diesel imports and make use of cleaner and locally available natural gas. The project would require about 0.4 MMscfd (~0.4 TJ/d) of natural gas to run a 1.5 MW power plant or 1.5TJ/d for a 6 MW power plant. CNG can be trucked at a capacity of 1TJ per truck load. This means a truck movement of one every two days to one or two per day at full scale.

The project should also consider whether renewable energy sources or alternative technologies can be implemented to generate power or reduce the overall power required in light of the current administration's renewable energy target.

DPIR acknowledges the substantial economic benefit that this project represents, not only to the Northern Territory, but to the Australian economy. The scale of this aquaculture project is without parallel in Australia and its successful delivery will have long-standing and far reaching value for regional communities.

Proponent Response

It is unclear where the submitter's reference to 6 MW power generation capacity is from. As stated in Section 7.4.1.6 of the Project Description (Volume 1, Chapter 3), initially power will be provided by small standalone packaged generating sets of 1 MW and 2 MW size, located at each farm substation and at the Forsyth Creek seawater pump sub-station. As the operations gain momentum a central power station will be developed. Power generation will comprise an integrated system including dual fuelled engines powered initially by diesel (with a 17.5 MW capacity sized for the night time load), distributed solar photovoltaic (PV) generation of approximately 17.5 MW capacity for the daytime load, a control system (Danvest or similar) that will maximise the solar generation, and a 132 kilovolt (KV) transmission overhead line.

The proponent investigated all forms of energy supply including compressed natural gas (CNG), liquefied natural gas (LNG), and a variety of renewable technologies. DPIR notes that a CNG project is 'under consideration' however timing of this potential development does not accord with the development time-frame of this Project. Development risk associated with the proposed CNG development means that the proponent cannot commit to CNG. Furthermore, submissions received from a number of energy suppliers conclusively point to the fact that Legume is too far from Darwin or any other source of CNG generation.

Trucked LNG was also canvassed with the supplier market, and found to be prospective, once the Project is established enough to make the contractual commitments. Options presented to the proponent include the existing LNG source at Karratha, WA where LNG is trucked to a number of mine sites, and prospective LNG operators planning to produce LNG in Darwin and Katherine for trucking throughout the North. For this reason the proponent has allowed for dual fuelled engines in Stage 1, to be able to accommodate LNG if it is competitive. The draft EIS was written on the most conservative and feasible energy source being diesel, for now.

Discussions were held with prospective Oil and Gas producers hoping to develop onshore gas supplies from the Joseph Bonaparte gas basin in the area of the Project. As these developments are only at the test well stage, again it was decided to write the draft EIS on the most certain current situation.

Future stages of the Project may see LNG or a shore-based gas pipeline or other energy become available with sufficient economic competitiveness and security to be viable.

The proponent desires to maximise renewable energy for power generation. Separate investigations are being held into funding schemes to help make a high penetration of renewables through PV arrays feasible. Again, these considerations would confuse the reader and were therefore omitted from the draft EIS.

The proposed solution as part of a staged approach is to commence with diesel and then invest in Danvest Low Load Technology enabled gensets and photovoltaic arrays. Such a solution has been modelled in detail and shows significant solar penetration. This is the preferred technical solution considering the load, demand and security profiles required and currently available technology; however, it is not economically viable at the commencement of the Project unless there were a 4-5 fold direct subsidy.

A gas-solar hybrid technology solution suitable for the operation of the facility is not yet available without significant subsidies.

3.11 DEPARTMENT OF HEALTH

3.11.1 Comment 1

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Approvals, Conditions and Agreements
Date Submission Received	25 November 2016	Submitters Reference to EIS Section (if provided)	Executive Summary

Details of the Submission

The NT *Food Act* should be added to the list of NT legislation which is applicable to the project.

Proponent Response

Listing of the NT *Food Act* was accidentally omitted from the Executive Summary; however, Volume 1, Chapter 6 of the draft EIS (Approvals, Conditions and Agreements) states that the Project will comply with the Northern Territory *Food Act*.

3.11.2 Comment 2

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Project Description
Date Submission Received	25 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

Under the *Public and Environmental Health Act 2011* all public accommodation including staff accommodation must be maintained in a good state of repair and in a clean and sanitary condition so as not to cause a public health nuisance. The Public and Environmental Health Guidelines for Public Accommodation outline the general requirements for conducting a public accommodation business such as the need to prevent overcrowding and provide an acceptable standard of sanitation, amenity and safety.

It is noted that a mess and a wet mess will be provided as part of the accommodation village. The Northern Territory *Food Act* defines a food business as 'any business or activity that handles food intended for sale or selling regardless whether the business is of a commercial, charitable or community nature, or whether it involves handling or selling on one occasion only'. Consequently the accommodation village's commercial food preparation area and bar area are considered to be a food business and will therefore require registration with the Environmental Health Branch in accordance with the Northern Territory *Food Act*.

It is recommended that the proponent also contact Licensing NT, Department of the Attorney-General and Justice in regards to the service of alcohol.

It is noted that the mess and dining hall will be designed to be used as a shelter in the event of a cyclone. It is recommended that the proponent contact NT Emergency Services in regards to emergency preparations.

Proponent Response

The proponent recognises the Public and Environmental Health Guidelines for Public Accommodation as applicable to the Project in the Approvals, Conditions and Agreements chapter (Volume 1, Chapter 6, Section 3.3.3) of the draft EIS. The proponent commits to adhere to the general requirements of the guidelines.

The Approvals, Conditions and Agreements chapter also states that all food preparation at construction camps will be required to conform to the *Food Act*, and food safety standards (Volume 1, Chapter 6, Section 3.2.5).

The Approvals, Conditions and Agreements chapter also states that a liquor licence is required under the *Liquor Act* to sell alcoholic beverages on a specific premise. The proponent will apply for a liquor licence should alcohol be sold in the mess areas for the accommodation camp (Volume 1, Chapter 6, Section 3.2.7).

The proponent commits to the preparation and implementation of a Health and Safety Plan to mitigate the risk of the Project on human health and safety. The Health and Safety Plan will include the mitigation and monitoring measures referred to the Human Health and Safety chapter (Volume 3, Chapter 3). It will also include detailed emergency plans and response procedures in the event of an emergency or accident. Responsibilities and liabilities in the event of an emergency or accident will be identified in the Health and Safety Plan. Prior to the preparation of the plan the proponent will contact the Northern Territory Emergency Services in regards to emergency preparations, including in the event of a cyclone.

3.11.3 Comment 3

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Project Description
Date Submission Received	25 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

It is noted that potable water will be sourced from Forsyth Creek Dam and treated by chlorination and UV. The potable water supply must meet the 2011 NHMRC Australian Drinking Water Guidelines (ADWG).

In accordance with the Australia New Zealand Food Safety Standards the mess and wet mess as a Food Business must be supplied with potable water. For the purpose of the annual *Food Act* registration it is necessary for Food Business owners to demonstrate to Environmental Health that they have a potable water supply. The proponent will need to arrange for a certified analysis of the water to confirm the water meets the requirements of the ADWG, i.e. an annual credible analysis of a kitchen tap sample showing “pass” in total coliform and E. coli.

Proponent Response

The proponent recognises the Australian Drinking Water Guidelines as applicable to the Project in the Approvals, Conditions and Agreements chapter (Volume 1, Chapter 6, Section 3.3.3) of the draft EIS. The proponent commits to adhere to the requirements of the guidelines in regard to potable water supply. The proponent will comply with all relevant provisions of the *Food Act*, including certified analysis of water to confirm potable water meets the requirements of the Australian Drinking Water Guidelines.

3.11.4 Comment 4

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Waste Management
Date Submission Received	25 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

It is noted that sewage will be managed via a packaged wastewater treatment plant and that treated effluent will be disposed to land application areas using either subsurface or surface irrigation or evapotranspiration beds. The NT Department of Health is the approval authority for onsite wastewater systems and must be contacted prior to the installation of any system.

Proponent Response

The proponent will liaise with the Department of Health prior to the installation of the wastewater treatment systems.

3.12 UNIVERSITY OF TECHNOLOGY SYDNEY

3.12.1 Comment 1

Submitter Type	Educational Institutions	TOR Category or EIS Chapter	Other
Date Submission Received	24 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

Project Seagrass Dragon should be commended for their well-presented and considered Environmental Impact Statement which includes a design of the Legume Station Grow-out Facility (Stage 1) based on the Aquaculture Stewardship Council Shrimp Standard and the Environmental Code of Practice for Australia Prawn Farmers. This shows the company's willingness to work co-operatively and collegially with local and international ecologically sustainable aquaculture practices.

Proponent Response

Noted - no response required.

3.12.2 Comment 2

Submitter Type	Educational Institutions	TOR Category or EIS Chapter	Executive Summary
Date Submission Received	24 November 2016	Submitters Reference to EIS Section (if provided)	Executive Summary, Pg 5, Pg 10

Details of the Submission

We would like to provide several comments to enhance nutrient recycling strategies described in this proposal. The proponents describe how the effluent water from the grow-out facility will be passed through the EPZ and then into the Alligator Creek (Executive Summary, page 5). This practice could be further improved by passing this water through an "algal scrubber". Such a solution could include a large sloping open raceway where microalgae form a biofilm on the bottom of the channel and remove nutrients as the algae grows. The algal biomass could be harvested and used as a component in a fishmeal replacement. The selection of the most effective algal strain would need to be carefully considered.

Proponent Response

The proponent's investigations indicate that use of the internal farm recycling ponds and the Environmental Protection Zones (EPZ), with the appropriate residence times, represent the 'best practice' water treatment to improve waste water prior to discharge to Alligator Creek. The benefits of settling prior to discharge have been included within the design of the EPZ which provides an additional design capability for biological assimilation of nutrients. The submission suggests a specific technological approach that has been considered and is elaborated below. There are a number of flaws in the concept that mean that it is simply not feasible to implement. These are:

- There is not an algal product market supply chain or logistics chain that can accept these products, there is in fact a greater risk of creating algal biomass that needs to be disposed of in a less acceptable manner.
- Techniques for harvesting algae from biofilms are in their infancy and generally require significant energy input.

- As the submitter acknowledges, *"the selection of the most effective algal strain would need to be carefully considered"*, the science to support the most effective algal strain in this environment does not exist and, furthermore, it has been shown through experience in other contexts (e.g. algae to oil applications) that in open environments such as Legume Station it is almost impossible.

The over-arching principle of employing bio assimilation as a strategy is built into the EPZ, the difference between the proposed design and the submitter's proposal is that the proponent anticipates that the EPZ will involve the use of macrophytes (e.g. samphire species and mangroves) in addition to microalgae.

The modelling undertaken for the draft EIS shows that the zone in which the nominated interim site-specific trigger values may be exceeded is small (i.e. approximately 200 m upstream, and 200 m downstream of the discharge location). Furthermore, those discharge concentrations contributing to those elevations above interim site-specific trigger values in the modelling, will certainly be less in reality, given the conservative nature of the modelling (explained in Section 4.5 of Volume 2, Chapter 2 [Marine and Estuarine Water]). Note also that the EPZ is expected to result in some improvement in discharge water quality, but this has not been factored into the modelling (testing during Stage 1 will enable the performance of the EPZ to be determined).

Seafarms nonetheless investigated water treatment options in addition to recycling and settling. As part of its initial scoping Seafarms undertook a thorough investigation of potential 'additional' water treatment options. In particular, Seafarms commissioned CSIRO to advise on environmental treatment during the company's concept investigations. CSIRO identified a combination of technologies represented in Figure 5 below. This theoretical system has not been demonstrated at scale and relies on very high intensity bioflocculation (biofloc) systems. These are not applicable to the semi-intensive system to be deployed at Legume.

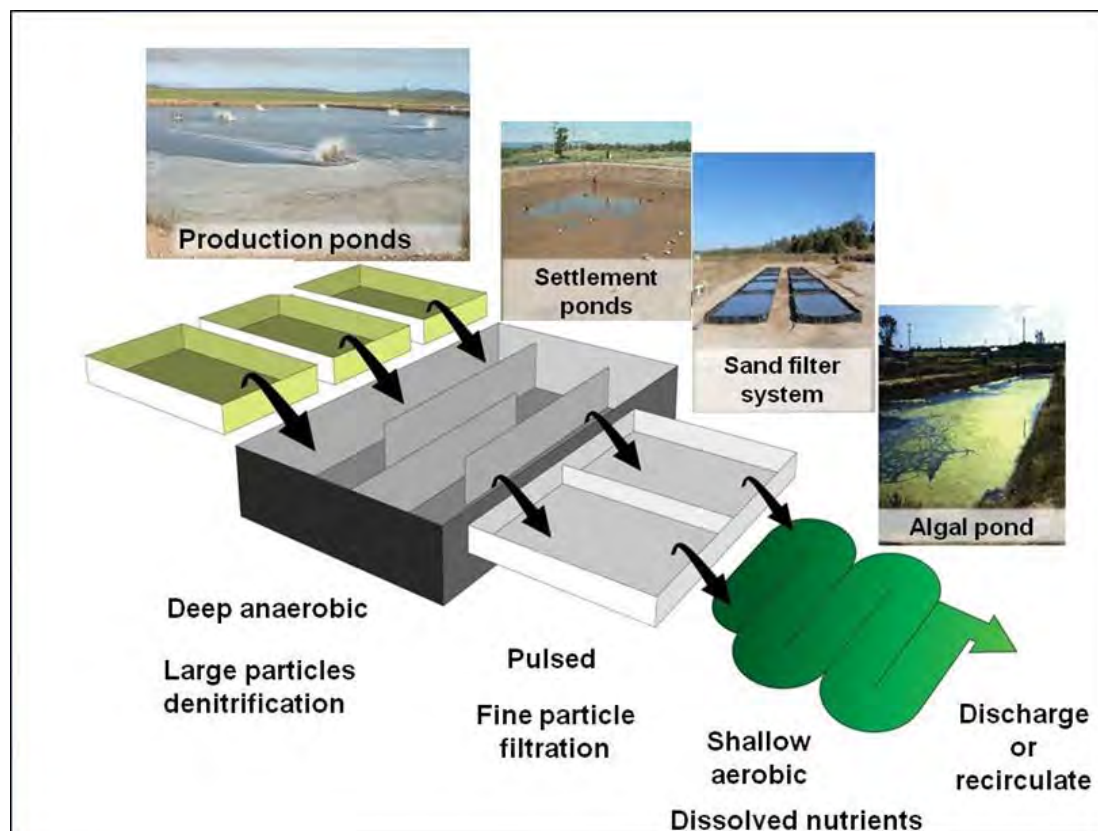


FIGURE 5 POTENTIAL TREATMENT SYSTEMS

The proponent is also aware of algal-based 'solutions' to nutrient discharge promoted by some companies (for example, a project at Pacific Reef Fisheries at Ayr). The proponent's investigations of these technologies not only indicate that they are not economic, but they also lead to unacceptable accumulations of algae that require either 'use' as a 'product', or have to be disposed of some other way. The commercial reality is that there are no ready markets or channels to market for seaweed products likely to be produced as a result of bio-nutrient stripping technologies. Considering that the predominant source of nutrient liberated with culture water is associated with unutilised or unconverted feed, there is a very strong commercial imperative to improve feed conversion ratios within the production process. Thus avoidance over time is the primary strategy to reduce impact. Key technologies within the pipeline include: (i) recirculation (ii) improved feed formulations (iii) improved feed regimes (such as through better timed feeding and smart sensor technologies) and (iv) breeding strategies that improve feed conversion.

3.12.3 Comment 3

Submitter Type	Educational Institutions	TOR Category or EIS Chapter	Executive Summary
Date Submission Received	24 November 2016	Submitters Reference to EIS Section (if provided)	Executive Summary, Pg 12

Details of the Submission

A similar solution could be implemented to reduce nutrients in the Internal Farm Recycling Pond (IFRP; see page 10) by using an algal scrubber, which would also produce algal biomass.

Proponent Response

The submitter may have misunderstood part of the purpose of the Internal Farm Recycling Pond which is to conserve and reuse nutrients for the next phase of culture. The central idea is that through water reuse the operators can reduce the additional nutrients required to initiate culture with the algae (and nutrients) effectively acting as an inoculum for the start of each crop. In other words the proponent expect algal biomass (as phytoplankton) to be present in the Internal Farm Recycling Pond water and this biomass to provide a beneficial use.

3.12.4 Comment 4

Submitter Type	Educational Institutions	TOR Category or EIS Chapter	Executive Summary
Date Submission Received	24 November 2016	Submitters Reference to EIS Section (if provided)	Executive Summary, Pg 12

Details of the Submission

The proponents suggest that dried/leached pond sediment (mud/algal accumulation) could be used to help revegetate pond banks (see page 12). Although this strategy will remove nutrients from the pond floor, it is unlikely to remove nutrients from pond water. After any rainfall event, nutrients trapped in dried mud on top of the banks will be re-mobilised (dissolved) and run off the banks back into the pond, resulting in possible eutrophication and a decrease in dissolved oxygen in the pond water. This pulse of nutrients could also trigger algal blooms, which would be uncontrollable in both timing and species composition. We suggest that it would be more effective to consider options where organic rich sediment is actually removed from the catchment of ponds. Alternatively, the nutrients could be used to produce additional algal biomass that could be used as part of a replacement fish meal.

Proponent Response

Refer to Section 3.9 of Appendix F which provides additional information on the management of pond and channel waste. This material is to be solar dried and aerated in a designated area between farms 1 and 2, rolled out and compacted, with bunding and vegetation used to control erosion and sediment loss of this material. Once leached of salt (the material will be spread in thin layers of ~1m depth in any season, suitable for flushing of salts over a small number of wet seasons), this material, with its high levels of organic material, can be used to help revegetate pond and channel banks. This will be in accordance with relevant guidelines and standards, with the intent to comply with the Environmental Code of Practice for Australian Prawn Farmers requirements (Donovan, 2001, pp19-20).

3.13 DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

3.13.1 Comment 1

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Terrestrial Fauna and Avifauna
Date Submission Received	25 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

The key ecological value of the site is the internationally significant aggregations of waterbirds. The dynamics of these species and their habitats on Legume are complex, and there remains some uncertainty about the potential impacts on the development on this value, particularly in relation to any changes in the hydrology and inundation regimes of the freshwater wetlands.

Proponent Response

The draft EIS identifies two potential impacts to significant aggregations of waterbirds from changes in floodplain hydrology:

1. Modification of existing infrastructure and development of project infrastructure.
2. Changes in the operation of Forsyth Creek Dam.

Modification of existing infrastructure and development of project infrastructure

In regard to the modification of existing infrastructure, the draft EIS concludes that, in the wet season, the effect of the proposed development is an increased flood depth and flood extent at various locations and a reduction in the amount of water reaching the downstream section of Alligator Creek (Volume 2, Chapter 6, Section 4.2.1.2), however, this can be successfully mitigated by the measures outlined in Volume 2, Chapter 3.

The submitter concurs with the findings of the draft EIS, stating that "*upgrading the site access road for all weather conditions is the major infrastructure development with potential to impact on wet season waterbird habitat*", and that the use of road culverts '*would minimise changes to wet season surface flows, to the extent that impacts from upgrading the access road pose a low risk to waterbird habitat values*' (Department of Environment and Natural Resources 2016, pg. 6).

Changes in the operation of Forsyth Creek Dam.

The draft EIS also identifies that the cessation of dry season freshwater flow from Forsyth Creek Dam has the potential to result in changes to wetland fauna habitat characteristics.

The annual release of water from Forsyth Creek Dam has occurred for 10 years (the dam has only been in existence since 2006, with the first release in 2007). The release of water from year to year has been highly variable in regards to the amount of water released, and the areas of the floodplain the water release is directed into (this is at the discretion of the pastoral operator who direct the water to best support whichever paddocks they wish to encourage vegetation growth within). However, regardless of where it is directed to, the release results in an artificial inundation of some of the floodplain during the dry season for approximately 4 - 8 weeks a year (the duration of the inundation is variable depending upon the amount released and the climatic conditions during the inundation period). Therefore, ceasing the dam release will result in a decrease in the extent of surface water for 4 - 8 weeks, thus a reduction in available habitat for waterbirds over this time.

The Alligator Creek wetland system extends from where it is bunded near its tidal limit (Point D as shown on Figure 6 below), for approximately 15-20 km upstream. This area consistently supported the highest waterbird density and species richness of any wetland habitat surveyed on the site during the EIS survey events. It is important to note, however, that review of satellite imagery from before the dam was constructed shows that water did, and still does remain throughout the lower section of Alligator Creek and associated wetlands even in the absence of the dam release (see Figures 7-9 in Chapter 3 [Freshwater] of the draft EIS). This was verified in the 2016 dry season, in which water remained in Alligator Creek throughout the dry season despite coming out of an extremely poor wet season over 2015-2016 and a 2016 dam release in which no flows were directed into the Alligator Creek system past Crocodile Crossing - see Figure 6 below. A further point worth noting is that internationally significant aggregations of waterbirds were observed around Legune prior to the instatement of the dam and the regime of releasing the dam waters in the dry season (Chatto 2000, 2003, 2006, Jaensch 1994)

Nonetheless, the proponent accepts that it is not possible to confidently determine the degree of the assumed change in waterbird abundance, following the proposed cessation of an annual release from Forsyth Creek Dam, and that this risk will need to be managed through the preparation and implementation of a waterbird monitoring program that allows for adaptive management to occur should adverse impacts to waterbird species richness and abundance be detected. A framework for that monitoring program has been prepared in consultation with the Northern Territory and Commonwealth Governments. The Waterbird Monitoring Program framework is provided in Appendix A of this document.

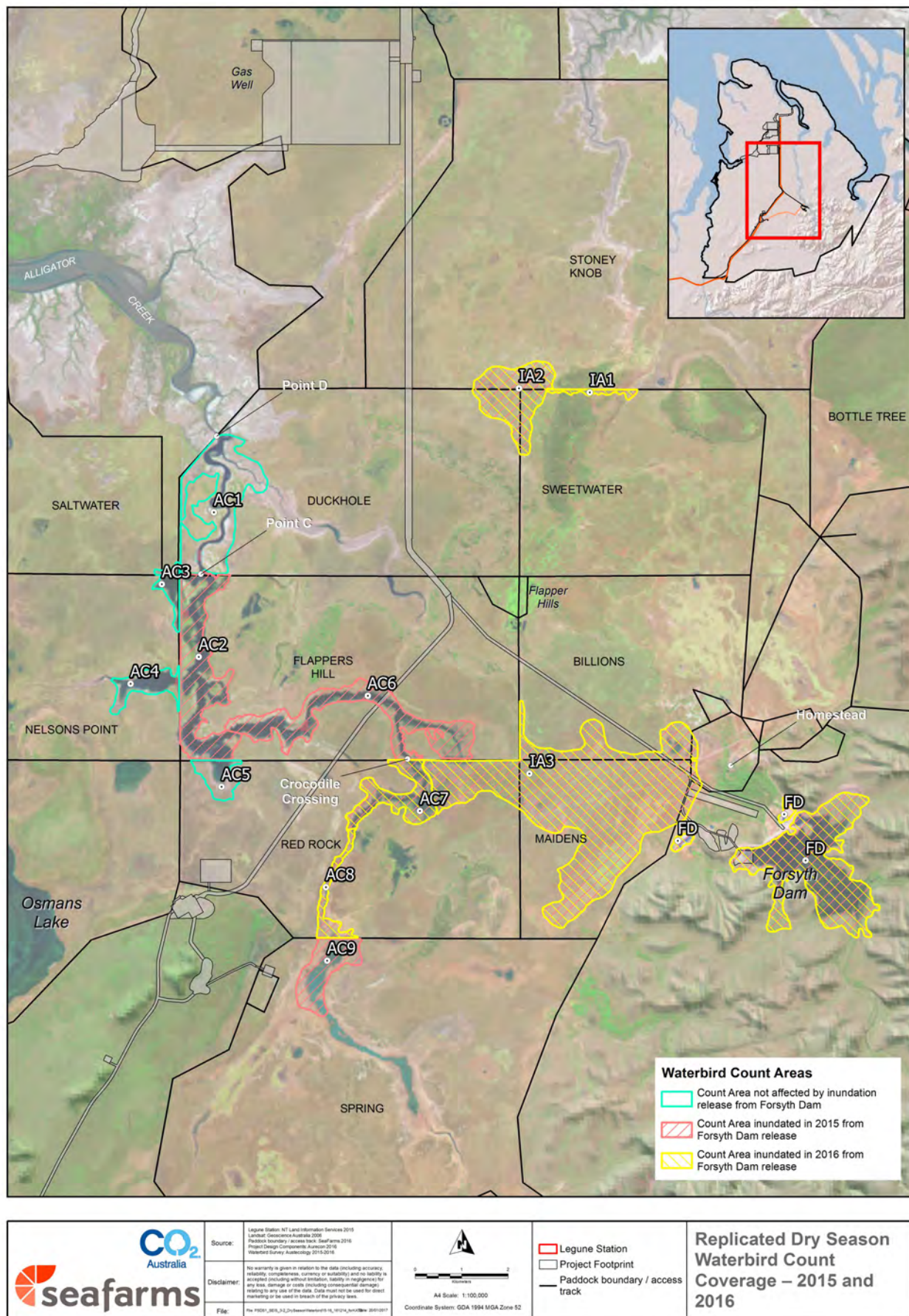


FIGURE 6 REPLICATED DRY SEASON WATERBIRD COUNT COVERAGE - 2015 AND 2016

3.13.2 Comment 2

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Terrestrial Fauna and Avifauna
Date Submission Received	25 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

The Draft EIS does not adequately consider the need for a robust medium-term monitoring program for waterbirds, which may inform an adaptive response in management of the site if negative impacts are observed.

Uncertainty about the potential impact of the proposed development on waterbird habitat, particularly arising from changes in floodplain hydrology and inundation regimes, means that a monitoring program that can robustly track changes in waterbird composition, abundance and habitat usage over medium timeframes is essential. This is not adequately addressed in the Draft EIS.

Limited detail is provided in the Draft EIS of any monitoring of biodiversity that may be potentially impacted by the project, and proposed fauna and flora monitoring is generally limited to the construction period (Vol 2, Ch 6, section 5; Vol 4, Ch 3 C6). As described above, the key ecological value of the site is the internationally significant aggregation of waterbirds, and there remains some uncertainty about the impacts of the development on this value, particular in relation to any changes in the hydrology and inundation regimes of the freshwater wetlands. It is therefore important that a monitoring framework is developed that can robustly track waterbird composition, abundance and habitat usage over medium timeframes, and potentially allow for an adaptive response in site management if negative impacts are observed. This requirement is likely to become increasingly important if future stages of the development proceed. In addition to monitoring waterbirds directly, the monitoring framework may also consider indicators of habitat quality, but the former is an essential component. The draft EIS and EMP should address this issue in much greater detail.

Proponent Response

To mitigate the potential impact of the cessation of annual flows from Forsyth Creek Dam on waterbirds, the proponent has committed to preparing a Waterbird Monitoring Program in conjunction with a Scientific Advisory Group (SAG). As part of this SEIS the proponent has prepared a framework for the monitoring program and this is provided in Appendix A. The objective of the monitoring program is to outline a monitoring program and associated data analysis and interpretation, of sufficient power to determine whether limits of acceptable change in waterbird usage of freshwater wetlands of the site have been exceeded, and if so, whether such changes are attributable to developments at Legume.

3.13.3 Comment 3

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Terrestrial Flora
Date Submission Received	25 November 2016	Submitters Reference to EIS Section (if provided)	Volume 2, Chapter 6, Section 5.5

Details of the Submission

The major potential pathway for impact from the proposed development on terrestrial fauna (and flora) is through facilitating the introduction and spread of environmental weeds and feral animals. Species of particular concern include Gamba Grass, Mimosa and Black Rat (*Rattus rattus*). The treatment of introduced

species in the Draft EIS (Vol 2, Ch 6, section 5.5) needs to be reconsidered to focus effort on biosecurity and surveillance and management of high priority species.

It is highly recommended that follow-up chemical control occur post land clearing activities to manage weed germination triggered by soil disturbance. If the land manager is unsure of the best ways to control any newly germinated species, advice should be sought from the Weed Management Branch.

All land in the Northern Territory is subject to the NT *Weeds Management Act* which states that the owner and occupier of land must - (a) take all reasonable measures to prevent the land being infested with a declared weed; (b) take all reasonable measures to prevent a declared weed or potential weed on the land spreading to other land.

Mimosa, gamba grass, parkinsonia and neem are all subject to Statutory Weed Management Plans. Management obligations outlined in the plans must be adhered to by all landholders.

Cane toads are well established in the Legume area and localised control of toads is likely to be token, rather than have real biodiversity benefits. Similarly, broad-scale control of feral cats is ineffective while populations adjacent to the site remain unmanaged. More critically, cats should not be able access potential food sources such as rubbish dumps and bins around the project site.

Proponent Response

Terrestrial flora field surveys were conducted over 18 days in early May 2015 and 2016 by two botanists, with the objective to map vegetation communities present and determine the presence, or likelihood of presence, of threatened species and declared weeds.

One Class A declared weed was detected in Legume Station – gamba grass (*Andropogon gayanus*). Two individuals of this species were found in one location, in a fenced enclosure for a pump at the Linden's bore yards. It is not accessible to stock and it does not appear to be spreading. Since submission of the EIS, mimosa (*Mimosa pigra*) - another Class A weed - has been identified as present on site. As such it has also been included on the list of weeds of concern to the project and the EMP has been updated to include this species.

Eight weeds declared in Class B were recorded in Legume Station (note, only seven are declared for this part of the NT):

- Neem (*Azadirachta indica*) – present beside the road near the far southern end of Legume Station, and beside Forsyth Creek near the homestead.
- Caltrope – widespread on the estuarine-deltaic plain – however, this species does not have declared status in this part of the NT (north of latitude 16°30').
- Flannel weed (*Sida cordifolia*) – present in sclerophyll woodland, *Calytrix exstipulata* tall shrubland and non-remnant areas, as a minor component of the ground layer.
- Olive hymenachne – present in shallow water along the bank of the Forsyth Creek channel, approximately seven kilometres downstream of the Forsyth Creek Dam.
- Hyptis – widespread in sclerophyll woodland, *Calytrix exstipulata* tall shrubland, fringing open forest, some wild plum low open woodland, and monsoon vine thicket, particularly on the coastal erosional plain within the vicinity of watering points and roads.
- Parkinsonia – stands of this thorny shrub were present on the estuarine-deltaic plain in grassland ranging from very sparse/absent over most of the plain, to mid-dense/dense, with the more concentrated

densities generally associated with areas in the vicinity of Forsyth and Alligator Creeks.. This species is a Weed of National Significance (Australian Weeds Committee 2012).

- Sicklepod – this tall herb is present in dense patches on the estuarine-deltaic plain, within the woodland and grassland mosaics. It is also present in fringing open forest.
- Spinyhead sida – widespread in sclerophyll woodland (particularly ghost gum woodlands and *M. dealbata* low open woodland), tending to dominate areas such as ‘cattle camps’ where cattle congregate for shade, water, and shelter on or beside the estuarine-deltaic.

The draft EIS commits to the preparation and implementation of a Weed Management Plan for both the construction and operation stages of the Project (Volume 2, Chapter 5, Section 5.3; Volume 5, Appendix 5, Weeds and Pests Strategy). Additionally, the Weeds and Pests Strategy presented in the draft Environmental Management Plan (Volume 4, Chapter 3) consolidates and summarises the commitments made as part of the draft EIS, and will be used to develop site specific management procedures after approval of the Project.

Prior to construction commencing, a detailed, comprehensive weed survey will be conducted in the Project footprint + 200m buffer. This will be used to prepare a weed map of the site. Ongoing weed monitoring will be undertaken to track changes over time. The Weed Management Branch of the Department of Environment and Natural Resources will be consulted prior to the commencement of this survey.

Weed control methods will be outlined in the Weed Management Plan. Control measures will focus on high priority species and will include biosecurity and surveillance measures to prevent the introduction and spread of weeds. In developing the Weed Management Plan the proponent commits to engaging with the Weed Management Branch of the Department of Environment and Natural Resources to ensure consistency with control measures recommended by the branch. Following land clearing activities the proponent will undertake follow-up chemical control to manage weed germination triggered by soil disturbance.

The Weed Management Plan will ensure that the proponent complies with the requirements of the *Weeds Management Act*, and that any obligations outlined in Statutory Weed Management Plans are adhered to.

The draft EIS also commits to the preparation of a Fauna Management Plan which will include pest animal management strategies for both the construction and operational phases of the Project (Volume 2, Chapter 6, Section 5.5.1; Volume 5, Appendix 5, Weeds and Pests Strategy). As stated in the draft EIS, the Project will, wherever practical and feasible, be managed to avoid creating favourable habitat for pest animal species, and through monitoring, ensure timely implementation of controls where necessary. The proponent will ensure that pest control focuses on high priority species, including the black rat (*Rattus rattus*), and involve management strategies commensurate with achieving real biodiversity outcomes. This will include surveillance and biosecurity measures.

3.13.4 Comment 4

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Freshwater
Date Submission Received	25 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

The Proponent states that between seven and 10 GL of freshwater will be required per year for the project. This water will be sourced from Forsyth Dam. Legume Land Pty Ltd is currently the holder of a 50 GL/year surface water extraction licence (811019) for Forsyth Creek (Dam) for the beneficial use of Irrigation. This

licence is valid until 18 September 2018. The Proponent will need to demonstrate its stake in this licence in order to extract water from Forsyth Dam. The development poses a change to the beneficial use of the water and the licence holder will need to apply to change the beneficial use.

Proponent Response

As stated in Volume 1, Chapter 6, Section 3.2.16 of the draft EIS (Approvals, Conditions and Agreements), in accordance with the Northern Territory *Water Act*, the proponent will apply to have the current surface water extraction licence (811019) for Forsyth Creek Dam transferred following the acquisition of Legume Station. This will include applying to change the beneficial use.

3.13.5 Comment 5

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Marine and Estuarine Water
Date Submission Received	25 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

The Proponent states that on average, the seawater consumption requirement will be 575 ML/day from Forsyth Creek. The NT *Water Act* states that a person is required to hold a licence to take any water flowing or contained in a waterway; groundwater; or tidal water. The Proponent will need to apply for a licence to extract seawater.

Proponent Response

As stated in Volume 1, Chapter 6, Section 3.2.16 of the draft EIS (Approvals, Conditions and Agreements), in accordance with the Northern Territory *Water Act*, a surface water extraction licence will be obtained for the Project prior to the extraction and use of saline water from Forsyth Creek.

3.13.6 Comment 6

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Freshwater
Date Submission Received	25 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

Management of storm water drainage and overland flow are important to reduce impact on environment. Flood mitigation measures have been mentioned. In channel and dam designs, the updated rainfall intensities should be used.

Proponent Response

The proponent commits to utilising updated rainfall intensities in channel designs. A weather station was installed in 2015 to provide improved local rainfall data and to provide the ability to corroborate rainfall events at the northern area of the property with the Australian Bureau of Meteorology published data.

3.13.7 Comment 7

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Marine and Estuarine Water
Date Submission Received	25 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

The wastewater license should set maximum annual or seasonal loads of total N, total P and TSS, and not only water quality concentration maximum.

Proponent Response

The average daily discharge into Alligator Creek is 420ML/day. This has been combined with the daily average concentration of total nitrogen (TN), total phosphorus (TP) and total suspended solids (TSS) to provide maximum total annual loads. The annual loads are shown below.

TABLE 7 MAXIMUM ANNUAL LOADS OF NUTRIENTS TO ALLIGATOR CREEK

Parameter	Average rate/concentration	Annual total
Discharge water	420 ML/day	154 GL
Nitrogen	0.8 mg/L	122.6 tonne
Phosphorus	0.1mg/L	15.3 tonne
Total suspended solids	20mg/L	3,066 tonne

It is important to contextualise these annual loads with reference to the loads in the existing environment. For comparison, the annual volume of water exchanged within Alligator Creek and the average existing total annual loads of N, P and TSS are presented below. The volume of water exchanged is based on the average tidal prism (volume of water during high tide minus the volume of water during low tide) across the neap and spring tides. The concentration of the respective water quality parameter is based on the median value of measured data around Legume (not specifically Alligator Creek), found in Table 4, Volume 2, Chapter 2 of the draft EIS.

As can be seen from Table 6, the annual volume of water added to the system from the farm (154 GL) is less than 0.5% of the annual volume of water exchanged through tidal movements. The nutrients within the discharge water are also a fraction of the average volume of nutrients entering and exiting Alligator Creek over the course of a year (i.e. TN 1.5%, TP 0.3%, TSS 0.04%).

TABLE 8 EXISTING ANNUAL CONCENTRATIONS OF NUTRIENTS IN ALLIGATOR CREEK

Existing environment	Tidal exchange / existing concentration	Annual total
Tidal water exchange	Spring tide ebb-flood tidal exchange = 90 GL Neap tide ebb-flood tidal exchange = 22 GL Average flood-ebb tidal exchange = 56GL	~ 40,880 GL
Nitrogen	0.2mg/L	8,176 tonne
Phosphorus	0.1mg/L	4,088 tonne
Total suspended solids	190mg/L	7.7 Megatonne

3.13.8 Comment 8

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Marine and Estuarine Water
Date Submission Received	25 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

The Department recommends the development of seasonal trigger values, for periods of catchment inflow (e.g. January to April) and no or negligible inflow (remainder of the year). Additionally, trigger values be determined for different waters, such as within close proximity to the mixing zone (may be contained within Alligator Creek), and more distant, Keep River estuary.

Proponent Response

This issue has been addressed in response to Comment 27 from the NT EPA (see Section 3.19.27 of this SEIS).

3.13.9 Comment 9

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Marine and Estuarine Water
Date Submission Received	25 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

Monitoring chlorophyll a and turbidity are the highest priority, and can be done by the use of logging instruments (e.g. Seabird instruments, recently used by INPEX for Darwin Harbour), which could be considered for monitoring, though there are some challenging practical considerations about deployment in a macro-tidal environment that may be overwhelming. Certainly, this would provide a much better baseline data, and monitoring program when the project is in operation.

Proponent Response

Monthly samples of chlorophyll and turbidity are being collected and analysed from the waterways around Legume. An 18 month data set has been collected thus far and provides a range of concentrations.

Data loggers deployed within Alligator Creek would require frequent cleaning and calibration. Unlike Alligator Creek, the INPEX/Darwin Harbour data logging was carried out in deeper water, which is easily accessible with available infrastructure to support data logging and deployment operations. Ambient suspended sediment levels in and around the INPEX sites were also far lower than those observed in Alligator Creek.

Logging within Alligator Creek will also be very hazardous and the value of any additional data collected by continuous logging is not considered to be high compared with the safety and logistical issues involved in the logging.

3.13.10 Comment 10

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Environmental Management Plan
Date Submission Received	25 November 2016	Submitters Reference to EIS Section (if provided)	Appendix C1, Draft Environmental Management Plan

Details of the Submission

An "Erosion and Sediment Control Strategy" has been provided in Appendix C1 of the draft Environmental Management Plan (EMP); however, preparation and implementation of a detailed Erosion and Sediment Control Plan (ESCP) will still be required. Previous comments provided on 11/8/2016 for the Notice of Intent (NOI) (DLRM2015/5021) regarding an ESCP remain valid.

Proponent Response

To ensure that land, soil and water resources are protected both now and in the future, such that the ecological health and land uses, and the health, welfare and amenity of people are maintained, the following chapters of the draft EIS include the commitment to develop a site specific Erosion and Sediment Control Plan prior to the commencement of construction:

- Geology, Geomorphology and Soils (Volume 2, Chapter 1)
- Marine and Estuarine Water (Volume 2, Chapter 2)
- Freshwater (Volume 2, Chapter 3)
- Marine and Estuarine Ecology (Volume 2, Chapter 7)
- Commitments (Volume 5, Appendix 5)

The Erosion and Sediment Control Strategy presented in the draft Environmental Management Plan (Volume 4, Chapter 3) consolidates and summarises the commitments made as part of the draft EIS, and will be used to develop site specific management procedures after approval of the Project. Previous comments on the NOI in regard to an ESCP have not been provided to the proponent; however, the proponent understands that comments on the NOI that were received by the NT EPA were considered in development of the Project Sea Dragon Stage 1 Legume Grow-out Facility Terms of Reference for an Environmental Impact Statement.

3.13.11 Comment 11

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Terrestrial Fauna and Avifauna
Date Submission Received	25 November 2016	Submitters Reference to EIS Section (if provided)	Waterbirds - risks and mitigation

Details of the Submission

The EIS states that ceasing water release from Forsyth Dam has the effect of "delaying" the availability of waterbird habitat by 4-8 weeks and implies that this is relatively trivial. It is not clear how this figure is derived - if water is typically released in August and substantial rainfall to replenish wetlands does not reliably occur until December, then the "delay" is closer to 12-16 weeks. "Natural" environmental flows to the Forsyth Creek floodplains will also remain restricted by the Forsyth Dam, without any compensatory dry season water release.

Proponent Response

The draft EIS does not state that *"ceasing water release from Forsyth Dam has the effect of "delaying" the availability of waterbird habitat by 4-8 weeks"*. Section 4.1.2.2 of Terrestrial Fauna and Avifauna Chapter (Volume 2, Chapter 6) states that 'the effect of ceasing water flow from the annual release of Forsyth Creek Dam is a decrease in the extent of surface water for approximately 4 – 8 weeks'.

Depending on the volume released, water from the dam can inundate the floodplain for a period of 4 - 8 weeks. Analysis of aerial imagery showed that inundation of the floodplain in the 2013 dam release lasted for 4 weeks, and did not penetrate through the lower catchment, whilst the 2015 dam release inundated the floodplain for approximately 6 weeks with much greater flood extents than the 2013 event (Water Technology 2016a, Appendix 11 of the draft EIS). Consequently, the effect of ceasing the release of water from Forsyth Dam is that for 4 - 8 weeks of the dry season there would be no artificially created habitat for utilisation by waterbirds.

For example, if the dam is released on the 1st of August, water will flow across the floodplain with the flow path dependent on the location of bunds in that year. This water flow interrupts dry season conditions and inundates areas of the floodplain that would be dry under typical dry season conditions. By the end of September, water availability across the floodplain will have returned to that which is typical of dry season conditions. Hence, this is how the 4 - 8 weeks figure is derived.

3.13.12 Comment 12

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Terrestrial Fauna and Avifauna
Date Submission Received	25 November 2016	Submitters Reference to EIS Section (if provided)	Waterbirds - risks and mitigation

Details of the Submission

The Draft EIS provides only limited detail on the management of prawn predation by birds, and some trials are proposed on the use of drones or helicopters to deter predators, while minimising impacts on resident waterbirds. More explicit detail is required (drawing from literature and the proponent's experience of bird predation on other prawn farms), including information on the likely predator species, current knowledge of the distribution and abundance of these predator species in the broader Legume region (or the ability for such birds to arrive), the current options for management, and a detailed assessment of how would these options could impact on the waterbird values of the wetland. It should be noted that any future proposed "pest mitigation" of native predatory birds would require a permit under the *Territory Parks and Wildlife Conservation Act*, and it is highly desirable that other mitigation measures make this unnecessary.

Proponent Response

As part of the draft EIS a literature review was undertaken to assess the efficacy of bird deterrent methods. Subsequent to that, in response to this submission, a more detailed review has been undertaken which is provided as Appendix B (Avian Predation Submission) to this SEIS. The findings indicate that, whilst a high level overview of the feeding habits and diet of the species present at Legume might suggest that there are potentially a large number of species that could potentially feed upon the prawns, when the design features of the ponds, and the known species specific feeding behaviours are taken into account, as outlined in Table 2-1 of Appendix B, it is apparent that there is a negligible to low potential for predation impact associated with the majority of listed waterbirds. However, a comparatively higher potential for predation impact may be linked to cormorants, and also the Australasian darter.

The distribution and abundance of cormorants and Australian Darters at Legume was reported in Attachment F to Appendix 15 of the draft EIS. **Error! Reference source not found.** below provides the total numbers for each of the four species of cormorant and the Australian darter (i.e. total of the records from all sites at Legume Station) that were surveyed each month between June and November 2015. All of these species would be common in areas of inland waters across the top end.

TABLE 9 TOTAL NUMBERS OF CORMORANTS AND AUSTRALASIAN DARTER PER MONTH AT LEGUNE STATION FROM JUNE TO NOVEMBER 2015

2015	Little Pied Cormorant	Great Cormorant	Little Black Cormorant	Pied Cormorant	Australasian Darter
June	51	35	252	24	69
July	185	-	228	231	152
August	44	-	324	27	242
September	18	-	87	127	183
October	33	-	238	82	142
November	69	-	38	37	10

It is widely recognised that prawn farmers must utilise a combination of techniques, with the appropriateness of any one (or combination) of these management techniques guided by site-specific attributes associated with the proposed facility. For example, the efficacy of management techniques is influenced by the size and number of individual ponds, the proximity of facilities to known predator roosting or feeding areas or the tidal characteristics of land within the vicinity of the facility (e.g. intertidal, supratidal). Because of these complex interactions, it is often recommended that producers should first determine whether birds are actually causing economic losses in order to decide what management techniques to use and to decide whether control is economically justified (Littauer et al. 1997).

The literature reviews have identified a variety of barrier and frightening techniques to consider in relation to the management of birds at prawn farms. Techniques prescribed were generally consistent with those identified in the Environmental Code of Practice for Australian Prawn Farmers (Donovan 2001).

A summary of the results of the review for undertaken for the draft EIS is presented in the Project Description (Volume 1, Chapter 3, Section 8.1.13). Based on this analysis, three potentially successful methods, human disturbance, the use of helicopters and drones, were been further assessed in terms of potential effectiveness and impact on birds. Human disturbance (patrols on foot or in a vehicle) has been shown to be effective (Draulans 1987), and there is some evidence which suggests the use of helicopters or drones could be an effective method (Moerbeek et al. 1987; Komenda-Zehnder et al. 2003; Brann 2016), with minimal impacts to birds when implemented appropriately. The findings of the review undertaken to support this SEIS (Appendix B) confirmed that the aforementioned strategies are still relevant as potential waterbird deterrents.

A preliminary analysis of the use of helicopters for bird scaring (considered a higher impacting option compared to drones) indicates that impacts on non-target waterbirds can be reduced through the implementation of the following strategies:

- Restrict low altitude helicopter movements (i.e. <450m above ground level [AGL]) to airspace above the farm footprint will be restricted.
- When transiting between farms, constrain routes to airspace above the Project footprint.
- When transiting from the farm complex to other parts of the site, or off-site, maintain an altitude of >450m AGL and restrict movement to airspace above the Project footprint (e.g. infrastructure corridor).
- When transiting between farms or from the farm complex to other parts of the site, or off-site, operate flights procedures which minimise the incidence and duration of rotor blade slap noise.

Based on this preliminary analysis it has been determined that:

1. Birds can be managed in a way that will not impact upon the financial viability of the Project.
2. Management strategies can be undertaken in a way that will not result in a significant impact on important bird aggregations.

The proponent commits to undertake a series of experimental trials during the 2018/2019 wet season to assess responses of waterbirds to helicopters and drones within wetland habitat adjacent to the farms. A primary objective of this work will be to investigate practical flight protocols for future operations, and the potential for impact to non-target species. The proponent does not intend to directly harm native predatory birds through the implementation of the experimental trials; however, the proponent will consult with the Department regarding any permits required under the NT Territory Parks and Wildlife Conservation Act prior to their implementation

3.13.13 Comment 13

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Terrestrial Fauna and Avifauna
Date Submission Received	25 November 2016	Submitters Reference to EIS Section (if provided)	Waterbirds - risks and mitigation

Details of the Submission

The proposal to investigate the viability of establishing a 150m band of trees and shrubs as permanent screening on either side of Alligator Creek infrastructure corridor seems impractical (there's a reason why trees don't grow on floodplains), but may also have perverse outcomes if it reduces habitat quality for waterbirds. Strictly enforced speed limits and possibly restrictions on the daily timing of traffic are likely to be more effective mitigation measures.

Proponent Response

As stated in the Terrestrial Fauna and Avifauna chapter (Volume 2, Chapter 6, Section 5.4.2), in regard to works within 150 m of either Forsyth Creek or Alligator Creek the following mitigation measures will be employed:

- Initial construction operations progressing within 100 m either side of the main crossing of Alligator Creek will be subject to monitoring avifauna responses and dependent on findings, temporary noise barriers will be instated to provide acoustical shielding during the progression of construction operations.
- Maximise the retention period of existing woody vegetation (natural screening) prior to initiation of construction activities within that area.
- Develop construction schedules which minimise the period required to complete works, thus reducing the period of exposure to waterbirds within adjacent habitats.
- Design and implement temporary measures for visual buffer/screening between works areas and adjacent intertidal feeding habitat.

In addition, to further mitigate the impacts of visual disturbance to waterbirds, the proponent will investigate the viability of establishing a band of trees and shrubs along either side of the Alligator Creek infrastructure corridor extending up to 150 m either side of the crossing point. For flood immunity, the Central Services Road will be built above the floodplain, thus there may be merit in planting trees in the road verges (above the floodplain). However, as stated in the draft EIS, this mitigation measure would be thoroughly investigated and if found to be not viable, it would not be implemented.

As stated in Section 4.1.4.2 of Volume 2, Chapter 6 of the draft EIS (Terrestrial Fauna and Avifauna), the findings of various studies indicate that habituation is likely to occur if the threat (disturbance) is repetitive and non-lethal and individuals can be expected to become habituated in order to reduce fitness costs (e.g. Deniz et al. 2003; Sutherland 2007; Dwyer 2010). Vehicles and vehicle movements are thought to be tolerated much more readily than people (Hill et al. 1997), probably because disturbance from road traffic is restricted spatially and, compared to that of walkers, is relatively predictable (Klein et al. 1995; Burton et al. 2002).

Notwithstanding, the draft Fauna Management Strategy presented in Volume 4, Chapter 3 of the draft EIS (Draft Environmental Management Plan) outlines traffic mitigation measures to minimise the risk of significant impacts to fauna. These include controlling access to the site, ensuring vehicles stay on pre-determined routes, clearly signposting speed limits, and enforcing speed limits.

Whilst construction schedules will be developed which minimise the period required to complete the works, it is not feasible to restrict the daily timing of traffic. It is also not understood how this would mitigate potential impacts on waterbirds given that use of the adjacent wetlands is not known to be predictable.

3.13.14 Comment 14

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Terrestrial Fauna and Avifauna
Date Submission Received	25 November 2016	Submitters Reference to EIS Section (if provided)	Shorebirds - risks

Details of the Submission

There is some uncertainty in relation to the habitat value for shorebirds of the intertidal banks of Forsyth and Alligator Creeks. The EIS downplayed the potential value of these areas due to the low abundance of benthic invertebrates. However, there is no evidence presented to demonstrate that a low number of benthic macro-invertebrates at the sampling intensity undertaken relates to "poor habitat", and extensive comparison to other studies would be required to support this conclusion. For example, the mean abundance of benthic invertebrates in the sampling undertaken for the EIS did not appear to be significantly higher at Turtle Point, although this supports higher numbers of shorebirds (Fig 7.2 Ch 5 App 9).

Proponent Response

Considerable effort was employed to understand shorebird species, numbers and usage of the site (see both Appendix 15 and Volume 2, Chapter 6). Based on the findings of field surveys, the draft EIS concludes that the intertidal banks of Forsyth and Alligator Creek are not considered important habitat areas for shorebirds as:

- the results of both dry and wet season surveys of Forsyth and Alligator Creeks do not reveal either a high species richness or abundance of waterbirds.
- counts of individual waterbird species within the estuarine wetlands (including Forsyth and Alligator Creeks) were not considered to be significant in the context of Criterion 6 of the Ramsar Convention (the 1% population threshold) and the EPBC Act Policy 3.21 (the 0.1% population threshold).
- data from aerial count transects along Forsyth, Bob's and Alligator Creeks under high tide conditions show that no significant or notable congregations of birds (at roost) were present during the survey periods (September 2015, November 2015, and March 2016).
- results from the EIS are consistent with the findings of low counts by other surveys of relevance to the site. For example, low shorebird numbers were recorded along a 130 km section of coastline between the Ord

River and the Northern Territory border (Hassell et al. 2005 as reviewed in Rogers et al. 2011), and Chatto (2003) recorded low counts of shorebirds in the adjacent Northern Territory sections of Bonaparte Gulf.

In addition to the above findings, the draft EIS also shows that the abundance and diversity of benthic macroinvertebrates communities at targeted locations on Alligator, Forsyth and Bob's Creek were low, and likely to be limited by the high turbidity, high sediment mobility, and long exposure periods. Macroinvertebrate abundance was found to be highest at Forsyth Creek and lowest (zero) at sites on Alligator Creek. It is postulated that the reason for the low species richness and abundance of waterbirds at Alligator and Forsyth Creeks may be attributed to the existing low abundance and diversity of benthic macroinvertebrate communities. Additionally, the low species richness and abundance of waterbirds is also likely attributable to the absence of high tide roost sites.

The exception to the above was the abundance of waterbirds, particularly migratory shorebirds, recorded from the Turtle Point high tide roost area. Surveys recorded 39 waterbird species (including 21 migratory shorebirds) and an average count of 2,288 birds. Despite the relatively higher abundance and diversity of waterbirds at Turtle Point, data clearly show that the diversity and abundance of macroinvertebrates at Turtle Point are not significantly different to the other areas sampled for macroinvertebrates around Legume Station. The reason for the comparatively larger numbers of shorebirds at Turtle Point (relative to other areas around Legume Station at high tide) is the availability of high tide roost sites, which, despite concerted effort to locate them, appear to be relatively scarce around Legume Station. As stated above, data from aerial count transects along the entire length of the three larger tidal waterways (Forsyth, Bob's and Alligator Creeks) under high tide conditions showed that no significant or notable congregations of birds (at roost) were present along any of the tidal waterways during the survey periods. Additionally, despite extensive aerial searches along the Keep River (true right side), across estuarine habitats surrounding the Legume floodplain, along the north coast of Joseph Bonaparte Gulf, and along the Victoria River (true left side), no other significant aggregations of waterbirds (including shorebirds) were detected. See also the information regarding macroinvertebrates, shorebirds and Turtle Point given in response to the submission from the Department of Tourism and Culture (Arts and Museum) in Section 3.5.2.

3.13.15 Comment 15

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Terrestrial Fauna and Avifauna
Date Submission Received	25 November 2016	Submitters Reference to EIS Section (if provided)	Shorebirds - risks

Details of the Submission

Increased noise and vibration from construction activities such as pile driving may have localised impacts on cetacean species, it is not clear how long these impacts persist after construction. Some measures are described in the Draft EIS to minimise potential impacts to marine fauna, and the Flora and Fauna Division also recommend undertaking pile driving activities at low tide to minimise the sound and vibration footprint through the marine environment.

Proponent Response

The proponent notes the recommendation for no pile driving at low tide. In accordance with the response to Comment 15 from the Commonwealth Department of Environment and Energy, if marine fauna are observed within 500 m of the noise emitting source, pile driving will cease until the animal has passed.

During the Project's construction phase, only 22 piles will be immersed in water at Forsyth Creek, measured from Mean High Water Springs (MHWS). Due to the risks associated with high tidal range and currents, no floating plant will be used for pile driving. Instead, construction will occur from the shore using a launch-beam method. Shore based construction will minimise noise and vibration impacts on marine fauna, compared to a piling barge which would otherwise tend to transmit the pile driving impacts (noise and vibration) through the barge into the water. Additionally, pile driving will be into soft sediments which also minimises noise and vibration impacts, and reduces the duration of driving activity compared to driving into hard rocks. Under a worst case scenario, one pile will be driven into the sediment per day, resulting in 22 days of driving activity. The duration of each drive is expected to be approximately 2 to 3 hours. Therefore, at worst 66 hours of pile driving will occur.

Based on the above, and the mitigation measures presented in the Estuarine and Marine Ecology chapter (Volume 2, Chapter 7, Section 5.1.6), noise and vibration associated with pile driving will result in a low impact on matters of national environmental significance (MNES). This is supported by evidence collected under the Ichthys nearshore environmental monitoring program (Cardno 2015a, b) for a large scale dredging and pile driving program in the Darwin region. Monitoring results found no indication that dredging activities affected turtle distribution or population sizes (Cardno 2015a) and found relatively small changes in coastal dolphin abundance and distribution (Brooks and Pollock, 2015). These disturbances are, therefore, considered to be small, cause negligible ecological change, and be temporary in nature.

3.13.16 Comment 16

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Marine and Estuarine Ecology
Date Submission Received	25 November 2016	Submitters Reference to EIS Section (if provided)	Marine Species - Potential Impact

Details of the Submission

Increased human access to the site may result in increased recreational fishing with a potential negative impact on threatened sawfish species, as incidental bycatch and mortality is a common threat to these species. This risk could be reduced by induction material for new staff including education on how to identify and safely release sawfish.

Proponent Response

A Recreational Fishing Management Plan will be developed for the Project which will include strategies to minimise the risk to protected sawfish and river shark species posed by recreational fishing on the property. The details of the Recreational Fishing Management Plan will not be finalised until the Indigenous Land Use Agreement (ILUA) has been completed as this is expected to address matters including access and fishing rights of the Native Title Holders. However, the following measures, which are aimed at reducing the risk posed by recreational fishing to sawfish and river shark species, are expected to be included in the Recreational Fishing Management Plan:

- Recreational fishing by the general public on the property will not be permitted.
- Seafarms construction personnel will not be permitted to fish on the property. During operations the company plans to restrict access to fishing places, if not ban recreational fishing activity on the property altogether for health and safety reasons (e.g. crocodiles, uncharted waters, large tidal variations).

- In the event that some limited recreational fishing by Seafarms operations personnel is allowed, the proponent will seek advice on tackle and bait that is unlikely to be attractive to sawfish and river shark species and will require that any staff limit their gear accordingly.
- The proponent will train personnel in appropriate recognition and catch-release protocols in the event that these species are inadvertently caught.
- The proponent will work with the Native Title Holders, subject to voluntary agreement, to assist in the management of sawfish and river shark species.

Further detail regarding access and recreational fishing protocols that will be put in place as part of the Project is provided in Appendix D.

3.14 COMMONWEALTH DEPARTMENT OF ENVIRONMENT AND ENERGY

3.14.1 Comment 1

Submitter Type	Commonwealth Government	TOR Category or EIS Chapter	Project Description
Date Submission Received	28 November 2016	Submitters Reference to EIS Section (if provided)	Section 5.1, Site Establishment, Pg. 3-28

Details of the Submission

Construction will occur during the dry season when wetland habitat naturally retracts.

1. Care should be taken to minimise the clearing of mangrove habitat when construction activity occurs at the intake and outfall structures. Any innovations or solutions to minimise the area of cleared mangrove forest are encouraged so that potential impacts on this important habitat for dwarf and green sawfish (*Pristis clavata* and *Pristis zijsron*) will be minimised.

Proponent Response

The proponent agrees that care should be taken to minimise clearing of mangrove habitat. As detailed in Section 2.6 of the Project Description (Volume 1, Chapter 3, p. 8), the amount of mangrove clearance proposed has been minimised to as low as is reasonably practicable through design, which explicitly sought to avoid the intertidal zone to the greatest extent possible. Design has been such that the only two pieces of infrastructure that will impact upon mangrove communities are the intake and outfall structures. By virtue of their necessary interface with the marine environment it is impossible to locate these outside of the intertidal zone. For the intake channel, relative to the size of the mangrove habitat in Legume Station (~17,000 ha), the impact to the mangrove community is very low, being 6 hectares, which equates to 0.04 % of the extent of this community on Legume Station. For the outfall structure the impact to the mangrove community is 3 ha, which represents only 0.02 % of this community on Legume Station (see Volume 2, Chapter 5, Table 2).

3.14.2 Comment 2

Submitter Type	Commonwealth Government	TOR Category or EIS Chapter	Project Description
Date Submission Received	28 November 2016	Submitters Reference to EIS Section (if provided)	Section 8.4.1, Solid Waste Management Pg. 3-86

Details of the Submission

Farm pond and channel waste is to be used for multiple purposes in a range of environments both onsite and offsite.

2. Please characterise this waste material and describe the likely impacts to water quality in areas it may be used.

Proponent Response

Refer to Section 3.9 in Appendix F, which describes this material, and the fact that, since it will be used almost entirely within the farm water system area, and at volumes and in select areas outside of farms that will not cause pollution, that there will be no impacts to water quality from this material. The material provides for an excellent source of fertilised substrate to assist in revegetation.

3.14.3 Comment 3

Submitter Type	Commonwealth Government	TOR Category or EIS Chapter	Project Description
Date Submission Received	28 November 2016	Submitters Reference to EIS Section (if provided)	Section 2.2, Terms of Reference, Table 1

Details of the Submission

Table 1 states that 'barge landing' is a component of the proposed action. However, there is no further information provided on the construction of a barge landing or use of a barge during construction or operation.

3. Please describe the use of barges and likely impacts to MNES if they are to be used during the construction or operation of the proposed action.

Proponent Response

Barge landing has been discounted as a possible option. As detailed in Section 4.9 of Volume 1, Chapter 4 (Project Alternatives), "two transportation options were considered for the Project:

1. Barging between Legune Station and Darwin.
2. Road transportation. This would involve the upgrade of the Cave Springs Road between the boundary of Legune Station and the West Australian border to allow all weather access to the Project area.

The option of barging between Legune Station and Darwin was rejected based on:

- Navigation risks associated with the waterways surrounding Legune Station, including the highly dynamic nature of the channels, high velocity currents and large tidal variations (see Volume 5, Appendix 8).
- Costs associated with the development of port infrastructure on Legune Station and dredging that would be required to keep the waterways navigable. "

Consequently the preferred option is for road transport."

3.14.4 Comment 4

Submitter Type	Commonwealth Government	TOR Category or EIS Chapter	Water Balance
Date Submission Received	28 November 2016	Submitters Reference to EIS Section (if provided)	Section 4.3, Graphical Representation of a Steady-State Case, Figure 12

Details of the Submission

The inter-annual variability in discharge volumes into Alligator Creek is not shown.

4. Please provide a comparison of the proposed discharge volumes and velocities against the prevailing tidal conditions within Alligator Creek at the time of discharge.

Proponent Response

The inter-annual variability is shown in Figure 12 of the Water Balance chapter of the draft EIS (Volume 1, Chapter 5). The scale of Figure 12 has been revised and is presented below in Figure 7.

Modelling of the discharge has been completed using an average flow rate of 420ML/day. As seen in Figure 7, this is in excess of the 99% probability maximum volume and thus represents a conservative analysis of the potential impact of the discharge on water quality and discharge current speeds.

The inter-annual variability of the discharge will be highest during the wet season when annual rainfall totals and patterns result in the largest range of potential discharge rates. Dry season conditions are considered to be the “worst-case” scenario at Legume when the concentration of discharge will not be diluted by additional freshwater through rainfall or runoff. The variability of discharge through the dry season is low and thus inter-annual variability is not considered a major factor in the impact of the discharge on the waterways.

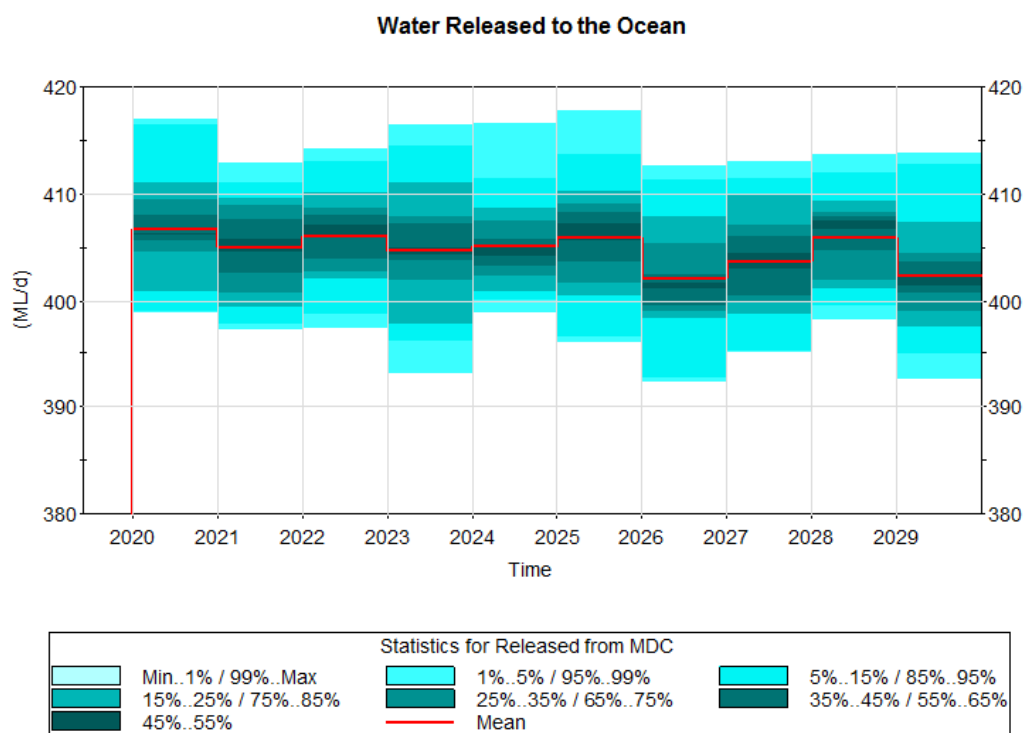


FIGURE 7 WATER RELEASED INTO ALLIGATOR CREEK (ML/DAY)

3.14.5 Comment 5

Submitter Type	Commonwealth Government	TOR Category or EIS Chapter	Water Balance
Date Submission Received	28 November 2016	Submitters Reference to EIS Section (if provided)	Section 4.4, Reliability of Freshwater Supply Pg. 5-18

Details of the Submission

Freshwater demand modelling indicates that there is a 2 per cent chance that in a five-year interval the dam volume may fall below the 10 GL threshold.

5. Contemplating this as a 'worst-case' scenario, please discuss the likely impacts of this with regard to habitat contraction for migratory birds.

Proponent Response

There are no negative implications of this for habitat contraction for migratory birds. As stated in Section 3.2.5 of the Terrestrial Fauna and Avifauna chapter (Volume 2, Chapter 6), whilst Forsyth Creek Dam supports a large area of surface water, it did not support notable numbers of waterbirds. The only exception to this was following the release of dam water in late-July 2015. After the release of dam water, significantly greater numbers of waterbirds were attracted to the dam's significantly lower water level, which resulted in greater access to resources, particularly those for piscivores. Hence the likely implication (if any) of the dam volume falling below 10 GL is an increase in access to fish for piscivorous bird species.

3.14.6 Comment 6

Submitter Type	Commonwealth Government	TOR Category or EIS Chapter	Approvals, Conditions and Agreements
Date Submission Received	28 November 2016	Submitters Reference to EIS Section (if provided)	Section 3.3, Northern Territory Policies and Guidelines, Pg 6-14

Details of the Submission

This section outlines the relevant guidelines and policies relevant to the legislation implemented by the NT EPA.

6. Please outline the relevant EPBC Act policies and guidelines relevant to the proposal.

Proponent Response

There are a number of general EPBC Act policies and guidelines relevant to the Project. These include:

- EPBC Act assessment and approval process policies
- *Environment Protection and Biodiversity Conservation Act 1999* Condition-setting Policy
- Significant impact guidelines 1.1 - Matters of National Environmental Significance
- Environmental Management Plan Guidelines

In addition there are a number of guidelines which provide guidance on specific threatened and migratory species. Guidelines relevant to the proposal include:

- EPBC Act Policy Statement 3.21 - Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species
- EPBC Act Referral guideline for the endangered northern quoll *Dasyurus hallucatus* 2016

The Department of the Environment and Energy also has developed survey guidelines which provide advice on survey techniques for specific threatened species. Fauna surveys for the Project were conducted with reference to the following survey guidelines:

- Survey Guidelines for Australia's threatened bats - 2010
- Survey Guidelines for Australia's threatened birds - 2010
- Survey Guidelines for Australia's threatened frogs - 2010
- Survey guidelines for Australia's threatened fish - 2011

■ Survey guidelines for Australia's threatened mammals - 2011

■ Survey guidelines for Australia's threatened reptiles - 2011

3.14.7 Comment 7

Submitter Type	Commonwealth Government	TOR Category or EIS Chapter	Geology, Geomorphology and Soils
Date Submission Received	28 November 2016	Submitters Reference to EIS Section (if provided)	Section 4.2.5, Soil Salinity and Sodicity, Pg. 1-35

Details of the Submission

Ponds and channels will only be lined with surface water soils. The suitability of the local topsoil for pond lining is unclear as no formal seepage analysis or permeability testing was reported and the thickness of the proposed liner is unclear.

7. Provide evidence that surface soils are impermeable to the saline water that will be utilised in ponds and channels and will safely prevent that salinization of soils and groundwater.

Proponent Response

Sections 2.1 and 3.3 in Appendix F describe the soil permeability found on the site and the geotechnical investigations, including specific permeability and seepage tests, that have been undertaken, which have demonstrated that the soils have a s a better permeability than required for these types of structures (with reference to the Queensland Guidelines for constructing and maintaining aquaculture containment structures, Department of Primary Industry and Fisheries 2007). Section 3.4 in Appendix F further discusses salinity and both why and how salinisation of soil and groundwater will be safely minimised and controlled.

3.14.8 Comment 8

Submitter Type	Commonwealth Government	TOR Category or EIS Chapter	Freshwater
Date Submission Received	28 November 2016	Submitters Reference to EIS Section (if provided)	Section 4.1.1, Changes in Floodplain Hydrology - Flood Events, Pg. 3-27

Details of the Submission

In rainfall events greater than a 50 year ARI, the capacity of swales may be exceeded, resulting in the uncontrolled release of pond water into biosecurity zones to be discharged into the tidal floodplain.

8. Please describe the likely impacts of an unplanned release.

Proponent Response

Section 4.1.1.3 of the draft EIS, Volume 2, Chapter 3 (Freshwater) states that under *"extreme rainfall events (> 50 year ARI), the capacity of the swales may be exceeded, resulting in an uncontrolled release of water into the bio-security zones between farm 1 and farm 2. The excess water would then be channelled along the biosecurity zone and discharged to the tidal floodplain through a culvert under the main discharge channel (MDC)."*

Section 4.2.1.3 provides an assessment of this release, stating that inundation extent is limited and depths are shallow, with ponding within the floodplain providing for minimal effects to tidal creeks (which would regardless be affected by the same rainfall event from other catchment areas). The section states *"This*

inundation extent is considered insignificant when compared to the likely flooding conditions during a rainfall event that would cause this degree of overtopping."

In terms of water quality impacts, any overflow from the ponds would be in a diluted form (fresher rainfall sourced water overlying more saline waters being released by decanting through the spillway), and mixing in a flood affected catchment to become further diluted. Given the already saline nature of soils and groundwater in this area during dry season conditions, and the predominant freshwater inputs from the >50 year average recurrence interval (ARI) storm itself, no impacts are anticipated for this type of relatively short duration event.

3.14.9 Comment 9

Submitter Type	Commonwealth Government	TOR Category or EIS Chapter	Freshwater
Date Submission Received	28 November 2016	Submitters Reference to EIS Section (if provided)	Section 4.2.1.2, Cessation of Forsyth Creek Dam Release, Pg. 3-31

Details of the Submission

The Department also considers that reduced groundwater recharge may occur as a result of the cessation of the Forsyth Dam release.

9. Please discuss the likely impacts to MNES as a result of reduced groundwater recharge.

Proponent Response

Volume 2, Chapter 4, Section 3.3 of the draft EIS (Groundwater) outlines the recharge zones identified in the Project Area. Within Legume Station, the major recharge zones are the porous soils associated with the ranges and the coastal erosional plain, with less widespread recharge through streams whose flow is connected to localised or more widespread aquifers, and minor recharge occurring around small residuals located on the estuarine-deltaic plain. Overland flow is also identified in the draft EIS, though this is more correctly indicated in the above types.

As shown in Figure 10 in Volume 2, Chapter 3 of the draft EIS (Freshwater), and with reference to the major landforms in Figure 4 in Volume 2, Chapter 1 (Geology, Geomorphology and Soils), the dam release is constrained entirely to the estuarine-deltaic ('black soil') plains, with little opportunity for widespread infiltration through the low permeability clay soils, and providing a 'very limited' contribution to groundwater recharge. Section 3.3.3 in Volume 2, Chapter 4 discusses the rapid closing of surface cracks in these soils leading to impervious conditions.

Other than spillover onto the estuarine-deltaic plains, dam releases more generally follow the Forsyth and Alligator Creeks. Section 3.3.2 in Volume 2, Chapter 4 discusses that creek recharge zones are unlikely to provide any significant recharge to groundwater, with small localised recharge at best in some locations.

Recharge from small residuals and rises will be unaffected, as these are rainfall sourced (infiltrating the top of the rises) and not sourced from any overland flow.

Overall, given the above, and that the flow path of the release of the dam does not coincide with any large area of groundwater recharge, it is considered highly unlikely that ceasing the dam release will significantly reduce groundwater recharge.

It has also been described within the draft EIS (Section 3.8, Volume 2, Chapter 5, Terrestrial Flora) that there are no obligate groundwater dependent ecosystems on Legume Station. There are some communities that may

have a facultative dependence on groundwater (i.e. they make use of, but do not rely upon, groundwater). However, none of these communities provide important habitat for any of the EPBC Act listed fauna species that occur on the property.

3.14.10 Comment 10

Submitter Type	Commonwealth Government	TOR Category or EIS Chapter	Freshwater
Date Submission Received	28 November 2016	Submitters Reference to EIS Section (if provided)	Section 4.2.1.2, Cessation of Forsyth Creek Dam Release, Pg. 3-31

Details of the Submission

Shorebirds recorded foraging in Alligator Creek would be utilising tidal areas and as such the impacts of ceasing the release of freshwater from Forsyth Creek Dam are unlikely to impact these species. It is also noted that glossy ibis (*Pegadis falcinellus*; EPBC Act listed migratory) were recorded in high numbers. This species is nomadic, following seasonally inundated wetlands for breeding and foraging.

10. It is recommended that further long-term monitoring of the site is undertaken to assess whether there is a downward trend in bird numbers or spatial variation in habitat use as a result of the proposed action. If modelled impacts are exceeded, revision of management measures is required to avoid ongoing impacts on birds and habitat use.

Proponent Response

In consultation with the Commonwealth and Northern Territory Governments the proponent has prepared a framework for the development of a waterbird monitoring program. The framework is provided in Appendix A. The monitoring program will be based on an adaptive management approach.

3.14.11 Comment 11

Submitter Type	Commonwealth Government	TOR Category or EIS Chapter	Freshwater
Date Submission Received	28 November 2016	Submitters Reference to EIS Section (if provided)	Section 4.2.1.2, Cessation of Forsyth Creek Dam Release, Pg. 3-31

Details of the Submission

The cessation of the Forsyth Dam release will lead to a 'return to natural dry season conditions' in the Forsyth and Alligator Creek catchments. It is unclear what 'natural dry season conditions' are for the Forsyth Creek and Alligator Creek catchments given that natural flows are impeded by the dam.

11. Please describe the predicted changes to wetlands and waterholes in these catchments once dry season releases are suspended and likely impacts to sawfish species, which are known to move onto inundated floodplains during the wet season and use waterholes as refuges during the dry season. Please note, it is considered that dry season refuge habitat may be lost as a result of the proposed action, which may impact on sawfish individuals occurring in floodplains of upper Forsyth Creek and upper Alligator Creek which receive water from the Forsyth Dam.

Proponent Response

Section 4.2.1.2 of the Freshwater chapter (Volume 2, Chapter 3) does not state that *"the cessation of Forsyth Dam release will lead to a 'return to natural dry season conditions' in the Forsyth and Alligator Creek catchments"*. It states that 'in regards to dry season conditions, the effects of ceasing water flow from the annual release of Forsyth Creek Dam is a decrease in the extent of surface water for approximately 4 to 8 weeks'. There are no natural dry season conditions on this site, given the floodplain hydrological conditions of both the Forsyth Creek and Alligator Creek catchments have been substantially modified over time as part of the pastoral operations, including installation of roads that act as bunds between paddocks, and bunding to limit the extent of tidal movement in both creeks, as well as the construction of Forsyth Creek Dam and the annual use of freshwater to improve pastures.

Current dry season conditions vary from year to year depending on environmental and land management factors including the amount of rain from the preceding wet season, how much water is released from the dam, the timing of the release of water and the direction in which water is forced to flow. The variation in wet season conditions affects wetlands and waterholes across the site in the dry season. .

Unlike other sawfish that may be found in the vicinity of the proposed works that are predominantly found in estuarine and marine waters for their entire life cycle, juvenile largemouth sawfish (*Pristis pristis*) are also found in freshwater habitats. That is, largemouth sawfish have an ontogenetic shift in habitat use with neonates and juveniles primarily occurring in the freshwater reaches of rivers and floodplain lagoons, and adults found in marine and estuarine environments (Peverell 2008). Dry season refugial waterholes are important habitat for young (P. Kyne pers. comm. Charles Darwin University/NESP Marine Biodiversity Hub).

The likely impact of ceasing dam releases in the late dry season on sawfish is summarised below for the Alligator and Forsyth Creek systems. Geographical nomenclature is as presented in Appendix 15 and Appendix 12 of the draft EIS.

Alligator Creek System

During the dry season, the bunds at Points C and D on Alligator Creek (see Figure 6) are higher than the water level, preventing upstream movement of sawfish in this season. During peak flows in the wet season water may overtop these bunds and juvenile sawfish may move upstream; however, they are not overtopped every year. Dam releases did not overtop these bunds in either 2015 or 2016. That is, the only opportunity for juvenile sawfish to move upstream of Point C is during peak flows in some wet seasons, when water velocities are likely to be high. Crocodile Crossing provides another barrier to the upstream movement of juvenile sawfish. However, during some dam releases, this bund is broken and water is released downstream to Point C. This release may provide an opportunity for any juvenile sawfish (if present) in the creek to move further upstream. Bunds around Maidens and Red Rock paddocks would also inhibit movement of largemouth sawfish upstream except in flood conditions, or if they are deliberately breached by the site managers.

During the 2016 dam release water was held in Maidens and Red Rock Paddocks (see Figure 6), and consequently conditions downstream of Crocodile Crossing essentially reflected pre-dam dry season conditions (pers obs. L. Agnew 2016). During this time there was water between Crocodile Crossing and Point C, and if any juvenile sawfish were in this area they would have had access to dry season refugial aquatic habitat.

Similarly, water persisted in the vicinity of AC7 (Figure 6) providing a potential dry season refugial habitat, however the upstream area around AC8 contracted significantly, resulting in a relatively narrow, shallow channel (approximately 5-40 m in width) (pers obs. L. Agnew 2016). As a result of the cessation of any dam releases, it is expected that, upstream of Crocodile Crossing the area around AC7 will support a continuous section of water in the channel, with a series of isolated small pools persisting near AC8 (pers obs. L. Agnew

2016). That is, in the absence of any releases from the dam, there would still be a significant area of dry season refugial habitat in this area. The fact that water remains in the lower sections of Alligator Creek is explained is shown in Figures 7-9 of Volume 2, Chapter 3 of the draft EIS, which shows aerial imagery of the site from 2002 to 2005, prior to the dam construction. These figures demonstrate that water did remain throughout the lower section of Alligator Creek and associated wetlands throughout the dry prior to the advent of the dam releases in the dry season.

Existing bunds around Maidens Paddock, and between Red Rock and Spring Paddocks would currently prevent the movement of sawfish downstream as these areas dry out.

Cessation of the dry season dam release to the Alligator Creek system is not expected to have a significant impact on sawfish as:

- it would be a rare event for sawfish to be able to navigate the instream barriers to areas that are inundated by the dam release
- even without input of water from the Dam release, there are substantial areas of freshwater between Point C and Crocodile Crossing, and in Red Rock Paddock that would provide dry season refugial habitat.

Forsyth Creek System

On Forsyth Creek there is a road crossing at Site F14 (see Figure 8), which acts as a tidal barrier (approximately 2 m above the water level), water pools upstream of this barrier in the dry season. While juvenile sawfish may be able to cross this barrier during peak wet season flood events, it is unlikely a dam release during the dry season would provide sufficient water. The track between Stoney Knob and Sweetwater Paddocks also forms a barrier to fish passage.

Upstream of the road crossing at site F14 the flood plain largely dries out prior to the dam release, and there is little refugial habitat. The catchment is heavily used for cattle grazing, and water quality in the very few remaining water bodies is likely to be extremely poor.

That is, cessation of the dry season dam release to the Forsyth Creek system is not anticipated to have a significant impact on sawfish as:

- it would be a rare event for sawfish to be able to navigate the instream barriers into the upstream areas
- the area of water immediately above the road crossing at site F14 is likely to remain in the dry season, even without input from the dam release and
- prior to the dam release each year, there are very few areas that provide suitable habitat in the upstream sections of Forsyth Creek (i.e. in Sweetwater and Billions paddocks).



FIGURE 8 FRESHWATER SURVEY SITES

3.14.12 Comment 12

Submitter Type	Commonwealth Government	TOR Category or EIS Chapter	Marine and Estuarine Ecology
Date Submission Received	28 November 2016	Submitters Reference to EIS Section (if provided)	Section 4.1.7, Spread of Diseases and/or Pathogens, Pg. 7-34

Details of the Submission

In the case of a disease being identified, steps will be taken to contain the disease to the pond(s) in which it has been identified, which will prevent any water being released from the ponds.

12. Please describe how contaminated water will be disposed of in the case of a disease outbreak.

Proponent Response

This response also relates to the following submissions:

- Section 0 Comment 2 from the Northern Land Council
- Section 0 Comment 7 from the Northern Land Council
- Section 3.19.47 Comment 47 from the Northern Territory EPA

The matter of the risk of disease incursion and subsequent management has been discussed with the Northern Territory Department of Primary Industries and Resources. The Department of Environment and Energy should be aware that there is a series of statutes and nationally agreed protocols that enter into force in such an event. The NT *Fisheries Act* and Regulations would be the primary instrument used to guide actions in the event of an outbreak. Under this Act it is the responsibility of the operator in the first instance to notify the relevant authorities. In the case of the grow-out ponds at Legume Station the relevant authority is the Department of Primary Industries and Resources. The Emergency Response Investigation Protocol for Aquatic Animal Pests and Disease is implemented by the Department of Primary Industries and Resources as a first stage of any response.

The Northern Territory Government is a signatory to the Intergovernmental Agreement on Biosecurity, under which nationally agreed approaches are established and all jurisdictions have roles and responsibilities. The *Commonwealth Biosecurity Act 2016* commenced in June 2016 as the primary piece of national biosecurity legislation. It is co-administered by the Ministers responsible for Agriculture and Water Resources and Health.

As already noted, in the event that a notifiable disease is confirmed the proponent is required to contact the authorities. In practice however, it is most likely that the authorities will have already been notified as they may have been included in verifying the pathogen, since typically government laboratories and agencies participate in the investigative phase.

In terms of disposal of contaminated water the short direct response to the Department's question is that the water will likely no longer be contaminated because it will have been treated to the satisfaction of authorities prior to release. The proponent notes that there is sufficient capacity engineered within the system to manage the holding of water.

There is a range of possibilities in relation to management of disease with an extraordinary number of variables to consider in order to inform evidence-based management of an outbreak. Such variables include (but are not limited to):

- the pathogen (e.g. whether exotic or endemic, whether viral, bacterial or fungal)
- the extent of the infection (e.g. number of ponds displaying signs of stress)
- how the pathogen was vectored into the facility (e.g. workers, recreational fishers, intake water from the environment, crabs, birds)
- the virulence of the infection
- the displayed symptoms
- the age/phase of the crop (e.g. treatment may be different immediately after stocking compared with a near harvestable crop) and
- environmental circumstances and context (e.g. outbreaks in the region etc).

Given the above, it is essential to respect and recognise Australia's well developed biosecurity framework which includes, legislation and the operation of the Aquavet Plan (see: <http://www.agriculture.gov.au/animal/aquatic/aquavetplan>) and a raft of other measures that include changes to translocation permits and the activation of expert groups. For example it may be deemed necessary to activate the Consultative Committee on Emergency Animal Disease (CCEAD) (see: <http://www.agriculture.gov.au/animal/health/committees/ccead>) under the intergovernmental Emergency Animal Disease Response Agreement (see: <https://www.animalhealthaustralia.com.au/what-we-do/emergency-animal-disease/ead-response-agreement/>).

In the event that in-situ full pond sterilisation were required it is likely that a number of options would be considered in terms of chemical treatment. These include: chlorine, trichlorfon, hydrogen peroxide and hydrated lime (the latter to be used on the pond floor).

In terms of potential disposal of mortalities it is incorrect to assume that up to 5,000 tonnes would need to be destroyed as stated in Section 0 Comment 7 from the Northern Land Council. That estimate assumes maximum biomass in every pond across the entire facility. This is inconsistent with continuous operations and implies a single in-out batch operation across the entire facility.

The range in standing stock at full operation is estimated to be 1,700 to 4,000 tonnes. However, a typical range in standing biomass is 2,700 to 2,800 tonnes, assuming that the same number of ponds are stocked each week and thus reach terminal biomass each week, and each farm is stocked over about 10 weeks. If 4,000 tonnes were considered the worst case case it should be noted that this in itself represents a series of extraordinary conditional probabilities that: (i) biosecurity surveillance has failed, (ii) the infection has not been able to be contained to either a single or limited number of ponds, (iii) or to one farm, (iv) all farms are stocked to achieve maximum standing stock and the crops are at the maximum biomass within the crop cycle, (v) the infection and symptoms appear instantaneously.

The principle of 'Maximum Reasonable Adversity' which is the loss after all reasonable and planned practices are implemented should be applied. In addition to being focussed on preventative measures, the reactive biosecurity protocols focus on isolation and containment so that the requirement for terminal harvest due to disease becomes limited, it is very unlikely that all ponds in the facility would be affected. Given the nature of on farm responses to a biosecurity event, a more realistic scenario of loss for a single farm of 40 ponds is 525 tonnes as outlined below:

- The index pond (1 pond) results in 100% loss = 50 tonnes

- Secondary ponds (8 ponds) results in 50% loss = 200 tonnes
- Tertiary ponds (16 ponds) results in 25% loss = 200 tonnes
- Remaining farm ponds (15 ponds) results in 10% loss = 75 tonnes

Thus, for contingency planning less than 1,500 tonnes is more realistic than a theoretical maximum.

As requested by the NT EPA (see Section 3.19.47, Comment 47) that the proponent identify 'potential sites and pathways for the appropriate disposal of major quantities of prawn carcasses that reflect common risk and operational practices to the industry' the proponent notes that subject to the caveats already, the four more plausible scenarios are:

- (i) As a result of holding the pond water and disinfection the in-pond mortalities have rotted out and 'mass disposal' is not needed.
- (ii) Disinfected water is released, mortalities are retained in the pond and decompose in-situ or are ploughed-in, with subsequent treatment to sterilise the pond floor (noting that treatment may be as benign as extended dry-out or may include treatment with lime).
- (iii) Mortalities are 'harvested' and are buried within a trench or pit on site and treated with hydrated lime, as required.
- (iv) Incineration - this may be an option but does not fall within the criterion of common operational practices.

3.14.13 Comment 13

Submitter Type	Commonwealth Government	TOR Category or EIS Chapter	Marine and Estuarine Ecology
Date Submission Received	28 November 2016	Submitters Reference to EIS Section (if provided)	Section 4.1.9, Increased Light, Pg. 7-35

Details of the Submission

Increased illumination has the potential to impact nesting turtles and hatchlings.

13. It is noted that the proposed action area is a significant distance from known turtle resting areas. However, please describe the design and level of lighting that will be used on-site and the expected distance that light glow could be visible.

Proponent Response

The Environmental Assessment Guideline for Protecting Marine Turtles from Light Impacts (Environmental Protection Authority [EPA] 2010) state that the first step to protecting marine turtles from light impacts is 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 minimum distance between the northern beaches of Turtle Point and the Project infrastructure, is approximately 24 km. The area between the Project and the turtle nesting beach consists of samphire forbland and mangrove low closed forest. Thus natural mangrove vegetation between these two points is likely to shield the nesting beach light at turtle eye level.

In addition to distance, the proponent commits to minimise the use of lights to only essential purposes. Only low intensity lighting will be required for the Project to satisfy occupational health and safety purposes. In accordance with the guideline (EPA 2010) the proponent will, *inter alia*:

- use the minimum number of lights required

- design light fixtures that are mounted low down, shielded and aligned to direct light onto the target area only
- turn lights on only when they are needed
- reduce the wattage and brightness of individual light as low as possible
- use light emitting diodes (LEDs) for lighting wherever possible
- reduce directivity by avoiding intense lights or clusters of lights
- use long wavelength (550-700 nanometres, orange to red) lights wherever possible
- use amber filters on high pressure sodium lights if their use cannot be avoided.

Research investigating the impact of light pollution on the sea-finding behaviour of flatback turtle hatchlings found that the sea-finding behaviour of hatchlings on Peak Island was unaffected by lighting associated with urban and tourist development approximately 13 km away in Keppel Bay (Kamrowski et al. 2014). Researchers found that very little light was visible on Peak Island, and the hatchlings were orientating correctly to the sea.

The same study also investigated the impact of light pollution on the sea-finding behaviour of flatback turtle hatchlings located on Curtis Island approximately 15 km from the heavily industrialised Port Curtis area in Queensland. In contrast to the Peak Island study, this research concluded that light levels were significantly brighter than light levels observed at Peak Island, and that the sea-finding ability of hatchlings on Curtis Island was moderately impaired by light pollution associated with the nearby industrial development (Kamrowski et al. 2014).

Lighting associated with the Project is considered to be commensurate with the lighting at Keppel Bay which is associated with urban and tourist developments. This lighting has been found to not be visible approximately 13 km away at the turtle nesting beach on Peak Island. Industrial lighting (for example, lighting associated with an aluminium refinery and smelter, or a power station) such as those located within the Port Curtis region, is simply not required for a project of this nature.

Therefore, given the type of lighting proposed to be utilised, and the significant distance between the Project and the nesting beach on Turtle Island (a minimum distance of 24 km), the proponent concludes that it is highly unlikely that light glow from the proposed development will be visible to the extent that it would have a significant impact on the sea-finding ability of the hatchlings.

3.14.14 Comment 14

Submitter Type	Commonwealth Government	TOR Category or EIS Chapter	Marine and Estuarine Ecology
Date Submission Received	28 November 2016	Submitters Reference to EIS Section (if provided)	Section 4.2.1 Listed Threatened Species under the EPBC Act and/or TPWC Act, Table 11

Details of the Submission

The draft EIS states that the largetooth sawfish is unlikely to occur in the vicinity of the seawater intake at Forsyth Creek and the discharge point at Alligator Creek as 'freshwater sawfish occur in rivers and upper estuarine areas'.

14. This statement is unfounded as the species is not limited to upper estuaries or the upper reaches of rivers and has been recorded in habitat similar to that within the proposed action area. Please provide an assessment of impacts on the largemouth sawfish, taking the above information into consideration.

Proponent Response

Pups of the largemouth sawfish (which are likely to be most sensitive to the proposed action) are thought to occur in freshwater reaches of rivers and upper estuaries and are unlikely to be common near the intake and discharge. Adults are found in marine and estuarine environments and may occur near the intake and discharge. The proponent acknowledges that this distinction between adults, and the more 'at risk' juveniles, should have been made clearer in the draft EIS.

Individuals have been recorded in rivers up to 400 km inland and in waters up to 100 km offshore, although they generally inhabit sandy or muddy bottoms of shallow coastal waters, estuaries and river mouths, as well as the central and upper reaches of freshwater rivers and isolated waterholes (Peverell 2009). Largemouth sawfish are thought to pup in the estuary in the wet season with young moving upstream. Dry season refugia waterholes are important habitat for young (P. Kyne pers. comm. Charles Darwin University/NESP Marine Biodiversity Hub). Largemouth sawfish have an ontogenetic shift in habitat use with neonates and juveniles primarily occurring in the freshwater reaches of rivers and estuaries and adults being found in marine and estuarine environments (Peverell 2008). Largemouth sawfish are mainly bottom feeders, consuming slow-moving shoaling fish, which are stunned by sideswipes of the snout, and molluscs and crustaceans that are swept out of the mud by the saw.

The presence of both adults and pups near the discharge and intake is assumed as a precautionary approach - , recognising that this is likely a 'worst case scenario' because, as mentioned above, juveniles are thought to primarily occur in freshwater reaches of rivers and upper estuaries - and the revised significant impact assessment for *Pristis pristis* is outlined below in Table 10. Based on this analysis, no significant impact is predicted.

TABLE 10 SIGNIFICANT IMPACT ASSESSMENT - LARGETOOTH SAWFISH

An action is likely to have a significant impact if there is a real chance or possibility that it will:	Analysis and conclusions
Lead to a long-term decrease in the size of an important population of a species	Largetooth sawfish may occur in the vicinity of the intake and discharge, and may also use the floodplain. The discharge of wastewater into Alligator Creek is unlikely to impact largetooth sawfish if they were to occur there. Given median concentrations of chlorophyll a and nutrients in the receiving environment will be below the proposed interim site-specific trigger values (i.e. 80 percentile of background concentrations) outside the immediate mixing zone (approximately 200 m), the discharge is likely to have minimal impact on the aquatic ecology in general, or sawfish in particular. Impacts are likely to be largely confined to the mixing zone, which represents a relatively small area of Alligator Creek. However, there may be a slight increase in food (fish) availability. The intake is unlikely to cause the impingement or entrainment of largetooth sawfish. The location of the intake structure is naturally subject to strong tidal currents. Spring tide current speeds within the southern channel in the vicinity of the intake are in the order of 1.75 – 2.0 m/s during the peak ebb tide and 0.13 – 0.16 m/s during the peak flood tide (Water Technology 2016b). As such, resident and transient fish (including sawfish pups that are approximately 72 to 91 cm at birth) are likely to be able to negotiate these currents and therefore have a low likelihood of entrapment or impingement. Given the proposed mitigation measures, there is unlikely to be any long-term decrease in the size of the population from the proposed Project due to the intake or discharge. Largetooth sawfish juveniles and pups potentially may also use the floodplain associated with Alligator and Forsyth Creeks, and could potentially be impacted by the cessation of the dry season dam release. Reduction or cessation of the dry season dam release is unlikely to have a significant impact on sawfish as: ■ few sawfish are likely to navigate the instream barriers into the upstream areas ■ in Alligator Creek, even without input of water from the dam release, there is a substantial area of water between Point C and Crocodile Crossing that any sawfish could continue to use ■ the area of water immediately above the downstream road crossing in Forsyth Creek is likely to remain in the dry season, even without input from the dam release ■ prior to the dam release each year, there are very few areas that provide suitable habitat in the upstream sections of Forsyth Creek (i.e. in Sweetwater and Billions paddocks).

An action is likely to have a significant impact if there is a real chance or possibility that it will:	Analysis and conclusions
	That is, inundation by the release of dam water may create some drought refugia for largemouth sawfish pups and juveniles. However, access to them is limited due to the existing barriers, and even without the dam release there will still be substantial areas that could be used as drought refugia. Consequently, cessation of the dam release is not likely to lead to a long term decrease in the size of an important population of this species.
Reduce the area of occupancy of an important population	There will be a small area of estuarine habitat lost under the Project footprint, which is not expected to impact the area of occupancy of this species. While cessation of the dam release may reduce the availability of drought refugia for sawfish juveniles and pups, existing barriers to fish passage are likely to have significantly reduced access to these areas, there will still be substantial areas that could be used as drought refugia (see Section 3.14.11). Other indirect impacts are unlikely to reduce the area of occupancy for this species, such as changes to water quality, changes to water velocity, noise or light.
Fragment an existing important population into two or more populations	The proposed Project will not fragment populations into two or more populations.
Adversely affect habitat critical to the survival of a species	All areas where aggregations of individuals have been recorded displaying biologically important behaviour such as breeding, foraging, resting or migrating, are considered critical to the survival of the species unless population survey data suggests otherwise. The area potentially impacted by the Project is unlikely to be habitat critical to the survival of this species given their circumtropical distribution and large areas of similar, suitable habitat in waterways around the Project site.
Disrupt the breeding cycle of an important population	Pupping (around 12 pups) is likely to occur in less saline waters late in the wet season and outside the area of impact of the intake and discharge. Construction of the intake and outfall structures is not proposed to take place in the wet season: hence only potential impacts during operation may occur in the breeding season. Further, pups (approximately 72-91 cm) are likely to be able to swim against the velocity of the intake. Therefore, given the proposed mitigation measures, there will be no disruption to the breeding cycle of the population.
Modify, destroy, remove, isolate or decrease the	The Project is not predicted to modify, destroy, remove, isolate or decrease the availability or quality of habitat to the

An action is likely to have a significant impact if there is a real chance or possibility that it will:	Analysis and conclusions
availability or quality of habitat to the extent that the species is likely to decline	extent that the species will decline.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat	Given the proposed mitigation measures, there are no marine or freshwater invasive species predicted to be introduced from the proposed Project.
Introduce disease that may cause the species to decline	Given the proposed mitigation measures, potential impacts associated with the introduction or spread of diseases is considered to be of low risk to largetooth sawfish.
Interfere with the recovery of the species	The objectives of the sawfish recovery plan are to reduce (and where possible eliminate) adverse impacts of commercial, recreational, indigenous and IUU fishing; marine debris; collection for public aquaria as well as improve the information base, develop research programs and improve community understanding of this species (Commonwealth of Australia 2015). The proposed Project will not interfere with the recovery of sawfish outlined in the recovery plan.

3.14.15 Comment 15

Submitter Type	Commonwealth Government	TOR Category or EIS Chapter	Marine and Estuarine Ecology
Date Submission Received	28 November 2016	Submitters Reference to EIS Section (if provided)	Section 5.1.6, Increased Noise, Pg. 7-56

Details of the Submission

The proponent states that if, after works have commenced, marine fauna are observed within 100 m of the noise emitting source, pile driving will cease until the animal has passed.

15. Please provide evidence and justification for this distance as a mitigation measure to assist in the assessment of whether 100 m is a sufficient distance to mitigate impacts. Alternatively, in accordance with previous EPBC approvals with potential impacts to a similar suite of marine megafauna, a 500 m exclusion zone should be established.

Proponent Response

The proponent commits to establishing a 500 m exclusion zone. Should an animal be observed within 500 m of the noise emitting source, pile driving will cease until the animal has passed.

3.14.16 Comment 16

Submitter Type	Commonwealth Government	TOR Category or EIS Chapter	Marine and Estuarine Ecology
Date Submission Received	28 November 2016	Submitters Reference to EIS Section (if provided)	Section 5.1.8, Increased Access, Pg. 7-57

Details of the Submission

The proponent states that visitor access to the proposed action area will be managed. It is noted that there will be a large construction population present for up to two years and both construction and operation workers may want to participate in recreational activities such as fishing.

16. Please discuss potential impacts resulting from recreational activities and any relevant mitigation measures. This should include the management of access to all important roosting and foraging areas for shorebirds.

Proponent Response

As described in Section 4.2 of the Amenity chapter of the draft EIS (Volume 3, Chapter 5), Legume Station is currently frequented by recreational visitors who come to camp, hunt and fish on the property. Potential impacts from these recreational activities include overfishing and the dumping of rubbish.

Measures will be put in place as part of the Project to restrict access and recreational fishing by unauthorised third parties on the property. An Access and Recreational Fishing Policy has been prepared to consolidate and clarify the access and recreational fishing protocols that were proposed as part of the draft EIS for the Project and is included as Appendix D.

In addition, further clarification is provided in Appendix D regarding Seafarms personnel participating in recreational fishing activities onsite. It is anticipated that the following protocols will apply to Seafarms personnel:

- Construction personnel will not be permitted to fish on the property.

- During operations the company will restrict access to fishing places, if not ban recreational fishing activity on the property altogether for health and safety reasons (e.g. crocodiles, uncharted waters, large tidal variations).

Fishing by the Native Title Holders on the property is being negotiated as part of the ILUA.

These protocols will be formalised in a Recreational Fishing Management Plan which will be developed for the Project. The details of the Recreational Fishing Management Plan however will not be finalised until the ILUA has been completed, which is expected to address matters including access and fishing rights of the Native Title Holders.

Consequently, impacts from recreational activities are likely to reduce as a result of the Project as the current informal arrangements are replaced by a more formal management regime. Furthermore, there will be no impact on important roosting and foraging areas for shorebirds as these areas are far removed from the Project site and difficult to access. The shorebird roost site at Turtle Point on Turtle Point is 25 km as the crow flies from the nearest part of the Project footprint and, as it is an island, is only accessible by boat or helicopter. As such no recreational activities, fishing or otherwise, are likely to occur in these areas.

3.14.17 Comment 17

Submitter Type	Commonwealth Government	TOR Category or EIS Chapter	Marine and Estuarine Ecology
Date Submission Received	28 November 2016	Submitters Reference to EIS Section (if provided)	Section 5.1.8, Increased Access, Pg. 7-57

Details of the Submission

The proponent states that visitor access to the proposed action area will be managed. It is noted that there will be a large construction population present for up to two years and both construction and operation workers may want to participate in recreational activities such as fishing.

17. Recreational fishing may increase the risk of capture of sawfish and river shark species. Please provide details of any relevant mitigation measures, which may include educational materials and signage on the property about the protected status of the sawfish and river shark species or prohibiting recreational fishing.

Proponent Response

As described in the response to the previous comment (Comment 16, Section 3.14.16) and in the Access and Recreational Fishing Policy (Appendix D), recreational fishing on Legume Station by unauthorised third parties and Project Sea Dragon employees will be restricted. Fishing by the Native Title Holders is being negotiated as part of the Indigenous Land Use Agreement (ILUA).

A Recreational Fishing Management Plan will be developed for the Project to formalise these arrangements and detail strategies to minimise the risk to protected sawfish and river shark species posed by recreational fishing on the property. The details of the Recreational Fishing Management Plan will not be finalised until the ILUA has been completed as this is expected to address matters including access and fishing rights of the Native Title Holders. However, the following measures which are aimed at reducing the risk posed by recreational fishing to sawfish and river shark species, are expected to be included in the Recreational Fishing Management Plan:

- Recreational fishing by the general public on the property will not be permitted.

- Seafarms construction personnel will not be permitted to fish on the property. During operations the company plans to restrict access to fishing places, if not ban recreational fishing activity on the property altogether for health and safety reasons (e.g. crocodiles, uncharted waters, large tidal variations).
- In the event that some limited recreational fishing by Seafarms operations personnel is allowed, the proponent will seek advice on tackle and bait that is unlikely to be attractive to sawfish and river shark species and will require that any staff limit their gear accordingly.
- The proponent will train personnel in appropriate recognition and catch-release protocols in the event that these species are inadvertently caught.
- The proponent will work with the Native Title Holders, subject to voluntary agreement, to assist in the management of sawfish and river shark species.

3.14.18 Comment 18

Submitter Type	Commonwealth Government	TOR Category or EIS Chapter	Noise and Vibration
Date Submission Received	28 November 2016	Submitters Reference to EIS Section (if provided)	Section 3.2, Noise Emissions Inventory, Table 3

Details of the Submission

Table 3 states that noise levels associated with pile driving can be recorded at 133 dBA. However, pile driving is not mentioned again in this chapter and the noise contour figures (Figures 2-4) do not show any values greater than 80 dBA.

18. Please provide additional information on the noise impacts of piling on MNES, including noise modelling that will inform caution and shutdown zones if required.

Proponent Response

In accordance with the response to Comment 15 from the Commonwealth Department of Environment and Energy (see Section 3.14.15), if marine fauna are observed within 500 m of the noise emitting source, pile driving will cease until the animal has passed.

During the Project's construction phase, only 22 piles will be immersed in water at Forsyth Creek, measured from Mean High Water Springs (MHWS). Due to the risks associated with high tidal range and currents, no floating plant will be used for pile driving. Instead, construction will occur from the shore using a launch-beam method. Shore based construction will minimise noise and vibration impacts on marine fauna, compared to a piling barge which would otherwise tend to transmit the pile driving impacts (noise and vibration) through the barge into the water. Additionally, pile driving will be into soft sediments which also minimises noise and vibration impacts, and reduces the duration of driving activity compared to driving into hard rocks. Under a worst case scenario, one pile will be driven into the sediment per day, resulting in 22 days of driving activity. The duration of each drive is expected to be approximately 2 to 3 hours. Therefore, at worst, 66 hours of pile driving will occur.

Based on the above, and the mitigation measures presented in the Estuarine and Marine Ecology chapter (Volume 2, Chapter 7, Section 5.1.6), noise and vibration associated with pile driving will result in a low impact on matters of national environmental significance (MNES). This is supported by evidence collected under the Ichthys nearshore environmental monitoring program (Cardno 2015a, b) for a large scale dredging and pile driving program in the Darwin region. Monitoring results found no indication that dredging activities affected

turtle distribution or population sizes (Cardno 2015a) and found relatively small changes in coastal dolphin abundance and distribution (Brooks and Pollock, 2015). These disturbances are, therefore, considered to be small, cause negligible ecological change, and be temporary in nature.

3.14.19 Comment 19

Submitter Type	Commonwealth Government	TOR Category or EIS Chapter	Appendix 8: Coastal Assessment and Hydrodynamic Modelling
Date Submission Received	28 November 2016	Submitters Reference to EIS Section (if provided)	Executive Summary

Details of the Submission

While the draft EIS states that under the preferred release option (only during ebb tide) potential for impacts to migratory shore birds as a result of the discharge release into Alligator Creek is minimal, it is important to note that this is only based on modelling.

19. Long-term monitoring of migratory shorebird populations is required to assess whether a downward trend in bird numbers or spatial variation in habitat use as a result of the proposed discharge into Alligator Creek. If modelled impacts are exceeded, revision of management measures is required to avoid ongoing impacts on birds and habitat use.

Proponent Response

In consultation with the Commonwealth and Territory Government's the proponent has prepared a framework for the development of a Waterbird Monitoring Program. The framework is provided in Appendix A. The monitoring program will be based on an adaptive management approach.

3.14.20 Comment 20

Submitter Type	Commonwealth Government	TOR Category or EIS Chapter	Appendix 8: Coastal Assessment and Hydrodynamic Modelling
Date Submission Received	28 November 2016	Submitters Reference to EIS Section (if provided)	Section 2.4.5, Local Currents

Details of the Submission

Estimated current velocities in the proposed action area are based solely on modelling.

20. Please provide measurements of current velocities in the proposed action area to validate model predictions.

Proponent Response

The model has been calibrated to several periods of measured water levels across the Legume waterways, collected on a number of occasions. Discharge flow rate and current velocity measurements were attempted in November 2015 when bathymetric data was being collected. However, the shallow waters of Alligator Creek and the short window of available depth to collect data resulted in unsafe conditions for data collection. These safety concerns, combined with the high flow velocities and highly mobile bed of both Alligator Creek and Forsyth Creek, made collection of data unfeasible.

Current speeds were assessed visually on site by timing the speed of floating items (oranges) across a known distance. Whilst a coarse measurement of stream velocity, the results indicated that the model was producing comparable currents speeds.

Given the extensive calibration to measured water levels, the model is considered to be providing a good representation of conditions on site.

3.14.21 Comment 21

Submitter Type	Commonwealth Government	TOR Category or EIS Chapter	Appendix 8: Coastal Assessment and Hydrodynamic Modelling
Date Submission Received	28 November 2016	Submitters Reference to EIS Section (if provided)	Section 2.4.5, Local Currents

Details of the Submission

The estimated flow rate in the northern channel of Alligator Creek during neap tide conditions is expected to be less than 50 m³/s. However, the discharge rate at this time, due to the limited discharge window during some ebb flows, may exceed 60 m³/s in order to achieve the long-term average daily discharge rate of 420 ML.

21. Please provide further discussion of changes in flow volumes in the northern channel due to discharges from the proposed action and an analysis of how this could affect erosion, scour and channel migration. The effects of the island upstream of the discharge point and its effect on flow characteristics and the variation in erosion rates depending on the overall movement of the sub-channels should be included in this discussion, as well as consideration of a variable volume discharge regime in which the volume discharged is proportionate to the tidal volume in the relevant sub-channel.

Proponent Response

The banks, channels and bedform of Alligator Creek are highly mobile. Significant accretion and erosion within the creek is observed in the relatively short period of available imagery of the creek. For instance, the island upstream of the discharge is a relatively new feature of Alligator Creek, not visible in satellite images prior to the year 2000. This island footprint is not stable and data collected and observations made in 2015 indicated both erosion and accretion of the island footprint and constant change of the channels around the island. Thus the “effect of the island...and its impact on flow characteristics” are varied and will certainly continue to change into the future.

Modelling of Alligator Creek indicates that the flow rate in the local discharge channel varies from 50m³/s during the neap tide to over 400 m³/s during spring tide. Across the full width of the Alligator Creek channel at the discharge point, the flow varies between 800m³/s and 5,400m³/s (refer to Section 2.4.5 and Figure 2-82 of Appendix 8 of the draft EIS). Thus, whilst discharge rates during neap ebb tides may be higher than the local channel flow, the magnitude of the discharge is minimal in comparison to the existing flow within Alligator Creek itself which drives the constant flux of banks, channels and bed forms.

Potential erosion caused directly by the discharge will be limited to the area around the discharge. Natural erosion (and accretion) processes within the creek as a whole will continue at a magnitude far in excess of the potential local erosion that may be caused by the farm discharge flows.

3.14.22 Comment 22

Submitter Type	Commonwealth Government	TOR Category or EIS Chapter	Appendix 8: Coastal Assessment and Hydrodynamic Modelling
Date Submission Received	28 November 2016	Submitters Reference to EIS Section (if provided)	Section 3.4.5, Nutrients, Figure 3-20

Details of the Submission

Results of numerical modelling of solute transport identified a discharge regime with discharge occurring on every ebb tide as giving the best water quality outcomes for the receiving environments of Alligator Creek and Keep River.

22. It is noted that discharge in this model is stopped before the base of the tide, however it was unclear what timeframe was selected. Please provide clarification.

Proponent Response

Extensive testing was undertaken to assess the effectiveness of different discharge regimes on reducing effluent concentrations within Alligator Creek. Testing included discharging every ebb tide (i.e. two discharges per day), only one ebb tide per day, and every third ebb tide (i.e. two discharges over three days) along with the timing around the ebb tide flow (i.e. discharging across the whole ebb tide, finishing the discharge 1, 2, 3+ hours before the end of ebb tide etc).

Due to the time lag between flood and ebb tides in Alligator Creek and the Keep River, it was found that better flushing and dilution of discharge water was achieved by timing the discharge to coincide with ebb tide in the Keep River rather than Alligator Creek. The timing presented in the report represents a scenario where the discharge to Alligator Creek begins 1 hour before the ebb tide starts in Alligator Creek, but is close to beginning in the Keep River, and discharge finishes 5.5 hours before the ebb tide finishes in Alligator Creek, providing sufficient time for material to be diluted in the outgoing tide in the Keep River.

3.14.23 Comment 23

Submitter Type	Commonwealth Government	TOR Category or EIS Chapter	Appendix 8: Coastal Assessment and Hydrodynamic Modelling
Date Submission Received	28 November 2016	Submitters Reference to EIS Section (if provided)	Section 3.4.5, Nutrients, Figure 3-24

Details of the Submission

Diagrams of probable concentrations of nitrogen, phosphorous and chlorophyll a are based on a discharge concentration equivalent to the mean licence condition concentration. The proponent states that the model inputs shown in Table 3-3 account for a range of tidal cycles and model dry season conditions to provide an estimate of the 'worst-case scenario'.

23. To demonstrate an accurate 'worst-case scenario', please re-run the model using the maximum proposed discharge concentrations (i.e. the maximum licence conditions as outlined in Table 3- 2).

Proponent Response

The model has been run to simulate discharge at the average concentration and above average flow rate over a period of 12 weeks. The simulation occurs during the dry season with no freshwater flow into the upstream

end of Alligator Creek to help flush the creek. This represents the “worst case” in terms of the receiving environment.

As shown in Figure 11 of Volume 1, Chapter 5 (reproduced below as Figure 9), the discharge of water from the prawn grow out ponds will vary considerably. For short periods during or following a harvest, the concentration of the discharge water will be high and close to maximum discharge licence levels. However, these periods are short lived and for most times concentrations will be closer to the average discharge licence level. The average discharge license conditions will be the average of this fluctuation.

Thus, it is not correct to model the maximum discharge license concentrations for a 12 week period. This would result in this level being the average condition. The model has indicated that Alligator Creek is relatively well flushed and the concentration of the discharge within Alligator Creek is likely to build up slowly over the dry season before being flushed out with catchment flows in the wet season.

Thus, the variation of discharge concentration as shown in Figure 9 is likely to result in better water quality than the (more conservative) constant average concentration scenario that has been modelled.

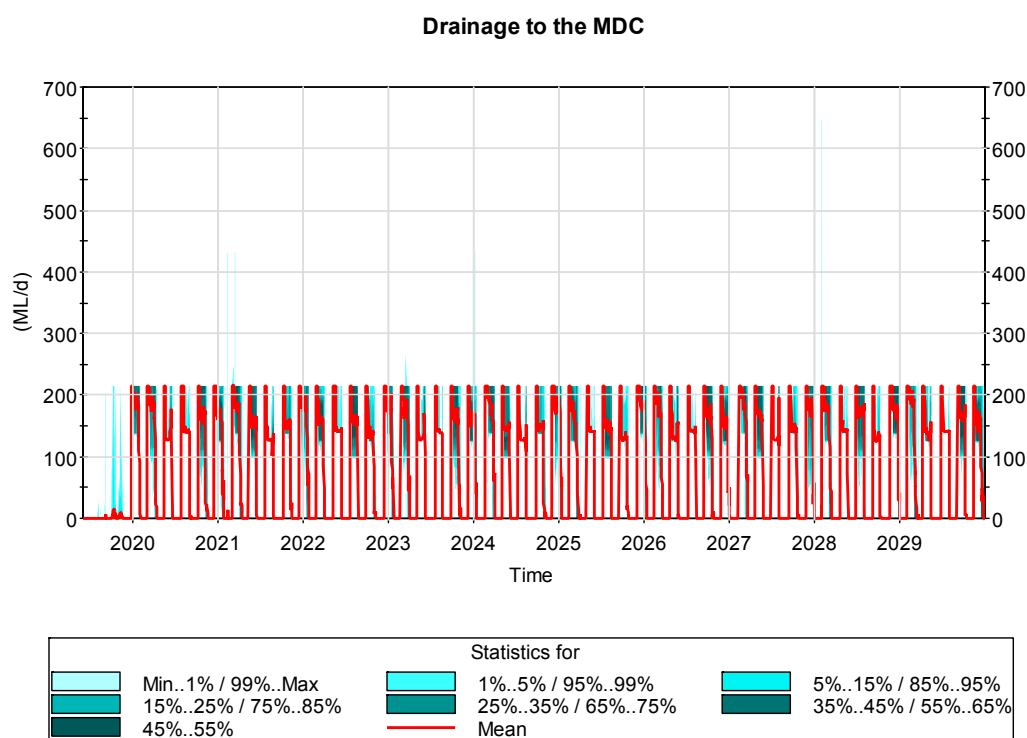


FIGURE 9 RELEASE OF HARVEST WATER INTO THE MAIN DISCHARGE CHANNEL

3.14.24 Comment 24

Submitter Type	Commonwealth Government	TOR Category or EIS Chapter	Appendix 9: Estuarine and Marine Water Quality and Ecology
Date Submission Received	28 November 2016	Submitters Reference to EIS Section (if provided)	Section 17.1, Water Quality, Pg. 220

Details of the Submission

Baseline water quality data is temporally limited, however the proponent has committed to continuing collection until two years' worth of data is available, then calculating final site specific water quality guidelines.

24. Water quality sampling should occur in the Environmental Protection Zone (EPZ) in addition to the proposed monitoring sites to ensure water quality objectives are met.

Proponent Response

Operational monitoring will include monitoring of elements within the operational system (including the EPZ) as well as locations in the receiving environment.

3.14.25 Comment 25

Submitter Type	Commonwealth Government	TOR Category or EIS Chapter	Appendix 9: Estuarine and Marine Water Quality and Ecology
Date Submission Received	28 November 2016	Submitters Reference to EIS Section (if provided)	Section 17.1, Water Quality, Pg. 220

Details of the Submission

The proponent has stated that water quality sampling will occur only outside the wet season and on neap tides and that sampling will occur approximately fortnightly on the lowest tide.

25. Water quality sampling should occur year-round when it can be undertaken safely. While the proposed sampling regime may be appropriate, initial weekly sampling would assist in characterising the discharge environment and informing management. Sampling should occur soon after discharge commences in order to capture actual discharge conditions.

Proponent Response

Refer also to the response to Comment 27 from the NT EPA in Section 3.19.27 of this SEIS.

As per commitments made in the draft EIS (see Volume 2, Chapter 2; Volume 5, Appendix 5), the proponent will prepare and implement a water quality monitoring program. The water quality monitoring program will be designed to ensure that any potential impacts on matters of national environmental significance can be avoided and mitigated.

The proponent agrees to undertake year round sampling, where it can be undertaken safely. To assist in characterising the discharge environment and informing management, the proponent agrees to undertake weekly sampling initially at some sites, where it can be undertaken safely. The proponent agrees to undertake sampling when discharge commences in order to capture actual discharge conditions.

3.14.26 Comment 26

Submitter Type	Commonwealth Government	TOR Category or EIS Chapter	Appendix 13: Groundwater Data
Date Submission Received	28 November 2016	Submitters Reference to EIS Section (if provided)	Table 3, Summary of Groundwater Data from Bore Logs

Details of the Submission

The data presented on groundwater quality is limited both spatially and temporally as recent data is only shown for RN038543 (May 2014), located on the western edge of Farm 3.

26. Please provide further observations to confirm the conceptual model in the area of the grow out ponds.

Proponent Response

As stated in Appendix F, particularly Section 3.2, the Legume floodplain is quite uniform in terms of the soil layers present - that is, the geological framework is quite consistent, forming the aquifers for the water table on the plains. In terms of groundwater, all of the Project infrastructure other than the Central Facilities and Forsyth Dam borrow pits have been mapped by previous Northern Territory government agency programs (notably Tickell and Rajaratnam, 1995, 2001, 2003) as quite uniformly saline in the area impacted by the grow out ponds, based on numerous extant bores and bore records. Another key investigation into salinity on Legume Station found the same results (Tickell and Hill 2001) over the same soil types and in the same general area. This was further backed up by soil test pitting and soil salinity showing this same salinity profile as found in these agency reports.

In terms of data, in total there are 19 bores or test pits located in the area of the grow-out ponds that were used to define the groundwater conceptual model. These comprised 6 existing bores:

- RN027014 and RN038543 with water quality sampling data showing saline waters (~20 - 45 dS/m) relatively close to the surface
- RN005135 with water quality sampling data showing less salty water (~4.4 dS/m) but at a depth of ~40m below ground (with a standing hydraulic water level rising to ~20 m below ground)
- RN005666 and RN027014 stated as encountering salty water at a similar relatively shallow depth to the RN027014 and RN038543 bores.

This data ranges between 1965 and 2014, and was combined with additional data from the drilling program (Volume 5, Appendix 9 of the draft EIS) and the work by Tickell and Rajaratnam (1995, 2001, 2003) and Tickell and Hill (2001), and based on the hydrology/geology of the floodplain, with many similarities to other coastal floodplains in northern Australia.

Surface water levels for groundwater from the above bores, Tickell and Hill (2001), and the drilling program (including the installed peizometers) were also quite consistent.

Given that the key risk to be assessed is in relation to the saline waters in the ponds over the intermittently saline/freshwater floodplain, the above information is considered to be quite suitable to the level of the investigation, noting that the quality of groundwater is not anticipated to undergo any change due to site operations.

Note however that a number of peizometers have been installed and along with the existing bores form part of the proposed groundwater monitoring program outlined in Appendix C8 of the draft EMP (Appendix H), comprising:

- A baseline monitoring program prior to works starting, on a quarterly basis until operations begin
- Ongoing monitoring during operations (6 monthly for two years, and annually thereafter), along with monthly analysis of logged water level in proximity to the farms.

Overall, further water quality data is not considered necessary given the nature of the groundwater system and the type of works proposed.

3.14.27 Comment 27

Submitter Type	Commonwealth Government	TOR Category or EIS Chapter	Appendix 13: Groundwater Data
Date Submission Received	28 November 2016	Submitters Reference to EIS Section (if provided)	Table 3, Summary of Groundwater Data from Bore Logs

Details of the Submission

The data presented on groundwater quality is limited both spatially and temporally as recent data is only shown for RN038543 (May 2014), located on the western edge of Farm 3.

27. Please note, the EC units in Table 3 are incorrect. They should be μSiem not d S/m ($1 \text{ d S/m} = 1000 \mu\text{Siem}$), otherwise salinity would be extremely high.

Proponent Response

Refer to the response to Comment 26 above (Section 3.14.26).

In terms of the EC units, the table header is an error and should have stated $\mu\text{S/cm}$, however the assessment was conducted against the salinity values as $\mu\text{S/cm}$.

3.14.28 Comment 28

Submitter Type	Commonwealth Government	TOR Category or EIS Chapter	Appendix 16: Biosecurity Assessment
Date Submission Received	28 November 2016	Submitters Reference to EIS Section (if provided)	Section 4.1.1 Development of Domesticated Prawn Stocks, Pg. 8

Details of the Submission

The proponent plans to develop stocks of Specific Pathogen Free prawns.

28. Please discuss whether antibiotics will be used at any stage of the production process, including those not included in the stage of development subject to this assessment. If antibiotics will be used, please discuss the potential impacts that the release of treated water or escapees may have on MNES as a result of entering the food chain.

Proponent Response

The Operational Policy - Marine Prawn Aquaculture - Licensing Wastewater Releases from Existing Marine Prawn Farms in Queensland (Department of Environment and Heritage Protection 2013) states:

"The only drugs and chemical substances allowed to be used in prawn farms are those authorised by the Australian Pesticides and Veterinary Medicines Authority (APVMA), prescribed by a veterinarian or those substances that have been declared "Exempt from Registration" and their use shall be in accordance with the label's requirements."

All drugs and chemicals authorised to be used at the facility shall only be discharged to the receiving environment at a level prescribed or authorised by the administering authority in accordance with ANZECC Guidelines."

The proponent already operates under these Guidelines. The proponent has stated that it will not use antibiotics in grow-out at the Legume Grow-out Facility. That position has not changed.

The Department has asked the proponent to "discuss whether antibiotics will be used at any stage of the production process, including those not included in the stage of development subject to this assessment". Antibiotics are not intended to be used routinely in any part of the production process. However the proponent cannot categorically rule out ever using antibiotics, because they may be required to by a government authority or agency.

If antibiotics were to be administered, it would need to be done so under the prescription and supervision of a registered and authorised veterinarian, in accordance with Australian Pesticides and Veterinary Medicines Authority, which includes requirements for appropriate holding times for both animals and water that after treatment. As such, it is clear that any antibiotic use would conform to the Queensland Operational Policy as described above.

In the highly unlikely event that antibiotics were ever to be used at Legume, any use would need to be administered under the prescription and supervision of a registered and authorised veterinarian in accordance with Australian Pesticides and Veterinary Medicines Authority, and holding times would need to be adhered to. Therefore, in order to impact on MNES any antibiotics used would need to:

- a) first need to be used (highly unlikely at Legume)
- b) enter the food chain (via an unknown mechanism), and
- b) once within the food chain, be at sufficient concentration or efficacy to produce an impact on listed threatened species and communities, or migratory species.

Given requirements for holding times, treated water would not have antibiotics within it - certainly not at detectable levels and it is difficult to see how the concentration of antibiotics would be sufficient to be detectable at any stage within the farms. The post larvae (PLs) to be used in stocking the ponds would not carry antibiotic residues capable of detection.

Under the conditions described above it is extremely difficult to see how antibiotics could enter the food chain as speculated by the Department. It is also extremely difficult to construct, however artificially, a scenario in which the second condition within the risk assessment (that is a detectable impact on listed species or migratory birds) could be met.

Therefore, the risk of antibiotic use impacting MNES is ranked Likelihood 1 and Consequence 1 - Risk Very Low, using the risk methodology as set out in Volume 1, Chapter 8 of the draft EIS.

3.15 ANONYMOUS PUBLIC COMMENT

3.15.1 Comment 1

Submitter Type	Private Individual	TOR Category or EIS Chapter	ToR Section 2.1
Date Submission Received	5 December 2016	Submitters Reference to EIS Section (if provided)	Section 2.8.6 (the proponent assumes this refers to this section of Volume 1, Chapter 3)

Details of the Submission

Sea Farms do not layout the overall map on what the future stages will potentially look like. This makes it difficult for the public (especially those that cannot read) to get a understanding on the immense size of this proposed Prawn Farm. It is my understanding that a large portion (percentage wise) of the cracking black soil plan will be effected by the future stages of the project. This will have signficante impacts on the fresh water layers in the water table and consequently, the large percentage of the fresh water flora and fauna that rely on this fresh water to support their habitat will be effected.

Proponent Response

This EIS is confined to assessing Stage 1 as per the Notice of Intent, Referral to the Commonwealth Government and the Terms of Reference for the EIS. The potential impacts associated with future stages would be addressed through future environmental assessment processes as required.

3.15.2 Comment 2

Submitter Type	Private Individual	TOR Category or EIS Chapter	ToR Section 2.1
Date Submission Received	5 December 2016	Submitters Reference to EIS Section (if provided)	Section 2.8.6 (the proponent assumes this refers to this section of Volume 1, Chapter 3)

Details of the Submission

My current understanding is that the Black Cracking clay soil will be infiltrated with high contents of salt water that would limit any further fresh water fauna growth and kill off what is in existence currently. This would have consequential effects on the fauna and Flora that rely on a natural fresh water environment to survive. As it is well known the Legume Floodplain is a Freshwater Wetland of International significance that needs to be preserved.

Proponent Response

Outside of the areas that will become the grow-out ponds, there will be no infiltration of the black cracking clay soils with saltwater. There have been extensive investigations (see draft EIS, Appendix 7b), as well as on-site trials (see Section 3.8 of Chapter 1, Volume 2), to understand the soil impermeability, as retaining the water within the ponds is critical to successful operations. These investigations have shown that the surface soils (the black cracking clay soils on the estuarine-deltaic plain) provide the impermeability needed to retain the water for operations.

Further information is provided in Appendix F, particularly Sections 2.1, 2.2 and 3.3.

3.15.3 Comment 3

Submitter Type	Private Individual	TOR Category or EIS Chapter	ToR Section 2.1
Date Submission Received	5 December 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

I cannot find any reference to Mapped areas identified for future expansion except for generalities regarding size in written text. This does not well inform all people especially those that cannot read.

Proponent Response

The submitter makes reference to the ToR, Section 2.1 which asks for "a brief background and context to the project", including "identification of areas proposed for future expansion, or any other potential future activities being planned".

This EIS is confined to assessing Stage 1 as per the Notice of Intent, Referral to the Commonwealth Government and the Terms of Reference for the EIS. The potential impacts associated with future stages would be addressed through future environmental assessment processes as required.

As per the requirements of the Terms of Reference a brief background and context to the proposed future stages has been given in Volume 1, Chapter 3, Section 2.8.6.

3.15.4 Comment 4

Submitter Type	Private Individual	TOR Category or EIS Chapter	ToR Section 2.2.3 Decommissioning and Rehabilitation
Date Submission Received	5 December 2016	Submitters Reference to EIS Section (if provided)	Volume 1, Chapter 3, Section 11

Details of the Submission

Under Volume 1, chapter 3, section 11 of Sea Farms Draft EIS it is mentioned by Sea Farms that the project will be an ongoing sustainable venture and there is no real need/plans for a rehabilitation plan. For an area recognised as a conservation site of international importance, this is certainly an unacceptable line of thinking and not in the best interest of the environment.

Proponent Response

This is a misleading representation of the statement that was made in regards to the perceived lack of need for rehabilitation in Volume 1, Chapter 3, Section 11. The full context reads "The Legume Stage 1 Grow-out Facility is proposed as an ongoing sustainable venture, with no plans to discontinue these activities on the site. However, to manage and provide for uncertainty, a Decommissioning and Rehabilitation Plan will be developed for the site, to detail procedures and methods to use should they be required. The sections below outline the overarching Decommissioning and Rehabilitation planning for the Project. The detailed plan will be completed after the requirements of the various approvals and agreements are finalised." Six pages outlining the overarching Decommissioning and Rehabilitation follow this statement. The point of this statement was that the venture is proposed to be ongoing, which is entirely possible for a project of this nature, which is not reliant on a finite resource (unlike a resources enterprise). The proponent has committed to providing a Decommissioning and Rehabilitation Plan to provide for potential closure at some time in the future.

3.15.5 Comment 5

Submitter Type	Private Individual	TOR Category or EIS Chapter	ToR Section 2.2.3 Decommissioning and Rehabilitation
Date Submission Received	5 December 2016	Submitters Reference to EIS Section (if provided)	Volume 1, Chapter 3, Section 11

Details of the Submission

Sea farms propose to construct most of their earthen structures using the black cracking clay including the topsoil. The top 300mm of this clay (which is what is being used) makes up the topsoil that supports the existing fresh water ecosystem that are present on the Deltaic Estuarine Plain. The question needs to be asked:

Proponent Response

The topsoil is very thin in the area of the farms, with actual topsoil (as opposed to the upper 'black soils') being ~0.05 m thick.

Regardless, with the exception of some direct impacts to minor drainage lines that would exist during a rainfall event in the dry season, or the start of the wet season, the Project footprint avoids direct impacts to the semi-permanent water bodies on-site and will not extend over large water bodies, such as Osman's Lake.

During the wet season, much of the Legume floodplain becomes one major water body for months at a time. The development of the Project will result in the loss of a relatively small area of ephemeral wetland habitat in the wet season (as illustrated in Figure 4, Chapter 8, Volume 2). The potential impacts to, and mitigation and management measures to ameliorate those potential impacts are detailed in Volume 2, Chapter 8 Freshwater Ecology. The findings of the assessment were that there was unlikely to be any significant impact to any flora or fauna species or ecological communities.

3.15.6 Comment 6

Submitter Type	Private Individual	TOR Category or EIS Chapter	ToR Section 2.2.3 Decommissioning and Rehabilitation
Date Submission Received	5 December 2016	Submitters Reference to EIS Section (if provided)	Volume 1, Chapter 3, Section 11

Details of the Submission

The question needs to be asked:

How do Sea Farms propose to rehabilitate the site when the topsoil will be destroyed in the bank building process and the subsequent filling of those bank structures with Sea Water that will ultimately saturate the topsoil with salt water?

Proponent Response

Volume 1, Chapter 3, Section 11 sets out the proposed approach to Decommissioning and Rehabilitation. Among other things, there is a commitment to prepare a detailed site Decommissioning and Rehabilitation Plan following Project approval, which will be adapted based on findings during the operation of Stage 1.

Topsoil when encountered will be stockpiled prior to works commencing, although this was found to be very thin to non-existent in parts of the coastal zone (particularly the coastal erosional plain). The preliminary Decommissioning and Rehabilitation Plan in the EIS (Volume 1, Chapter 3, Section 11) provides for topsoil

conditioning and preparation with the exact methods to be confirmed during a trial program, committed to at the start of operations and throughout Stage 1. This would utilise the stockpiled topsoils, with additional controls/treatment utilised where required, such as bioremediation, and addition of gypsum and/or organic matter (such as stabilised and naturally flushed pond spoil).

Notwithstanding the above, Appendix C2 of the draft EMP (Land and Soils Strategy) has been updated to include a more explicit strategy relating to topsoils. The updated EMP is included as Appendix H of this SEIS.

3.15.7 Comment 7

Submitter Type	Private Individual	TOR Category or EIS Chapter	ToR Section 2.2.3 Decommissioning and Rehabilitation
Date Submission Received	5 December 2016	Submitters Reference to EIS Section (if provided)	Volume 1, Chapter 3, Section 11

Details of the Submission

Currently in Australia, all mining operations need to conserve topsoil for later rehabilitation processes. Given that Sea Farms are using this topsoil in their banks this will be difficult if not impossible to do. There is mention in the EIS that topsoil would be stockpiled for later use but in the Rehabilitation process in the EIS document, the method proposed does not mention the use of any stock piles of topsoil.

Proponent Response

Section 5.3 of Chapter 3, Volume 1 states "No pre-stripping of topsoil is proposed, as all the surface clay soils will be consumed in the bulk earthworks". This relates to the surface soils, with very thin to non-existent topsoil material in many locations across the Estuarine Deltaic Plain. However, stockpiling of topsoils will occur where encountered, and additional topsoil rehabilitation measures employed as described in the response to Comment 6 above (Section 3.15.6).

3.15.8 Comment 8

Submitter Type	Private Individual	TOR Category or EIS Chapter	ToR Section 2.2.3 Decommissioning and Rehabilitation
Date Submission Received	5 December 2016	Submitters Reference to EIS Section (if provided)	Volume 1, Chapter 3, Section 11

Details of the Submission

If Sea Farms are serious about being able to rehabilitate the site, they should be made to demonstrate the rehab process with Trials before the approval is given to disturb the site.

Proponent Response

As specified in Section 11.3.2 of Volume 1, Chapter 3 of the draft EIS (Rehabilitation Planning), "In particular, a trial of rehabilitation methods for pond and channel infrastructure will be developed during the operation of Stage 1, implemented when operations first begin on the site".

This is discussed briefly in the responses to Comments 6 and 7 above (Sections 3.15.6 and 3.15.7).

3.15.9 Comment 9

Submitter Type	Private Individual	TOR Category or EIS Chapter	ToR Section 2.2.3 Decommissioning and Rehabilitation
Date Submission Received	5 December 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

The EIS fails to mention that the fully developed Venture will cover a large portion of the Estuarine Deltaic Plain, that will highly likely effect all this area environmentally. The area covered by Stage one is said to be 3239Ha. The rehabilitation Plan should show how Sea Farms would be rehabilitating the entire 40,000Ha of plain that surrounds all stages of the proposed Farm in this event. It is highly likely that the surrounding estuarine plain will be detrimentally effected by water with higher than naturally occurring concentrates of salt. The consequences to the area of International Conservation Significance would be dramatic. A rise in water table that contains higher concentrates of salt will cause a loss in surrounding vegetation that would lead to increased erosion from wet season flooding events on the topsoil. This would allow high tides to flow further into the Deltaic Plain leading to further degradation of the fresh water environment.

Proponent Response

This EIS is confined to assessing Stage 1 of the Legume Grow-out Facility as per the Notice of Intent, Referral to the Commonwealth Government and the Terms of Reference for the EIS. The potential impacts associated with future stages would be addressed through future environmental assessment processes as required.

3.15.10 Comment 10

Submitter Type	Private Individual	TOR Category or EIS Chapter	ToR Section 2.6 Ecologically Sustainable Development
Date Submission Received	5 December 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

Sea Farms need to address how their development at Legume Station is ecologically sustainable. They do not address how a change in ground water hydrology (from their salt water ponds) is going to be addressed. A change in Ground water salt content is going to dramatically change the existing fresh water ecosystems that form part of the land that the Grow-Out Ponds are situated as well as the surrounding areas as these will be effected by rising salt water tables.

In Sea Farms EIS in volume 1 chapter 7, they discuss how they will comply with ASC Shrimp standards which list a number of objectives, none of which however, are specific to the site at Legume.

I do not see anywhere in this chapter that shows how Sea Farms will minimise the change in the existing ecosystems at the Legume Station site that need to be conserved.

Proponent Response

Volume 1, Chapter 7 of the draft EIS outlines how the Project complies with, and contributes to, the core objectives and guiding principles of ecologically sustainable development as defined in the National Strategy for Ecologically Sustainable Development.

See response to Comment 26 from the Department of the Environment and Energy for a discussion on groundwater (Section 3.14.26).

Various chapters of the draft EIS deal with avoidance and mitigation of the impacts of the development on existing ecosystems, of particular note are the following chapters:

- Volume 2, Chapter 2 - Marine and Estuarine Water
- Volume 2, Chapter 3 - Freshwater
- Volume 2, Chapter 4 - Groundwater
- Volume 2, Chapter 5 - Terrestrial Flora
- Volume 2, Chapter 6 - Terrestrial Fauna and Avifauna
- Volume 2, Chapter 7 - Marine and Estuarine Ecology
- Volume 2, Chapter 8 - Freshwater Ecology

3.15.11 Comment 11

Submitter Type	Private Individual	TOR Category or EIS Chapter	ToR Section 3.1 Physical and biological
Date Submission Received	5 December 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

The deltaic Plain consist of a dark black cracking clay of various thickness (300mm to 700mm) that is relatively impervious to water. It is underlayed by 3 to 4 m of sandy silty clay which is not impervious to water, and this is underlayed by estuarine clay which is again impervious to water. The sandy silty clay is very dispersive when exposed to fresh water.

The water table sits within the middle layer of pervious silt and moves up and down in direct relation to the recharge from either overland flow/rainfall or by nearby streams and or water capturing landforms which are connected to the Estuarine plain. After an average wet season the water table is at the surface and slowly drops as the dry season develops to around 1.5 to 2 m below the surface. The water table consists of saline water with the water with the least salt content (< than 7 parts per thousand) sitting above the saltier water (up to 35 parts per thousand). Most of the grasses that are present on the black soil plains access this fresh water for their growth and survival. The volume of low salt content water as a percentage in the water table goes up after wetter years and likewise is the opposite (less fresh water) in dryer years.

The concern I have is this:

Turkey Nest's constructed at legume over the last 30 years have the borrow pits (where the construction dirt is accessed) situated outside of the water holding structure. This is because the layer of impervious black clay needs to be maintained to stop the structure from leaking its water into the pervious clayey silt in the lower soil layers. To check this one needs to access Google earth to confirm this. Any turkey nest (and there are some) which have been constructed with the borrow pits on the inside at Legume do not hold water (fact). The water leaks down into the lower layers of soil and eventually the Turkey Nest is dry within a few months. This would indicate that if the construction methodology on the Prawn Farms was to use most of the Black cracking clay then the result would ultimately be that water (and in this case very salty) would leach into the water table below. This would raise the water table on the Estuarine Deltaic plain exposing the surrounding Fresh water

reliant grasses to saltier water than what they can tolerate. The result would be large areas of grass lands would cease to exist and the subsequent topsoil that these grasses grew would be highly exposed to wet season erosion. The grasses on the floodplain hold the black cracking clay together in flood events.

The grass is the densest during the wet season and act to not only slow the movement of water across the floodplain, by removing the energy from the water, they also act to shield the soil as the grasses lay over and protect the soil from the water turbulence when the water is flowing across the plain towards the ocean during flooding events. This flooding happens in most years.

If this was to happen, the erosion would be irreversible as the wet season flooding at Legume Station is extreme in wet years. If erosion started, small channels would be formed within weeks and they would rapidly form into creeks and eventually (3 or 4 weeks) a large channel is formed. The silty sandy clay is extremely dispersant when exposed to fresh water.

The result would be a large channel that would link the ocean to where the erosion started. This would in turn let the sea water under high tide scenario to run further into the freshwater wet land further adding to the problem. This is of real concern and needs to be addressed.

Flooding at Legume is extreme and mitigation measures to stop erosion during wet season flooding on country that has no grass cover is all but impossible. Any earthworks that are exposed to floodwaters will experience erosion if the structures are not grassed or protected.

Sea Farms should be made to trial this leakage by constructing a pond with the same dimensions to that, which would be used during operation and filled with fresh water to simulate the same static head that would be present during operations. Trials should measure the amount of leakage into the subgrade to prove that the structures would hold water. If the Structure does not hold water, then the Construction Methodology should be altered with Engineering practices and retrial the structure to prove that it does.

This consequential harm to the environment from leakage of Sea Water into the ground water would be catastrophic.

As above, the local water table surrounding the Grow- Out Ponds would possibly be effected by the increased inflow of salt water. If this was to happen, it would have far reaching consequences.

Proponent Response

While the black cracking clay surface soils and the lower estuarine clays were ubiquitous within the Project footprint, as described in Section 3.3.2 of Volume 2, Chapter 1 of the draft EIS, intermediate soils are invariably medium to heavy clays (not sandy silty clay as asserted by the submitter), with only scattered sandier deposits within the footprint. Volume 5, Appendix 7b of the draft EIS (Table 8) shows some analysis of the clay/silt/sand fractions, with generally very low sand proportion in the layers to be disturbed by site works. Sandier horizons (sandy silts/clays and some sands) were identified to the east of the farm area.

In regards to groundwater, investigations found groundwater levels at around 3 m (not 1.5 to 2 m as asserted by the submitter) below ground level (mid October 2015), with the Project footprint on the plains classified as saline waters (salinity up to 44.5dS/m, refer to Volume 5, Appendix 13). None of the available data indicates the shallow water table provides for a fresh top layer providing water supply to grasslands. There does appear to be a fresh upper layer associated with isolated hills and rises, as described in the draft EIS, Volume 2, Chapter 4, Section 3.4.1 (refer in particular to Figure 3 in that section). However, these do not occur within the footprint of the grow-out ponds.

Further, examination of groundwater dependence on the plains outlined in Section 3.4 of Volume 2, Chapter 4 of the draft EIS (Groundwater) found that while there are some facultative relationships (i.e. making use of, but not dependent upon groundwater), these are not associated with the grasslands on the deltaic plains. Since these grasses are not deep rooted, with root zones extending at most 0.5 - 1 m below the surface, the dry season groundwater table at 2 - 3 m depth is not generally accessible.

Theses grasslands on the estuarine-deltaic plain may be seasonally reliant on the wet season rain saturating the soil, which because of the high clay content is held in the upper layers of the soil and on the surface for long periods of time. However this is soil and surface water, not groundwater, and any changes to groundwater (notwithstanding the above) would be highly unlikely to affect the surrounding grasslands, noting also that it does reach very high salinities naturally.

Appendix F, Section 2.1 describes the observations made of the turkey nest dams, and the lack of the sandy material described above in the area of the ponds. In terms of the loss of water from existing turkey nest dams due to unsuitable soils, the available climate data clearly show that the evaporation is a sufficient explanation alone to account for empty Turkey Nest Dams - the rate of evaporation in most months (in fact most days) exceeds the total annual precipitation. To illustrate, Figure 10 shows the monthly climate statistics from Victoria River Downs (Bureau of Meteorology Station No. 014825¹) clearly showing average evaporation to exceed average rainfall in all months, and exceeding the 90th percentile rainfall during all but the January - March period (i.e. the entire dry season and early wet).

Reference to the daily evaporation and rainfall observations over the past 13 months also shows that evaporation exceeded rainfall for 90% of all days where evaporation data was available.

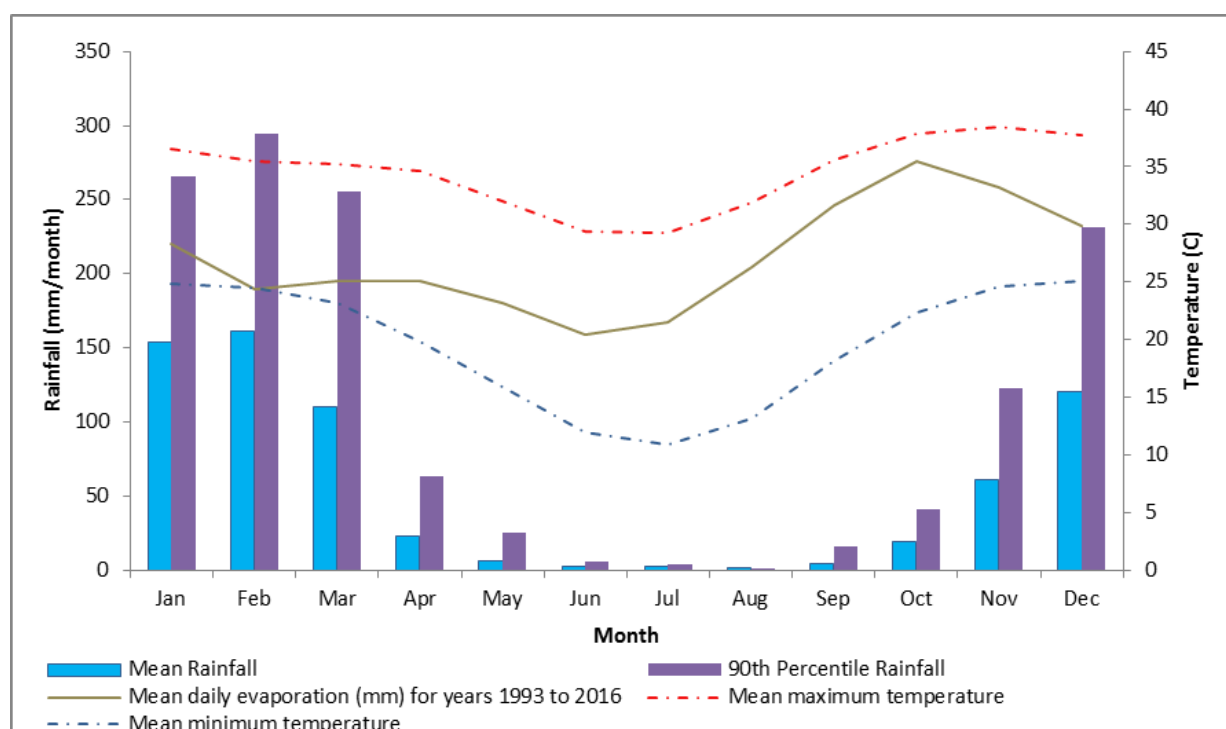


FIGURE 10 CLIMATE STATISTICS, VICTORIA RIVER DOWNS

¹ The closest Bureau of Meteorology station including both rainfall and evaporation data

Permeability and seepage tests are described in Sections 2.2 and 3.3 in Appendix F, showing that the implied leakage of massive quantities of saltwater to the surrounding plains would not occur. Note also that expansive areas of natural surface salinity occur presently on Legume Station, with the major cause being surface expression of saline shallow water tables (Section 3.5.1 of Volume 2, Chapter 2 of the draft EIS). Soil salinity generally ranged from 1 - 2 dS/m at the surface to 2 - 5 dS/m in mid soils and up to 7 - 10 dS/m in the estuarine clays, but with areas of saline surface soils at ~8 dS/m (refer Section 3.5.1 of Volume 2, Chapter 1 of the draft EIS).

Regardless of the above, erosion and sediment controls have been proposed and will be utilised during the works, as outlined in Volume 2, Chapter 1 (Geology, Geomorphology and Soils) and Volume 4, Chapter 3 (draft Environmental Management Plan) of the draft EIS (Appendix C1).

In terms of trial ponds, a series of trial ponds, embankments and specific seepage tests have been conducted, and are ongoing, with the results to date informing the engineering design and construction process, and finding the methodology suitable to achieve the required low permeability. This is further described in Section 2.2 in Appendix F.

3.15.12 Comment 12

Submitter Type	Private Individual	TOR Category or EIS Chapter	ToR Section 4.1 Risk assessment approach
Date Submission Received	5 December 2016	Submitters Reference to EIS Section (if provided)	Volume 1, Chapter 8

Details of the Submission

The issues with ground water being filled with high concentrates of salt result in a High to Very High Consequence category across several fronts. Given that what we know about Turkey Nest's at Legume Station discussed above and the similar static head that ponding water within these structures produces (both prawn farm grow out ponds and Turkey Nest Ponds), this is almost certain to happen. This puts a Risk Ranking on several fronts in the High to Extreme classification.

I do not agree with the risk ranking in the EIS put forward for this reason.

As discussed above, it is likely that the Salt levels in the ground water will be changed considerably resulting in major environmental damage and or change. Additionally, given that the topsoil will be destroyed in the proposed bank building methodology, rehabilitation of the area would be almost impossible to achieve without careful planning and trailing ways to achieve an acceptable methodology that would result in an acceptable outcome.

Proponent Response

See response to Comment 26 from the Department of the Environment and Energy for a discussion on groundwater (Section 3.14.26).

See response to Comment 5 above regarding topsoil and rehabilitation (Section 3.15.5).

3.16 DEPARTMENT OF TREASURY AND FINANCE

3.16.1 Comment 1

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Socio-economic
Date Submission Received	29 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

The Economic Impact Assessment (EIS) has been prepared by ACIL Allen Consulting, a reputable and well credentialed economic consulting firm.

It appears that Acil Allen has taken a rigorous approach and used relatively conservative assumptions. The computable general equilibrium (CGE) model that has been used is a widely accepted methodology for undertaking economic impact analysis.

The EIA anticipates an increase in the Territory's real gross state product (GSP) by a cumulative total (to 2032) of \$502 million, which is equivalent to about 1.5 per cent of the Territory's GSP. In addition, the modelling projects an increase in the average annual employment for the Territory of around 161 full time equivalent jobs. This is a significant positive impact on the Territory economy.

In DTF's view, the Project has the potential to provide significant economic benefits for the Territory and northern Australia.

Proponent Response

Noted - no response required.

3.17 DEPARTMENT OF TRADE, BUSINESS AND INNOVATION

3.17.1 Comment 1

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Socio-economic
Date Submission Received	17 November 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

The Department of Trade, Business and Innovation (DTBI) does not have any major issues in relation to the draft EIS.

The economic impact modelling shows the valuable potential socio-economic contributions of this project to the Northern Territory economy. The economic modelling approach is appropriate and given the current project assumptions and potential risks, provides a realistic estimation of the net benefits (direct and the flow-on impacts) of the project on the region as well as the broader Territory economy.

The project proponent's community and stakeholder engagement pathways are suitable and considered important particularly with respect to potential community effects and employment opportunities.

DTBI notes that the Project Sea Dragon will be implemented in stages and the socio-economic benefits will build up as various stages are constructed and become operational.

Proponent Response

Noted - no response required.

3.18 NORTHERN LAND COUNCIL

3.18.1 Comment 1

Submitter Type	Independent Statutory Authority	TOR Category or EIS Chapter	Project Description
Date Submission Received	5 December 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

Pond and channel walls are to be lined with surface soils taken from adjacent areas of the floodplain. Stability and reduced permeability are to be achieved by compaction. Issues arising from this approach are:

- ambiguity about the dispersivity of these materials: laboratory measures and related statements in the EIS indicate susceptibility² but anecdotes around observations in the field suggest stability in field conditions.³ We further note:

- further testing proposed by the geotechnical consultants to the project do not appear to have been done, or have not been reported;
- the manner in which existing structures were created (source of materials, compaction etc) and the conditions to which they were exposed (water quality, flow rates, traffic over structures) are unknown or at least unreported; and
- patchiness of soil quality and depth of the most suitable soils is acknowledged,⁴ but how risks of incorporation of less favourable soils in or underlying key structures is to managed is not explained in detail, indeed it is argued that stockpiling and transport of favourable soils will not be required.

- related ambiguity about stability under operating conditions. We further note:

- very large ponds with consequently greater than usual turbulence on pond walls;
- frequent on-embankment traffic (multiple daily traverses) for food delivery;
- regular, albeit less frequent, over-embankment traffic associated with harvest and removal of large volumes of waste from the centre of emptied ponds; and
- approaches to restoration of traffic-affected areas, especially if done under unfavourable conditions (incomplete drying, unanticipated (e.g. unseasonal) rains).

- related ambiguity about likely frequency of chronic leaks or more severe failure. We note:

² p. 1.28 Volume 2, Chapter 1 of EIS: "Soils across the farm area appear to be generally sodic, with the potential to disperse when wet".

³ p. 1.36 Volume 2, Chapter 1: "Some potentially dispersive and reactive soils to be used for embankments implies a potential issue in their long term stability, however, inspection of the currently existing numerous channels and farm dams in the area constructed of similar soils showed no signs of dispersion".

⁴ e.g. p. 1.26 "Sampling also indicates that some soils are potentially dispersive, though this is not widespread, and is also relatively patchy".

- frequent references to monitoring for leaks and evidence of greater than anticipated seepage (through groundwater observations) acknowledge the risks,⁵ but this awareness is not reflected in convincing treatment of risks for other aspects of operations (like water management).
- related ambiguity about permeability generally: We note:
 - no hard data (direct measurements) of permeability and its variance have been reported;
 - a small scale trial construction undertaken in June 2016 and reported to the ASX in August 2016⁶ emphasises workability of soils with light equipment but offers no hard data on permeability or trafficability in wet season conditions; and
 - acknowledgement of risks and related assurances about quality of construction supervision are not reflected in formal quantitative treatments of risks.

Proponent Response

Dispersivity is discussed further in Section 3.1 in Appendix F, and the variability of soils in Section 3.2 in Appendix F, with further background information related to design of earthen structures in Section 2 in Appendix F. Importantly, a pre-construction soil monitoring program has been committed to in the EIS (refer to Appendix C2 in the draft EMP, Appendix H). While the soil profile is well understood and quite uniform for surface soils, the intent of this pre-construction monitoring is to provide both a baseline, and to pinpoint exact depths in areas of construction where any uncertainty exists, to inform the detailed design.

Sections 3.1 (stability), 3.3 (leaks, permeability), 3.5 (pond turbulence and tides), 3.6 (traffic on ponds) and 3.8 (soft soils) in Appendix F provide responses to the above submission in terms of stability of structures, permeability and the potential for and controls adopted in relation to leaks and spills. The observational data in relation to existing structures is discussed in Section 2 in Appendix F.

In general, a worst case approach has been taken for the purposes of the EIS assessment, such as for sodicity and dispersivity (some areas did not evidence dispersive/sodic tendency), where it has been assumed that all soils are sodic and dispersive, until proven otherwise. Geotechnical assessment and engineering design has been aimed towards control of soils assuming all are dispersive, and the field trials selected a less optimal location to better understand worst case conditions.

Note that in addition to the discussions in Appendix F relating to permeability and control/monitoring of leaks, a specific seepage factor has been incorporated into the water balance model (refer Volume 1, Chapter 5 of the draft EIS) which is in agreement with expected impermeability found during site investigations on actual soil material. As such, no further impacts to the water balance are anticipated. Regardless, ongoing monitoring of water use and availability (as described in Volume 1, Chapter 3 of the draft EIS) will allow for early warning of any potential water use limitations, with sufficient time to adjust operations to suit.

⁵ see Appendix C2 Land and Soils Strategy and C8 Groundwater Management Strategy Vol 4 Chapter 3 (EMP).

⁶ Seafarms Group Limited (2016) Media Release. Successful earthworks trial completed for Project Sea Dragon grow-out farms at Legume Station, Northern Territory. 4 pp.

3.18.2 Comment 2

Submitter Type	Independent Statutory Authority	TOR Category or EIS Chapter	Freshwater; Marine and Estuarine Water
Date Submission Received	5 December 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

The health of the farms' prawn population and production outcomes depend on skilled management of seawater and freshwater to maintain favourable conditions. Large inputs of water are required to manage salinity, temperature, and concentrations of nitrogenous and other wastes within relatively narrow bands. Understanding total water demands and the mix of water sources required are critical factors in successful operation.

The water balance presented for the project indicates steady-state intakes of 575 ML/day of seawater from Forsyth Creek, 35 ML/day fresh water from Forsyth Dam during the dry season (7-10 GL/yr), with 410 ML/day of waters from ponds discharged to Alligator Creek.⁷ Most of the difference between inputs and discharge is due to evaporation and seepage, after taking account of unmanaged inputs from rainfall.

Obviously such an operation — responding to variation in climatic conditions, rapid discharge of water at time of harvest or other un-programmed losses — is never at a steady state. Inputs from managed water sources may vary from zero to many times average rates. Whilst the highly dynamic nature of such operations complicates presentation of water use, both the robustness and presentation of information should be improved. In particular, better analysis and presentation should include, in addition to simulation of influences of climatic variation:

1. permeability parameters based on measurements and simulation encompassing variance in values on predicted seepage losses;
2. allowance for other unmanaged losses through chronic leaks and more severe failures, again in a probabilistic way;
3. inclusion of simulations of un-programmed water releases required by, for example:
 - ▀ drainage to repair leaks or other failures; and
 - ▀ accelerated harvest to avoid problems associated with equipment failure, meet maintenance needs or deal with disease emergence on one or more of the farms;
4. all of the above under unconstrained water movement capabilities and separately within anticipated design constraints;
5. clarification of the influence, if any, of water temperature management on scale and timing of water inputs;
6. model runs long enough to allow confident predictions of maximum plausible daily and longer term demand; and

⁷ See page 3.21 of Volume 4, Chapter 3 of EIS. To further illustrate the scale of use, the city of Darwin and Palmerston use about 45 GL of reticulated water annually or an average of 123 ML/day, obviously higher in the dry.

7. as well as measures of central tendency, variance and range, presentation of all model outputs in plots of relative frequency of daily demands from both marine and freshwater sources, perhaps broken into at least wet season and dry season or production schedules.

The goal would be to allow the reader to see the full range of variation in total demands and assess their implications for impacts on both supply and discharges under plausible operating conditions. And then to see how outputs have been reflected in treatment of all “downstream” issues in related parts of the EIS, including contingency management.⁸ Such an approach would be much closer to quantitative risk assessment of the sort mentioned in the Terms of Reference for the EIS.

Better presentation would permit useful interrogation of the appropriateness of some design decisions, like movement of freshwater in many km of open channel rather than through pipes, given that all such water use represents a diversion from the Legume floodplain wetlands, which have high conservation, cultural and utilitarian value for the region’s Aboriginal interests.

The EIS argues that demands on water use can be managed by reducing production. However, such decisions are obviously commercially difficult. Reliance on willingness and capacity to underutilise a major capital investment rather than specify other responses to acute demand makes for a fragile environmental management platform.

Proponent Response

"Large inputs of water are required to manage salinity, temperature, and concentrations of nitrogenous and other wastes within relatively narrow bands."

The operating water parameters for prawn culture are in fact relatively broad with key variables from the standard manual (Volume 5, Chapter 6 of the draft EIS) being:

- Temperature: 22 °C- 34 °C
- Salinity: 10 parts per thousand (ppt) - 41 ppt
- Total Ammonia Nitrogen ≤3 parts per million (ppm).

It should be noted that these values are not absolutes.

These required tolerances are not considered narrow. The large inputs of water required are not simply to manage wastes - large inputs of water are required to manage losses of water to the atmosphere and therefore salinity mostly during the dry season.

"Whilst the highly dynamic nature of such operations complicates presentation of water use, both the robustness and presentation of information should be improved. In particular, better analysis and presentation should include, in addition to simulation of influences of climatic variation:

1. permeability parameters based on measurements and simulation encompassing variance in values on predicted seepage losses;

The water balance model has been constructed by experienced civil engineering consultants Golders. A total 'allowance' for seepage was parameterised in the water balance model and the assumed value is shown in Table 3 of Volume 1, Chapter 5 (Water Balance). This takes into account losses through pond and channel walls

⁸ Appendix E, Volume 4, Chapter 3 of EIS.

and floor, based on the measured data for impermeability and design criteria for compaction of the soils. Further detail in relation to impermeability is provided in Section 3.3 in Appendix F. Given the other water fluxes in the system - and the variability of these fluxes - it is difficult to sustain an argument or even contemplate a scenario in which seepage losses are material compared with other system fluxes.

2. allowance for other unmanaged losses through chronic leaks and more severe failures, again in a probabilistic way;

Ponds are filled and emptied between crops, thus if there were to be an observable leak it would routinely be repaired at the end of the crop cycle as part of normal pond maintenance. Maintenance includes a range of interventions that may include dry-out, removal of organic material, regrading and re-profiling the ponds and berms, and re-compaction as required. Prawn farm ponds have operated successfully in respect of their structural integrity in many places around the tropics and in many cases in soils with less favourable structural integrity and permeability characteristics. Maintenance of these structures is well understood. As part of this SEIS a detailed response in relation to permeability and performance of the soils has been prepared (see Section 3.3 in Appendix F). The largest unmanaged and unmanageable loss is to the atmosphere (136 ML/day in the dry season), thus in terms of modelling any variances due to leaks is insignificant.

3. inclusion of simulations of un-programmed water releases required by, for example:

-  ***drainage to repair leaks or other failures; and***
-  ***accelerated harvest to avoid problems associated with equipment failure, meet maintenance needs or deal with disease emergence on one or more of the farms;***

The underlying assumption of this comment is that un-programmed water releases cannot be managed within the tolerances built into the design of the system. This is not correct. As already outlined, it is normal practice to 'repair' ponds or address failures in between crops. Partial harvests have been built into the simulations. Table 2 in Volume 1, Chapter 5 (Water Balance) shows the capacity of the system which is sufficient to avoid the need for un-programmed water releases as postulated in the submission.

In relation to 'disease emergence' this is addressed separately in Section 3.14.12 in response to Comment 12 from the Department of Environment and Energy.

4. all of the above under unconstrained water movement capabilities and separately within anticipated design constraints;

The modelling was performed using expected design constraints described in the Basis of Design, which is controlled and managed by the proponent for this Project. These constraints include, for example, the seawater intake volume (constrained by pump size and hours of pumping per day). The design constraints (limits) are clearly outlined in Table 3 of Volume 1, Chapter 5 (Water Balance).

5. clarification of the influence, if any, of water temperature management on scale and timing of water inputs;

Table 3.2 in Volume 5, Appendix 6 (Australian Prawn Farming Manual) shows the generally preferred temperature range for optimal growth in prawn ponds as above 24 °C and below 34 °C. Measurements within Turkey Nest dams on the property show that notwithstanding higher air temperatures, water temperatures remain within this range. Water temperature cannot realistically be manipulated to any meaningful degree by water inputs. Hence temperature management will not influence the scale or timing of water inputs.

6. model runs long enough to allow confident predictions of maximum plausible daily and longer term demand; and

The model runs undertaken are sufficient for this purpose and are captured within the statistics that are presented. Daily demand is constrained by engineering design, for example:

- Maximum daily seawater draw is limited by the size of pumps at the seawater intake - the 'unconstrained water movement' referred to in the previous part of the comment is zero at the point of intake since, as shown in Volume 1, Chapter 3, Section 6.2 of the draft EIS (Project Description), active pumping is required and water does not enter the system unless it is pumped in.
- Maximum daily freshwater draw is informed by the size of pumps at the freshwater channel/farm interface, again Table 3 of Chapter 5, Volume 1 (Water Balance) clearly shows the constraints.

The models are run at a sub-daily time step. Statistics as presented in the draft EIS include central tendency, variance and range, over a number of forecast years that by inference include both wet and dry seasons.

7. as well as measures of central tendency, variance and range, presentation of all model outputs in plots of relative frequency of daily demands from both marine and freshwater sources, perhaps broken into at least wet season and dry season or production schedules."

The model results shown include central tendency, variation and range as key outputs, across both dry and wet seasons and incorporating production schedules. Freshwater demand, as shown in the modelling results, is concentrated towards the second half of the dry season. Seawater demand, aside from farm fill demand, is less variable than freshwater demand but also shows, less interannual and inter-seasonal variability (see Figures 8 and 9 Chapter 5, Volume 1 - Water Balance).

"movement of freshwater in many km of open channel rather than through pipes, given that all such water use represents a diversion from the Legume floodplain wetlands"

Pipes were considered but ruled out as not feasible both on the grounds of capital cost of piping and because the open channel minimises the disruption of overland water flow by following the natural boundary of Alligator and Forsyth Creek catchments. The current use of freshwater at Legume is far from optimal from any perspective: economic, environmental or social. Its sole aim is to improve pastoral operations and the inundation of the floodplain is highly variable from year to year. Most of the water that is released to the floodplain is rapidly lost to the atmosphere via evaporation since the practice is effectively to create a massive surface area across which evaporation can take place. The draft EIS clearly identifies the biodiversity and wetland values of Legume Station and shows that the amount of water released, the timing of water release and the area over which water is released varies from year-to-year such that, in this highly engineered landscape in which management decision-making prevails, there is no baseline condition from which to neatly distinguish the effect of the proposed action.

3.18.3 Comment 3

Submitter Type	Independent Statutory Authority	TOR Category or EIS Chapter	Terrestrial Flora; Terrestrial Fauna and Avifauna
Date Submission Received	5 December 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

Management of fresh water is a critical issue for both the project and the landscapes in which it is sited. The EIS deals in considerable detail with the formally-recognised values associated with both the direct footprint of the Stage 1 development, and direct and indirect effects on coastal marine wetlands. At this level, conclusions that matters of national environmental significance (MNES) such as threatened and migratory species are unlikely to be directly and substantially impacted by Stage 1 appear, in general, robust.

The integrity of this site, recognised as regionally (Northern Territory),⁹ nationally,¹⁰ and internationally significant is considerably less clear. Whether values not directly taken into account in these formal assignments of standing, but important for Aboriginal land interests, will be sustained is also unclear. As noted in the preamble to the document nominating the Legume wetlands as nationally important, such places are most usefully viewed as networks of sites. In the aggregate they reliably sustain large regional populations of wetland flora and fauna. Smaller individual components may be important seasonally and then for relatively short periods and also vary in significance from year to year. Snapshots of the sort inevitably generated by the time-constrained EIS process are of limited utility for assigning significance.

Nonetheless, data presented in the EIS illustrate this point nicely. Aerial surveys show how very large numbers of waterbirds—the great majority of those counted over the whole of the wetlands —aggregated briefly in areas flooded by waters released from the Forsyth Creek Dam. These aggregations included large numbers of Magpie Geese,¹¹ which make particularly important contributions to the customary economies of the region's Aboriginal people who focus much of their hunting effort on wetlands.¹²

With diversion of water that would otherwise reach the floodplain, values of the local network certainly change: and species most affected will include those of particular Aboriginal interest. Long-necked turtle that, while not observed in EIS surveys, are known to be hunted by local people¹³ are also most abundant in seasonal wetlands. They have evolved nesting behaviours that include laying eggs underwater, with embryonic development being delayed until the water above the nest dries and hatchlings escaping from the nest following rewetting.¹⁴ Obviously such adaptations are ill-matched to large, arbitrarily timed releases of water to the floodplains. Neither present pastoral practice nor the complete withdrawal of waters favours persistence of this species in affected areas.

The EIS acknowledges risks of damaging change,¹⁵ and outside the footprint of major structures like the ponds, steps are taken in layout of roads and channels and placement of culverts to minimise additional impacts on patterns of flow and inundation. However, there are no corrective actions proposed to compensate for loss of water from the floodplain and changes in distribution and abundance of resources important to Aboriginal people. In this Stage 1 proposal, there are no simple solutions to the diversion of freshwaters to prawn

⁹ Harrison L, McGuire L, Ward S, Fisher A, Pavey C, Fegan M & Lynch B (2009) *An inventory of sites of international and national significance for biodiversity values in the Northern Territory*. Department of Natural Resources, Environment, the Arts and Sport, Darwin.

¹⁰ Whitehead PJ & Chatto R (1996) Northern Territory. Pp 119-176 in *A directory of important wetlands in Australia*, Australian Nature Conservation Agency, Canberra.

¹¹ See page 6.31, Table 4, Vol 2, Chapter 6 of EIS.

¹² Jackson S, Finn M & Featherston P (2012) *Aquatic Resource Use by Indigenous Australians in Two Tropical River Catchments: the Fitzroy River and Daly River*. *Human Ecology*, 40, 893-908.

¹³ Simon Watkinson, personal communication October 2016

¹⁴ Fordham D, Georges A & Corey B (2006) *Compensation for inundation-induced embryonic diapause in a freshwater turtle: achieving predictability in the face of environmental stochasticity*. *Functional Ecology*, 20, 670-677.

¹⁵ see Volume 2, Chapter 8, pages 8.25-8.26

production, and suggestions that additional local dams may be built¹⁶ if the project expands obviously creates concerns.

Proponent Response

Development of the Project necessitates changes to the operation of Forsyth Creek Dam, including cessation of the existing annual release of freshwater to the floodplain. Freshwater from Forsyth Creek Dam will instead be used to meet the Project's freshwater demand. The proponent acknowledges that this change in land management may result in changes to floodplain wetland characteristics.

The annual release of water from Forsyth Creek Dam to the floodplains is a relatively new land management practice; with the first release of water in 2007. Its sole aim is to improve pastoral operations and the inundation of the floodplain is highly variable from year to year. The amount of water released is dependent on the amount of rain in the preceding wet season, and the distribution of water is dependent on the placement of bunds, which are used to direct water into particular paddocks. The variation in inundation extents is illustrated in Figure 11 which shows the waterbird count area which was inundated from the release of Forsyth Creek Dam in 2015 and also in 2016. Due to a drier preceding wet season, and also changes in the placement of bunds, the inundation extent for 2016 is reduced compared to the 2015 inundation extent.

Regardless of where the water is directed to, the release results in an artificial inundation of the floodplain during the dry season for approximately 4 - 8 weeks a year. Therefore, ceasing the dam release will result in a decrease in the extent of surface water for 4 - 8 weeks. However, it is important to note that the release of the dam augments surface water for only 4 - 8 weeks a year, and review of satellite imagery from before the dam was constructed shows that water did, and still does remain throughout the lower section of Alligator Creek and associated wetlands even in the absence of the dam release (see Figures 7-9 in Chapter 3 [Freshwater] of the draft EIS)

Assessment of changes in the operation of Forsyth Creek Dam has focused particularly on changes to wetland habitat and the potential impact this may have on waterbirds. To mitigate the potential impact of the cessation of annual flows from Forsyth Creek Dam on waterbirds, the proponent has committed to preparing a Waterbird Monitoring Program. As part of this supplementary EIS the proponent has prepared a framework for the monitoring program and this is provided in Appendix A. The overall objective of the monitoring plan is to outline a monitoring program and associated data analysis and interpretation, of sufficient power to determine whether limits of acceptable change in waterbird usage of freshwater wetlands of the site have been exceeded, and if so, whether such changes are attributable to the development and operation of the Project at Legume Station.

It is expected that the future finalised monitoring plan will be developed consistent with guidelines such as those provided by the Australian Government (DE 2014). The plan will make provision for corrective action strategies and procedures

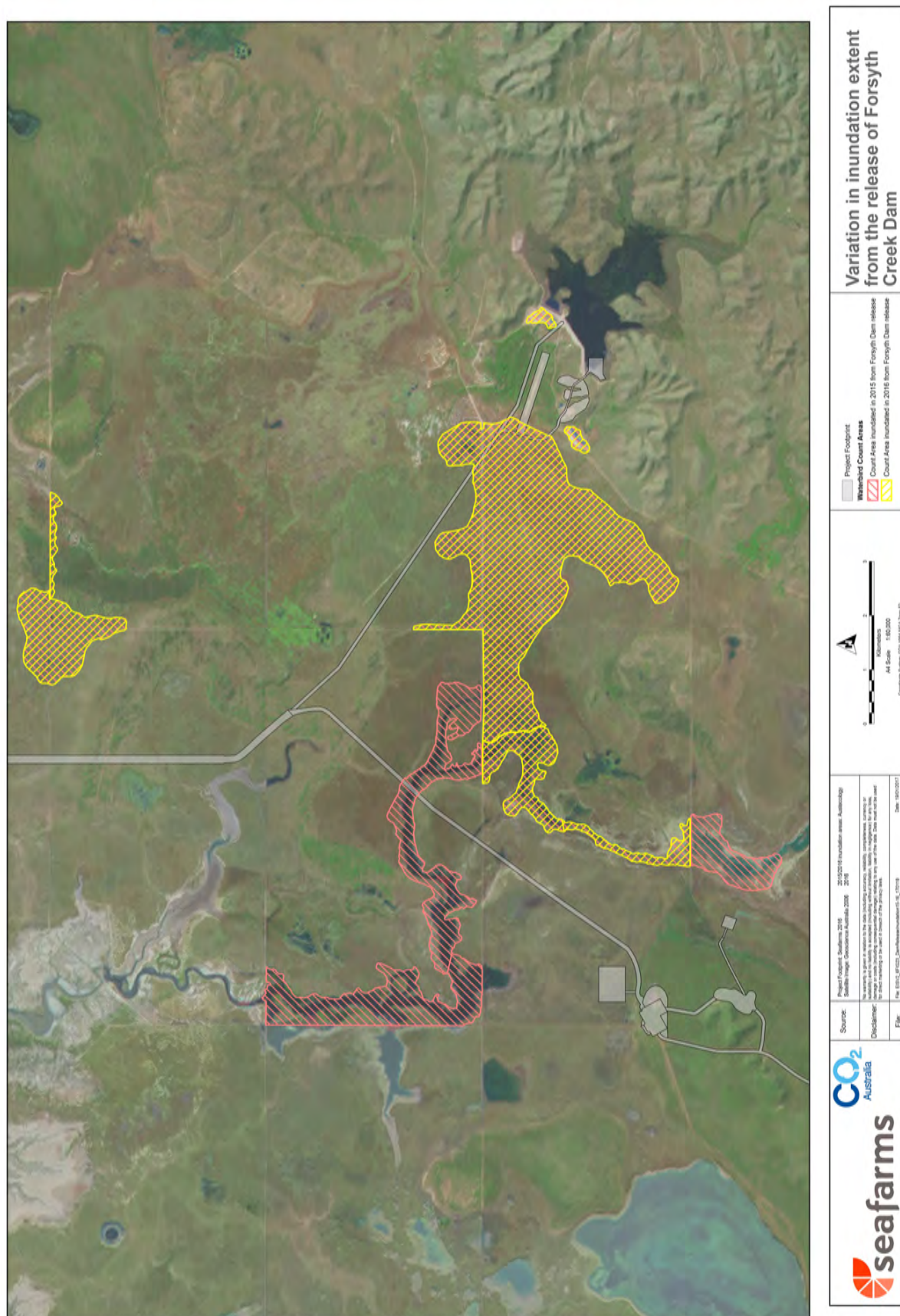
- Role of Scientific Advisory Group
- Plan review schedule and
- Glossary.

As stated in Volume 3, Chapter 2 of the draft EIS, mitigation and monitoring of identified risks to historic and cultural heritage will be directly addressed in the ILUA and through the conditions applying to the proposed

¹⁶ Volume 5, Appendix 17, page 2.

works established by the Aboriginal Areas Protection Authority (AAPA) following consultation with the Aboriginal custodians (Gadjerrong Native Title holders).

Potential development of future stages of Project Sea Dragon, including the development of future water sources, will be subject to environmental assessments, and consultation processes, under relevant Territory and Commonwealth laws.



118

3.18.4 Comment 4

Submitter Type	Independent Statutory Authority	TOR Category or EIS Chapter	-
Date Submission Received	5 December 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

The EIS argues that treatment of many aspects of Aboriginal values will be dealt with through an Indigenous Land Use agreement (ILUA) to be made under the Native Title Act.¹⁷ At this time this is speculative as no agreement has been finalised and so the content of such an agreement has not yet been determined. This opinion in the EIS therefore cannot be supported. In any event this does not justify failure to deal with the perspectives of Aboriginal people on all impacts and their management. To do so is akin to assuming that the views of the Territory's non-Indigenous society will be captured by delegating the task of identifying and protecting values at risk to non-Indigenous pastoralists or other landowners. Agreements with Aboriginal landowners should not be assumed to capture the interests of all Aboriginal residents of the Territory. Effort should be made to deal with the legitimate and reasonably anticipatable interests and concerns of all sectors of society in framing an EIS. Supplementing the enormous literature on mainstream concerns, there is a growing literature on Aboriginal perspectives to help meet this obligation.¹⁸ Taking this responsibility seriously will create opportunity to access valuable local and situational knowledge for management.¹⁹

Unfortunately a narrow approach is encouraged by the NTEPA, which has issued guidelines that urge treatment of concerns about residual environmental damage as a social rather than biophysical issue. This deliberate confounding of environmental obligations with social benefits²⁰ is unique to the NT and inconsistent with best practice recognised by numerous industry bodies and most governments in regard to offsets for residual damage. An independent review recommended corrective action²¹ and the previous (Giles) government agreed to restore requirements for offsets with a view to directing delivery to Aboriginal people wherever possible.²²

It is unreasonable to expect the proponent to have proposed offsets for identified residual damage and risks when urged to do otherwise. Indeed, the EIS rejects an obligation to offer offsets on the reasonable grounds that the Commonwealth Offsets Policy does not apply: because MNES are not significantly affected.²³ Nonetheless, the project offers many opportunities to address, through well-designed offsets, values and impacts of broad public interest as well as the particular interests of Aboriginal people, including those who have no direct connection to the site. Among the most obvious unmitigated (residual) impacts are:

¹⁷ page 1, Volume 1, Chapter 8

¹⁸ Stoeckl N, Jackson S, Pantus F, Finn M, Kennard M & Pusey B (2013) An integrated assessment of financial, hydrological, ecological and social impacts of 'development' on Indigenous and non-Indigenous people in northern Australia. *Biological Conservation*, 159, 214-221. Finn M & Jackson S (2011) Protecting indigenous values in water management: a challenge to conventional environmental flow assessments. *Ecosystems*, 14, 1232-1248. Barber M (2013) Indigenous water values, rights and interests in the Flinders and Gilbert catchments CSIRO: *Water for a Healthy Country National Research Flagship*, Darwin. 211 pp. Robinson C, James G & Whitehead PJ (2016) Negotiating Indigenous benefits from payment from ecosystem (PES) schemes. *Global Environmental Change*, 28, 21-2.

¹⁹ Tengo M, Brondizio E, Elmqvist T, Malmer P & Spierenburg M (2014) Connecting Diverse Knowledge Systems for Enhanced Ecosystem Governance: The Multiple Evidence Base Approach. *Ambio*, 43, 579- 591

²⁰ NTEPA (2013) *Guidelines on environmental offsets and associated approval conditions. Version 2.0. November 2013. Northern Territory Environment Protection Authority, Northern Territory Environment Protection Authority, Darwin. 6 pp.*

²¹ Hawke A (2015) *Review of the Northern Territory Environmental Assessment and Approval Processes. May 2015. Northern Territory Government, Darwin. 38 pp.*

²² Northern Territory Government (2015) *Territory Government Response to the Review of the Northern Territory Environmental Assessment and Approval Processes. November 2015. 13 pp.*

²³ See Volume 2, Chapter 5, page 51 of the EIS.

1. the project's substantial greenhouse gas (GHG) emissions during construction and subsequent operations:
 - over the life of the project, GHG emissions of > 2 million tonnes CO₂-e could be offset by improved fire management and other (carbon sequestration) activity on and off site, and present value of about \$25 million is likely to increase;
2. reduced abundance of wildlife that determine the character and hence amenity of affected landscapes;
3. reduced abundance of wild resources important in the customary economy,
 - given the scale of infrastructure, it may be possible to actively manage some areas (through a mix of supplemented water availability and favourable disturbance regimes) to directly favour culturally and otherwise important species; and
 - well managed grazing can be used to maintain wetland values (especially use by waterbirds) and there may be important roles in re-integrating pastoralism into a modified environment that demands more intensive management;²⁴
4. reduced amenity through an obligation to share access to a smaller area with more visitors:
 - the EIS is ambiguous about approaches to visitor management, on the one hand emphasising exclusion for biosecurity reasons²⁵ and on the other promoting the idea of a Recreational Fishery Access Policy;²⁶
5. an effectively permanent change in the status of Alligator Creek which may make it less attractive as a site for recreation or food for people
 - a role in monitoring may be important to familiarise local people with the extent and significance or otherwise of change;
6. damage to a regionally unique vegetation association (Wild Plum low open woodland);
7. acceptance of high risk of additional exotic plant invasions with additional disturbance of many areas:
 - many damaging weed species are already present and there is an acute risk of increased spread and abundance, which will require active management during construction and beyond;
8. greatly increased vehicle traffic within the site;
9. considerably reduced amenity due to regular presence of helicopters and drones over the ponds and their surrounds:
 - a level of disturbance capable of displacing feeding birds is likely also annoy human observers and impact on traditional uses of the land; and
10. acceptance of the considerable risk of further reduction of use options and cultural value as the project grows.

²⁴ Statements at page 28 Volume 3, Chapter 1 promote the idea of Aboriginal employment in pastoral operations, which would be separate from this environmental management role.

²⁵ See Volume 3, Chapter 3, page 15

²⁶ See Volume 3, Chapter 1, page 47

In combination with other land and resource management activities like crocodile and fire management, working to offset this suite of damages and risks would address many of the commitments made in the EIS documents by placing them in the hands of a suitably trained and equipped Aboriginal ranger group. The project is large enough and will run long enough to make establishment and consolidation of the necessary structures and workforce a realistic target.

Ideally commitments to an offset program would be incorporated in conditions of approval under the various applicable laws. However, given the instructions issued to the proponent, in this case it may be necessary to rely on private agreement between the proponent and relevant traditional owners.

Proponent Response

Chapter 2, Volume 3 of the draft EIS addresses the terms of reference for the EIS. Beyond this, the NLC submission does not correctly interpret the intention, nor the process, that the proponent has discussed with the NLC and other stakeholders in relation to wider indigenous interests and views. The overall project is larger than the Legume component, and in discussions with stakeholders the proponent's understanding is that discussions of interests wider than those covered by an ILUA need to be addressed such that negotiations within the context of an ILUA would not be prejudiced. Thus an indigenous engagement strategy that addresses issues raised by the NLC was always intended to be developed, in consultation, with stakeholders. However, such discussions if conducted too early, may in fact be problematic. Nonetheless the proponent has held discussions with MG Corporation and Kununurra Warringari Corporation, as examples of relevant local indigenous organisation as a part of early engagement. It should be noted that Section 10.1.4 of the draft EIS Executive Summary does recognise a number of measures mooted by the NLC, including specifically the establishment of indigenous rangers groups or programs etc. Moreover, the NLC itself notes, *"that it may be necessary to rely on private agreements between the proponent and relevant traditional owners"*. As suggested by the NLC such elements of any agreement would only be understood once approvals are given.

As noted in the submission, the NT EA Act makes no provision for the imposition of environmental offsets as part of an assessment or approval process. Whilst the Commonwealth Government's EPBC Act Environmental Offsets Policy is applicable to the Project, the Project will not result in significant impacts to Matters of National Environmental Significance and therefore, offsets are not required to be delivered.

Many of the suggestions raised in the submission are dealt with through the implementation of the Project's Environmental Management Plan (e.g. weed, traffic and vegetation management), which ensures a comprehensive adaptive management and monitoring program is maintained throughout the life of the Project. Additionally the ILUA aims to address a variety of matters important to Native Title Holders.

Nonetheless the proponent agrees there are opportunities to address potential Project impacts through voluntary measures. The proponent is already considering or pursuing a number of the proposed measures presented in the submission, including improved fire and land management on Legume Station, reducing potential impacts on amenity (for example see the Access and Recreational Fishing Policy in Appendix D) and the engagement of Indigenous rangers for the provision of a variety of services, including monitoring.

3.18.5 Comment 5

Submitter Type	Independent Statutory Authority	TOR Category or EIS Chapter	
Date Submission Received	5 December 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

A site decommissioning and rehabilitation plan is to be prepared after project approval. Presumably this would be done under the remedial plan provisions of the *Pastoral Lands Act* or possibly within the terms of a future ILUA, which raises questions about power to require bonds or other guarantees. More significantly from the perspective of Aboriginal interests, the EIS mentions potential to re-use structures as ponded pastures or, if rehabilitation for pastoralism proves impossible, environmental purposes.

These propositions create both risks and opportunities for protection of Aboriginal values and interests. Ponded pastures and the invasive pasture grasses they favour simplify wetlands so that they do not offer the mix of resources needed for diverse wildlife assemblages,²⁷ or even for single species like Magpie Geese.²⁸ Use for environmental purposes may create options for Aboriginal management in partnership with government or NGOs, but benefits would obviously depend on the particular arrangements.

At worst, premature failure of the venture could leave Aboriginal interests with a grossly degraded site placed on a low return, high environmental cost pastoral development pathway that would not have been possible without a major injection of capital for constructing great lengths of embankments and other infrastructure. It will be important that the roles of native title holders in determining future use are clearly established in pastoral lease conditions or other binding agreement. Ideally, capacity of Aboriginal interests to influence future protection of environmental and cultural values should be a condition set by the Minister for approval of non-pastoral use.

It is likely that development beyond Stage 1 would raise questions about pastoralism as the dominant use and perhaps trigger a necessary change of tenure. This should be considered in framing options to protect Aboriginal influence over protection of environmental and cultural values over the longer term.

Proponent Response

Several issues raised in the comment fall within the remit of government and Northern Territory legislation rather than the proponent.

The rehabilitation plan discusses a range of post-land use options, and that consideration would be made in consultation with all relevant stakeholders. The plan provided for a particular scenario (see Volume 1, Chapter 3, Section 11), reinstating pastoral use (as an anticipated requirement under the non-pastoral use permit requirements), with environmental uses where this was not possible. In developing and continuing to refine the plan before and during Stage 1, the preferred post project land use (or range of uses) will be further defined with relevant stakeholders.

The proponent acknowledges that there may opportunities for Aboriginal management 'post-use' and at the least would anticipate that Aboriginal interests would be clearly included in any 'post-use' discussions and arrangements. The proponent also notes that it is difficult to detail what such arrangements may be without prejudicing ILUA discussions which includes understanding better the aspirations of Native Title Holders and being able to take into account wider Aboriginal interests.

The proponent is fully aware of the nature of the Non-Pastoral Use permit. The size of the Stage 1 development clearly poses less risk of the undesirable outcomes speculated within the submission than would a more expansive development. Future stages of Project Sea Dragon are outside the scope of this EIS and this

²⁷ Clarkson J (1995) *Ponded pastures: a threat to wetland biodiversity*. Pp 206-211 in C Finlayson (ed) *Wetland research in the wet-dry tropics of Australia*. Environmental Research Institute of the Supervising Scientist, Jabiru.

²⁸ Whitehead PJ & Dawson (2000) *Let them eat grass*. *Nature Australia*, Summer 2000, 46-55.

comment from the submitter illustrates why the staged and adaptive management approach has been adopted.

3.18.6 Comment 6

Submitter Type	Independent Statutory Authority	TOR Category or EIS Chapter	
Date Submission Received	5 December 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

Despite the decision to restrict considerations to Stage 1, the EIS floats options for additional water supply, including access to water brought to the region through the proposed Ord Stage 3.²⁹ The Northern Territory Government has proposed that it may “if required, provide a land corridor to enable a water supply channel for proposed developments on the Legume Pastoral Lease”.³⁰ However, the progress of the Ord Stage 3 project is entirely unclear without further public comment from the Northern Territory Government since the Request for Proposal registration date closed on Friday 27 May 2016.³¹

If the project is to access water brought to the region through Ord Stage 3 (which has been opposed by local Indigenous interests to date) then there is clearly potential to restore freshwater flows to the wetlands and to avoid risks of further diversions through additional local dams, as mooted in the EIS. But the footprint of another 800+ 10 ha ponds and supporting infrastructure may render such options irrelevant. It may be reasonable to seek agreement to a cap on the pace of development—including a lengthy pause after Stage 1—to allow proper consideration of the full implications at a regional scale.

Clearly it is impossible to abstract consideration of Stage 1 from options for expansion and connected decisions. The absurdity of the attempt is illustrated by the NTEPA request for a cumulative impact assessment accounting for “reasonably foreseeable future development”, while apparently disregarding that full implementation of Project Sea Dragon is unforeseeable or irrelevant. The bureaucratic drivers of such a contradictory approach are perhaps understandable, but effectively avoid serious land use planning, which was also recognised as essential in the Hawke review.

All EISs should facilitate public understanding of the implications of a proposed development. That task is more complex when genuinely informed consent is sought from Aboriginal people who may have no previous exposure to such issues and may infrequently use written or even spoken English for routine communications. We note that the proponent has sought to engage with the NLC in respect of facilitating some of this communication with Aboriginal stakeholders. However, better Government coordination of the various regulatory approvals, including in particular recommending obtaining of an authority certificate pursuant to the Northern Territory *Sacred Sites Act* and consultations with Aboriginal stakeholders as an initial or even preliminary step in any development proposal would result in better outcomes for Indigenous stakeholders.

Even briefly removing the blinkers raises obvious questions for traditional owners and other Aboriginal interests: will agreement on Project Sea Dragon increase pressure to agree to Ord Stage 3 (should it still be a

²⁹ See, for example Volume 5, Appendix 17, page 2 “As the project expands, additional water from either an additional dam which could be sustained on the property or accessed via the adjacent ORIA”.

³⁰ Northern Territory Government & Northern Territory Land Corporation (2016) *Ord Stage 3 Expansion: Request for Proposal (April 2016)* 6 pp.

³¹ *Ord Stage 3 Expansion - Spirit Hills*, <https://nt.gov.au/industry/major-projects-in-NT/ord-stage-3-expansion-spirit-hills>, visited on 29 November 2016.

live proposal), even though the area proposed for development is less than optimal for agriculture³² and traditional owners regard the Stage 3 sites as unsuitable for broad-scale development on cultural grounds?³³ Obviously the business case for investment in water infrastructure for Ord Stage 3 will be greatly improved if a major user is already in place near the terminus of that canal.

The next obvious question, which the EIS has not sought to address, is about cumulative effects on environmental, social and cultural values delivered by both developments in tandem?

How should the prospects of such synergies influence conditions of approval and related agreements about compensating benefits for the region's Aboriginal people?

Proponent Response

The proponent has planned the development of the Project at all scales on the basis that water from the Ord system is not required. Thus within the EIS the base assumption is that future Ord Stages may not (or would not) proceed.

The proponent spent considerable time attempting to determine whether a meaningful cumulative impact assessment could be undertaken taking a future Ord development in 'tandem' with the Project into account. The genuine unknowns, in the proponent's view made a cumulative impact assessment of both projects in tandem at best meaningless and more likely grossly misleading. Key requirements to attempt a cumulative impact assessment include:

- the areal extent of any future Ord development (unknown)
- the land use and land-use mix (e.g. cropping, grazing, feed-lotting, forestry, conservation reserves, cultural reserves inclusions or exclusions, also unknown)
- water use and water requirements (unknown and closely related to land-use, but also operational management)
- infrastructure developments (unknown)
- infrastructure costs and financing (unknown).

Any development (or not) of Ord 3 is not within the remit of the proponent.

Furthermore there is a general misapprehension of the purpose of cumulative impact assessments. Such assessments are intended to assess the risk to the environment in which a new or even small-scale (or otherwise minor) development incrementally adds an environmental impact (or load) which causes a threshold to be exceeded or breached. Alternatively put, a development causes a state-change in a receiving or local environment because of the pre-existing developmental condition of that environment. Thus the appropriate way of capturing a cumulative impact of both the Project and Ord 3 is during subsequent environmental assessments when an assessable proposal actually exists.

³² Petheram, C. et al. (2014) *Northern rivers and dams: a preliminary assessment of surface water storage potential for northern Australia. Technical Report. CSIRO Land and Water Flagship Technical Report. 5 December 2014. CSIRO Land and Water Flagship, CSIRO, Canberra, 79 pp.*

³³ Warchivker, I. et al. (2012) *Victoria River District Economic Development Opportunities. STAGE 1: Scoping Study Report for Northern Land Council. December 2012. TopEndFarm for Centrefarm Aboriginal Horticulture PL, Alice Springs. 76 pp.*

3.18.7 Comment 7

Submitter Type	Independent Statutory Authority	TOR Category or EIS Chapter	
Date Submission Received	5 December 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

Because turnover of large volumes of water is required to manage high evaporation rates in the dry and dilution in the wet, it is not clear how pond water would be managed without release to the environment immediately after a “notifiable” disease was detected. The issues go beyond the disposal of the great mass of prawns (up to 5,000 tonnes) to be destroyed in the event of a serious disease.

Commitments are made to avoid use of toxicants or antibiotics that may enter discharge, but it is not clear how this could be maintained if treatment for a (say) bacterial or fungal disease was required, given the size of the facility.

Given the presence of disease in wild prawn populations and the large intakes of seawater and other pathways for entry of disease organisms (e.g. in birds’ excreta) significant disease issues are likely to arise during the life of the project. Their implications for all aspects of management and impacts on the environment should be thoroughly documented and meaningful responses put in the EIS.

Proponent Response

See responses to submissions raised by the Commonwealth Department of Environment and Energy in Section 3.14.7 (Comment 12) and Section 3.14.28 (Comment 28).

3.18.8 Comment 8

Submitter Type	Independent Statutory Authority	TOR Category or EIS Chapter	Human Health and Safety
Date Submission Received	5 December 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

There is little information presented on capacity to restore operations in the event of loss or damage to fixed and mobile equipment through major cyclones or other storms.

Proponent Response

Volume 3, Chapter 3 of the draft EIS (Section 2.1.2) describes emergency measures to be employed, including emergency fuel supply, generators, emergency response plant and equipment, suitable fuel stores, emergency response centre, provision of suitable rations for emergency situations. Post cyclone response is described, stating that once *“the cyclone threat has passed and the all clear has been issued by the relevant emergency services, the relevant managers will conduct a site assessment to identify any potential hazards and take note of the recovery actions required to be undertaken.”* Access to various parts of the Project site will be restricted to personnel until safety is assured.’

Design has been undertaken taking into account potential major storm damage, particularly isolation, with major access roads built to be passable for the 1 in 100 year storm event. A detailed Adverse Weather Preparedness Plan will be prepared, as committed to in the aforementioned draft EIS section. Procedures will detail forewarning, site preparation, and post storm response procedures. Seafarms Queensland operates with

an Adverse Weather Preparedness Plan which provides details of steps to be taken to protect fixed and mobile plant, prawns and people in the event of adverse weather. This existing plan is largely transferable to Legume operations and will be reviewed once final design and assets are identified.

Additional information on the proponent's capacity to restore operations in the event of a cyclone is provided in response to Comment 15 from the NT EPA in Section 0.

3.18.9 Comment 9

Submitter Type	Independent Statutory Authority	TOR Category or EIS Chapter	Project Alternatives
Date Submission Received	5 December 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

Project Alternatives: Treatment is mostly about the proceed/don't proceed binary rather than issues in design like the decision to use open unlined channels for water management rather than pipes.

Proponent Response

The Project Alternatives chapter (Volume 1, Chapter 4) discusses the various alternatives to the Project as well as the various components of the Project that were considered during the planning and design phases. Alternatives that were considered in this chapter included:

- not proceeding with the Project
- the location of the Project
- the location and design of various Project components, including water distribution infrastructure
- operational processes.

Options for seawater distribution are discussed in Section 4.2. An open channel was chosen as the preferred option as the construction of a pipeline would be more expensive, have a larger footprint and would be more difficult to maintain due to marine fouling. Additionally, marine fouling of the pipeline would have resulted in regular chlorination and higher downtime for mechanical cleaning.

Options for freshwater distribution are discussed in Section 4.5. An open channel was chosen as the preferred option (as opposed to a pipeline) as, while both options were considered equal in terms of potential for environmental impacts, the open channel involves less capital and operating costs, and minimises the disruption of overland water flow by following the natural boundary of Alligator and Forsyth Creek catchments.

Section 5.3 of the Project Description chapter (Volume 1, Chapter 3) states that ponds and channels will not be lined with any other materials, as the surface soils (the black clay soils on the estuarine-deltaic plain) provide the impermeability needed to retain the water for operations, as shown by both the geotechnical investigations (Douglas Partners 2016) and the on-site trial investigations. Further information on the impermeability of the soils is provided in Appendix F of this SEIS.

3.18.10 Comment 10

Submitter Type	Independent Statutory Authority	TOR Category or EIS Chapter	Freshwater
Date Submission Received	5 December 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

The ToR for the EIS require “options for minimising water use” (page 16). It is questionable whether the decision to use very long open channels for delivery of freshwater meet this requirement, given that delivery to the floodplain of water excess to farm demands (because not lost to evaporation) could be used to maintain some important values at at least some sites.

Proponent Response

The decision to use open channels relates to the economics of using large bore long distance pipelines which are a very expensive alternative to open channels. These open channel structures have been used in agricultural systems, particularly large scale systems in northern Australia, since they are generally more practical in terms of construction and operational costs, management and maintenance.

The modelling conducted (refer to Volume 1, Chapter 5 of the draft EIS) provides for evaporation in the freshwater channel showing that the scheme is a small percentage of the total freshwater supply, and does not represent a major loss to the water balance. To illustrate, Forsyth Creek Dam has an operating surface area of approximately 414 ha, depending on the storage height. The freshwater channel has a surface area of approximately 67 ha in its run from the dam to farm. Therefore the freshwater channel represents 14% of the Forsyth Creek Dam area. The evaporation losses from the freshwater channel will be significantly less, because the freshwater will only be released from the dam when the farms are drawing in freshwater for salinity control purposes. This is, according to the water balance model, in the dry season for 3-4 months of the year.

3.18.11 Comment 11

Submitter Type	Independent Statutory Authority	TOR Category or EIS Chapter	-
Date Submission Received	5 December 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

Wildlife mortalities and injury on roads is treated primarily as an issue for the maintenance of populations. More attention should be given to related animal welfare issues.

Proponent Response

It is not clear in what regard the draft EIS treats wildlife mortalities as *“an issue for the maintenance of populations”*.

The draft Fauna Management Strategy presented in the draft Environmental Management Plan (Volume 4, Chapter 3, Table C6.1) states the following aim:

- To maintain the conservation status, abundance, diversity, geographic distribution and productivity of flora and fauna at species and ecosystem levels through the avoidance or management of adverse impacts on the Project area and on adjacent areas that may be impacted.

Two objectives of the strategy are:

■ Minimise the impacts of clearing and construction on flora and fauna

■ Minimise impacts of operations on fauna

Targets to meet these objectives include:

■ No harmful incidents involving wildlife

The draft Fauna Management Strategy outlines a number of actions/mitigation measures to achieve these targets, as well as monitoring, reporting and corrective actions. The draft Environmental Management Plan and Fauna Management Strategy will be finalised following Project approval, and will continue to include measures to address animal welfare issues.

3.18.12 Comment 12

Submitter Type	Independent Statutory Authority	TOR Category or EIS Chapter	-
Date Submission Received	5 December 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

Fire issues are treated primarily as avoidance of wildfire and impacts on infrastructure. Although obviously critical, these objectives will be better secured within a landscape managed intensively to reduce risk and support good environmental outcomes. This potential for Aboriginal people to offer this service should be recognised in any agreements with the proponents.

Proponent Response

The proponent agrees with the substance of this comment and attempted to open discussions in relation to engaging Aboriginal services and for the establishment of ranger groups. This matter was raised in private discussions but the proponent was advised at the time by some Aboriginal organisations that such discussions were premature. The proponent has signed confidentiality agreements with some Indigenous organisations and has commenced discussions in relations to services that may be delivered. The proponent notes that this is only one of many prospective areas for Aboriginal engagement in the Project.

3.19 NT EPA

3.19.1 Comment 1

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	-
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	General comments

Details of the Submission

The Proponent is the largest producer of farmed prawns in Australia and currently operates aquaculture facilities across three locations in north Queensland, including 148 ponds over 160 hectares and producing in excess of 1000 tonnes/annum. The stage 1 Legume Grow-out facility is an order of magnitude larger than the Proponent's current operations consisting of 40 grow-out ponds, internal recycling ponds and channels covering 1,080 hectares and producing 14,000 tonnes/annum. The project requires saltwater inputs of 575 ML/day from Forsyth Creek, 410 ML/day of wastewater discharge into Alligator Creek and on average freshwater inflows of 35 ML/day from Forsyth Dam. With such a large-scale project, it is essential that elements such as pond construction, freshwater inputs and wastewater discharge be managed to ensure the environmental values of the Legume wetlands are maintained. The significant issues from review of the draft EIS are:

- There is significant uncertainty of the effects of the change from a Dry season water release regime to a water withholding/diversion regime at Forsyth Dam on waterbird populations at Legume, particularly in the Alligator Creek freshwater system. Given the significance of waterbird populations at Legume, a statistically robust avifauna monitoring and management plan is essential to ensure an adaptive response in management of the site if negative impacts are detected. A monitoring and management program developed in consultation with relevant Northern Territory and Australian Government advisory agencies is required in the Supplement to enable the NT EPA to complete its assessment;
- There is significant uncertainty about management techniques for predatory birds; both the effectiveness and the potential impacts to non-target bird populations in the area. Given the issue presents an operational risk to the project, a review of contemporary bird predation mitigation methods should be provided, including both literature and experiences from the Proponent and other aquaculture and relevant industries (e.g. agriculture, mining) in Australia and internationally;
- A lack of interpretation and synthesis of the geotechnical results does not allow assessment of the material suitability of the soils for project design and pond construction. The results from soil investigations and trial earthworks need to demonstrate the soils will provide sufficient impermeability and long term stability of pond and channel structures; and
- There is some uncertainty that the proposed discharge criteria for wastewater into Alligator Creek can be met based on the information provided in the draft EIS.

Proponent Response

These points are addressed in response to specific comments listed below.

3.19.2 Comment 2

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Project Description
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Volume 1 – Chapter 3; Section 2.6 Location

Details of the Submission

The grow-out ponds comprise a major part of the project area and are located above RL 4.5m AHD. The area that is subject to regular tidal influence is nominally between RL 4.5 - 5.0 AHD. Confirm that all ponds are above these regular tidal influences (i.e. above 5.0 AHD). If not, discuss measures that will be used to minimise impact to pond infrastructure from tidal influences and potential storm surge.

Proponent Response

As detailed in Section 2.1.3 (Intertidal Plains - page 26) of Appendix 8 (Coastal Assessment and Hydrodynamic Modelling), offshore, the highest astronomical tide (HAT) is in the order of 5.1m Australian Height Datum (AHD), however the HAT level will vary across the site as the tidal flows are funnelled through the estuaries and creeks. A step change in the topography is observed in the LiDAR, aerial imagery and site inspections (see Image 7 of Table 2-1 in Appendix 8 of the draft EIS) at the interface between the intertidal plain and the higher floodplain and also Plates 1 to 3 below. This step change generally occurs between 4.5 to 5.1 m AHD. Hence the level of HAT varies across the site from 4.5 to 5.1 m depending upon local variations in topography. The grow-out ponds are all located above the aforementioned step change that denotes the boundary of HAT.

The only infrastructure exposed to tidal influence are the intake structure (pier and pumps), the intake channel, settlement pond, and the discharge weir, all of which have been engineered to withstand tidal influences in these locations (refer to Section 3.5 in Appendix F of this SEIS). These areas will be armoured for protection against storm surge (as stated in Section 6.3 of Volume 1, Chapter 3 of the draft EIS), and sited to best take into account scour and erosion processes (see Section 6.14.1 of Volume 1, Chapter 3 of the draft EIS). Scour protection is shown in various drawings within this chapter, including for example Figures 11, 12 and 24.



PLATE 1 STEP CHANGE IN TOPOGRAPHY SHOWING ABOVE AND BELOW HAT - NOTE THE PRESENCE OF VEGETATION ABOVE HAT



PLATE 2 STEP CHANGE IN TOPOGRAPHY (AND DINGOES) SHOWING ABOVE AND BELOW HAT - NOTE THE BANDS OF DIFFERING VEGETATION WITH INCREASING TOPOGRAPHY



PLATE 3 STEP CHANGE IN TOPOGRAPHY

3.19.3 Comment 3

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Project Description
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Volume 1, Chapter 3, Section 2.9.1 - Legume Pastoral Operations; Volume 4, Chapter 1, Cumulative Impact Assessment

Details of the Submission

Stage 1 of Project Sea Dragon will remove around 3239 ha areas of estuarine-deltaic plain, which comprises around 50 000 ha of the 178 800 ha pastoral lease, from pastoral activity. In addition, water from Forsyth Creek Dam will be redirected from pastoral irrigation to prawn pond management. The details of how the pastoral and aquaculture operations will be managed will be specified in the Non-Pastoral Use agreement.

This section states that existing pastoral operations on Legume station will continue during the construction and operation of all stages of the project. Cattle grazing can have substantial effects on erosion processes and associated water quality effects which may result in cumulative impacts on water quality unless cattle destocking in the catchments occurs. Provide details on expected changes to stocking rates and pastoral use in and around the footprint area and the potential for rehabilitation of the natural environment that may reduce sediment and nutrient runoff from the site itself.

Proponent Response

Legune Station is currently managed as a large-scale pastoral operation, carrying up to 22,000 head of cattle. Pastoral operations on Legune will be impacted by construction and operation of the Project due to:

- Reduced pasture area - as currently grazed floodplain is covered by prawn ponds and infrastructure
- Restricted cattle operations movement – due to water channels and traffic corridors
- Reduction/cessation of pasture irrigation – as water is prioritised for use in the prawn farms.

Table 11 indicates the land and water resources required for the Project and consequences for stocking rates. For Stage 1, 900 hectares of the fertile floodplain is removed from grazing, reducing grazing capacity by 900 adult equivalents. Figure 12 shows the impact of the Project on pastoral operations.

In terms of rehabilitation, the site will continue to be managed as an ongoing pastoral operation in conjunction with the aquaculture operations. Ongoing site maintenance will continue with an aim to minimise erosion and nutrient loss to the environment, amongst other activities such as weed control. Volume 2, Chapter 1 of the draft EIS (Geology, Geomorphology and Soils) describes the ongoing use of erosion controls, revegetation and rehabilitation works that will be undertaken to ensure the stability of the Project footprint. Many areas of the site are naturally erosive however (particularly at the fringes of tidal areas), and control of natural erosion in areas not affecting the Project will not be targeted for ongoing rehabilitation. There is the opportunity, as outlined in Section 3.6 of Volume 2, Chapter 9 of the draft EIS (Waste Management), for the use of silt from the sediment dam and pond/channel waste in revegetation processes.

TABLE 11 AREA ON LEGUNE OCCUPIED BY NON-PASTORAL ACTIVITY AND CONSEQUENCES FOR STOCKING

	Before the Project	Stage 1
Grow-out pond area (ha)	0	1,080
Fertile floodplain used by the Project (ha)	0	3,000
Fertile floodplain available for grazing (ha)	53,000	50,000
Fresh water used by the Project per year (GL)	0	9
Reduction of floodplain grazing capacity due to development of the Project (* assumes 30 AE/km ²) (AE)		900
Estimated cattle carried on fertile floodplain (AE)	15,900	15,000
Estimated cattle carried elsewhere on Legune Station	6,100	6,100
Estimated cattle carried on Legune Station (AE)	22,000	21,100

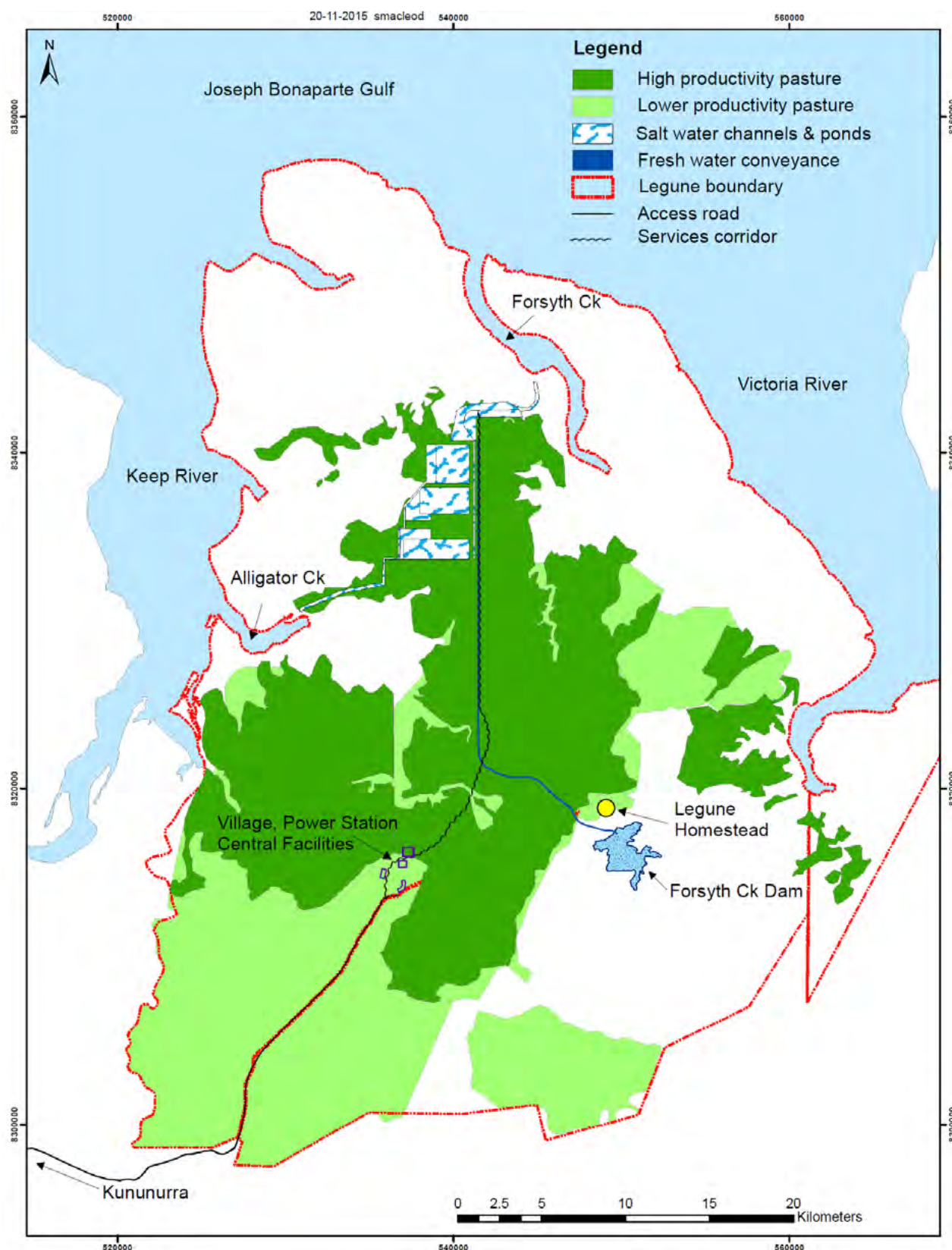


FIGURE 12 PASTORAL OPERATIONS AND STAGE 1

3.19.4 Comment 4

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Project Description
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Section 5.3 - Pond, Channel Walls and Berm Construction

Details of the Submission

Ponds and channels will not be lined as the surface soils (black clay soils) provide the impermeability needed to retain the water for operations, as shown by both the geotechnical investigations and the on-site trial investigations.

It is recognised that suspended soils and ammonium discharge loads can be reduced by lining banks or entire ponds to reduce or eliminate erosion (Burford et al. 2003). In addition, there may be potential for dispersion of sodic soils in the upper batters during rainfall events. Clarify whether consideration has been given to improving water quality through lining internal batters to reduce potential erosion.

Include the results on the on-site trial investigations that demonstrated the required impermeability had been met.

Proponent Response

Section 3.1 in Appendix F of this SEIS discusses bank lining and dispersivity/stability, following trials and discussions for activities on similar soils in the region (Section 2.1 in Appendix F), and permeability is discussed in Section 3.3 in Appendix F. with reference to water quality, overall, while pond lining was considered as part of the Project design, it was considered unnecessary to line the banks in this manner, since water quality limits can be met (refer to the draft EIS, Volume 2, Chapter 2, Marine and Estuarine Water)

Overall the laboratory and field works show that the required impermeability can be met.

3.19.5 Comment 5

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Project Description
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Section 6.1 - Figure 9

Details of the Submission

Figure 9 does not provide an indication of water recycling from the internal farm recycling pond and should be amended.

Proponent Response

The backwards facing arrow from the IFRP was inadvertently omitted in the Figure 9 of Volume 1, Chapter 3. The corrected figure is provided below.

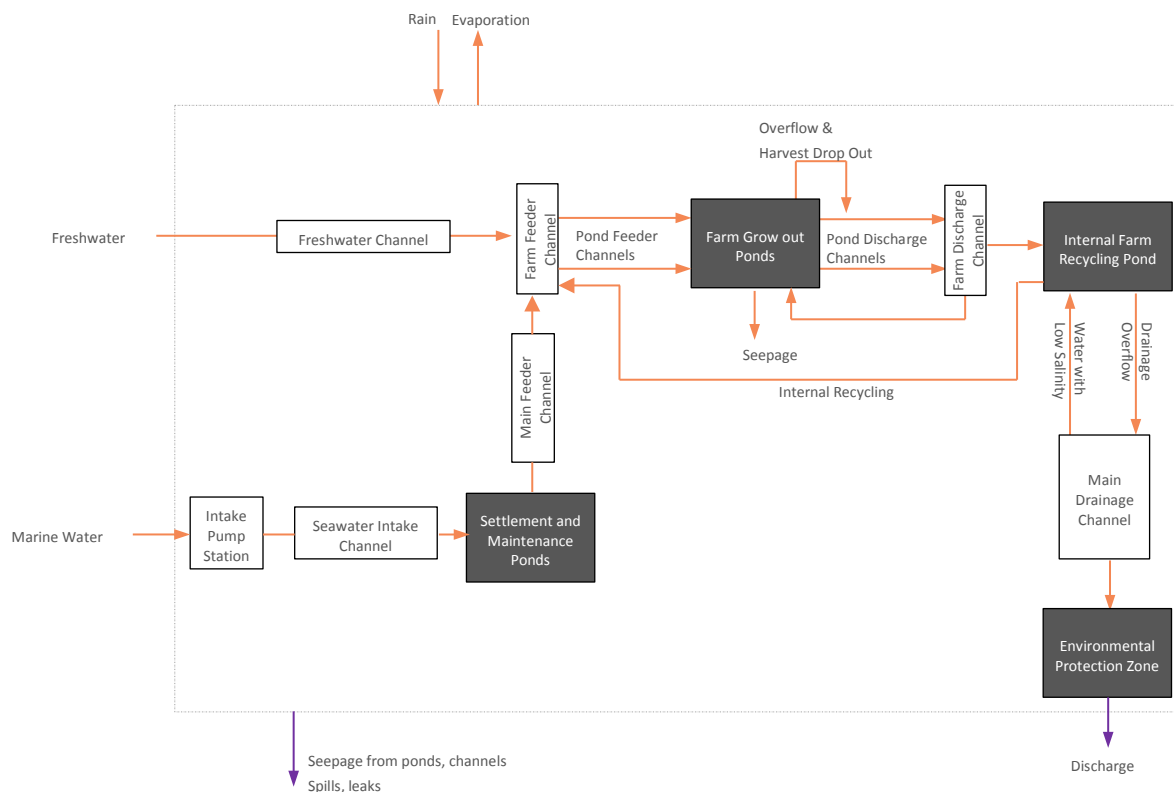


FIGURE 13 CORRECTED GROW-OUT CENTRE WATER FLOW DIAGRAM

3.19.6 Comment 6

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Project Description
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Section 6.10 Ponds

Details of the Submission

Stop-log designed to allow automatic overflow to the PDC in high intensity storm events, so that the ponds are not overtopped in the minor design level storm event.

For greater than the major design event, a lined swale will be provided in the berm of the outermost channel for planned release to the environment. In such events, the salinity of the water being released is expected to be very diluted by the rainfall event.

For events greater than the design event, the stormwater will be released to the environment, through controlled release lined swales (or low points in the bund wall)

Provide details on:

-  how these stop logs would work during high intensity rainfall events when all ponds are approaching maximum capacity;
-  whether the ponds have a designed spillway to maintain integrity of bund walls;

- freeboard height for the ponds;
- management of prawn escapes from potential stormwater release; and
- whether this planned release into the environment requires licencing.

Proponent Response

The referenced draft EIS section (Volume 1, Chapter 3, Section 6.10) contains further information not included in the above submission. Essentially, the stop logs allow automatic overflow to avoid any overtopping during the minor design level storm event (10 year ARI).

For events between the minor and major design event level (>10 year up to the 50 year ARI events), controlled gravity release will be undertaken through weir structures to the Internal Farm Recycling Pond and then to the Main Discharge Channel. The lined swales are then used to contain flows above the major design event.

Section 8.1.12 of Volume 1, Chapter 3 of the draft EIS also provides for controlled lowering of the water level in the farm pond/channel system by pumping through to the Main Discharge Channel. Ponds would overflow via their emergency spillway into this larger system.

Further detail on the above, and on management of water levels, is provided in Section 3.7 in Appendix F.

In terms of licensing, the releases would be captured under the normal operational license, and would be required to comply with this license. Control would be implemented to adhere to daily flow limitations where possible, and up to designated storm events.

3.19.7 Comment 7

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Project Description
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Section 6.14 Environmental Protection Zone (EPZ) and outfall

Details of the Submission

The proposed impoundment area referred to as the Environmental Protection Zone (EPZ) appears to be primarily a hydraulic balance structure that would utilise the landform of the estuarine-deltaic plain. The EPZ is not a buffer between the project and the environment, it is an operational requirement for the management of discharge from the site (and it will be modified from its natural state as a function of its purpose) and should therefore be clearly identified as a project component within the project footprint.

Proponent Response

The basis of this statement is unclear as Section 6.14 states that *"the primary function of the EPZ is to regulate the flow of the discharge water by reducing the velocity and holding the water so that discharge can be timed to the ebb tides and can be discharged at a constant level of 410 ML/day during those ebb tide releases."*

The EPZ is in fact openly and clearly identified throughout the entire EIS as part of the Project, and is shown on all the figures in the EIS as a project component. Table 5 'Major Project Components and Design Particulars' of the Project Description (Volume 1, Chapter 3) identifies the footprint of the EPZ as 376.44 ha. This area is included in the Project footprint.

3.19.8 Comment 8

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Project Description
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Section 6.14 Environmental Protection Zone (EPZ) and outfall

Details of the Submission

Adverse impacts have been associated with broad scale development of ponds and channels within floodplains in many areas of Australia. Although acceptable in the past, it is now less acceptable to locate aquaculture pond systems within sensitive environments such as floodplains. Risks associated with the proposed structure, include potential for:

- impacts on local groundwater hydrology and natural vegetation due to infiltration of saline water, and
- episodic release of wastewater with high concentrations of metals, low dissolved oxygen, high oxygen demand, due to potential fluxes in the oxidation state in the water column and sediment.

The EIS should detail how such impacts will be prevented and provide details to demonstrate that the EPZ will be designed, monitored and operated to:

- prevent stratification and nuisance algal growth
- achieve specific objectives for contaminant removal from the wastewater stream
- ensure long term impermeability to prevent infiltration of saline water.

Proponent Response

Discussion of the impermeability of site soils and the lack of impact on existing saline groundwater tables is described in responses to the Department of Environment and Energy Comment 26 (Section 3.14.26), with discussion of impacts in relation to salinity in Section 3.4 in Appendix F, and low permeability discussed in Section 3.3 in Appendix F. The EPZ will operate within the surface black clay soils, with existing in-situ low permeability.

In terms of episodic releases of high metal, low dissolved oxygen, high oxygen demand waters, this would presumably be due to poor water quality resulting in oxidating / reducing fluxes from sediments. Pond water quality management is the major element of the Project, with substantial live monitoring and control implemented on the site. The kind of episodic conditions described would only result from unusual circumstances (for example, major equipment failure after storm conditions). There are a number of measures in place to negate the likelihood of equipment failure, for example, backup fuel supply provided for extended operation for the on-site generators in the event of inability to access off-site fuel supplies. There is also opportunity for operational contingency measures for maintaining pond water oxygenation such as dosing with hydrogen peroxide for emergency oxygenation.

The EPZ operation is described in Volume 1, Chapter 3, Section 6.14 of the draft EIS (Project Description), stating specifically that the *"primary function of the EPZ is to regulate the flow of the discharge water"*, rather than providing for nutrient removal. There will not be any contaminants in the discharge water and as mentioned above, the potential for generation of metals and water with low dissolved oxygen would only result from unusual conditions, for which contingency measures have been put in place. The effectiveness of the EPZ for removal of nutrients in particular will be monitored during Stage 1 to understand and quantify the

removal achieved, for use in the design of later stages. The EIS took the conservative approach that no removal of nutrients would occur in the EPZ and, on the basis of that, and other conservative assumptions (see Volume 2, Chapter 2 of the draft EIS) has demonstrated that, outside of a very small initial mixing zone, the Interim Water Quality Trigger Values can be met.

The EPZ has been designed with a 100 m wide channel in the centre of the EPZ to ensure sufficient flow through, but avoid significant depth, avoiding both stagnation and stratification and algal growth (relatively high turnover compared to areas at risk of algal blooms).

3.19.9 Comment 9

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Project Description
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Section 8.1.2 Pond Conditioning Section 8.1.4 Pond Water Quality Management

Details of the Submission

Clearly identify all potential inputs into the farm ponds (e.g. synthetic and natural components of stock feed, including their decay products, fertilizers, conditioners, food grade dyes etc.).

Proponent Response

Table 12 identifies all potential inputs into the farm ponds, their constituents, purpose and fate.

TABLE 12 FARM POND INPUTS

Input	Constituents	Purpose	Outputs/Residues/Fate
Filtered seawater	-	To manage pond volumes and salinity levels	Seawater, excess seawater is discharged to Alligator Creek.
Freshwater	-	To manage pond volumes and salinity levels	Seawater, excess seawater is discharged to Alligator Creek.
Formulated feed	Fish meal (23%), soya bean meal (35%), whole wheat (29%), other micronutrients, minerals, vitamins and stabilisers (13%)	To optimise growth and animal health	Animal protein, microbial colonies, microalgae, mineralisation of nutrients. TN, TP limits are imposed on discharge water.
Hydrated lime	Calcium hydroxide	Renovation of the pond beds during farm dry-out	Mineral form utilised within the pond soils and benthic biota during pond filling.
Agricultural lime	Calcium carbonate	Renovation of the pond beds during farm dry-out	Mineral form utilised within the pond soils and benthic biota during pond filling.
Commonly used	Silicate, sodium bicarbonate and sodium	To achieve correct pH balance and to develop a	Fertilisers will be transformed through biological processes into

Input	Constituents	Purpose	Outputs/Residues/Fate
agricultural fertilisers	nitrate	healthy and stable bloom of algae and other phytoplankton	animal protein, microbial colonies, microalgae, mineralisation of nutrients. TN, TP limits are imposed on discharge water.
Molasses	Calcium, magnesium, manganese, potassium, copper, iron, phosphorous, chromium, cobalt, sodium, niacin, vitamin B-6, thiamine, riboflavin	To add soluble carbon to the ponds to occasionally adjust the carbon/nitrogen ratio in the ponds	Molasses will be transformed through biological processes into animal protein, microbial colonies, microalgae, mineralisation of nutrients. TN, TP limits are imposed on discharge water.
Hydrogen peroxide		Emergency oxygenation during grow-out, pond sediment disinfection	As an aggressive oxidiser, H ₂ O ₂ will break down rapidly to H ₂ O and O ₂ in seawater.
Chlorine	Sodium hypochlorite	Disinfection of pond areas and drains that do not dry.	Sodium hypochlorite rapidly breaks down as an oxidiser in the presence of organic matter. Decomposes to Sodium Chloride (salt) and oxygen.
Pond Dye	Food grade dye	Used to colour the water early in a crop and shade the pond floor. This stops the formation of benthic algal colonies which are dominated by BG Algae and can be harmful to PL. Only used if the fertiliser regime does not work (due to weather conditions)	Dye is used in the early stages of the crop. Due to dilution and natural break down no dye is expected to be released from the facility.
Probiotics	Bacterial colonies (typically <i>Lactobacillus</i> and <i>Bacillus</i>)	Natural microbial ecosystem with added stabilizers and growth stimulants for detoxifying aquaculture grow-out ponds. It eliminates water-fouling waste products such as ammonia, nitrites and hydrogen sulfide, thereby lowering stress and providing a healthier environment for aquatic animal growth.	Probiotics could possibly be contained within the purchased feed (see Section 3.21.5). Bacteria is utilised within the pond environment and internal farm recycling pond and is in dilute form before being released with discharge water to the MDC and EPZ system. As per studies by Trott and Alongi (2000) and Preston et al (2001), bacteria and nutrients released from prawn farms (in this case into the MDC and EPZ) will be transformed into proteins (used as food by zooplankton and fish).

3.19.10 Comment 10

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Project Description
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Chapter 3, Section 8.1.13, Bird Predation Management Strategies

Details of the Submission

The risks associated with bird predation and proposed mitigation measures need to be assessed in more detail, particularly in relation to:

- impacts of predation on the project (i.e. loss of revenue and potentially, overall economic viability);
- impacts of proposed mitigation measures on sensitive environmental receptors (particularly waterbird populations)

The project is located in an area with extensive wetlands that are recognised for their value to birds and will be a potential existing source of bird predators. The discussion provided in Section 8.1.13 does not demonstrate that this issue can be effectively managed given that:

- exclusion (e.g. nets) is one of the only recognised effective methods of managing bird predation, yet this has been ruled out on the basis of cost and operational constraints;
- visual and acoustic deterrents are recognised as being limited in effectiveness, or completely ineffective;
- there is only '*some evidence*' of the effectiveness of the proposed use of helicopters/drones; and
- disturbance by patrols on foot or vehicles may have little impact.

A series of experimental trials will be undertaken during the 2018/2019 wet season to assess responses of water birds to bird predation mitigation strategies within wetland habitat adjacent to the farms. Provide information on:

- likely bird predator species that may require management
- potential issues associated with utilising helicopters as a management issue for bird predation, including unintended impacts (e.g. noise impacts and bird strikes) to non-target birds utilising nearby wetlands.

Proponent Response

Refer to response to Comment 12, Section 3.13.12 above, and to Appendix B.

3.19.11 Comment 11

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Project Description
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Chapter 3, Section 8.1.13, Bird Predation Management Strategies

Details of the Submission

A review of contemporary bird predation mitigation methods should be provided, including both literature and experiences from the Proponent and other aquaculture operations in Australia and internationally. It is recommended that the review consider other industries (e.g. agriculture, mining), in addition to aquaculture.

Proponent Response

A comprehensive review has been undertaken and is included as Appendix B of this document.

3.19.12 Comment 12

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Project Alternatives
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Volume 1, Chapter 4, Section 4.3 – Growout Farms

Details of the Submission

The Proponent states project economics and energy efficiency led to large ten hectare ponds being the preferred option, with reference to successful trends overseas. Provide:

- examples of successful prawn farming operations with similar large pond sizes and intensity of the operation and how risks associated with wastewater discharge, erosion/seepage and overtopping are managed;
- details on whether larger ponds may result in any operational challenges/risks compared to smaller ponds (e.g. aeration, even distribution of feed, protection from bird predation, pond liners); and
- details on how pond size and design meet best practice industry standard. For example, the Australian Prawn Farming manual specifies most grow-out ponds are approximately 1 hectare in area.

Proponent Response

Volume 1, Chapter 4, Section 4.3 of the draft EIS stated that 10 ha ponds were the 'preferred' option over smaller sized ponds - it is more accurate to say that as a result of the Concept Study investigations conducted in 2013, the 10 ha pond size was determined as the feasible option.

It is not possible for the proponent to document all the successful variants in prawn aquaculture. This has been done and can be found in text books such as Alday-Sanz (2010). It is also not possible to point to a carbon copy of the Project Sea Dragon proposal since the design solution and proposal that the draft EIS presents and the NT EPA is to assess, reflects the particular environmental conditions of the site and of the Top End of Australia more generally. The proposal has been also designed to be commercially successful taking into account Australia's costs structures, the state of infrastructure in the region, and the state of technology development within the prawn aquaculture sector.

Risks associated with waste water discharge, overtopping, erosion/seepage are managed across a wide spectrum. This spectrum ranges from the risks are either not managed or not perceived to be significant to the testing of innovations such as lined ponds.

The key point to draw is that, taking global experience into account, there is no single (unitary) model of prawn production that can be regarded as 'best practice'. Prawn culture is practiced across the tropics in a diverse range of physical environments (e.g. soil types), across many countries with a wide variety of social and economic conditions and with very different histories, including industry histories. The Chief Operating Officer

at Seafarms operated a major production facility in Saudi Arabia which grew to 4,500 ha under his stewardship. That facility operated 10 ha ponds successfully.

In terms of global 'best practice' in relation to wastewater discharge, the CSIRO in a submission to the Joint Select Committee on Northern Australia: Scaling Up - Inquiry into opportunities for expanding Aquaculture in Northern Australia', stated (emphasis added):

*'...the Australian prawn farming industry developed and implemented discharge water treatment systems that enabled them to comply with the strictest aquaculture discharge standard in the world (set by QLD EPA and endorsed by GBRMPA in 2002). A direct result of the comprehensive body of scientific research on the environmental impacts of prawn farm discharges, the introduction of discharge treatment systems and compliance with the **strictest discharge water quality standards in the world**, is that the industry has operated for 20 years with no adverse impacts on adjacent ecosystems.'*

The 10 ha ponds are more likely to reduce rather than increase operating risk. Within a prawn production system each pond is a 'control point'. In other words it is the smallest operating unit within which control must be maintained. The systems that Seafarms operate in Queensland have 148 operating control points, whereas the Stage 1 system for Project Sea Dragon will have 100 operating control points. Thus the design intrinsically leads to greater operational efficiency and less risk per unit of production. This is simply a matter of scale. Larger water bodies are not more difficult to manage and arguably offer greater buffering capacity within the system.

There are not greater challenges in aeration with 10 ha ponds and, as described, the design is to use Aquacombo units which are a standard piece of technology used world-wide that both aerate and assist in water circulation. Aeration is used to enable an increase in biomass within the ponds, it works to ensure that there is sufficient dissolved oxygen within the ponds to meet overall respiratory demand. Thus the amount of aeration provided is largely a matter of design choice influenced by species under culture, the desired maximum biomass, the proposed husbandry (which affects respiratory demand), available capital and deployment thereof, and the species being cultured. In general the smaller ponds typically found in Asian prawn culture systems are a function of ownership and associated enterprise structure, scale of operation and the species under culture. *Penaeus vannamei*, the most commonly cultured species in Asia and globally, is a species that occupies the entire water column and is highly tolerant of high population densities. These characteristics of *vannamei* have led to experiments with super intensive 'closed', 'semi-closed' or 'recirculation' systems. An example of a large scale intensive system currently of 100 ha and planned to go to 1,000 ha consisting of production ponds each of 500 m² and yielding 70 tonnes per hectare is shown in Plate 4. Such a form of culture would be unsuitable given the proponent's current understanding of *P. monodon* biology and husbandry. It should be noted that the facility shown in Plate 4 was designed, approved and constructed by a Vietnamese-Australian company within 18 months. There is no single industry 'best practice' in relation to pond size. The analogy would be to seek to identify a single best practice industry standard wheat field across all global domains in which wheat is grown.

In contrast to *P. vannamei*, *Penaeus monodon* is epibenthic (meaning it prefers to occupy the lower part of the water column) near the bottom of the pond. It is also less tolerant of high stocking. For these reasons black tiger prawns are typically grown in less intensive systems than *vannamei*. These range from unaerated 10-20 ha ponds that yield <5 tonnes per hectare per crop to more intensive systems that may utilise bioflocs. The Australian commercial record for black tiger prawns was 17 tonnes per hectare for a single crop. The question of aeration in large ponds is also linked to infrastructure: an unaerated solution in many cases simply reflects capital and infrastructure constraints.

The Australian Prawn Farming Manual refers to 1 ha ponds simply because larger ponds are not common in Australia (although the proponents operations in Queensland include ponds of 2.06 ha and the LGP property in Proserpine had ponds that were up to 1.6 ha). It is difficult to develop a manual based on 'best practice' when common practice was 1 ha ponds. The Australian industry is the most highly regulated globally. Global best practice is generally regarded as the Aquaculture Stewardship Council Shrimp Standard which was developed in the context of an industry almost exclusively based in developing countries. As such it contains provisions that may directly conflict with (for example) Australia's labour market regulations and laws.



PLATE 4 VIET UC INTENSIVE PRAWN CULTURE FACILITY SOUTHERN VIETNAM

3.19.13 Comment 13

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Water Balance
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Volume 1 Chapter 5 - Water Balance

Details of the Submission

Table 2 shows the water holding capacity of the system. Provide details on:

-  the rainfall event that would exceed a freeboard allowance of 10 000 000 m³ for all farms
-  the individual freeboard allowance for each grow out pond.

Proponent Response

The 10 GL quantity stated relates to the 700 mm freeboard allowance for the farm ponds and channels. While a rainfall event of 700 mm might be seen as sufficient to overcome this freeboard, in reality a mixture of controls provides that ponds would not overtop, with controlled release up to the 1 in 50 year ARI storm event, and controlled weir overflow for above the 1 in 50 year event. Control of pond levels can also be undertaken prior to storm events occurring where required. Refer to the response to Comment 6, Section 0 and to Section 3.7 in Appendix F.

3.19.14 Comment 14

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Environmental History and Ecologically Sustainable Development
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Volume 1, Chapter 7 - Environmental History and Ecologically Sustainable Development

Details of the Submission

Seafarms currently produces in excess of 1000 tonnes/annum from 160 ha of ponds across three locations in north Queensland and is the largest producer of farmed prawns in Australia. Project Sea Dragon is an order of magnitude larger and more intensive than the proponent's current operations, proposing 14000 tonnes/annum of produce from 1080 ha of ponds. To put this into perspective, the total Queensland aquaculture production (tonnes) for prawns in 2014-15 was 4951.5 tonnes. Discuss the potential technical challenges associated with significantly up-scaling an aquaculture project of this nature and how environmental values are maintained.

Proponent Response

First, the proponent needs to correct the comment. The proposed development is for 1,120 ha of grow-out ponds configured as three farms of 10 ha ponds with the farms containing 40, 36 and 36 ponds. The draft EIS clearly showed this configuration but the 1,080 ha documented in the draft EIS was an error arising from a 36 ponds x 3 farms assumption earlier in the design phase, rather than the refined design which emerged as 36 ponds x 2 farms + 40 ponds x 1 farm.

The second correction relates to 'intensity', the EPA states that the proposed development is 'more intensive'. This is not correct. Initial assumed maximum biomass densities for the development at Legume are of the order of 5 tonnes per hectare per crop, or stocking rates of 27 animals per m² (the Seafarms' production this cropping season was greater than this). Typical Australian black tiger operations stock at between 40 and 60 animals per m² and carry maximum biomass of up to 8 tonnes per hectare. The greater annual biomass (at 14,000 tonnes) in the first instance is assisted by more favourable growing conditions (i.e. air temperatures) at Legume than at Cardwell where there is a 6-8 week period in which the rate of animal growth is sub-optimal. Second the operations at Cardwell have, until very recently either cultured the domesticated but slower growing banana prawn or relied upon unimproved wild-caught black tiger prawn broodstock. The ultimate scale of production in terms of tonnes produced per year at the proposed facility depends on a large number of variables including: stocking rate, survival, average weekly growth, crop length, target animal size, harvest strategy, maximum pond biomass (related to aeration as an input). The expectation is that through selective breeding Project Sea Dragon will be able to achieve significant increases in productivity (in terms of tonnes per hectare per unit of time) but this does not equate to a more intensive system, it is a more efficient system.

The scale of the proposed operation at Legume changes the economies of scale markedly resulting in greater commercial returns on the breeding program and on R & D more generally. As one example, the advice from geneticists is that improvements in growth rates of 10-14% per generation will be achieved. Simple economies of scale show that on a production base of 1,000 tonnes a 10 % improvement yields an additional 100 tonnes. On a production base of 10,000 tonnes the same 10% improvement yields an additional 1,000 tonnes. The difference in investment in research and development between the two cases is minimal. Such an improvement does not require a 'more intensive' production system. This model has been deployed in most other commercial animal production systems (beef, pork, dairy, sheep, poultry and salmon).

Another significant opportunity to reduce environmental risk and maintain environmental values, is to improve the efficiency with which nutrients are utilised within the production system. This is why Project Sea Dragon has adopted the ability to recycle production water - fundamentally this is a nutrient recycling measure, although it also reduces the requirement for incoming marine/estuarine water and thus commensurately reduces the risk of exposure to incoming disease.

Overall efficiency of nutrient use is often benchmarked via a food conversion ratio (FCR) - crudely the mass of food applied to ponds vs the mass of prawns produced (that is an achieved FCR of 1.7 required 1.7 tonnes of food to be applied to the ponds in order to harvest 1 tonne of prawns). Given that feed is the largest single input cost to production there is a massive incentive to increase efficiency of feed utilisation. There are many factors that could come into play that would reduce the FCR, and improve yield. For example, feed formulas that improve the FCR, selective breeding for higher performing animals, as well as advances in the feeding regime have all been shown to reduce FCRs, and hence improve yield. Thus FCR is a variable outcome of genetics and husbandry and is a measure of production efficiency. It is possible that 20,000 tonnes of prawns produced at an FCR of 1.2 would require a comparable feed input for the production of 14,000 tonnes at an FCR of 1.7.

The net effect of these scale improvements is greater efficiency in the system.

The comment also implies that environmental values at the Queensland sites are comparable to the environmental values at Legume Station. Significant effort has gone into identifying the environmental values at Legume Station specifically as part of the investigations for the draft EIS and these have been documented. The maintenance of environmental values at Legume Station are specific to Legume Station and are not directly comparable to the environmental values to the Hinchinbrook Channel.

Volume 1, Chapter 4, Section 3 of the draft EIS outlines the considerations that went into selecting Legume Station as the preferred site. The scale of the landscape is suited to the scale of the proposed development, for example, the draft EIS clearly shows that the discharge water represents (see Table 2, Volume 2, Chapter 2) a smaller fraction of the tidal prism into Alligator Creek than is accepted into mangrove creeks in Queensland.

The production systems in Queensland are intrinsically scalable from a husbandry perspective with the exception of labour inputs. The best example of production efficiency in modern aquaculture can be found in the salmon industry where labour efficiency is such that 100 tonnes are produced per full time equivalents. The proposed scale of the Project offers the opportunity to utilise modern control technologies thus reducing both production and environmental risks.

3.19.15 Comment 15

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Environmental History and Ecologically Sustainable Development
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Volume 1, Chapter 7 - Environmental History and Ecologically Sustainable Development

Details of the Submission

The Proponent's farm management practices are based on the Australian Prawn Farmers manual and state that environmental sustainability is based on the Aquaculture Stewardship Council Shrimp Standard and the Environmental Code of Conduct for Australian Prawn Farmers.

Management plans for the project should draw on aspects of these codes and standards to ensure environmental sustainability and demonstrate how design and operation of the farm will meet the requirements for accreditation from ASC.

Details are required on how the Proponent has managed its existing facilities to protect the environment and meet sustainability objectives in accordance with the relevant codes and standards.

In particular, provide discussion on lessons learnt in terms of:

- bird predation mitigation measures used by Seafarms in Queensland, comparing the environmental similarities and differences of the sites, and their effectiveness of the measures;
- cyclone preparedness and resilience including details of the consequence, lessons learnt and results of any monitoring conducted following an extreme rainfall or cyclone event; and
- waste water discharge management and pond construction (e.g. erosion and seepage rates).

The EIS should provide more detail on the suite of measures necessary to minimise concentrations and mass loads of contaminants in wastewater discharged to Alligator Creek and the Keep River, with reference to best practice environmental management principles for prawn farm systems design.

Proponent Response

Environmental Sustainability

Management plans for the project should draw on aspects of these codes and standards to ensure environmental sustainability and demonstrate how design and operation of the farm will meet the requirements for accreditation from ASC.

As stated in Volume 1, Chapter 3 of the draft EIS (Project Description), and in the draft EMP (Appendix H), the Project design and farming process has been developed in accordance with the Aquaculture Stewardship Council (ASC) Shrimp Standards and the Environmental Code of Practice for Australian Prawn Farmers. The draft EMP has drawn on both the ASC Shrimp Standards and the Environmental Code of Conduct for Australian Prawn Farmers in the design and implementation measures provided. Management plans for the project will also draw on relevant aspects of the code, the Australian Prawn Farmers manual, and the ASC Shrimp Standards.

As stated in the draft EIS the proponent intends to apply for accreditation under the ASC Shrimp Standards and has undertaken an internal audit of its ability to conform to the standards. Additional information is provided in regard to the ASC Shrimp Standards in Environment Centre NT Comment 1 (Section 3.21.1) and Comment 5 (Section 3.21.5).

Bird Predation Management

In particular, provide discussion on lessons learnt in terms of:

- ***bird predation mitigation measures used by Seafarms in Queensland, comparing the environmental similarities and differences of the sites, and their effectiveness of the measures;***

In the Queensland operations the main birds that are regularly found around the ponds are species of egrets, cormorants and terns, as well as Australian pelicans, nankeen night-heron and Australasian darters. There is generally a regular human presence around the ponds of the Queensland operations and, as such, personnel are able to actively drive away birds, particularly cormorants, pelicans and terns, wherever possible. Pelicans do not present a problem for predation of black tiger prawns as they do not exhibit plunge diving behaviour in the ponds and, as such, are unable to reach the prawns (black tiger prawns are bottom dwellers). Egrets are more difficult to drive away, and as such a given level of predation by egrets is accepted. However, both terns and egrets only feed opportunistically when prawns are near the surface (which is uncommon given the benthic habit of tiger prawns).

In extreme circumstances a very problematic cormorant, Australian darter or nankeen night-heron may be dispatched in accordance with the Seafarms damage mitigation permit issued by the Queensland Department of Environment and Heritage Protection.

With reference to similarities and differences between the sites, the main difference of relevance to bird predation issues is the scale of the operations, and the difficulty in using human (on ground) presence as a deterrent at Legume. Whilst human deterrence is still intended to be a component of a suite of waterbird deterrent methods at Legume, it is important to note that, by virtue of the size of the operation at Legume Station as compared to the Queensland, the aforementioned measures will be less likely to be successful - hence the proposition for aerial measures as a deterrent, which would allow rapid response and coverage of large areas.

See Appendix B - Avian Predation Submission.

Cyclone Planning

In particular, provide discussion on lessons learnt in terms of:

- ***cyclone preparedness and resilience including details of the consequence, lessons learnt and results of any monitoring conducted following an extreme rainfall or cyclone event; and***

In relation to cyclone preparedness and resilience, Seafarms operates facilities in far North Queensland and has in place an Adverse Weather Preparedness Plan. The most extensive of Seafarms production facilities are two farms near Cardwell. Prior to current ownership of these farms the epicentre of Cyclone Yasi (a Category 5 cyclone) passed extremely close to, if not directly over, the Cardwell farms (by contrast Cyclone Tracy was a Category 4 storm). The pond infrastructure was essentially undamaged. At the time the farm was close to fully stocked and a reported 150-200 tonnes of prawns were lost. This loss was primarily due to the failure of aeration. At that farm most of the power comes to the farm in overhead powerlines. There was insufficient back-up generation as described by the CEO at the time (see <http://www.abc.net.au/site-archive/rural/news/content/201103/s3155038.htm>):

Trevor Anderson, CEO of Seafarm, says that one unexpected lesson had to do with the way rain falls during a cyclone.

"We learnt about the vulnerability of generators to rainfall that goes horizontally or vertically, so we lost a lot [sic] of generators with water in them, so we'll improve the structures that protect those."

In terms of cyclone recovery contemporaneous coverage includes the following (see <http://www.aquacultureinsurance.com/Aquaculture-Insurance-and-Risk-Management-News/Crystal-Bay-Prawns-survive-Yasi-to-take-out-award>):

- *"Four weeks to the day after surviving Cyclone Yasi, Crystal Bay prawns were yesterday awarded a Gold Medal and the Champion Prawn Award at the 2011 Sydney Royal Fine Food Show Summer Aquaculture competition."*
- *The Crystal Bay Prawns recognised with these awards were grown and processed in Cardwell, North Queensland – Seafarm's main site.*
- *Cardwell was very close to the epicentre of Cyclone Yasi, and the town itself was severely damaged.*
- *Seafarm's operations were also significantly impacted, with substantial losses of prawns – it is estimated some 150-200T of prawns which were ready for harvest died as a result of the cyclone."*

Seafarms has added back-up generation to its east coast operations and increased storm protection of critical gensets. Seafarms implements a cyclone readiness program each year and maintains a cyclone plan.

At Legume as described in the Project Description of the draft EIS (Volume 1, Chapter 3):

- All buildings will comply with the Building Code of Australia, including cyclone rating requirements for Region C.
- All structures will be designed to handle Category 'C' cyclone wind loading, whether or not the structures are second-hand or new.
- The mess and dining hall will be designed to be used as a shelter in the event of a cyclone.
- Emergency power generation units will be deployed around the farms to cover the situation where the storm or cyclone may have caused a transmission line outage, or similar.

Volume 2, Chapter 11 of the draft EIS addresses Climate and Meteorology, including occurrence of cyclones in the region.

Water Management

In particular, provide discussion on lessons learnt in terms of:

- ***waste water discharge management and pond construction (e.g. erosion and seepage rates).***

The EIS should provide more detail on the suite of measures necessary to minimise concentrations and mass loads of contaminants in wastewater discharged to Alligator Creek and the Keep River, with reference to best practice environmental management principles for prawn farm systems design.

Discharge water quality is addressed in response to Comment 30 from the NT EPA (Section 3.19.30 below). Response to Comment 12 (Section 3.19.12) from the NT EPA addresses 'best practice' more generally.

As stated in Section 8.1 of Volume 1, Chapter 3 of the draft EIS, a detailed description of all measures to be employed in managing the farm was not provided, since this material is covered in depth in the Australian

Prawn Farming Manual. As an example, effluent treatment through sedimentation and water reuse is described in Chapter 2 of the Australian Prawn Farming Manual, and efficient feed management and conversion in Chapter 6.

Section 8 of the aforementioned draft EIS Chapter describes pond conditioning and water management, stocking, aeration, feed monitoring, pond waste management and solid and liquid waste management, all contributing elements to minimising concentrations and mass loads of nutrients and sediment in discharge waters. The key controls are feed management, aeration and pond water quality management, settlement and reuse of water, and maintenance of prawn health.

3.19.16 Comment 16

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Risk Assessment
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Volume 1 Chapter 8 - Risk Assessment

Details of the Submission

In many cases, the risk assessment has reduced the consequence following the implementation of mitigation measures. This is highly unusual as the consequence of a risk event is usually fixed, with controls normally only altering the likelihood of an event occurring.

Proponent Response

The risk assessment methodology employed was a standard semi-quantitative risk assessment consistent with AS/NZS ISO 31000:2009 'Risk Management – Principles and Guidelines'. Section 5.5 of AS/NZS ISO 31000:2009 outlines the process for risk treatment following risk evaluation, and the options of risk treatments are outlined below. One of the options for risk treatment is changing the consequences. Accordingly, for some risks in the draft EIS risk assessment, control strategies were developed which alter the consequence of the risk. For example, the introduction or spread of weeds/pest animals may result in the change or loss of habitat/biodiversity for threatened flora and threatened and migratory fauna. The likelihood of this risk is reduced through a number of control measures including vehicle and equipment wash-down procedures, and managing landfill and putrescible waste to control feral and pest animal ingress. In addition, the consequence can also be reduced through ongoing monitoring and the implementation of weed and fauna management plans, including management actions in response to identified outbreaks.

"5.5 Risk treatment

5.5.1 General

Risk treatment involves selecting one or more options for modifying risks, and implementing those options. Once implemented, treatments provide or modify the controls. Risk treatment involves a cyclical process of:

- *Assessing a risk treatment*
- *Deciding whether residual risk levels are tolerable*
- *If not tolerable, generating a new risk treatment*
- *Assessing the effectiveness of that treatment*

Risk treatment options are not necessarily mutually exclusive or appropriate in all circumstances. The options can include:

- *Avoiding the risk by deciding not to start or continue with the activity that gives rise to the risk*
- *Taking or increasing the risk in order to pursue an opportunity*
- *Removing the risk source*
- *Changing the likelihood*
- *Changing the consequences*
- *Sharing the risk with another party or parties (including contracts and risk financing)*
- *Retaining the risk by informed decisions"*

3.19.17 Comment 17

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Risk Assessment
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Volume 1 Chapter 8 - Traffic movements – mortality or injury of threatened or migratory terrestrial fauna or avifauna species

Details of the Submission

The risk assessment states the following in relation to potential impacts of road traffic on terrestrial/bird species:

"The majority of threatened and migratory species known to be present on site are avian and unlikely to inhabit road verges."

With proposed upgrades to create all-season road access as part of this project, the potential for interaction between wildlife and traffic may increase substantially. During the Wet season, when much of the project area would be inundated, fauna may congregate on road verges in areas where the roads possibly represent the only dry ground for some distance. The risk and potential impacts to fauna in this context should be discussed in the Supplement.

More control strategies are available to manage fauna impacts from traffic e.g. road design, speed limits, limit driving to daylight hours and avoid driving at dusk and dawn. Management strategies, if required, targeting particular at-risk species should be discussed. Outline the response to and management of injured/dead fauna.

Proponent Response

The ecological surveys conducted for the Project supports the statement from the draft EIS regarding road use by avian species. Parts of the existing vehicular tracks are known to be exposed during the height of the wet and anecdotal observations do not indicate that birds congregate and create any issues. The Project roads will not be supporting high speed traffic, with traffic speed limits applied in consultation with Project ecologists to ensure that birds will have time to move. In terms of threatened species, curlew sandpiper is the only threatened species likely to be present in the vicinity of the roads and will be in very low numbers (reduced habitat in wet season) and highly unlikely to roost on the road.

The existing management strategies incorporated into the draft EMP (included as Appendix H) include:

- Implementation of speed limits (draft EMP, Appendix C6, Actions - Traffic; and Appendix C14, Actions)
- Removal of roadkill off the road immediately to avoid further injury to scavengers (draft EMP, Appendix C6, Actions - Traffic)
- Recording of all incidents involving fauna (draft EMP, Appendix C6, Reporting).

Design of roads, waterway crossings and culverts will also allow for terrestrial and aquatic fauna passage. The approach to be taken during detailed design is to adopt fauna friendly crossing points for terrestrial fauna where nominated as required by the Project ecologists, designed to applicable standards, such as the Queensland Technical Manual Fauna Sensitive Road Design (refer to Volume 2, Chapter 6 of this manual).

Additional controls will include environmental education for staff (the above speed limits, roadkill management and reporting, horn-blowing, etc.) and limiting driving at night and particularly dusk and dawn where possible (implemented for safety reasons regardless).

3.19.18 Comment 18

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Risk Assessment
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Volume 1, Chapter 8 - Threatened and migratory species

Details of the Submission

Provide the reference for published data that most fish can swim against a current of 0.4m/s and all fish against currents of 0.1m/s.

Proponent Response

An approach velocity of 0.1 m/s is likely to avoid entrainment and impingement of all fish while a velocity of 0.4 m/s is likely to avoid entrainment of most fish (Boys et al. 2012). The full reference, as was reported in the draft EIS reference list, is, Boys, C., Baumgartner, L., Rampano, B., Robinson, W., Alexander, T., Reilly, G., Roswell, M., Fowler, T. & Lowry, M. 2012. Development of Fish Screening Criteria for Water Diversions in the Murray-Darling Basin. NSW Department of Primary Industries, Port Stephens Fisheries Institute, Nelson Bay, NSW.

While this reference is for more temperate fish, data for tropical species included in Section 16.3 of Appendix 9 of the draft EIS supports this. Fish swim speeds can be classified into 'sustained' and 'burst' speeds. Sustained speeds are lower, while burst speeds can be achieved for a short duration, such as that may be required to avoid entrainment or impingement on the intake. For example, juvenile barramundi have a sustained swim speed of 0.4 m/s and a burst speed of 0.66 m/s.

Further, the location of the intake structure at Forsyth Creek is naturally subject to strong tidal currents. Spring tide current speeds within the southern channel in the vicinity of the intake are in the order of 1.75 – 2.0 m/s during the peak ebb tide and 0.13 – 0.16 m/s during the peak flood tide (Water Technology 2016b). As such, resident and transient fish in this area are likely to be able to negotiate these currents and therefore have a low likelihood of entrapment or impingement.

3.19.19 Comment 19

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Geology, Geomorphology and Soils
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Volume 2, Chapter 1; Appendix 7 Grow-out ponds

Details of the Submission

The draft EIS does not provide sufficient interpretation and synthesis of the geotechnical results presented in Volume 5, Appendix 7 to assess the material suitability of the soils for project design and pond construction. Table 4 provides a description of soils however an overall soil map with locations of the soil sampling conducted and properties of the soil over the project footprint should be provided. In particular, locations of soil testing and soil properties for areas that will have water holding bodies (e.g. grow-out ponds, recycling ponds, main discharge channel, EPZ) should be illustrated.

Proponent Response

A short description of the available data, a plan showing the test locations, and locations of this data within the EIS is provided in Section 2.1 of Appendix F. The available data is discussed together in Volume 2, Chapter 1, Section 3.3.2 of the draft EIS.

3.19.20 Comment 20

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Geology, Geomorphology and Soils
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Volume 2, Chapter 1; Appendix 7 Grow-out ponds

Details of the Submission

Clearly demonstrate how the results from preliminary soil investigations and trial earthworks show that the soils are suitable for pond and channel construction. Based on these results, it must be clear the ponds will be stable, effective and the potential for environmental harm is minimised.

For example:

With regards to the following statements in Volume 1, Chapter 3 Section 5.3:

“Ponds will involve the excavation of around 300 mm of the surface clay material to form embankments walls for the ponds and channels.”

“Ponds and channels will not be lined with any other materials, as the surface soils (the black clay soils on the estuarine-deltaic plain) provide the impermeability needed to retain the water for operations, as shown by both the geotechnical investigations (Douglas Partners 2016)”

Review of the preliminary soil investigation test data (Appendix 7) does not appear to indicate that the surface soils are clay but rather are generally described as silt, mostly found to a depth of at least 1 m. Results of falling head permeability tests also show coefficients of permeability in the order of 4×10^{-10} m/sec. Clarify:

- using examples of the geotechnical data, that the permeability results for the soils tested show that black clay soils provide the impermeability needed to meet industry standards to prevent potential impacts from

seepage to groundwater and to avoid higher than expected volumes of salt and fresh water for pond water make-up

- whether the base of the ponds will be tested to ensure adequate compaction for impermeability.

Proponent Response

The permeability of the soils and for embankments and ponds/channels is described in more detail in Section 3.3 in Appendix F. Note that while the geotechnical descriptions are of silts, in reality these materials are a medium to heavy clay using soil science (as opposed to geotechnical) soil descriptions, as evidenced by the Tickell & Hill (2001) study, the mapped soil horizons, and other soil mapping and monitoring in the region on similar soils (as well as the permeability results). Refer also to the description for unit 1 soils in Section 6.2 of Volume 5, Appendix 7b ('however these materials are expected to behave as high plasticity clay in accordance with the Atterberg limit results plotted on the Casagrande chart in Figure 2, Section 8.1 of this report, as well as visual and tactile assessment').

In terms of the stated permeability, the Queensland Guidelines for constructing and maintaining aquaculture containment structures (Department of Primary Industry and Fisheries 2007) requires permeability in the range of 2×10^{-8} m/s to 1×10^{-9} m/s, substantially above that measured. To put this into context, waste storage typically requires $\sim 1 \times 10^{-9}$ m/s to $\sim 1 \times 10^{-10}$ m/s depending on the source, for example:

- the Western Australian Water quality protection note 26 - Liners for containing pollutants, using synthetic membranes requires that 'All synthetic fluid containment liners should have a coefficient of permeability of less than 2×10^{-10} m/s'.
- The South Australian Wastewater Lagoon Construction guideline (EPA 509/14) requires a liner of lower permeability than 1×10^{-9} m/s.

Overall, the test results very clearly show the black soils (as well as deeper unit 2A, 2B soils) have the required low permeability.

3.19.21 Comment 21

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Geology, Geomorphology and Soils
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Volume 2, Chapter 1; Appendix 7 Grow-out ponds

Details of the Submission

During construction, compaction of berms will be measured to Australian Standards for in-situ density and moisture content, for acceptance or rejection. Earthworks construction procedures should be in accordance with the Australian Standard AS 3798-2007.

The Australian Standard AS 3798-2007 Guidelines on earthworks for commercial and residential developments is not applicable for water retaining structures. Provide details on:

- what relevant standards will be used for testing of soils for their suitability for pond construction; and
- whether the Guidelines for constructing and maintaining aquaculture containment structures by the Queensland Department of Primary Industries and Fisheries, or other leading best practice standards have been considered to assess the requirements for pond construction and channels.

Proponent Response

The Department of Primary Industries and Fisheries (2007) Guidelines for constructing and maintaining aquaculture containment structures has been considered in the design of the ponds and channel structures, and the bulk of the earthworks testing and trials aimed to determine the achievable compaction to achieve low permeability material, with methodologies being determined to reach optimal moisture content and provide for satisfactory compaction in the field (refer to Sections 2.2 and 3.3 in Appendix F).

As such, engineering testing will be undertaken throughout the earthworks phase to ensure adequate compaction is being achieved, along with permeability testing of formed embankment material as checks on the compaction methods to ensure adequately low permeabilities are achieved. AS3798 provides for guidance on control testing of earthworks and associated site preparation works, and on the interpretation and application of the relevant test methods specified in the AS 1289 Methods of testing soils for engineering purposes series of standards, which includes:

- AS 1289.5.1.1 Soil compaction and density tests - Determination of the dry density/moisture content relation of a soil using standard compactive effort, and/or AS 1289.5.2.1 Soil compaction and density tests - Determination of the dry density/moisture content relation of a soil using modified compactive effort
- AS 1289.6.7.1 Soil strength and consolidation tests - Determination of permeability of a soil - Constant head method for a remoulded specimen and/or AS 1289.6.7.3 Soil strength and consolidation tests - Determination of permeability of soil - Constant head method using a flexible wall permeameter.

Note that these methods are used in the Department of Primary Industries and Fisheries (2007) standard.

3.19.22 Comment 22

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Geology, Geomorphology and Soils
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Soil Sodidity and Dispersion

Details of the Submission

The draft EIS identifies risks relating to the use of sodic soil to construct ponds and channels in some areas of the site. Dispersive soils can lead to wall failure due to erosion and tunnelling, and erosion of pond bottoms when ponds are drained. Soil chemistry data suggests that soil stability may become an issue during dry-out periods for ponds if dispersive soils are exposed to heavy rainfall.

The draft EIS included observations by Douglas Partners of existing pavements, the Forsyth Creek Dam wall, existing rip-rap emplacements, bridging layers along access ways and causeways that the material currently used on site is performing well and is durable, though more frequent maintenance is sometimes required on softer materials (such as siltstones compared to laterites). While these existing structures on site (e.g. turkey nest dams, embankments, roadways and channels) have been noted to have no visual evidence of enhanced erosion and structural decline (Vol 2, Chap1, 1-30), no information has been provided on the similarity of these structures (e.g. height, slope, volume capacity) compared to the pond and channel construction and how soil sodicity and potential for erosion will be managed for a 30 year project life.

In addition, these similar structures have not been subject to bank scouring that may occur as a result of tidal movements (if applicable), wind/wave action and water movements that may affect the internal pond walls. It appears the Proponent is expecting some erosion of pond walls and that batter slopes may require some annual re-profiling (section 6.10.2).

The mitigation measures proposed for management of saline-sodic and dispersive soils include suitable compaction, using gypsum ameliorant. This seems counterintuitive to the industry standard that advises large earthwork projects should not attempt to correct geotechnical problems with soil amelioration (Volume 5, Appendix 6).

Appendix 7 details that further assessment of dispersive characteristics should be undertaken to more accurately define the risk of dispersion and adopt appropriate risk mitigation measures. Provide an indication of when this assessment will be undertaken.

Proponent Response

Sections 3.1 and 3.5 in Appendix F discuss dispersivity and wind/wave action, although there will be minimal infrastructure exposed to tidal forces (refer to response to Comment 2, Section 3.19.2). A description of the site investigations including of site features is provided in Section 2.1 in Appendix F.

Observations were also made of the 22 turkey nest dams on the property, including how these were constructed, and how they have performed in terms of slope stability, structural integrity, wet season erosion and cattle traffic on the embankments. No signs of structural distress, significant leakage or catastrophic failure were observed or reported, even though it is understood that many of these dams were not engineered or compacted to an accepted engineering standard. In terms of the soil materials, given the locations of many of these structures on the estuarine-deltaic plain, the construction materials can only have been the upper Unit 1 and 2A materials, or at worst the deeper, sandier and less permeable, and generally more sodic soils. Given that the earthworks plan and design has designated Unit 1 and 2A as suitable, with 2B and other soils as unsuitable, the observations show that the available soils are suitable for long term stability.

Note that the statement advising against attempting to correct geotechnical problems with soil amelioration in Volume 5, Appendix 6 of the draft EIS (page 19 - 20) relates to cost, specifically by importing of bentonite or other clays to line ponds (which would be very expensive), or undertake massive soil amelioration works.

Site earthworks show that waterholding capacity can be quite easily achieved (and thus why the site was chosen), with compaction being a suitable control for dispersivity of surface soils. Treatment with gypsum to better stabilise some soils is a suitable approach that has been costed by Seafarms, and is not cost prohibitive, based on design, geotechnical assessment and the earthworks trials.

Finally, a pre-construction monitoring program has been committed to in Appendix C2 of the draft EMP (Appendix H), to provide a baseline and pinpoint potential resource and limitation depths and extents for use in the detailed design phase.

3.19.23 Comment 23

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Geology, Geomorphology and Soils
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Acid Sulphate Soils Volume 2, Chapter 1, Figure 5 Volume 5, Appendix 7 Appendix E - Drawing 7 – ASS; Table 16

Details of the Submission

The inferred (Acid Sulphate Soils) ASS map shows the high risk areas to be:

- inlet, settlement pond and maintenance pond in the north
- the Main Discharge Channel (MDC) from farms 1 and 2, the Internal Farm Recirculation Pond (IFRP) in Farm 2 and the Environmental Protection Zone (EPZ).

Test pits were conducted and two samples indicated medium or high risk along the intake channel and north of farm 1 (Figure 5). PASS was also confirmed at a number of locations at or below 2.5 – 3 m below ground level.

In addition, where PASS was located, there appears a good chance that soils will have sufficient ANC to result in no Net Acidity (i.e. no chance for PASS to produce acid leachate or runoff).

The geotechnical consultant indicates that the term ANC should only be used when the soil contains fine (<0.5mm in size) shell fragments or other similar calcium carbonate material. The ANC capacity (e.g. shell material encountered) that may offset ASS can also not be assumed without adequate assessment of the fineness of the ANC material and acid base accounting.

Given excavations ranging up to 3 m depth along channel alignments will occur, the risks of ASS occurrence may be high in these areas. Provide:

- confirmation on whether any further pre-construction testing around the channel or other areas that have been identified as medium or high risk will occur; and
- commitment that if disturbance of ASS are proposed, an acid sulfate soil management plan will need to be prepared by a suitably qualified and experienced professional, in accordance with the Queensland Acid Sulfate Soil Technical Manual: Soil Management Guideline (Dear et al. 2014) or the Western Australian The Acid Sulfate Soils Guideline Series (DER 2015).

Proponent Response

A pre-construction monitoring program has been committed to in Appendix C3 of the draft EMP (Appendix H). This states that 'pre-construction monitoring will be conducted for all areas of excavation below 2 m depth or 2.5 m AHD (whichever is the highest absolute elevation) on Estuarine-Deltaic and Coastal Plains. This will involve testing to the depth of disturbance + 0.5 m in accordance with Dear et al. (2014) (field and oxidised pH at 0.25 m intervals, chromium reducible sulfur suite analysis at 0.5 m intervals).'

The strategy allows for strategic reinternment, in accordance with the guidelines where appropriate (soils that can be reinterred within 12 hours and where the volume at the location is <100 m³ will be recorded (these will be reinterred with a nominal liming rate applied).'

More generally, the strategy requires acid sulfate soils to be managed as follows:

1. Acid sulfate soils are to be avoided, and groundwater level not lowered in their vicinity, OR
2. The neutralising capacity of any exposed acid sulfate soil (after treatment) must exceed the existing plus potential acidity of the soil, with a Factor of Safety of 1.5, AND
3. Acid Neutralising Capacity, whether naturally available or added, must be sufficiently fine to counteract oxidation and acid generation, as outlined in Dear et al. (2014).

Note that it is acknowledged that the fineness of the ANC fraction is important, as stated in the draft EIS, however where tested the ANC fraction was found to be sufficiently fine to suitably neutralise the potential acid sulfate soil (PASS) material. It has been assumed this is not the case in the preparation of the Acid Sulfate Soil Management Plan (ASSMP), but stated that it will be likely in at least some areas - shell fragments themselves are likely to be widely present.

3.19.24 Comment 24

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Geology, Geomorphology and Soils
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Section 3.4; Figure 5

Details of the Submission

Acid sulfate soil mapping - overlay project infrastructure, including the EPZ and location of the trial earthworks program conducted by the Proponent in June 2016 on this figure to link with the discussion of where actual ASS results were encountered. (in Drawing 1 – Vol 5, Appendix 7 shows test pit locations not ASS results)

Pg 1-35 –majority of project footprint is located in areas considered likely to contain Potential Acid Sulfate Soils at depths at or below 2.3m. Majority of earthworks will be confined to the top 2m.

On Figure 5, it appears no soil sampling was undertaken in the ASS high risk mapping zone where the main discharge channel is located (proposed 3m deep by 100 m wide). Provide an indication of whether further ASS testing will be conducted in this area to determine the requirement for the implementation of measures in accordance with an Acid Sulfate Soil Management Plan.

Proponent Response

Refer to Volume 2 Chapter 1, Figure 5 of the draft EIS, which shows Acid Sulfate Soil mapping and results from the Douglas Partners study noted above, plus other investigations listed in this draft EIS chapter. As noted in the response to Comment 23 (Section 0) further sampling will be conducted.

Section 2.2 in Appendix F contains a figure showing the location of the trial earthworks program.

3.19.25 Comment 25

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Geology, Geomorphology and Soils
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Section 3-8; Earthworks Field Trial

Details of the Submission

An earthworks field trial consisting of a 2.4 ha trial pond and a 60m wide channel was undertaken.

It is not clear where the location and results of this trial earthworks program are included in the draft EIS. Please provide the results of this trial in the Supplement and discuss the implications of this for groundwater quality, water supply requirements and landform stability.

Proponent Response

While this earthworks trial and its key results were discussed in Section 3.8 of Volume 2, Chapter 1 of the draft EIS, further detail is provided in Section 2.2 in Appendix F. The trial confirmed the other findings of previous studies, particularly in relation to groundwater quality and landform stability (as further discussed in Section 3.1 in Appendix F). The only findings in relation to water were the requirements for wetting of soils, with no implications as such for water supply for the Project.

3.19.26 Comment 26

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Marine and Estuarine Water
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Volume 2, Chapter 2 Marine and Estuarine Section 2.6 Interim Site-Specific Trigger Values

Details of the Submission

The Proponent has chosen to classify the receiving environment as a “slightly to moderately impacted ecosystem” as per the AWQG. Provide a clear justification for why a “slightly to moderately impacted ecosystem” classification was adopted given that the National Land and Water Resource Audit (2002) classified the condition of the Keep River estuary as “near-pristine”.

Proponent Response

It is important to note that in its submission on the draft EIS, the NT Department of Environment and Natural Resources made the following comment in relation to the categorisation of the receiving ecosystem as 'slightly to moderately disturbed':

"The adoption of the of 'slightly to moderately system' (condition 2) could be justified based on catchment grazing and its impact on wet season sediment loads, which are assumed to have an impact during the dry season when river inflows cease. Note, in the future, the Keep River Irrigation Area will further impact on runoff water quality. In Summary, the adoption of the 'slightly to moderately disturbed' system seems reasonable."
(Department of Environment and Natural Resources 2016, pg. 3).

The Australian and New Zealand Guidelines for fresh and marine water quality (Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand [ANZECC & ARMCANZ] 2000), often referred to as the Australian Water Quality Guidelines (AWQG) recognise 3 levels of ecosystem condition (Section 3.3.2.3, page 3.3-6 of the AWQG):

1. high conservation/ecological value (condition 1 ecosystems)
2. slightly or moderately disturbed (condition 2 ecosystems) and
3. highly disturbed (condition 3 ecosystems).

The definition (from the AWQG) for Condition 1 and Condition 2, and comments on the definitions with reference to the receiving environment are provided below.

Condition 1 Ecosystem

High conservation/ecological value systems — effectively unmodified or other highly-valued ecosystems, typically (but not always) occurring in national parks, conservation reserves or in remote and/or inaccessible locations. While there are no aquatic ecosystems in Australia and New Zealand that are entirely without some human influence, the ecological integrity of high conservation/ecological value systems is regarded as intact.

The surrounding catchment is significantly modified (i.e. is not in a natural state, like a National Park). In particular the drainage systems have been modified by the construction of tracks, roads, bunds and dams, and the area has been modified by cattle grazing. Therefore, the receiving environment does not meet the definition of a condition 1 ecosystem.

Condition 2 Ecosystem

Slightly to moderately disturbed systems — ecosystems in which aquatic biological diversity may have been adversely affected to a relatively small but measurable degree by human activity. The biological communities remain in a healthy condition and ecosystem integrity is largely retained. Typically, freshwater systems would have slightly to moderately cleared catchments and/or reasonably intact riparian vegetation; marine systems would have largely intact habitats and associated biological communities. Slightly–moderately disturbed systems could include rural streams receiving runoff from land disturbed to varying degrees by grazing or pastoralism, or marine ecosystems lying immediately adjacent to metropolitan areas.

The marine ecosystem surrounding the Project Area is in a relatively healthy condition and ecosystem integrity is largely retained. The biological components of this ecosystem are adapted to the extreme natural conditions of the estuary including high tidal range, high turbidity, strong currents, eroding creek banks, shifting intertidal banks. Biological diversity is relatively low compared to other systems without these constraints (e.g. no seagrass or coral communities). It is difficult to measure human impacts to this ecosystem, due to the dynamic nature of the system (rapidly eroding banks, shifting intertidal banks), the extremely high natural turbidity, and at times high nutrient levels. However, the catchment is disturbed by grazing and infrastructure has been developed that has significantly impacted natural flows, and this will have affected the receiving marine environment. Therefore, the receiving environment has been classified as a slightly to moderately disturbed ecosystem.

Also of note is that Bennett and George (2014) also categorised the lower Keep River as Condition 2, stating (p 62) *"The physicochemical baseline data indicate that the lower Keep River is best classified as a 'Category 2' system, being a 'slightly to moderately disturbed system', rather than 'Category 1', which is defined as a 'high conservation/ecological value system'. The lower classification is a result of the influence of natural (tidal influence, climate variability, groundwater discharge, heavy metal mineralisation, terrestrial vegetation growth dynamics and run-off dynamics) and anthropogenic (rangeland cattle grazing) factors. It was not possible to quantify the relative influence of each of the natural and anthropogenic factors on the condition of the lower Keep River. It does appear, however, that the anthropogenic influences mainly affect the nutrient aquatic stressors N and P."*

3.19.27 Comment 27

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Marine and Estuarine Water
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Volume 2, Chapter 2 Marine and Estuarine Section 2.6 Interim-Site Specific Trigger Values

Details of the Submission

The draft EIS proposes water quality objectives (Interim WQO) based on local baseline data. The interim WQOs are useful for assessment of likely change to water quality concentrations due to the discharge. However the validity of the interim WQOs is limited in key respects. The primary limitation relates to a lack of standardisation of the sampling strategy with respect to tidal stage and lunar cycles, which fundamentally influence water quality in the receiving environment.

The lack of such standardisation compromises the utility of the data as baseline for the purposes of monitoring the impacts of Stage 1 operations, and for developing 'final' WQO for long term operation (including any future

potential expansion). Continuation of the current sampling approach is not likely to provide a suitable basis for development of final WQOs.

To address this deficiency the EIS should include:

- analysis of all data to determine the most suitable method for standardising data collection methods to minimise the confounding effects of natural water quality variation due to tidal variation. Data points that do not meet standardisation criteria should be removed from the WQO datasets;
- an amended sampling program reflecting changes to improve the usefulness of future data collection for baseline and impact monitoring purposes;
- commitment to continue collection of a baseline dataset to develop final water quality objectives.

The draft EIS does not adequately characterise water quality variation in the receiving environment in terms of the upper/lower margins of variation. The EIS should provide water quality data summaries for the receiving environment that include the range, and 5 and 95 percentile values.

Proponent Response

The draft EIS proposes 'interim site-specific trigger values' based on the data collected during the baseline surveys. 'Trigger' or 'Guideline' values are precursors to 'Water Quality Objectives'. The method for deriving these trigger values followed the methods in the AWQG i.e. local and regional reference data were used, so that the proposed trigger values were relevant to the site. Ideally, according to the AWQG, background data should be collected on a monthly basis for two years. However, interim trigger values can be calculated from data collected over a shorter period. Consequently, data collected in the surveys in May 2013, and from June 2015 to July 2016 were used to derive interim trigger values. In addition, satellite imagery was used to provide longer term information on turbidity.

Where there are strong seasonal or event-driven processes (e.g. in tropical wetlands), the AWQG suggest it may be appropriate to develop trigger values corresponding to these periods. The baseline monitoring program was designed to determine if there were any strong seasonal or event-driven processes, and consequently whether it would be appropriate to develop trigger values accordingly.

Analysis of the data collected for the EIS indicates that:

- water quality was characterised by high turbidity and by concentrations of total phosphorus, filterable reactive phosphorus and oxides of nitrogen that were over the AWQG at most sites in most surveys
- there was no vertical stratification of temperature or salinity
- there were no consistent patterns with tidal cycles
- turbidity was high in both the dry and wet season, and when both long term data from satellite imagery and the baseline data were considered, was higher in the dry season than in the wet season
- turbidity was similar on neap and spring tides, and slightly lower in the intervening period and
- the concentration of total nitrogen, oxides of nitrogen and ammonia were higher in the dry season than in the wet season.

That is, the main consistent differences in water quality were associated with the dry and wet season. However, it was considered that data had not been collected over a long enough time to derive separate

trigger values for both the wet and dry season. As a consequence, interim trigger values were calculated for the full year, using all the surface water quality data that was available.

The proponent has committed to the formulation of Water Quality Trigger or Guideline levels (i.e. the 'actual' not 'interim' triggers) as part of the Water Quality Monitoring Program (refer to Section 5.3.3 of the Marine and Estuarine Water Chapter of the draft EIS [Volume 2, Chapter 2]) and as such has continued to collect water quality data to enable this to occur. Analysis of the data will also continue to include statistics such as the range, and 5th and 95th percentiles. The data will also be re-analysed to determine if there are any significant variations due to tide, lunar cycles or season, and trigger values established on that basis. Given the analysis to date, it is not anticipated that these trigger values will be significantly different from the proposed interim triggers, however, seasonal triggers may be appropriate for some parameters (e.g. turbidity). The most suitable times for data collection for the ongoing water quality monitoring program will be refined as further data is collected. The proponent anticipates that, moving forward, data collection will be standardised on the neap tides.

3.19.28 Comment 28

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Marine and Estuarine Water
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Section 2.8 Numerical modelling

Details of the Submission

A 2-Dimensional model, MIKE21, was used to assess the likely dilution rates of prawn farm effluent on the waters around Legume Station. While MIKE21 is considered an appropriate tool for an exercise such as this, it is not considered particularly good at simulating effluent mixing and dilution due to the extreme difficulty in representing turbulent mixing processes in the model formulation. Validation of predictions of effluent dilution is therefore very important. In the draft EIS, validation of the model's ability to simulate dilution rates is restricted to the modelling of the recovery of salinity in Alligator Creek following rainfall events compared with measured salinities during these times. This is a valid approach and is one of the only ways to assess the mixing performance of the model prior to effluent release. However, the comparisons appear cursory and unconvincing. Certainly, the analysis does not include an assessment of the limits of model validity. The Supplement should include an assessment of the reliability of the model to predict effluent dilution using analysis of the recovery of salinity, with the results reported as confidence levels.

Proponent Response

MIKE21 has been utilised for numerous water quality and effluent transport projects across Australia and internationally. Water Technology (the Project's hydrodynamic modelling consultant) has used MIKE21 to simulate discharges from a range of aquaculture and industrial facilities with considerable success, including model validation through the use of fluorescein dye.

The default model parameters within MIKE21 for mixing have been established through a study of numerous peer reviewed studies and accepted practices, and perform well under a wide range of circumstances.

Based on the experience of Water Technology, the success of a contemporary water quality model such as MIKE21 is more related to the accuracy of the hydrodynamic inputs such as discharge rates, tidal and wave generated currents than to the model parameterisation. This is especially true at Legume Station given the 9m+ tidal range. This macro-tidal environment around Legume Station results in very little, to no, vertical stratification within the water column. This has been confirmed by water quality depth profiling collected at

Legume during the EIS investigation. Sensitivity testing using MIKE3 (which includes vertical layering) also verified that a discharge within Alligator Creek will be well mixed through the tidal forces in close proximity to the discharge point.

The initial mixing and dilution of the MIKE21 modelling has also been validated by comparing the initial mixing with the near-field mixing program CORMIX, which showed similar results.

Validation using measured salinity

Due to the remote location of Legume Station, limited measured rainfall and freshwater flow data are available to undertake detailed calibration of the mixing processes within the model. The model validation assessed the impact of a short rainfall event on salinity in Alligator Creek and used estimated flow rates and flow duration at the upper end of Alligator Creek as there is no gauged flow data on the waterway. Daily rainfall totals are measured at the Legume Station homestead.

The flow rate and duration of the flow event has thus been based on observations and is an estimation only. The model responded well to these estimated inflow rates and durations and measured water levels indicated a good representation of the hydrodynamic conditions during the flow event. Improved 'calibration' of the predicted salinity within Alligator Creek could have been achieved by altering these inflow conditions, as well as those within the Keep River, to provide a more precise match in the measured versus modelled salinity, however, this was not deemed suitable as only a single flow event occurred during monitoring and the fine-tuned inflows could not be validated against another event.

3.19.29 Comment 29

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Marine and Estuarine Water
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Section 4.5 Water quality

Details of the Submission

The draft EIS assesses the potential for Water Quality Objectives (WQO) to be exceeded by the proposal based on the average likely concentrations of water quality indicators. The draft EIS does not provide adequate information to characterise sustainable loads for key contaminants and the potential for acute water quality events (such as anoxic/anaerobic events) in Alligator Creek during high risk scenarios.

The EIS should analyse relevant data relating to:

- sustainable loads of key contaminants from the discharge in relation to total loads from the catchment and other sources;
- potential biological response to the discharge including consideration of the potential for algal blooms involving benthic intertidal species and species that may bloom in surface layers of the water column; and
- likelihood of acute water quality events (algal blooms or hypoxia events) within Alligator Creek involving low background dissolved oxygen and pH in the receiving environment and worst-case scenarios for wastewater discharge, including night time discharges (when pH and dissolved oxygen are likely to be lowest).

Proponent Response

A discussion on maximum annual loads of TN, TP and TSS from the Project, and a comparison of these loads with existing concentrations estimated within Alligator Creek, is provided in response to Comment 7 from the Department of Environment and Natural Resources (Section 0).

Algal blooms are considered highly unlikely in the receiving environment due to the very high turbidity naturally occurring in the environment results in rapid light extinction which limits primary production.

Water quality modelling investigations were conducted to investigate the potential for dissolved oxygen (DO) sags to develop in Alligator Creek in the event that the chlorophyll/algal carbon content of the proposed prawn farm discharge rapidly decays upon entering the light limited receiving waters (see complete methods and results in Appendix E).

Mean, median and minimum surface and bottom DO concentrations and saturation levels at the discharge location are shown in Figure 14 to Figure 16. Varying discharge scenarios tended to produce slightly lower DO concentrations when compared with the constant discharge scenarios. As expected, DO concentrations reduced when wind-induced reaeration was switched off (Figure 17) and the reduction became more obvious as the BOD5 loading increased.

Generally speaking, there was no significant decrease in DO concentrations for simulations with BOD5 concentration below 20 mg/L, even when the wind was switched off. This indicates that DO depletion is unlikely to occur in Alligator Creek as a result of wastewater discharged from the proposed prawn farm.

When the lower bound ANZECC & ARMCANZ median water quality guideline level for DO in tropical estuaries is considered, this being 80% saturation (see the red line in Figure 15), it is apparent that provided BOD5 levels in the discharge remain below 50 mg/L for all 'with wind' cases, that there is no violation of the guideline value. For the highly conservative 'no wind' case, the threshold BOD5 value for potential impact becomes typically 30 mg/L, with the exception of bottom DO levels for the varying discharge case where impacts occur for a discharge level of 10 mg/L. As this is a quite extreme case, that is two weeks with no wind, a more realistic recommendation for a maximum BOD5 in the discharge is between 20 and 30 mg/L. As stated earlier in this regard based on available data, it is expected that the site will discharge at levels more like 7-12 mg/L, and as such no adverse DO impacts are expected.

Based on this analysis there is no potential risk of hypoxia events occurring within Alligator Creek as a result of the release of discharge water from the Project.

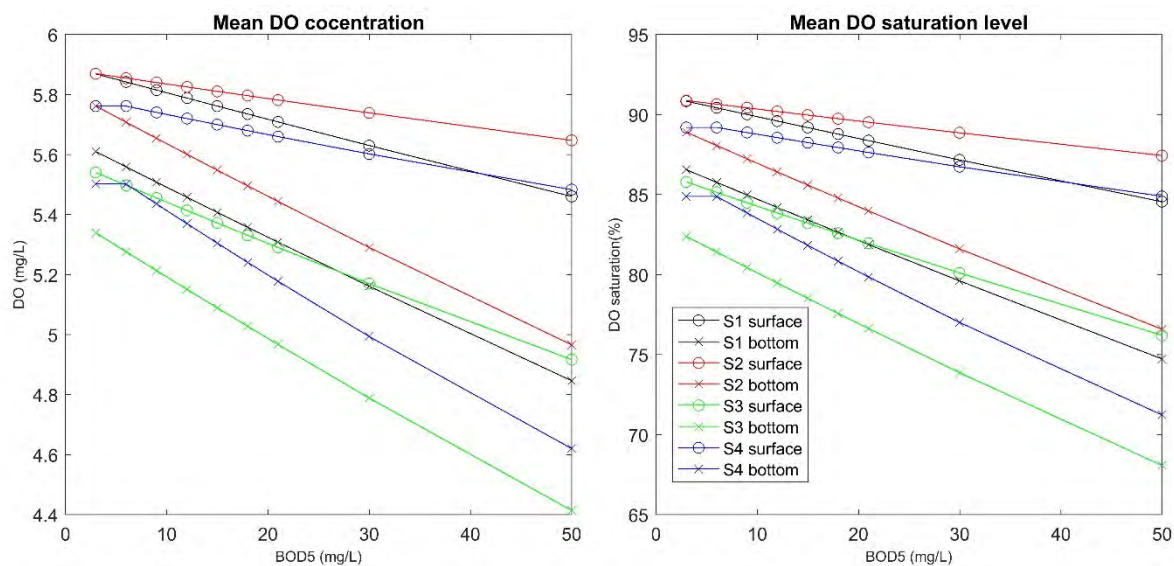


FIGURE 14 MEAN DO CONCENTRATION

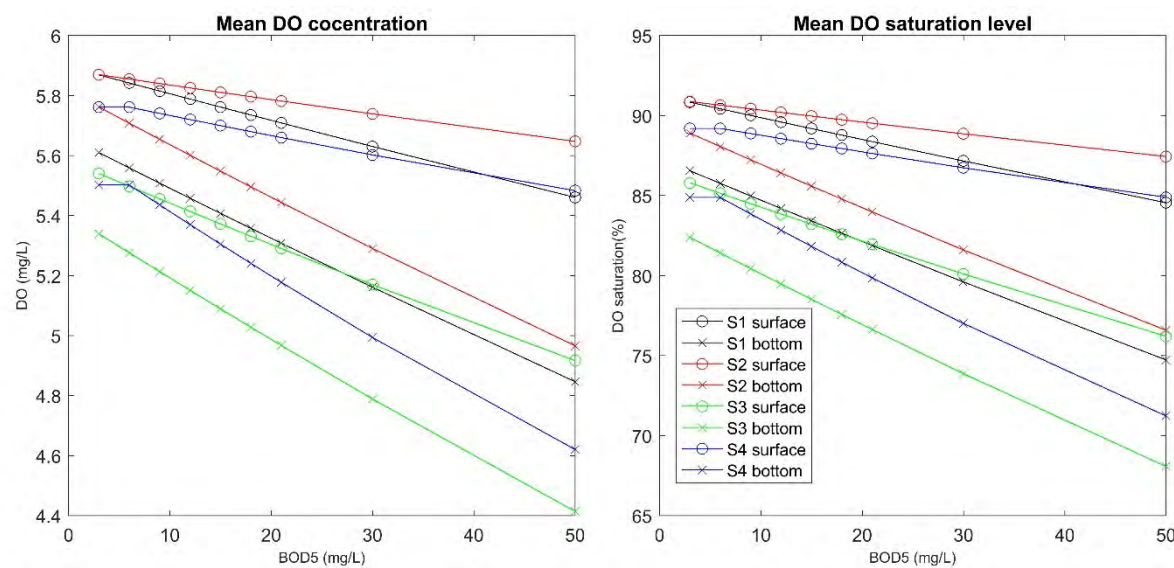


FIGURE 15 MEDIAN DO CONCENTRATION

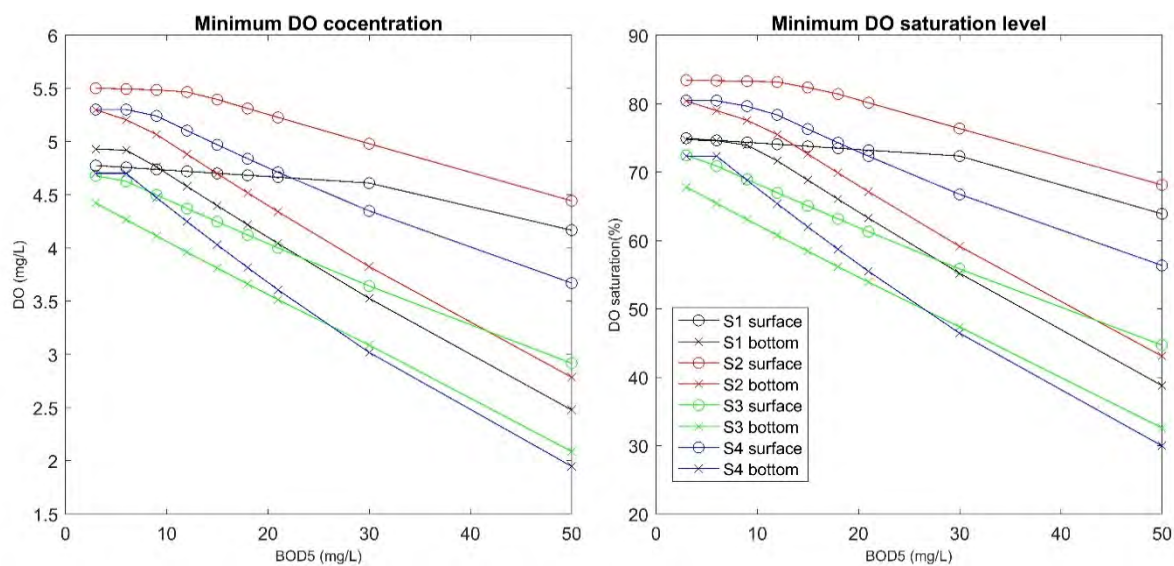


FIGURE 16 MINIMUM DO CONCENTRATION

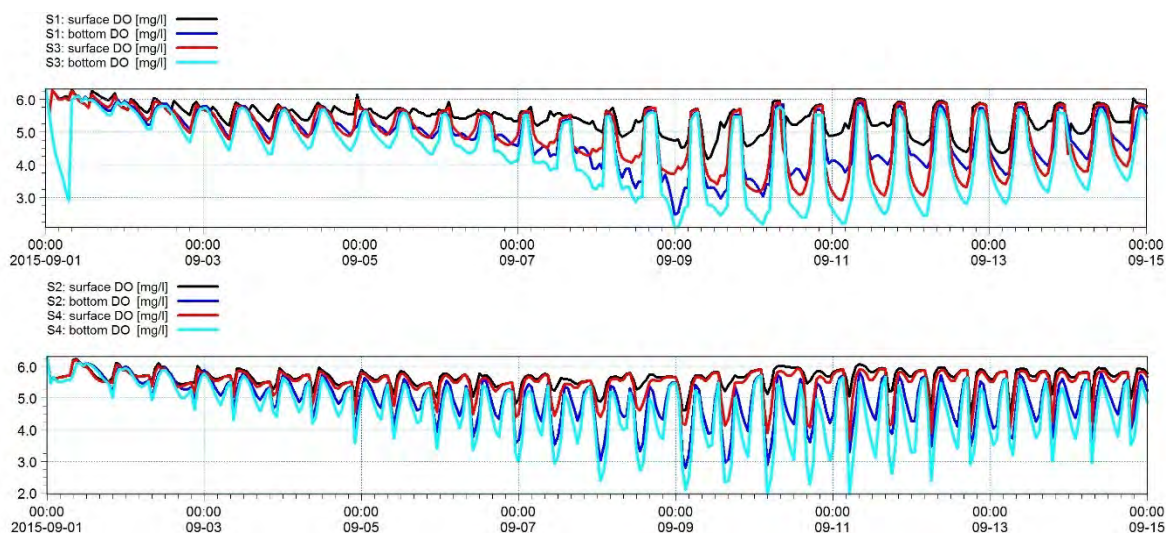


FIGURE 17 SURFACE AND BOTTOM DO CONCENTRATION, BOD = 50 MG/L

3.19.30 Comment 30

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Marine and Estuarine Water
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Section 4.5 Water quality

Details of the Submission

The proponent states that the discharge licence requirements will be met through the use of recycling ponds making up 30% of the total pond area.

The use of treatment ponds and recycling has been successfully practised by the Australian prawn farming industry for a number of years. This approach is consistent with the published work of Jackson et al. (2003) and industry manuals for an appropriate treatment pond/grow-out pond area ratio.

However, the Jackson et al. (2003) research was undertaken when production per hectare was lower. For Project Sea Dragon, the Proponent claims to be able to meet the stringent Great Barrier Reef Marine Park requirements for nitrogen and phosphorus discharge loads despite higher production per hectare. This would entail an improvement in treatment processes to deal with the higher waste loads. It is unclear from the document whether there have been any improvements in treatment methods in more recent years, and there is no information given in the draft EIS on the performance of Seafarm's Cardwell farm to demonstrate this. More specifically, there are no discharge values for TSS, TN and TP given on page 2-62 to substantiate the statement that prawn farms are using a range of waste mitigation strategies.

The following details should be included in the Supplement to allow a more informed assessment of how effective the approach used for the Project is likely to be:

- data on total nitrogen, total phosphorus and total suspended solids concentrations, and percentage reductions achieved for Seafarms other operations, as a result of treatment pond/s
- information on the mechanisms used to maintain treatment ponds to ensure they continue to be effective.

Proponent Response

The matters raised in this comment are in part addressed in the response to the previous NT EPA comments.

First it is necessary to respond to the comment by way of correction. The proponent has proposed a prawn production system that includes, *inter alia*:

- a modern 'green water' prawn production system that uses in-situ primary production as part of the production process
- a system of internal farm recycling ponds that facilitate both nutrient treatment and facilitate recirculation and therefore nutrient recycling and re-use
- the design of the main drainage channel to be engineered with design velocities that assist sediment fall out
- an EPZ that has been designed to enable hydraulic control and settlement as well as biological assimilation of nutrients through the colonisation and/or planting of samphire and other species.

It is therefore a gross oversimplification to state that, "*discharge licence requirements will be met through the use of recycling ponds making up 30% of the total pond area*". The entire system has been carefully designed in relation to water management and environmental performance. The reference to the 30% of pond area is primarily to enable assessors to benchmark the sizing of these ponds compared with the production areas noting that the 30% is the guidance that is available from the peer-reviewed literature. It is not clear by what means the comment determined the production per hectare in the farms studied in the Jackson et al. (2003) paper, since that paper actually states: "*Details of production from this farm were not available,*" and then quotes 1997/1998 average production figures for *M. japonicus* (a species no longer cultured in Australia) together with food conversion ratios of 2.7 (a benchmark that would be considered unacceptable in today's systems). Thus while average production at Australian farms may have been lower at the time the paper referred to was written, production efficiency appears to have been lower and it is invalid to proceed on the

assumption that because the industry is more intense, the conclusions in the Jackson et al. (2003) are compromised or invalid.

This misunderstanding is reflected in the following comment:

'the Proponent claims to be able to meet the stringent Great Barrier Reef Marine Park requirements for nitrogen and phosphorus discharge loads despite higher production per hectare. This would entail an improvement in treatment processes to deal with the higher waste loads.'

First this misquotes what is in the draft EIS. The draft EIS simply states that the proponent would expect to be required to operate within licence conditions comparable to those issued for its Ingham facility which are stringent (see quote below). The draft EIS is silent on Ingham production per hectare which is commercial-in-confidence information. Second there is a clear misapprehension that higher production per hectare invariably leads to higher waste loads that necessitates an 'improvement in treatment processes'. The goal of industry is to improve efficiency, which is at least in part reflected in improvements in Food Conversion Ratios.

The comment also references Seafarms 'Cardwell' farms whereas the draft EIS clearly states (Volume 2 Chapter 2, p 2-63, emphasis added):

'the proposed grow-out ponds at Legume Station are expected to operate within the water quality limits applying to the existing Seafarms Group prawn farming operations at Ingham in North Queensland (Seafarms, 2016). The license conditions at Ingham are the most recent conditions issued by Queensland EPA for an operating farm and are amongst the strictest conditions imposed in Australia.'

The draft EIS (Volume 2, Chapter 2, Table 7) shows the licence conditions for Ingham which informed the modelling and impact assessment. The farm at Ingham makes use of a settling pond, there are no settling ponds at the Cardwell farms as these were amongst the earliest farms constructed in Australia prior to the adoption of settlement. Seafarms took over the Ingham farm in late 2014. Immediately prior to this, the operation was dormant and had been mothballed. Thus the proponent has a limited data set for this facility.

The key point of the water quality risk assessment presented in the draft EIS is to show that assuming: (i) the median licence condition is met, (ii) the modelled volume of water is discharged, and (iii) discharge is timed on the ebb tide; the interim site-specific trigger values as proposed are met at all points in Alligator Creek for TN and TP. The values for TSS are expected to be significantly less than in the ambient waters. There is a small mixing zone relevant to chlorophyll a (see Figure 3-25, Volume 5, Appendix 8 - this figure is reproduced below as Figure 18).

Figure 18 shows the modelled concentrations of nutrients (TN, top panel, TP middle panel and chlorophyll a lower panel) compared with interim site-specific trigger values derived from local data (dashed line) assuming a constant concentration of 0.8 mg/L TN, 0.1 mg/L TP and 20µg/L chlorophyll a in discharge waters that are released each tide. The points are representative of different locations in Alligator Creek with point 1 being at the estuarine mouth of the creek and point 20 upstream towards the bunding. The logic that was followed in the draft EIS reflects AWQG and the regulatory environment in which an operator is required to meet its licence conditions.

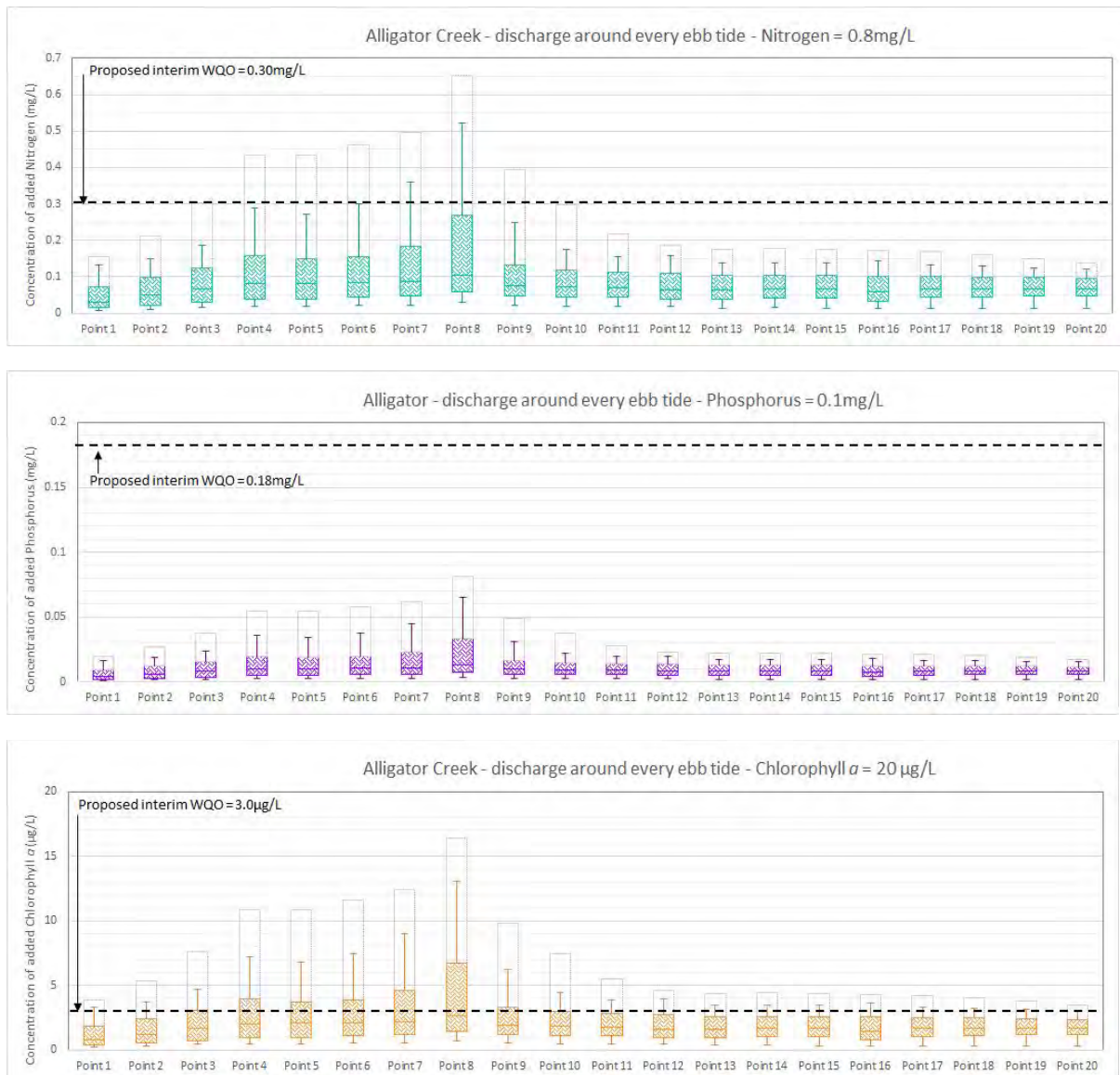


FIGURE 18 BOX AND WHISKER PLOTS OF ADDITIONAL NITROGEN, PHOSPHOROUS AND CHLOROPHYLL A

Finally, settlement ponds can be maintained through removal of sludge as necessary. As outlined in the draft EIS settlement ponds mostly work through physical processes, that is very low velocities of water and suitable retention times. The Aquaculture Stewardship Council Shrimp Standards (2014, p 107) states the following in regard to sludge disposal:

'Intensive aquaculture ponds and settling ponds and canals usually accumulate sludge and sediments that need to be removed periodically. The best way to dispose of saline sediment is to place it on the insides and tops of pond embankments after drying on pond bottom or in dedicated areas on the farm where sludge is extracted from ponds or canals. Alternatively, the best disposal sites have saline soil and, especially are in areas without surface or underground freshwater bodies.'

3.19.31 Comment 31

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Marine and Estuarine Water
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Section 4.5.1 Background and literature review

Details of the Submission

It appears that information in the Jackson et al. (2003) publication referenced in the draft EIS has been quoted incorrectly giving the impression of greater efficiency of nitrogen retention in prawn ponds than has been found to occur. Jackson et al. (2003) states that 57% of nitrogen is discharged, not 27% as indicated in Figure 14, and denitrification/volatilisation is given as 3% in Jackson et al. (2003), not 30% as shown in the draft EIS. Please check and correct these in the Supplement.

Please provide comment on whether these potential overestimates could impact the predicted nutrient concentrations at the point of discharge.

Proponent Response

Figure 14 in Volume 2, Chapter 2 of the draft EIS (Marine and Estuarine Water) was taken directly from the Australian Prawn Farming Manual rather than from Jackson et al. (2003). This data was part of a broader literature review for informative and contextual purposes only, and was not the basis of the estimates of the predicted nutrient concentrations at the point of discharge. As is explained in the following section of the draft EIS chapter (Section 4.5.2 - Proposed Licence Conditions) the predicted nutrient concentrations at the point of discharge that were used in the hydrodynamic modelling are based upon the license conditions from Seafarms Ingham operations (TN 0.8mg/L; TP 0.1 mg/L; Chlorophyll a 20 ug/L; TSS 20 mg/L). The key point of the water quality risk assessment presented in the draft EIS is to show that, assuming the mean licence condition is met with the modelled volume of water, and with discharge timed on the ebb tide, the interim site-specific trigger values as proposed are not exceeded at all points in Alligator Creek for TN and TP. The values for TSS are expected to be significantly less than in the ambient waters. There is a small mixing zone relevant to chlorophyll a (see Figure 35, Volume 5, Chapter 8).

3.19.32 Comment 32

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Marine and Estuarine Water
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Section 4.5 Water Quality Volume 4, Chapter 3 draft EMP

Details of the Submission

The Proponent is advised that it will be required to provide additional information on a continual improvement program, which is part of the Proponent's Environmental Management System through the Waste Discharge Licence process. Considerations may include:

1. management goals and objectives, which should reflect that at all times, reasonable and practicable measures will be implemented to minimise concentration and mass loads of contaminants to progressively work towards the objective of ensuring that the average net load of total nitrogen released to waters is zero. This can be achieved by recycling effluent during the whole of the prawn grow-out season; or by ensuring the average net load of total nitrogen released to waters as calculated under the environmental authority is zero.

2. design and operation of the pond systems with reference to the waste management hierarchy, including proposed measures to reuse or recycle water and contaminants within the pond systems, and treat wastewater prior to discharge. The following performance indicators should be considered in relation to the standards/benchmarks referenced in point 3:

a. discharge volumes including daily maximum, average, minimum; expressed as daily volume, and volume per hectare of production pond

b. discharge rates including maximum and average annual rates; expressed as total daily volume, and volume per hectare of production pond

c. quality of wastewater discharged to receiving environment; expressed as range and median, for parameters including dissolved oxygen, pH, biochemical oxygen demand, total suspended solids, chlorophyll-a, total and dissolved organic carbon, total nitrogen and phosphorous. Diurnal variation of pH and dissolved oxygen in wastewater may be significant, and should be characterised and incorporated in the statistics for pH and dissolved oxygen

d. contaminant mass load per hectare of production ponds for parameters including total nitrogen, total phosphorus and total suspended solids.

3. analysis of projected contaminant concentrations and loads with reference to relevant benchmarks for best-practice environmental management, including:

a. the operational policy Licensing wastewater releases from existing marine prawn farms in Queensland (<https://www.ehp.qld.gov.au/assets/documents/regulation/pr-op-wastewater-prawnfarm.pdf>)

b. relevant recirculation and zero-discharge prawn farm technology research and trials.

4. proposed discharge limits relating to mass loads and limits, including limits relating to statistical measures of distribution such as percentiles

5. specific measures considered to trial and develop water quality treatment and recycling strategies

6. improvement targets for reducing the mass load of nitrogen, phosphorus and suspended solids discharged to the receiving environment (such measures may include but not be limited to increased recycling of effluent, additional or more effective effluent treatment, bioremediation ponds, improved food conversion ratios and use of lower protein feeds).

Proponent Response

The proponent notes the requirement to provide additional information on a continual improvement program through the Waste Discharge Licence process. One of the most significant ways that continual improvement can be achieved is via the proponent's breeding program, which continues to breed stock that allows for the improving the efficiency of the food conversion ratio. This is a primary objective of the company due to high costs associated with feeding.

3.19.33 Comment 33

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Freshwater
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Volume 2, Chapter 3, Section 4.2.1.3 Uncontrolled release Figure 16

Details of the Submission

Figure 16 shows maximum flood depth for uncontrolled release and overtopping of ponds from farm 1 and 2. Provide discussion on whether a maximum flood depth was modelled for farm 3.

Proponent Response

The modelling focused on the release from Farms 1 and 2 as the worst case. Noting minimal to no impacts as outlined in the response to the Department of Environment and Energy Comment 8 (Section 3.14.8), the release from Farm 3 is likewise expected to result in no impacts.

Owing to the possible sensitivity of the heritage restricted zone to the north of Farm 3, similar releases from Farm 3 will report to the biosecurity zone south of the farm area, passing under the Main Discharge Channel to the floodplain as per the Farm 1 and 2 release. Similarly to Farms 1 and 2, the Farm 3 water management system includes the following (Section 6.10.1, Volume 1, Chapter 3 of the draft EIS):

'The stop-log will be designed to allow automatic overflow to the PDC in high intensity storm events, so that the ponds are not overtopped in the minor design level storm event. For events greater than the minor design event up to the major design event level, the stormwater will be managed by controlled release gravity drainage through the downstream weir structures from Pond and Farm Discharge Channels and the IFRP and then to the MDC (refer to Table 5 of Volume 1, Chapter 3 of the draft EIS for design events). For greater than the major design event, a lined swale will be provided in the berm of the outermost channel (Pond Feeder Channel or Pond Discharge Channel) facing the biosecure zone, for planned release to the environment. In such events the salinity of the water being released is expected to be very diluted by the rainfall event.'

To be clear, this applies to all of Farms 1, 2 and 3.

3.19.34 Comment 34

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Freshwater
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Volume 2, Chapter 3, Section 4.3 Water Quality Pg 3-37 Table 5

Details of the Submission

Given the existing poor water quality of Legume Station and the implementation of mitigation measures outlined in Section 5, including a Water Quality Monitoring Program, it is concluded that construction and operation of the Project will not further impact the freshwater quality within the Project Area and its surrounds.

Given that many of the sites were sampled in the dry season and values represent a single data point, this baseline assessment may not be accurate. The basis for a water quality monitoring program for freshwater sites should be provided and include at a minimum:

- surface water monitoring locations and monitoring frequency
- monitoring extent of freshwater habitat
- further commitment to obtaining an appropriate baseline dataset.

Proponent Response

A draft freshwater monitoring program is located in Appendix C7 of the draft EIS (Volume 4, Chapter 3, draft Environmental Management Plan). However, there were some errors in table numbering and referencing in that Section that have since been rectified. The relevant elements for this comment are:

- Table C7.1, Monitoring subsection
- Table C7.3 Interim water quality trigger values
- Table C7.4 Monitoring sites, parameters and frequencies (including for Freshwater)
- Table C7.5 monitoring site coordinates

This provides for continuing baseline data collection, and ongoing operational monitoring.

Note that monitoring of the extent of freshwater habitat will be part of the waterbird monitoring program, which is provided in Appendix A.

3.19.35 Comment 35

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Groundwater
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Volume 2, Chapter 4 Groundwater

Details of the Submission

A site wide groundwater monitoring program to monitor groundwater levels has been proposed as a mitigation strategy to provide early warning of potential impacts from the project. Monitoring is not mitigation. Preventative control strategies should be implemented where indicated, in order to minimise the potential for an impact to occur. In addition, trigger levels and appropriate management responses are required for instances that mitigation has not been effective and monitoring detects an impact.

Proponent Response

Both monitoring and mitigation measures were set out in the Groundwater Management Strategy, which can be found at Appendix C8 of the EMP (Appendix H). The key mitigation measures in that plan are:

- Implement Hazardous Materials, Waste, Acid Sulfate Soil and Effluent Management Strategies to avoid these sources of impacts to groundwater.
- Manage excavation depths in borrow pits and monitor groundwater levels to avoid lowering groundwater and damaging productive aquifers / bores.

- Ensure that stormwater diversions and flood management does not change the flow into and out of groundwater recharge zones - pre and post construction flooding levels to be as similar as practicable, using culverts and floodways to avoid excess ponding and allow for continuity of flow.
- Avoid impacting or drawing from pastoral use bores and borefield areas (freshwater supply will be from Forsyth Creek Dam via the Freshwater Channel).
- Implement procedures for rapid response to identified large pond and channel leaks. These will include:
 - Early detection of leaks through groundwater monitoring of tracers and/or fingerprinting of waters (anion/cation mixes, etc.);
 - Integrity testing of areas with the potential to leak;
 - Rectification of leaks, by in-situ repair works, with emptying of the pond in extreme situations.

The investigation works and design in relation to pond impermeability, described in more detail in Sections 2.1, 2.2, 2.3, 3.1, 3.3 and 3.5 in Appendix F, provide for the primary mitigation against leaks to groundwater from the ponds, along with the above early warning and rapid response procedures. Appendix C8 of the EMP (Appendix H) also provides corrective actions should a leak be identified. While not explicitly described, these corrective actions (to *"rectify leaks as soon as practicable once identified"*) could include emptying of a pond to allow reprofiling, compaction and plugging of any identified leaks in extreme cases.

In terms of trigger levels, a pre-construction monitoring program has been committed to (Volume 2, Chapter 4, Section 5.6 of the draft EIS, and Appendix C8 of the draft EMP (Appendix H). This data will be combined with the existing data to provide baseline levels for assessment of change following the commencement of operations.

3.19.36 Comment 36

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Groundwater
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Volume 2, Chapter 4, Groundwater, Section 3.3, Recharge zones

Details of the Submission

Alligator spring, located next to Alligator Creek, and its associated permanent wetland stretching downstream of its discharge point appears to be an area of fresh shallow groundwater. The location of this spring and wetland and other elevated land forms that may receive large amounts of freshwater recharge needs to be provided in Figure 1 to provide context of their proximity to the Project.

Proponent Response

Alligator Springs is spatially well removed from the Project footprint (the main access road is the closest project feature, approximately 9 km to the west) and will not be impacted by the Project. The location of Alligator Springs was shown on a number of figures in the draft EIS, including Figure 2 of Volume 2, Chapter 6 (Terrestrial Fauna and Avifauna) reproduced here in Figure 19.

As noted in the groundwater chapter, groundwater generally flows from the ranges towards the coast in sandstone, fractured rock and sand/colluvial deposits. As such Alligator Springs is 'upgradient' of the Project and there will be no potential for any groundwater impacts to Alligator Springs.

Refer also to the Conceptual Model provided in response to Comment 37 (Section 3.19.37 in this response).

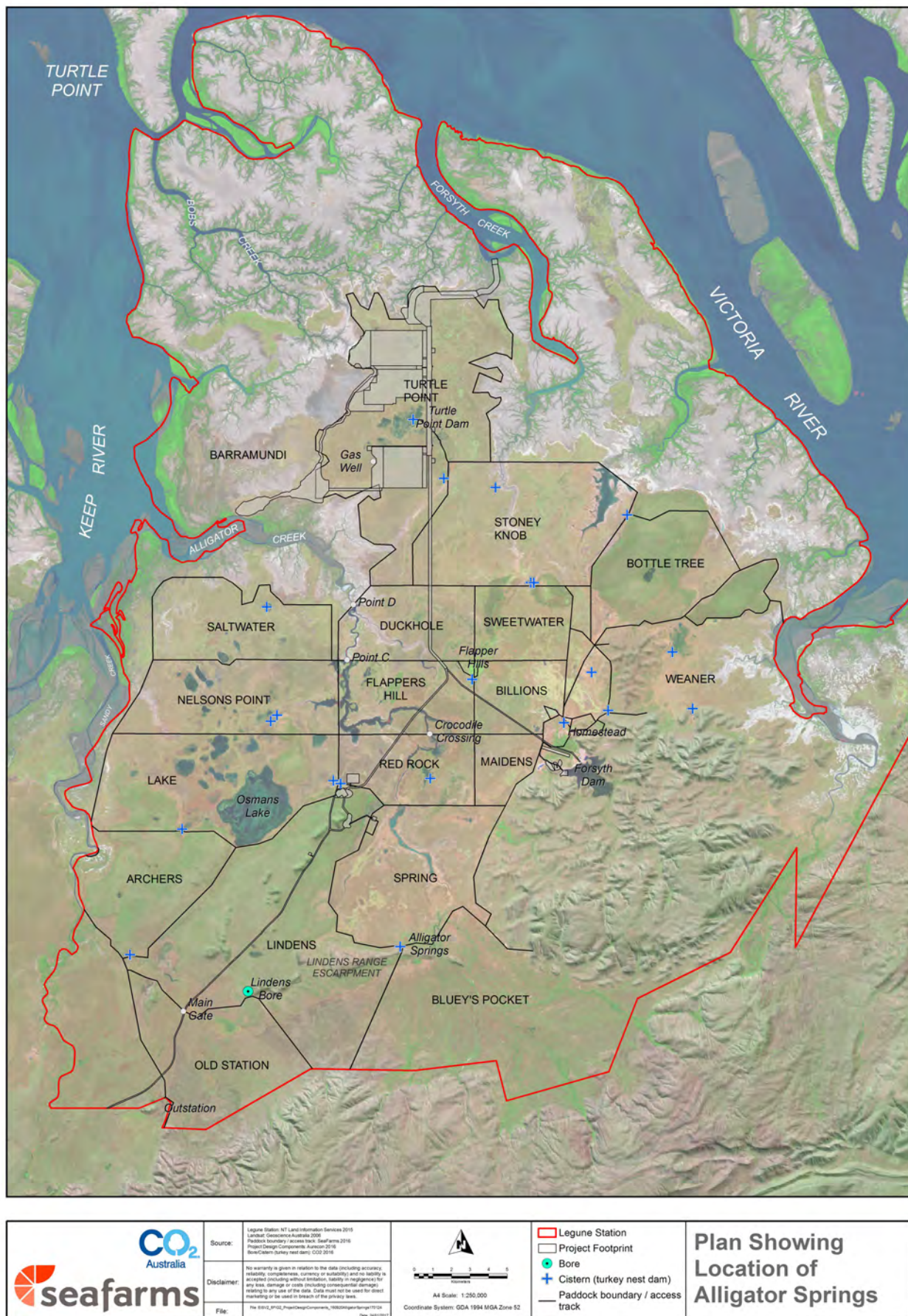


FIGURE 19 PLAN SHOWING LOCATION OF ALLIGATOR SPRINGS

3.19.37 Comment 37

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Groundwater
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Volume 2, Chapter 4, Groundwater, Section 3.3, Recharge zones

Details of the Submission

The conceptual model for groundwater on Legume Station is that water generally flows from the ranges towards the coast in sandstone, fractured rock and sand/colluvial deposits, with a corresponding but opposite flow of saline water from coasts back inland, each balanced by the relative hydraulic head.

The Terms of Reference listed the EPA guidelines on Conceptual Site Models which include the requirement to provide:

- key contaminants and their characteristics
- inferred sources and pathways
- mechanisms for transport
- potential receptors.

Provide this conceptual site model of groundwater flows on a figure with the project footprint to contextualise groundwater flows horizontally and vertically. A simple diagrammatic presentation of the main processes that may influence ground water quality should be provided.

Proponent Response

A conceptual model of groundwater in the Project area was provided in a descriptive format in Section 3.5 of Volume 2, Chapter 4 of the draft EIS. Figure 20 herein provides this as a diagram as requested.

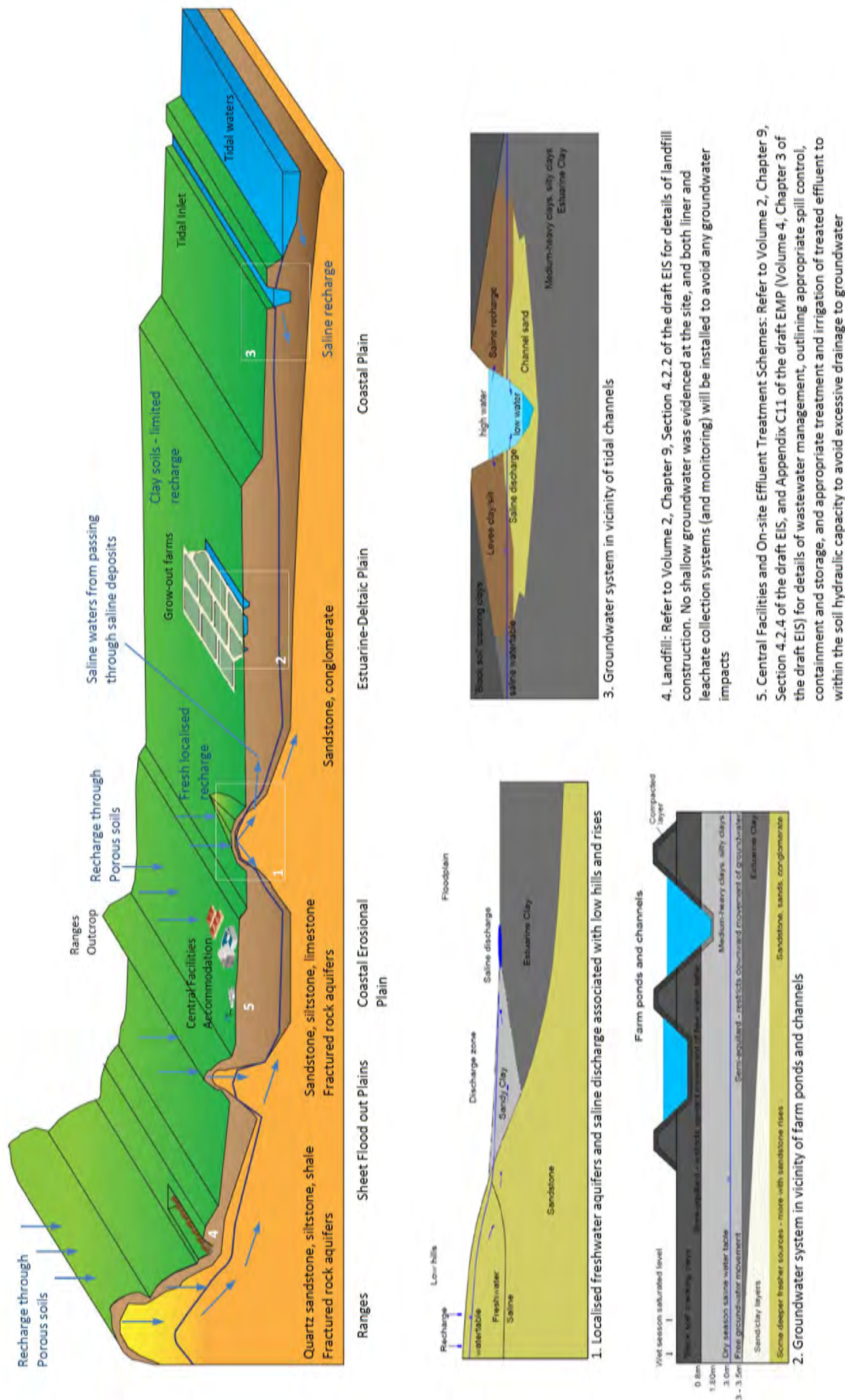


FIGURE 20 CONCEPTUAL HYDROGEOLOGICAL MODEL

3.19.38 Comment 38

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Groundwater
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Volume 2, Chapter 4, Groundwater, Section 4.2 Impact Assessment

Details of the Submission

Seepage, spills and overflows at the farm ponds and channels, raising saline groundwater levels in the dry season beyond the natural regime. However, given the proposed compaction and low permeability of soils used in these structures, large leaks are considered highly unlikely and only leaks of a large magnitude would be likely to have any chance of impacting water tables in this manner. As such, impacts would be essentially limited to water table changes rather than salinization of ground waters (which are already saline)

Groundwater data indicated a salinity range of 1.6 – 44 dS/m compared to the upper range of seawater at 50 dS/m that will be used within the farm ponds and channels. Seepage of the ponds and channels has been identified as 6 ML/day. Additional information is required to demonstrate that this seepage will not have detrimental impact on the receiving environment and what long term monitoring will be conducted to identify any pond structure failure. Provide details on:

- seepage rates from the ponds/channels and how that may impact groundwater levels and quality (salinity and nutrients); and
- impacts of groundwater mounding and maintaining groundwater levels required for embankment stability.

Proponent Response

Section 3.3 in Appendix F describes the findings in terms of permeability, and the low permeability able to be achieved for the ponds and channels, while the groundwater mitigation and monitoring program is addressed in response to Comment 35 (see Section 3.19.35).

In terms of seepage rates, this will be controlled by the permeability and the thickness of the liner, as outlined in the Department of Primary Industry and Fisheries (2007) Guidelines for constructing and maintaining aquaculture containment, particularly Table 4. Given the achievable permeability with site soils exceed those in Table 4, and that a nominal liner thickness of 200 - 300 mm is quite achievable, seepage rates will be suitably low to meet the requirements of that guideline, and therefore to protect groundwater systems.

Volume 5, Appendix 7 of the draft EIS contains information on stability modelling for the ponds and channels (Section 8.6.2.3), including modelling combinations of:

- drained and undrained conditions
- water levels at 1.5 m depth and 4 m depth (for ponds and channels respectively)
- groundwater at 2 m depth (dry season) and at the surface (wet season).

This modelling found acceptable factor of safety results for the farm ponds and channels, with recommendations to overcome some marginal results for inlet and outlet using ground improvement (stronger fill, etc.) where required to achieve suitable stability.

3.19.39 Comment 39

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Groundwater
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Volume 2, Chapter 4, Groundwater, Section 6, Commitments

Details of the Submission

Implement procedures for rapid response to identified leaks and other issues identified by the monitoring program.

Provide details on the response and timeframes for rectification in the event that monitoring finds impact to the shallow groundwater from excessive nutrients/salinity from the ponds/farm or from on-site waste irrigation areas.

Proponent Response

Refer to the response to Comment 35 (see Section 3.19.35) outlining the monitoring and mitigation measures for leak identification and response.

In terms of timing, should a pond be identified as subject to a leak, corrective earthworks would be implemented as appropriate. For channels, temporary closure of farm channels will be possible to enable maintenance works if required, with the larger channels requiring rectification either:

- during the farm fallow period when the channel can be emptied
- during the operating period, by fix-in-place methods of plugging by limited excavation and backfilling with compacted fill or impermeable membranes, without draining the water retaining structure
- for large/catastrophic leaks, this will consist of draining the pond or channel for a period until compacted fill can be placed to correct the breach.

As outlined in Section 3.3 in Appendix F, the maximum design seepage of 2 mm/day will be adopted for the purpose of liner permeability and thickness (nominally a minimum 300 mm, depending on the achieved permeability). Infiltration below this level attributable to a leak will be rectified after normal pond emptying, with leaks above this level requiring earlier intervention.

Note that this target will apply across the whole farm (though not averaged across all farms).

3.19.40 Comment 40

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Terrestrial Fauna and Avifauna
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Volume 2, Chapter 6, Figure 18

Details of the Submission

To provide a spatial context, provide updated figures of avifauna abundance and richness showing modelled extent of freshwater following dam release compared to freshwater extent without dam releases.

Proponent Response

Figure 21 to Figure 24 illustrates waterbird abundance, richness and diversity at each site for each survey event throughout the dry seasons of 2015 and 2016. The figures also illustrate the area of inundation following the release of Forsyth Creek Dam in both 2015 and 2016, and the typical dry season extent pre-dam release. On Figure 21, sites AC3, AC4, AC5 and FD1 where abundance is relatively low, count data is presented numerically.

Diversity is presented as both the Shannon-Weiner index (H) and Evenness (E). The Shannon-Weiner index reflects a measure combining species richness and evenness of abundance. The metric has no unit of measure and is effectively boundless, albeit with a minimum of 0. The Evenness measure reflects how similar the spread of abundance of species is to a completely even abundance of all species, taking into account species richness. Values range from 0 to 1, with a value of 1 reflecting a completely even number of all representative species, and a value of 0 (not actually possible to be exactly 0, but close to it) reflecting complete dominance of one species over others.

A supplementary waterbird survey program was undertaken during the 2016 dry season to further investigate waterbird usage of the Alligator Creek wetland system during the dry season, particularly in terms of abundance. The results of these supplementary surveys, including a review of both 2015 and 2016 dry season results, is presented in Appendix C.

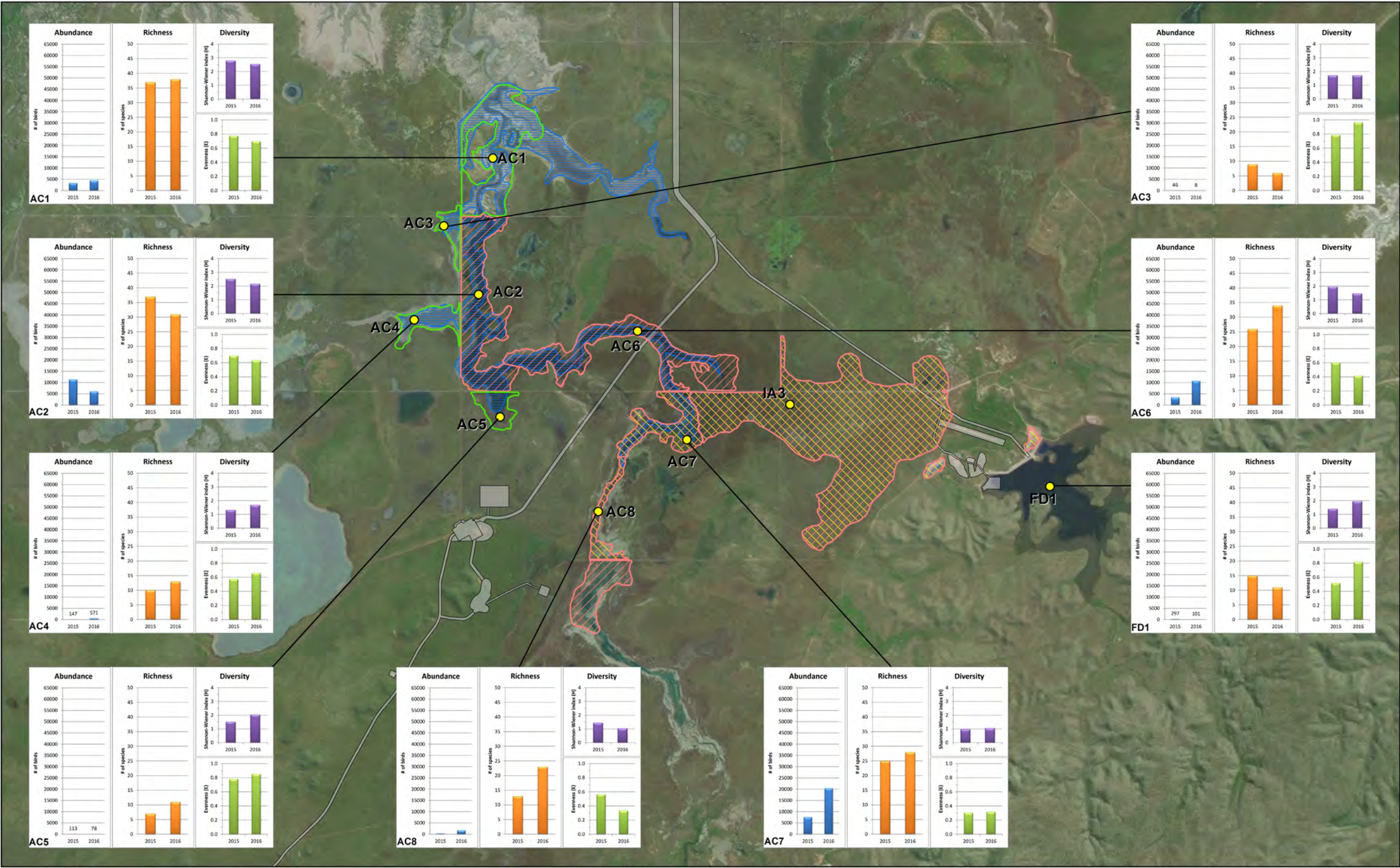
The 2015/2016 wet season was comparatively drier than the 2014/2015 wet season (Agnew 2016). As a result there was significantly less water available for release from Forsyth Creek Dam in 2016, i.e.:

- In August 2015, approximately 23 GL of water was available for release from Forsyth Creek Dam (pers comm. O. Stacy 2016).
- In August 2016, the release was limited to approximately 7 GL of available water (pers comm. O. Stacy 2016).

As stated in Attachment A (Agnew 2016):

"The 2015 and 2016 dry season survey program results demonstrate that significant components of the Alligator Creek wetland system which were not directly affected by the inundation from Forsyth Dam, support:

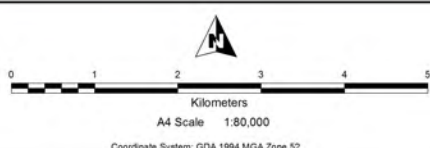
- *significant waterbird aggregations – in some instances exceeding the threshold for International importance (Ramsar Criterion 5) – throughout the extent of the survey period and through late dry season conditions*
- *individual species in abundance that exceeds the 1% population threshold for International importance or 0.1% flyway population threshold for National importance*
- *suitable habitat for the threatened curlew sandpiper throughout the extent of the survey period and through late dry season conditions*
- *suitable habitat for the majority (>90%) of waterbird species within each 'feeding guild' remained throughout the dry-season program."*



Source: Project Footprint: Seafarms 2016
Survey Data: Seafarms 2015/16
Satellite Image: Geoscience Australia 2006

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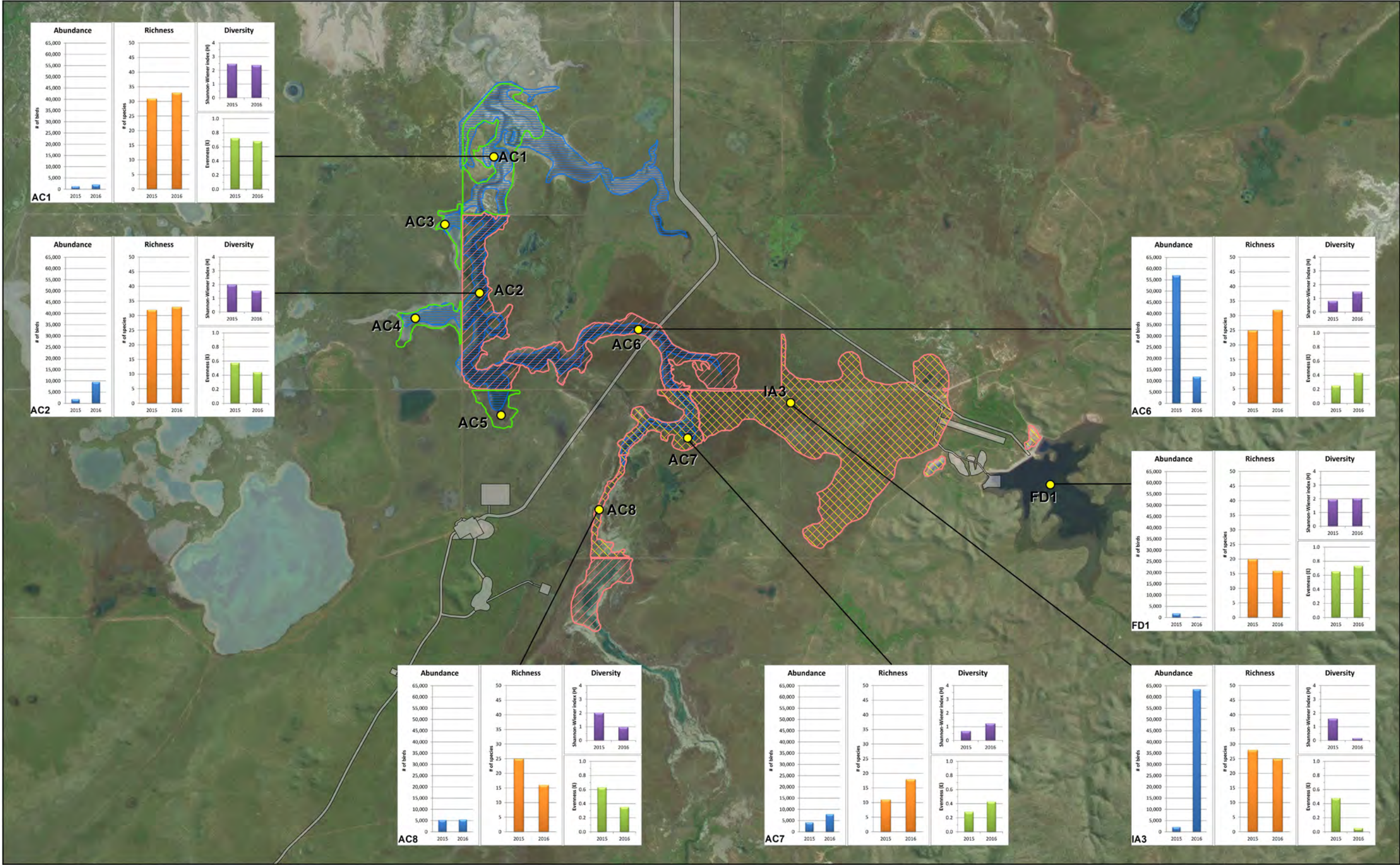
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Project Footprint
Survey Sites
Waterbird Count Areas
Count Area not affected by inundation release from Forsyth Dam
Count Area inundated in 2015 from Forsyth Dam release
Count Area inundated in 2016 from Forsyth Dam release
Typical Dry Season Extent Pre Dam Release

Avifauna abundance, richness and diversity: EVENT 1

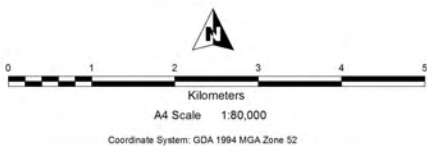
FIGURE 21 AVIFAUNA ABUNDANCE, RICHNESS AND DIVERSITY: EVENT 1



Source: Project Footprint: Seafarms 2016
Survey Data: Seafarms 2015/16
Satellite Image: Geoscience Australia 2006

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File: EISV2_6FIG20_DamReleaseAvifaunaEV2_170119 Date: 19/01/2017



Project Footprint
Survey Sites
Waterbird Count Areas
Count Area not affected by inundation release from Forsyth Dam
Count Area inundated in 2015 from Forsyth Dam release
Count Area inundated in 2016 from Forsyth Dam release
Typical Dry Season Extent Pre Dam Release

Avifauna abundance, richness and diversity: EVENT 2

FIGURE 22 AVIFAUNA ABUNDANCE, RICHNESS AND DIVERSITY: EVENT 2

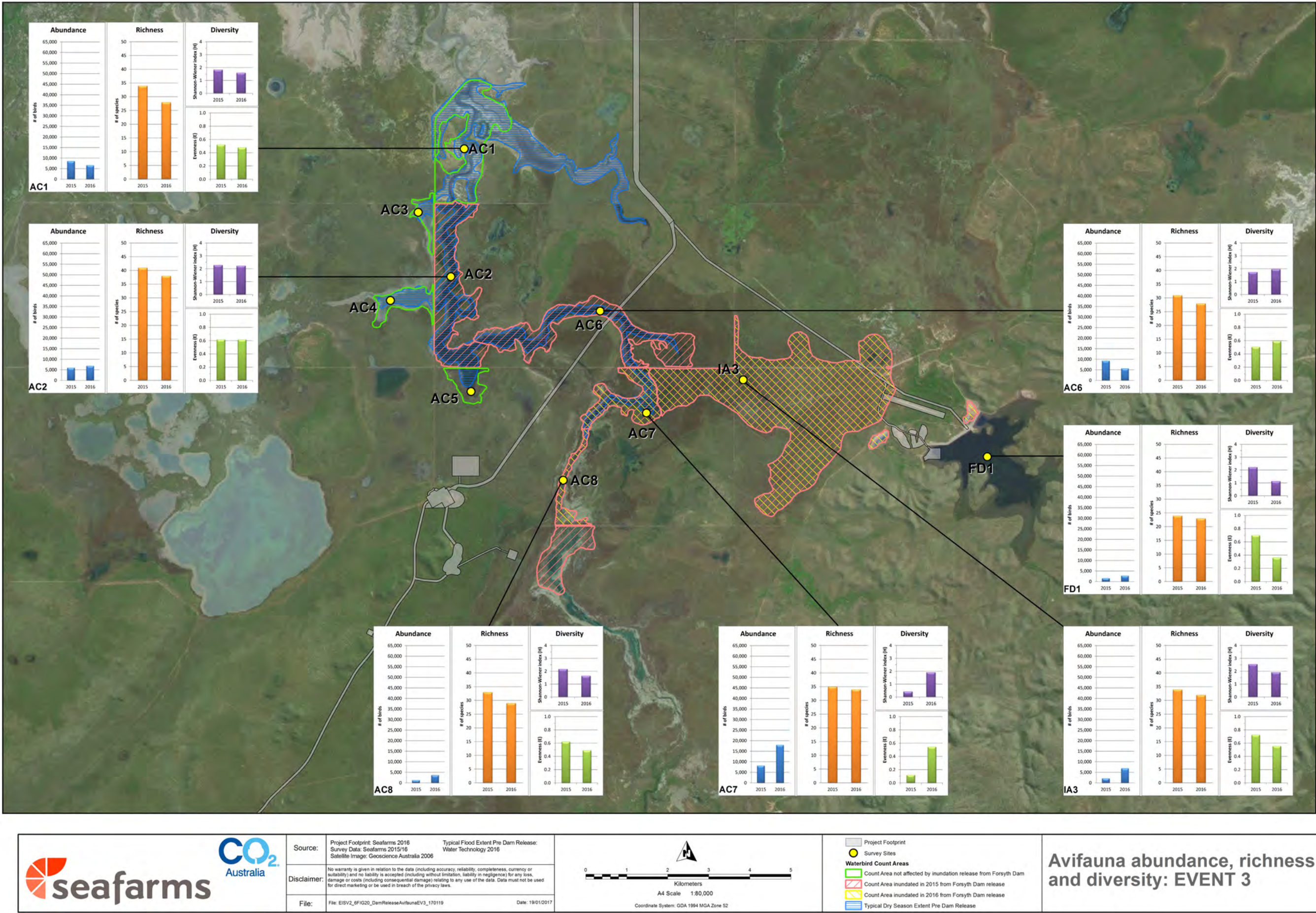


FIGURE 23 AVIFAUNA ABUNDANCE, RICHNESS AND DIVERSITY: EVENT 3

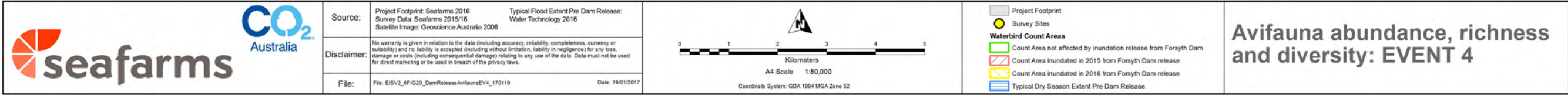
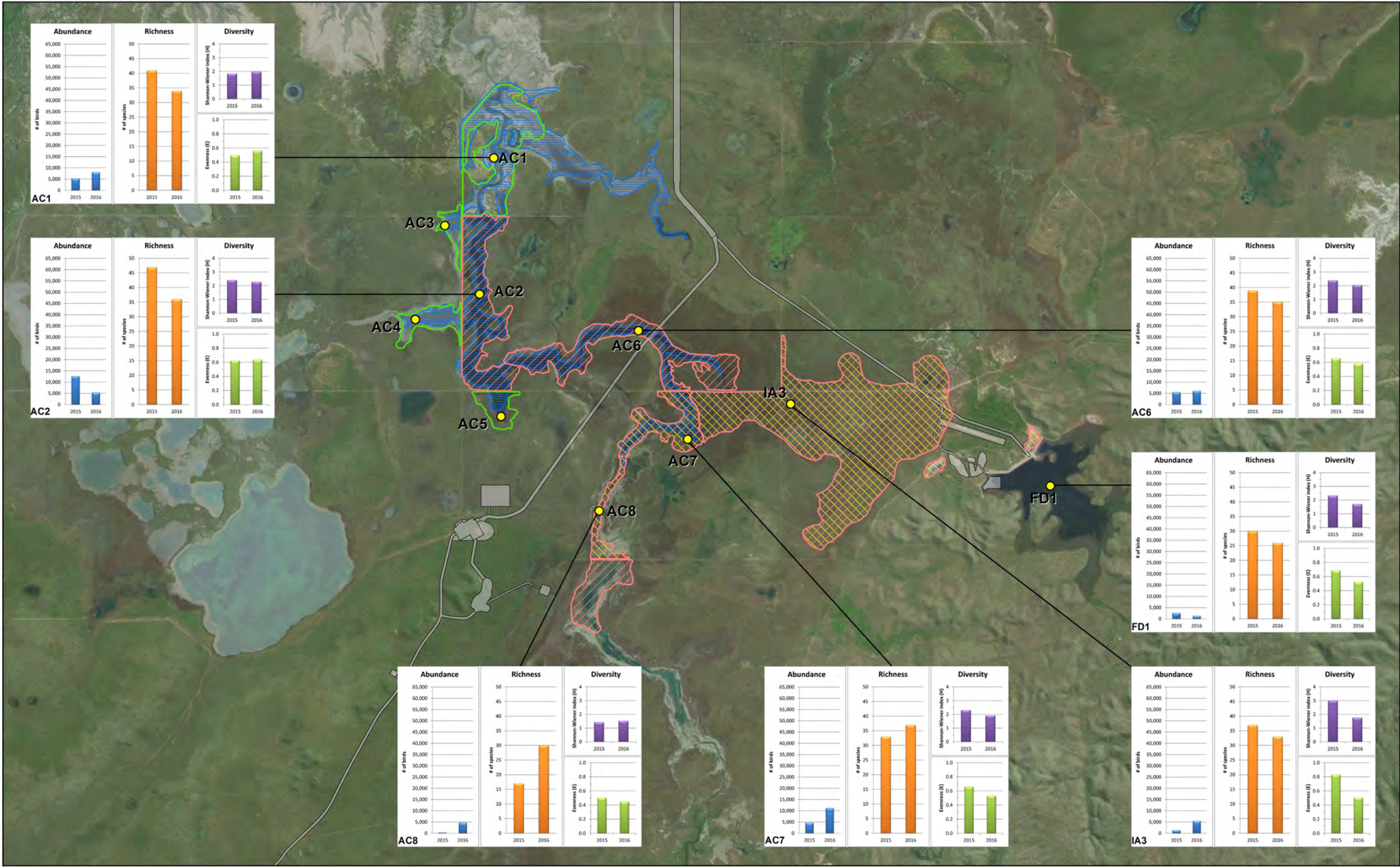


FIGURE 24 AVIFAUNA ABUNDANCE, RICHNESS AND DIVERSITY: EVENT 4

3.19.41 Comment 41

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Terrestrial Fauna and Avifauna
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Volume 2, Chapter 6, , Section 5 Mitigation and Monitoring

Details of the Submission

Section 4.3.3 of the Terms of Reference for the Project EIS stated:

The EIS should present management plans that include proposed safeguards, mitigation measures and monitoring programs to deal with the relevant impacts to biodiversity from the Project. Proposed management plans should:

- *identify clear environmental outcomes capable of objective measurement and reporting*
- *permit timely identification and resolution of problems that arise through the course of a project that may*
- *compromise the achievement of the appropriate environmental outcome.*

Specific and detailed descriptions of the proposed measures must be provided and substantiated, based on best available practices and advice from relevant Northern Territory and Australian Government advisory agencies and must include the following elements:

- *a consolidated list of mitigation measures proposed to be undertaken to prevent, minimise or compensate for the relevant impact of the Project, including:*
 - *a description of proposed safeguards and mitigation measures to deal with impacts including mitigation measures proposed to be taken by the Territory government, local government or the Proponent*
 - *assessment of the expected or predicted effectiveness of the mitigation measures*
 - *statutory or policy basis for the mitigation measures*
- *the name of the agency responsible for endorsing or approving each mitigation measure or monitoring program.*

Monitoring programs should identify objectives, clear thresholds and contingency measures in the event that construction and operational activities affect biodiversity. Monitoring programs should be capable of detecting change in a statistically robust manner. Management measures and monitoring programs should be prepared by a suitably qualified expert that has demonstrated experience in the mitigation and monitoring of adverse impacts to biodiversity and threatened species.

There is significant uncertainty with regards to the effects of withholding Forsyth Dam water from Dry season release on waterbird populations at Legume, particularly in the Alligator Creek freshwater system. The draft EIS provided a list of suggested mitigation measures for general impacts to waterbirds and committed to preparing a fauna management plan that includes monitoring and contingencies (not specific to waterbirds). However, management strategies did not consider impacts from withholding Dry season water releases and the monitoring strategies proposed in the draft EMP did not include reference to a monitoring program for avifauna. Given the significance of waterbird populations at Legume, a statistically robust avifauna monitoring and management plan is essential to ensure to ensure an adaptive response in management of the site if

negative impacts are detected. A monitoring and management program developed in consultation with relevant Northern Territory and Australian Government advisory agencies is required in the Supplement to enable the NT EPA to complete its assessment.

Proponent Response

In consultation with the Northern Territory and Australian Governments the proponent has prepared a Waterbird Monitoring Program framework. The framework is provided in Appendix A.

3.19.42 Comment 42

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Waste Management
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Chapter 9 - Waste Management, Section 1.3.4 Waste Management and Pollution Control Act

Details of the Submission

The activity proposed is regulated under the *Waste Management and Pollution Control Act*. Activities that require environment protection approval include -“Constructing, installing or carrying out works in relation to premises, other than sewage treatment plants, for the storage, re-cycling, treatment or disposal of listed wastes on a commercial or fee for service basis.”

Activities that require a licence include:

1. operating premises for the disposal of waste by burial that service, or are designed to service, the waste disposal requirements of more than 1 000 persons
2. collecting, transporting, storing, re-cycling, treating or disposing of a listed waste on a commercial or fee for service basis, other than in or for the purpose of a sewage treatment plant
3. operating premises, other than a sewage treatment plant, associated with collecting, transporting, storing, re-cycling, treating or disposing of a listed waste on a commercial or fee for service basis.

The proponent will be required to apply for the following:

- an environment protection approval (EPA) for the construction of the project potentially including pond
- construction, land fill and waste transfer stations
- an environment protection licence (EPL) for the ongoing operation of the facility.

The Proponent should consult with the NT EPA prior to applying for the EPA and EPL regarding providing information on:

- land fill design including appropriate leachate design, management and monitoring
- construction quality assurance plans
- irrigation management plans including monitoring of surface water , groundwater and soils
- emergency response plan.

Proponent Response

As stated in Section 3.2.15 of Volume 1, Chapter 6 of the draft EIS (Approvals, Conditions and Agreements) the proponent will apply for the appropriate approvals and licences under the *Waste Management and Pollution Control Act* for relevant activities during the construction and operational stages of the Project. The proponent will consult with NT EPA as the applications are being prepared and prior to (and following) submission.

3.19.43 Comment 43

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Waste Management
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Chapter 9, Waste Management, Section 1.3.12

Details of the Submission

Due to the size and scale of the waste potentially generated on site the Proponent should be referring primarily to “Guidelines for the siting, design and management of solid waste disposal sites in the NT” to promote best practice management rather than “Waste management guidelines for small communities in the NT”. The small communities landfill guidelines were created as part of an improvement plan for existing sites with historical, financial limitations and to assist them to work towards best practice. As this is a new site, the proponent should be referring to “Guidelines for the siting, design and management of solid waste disposal sites in the NT”.

Proponent Response

Note that both documents were referred to in Section 1.3 of Volume 2, Chapter 9 of the draft EIS, particularly for the design elements of the landfill. Regardless, only the latter document will be referred to in future documentation to avoid confusion.

3.19.44 Comment 44

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Waste Management
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Chapter 9, Waste Management, Section 1.3.16 Other Legislation and Guidelines

Details of the Submission

This section should be expanded to include National Environment Protection Measures (NEPM) and any other relevant interstate legislation required for the transportation of waste.

Proponent Response

Noted. Additional items to be included would be:

- National Environment Protection Measures (NEPM) particularly Assessment of Site Contamination (1999), and Movement of Controlled Waste between States and Territories (1998), although all of the measures are potentially relevant.

- Western Australian Environmental Protection (Controlled Waste) Regulations, 2004, which requires a controlled waste tracking form and Consignment Authorisation (CA) from the Department of Environment Regulation, along with a Waste Transport Certificate (WTC) from the Northern Territory.
- Similarly to Western Australian requirements, Queensland requires a WTC from the Northern Territory and CA from the Department of Environment and Heritage Protection, regulated under the Environmental Protection Regulation 2008.

3.19.45 Comment 45

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Waste Management
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Chapter 9, Waste Management, Section 3.6 – Farm Pond and Channel Waste Table 3

Details of the Submission

Based on the information provided in Table 3, for three farms the annual volume of farm pond waste could be up to 24,000 m³. Prawn pond sediment and detritus, filtration waste is considered a listed waste under the Waste Management and Pollution Control (Administration) Regulations. It is stated that this material will become "*an inert nutrient rich waste on drying*" that will be used for various operational purposes. Clarification needs to be provided in terms of the statement that this nutrient-rich material would be 'inert', as well as an assessment of the risks associated with high concentrations of nutrients and salts potentially being mobilised from farm pond waste into surface and/or groundwater systems.

Proponent Response

Refer to Section 3.9 in Appendix F which explains the approach taken in regards to the management of this material, including compliance with the Environmental Code of Practice for Australian Prawn Farmers requirements (Donovan 2001).

3.19.46 Comment 46

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Waste Management
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Chapter 9, Waste Management, Table 3 Waste Characterisation

Details of the Submission

Animal effluent and residues (abattoir effluent, poultry and fish processing waste) is a listed waste under Schedule 2 of the Waste Management and Pollution Control (Administration) Regulations. The Proponent identifies that "prawn pond sediment and detritus, filtration waste" is produced by the operations. Such a waste is considered a listed waste.

Proponent Response

This is discussed in Section 3.9 in Appendix F, and as noted in the response to Comment 42 (Section 3.19.42) the proponent will discuss licencing for this material with the Department. However, its management is not expected to change, being based on best practice for this type of material, regardless of its designation.

3.19.47 Comment 47

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Waste Management
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Chapter 9, Waste Management, Table 3 Table 5 – Dead Prawns

Details of the Submission

Dead prawns have been described as “minimal” in waste types and projected quantities. Provide details on the maximum quantity of prawns in the event of a catastrophic disease outbreak, equipment failure or natural event and how that waste will be managed. In the event of large scale mortality, disposal options need to be provided whether it is burial, incineration, onsite composting and/or offsite disposal.

The EIS advises that dead prawn disposal in the event of a disease outbreak will involve the development of a plan with Department of Fisheries and the Proponent. It is recognised that biosecurity and appropriate disposal is essential to not only the farm but wider community and industry, however, the development of a more robust emergency response plan specific to major quantities of dead prawns is required.

It is recommended that the proponent identify potential sites and pathways for the appropriate disposal of major quantities of prawn carcasses that reflect common risk and operational practices to the industry. This will ensure that if an event does occur, the advice within the action plan (created with Fisheries and the proponent) can be enacted as quickly as possible while minimising risk to the environment.

Proponent Response

See response to submissions raised by the Commonwealth Department of Environment and Energy in Section 3.14.12 (Comment 12).

3.19.48 Comment 48

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Waste Management
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Chapter 9, Waste Management, Section 4.2.3 Solid Waste Management

Details of the Submission

Farm pond and channel waste will be treated by solar drying and aeration in accordance with the Environmental Code of Practice for Australian Prawn Farming. Alternatively this material may be used in selected areas outside the farm to assist with scour erosion or included in the construction of new berms

It is unclear from the information provided if any infrastructure is required, or how any potential contaminants will be managed. A more detailed plan, including location, design and operational practices for the management of this material is required to address any environmental impact to the surrounding environment including groundwater or soil composition through the leaching of salts and other minerals in to the area and how stormwater will be managed.

Proponent Response

This is described in Section 3.9 in Appendix F.

3.19.49 Comment 49

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Waste Management
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Chapter 9, Waste Management, Table 5 Summary of Waste Management Approach for Waste Streams

Details of the Submission

Concrete batching will be conducted on site. The management of waste products for concrete batching should be considered in respect of maximisation of reuse and recycling of the water and materials.

Proponent Response

It is considered that normal operating procedures will be adopted for any concrete batching operations, including maximising reuse and recycling of water and materials. Waste minimisation for concrete batching is listed in Volume 2, Chapter 9, Table 5 of the draft EIS, however more generally Best Practice Environmental Management will be adopted, with reference to guidelines such as the Queensland Department of Environmental and Heritage Protection Code of Practice for the Concrete Batching Industry.

3.19.50 Comment 50

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Climate and Local Meteorology
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Volume 2, Chapter 11 – Climate and Local Meteorology

Details of the Submission

A detailed review of BoM data indicates that 44 cyclones have been recorded within a 200km radius of the proposed facility since 1906. 15 of these cyclones passed within 50km of Legume.

Cyclones have potential to cause increased wave energy, especially in a 10 ha pond area. Clarify whether this will impact unlined ponds.

Proponent Response

This is addressed in Section 3.5 in 4Appendix F.

3.19.51 Comment 51

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Cumulative Impact Assessment
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Volume 4, Chapter 1 Cumulative Impact Assessment, Section 4.1.2.1 Nutrients

Details of the Submission

The effluent dilution modelling should be checked in regards to the volumes of water coming into the Keep River from Ord stage 2. The values appear too low, which leads to questions regarding the veracity of the

finding in the draft EIS that the release of contaminants into the Keep River due to leakage from Ord Stage 2 would necessarily have negligible concentrations in Alligator Creek. Such a finding could underestimate the potential for cumulative impacts to occur.

Proponent Response

Ord Stage 2 has been designed to have negligible discharge into the Keep River with the extensive use of on-farm tail water management systems.

As specified in Section 5.1 of Appendix 8 of the draft EIS, studies completed for the Ord Stage 2 (Goomig Farmlands) (Bennett & George, 2014) detailed water quality data measured in runoff from Stage 1 of ORIA. In the absence of Ord Stage 2 (Goomig and Knox Creek Plains) or Ord Stage 3 (Keep River Plain) data, the cumulative impact modelling utilised Ord Stage 1 data to inform the assessment. However, the Ord Stage 1 development approval had no requirement for on-farm tail water management systems like that required, and implemented, on the Stage 2 (Goomig) Farmlands. It is considered highly likely that the approval conditions for Ord Stage 2 (Knox Creek Plains) and Stage 3 (Keep River Plains) would be similar to those for Ord Stage 2 (Goomig), which require the adoption of locally-derived water quality triggers designed to protect 99 per cent of species (as established under ANZECC/ARMCANZ guidelines (2000)). Furthermore, Ord Stage 2 (Goomig) approvals do not allow for dry season discharge to the Keep River via the ephemeral Border Creek. All irrigation tail water must be retained on site.

Under low catchment flow, tidal only flushing of the Keep River, any material from the upper reaches of the Keep River discharged from the Ord Stage 2 will undergo significant mixing within the Keep River, the upper section of the tidal Keep River estuary, and with waters from Sandy Creek before reaching the mouth of Alligator Creek.

Modelling has indicated that significant dilution and mixing occurs when discharge from the shallow waters of Alligator Creek enter the deeper and wider Keep River. Figure 25 shows the location of the modelling reporting points for the Keep River and Figure 26 shows the rapid dilution of the model tracer between the mouth of Alligator Creek and within the Keep River. It is expected that similar mixing and dilution will occur with discharge from the Keep River as it enters the deeper waters of the Keep River south of the mouth of Alligator Creek.

Under high flow conditions in the Keep River, discharge from Ord Stage 2 will be significantly diluted in the upper reaches and then exposed to additional tidal mixing and dilution processes in the Keep River estuary.

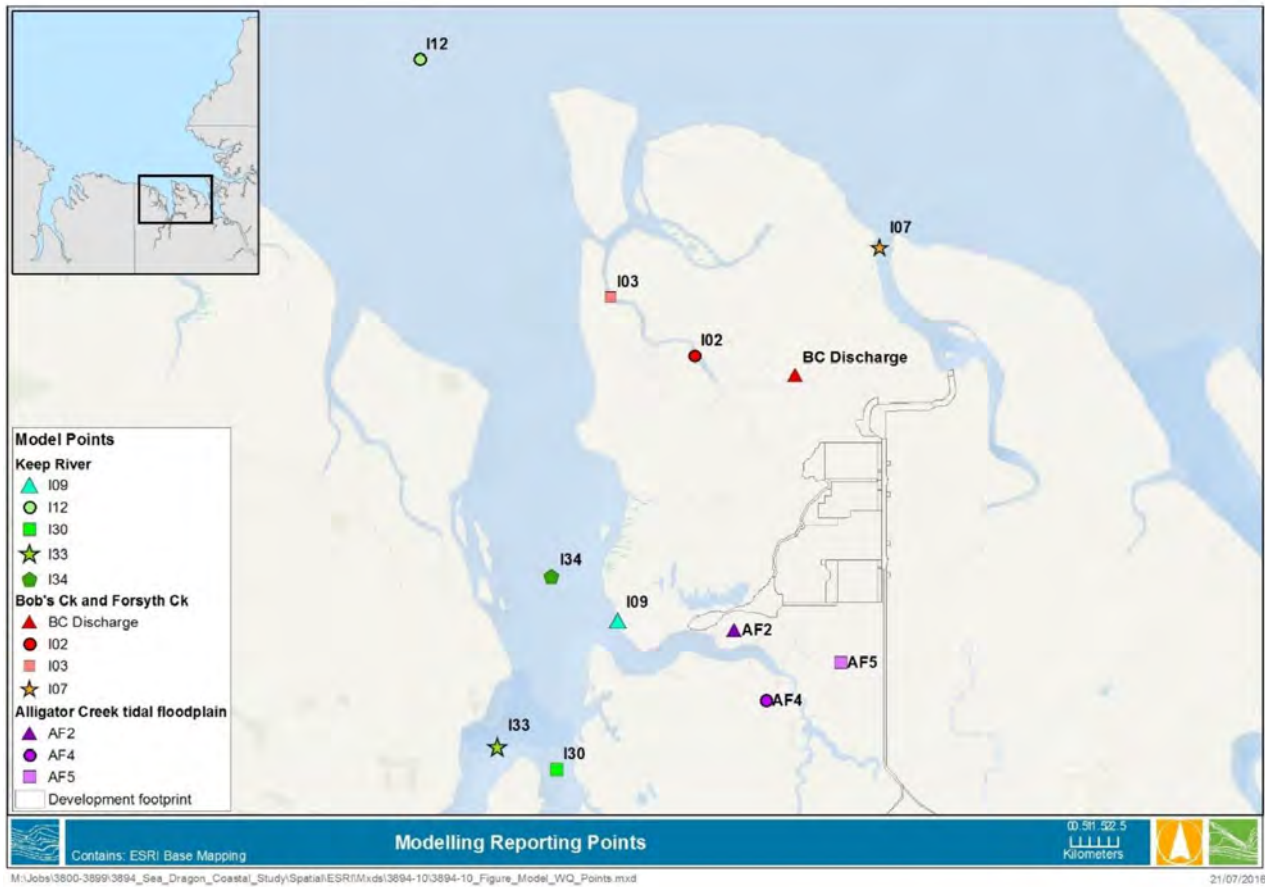


FIGURE 25 MODEL REPORTING POINTS - KEEP RIVER

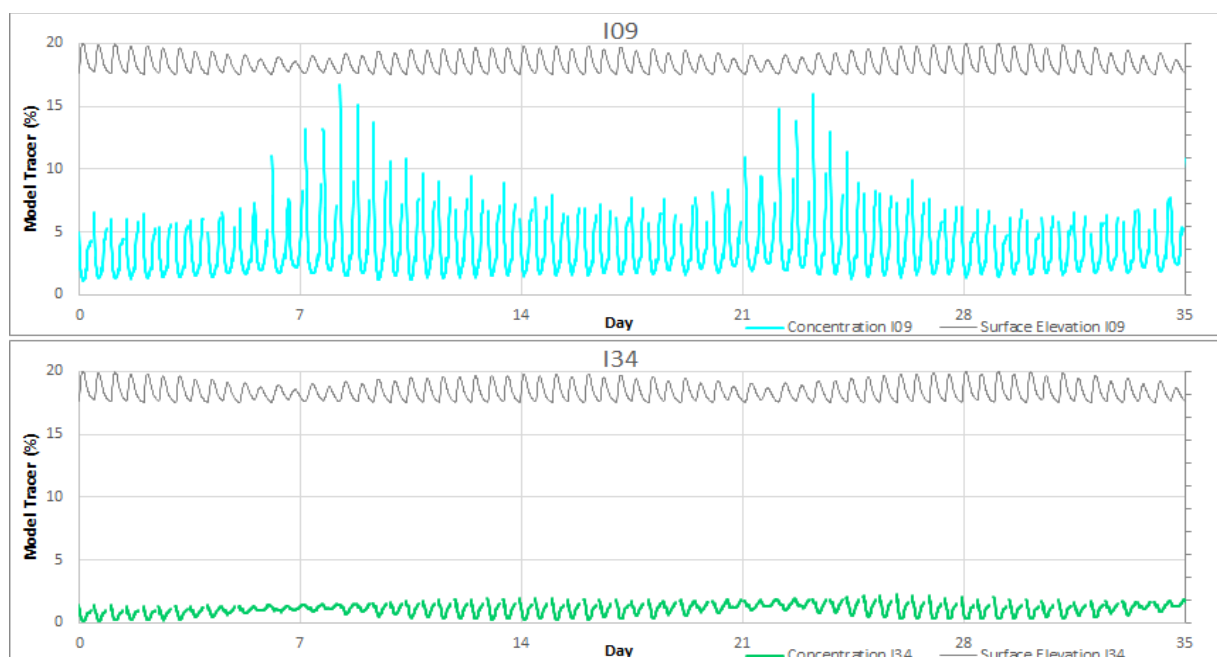


FIGURE 26 RAPID DILUTION OF MODEL TRACER BETWEEN THE MOUTH OF ALLIGATOR CREEK (I09) AND WITHIN THE KEEP RIVER (I34)

3.19.52 Comment 52

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Appendix 7 - Soil Investigations
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Volume 5 Appendix 7

Details of the Submission

Throughout Appendix 7 various recommendations were provided by the consultant and the proponent needs to clarify how the results of the geotechnical report and recommendations have been incorporated into project commitments, design and management. These include but are not limited to:

- It is considered possible that the surface soft clays may extend for appreciable depth in the northern parts of the site within the coastal plain, especially in close proximity to estuarine creeks, thus detailed investigation is recommended along the intake structure;

- *Careful consideration should be given to excavations which penetrate into the unit 2B very soft to firm clays due to potential for instability;*
- *The embankments are proposed to effectively dam water within channels or ponds. No formal seepage analysis or groundwater assessment has been undertaken as part of this investigation....However, compacting the embankments as outlined in this report provides stability and also reduces seepage (ie. permeability of the embankment materials).*
- *The use of an engineer designed keyway within the pond embankment foundation would further reduce seepage, but has not been included in this preliminary assessment, however it should be considered in the design stage.*
- *Embankments (pond, intake/outlet) that are designed to act as dams should include an emergency spillway to prevent overtopping and consequent scour and instability.*
- *Steeper cuts adjacent to structures of embankments may need localised engineered stabilisation measures such as sheet piles or culverts (to limit risk of channel excavation instability). All channel batters should be protected from erosion and scour*
- *It is suggested that the settlement parameters be confirmed and refined by more detailed investigation, followed by instrumenting trial embankments in the “trial” pond construction and monitoring the settlement.*
- *It is recommended that additional ASS investigation should be undertaken for areas in the southern and south-western parts of the site which have not been assessed and where disturbance of soils is proposed.*

Proponent Response

These elements are addressed in the supporting material in Appendix F of this SEIS and to other comments above, in particular:

- Further monitoring is discussed in Sections 2.2 and 2.4.
- Stability considerations in Section 3.1.
- Seepage and the engineer designed keyway in Section 3.3.
- Spillways have been incorporated into these structures, as outlined in Section 3.7.
- Erosion and scour protection in Section 3.1, and in Appendix C1 to the draft EMP (Appendix H of this SEIS).
- Detailed design in Section 2.4.
- Acid sulfate soil testing is described in response to Comment 23 (Section 0 in this SEIS).

3.19.53 Comment 53

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Appendix 7 - Soil Investigations
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Volume 5 Appendix 7, Pg 15 Section 9.1 Methods

Details of the Submission

45 test pits with test locations are shown on drawings 2, 3 and 4, Appendix D. Limited soil sampling has been conducted for farm 3 and the proponent needs to commit to further sampling in this area prior to disturbance.

Proponent Response

As noted in the response to Comment 52 above (see Section 3.19.52), additional geotechnical, fertility/baseline and acid sulfate soil testing has been committed to (refer to Comment 23 in Section 0, and Sections 2.2 and 2.4 in Appendix F, as well as the pre-construction soil monitoring program in Appendix C2 in the draft EMP (Appendix H).

3.19.54 Comment 54

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Appendix 5 - Commitments
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	Volume 5, Chapter 5 Commitments Section 1.1 Geology, Geomorphology and Soils

Details of the Submission

In addition to supervising construction works and additional sampling, testing and analysis, where required to confirm site conditions, the proponent should commit to preparing a report that confirms the project infrastructure has been built to an appropriate engineering standard and soil testing was conducted in accordance with relevant Australian Standards.

Proponent Response

This report will be prepared, and a specific reference to such a report has been included in the reporting requirements under Appendix C2 of the draft EMP (Appendix H).

3.19.55 Comment 55

Submitter Type	Northern Territory Government	TOR Category or EIS Chapter	Volume 5, Appendix 9
Date Submission Received	9 December 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

It is stated that there were diatoms in the estuary system but not chlorophytes or flagellates, but it is possible that the latter two groups did not fix well. It is highly unlikely that they do not occur. It would be safer to say that 'with the fixation methods used, there was no evidence of chlorophytes or flagellates'.

Proponent Response

Noted, however the report does not state that there are no chlorophytes or flagellates in the estuary system. It states in Section 5.7 of Appendix 9 (page 75) that that they were not recorded in the analysis undertaken in March 2016, i.e. *"phytoplankton communities were analysed in March 2016 and were dominated by diatoms, with no flagellates or green algae"*.

3.20 WORLD WILDLIFE FUND

3.20.1 Comment 1

Submitter Type	Non-government organisation	TOR Category or EIS Chapter	Biosecurity
Date Submission Received	15 December 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

As indicated in WWF's submission to the EIS's draft Terms of Reference (ToR), WWF recommends prawn farms should, at a minimum, ensure their systems and practices are consistent with the Aquaculture Stewardship Council (ASC) Shrimp Standard principles and criteria.

WWF supports the planning efforts identified in the EIS documentation to ensure the project will be conducted consistent with the ASC Shrimp Standard and the Environmental Code of Practice for Australian Prawn Farms, with husbandry practices as outlined in the Australian Prawn Farmer's Manual. WWF is however deeply concerned that some of the EIS documentation appears not to be consistent with these documents. In particular, and in light of the emerging outbreak of White Spot Disease south of Brisbane, WWF is strongly critical of farming operations that would not provide sufficient time for the ponds to adequately dry out between crops. As the Australian Prawn Farming Manual states: "Drying the floor of the pond is a proactive tool to minimise the risk of potential disease outbreaks and improve pond performance for the next crop." The economic drive to generate three crops per annum should not compromise the health of future stocks on the farm nor the environmental values of the receiving waterways.

Proponent Response

The proponent has responded to comments on the Project's commitment to the ASC Shrimp Standard in NT EPA Comment 15 (Section 0) and Environment Centre NT Comment 1 (Sections 3.21.1) and Comment 5 (Sections 3.21.5).

The comment from the submitter conflates two issues. First there is no evidence that the White Spot Disease outbreak referred to is in any way linked to lack of dry out or inappropriate husbandry. Second the standard practice for the Project will be to provide for a fallow period between crops. Whether this amounts to 'dry out' given climatic conditions at Legume during the wet season is the basis of the confusion. The fallow period is consistent with the ASC principles. The sterilising effect of a fallow period arises less from 'drying' as such but more from exposure to solar radiation and attendant UV exposure. Exposure to freshwater can also have a mild sterilising effect on marine microorganisms.

At Legume the pond floors will be made of a dense black cracking clay which has high impermeability (see Section 3.3 of Appendix F), and as such is unlikely to retain significant amounts of organic matter (the high impermeability of the soils is actually detailed in the draft EIS in the Geology, Geomorphology and Soils chapter (Volume 2, Chapter 1)). It is retention of organic matter that has the potential to cause health issues for prawns, and hence the need for dry out period. The clay base at the Legume site will allow for organic detritus to be moved into the centre pile of each pond during pond aeration and efficiently removed at the end of each cropping cycle. Furthermore, when dry outs are not feasible due to the wet season, hydrated lime can be applied to assist in sterilising the pond bottom (hydrated lime, not agricultural lime, is more suitable for the soil type at Legume).

The proponent is not driving to three crops per annum. The Project is proposing large target animals.

3.20.2 Comment 2

Submitter Type	Non-government organisation	TOR Category or EIS Chapter	Cumulative Impacts
Date Submission Received	15 December 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

Furthermore, the submission to the draft ToR also highlighted the need to include an overview of the cumulative impacts anticipated from the development operating at full capacity to provide stakeholders with a more comprehensive understanding of the scale of project.

Proponent Response

The draft EIS is confined to assessing Stage 1 as per the Notice of Intent, Referral to the Commonwealth Government and the Terms of Reference for the EIS. Future stages have not yet been designed to a level that would enable them to be included in the cumulative impact assessment in any meaningful way. As mentioned in Section 2.8.6 of the Project Description (Volume 1, Chapter 3) the Project will be developed progressively over several stages and it is intended to use Stage 1 of the project to test and refine process and environmental performance to inform future stages, as well as seek solutions to future water requirements. There are a number of benefits to staging the development of the project including the learnings obtained from each incremental stage. By committing to Stage 1 (1,120 ha of ponds) the proponent will be in a position to monitor impacts and collect vital data to shape the design and implementation of subsequent stages of expansion. Therefore, the expansion of the Project to full scale will be determined by the company as Stage 1 progresses and is subject to:

- the success of Stage 1 operations, and the learnings from Stage 1, including environmental management
- further statutory approvals
- project cash-flow

As such, it was noted in the Cumulative Impact Assessment (Volume 4, Chapter 1) that future stages of the Project Sea Dragon Grow-out Facility are planned, but that the layout, construction and operations for the future stages is yet to be determined, and may be quite different from that of Stage 1. Given that there is no data to draw upon, no consideration was given to future Project Sea Dragon Grow-out Facility stages in the cumulative impact assessment.

The appropriate way of capturing a cumulative impact of Stage 1 and any future stages is during subsequent environmental assessments when an assessable proposal actually exists.

3.20.3 Comment 3

Submitter Type	Non-government organisation	TOR Category or EIS Chapter	Marine and Estuarine Water
Date Submission Received	15 December 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

The draft EIS documents do not clearly identify the overall scale of the PSD at full production. WWF is concerned large financial commitments from the Australian government for infrastructure like roads will use future economic arguments around maximising returns on public investment to support ongoing farm

expansions without due consideration of the impacts these expansions will have on the environment. This issue is particularly important when it comes to water discharge quantity and quality. While it is acknowledged the Stage One of the project is expected to approach 1.4% of the water exchange at “maximum dry season total system volume”, discussion is needed to determine the impacts of a tenfold increase in this discharge to represent PSD at full production. This would potentially represent one in every seven litres of water in the system having passed through the PSD farm pond system.

In regards to water quality, WWF is concerned that there does not appear to be adequate details around how waste water will be managed “on farm” without relying on large tidal exchanges to dissipate nutrients within the receiving waters which the EIS reports suggest are limited in Nitrogen – a key waste product from aquaculture systems. Stage One has a single location for a settlement and maintenance pond, individual farm internal farm recycling ponds (IFRP’s), and a single Environmental Protection Zone (EPZ). Details on how the nutrient levels will be managed in the IFRP’s and the expected assimilative capacity of the EPZ to remove nutrients and solids are required as the area looks visually small compared to the three farms, let alone the full farm capacity. Reliance on the receiving environment to “cope” with discharge of waste water with heavy nutrient and sediment loads is no longer an acceptable practice for developing countries where water quality has led to productivity declines, let alone a developed country like Australia that prides itself for “clean and green” farming products.

While the proponent suggests Stage One will be managed using similar techniques to their farms on the Great Barrier Reef (GBR) Coast, there are major differences between the receiving waters and the farm scales and operations that require further investigation. As indicated in the draft EIS documents, the receiving waters have considerably lower Nitrogen concentrations than GBR waters, and as such, are likely to support ecological communities that are adapted to these nutrient poor and highly physically dynamic environments dominated by extreme tidal variation. WWF is concerned that the release of insufficiently treated waste water from Stage One, and any other future stages, will have the potential to increase primary production and bacterial growth within the receiving waterways through the supply of Nitrogen, Phosphorous and organic matter. These changes could then potentially influence the local ecological community as productivity increases. Furthermore, farm management of three crops per annum in large 10 hectare ponds is not consistent with the east coast practices, and is therefore likely to produce different water quality outcomes to the water quality modelling provided in the draft EIS.

While it is recognised a full two years of water quality information has not been collected to date, WWF would like confirmation that there is a process to incorporate new water quality information into the water quality guidelines for Stage One as the baseline sampling extends over time. Furthermore, WWF expects that the proponents will sufficiently monitor, analyse and model the local environment at the project site to determine site specific peer reviewed water quality targets and limits, and that these figures are made publically available.

Proponent Response

It is correct that the draft EIS does not identify the overall scale of Project Sea Dragon at full production, because this is out of the scope of this assessment. The approach is to assess future stages on an adaptive basis when better specificity of design and, for example, construction experience is available to inform a process of continuous assessment and improvement. The potential impacts associated with future stages would be addressed through future environmental assessment processes as required.

The submitter is correct in observing that the receiving waters of the Alligator Creek system are very different from those of the Great Barrier Reef. The information presented in the draft EIS shows that there is little risk of an increase in primary production. This is, in fact, because the environment is dominated by physical, rather than biological processes, and the very high turbidity naturally occurring in the environment results in rapid

light extinction which limits primary production. This very physical environment also results in rapid mixing and dispersion leading to a rapid attenuation of nutrient concentrations. Thus the environmental risks between the situation on the east coast and this environment are also different with the intrinsic risks actually being less in this environment than on the east coast. This is discussed in more detail in Volume 2, Chapters 2 and 7, and Volume 5, Appendices 8 and 9.

The key finding is that based on a discharge in which key nutrient concentrations are always at the median limit of an operational licence at Ingham (a conservative assumption), and based on proposed discharge volumes with releases on the ebb tide, the Project meets the proposed interim site-specific trigger values (see the response to NT EPA Comment 30 (Section 3.19.30)).

The proposed interim site-specific trigger values have been developed based on AWQG. As noted a full two year time-series has not been obtained. As stated in Section 3.19.27 (Comment 27 from the NT EPA):

The proponent has committed to the formulation of Water Quality Trigger or Guideline levels (i.e. the 'actual' not 'interim' triggers) as part of the Water Quality Monitoring Program (Section 5.3.3 of the Marine and Estuarine Water Chapter of the draft EIS [Volume 2, Chapter 2]) and as such has continued to collect water quality data to enable this to occur. Analysis of the data will also continue to include statistics such as the range, and 5th and 95th percentiles. The data will also be re-analysed to determine if there are any significant variations due to tide, lunar cycles or season, and trigger values established on that basis. Given the analysis to date, it is not anticipated that these trigger values will be significantly different from the proposed interim triggers, however, seasonal triggers may be appropriate for some parameters (e.g. turbidity). The most suitable times for data collection for the ongoing water quality monitoring program will be refined as further data is collected. The proponent anticipates that, moving forward, data collection will be standardised on the neap tides.

In terms of management of nutrient levels on farm, this is discussed in the response to University of Technology Sydney's Comment 2 (see Section 3.12.2) and the NT EPA's Comment 15 (see Section 0), outlining the feed conversion controls to minimise nutrient input and maximise the FCR (refer to the response to NT EPA Comment 14, Section 3.19.14), and the use of settlement and the EPZ to reduce outflowing constituents in discharge waters.

3.20.4 Comment 4

Submitter Type	Non-government organisation	TOR Category or EIS Chapter	Terrestrial Fauna and Avifauna
Date Submission Received	15 December 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

The Risk Assessment component of the Draft EIS suggests “Non-predatory birds are unlikely to be affected by the use of helicopters and drones as they are unlikely to be attracted to the grow-out farms”. It is well known that there is a high level of interaction between birds and aquaculture farms. In addition, WWF is not convinced that non-predatory birds which may not be attracted to the specific pond area of the farm would not have the potential to be influenced by helicopters and drones. WWF seeks further details on the anticipated impacts on bird species, and confirmation that these impacts will be consistent with the relevant component of the ASC Prawn Standards.

Proponent Response

Literature reviews have identified a variety of barrier and frightening techniques to consider in relation to the management of birds at prawn farms. Techniques prescribed were generally consistent with those identified in the Environmental Code of Practice for Australian Prawn Farmers (Donovan 2001).

The proponent has previously stated that it intends to pursue accreditation from the ASC. That commitment has not changed.

A preliminary analysis of the use of helicopters for bird scaring (considered a higher impacting option compared to drones) indicates that impacts on non-target waterbirds can be reduced through the implementation of the following strategies:

- Restrict low altitude helicopter movements (i.e. <450m above ground level [AGL]) to airspace above the farm footprint will be restricted.
- When transiting between farms, constrain routes to airspace above the Project footprint.
- When transiting from the farm complex to other parts of the site, or off-site, maintain an altitude of >450m AGL and restrict movement to airspace above the Project footprint (e.g. infrastructure corridor).
- When transiting between farms or from the farm complex to other parts of the site, or off-site, operate flights procedures which minimise the incidence and duration of rotor blade slap noise.

Based on this preliminary analysis it has been determined that:

1. Birds can be managed in a way that will not impact upon the financial viability of the Project.
2. Management strategies can be undertaken in a way that will not result in a significant impact on important bird aggregations.

The proponent commits to undertake a series of experimental trials during the 2018/2019 wet season to assess responses of waterbirds to helicopters and drones within wetland habitat adjacent to the farms. A primary objective of this work will be to investigate practical flight protocols for future operations, and the potential for impact to non-target species.

See Appendix B for more information in regards to avian predation.

3.20.5 Comment 5

Submitter Type	Non-government organisation	TOR Category or EIS Chapter	Marine and Estuarine Ecology
Date Submission Received	15 December 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

The Risk Assessment also appears to not have considered the impacts of light pollution on turtle hatchlings and nocturnal terrestrial species. Details on the level of impacts increases in lighting will cause in a remote area with limited light pollution is recommended. WWF seeks further details on this potential impact and its management.

Proponent Response

See response to Comment 13 from the Commonwealth Department of the Environment and Energy (Section 3.14.13).

3.20.6 Comment 6

Submitter Type	Non-government organisation	TOR Category or EIS Chapter	Human Health and Safety
Date Submission Received	15 December 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

Further details on a crocodile management plan are recommended given the sites proximity to saltwater crocodile habitats, noting this is a protected species which also represents a significant occupational safety issues.

Proponent Response

Section 3.1 of the Human Health and Safety Chapter (Volume 3, Chapter 3) sets out the proposed mitigation and monitoring procedures and protocols for crocodiles. Among other things, it specifies that when a crocodile has taken up residence within the Project Area, the NT Parks and Wildlife Commission or other such authority will be notified, and a request to trap and relocate the crocodile will be submitted. In addressing all occupational safety issues, the proponent commits to the preparation of a detailed Health and Safety Plan following Project approval.

3.20.7 Comment 7

Submitter Type	Non-government organisation	TOR Category or EIS Chapter	-
Date Submission Received	15 December 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

The large scale of the final Project Sea Dragon proposal of around 10,000 ponded hectares highlights the need for a measured and incremental approach to the proposed development of this farm site. A full assessment of baseline and operational monitoring information from Stage One should be comprehensively assessed prior to any future farm expansions. This assessment should be incorporated into an EIS and released for a public comment period of appropriate length for the community to adequately assess the relevant documentation. This will ensure the impacts on environmental, social and cultural values of each farm stage are appropriately considered before future expansions occur. As indicated in Attachment 1, the EIS for the Guthalungra farm expansion provide a best practice example of an EIS for a staged aquaculture farm development in terms of water quality targets and how they related to farm expansions.

Proponent Response

Noted, however, the level of assessment required for future stages is not a decision for the proponent to make. Future assessment processes, and the information required to be included in them, will be determined by the Northern Territory and Commonwealth Governments.

3.21 ENVIRONMENT CENTRE NT

3.21.1 Comment 1

Submitter Type	Community Environment Group (independent)	TOR Category or EIS Chapter	Environmental History and Ecologically Sustainable Development
Date Submission Received	5 December 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

To ensure best environmental and sustainable aquaculture practices, this proposal must comply with Shrimp Standards as prescribed by the Aquaculture Stewardship Council (ASC). The Operator must also obtain certification and accreditation by the ASC in accordance with their guidelines. Approval of this proposal should be conditional on the Operator obtaining and maintaining these standards.

Proponent Response

The proponent has undertaken an internal audit finding the Project can comply with the requirements of the ASC Shrimp Standard. However, ASC accreditation is based on a third party audit process and as such Seafarms is unable to unilaterally declare that it is able to obtain such accreditation. The proponent does commit to undergoing the audit and processes to achieve accreditation; however, it is noted that the ASC Shrimp Standard is a global standard and there are parts of the ASC standard that may conflict with Australian laws - laws which will in all cases be complied with in the event of any conflict with the ASC standard requirements. More importantly, accreditation cannot be obtained before operations commence because the operations themselves are audited as part of obtaining certification. Thus, it is technically not possible to approve the proposal 'conditional upon'.

3.21.2 Comment 2

Submitter Type	Community Environment Group (independent)	TOR Category or EIS Chapter	-
Date Submission Received	5 December 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

To ensure transparency and monitor impacts on the environment, a condition of this proposal must be that the Operator of the facility agree to fund a robust and independent monitoring program of the entire operation and its activities at an agreed frequency and at an agreed level of detail.

- a. The level of funding required for the independent monitoring program must be sufficient to undertake ongoing monitoring for the life of the project. The funding must be deposited into an independent account prior to any works commencing.
- b. The frequency of monitoring and the level of detail of the monitoring must be defined through a public process funded by the Operator.
- c. The independent monitoring program should be comprised of recognised experts in their field.
- d. The monitoring program will include triggers where the operation will be required to cease work if the agreed levels are exceeded and financial penalties will be imposed if this requirement is not met. The monitoring program should work with the appropriate NT government agencies to ensure compliance.

Proponent Response

Volume 4, Chapter 2 and Chapter 3 of the draft EIS (Draft Environmental Management System and Environmental Management Plan) outlines the comprehensive and extensive framework for environmental management including proposed monitoring programs to be implemented during construction and operation of the Project.

Monitoring programs are generally finalised following EIS approval and through secondary approvals where required, such as waste discharge licences and non-pastoral use permits.

The implementation of monitoring programs is considered part of the operating costs of the facility and is thus funded from cash-flow.

3.21.3 Comment 3

Submitter Type	Community Environment Group (independent)	TOR Category or EIS Chapter	Project Description
Date Submission Received	5 December 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

To safeguard against serious environmental damage, a requirement of this proposal should be that the Operator post a bond with the NT government for this facility that will be sufficient to cover any operational failures. This bond should also be sufficient to properly remediate the site to an agreed standard when the operation ceases. This bond should be deposited into an independent account prior to any works commencing.

Proponent Response

The draft EIS, through the comprehensive risk assessment (Volume 1, Chapter 8) shows that overall the risk of serious environmental damage is low. The draft EMP shows how specific risks shall be mitigated and managed. Section 11 of Volume 1, Chapter 3 (Project Description) of the draft EIS outlines contingencies for decommissioning and rehabilitation.

3.21.4 Comment 4

Submitter Type	Community Environment Group (independent)	TOR Category or EIS Chapter	Terrestrial Fauna and Avifauna; Terrestrial Flora; Marine and Estuarine Ecology; Freshwater Ecology
Date Submission Received	5 December 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

To protect the local biodiversity at the site in question, this proposal must require the Operator to ensure surrounding ecosystems and connectivity between habitats is maintained. This includes restoring any habitat lost as a result of this project such as mangrove forests.

Proponent Response

Maintaining Connectivity

Native vegetation buffers and wildlife corridors do not exist in the areas that will be cleared. The vegetation communities within the area to be cleared are widespread across the Legume plains and will continue to be well

represented outside of the project footprint, once clearing has occurred. There are no communities that occur as wildlife corridors across the project footprint.

Whilst there is potential for the services corridor that runs from north to south to act as a barrier to fauna movement, and in particular the freshwater channel, this is considered unlikely to occur for the following reasons.

- The services corridor will not be fenced
- A series of fauna friendly culverts under the freshwater channel are proposed. Whilst the primary purpose of the culverts is to provide for passage of wet season floodplain water, they will also allow for fauna passage.

Furthermore, the fauna assessments that were undertaken to support the draft EIS have revealed that the only fauna groups that are wide ranging enough to be potentially impacted by the barrier to movement that will result from the services corridor are macropod and snake species. None of the species in these groups are threatened species. Macropod species will easily be able to move around the services corridor, whilst snakes and other reptiles will be able to utilize the culverts. As mentioned above, there are no areas of unique or critical habitat for any species that will be isolated by the proposed services corridor. The barrier is only between areas of habitat that are common and widespread across all of Legume Station.

There will be an area of habitat between Farms 2 and 3 that will be isolated from the rest of the floodplain by the services corridor and the main discharge channel. Culverts will provide for passage of smaller terrestrial fauna between this area and external habitat. However macropods will be unlikely to traverse the culverts. This area of habitat is more than 1,000 ha and as such is large enough to support macropod sub-populations, should they become isolated within these areas. There is a turkey's nest dam within this area that provides year round water. Furthermore this area does not become completely inundated in the wet season, meaning that there will still be areas of habitat available in the wet season when floodplain inundation will be at its maximum extent.

Minimising impacts to mangrove communities

See response to Comment 1 from the Department of Environment and Energy regarding minimising impacts to mangrove communities (see Section 3.14.1).

Rehabilitation

Section 11 of Volume 1, Chapter 3 (Project Description) of the draft EIS outlines the proposed process for Project decommissioning and rehabilitation.

3.21.5 Comment 5

Submitter Type	Community Environment Group (independent)	TOR Category or EIS Chapter	Project Description
Date Submission Received	5 December 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

To prevent large scale trawling and depletion of wild fish stock, this proposal must minimise the use of wild fish as an ingredient for prawn feed and declare all sources of fishmeal, fish oil and other major ingredients in the feed.

Proponent Response

The proponent intends to pursue accreditation from the ASC. The ASC Shrimp Standards provide guidance on ethically sourcing feed.

For the Stage 1 Legume Grow-out Facility feed will be dry, cooked and pelletised as sourced from third party manufacturers. Australia currently has two suppliers of feed that service the domestic market, and the proponent also sources feed internationally. All imported feed is subject to strict Australian Quarantine Inspection Service requirements and prawn feed is regulated through the Department of Agriculture. The proponent has examined near-to-market feed innovations including CSIRO's patented Novacq technology but has not been able to trial the product. Feed manufacturers continually improve and modify primary feedstocks and the exact ingredients are usually considered commercial-in-confidence or Trade Secrets. The proponent has adopted an 'Ethical Sourcing Policy' for its feed to ensure it is sourcing its products in a responsible manner, it is providing clear guidance to its buying staff, and is protecting its corporate reputation and the reputation of its individual brands.

The proponent also notes that development of feed is the subject of a global research and development effort with the aim of reducing inputs from wild-caught fisheries and thus feeds are constantly changing.

3.21.6 Comment 6

Submitter Type	Community Environment Group (independent)	TOR Category or EIS Chapter	Waste Management
Date Submission Received	5 December 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

In order to prevent contamination and degradation of both water and soil quality, this proposal must ensure that there is licencing and applicable fees applied for the proper and safe disposal of waste materials, including waste water.

Proponent Response

Volume 1, Chapter 6 of the draft EIS (Approvals, Conditions and Agreements) outlines the regulatory framework applicable to the Project. As stated in this chapter, the purpose of the NT *Waste Management and Pollution Control Act* is to protect the environment through the encouragement of effective waste management and pollution prevention and control practices. The proponent will apply for the appropriate approvals and licences under the Act for relevant activities during the construction and operational stages of the Project. For the discharge of water to Alligator Creek, a waste discharge licence will be obtained under the NT *Water Act*. A waste water design approval will also be obtained under the NT *Water Supply and Sewerage Act* for the operation of the waste water treatment plant.

3.21.7 Comment 7

Submitter Type	Community Environment Group (independent)	TOR Category or EIS Chapter	Marine and Estuarine Water
Date Submission Received	5 December 2016	Submitters Reference to EIS Section (if provided)	-

Details of the Submission

To ameliorate environmental impacts, consideration must be given to the possibility of licencing for extraction of sea-water for commercial purposes.

Proponent Response

Volume 1, Chapter 6 of the draft EIS (Approvals, Conditions and Agreements) outlines the regulatory framework applicable to the Project. As stated in this chapter, under the NT *Water Act*, the proponent will obtain a licence to use saline water from Forsyth Creek.

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APPENDIX A WATERBIRD MONITORING PROGRAM FRAMEWORK



**PROJECT SEA DRAGON
STAGE 1 LEGUNE GROW-OUT FACILITY
SUPPLEMENTARY ENVIRONMENTAL IMPACT STATEMENT**

**APPENDIX A WATERBIRD MONITORING
PROGRAM FRAMEWORK**



A Waterbird Monitoring Plan for Freshwater Wetlands of the Legune Coastal Floodplain

Phase 1: Plan Framework and Supporting Information

Project Sea Dragon Stage 1 Grow-out Facility

Legune Station, Northern Territory

Prepared for:	CO2 Australia
Prepared by:	Lindsay Agnew (Austecology)
Report Status:	Final – 7 February 2017

Table of Contents

1.	Introduction	4
1.1.	Background	4
1.2.	Terminology, Nomenclature and Acronyms.....	5
1.3.	Acknowledgements	6
2.	Framework for Future Waterbird Monitoring Program.....	7
2.1.	Plan Objectives	8
2.2.	Monitoring Values and Hypotheses	8
2.3.	Monitoring Locations	12
2.4.	Monitoring Methods.....	12
2.5.	Monitoring Timing.....	13
2.6.	Monitoring Program Characteristics	14
2.7.	Monitoring of Parameters of Wetland Condition.....	15
2.8.	Reporting and Reviews	16
2.9.	Consultation and Expert Review	16
2.10.	Structure of a Future Monitoring Plan	17
3.	Supporting Information	18
3.1.	Existing Environment	18
3.1.1.	Overview of Floodplain Wetland Characteristics	18
3.1.2.	Current Management Practices which influence Waterbird Habitat.....	20
3.1.3.	Waterbird Surveys and Summary of Results	23
3.1.3.1.	Previous Assessments – 1993 to 2000	23
3.1.3.2.	Legune PSDS1 Surveys – 2015 to 2016	23
3.1.3.2.1.	Abundance	24
3.1.3.2.2.	Species Richness.....	25
3.1.3.2.3.	Records of Importance for Individual Species	25
3.1.3.2.4.	Threatened Species	26
3.1.4.	Key Seasonal Wetland Values	29
3.1.4.1.	Variability in Values	30
3.2.	Issues Relevant to Plan Development	31
3.2.1.	Key Features of Waterbird Occurrence and Indicative Variability	31
3.2.2.	Threats to Waterbirds	33
3.2.2.1.	Water Supply.....	33
3.2.2.2.	Food Supply	33
3.2.2.3.	Weeds and Feral Animals	34
3.2.2.4.	Other Threats	34
3.2.3.	Likely Off-site Influences on Waterbird Usage	35
3.2.3.1.	Regional influences – within Bioregion	35
3.2.3.2.	Regional influences – surrounding Bioregions.....	36
3.2.3.3.	Continental influences	37
3.2.3.4.	Flyway-scale influences	37
3.2.3.5.	Long-term Climatic Cycles	38
3.3.	Establishing Limits of Acceptable Change	40
4.	References	43

List of Figures

Figure 3-1	Infrastructure Controls Applicable to Forsyth Dam Releases	22
Figure 3-2	Location and Extent of 2015 and 2016 PSDS1 Waterbird Surveys	28
Figure 3-3	Relationship between Magpie Goose Abundance and River Flow	39

List of Tables

Table 1-1	Report Acronyms	6
Table 2-1	Recommended survey months for each monitoring hypothesis.....	15
Table 3-1	Major wetland habitats within 1,000 km of Legune coastal floodplain.....	36

List of Attachments

Attachment A	Summary of 2015-2016 Waterbird Surveys – Freshwater & Estuarine Wetlands..	48
Attachment B	Summaries of Ramsar Site Ecological Character Descriptions.....	50
Attachment C	Proposed Aerial Transect Design - Wet Season Survey Event.....	56

1. Introduction

1.1. Background

The Seafarms Group Limited proposes to develop Project Sea Dragon, a large, fully integrated, prawn aquaculture project located in northern Australia. Project Sea Dragon is a large project with a long development timeline (approximately seven years) between first operations and full scale operations.

An Environment Impact Statement has been prepared for the Project Sea Dragon Stage 1 Grow-out Facility to be situated on Legune Station in the Northern Territory (hereafter Legune PSDS1). A significant part of the PSDS1 operations are to be located on the Legune coastal floodplain.

A comprehensive assessment report¹ (Austecology 2016a) has previously been prepared as part of the Legune PSDS1 Environment Impact Statement. The report included seasonal surveys of waterbirds, and the findings confirm that the floodplain wetlands support significant waterbird values.

The EIS provided commitments to preparing and implementing a fauna management plan. As part of the EIS review process, both Commonwealth and Territory Government assessment agencies have sought further information, specifically in regard to a commitment to monitoring and management of waterbird values of the site to enable completion of their assessment.

On 20 December 2016, a meeting was held between representatives of the proponent and officers from the Northern Territory Environment Protection Agency (EPA), Northern Territory Department of Environment and Natural Resources (DENR), and the Commonwealth Department of the Environment and Energy (DEE).

The purpose of that meeting was to discuss the detail (content and timing) behind a request from the Northern Territory EPA for Project Sea Dragon to provide a waterbird management and monitoring program in the supplement to the EIS for the Stage 1 Legune Grow-out Facility (SEIS), and the subsequent discussions with the Northern Territory EPA and the Commonwealth DEE that this would be at the level of a framework only for the SEIS to enable completion of their assessment.

As agreed at the aforementioned meeting, this framework focuses on issues relevant to waterbirds of the freshwater wetlands of the Legune coastal floodplain.

This document provides a framework for waterbird monitoring and has been prepared on the basis of advice provided by government agency representatives during the 20 December 2016 meeting, and their further comments provided on the initial draft circulated in late January 2017.

¹ EIS Volume 5, Appendix 15, Austecology 2016.

1.2. Terminology, Nomenclature and Acronyms

Within this report, the following terms are used:

-) **Site** or **Legune Station** – the area comprising NT Portion 798 and Portion 3222 in the Victoria River District.
-) **Project area** - that part of Legune Station which is within the Stage 1 Legune Grow-out Facility (Legune PSDS1) development footprint.
-) **Legune coastal floodplain** – the extensive alluvial plain on Legune Station, above the normal influence of tides and containing various freshwater wetlands.
-) **Alligator Creek wetland system** – the extent of freshwater wetlands on the Legune coastal floodplain, associated with Alligator Creek in the dry season upstream of Point D (the tidal barrage).
-) **Region** or **surrounding area** - the lands within the Victoria Bonaparte Bioregion and northern parts of the Ord Victoria Plain Bioregion, both of which encompass land within the Northern Territory and Western Australia (IBRA version 7)².
-) **EAA Flyway** or the **flyway** – the East Asian - Australasian Flyway, being one of nine major migratory waterbird flyways (after Boere & Stroud 2006³), and extending from within the Arctic Circle, through East and South-east Asia, to Australia and New Zealand, stretching across 22 countries (after EAAFP⁴).
-) **Waterbird** - refers to those bird species⁵ which are ecologically dependent upon wetlands (after Kingsford & Norman 2002; and Wetlands International 2016).
-) **Shorebird** - refers to both resident and migratory species⁶ which are ecologically dependent upon shallow wetlands and form a subset of the waterbird grouping (after Geering *et al.* 2007).
-) **Threatened** - a common use term to collectively describe species listed as Critically Endangered, Endangered or Vulnerable species under Commonwealth EPBCA and/or the Northern Territory TPWCA.
-) **Waterbird count area** – a spatially defined part of the Alligator Creek wetland system subject to dry season surveys in 2015 and 2016, e.g. AC1 to AC9, and IA3.
-) **Survey program** – the series of consecutive survey events implemented within the Alligator Creek wetland system during the dry season.
-) **Survey event** – a set of surveys of the complete suite of waterbird count areas over consecutive days, which forms part of the survey program.
-) **Survey** - the activity by which waterbirds are searched for, identified and counted.
-) **Count** - the number of individuals counted for a particular species of waterbird.

² Interim Biogeographic Regionalisation for Australia, Version 7, 2012. Australian Government Department of Sustainability, Environment, Water, Population and Communities.

³ A flyway is the entire range of a migratory bird species (or groups of related species or distinct populations of a single species) through which it moves on an annual basis from the breeding grounds to non-breeding areas, including intermediate resting and feeding places as well as the area within which the birds migrate.

⁴ East Asian-Australasian Flyway Partnership. <http://www.eaaflyway.net>

⁵ From the following Families: Anseranatidae, Anatidae, Podicipedidae, Anhingidae, Phalacrocoracidae, Pelecanidae, Ardeidae, Threskiornithidae, Ciconiidae, Gruidae, Rallidae, Scolopacidae, Rostratulidae, Jacanidae, Burhinidae, Haematopodidae, Recurvirostridae, Charadriidae, Glareolidae, Laridae and Sternidae.

⁶ From the following Families: Scolopacidae; Burhinidae; Rostratulidae, Haematopodidae; Recurvirostridae; Charadriidae; and Glareolidae.

-) **Monitoring:** the collection of specific information for management purposes in response to hypotheses derived from assessment activities, and the use of these monitoring results for implementing management (after Ramsar Convention Secretariat 2010a).

Whilst acknowledging that natural seasons may “start” and “finish” at different times from year to year, this report uses the following terms to describe seasons and particular seasonal stages⁷:

-) **dry season and transition periods** are regarded generally as the period April to November.
-) **dry season** is regarded generally as the period May to October.
-) **mid-dry season** is regarded generally as the period centred on the month of July.
-) **late dry season** is regarded generally as the period centred on the month of October.
-) **wet season** is regarded generally as the period December to March.

Nomenclature used for this study follows Christidis & Boles (2008). Vegetation type descriptions used in this report are based on the structural types described by Astrebla Ecological Services (2016). The conservation status of a species is described in accordance with the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and/or the *Territory Parks and Wildlife Conservation Act 2000* and its regulations and amendments.

Table 1-1 Report Acronyms

Acronym	Name, Term or Expression
DEE	Commonwealth Department of the Environment and Energy
DLRM	Northern Territory Department of Land Resource Management
DENR	Northern Territory Department of Environment and Natural Resources
EAAF	East Asian-Australasian Flyway
EPBCA	Commonwealth Environment Protection and Biodiversity Conservation Act 1999
MNES	Matter of National Environmental Significance (as defined under the EPBCA)
EPA	Northern Territory Environment Protection Authority
Legune PSDS1	Project Sea Dragon Stage 1 Legune Grow-out Facility
Ramsar	Convention on Wetlands of International Importance
SEWPaC	Former Commonwealth Department of Sustainability, Environment, Water, Population & Communities
sp.	Species (singular)
spp.	Species (plural)
TSSC	Threatened Species Scientific Committee for the Commonwealth Department of the Environment
TPWCA	Northern Territory Territory Parks and Wildlife Conservation Act 2000
WMA	Northern Territory Weeds Management Act 2001
WoN	Weed of National Significance as listed by the Australian Weeds Committee 2012

1.3. Acknowledgements

Roger Jaensch has provided important inputs to Sections 3 and 4, and peer review of other parts of this report. Dr Julian Reid has provided invaluable advice in regard to the design of the future wet season waterbird aerial survey program. Dr Ed Meyer provided helpful review comments on report drafts.

⁷ The extent to which these actually reflect conditions typical of the nominated periods are subject to some variation for year to year depending on climatic factors.

2. Framework for Future Waterbird Monitoring Program

In order to determine if limits of acceptable change in waterbird usage of freshwater wetlands of the site have been exceeded, a future monitoring program targeting waterbirds should be designed and implemented. This document provides the key principles and elements (i.e. the framework) for the future monitoring program.

In preparing this framework, consideration has been given to a variety of guidelines and approaches as recommended in various studies, including:

-) Survey and monitoring guidelines: e.g. DEWHA 2009a; DEWHA 2010; Wetlands International 2010; Ramsar Convention Secretariat 2010a; and DE 2015.
-) Ramsar Ecological Character Descriptions in regard to recommended monitoring approaches and limits of acceptable change: e.g. Ord River Floodplain (including Parry Lagoons) (Hale 2008); Lakes Argyle and Kununurra (Hale & Morgan 2010); Kakadu National Park (BMT WBM 2010); Eighty-mile Beach (Hale & Butcher 2009); Roebuck Bay (Bennelongia 2009); and Cobourg Peninsula (BMT WBM 2011).
-) Guidelines for wetland assessment and description: e.g. DEWHA 2008; and Ramsar Convention Secretariat 2010a & b.
-) Guidelines in regard to development of environment management plans: e.g. DE 2014.
-) Guidelines in regards to assessment thresholds: e.g. DEWHA 2009b.
-) Government agency management plans for protected wetlands: e.g. WA DEC 2012; and NT P&WS 2014 & 2015.
-) Published literature: e.g. Rogers *et al.* 2011; Kingsford & Porter 2012, and Paton & Bailey 2012.

It should be noted that in deriving potential thresholds or limits of acceptable change as part of the current project, significant data and knowledge gaps are evident, and as a result, there are high levels of uncertainty associated with deriving meaningful robust limits. This is linked to:

-) a largely “preliminary” data set for key parameters such as waterbird usage and environment condition; and
-) remaining uncertainty regarding the extent of available wetland habitat and waterbird usage in the late dry season following the cessation of the regime of annual releases from Forsyth Dam (and the extent of available wetland habitat and waterbird usage due to management of releases between 2005 and 2014).

Beyond the above concerns (which are site focussed), there are a wider set of issues which influence confidence in developing thresholds or limits of acceptable change as part of the current project, e.g. the broader lack of scientific knowledge about the response of particular species and habitats to multiple stressors (for instance a combination of water flows, salinity and habitat availability). Further discussion in regard to such issues is presented in **Sections 3-2 and 3.3.**

As such, the potential thresholds or limits of acceptable change should be regarded as interim, and need to be subject to further evaluation and expert review over time at discrete points in time as knowledge of the site and ecological character improves, and as the wider population dynamics of species of interest change. The final monitoring plan will address this issue.

Were the proposed monitoring program implemented on an annual basis, it is recommended that following the 5th year of implementation, a comprehensive review of data be undertaken with the aim of consolidating and finalising all aspects of the methodology for the monitoring program.

2.1. Plan Objectives

The overall objective of the monitoring plan is to outline a monitoring program and associated data analysis and interpretation, of sufficient power to determine whether limits of acceptable change in waterbird usage of freshwater wetlands of the site have been exceeded, and if so, whether such changes are attributable to developments at Legune.

The maintenance of the values listed in **Section 2-2** should form the specific objectives of the future monitoring plan.

2.2. Monitoring Values and Hypotheses

There are two values relevant to Matters of National Environmental Significance and two linked to Ramsar-level⁸ values (see **Section 3**). In addition to these, dry season (refugial) waterbird habitat values are regarded as important. All of these values are the subject of monitoring hypotheses outlined below⁹. Hypotheses addressing other important “values” (e.g. breeding success) have not been included due to difficulties obtaining robust data sufficient for accurate monitoring¹⁰.

The current hypotheses, will be subject to further consideration by the Scientific Advisory Group in the formulation of the hypothesis for the finalised monitoring plan.

Value 1: Freshwater wetlands of the Legune coastal floodplain support a species listed under the EPBCA as threatened - Curlew Sandpiper, listed as Critically Endangered.

Monitoring (null) hypothesis 1: The Legune coastal floodplain continues to support the nationally-threatened Curlew Sandpiper.

⁸ It should be noted that the Legune Station – or part thereof- does not form part of a Ramsar-listed site. This report applies the widely accepted thresholds adopted under the Ramsar Convention on Wetlands for international importance in the absence of any similar nationally relevant criterion.

⁹ As discussed elsewhere, the process of preparing hypotheses (potential thresholds or limits of acceptable change) has revealed significant data and knowledge gaps, and as a result, there are high levels of uncertainty associated with deriving meaningful robust limits. The proposed hypotheses are intended to be used in the management of the system to maintain the observed values. Failure to meet a particular hypothesis does not by default mean that the potential change is attributable to site development operations. Failure to meet a particular hypothesis does provide a particular trigger point to investigate all potential sources of change. As highlighted in this report, off-site factors - within a bioregional, national and international context – have potential to strongly influence the waterbird values of the site.

¹⁰ e.g. values associated with breeding, such as breeding colonies, which in the final analysis were considered too difficult to assess consistently and are subject to a high level of natural variability.

Value 2: Freshwater wetlands of the Legune coastal floodplain support a species-rich waterbird assemblage, comprising 25 species listed as Migratory under the EPBCA and 46 other waterbird species that are not listed as Migratory.

Monitoring (null) hypothesis 2a: The Legune coastal floodplain supports at least 60% of the EPBCA-listed Migratory waterbird species recorded during the 2015 and 2016 surveys¹¹.

Monitoring (null) hypothesis 2b: The Legune coastal floodplain supports at least 80% of the non-Migratory waterbird species recorded during the 2015 and 2016 surveys¹².

Value 3: Freshwater wetlands of the Legune coastal floodplain regularly support 20,000 waterbirds, including 2,000 migratory shorebirds¹³.

Monitoring (null) hypothesis 3a: The Legune coastal floodplain supports at least 20,000 waterbirds (total count across all waterbird count areas from a single survey event) in at least three years within any five consecutive years of monitoring.

Monitoring (null) hypothesis 3b: The Legune coastal floodplain supports 80% of the mean of the total number of waterbirds recorded during the baseline 2016 and 2017 wet season surveys in at least three years within any five consecutive years of monitoring.

Monitoring (null) hypothesis 3c: The Legune coastal floodplain support at least 2,000 migratory shorebirds (total count across all waterbird count areas from a single survey event) in at least three years within any five consecutive years of monitoring.

Value 4: Freshwater wetlands of the Legune coastal floodplain have supported 1% of the applicable total population¹⁴ of Magpie Goose, Wandering Whistling-Duck, Green Pygmy-goose, Radjah Shelduck, Pied Heron and Little Curlew.

¹¹ Of the 25 species recorded during the 11 survey events in 2015 and 2016, 11 have been recorded only once or twice, i.e. Little Tern, *Gallinago* snipe, Great Knot, Little Ringed Plover, Pacific Golden Plover, Lesser Sand Plover, Long-toed Stint, Broad-billed Sandpiper, Ruff, Bar-tailed Godwit, and Whimbrel. Several of these species were recorded in very low numbers during baseline surveys, e.g. 1 to 3 individuals. For four species, it is considered that the freshwater wetlands of the Legune coastal floodplain do not represent typical habitat, i.e. Great Knot, Lesser Sand Plover, Broad-billed Sandpiper, and Bar-tailed Godwit. Changes in the presence/absence and abundance of these species are unlikely to be informative with regards to project impacts on freshwater wetlands of the Legune coastal floodplains. For this reason, monitoring hypotheses do not specifically address changes in the abundance of these species.

¹² Of the 46 species recorded during the 11 survey events in 2015 and 2016, eight may be considered vagrant or occasional visitors based on: having been only recorded once during the entire survey program, i.e. Black Swan, Sarus Crane, Australasian Shoveler, Black Bittern and Buff-banded Rail; or having been recorded well outside the well-known distribution of the species, e.g. Australian Shoveler; or considered to be rare to uncommon having been recorded only on less than four occasions and only as one or two individual birds, i.e. Purple Swamphen, and Great Crested Grebe. It is unreasonable to expect that all vagrant species/occasional visitors would be detected on monitoring surveys. The total number of species expected on site under the null hypothesis (i.e. no impact on wetland values) is therefore less than 46.

¹³ The “regular” occurrence of 20,000 waterbirds being a threshold for international importance (Ramsar Criterion 5) and the “regular” occurrence of 2,000 migratory shorebirds being a threshold for national importance (EPBC Act Policy 3.21);

¹⁴ In regard to the “applicable total population” - the number of waterbirds equivalent to this threshold (and related thresholds) is set to the current population estimate at the time of producing this report, i.e. Wetlands International 2016 (Waterbird Population Estimates 5th edition) or Bamford *et al.* 2008.

Monitoring (null) hypothesis 4a: The Legune coastal floodplain supports 1% of the applicable total population of Green Pygmy-Goose, Radjah Shelduck and Pied Heron in at least three years within any five consecutive years of monitoring¹⁵.

Monitoring (null) hypothesis 4b: The Legune coastal floodplain supports at least 80% of the mean (annual peak) abundance (as recorded during 2015 and 2016 surveys) Green Pygmy-goose, Radjah Shelduck and Pied Heron, in at least three years within any five consecutive years of monitoring.

Value 5: Freshwater wetlands of the Legune coastal floodplain have supported 0.1% of the applicable total EAAF population¹⁶ of the following listed migratory shorebirds: Marsh Sandpiper, Common Greenshank, Black-tailed Godwit, Little Curlew, Red-necked Stint, Sharp-tailed Sandpiper, Curlew Sandpiper, Oriental Plover, Wood Sandpiper, and Long-toed Stint.

Monitoring (null) hypothesis 5: The Legune coastal floodplain supports 0.1% of the applicable total EAAF population of Marsh Sandpiper, Sharp-tailed Sandpiper, and Little Curlew in at least three years within any five consecutive years of monitoring¹⁷.

Value 6: Freshwater wetlands of the Legune coastal floodplain have supported large numbers of waterbirds during the dry season.

Monitoring (null) hypothesis 6: The Legune coastal floodplain supports 80% of the mean of the total number of waterbirds recorded during the baseline July 2015 and July 2016 surveys of the Alligator Creek wetland system (Waterbird Count Areas AC1-AC8) in at least three years within any five consecutive years of monitoring.

¹⁵ The Magpie Goose, Wandering Whistling-Duck, and Little Curlew have not been included as records of their highest abundance were strongly linked to the development of highly suitable conditions generated by the annual release of Forsyth Dam, and such releases will be ceased with implementation of the Project. These species have not been included within the current hypothesis, though will be subject to further consideration by the Scientific Advisory Group in formulation of the finalised hypothesis.

¹⁶ The number of waterbirds equivalent to this threshold is set to the current population estimate at the time of producing this report, i.e. Wetlands International 2016 (Waterbird Population Estimates 5th edition) or Bamford *et al.* 2008.

¹⁷ Seven species have not been included within the current hypothesis, though will be subject to further consideration by the Scientific Advisory Group in the formulation of the finalised hypothesis. A summary of the reasons for current exclusion are as follows. During the 11 survey events in 2015 and 2016, the relevant threshold has only been surpassed once for the following: Common Greenshank, Black-tailed Godwit, Oriental Plover, Wood Sandpiper, and Long-toed Stint. For two of these species - Wood Sandpiper and Long-toed Stint - the single record was associated with conditions associated with timing coincidence of the arrival of birds (October/November) and wetland created/persisting in the late dry season as a result of earlier inundation from Forsyth Dam – a circumstance which will not occur in future due to the cessation of dam inundation. Records of threshold exceedance for the Red-necked Stint (2 records) and Curlew Sandpiper (3 records) are few and recent data on the abundance indicates considerable fluctuations and decline within Australia.

Each hypothesis should be applied in the context of limits of acceptable change, wherein a timeframe (in all cases) and a scale of change (where applicable) are specified. On this, the following is recommended:

-) The timeframe should be long enough to account for high natural variability (see above), thus at least three years; and
-) The timeframe should be short enough to enable significant change to be detected within a reasonable timeframe, thus less than 10 years.

Changes in waterbird values should therefore be evaluated over a five year period, in which case the null hypothesis (i.e. no loss or reduction of values) would be retained if existing (baseline) values were demonstrated on at least three occasions within any consecutive five year period.

Hypotheses 3b and 4b take account of the likelihood that governments will not wish to see present numbers of waterbirds decline markedly during, although not necessarily due only to, the Legune PSDS1 construction/operation phases, even though numbers may remain well above the Ramsar-type thresholds (as in hypotheses 3a and 4a).

Hypotheses recognises that there may be some variation in occurrence of species due to external factors.

-) For example, for hypotheses 3b and 4b, the percentage of acceptable decline should be large enough to be meaningful, thus at least 10%, but not so great as to prevent remedial action being taken soon enough to prevent irreversible decline (or the Ramsar thresholds of hypotheses 3a and/or 4a being passed), thus under 33%.
-) A recommended minimum acceptable decline (e.g. limit of acceptable change) in waterbird abundance is therefore 20%, which is consistent with approaches taken in the Ramsar site ECD LAC examples (see examples in **Attachment B**).
-) For some hypotheses (e.g. 2 a & b), care needs to be taken in determining the “baseline” from which the recommended hypothesis and minimum acceptable decline (e.g. limit of acceptable change) is derived (e.g. in regards to species richness measures, rare species being given the same weighting as common/regularly occurring species).

The overall number of waterbird species recorded is an easily-quantifiable measure of wetland health. However, the presence of just one individual of a species adds another species to the total, so the meaningfulness of this parameter is limited. Species richness is neither captured in any Ramsar criteria for importance nor cited as a particular value to be addressed under relevant Territory or Commonwealth Government legislation and no threshold for importance based on number of waterbird species is in wide use, worldwide. Furthermore, over time the numbers of species recorded at wetlands of reasonable size and with diverse habitats tend to converge, e.g. due to vagrant occurrences. Accordingly, the overall number of waterbird species is not considered an important focus for monitoring impacts of the Project on waterbird habitat values.

2.3. Monitoring Locations

The abovementioned five main values were documented from, and apply to, the entire system of freshwater wetlands on the Legune coastal floodplain. In the dry season, water is mainly confined to the Alligator Creek system with seasonal lakes and swamps - to the west, south, east and north - becoming progressively drier.

-) Early in the dry season (April to mid-June), monitoring would need to be widespread across the Legune coastal plain extending beyond the Alligator Creek wetland system and to include important habitat such as the Osmans Lake system;
-) During the mid- to late- dry season monitoring could be confined to the Alligator Creek wetland system and a small number of still-wet outlying depressions – e.g. waterbird count areas AC1-AC9 (see **Figure 3-2**).

2.4. Monitoring Methods

Methods employed in the 2015 and 2016 survey programs were considered to be highly effective and relatively cost efficient (with count areas well defined) and form a suitable basis for a monitoring program (see details in Austecology 2016a & b). Methods employed during these surveys are summarised as follows:

-) Ground surveys involving two observers working over 3-5 days for dry season surveys. Ground surveys are essential to identifying small shorebirds and thus testing of hypotheses 1 and 2.
-) Aerial surveys flown by helicopter over at least 23 parallel east-west transects would be the recommended approach for wet season surveys (see **Figure 3-2**). In addition to the pilot, two (ideally three) observers are needed and the program would extend over five days assuming transects are surveyed twice.

It should be noted that suggestions proposed by Dr Alaric Fisher (Department of Environment & Natural Resources)¹⁸ have been considered as part of the process of re-examining all aspects of the design of the survey approach implemented in March 2016 to assess waterbird abundance during the wet season. To assist, Dr Julian Reid (Australian National University) has reviewed the previous design and evaluated its effectiveness in meeting objectives of the proposed monitoring program.

Based on this advice, the number of parallel east-west transects will be increased from 23 in 2016, to 31 transects under the proposed methodology for monitoring (see **Attachment C**). In regards to the number of count replicates, it is concluded that two replicates will: a) be acceptable in regard to accounting for the low level of addressing varying totals linked to waterbird movements¹⁹; and b) provide a sufficiently robust platform for on-going analysis.

¹⁸ Email dated 20 December 2016.

¹⁹ Total waterbird abundance for the 2nd count in 2016 was less than 7% higher than the total recorded in the 1st count, which is not regarded as significant.

2.5. Monitoring Timing

Timing of the surveys of waterbirds for monitoring purposes should optimise the information to be gathered. It should also be time and cost-efficient. Enough information needs to be collected so that all of the monitoring hypotheses can be tested robustly, but this may require only a small number of surveys.

Timing surveys to generally coincide with those of the previous 2015-2016 survey events on the site would be advantageous, increasing the robustness of future data comparisons while also allowing results to be contextualised more easily.

Timing of site survey events to generally coincide with those of off-site long-term studies may provide useful information in contextualising site results, e.g.:

-) Waterbird monitoring. The East Australian Waterbird Survey (University of NSW) is an annual survey conducted in October each year since 1983. This long-term study provides waterbird data from aerial counts of up to 2,000 wetlands. The National Waterbird Survey (University of NSW) provides a continental expansion of the former, and provides waterbird data from aerial counts conducted in October since 2008.
-) Shorebird counts have been undertaken annually in the Kimberley Coast region (from the mouth of the Ord River to Eight Mile Beach) since 2004. Surveys in this region have been conducted between late October and early December. This is considered the best time of year to survey shorebirds on the Kimberley Coast²⁰, being at the end of the southwards migration period when all migrating shorebirds should have arrived in Australia²¹ (e.g. Bennelongia 2009; Rogers *et al.* 2011). For the area extending from Roebuck Bay to Eighty Mile Beach annual monitoring since 2004 has comprised two summer counts per year (late October and early December) and one winter count per year (June/July) (Kimberley Marine Research Program, Western Australian Marine Science Institution).

²⁰ Most migratory shorebirds arrive on the coast of North Western Australia between August and mid-October, so counts carried out earlier in the season are unlikely to represent peak numbers. Adults may stay for several months (from about late August/September to March/April, exact timing differing between species) while carrying out their annual flight feather moult. Many migratory shorebird species on the Kimberley coast have delayed maturity, and after arriving in North Western Australia within 3–5 months of fledging in the northern hemisphere, they remain there for 1–3 years before they first attempt to migrate north. As a result, migratory shorebirds can be found on the Kimberley coast at all times of year, but numbers are lowest during the dry season (about May to early August) when adults are breeding in the northern hemisphere and only immature shorebirds remain in Australia.

²¹ e.g. in regard to Roebuck Bay, Bennelongia (2009) note that this period should reflect stable shorebird populations, particularly as wet season rains are unlikely to occur before mid-December so that inland floodplains remain dry.

2.6. Monitoring Program Characteristics

A review of **Table 2-1** shows that up to four survey events per year may meet the requirements of the waterbird monitoring program for the Legune coastal floodplain. The following provides a summary of the key characteristics of each recommended survey event:

Dry Season Survey Event 1

-) Implementation during July.
-) Ground surveys over a four to five day period.
-) Surveys of waterbird count areas of the Alligator Creek and Osmans Lake wetland systems - with other wetlands likely to be dry or near-dry and therefore contributing little to the assessment of wetland values.
-) Waterbird count protocols as previously implemented (see Austecology 2016a and b) to provide consistency using tested, efficient, repeatable area count approach.
-) Optimal timing for hypotheses 3a, 4a, 4b, and 6, and good timing for hypotheses 1, 2a, 2b, and 3c.
-) Good survey conditions with most survey sites readily accessible.
-) Negligible likelihood of wet weather interrupting or preventing the survey event.

Dry Season Survey Event 2

-) Implementation during October.
-) Ground surveys over a three to four day period.
-) Waterbird count protocols as previously implemented (see Austecology 2016a and b) to provide consistency using tested, efficient, repeatable area count approach.
-) Surveys of waterbird count areas of the Alligator Creek wetland system (all other wetlands likely to be dry).
-) Optimal timing for hypotheses 1 and 2 and good timing for hypotheses 3, 4 and 5 in regard to most of the applicable waterbird species.
-) Good fieldwork conditions and most survey sites readily accessible.
-) Good timing for hypotheses 3b, 4b and 5, and optimal timing for hypotheses 1, 2a, 2b, 3c, 5 and 6.
-) Good fieldwork conditions and most survey sites readily accessible.
-) Low likelihood of wet weather interrupting or preventing the survey event.

Wet Season Survey Event

-) Implementation in March, coinciding with previous aerial survey in 2016.
-) Aerial surveys and some ground-truthing over a five day period.
-) Flown over the entire non-tidal part of the Legune coastal floodplain (see **Figure 3-2**).
-) Not ideal timing for hypotheses 1, 2a, 3c, and 5, but good timing for hypotheses 2b, 3a, 3b, 4a and 4b, in regard to most of the applicable waterbird species.
-) Conditions unsuitable for ground-based surveys with use of helicopter allowing access to entire coastal plain.
-) Wet weather (showers, storms, monsoonal rain) could interrupt, and possibly prevent, the surveys (in which case surveys may need to be rescheduled).

Table 2-1 Recommended survey months for each monitoring hypothesis

Monitoring Hypothesis	Information Required	Habitat and Location	Recommended Survey Months
1	Presence of Curlew Sandpiper.	Shallow drying wetlands of the Alligator Creek wetland system.	September to November for arriving migrants ²² , with overwintering birds throughout the dry season.
2a, 2b, 3c, 5	Presence of migratory waterbirds.	Shallow drying wetlands of the Alligator Creek wetland system.	September to November for arriving migrants with overwintering birds throughout the dry season.
3a, 3b, 4a, 4b ²³	Number of waterbirds (all species combined; and by species).	Entire inundated part of the non-tidal component of the Legune coastal floodplain (i.e. estuarine deltaic plain) at time of survey.	All year except if area of water is negligible ²⁴ .
6	Number of waterbirds (all species combined).	Shallow drying wetlands of Osmans Lake and the Alligator Creek wetland system.	July through to November.

2.7. Monitoring of Parameters of Wetland Condition

Potential abiotic/biotic parameters of wetland health which can be monitored, could be useful in assessing reasons for changed conditions, and could assist in ascribing a source(s) of change/impact. Habitat condition monitoring, principally in the form of monitoring underlying wetland ecosystem processes such as water quality and hydrological process are likely to be of most value.

Currently, management strategies proposed within the EIS, are being developed for the Project's more detailed environment management plan. Specific plans pertaining to surface water management (water quality and flood plain hydraulics) will incorporate objectives, targets and key performance criteria relevant to the monitoring and management of the ecological health of the Legune coastal floodplain freshwater wetlands. Relevant elements of those plans will be developed with regards to the pertinent aspects of the waterbird monitoring plan.

The aerial extent of wetland habitat will also be a useful parameter to monitor and could be done by remote sensing (e.g. aerial photography during wet season aerial surveys and/or Landsat imagery) coupled with ground truthing. Totally vegetated wetland, of which there can be large amounts at Legune in wetter months, may require a complementary approach to avoid being underrepresented. An alternative approach might be to deploy water depth/hydroperiod loggers at strategic locations. Data from these loggers could be downloaded during monitoring surveys.

²² Shorebirds may be present from December through to April but ground access can be very limited in those months. Small shorebirds cannot be accurately identified from aerial surveys. Small numbers of shorebirds also may be present at Osmans Lake after April.

²³ The suite of species occurring at 1% level collectively occupies most of the wetland habitats in the Legune coastal plain and is well represented when water is confined to the Alligator Creek system.

²⁴ Mid-late wet season (maximum water area), e.g. March, and mid-late dry season (birds concentrated but ample habitat), e.g. October, may be optimal.

2.8. Reporting and Reviews

It is recommended that an annual review be produced within three months of the completion of each dry-wet season monitoring cycle (e.g. by 30 June following the wet season survey event). The annual review should include the following:

-)] A summary of monitoring findings and assessment against monitoring hypotheses (interim thresholds-limits of acceptable change); and
-)] Identification of any issues affecting plan implementation.

Were the proposed monitoring program implemented on an annual basis, it is recommended that following the 5th year of implementation, a major review of data be undertaken with the aim determining whether the 5-year monitoring program has established a suitable baseline, and consolidating and finalising all aspects of the methodology for on-going monitoring.

The future finalised monitoring plan will be developed consistent with guidelines such as those provided by the Commonwealth (DE 2014).

2.9. Consultation and Expert Review

The development of the future, and more detailed, monitoring plan, will be developed in consultation with the relevant Northern Territory and Australian Government advisory agencies. As part of this process, a Scientific Advisory Group (SAG) will be established to provide expert input into the development of the plan. The key tasks for this stage will include, but may not be limited to, the following:

-)] Assessment of the interim thresholds/limits of acceptable change;
-)] Review of the methodological approach for monitoring; and
-)] Advice on data management and methods of data analysis.

Beyond the development of the initial monitoring plan, the on-going assistance of the Scientific Advisory Group will be sought, and will include, but may not be limited to, the following:

-)] Environmental advice on measures needed to protect freshwater habitats, and in response to changes in wetland character.
-)] Examination of the annual review;
-)] Advice on measures to improve data management and analysis.

Within the Scientific Advisory Group, key areas of expertise would include:

-)] Waterbird ecology, habitat management, and monitoring techniques; and
-)] Wetland processes and condition assessment.

2.10. Structure of a Future Monitoring Plan

It is expected that a future, and more detailed, monitoring plan will be developed consistent with guidelines such as those provided by the Australian Government (DE 2014). An outline of the structure of the plan will include, but may not be limited to, the following:

-) Objectives;
-) Roles and responsibilities;
-) Monitoring methods, frequency and duration;
-) Monitoring trigger thresholds;
-) Data collection and management procedures;
-) Linkages with allied management/monitoring plans;
-) Reporting requirements;
-) Auditing procedures;
-) Corrective action strategies and procedures;
-) Role of Scientific Advisory Group;
-) Plan review schedule; and
-) Glossary.

3. Supporting Information

3.1. Existing Environment

3.1.1. Overview of Floodplain Wetland Characteristics

Legune Station encompasses an area of approximately 186,000ha. It is characterised by a stepped series of plains which extend from the Legune ranges and Spirit Hills (adjacent and to the south of the site) northwards through the site to the delta between the mouths of the Keep and Victoria Rivers. The stepped series of plains which dominate the site's landscape are categorised as "coastal plain", "estuarine-deltaic plain", "coastal erosional plain" and "sheet flood fan plain" (after Astrebla Ecological Services 2016).

Key waterbird values are contained within the **estuarine-deltaic plain**. The coastal plain²⁵, which extends seaward from the estuarine-deltaic plain, provides wetland habitat for waterbirds, though significantly lower waterbird abundance and species richness and primarily within the wet season.

The **estuarine-deltaic plain** supports plains that are drier than the flood basins, although still seasonally inundated. Drainages are widely spaced to rare, incipient, very shallow, generally interrupted to disintegrated and often non-directional or centripetal, draining inwards to a playa (e.g. Osmans Lake). The two main waterways that dissect this plain are the Alligator and Forsyth Creeks. A mosaic of two main tussock grassland communities cover approximately 75% of the estuarine-deltaic plain (tall closed canegrass dominated tussock grassland and northern rice grass dominated tussock grassland)²⁶. Sedgeland comprises the other dominant vegetation community²⁷.

Forsyth Creek and Alligator Creek catchments are the two major waterway catchments of the site²⁸. Forsyth Creek flows in a northerly direction through the eastern part of the site to join the lower section (outer estuary) of the Victoria River (i.e. eastern side of the site). The Alligator Creek headwaters are located approximately 15km south of the site before travelling in a predominately north, then north-westerly direction through the site and discharging into the Keep River (i.e. western side of site). Since about 2005, rainfall from Forsyth Creek headwaters has been captured by Forsyth Dam, with annual releases from Forsyth Dam distributed between Alligator Creek and Forsyth Creek (see further discussion, **Section 3.1.2**).

The largest natural wetland feature is **Osmans Lake** complex. Osmans Lake is the largest "playa" within the system (app. 1,050ha). There are at least 30 other smaller playa wetlands

²⁵ The coastal plain comprises a marine depositional environment, with the supra-tidal zone interfacing with the estuarine-deltaic plain. Drainage is characterised by channels which are widely spaced to sparse and trellised. Vegetation is characterised by low closed mangrove forest (most well developed around edges of the main waterways and marine interface) and samphire forland which occurs within the supra-tidal zone (covering app. 70% of the coastal plain). Extensive bare or sparsely vegetated salt flats are a dominant feature of the coastal plain. The coastal plain comprises an area of approximately 60,000ha.

²⁶ The former dominated by *Ophiuros exaltatus*, *Cyperus scariosus*, *Imperata cylindrica*, with the latter dominated by *Xerochloa imberbis*, *Sporobolus virginicus*, and *Imperata cylindrica*.

²⁷ Dominated by *Cyperus scariosus*, *Schoenoplectus praelongatus*, and *Caldesia oligococca*.

²⁸ Catchment area of 707km² and 315km² respectively (Water Technology 2016).

extending mainly to the north and north-west of Osmans Lake. The average size of these “satellite” wetlands is approximately 21ha (range: 0.5 to 96ha). These wetlands are seasonal, and Osmans Lake persists the longest (through to late-July, possibly to early August). As with the other associated smaller playa features, Osmans Lake appears to be recharged predominately by direct precipitation, though this is possibly augmented by some runoff from the adjacent low hills²⁹. Major floods in Keep River or Sandy Creek may also provide some inflow in especially wet years.

There are also a small number of similar shallow closed wetland depressions within the northern part of the site (on the estuarine-deltaic plain; recharged predominately by direct precipitation). The dimensions of wetlands in this mosaic are not as large as that of the Osmans Lake system to the south. Many are in good condition and support healthy stands of northern bluebush *Chenopodium auricomum*. Small “gilgai” (“crab-hole”) depressions which form ephemeral wetlands, many with dense sedge (thought to be *Cyperus scariosus* and/or *Fimbristylis* spp.) are also associated with this area and are a distinctive and relatively common and widespread feature of the northern part of the estuarine-deltaic plain.

The primary permanent wetland habitat area is associated with Alligator Creek. This waterway is bunded at a variety of locations over a 20-25km section, upstream of what is colloquially known as “Point D” - near its tidal upstream limit and approximately 15km upstream of its confluence with the Keep River (see **Figure 3-2**).

Upstream of Point D, fringing paperbark woodland is discontinuous to patchy and eventually absent, while adjacent vegetation is generally a mixed species closed to open sedgeland, though also mixed grassland³⁰. The Alligator Creek wetland system supports areas of open water support extensive patches of macrophytes dominated by *Nymphaea* spp. (waterlilies). Permanent floodplain sedge swamps support a conspicuous herbaceous element (aquatic beds of helophytes and hydrophytes, and large areas of grassland dominated by Australian rice grass *Oryza australiensis*) which are located on the silty/sandy channel and adjacent flooded plain, notably in the south-east. Seasonally, dense thickets of legumes *Aeschynomene indica* and *Sesbania* spp. to 2-4m height occupy large areas of wetlands in the central plain. Introduced pasture grasses are widespread and dense in the central plain and seasonally may be naturally and/or artificially inundated.

In the wet season, the broadest areas of open water wetland occur four to 10km upstream of Point D. During the late-dry season, the extent of surface water associated with Alligator Creek can be greatly increased (typically from early August) as a result of inundation from the release of Forsyth Dam³¹. Undoubtedly, this annual release augments the extent and longevity of wetland and waterbird values throughout the remainder of the dry season (see further discussion).

²⁹ Osmans Lake has a catchment area of approximately 42km² (Water Technology 2016).

³⁰ e.g. *Schoenoplectus littoralis*, *S. laevis*, *Oryza australiensis* closed to open sedgeland.

³¹ Noting that this is dependent on the volume and direction of the flows, which in turn dependent upon the amount of water in the dam and the way the station operators choose to direct the flows.

The two largest artificial wetlands are Forsyth Dam and Weaner Dam. Both are within the south-eastern part of the site and within the Forsyth Creek catchment. Both dams provide large areas of open water³², and due to their depth and bathymetry, aquatic vegetation is restricted to a relatively narrow zone adjacent to water's edge. Both water bodies support habitat for waterbirds, though significantly lower waterbird abundance and species richness in comparison with shallower wetlands of the estuarine-deltaic plain.

3.1.2. Current Management Practices which influence Waterbird Habitat

Before European intervention, the Legune coastal floodplain would have supported extensive temporary (seasonal) wetlands and smaller, mostly riverine, semi-permanent wetlands. These were supplied fresh water from direct precipitation and in many cases from flooding of local creek systems, in the short wet season. Typically, only some of the deeper channels of Alligator Creek provided wetland habitat on the coastal plain in later parts of the dry season, the others having succumbed at various stages to intense evaporation. Within the last 50 years, pastoral land uses on the coastal floodplain have resulted in a variety of changes to hydrological regimes and wetland habitat values for waterbirds across the floodplain.

Forsyth Creek and Alligator Creek catchments are the two major waterway catchments of the site³³. The pre-intervention flood plain hydrological conditions of both Forsyth Creek and Alligator Creek catchments have been modified over time by the instatement of various bunds, simple water flow structures, embankments to support roads, and the establishment of ponded pastures.

The more substantive works were implemented after the purchase of Legune Station by the current owners in 1999, and completed during the dry seasons of 2001 to 2004 (*pers comm.* O. Stacy 2016). Since development in 2005, Forsyth Dam has created a significant abstraction of wet season flows within the Forsyth Creek catchment, and as a result of annual releases, has modified dry season conditions within both Forsyth and Alligator Creek catchments.

These post-1999 developments, operational for up to 15 years, have created changes to natural flow regimes, and associated wetland fauna habitat characteristics within both catchments.

Whilst Forsyth Creek is poorly defined on the estuarine-deltaic plain, Alligator Creek extends deep within estuarine-deltaic plain and is characterised by a continuous well defined channel and provides the primary permanent wetland habitat area within estuarine-deltaic plain. Given these characteristics, landform changes have had a comparatively greater influence on wetland availability for waterbirds within the Alligator Creek catchment.

³² At full supply levels, Forsyth Dam supports approximately 400ha of surface water, whilst Weaner Dam supports approximately 50ha of surface water.

³³ Osmans Lake is the largest of a mosaic of lacustrine, natural playa wetlands which are contained within a catchment separate to the predominant catchments of Forsyth Creek and Alligator Creek.

Alligator Creek is bunded at a variety of locations, being (from downstream to upstream; see **Figure 3-1**):

-) near its tidal upstream limit approximately 15km upstream of its confluence with the Keep River (colloquially known as “Point D”);
-) approximately 4km further upstream (colloquially known as “Point C”);
-) approximately 10km further upstream where the main access track crosses the creek (colloquially known as “Crocodile Crossing”);
-) two smaller bunds approximately a further 5km upstream (Red Rock Paddock); and
-) with station tracks/roads also acting as low bunds in some areas.

Of these, the bunds at Points D and C are maintained as permanent barriers to tidal ingress and downstream freshwater flow during the dry season (see **Figure 3-1**). Others are opened or retained in accordance with the Forsyth Dam release flow management strategy specific to the requirements of any particular year.

The creation and maintenance of these bunds has led to the permanent exclusion of tidal influences (lower reaches) and the subsequent expansion and longer persistence of freshwater wetland habitat during the dry season (upper reaches).

The other significant influence on floodplain hydrology and wetland availability is associated with the development and management of Forsyth Dam.

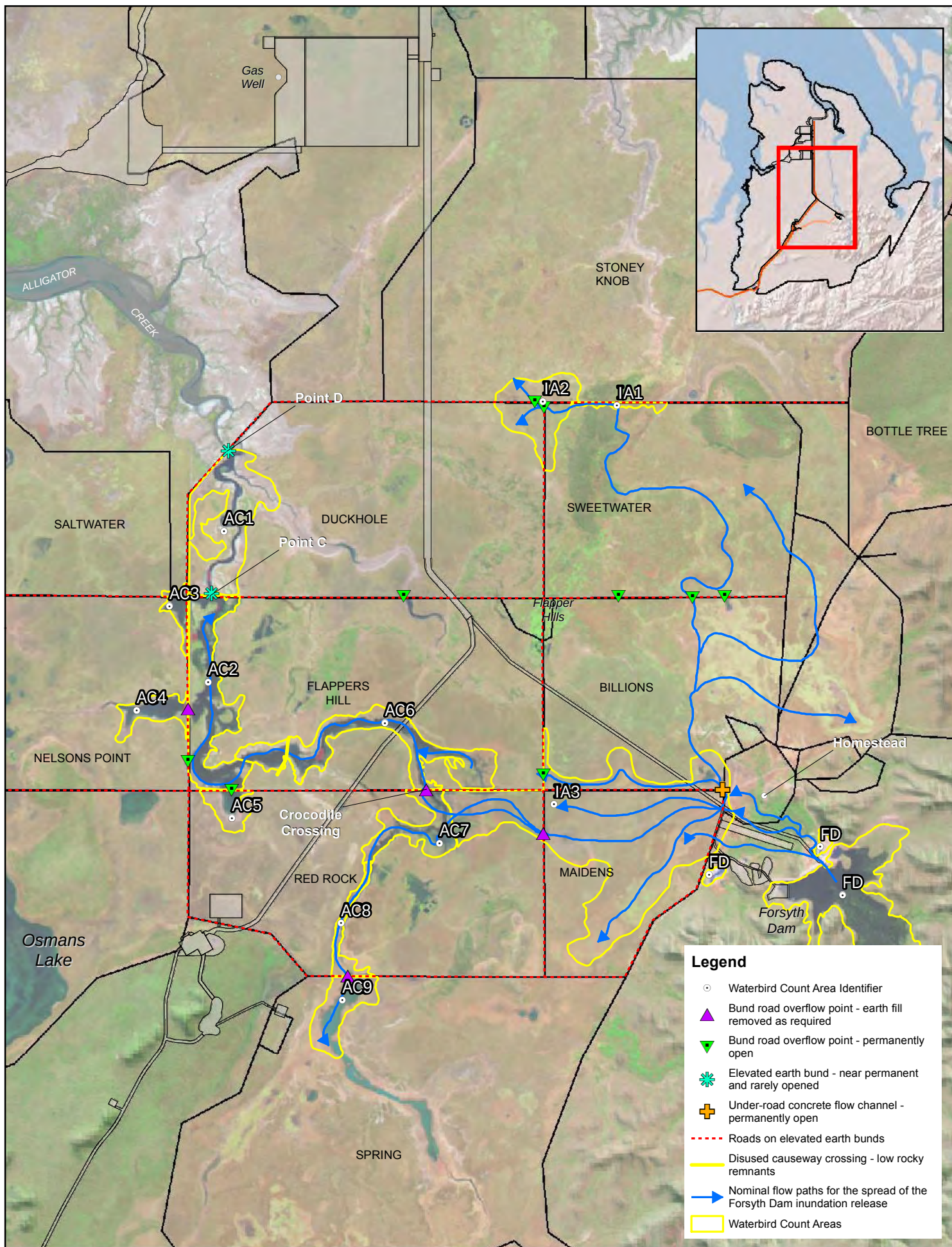
Forsyth Dam was constructed in 2005, with the purpose being (after Freeland 2004): provision of a single, dry season irrigation event to the wetlands; provision of water (through pipes) to stock across the northern wetlands of Legune; and for domestic, non-consumptive purposes.

Forsyth Dam has a catchment area of 56km² and holds up to 35GL of water at peak capacity. Annual dam releases commenced in 2007. Dam releases³⁴ typically occur in August, and can inundate the floodplain downstream, beyond the natural channel and vicinity, wherein water would naturally have been contained, for up to two months depending on the volume released.

Although probably not creating any newly permanent wetlands, these dam releases delay the post-wet-season drawdown of some floodplain wetlands by allowing water to persist for longer than it would if it was supplied by the preceding wet season alone. The net effect is to prolong the availability of temporary wetland habitat by up to two months - the number of weeks depending on bathymetry and location of a wetland as well as the volume of water captured and released, and the manipulation of artificial bunds and water flow structures by station operators.

Surveys of waterbirds were conducted in the dry seasons of 2015 and 2016. The amount, the timing, and the distribution of water were all different in each of these years. These surveys showed significant differences in waterbird usage, some of which may have been influenced by differences in availability and persistence on-site of wetland habitat. Manipulation of water flows clearly influences waterbird usage of the area (see Austecology 2016b).

³⁴ During each occurrence, all available water within Forsyth Dam is released - this may be less than the full supply level depending upon the amount of rainfall in a given year. When release flows cease, there typically remains approximately 1GL on the floor as a result of the design of Forsyth Dam.



3.1.3. Waterbird Surveys and Summary of Results

3.1.3.1. Previous Assessments – 1993 to 2000

Prior to work undertaken for the Legune PSDS1 EIS, waterbirds occurring on the site were the subject of assessments by Jaensch (1994) and Chatto (2000, 2003, & 2006).

Jaensch implemented limited waterbird surveys during April 1993. Data collected from the three wetland areas³⁵ assessed, indicated a cumulative total exceeding the Ramsar Criterion 5 (>20,000 waterbirds). Jaensch included the freshwater wetlands in the centre of Legune Station as one of five notable wetland systems assessed in the study, noting that: "... Osmans Lake and the Legune SE Swamps, probably would rate as outstanding if data from all component wetlands were combined and supplemented with data from further surveys conducted when shallow water was extensive (surveys were inadequate at the time in 1993)."

Chatto implemented several surveys – during March 1995, November 1998, March 1999, and June 1999. The results of the June 1999 waterbird surveys provided a cumulative total which exceeded the Ramsar Criterion 5 (Chatto 2006). Single counts for Glossy Ibis, Eurasian Coot, and Purple Swamphen were regarded as the largest made throughout the Top End surveys (Chatto 2006). Chatto (2006) identified four areas on Legune Station as supporting "significant waterbird records", and all four areas appear to occur within the Alligator Creek wetland and Osmans Lake wetland systems.

Chatto (2000) described three waterbird breeding colonies, two along the Keep River (Colonies 52 & 53) and a third at Alligator Springs (Colony 76) in the southern part of Legune Station. Colony 53 was regarded as nationally important and the only breeding colony for Glossy Ibis recorded in the Top End (being the only major colony of this species reported from coastal northern Australia and the only one from mangroves). Colonies 52 and 76 were regarded as sites of regional importance. In regard to target shorebird surveys, Chatto (2003) concluded that neither the estuarine wetland (i.e. coastal plain) nor the freshwater wetlands (i.e. estuarine deltaic plain) supported large numbers of shorebirds.

3.1.3.2. Legune PSDS1 Surveys – 2015 to 2016

During 2015 and 2016, a survey program was implemented to provide extensive coverage of natural and semi-natural freshwater wetlands under both dry and wet season conditions (Austecology 2016a). The survey program was designed to address the Terms of Reference for the Legune PSDS1 EIS. The main aspects of that work were:

-) A systematic ground-based survey program of all freshwater wetlands implemented during each of six survey events (June to November 2015 inclusive).
-) A systematic, transect-based aerial survey which covered all freshwater wetland habitat on the Legune coastal floodplain within an area of 46,452 hectares (March 2016).

In addition, a survey program was implemented during the 2016 dry season in support of the Legune PSDS1 SEIS (Austecology 2016b). That work provided systematic ground-based counts of waterbirds at all freshwater wetlands within the Alligator Creek wetland system and

³⁵ Bundaberg NNE Flats, Osmans Lake System, Legune South-eastern Swamps, and Alligator Springs Waterhole.

Forsyth Dam during each of four survey events (August to November 2016 inclusive). That work was implemented to provide a replication of the 2015 surveys to assess the influence of a significantly smaller water release in 2016 compared with the corresponding period in 2015.

Attachment A provides a summary of all survey work undertaken to assess waterbird usage of both freshwater and estuarine wetlands of the site. **Figure 3-2** describes the location and extent of the dry and wet season waterbirds surveys of freshwater wetlands.

3.1.3.2.1. Abundance

Dry season surveys were conducted at all of the major waterbodies holding water at the time, in each of the six months June 2015 to November 2015. The total number of waterbirds recorded during this period ranged from 31,992 (June) to 71,889 (August) with an average of 40,748 waterbirds (see Austecology 2016a). The most significant waterbird aggregations were recorded from the Alligator Creek wetland system, though results from Osmans Lake were also notable. The Dry season result clearly indicates that the Legune wetlands meet Ramsar Criterion 5³⁶.

In regard to the wet season aerial surveys, the number of waterbirds estimated to be present on the 46,452ha of floodplain wetlands surveyed in March 2016 was 74,393 individuals³⁷. The survey team was confident that this was a relatively robust and realistic estimate (see reasoning provided by Austecology 2016a). Count data showed a comparatively higher average waterbird density for the areas which generally coincide with the Alligator Creek wetland system, though also for wetland habitats associated with the Osmans Lake wetland system. The Wet season result clearly indicates that the Legune wetlands meet Ramsar Criterion 5.

Of the four survey events during the 2016 dry season program (focussed primarily within the Alligator Creek catchment), the highest count total was recorded during late August (101,042 birds) and the lowest during the final survey event (November; 42,726 birds). The Dry season result clearly indicates that the Legune wetlands meet Ramsar Criterion 5.

³⁶ Ramsar Convention on Wetlands Criterion 5: A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds.

http://www.ramsar.org/sites/default/files/documents/library/ramsarsites_criteria_eng.pdf

³⁷ Averaged from two aerial surveys using 23 transects each 200 m total transect width, spaced 1.5 km apart.

3.1.3.2.2. Species Richness

Survey programs in the 2015 and 2016 dry seasons collectively yielded records of 71 waterbird species, including:

-) waterfowl (ducks and geese) – 11 species;
-) grebes – three species;
-) darter, cormorants and pelican – five species;
-) herons, ibis, egrets, and spoonbills – 14 species
-) storks and cranes – three species;
-) crakes, rails and jacana – four species;
-) shorebirds (non-migratory) – six species;
-) shorebirds (migratory) – 19 species; and
-) terns and gulls – six species.

3.1.3.2.3. Records of Importance for Individual Species

The recorded abundance³⁸ of the following species exceeded the 1% threshold for international importance (Ramsar Criterion 6³⁹):

-) Magpie Goose (1% = 20,000) - 46,819 (August 2015), 27,439 (March 2016) and 61,840 (late August 2016).
-) Plumed Whistling-Duck (1% = 10,000) - 12,642 (August 2015).
-) Wandering Whistling-Duck (1% = 10,000) - 12,763 (March 2016) and 13,512 (August 2016).
-) Radjah Shelduck⁴⁰ (1% = 1,000) – 1,043 (October 2015), 1,886 (November 2015), and 1,813 (March 2016).
-) Green Pygmy-goose⁴¹ (1% = 1,000) – 1,441 (June 2015), 1,063 (August 2015), 1,943 (September 2015), 2,524 (October 2015), 3,456 (November 2015), 1,192 birds (early August 2016), 1,567 birds (late August 2016), 1,664 birds (September 2016).
-) Pied Heron (1% = 1,000) – 3,358 (March 2016).
-) Little Curlew (1% = 1,800) – 3,179 birds (November 2016).

³⁸ Dry season abundance data reported here are counts from a single count area, rather than the number of birds summed across all count areas surveyed on the day or week. These data provide a conservative estimate of the number present across all count areas. Abundance from wet season aerial surveys was assessed from the mean of two surveys across the entire coastal floodplain.

³⁹ Ramsar Convention on Wetlands Criterion 6: A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird. http://www.ramsar.org/sites/default/files/documents/library/ramsarsites_criteria_eng.pdf

⁴⁰ Assumed on the basis of geographic range to be subspecies *rufitgerum*.

⁴¹ Northern Australia population (not including overseas occurrence).

In regard to migratory shorebirds, only one species, the Little Curlew, exceeded the 1% population threshold (after Bamford *et al.* 2008 and/or Wetlands International 2016; Ramsar Criterion 6). The recorded abundance of the following shorebird species⁴² exceeded the 0.1% EAAF population threshold for identifying Nationally important habitat for migratory shorebirds under the EPBC Act Policy 3.21⁴³:

-) Marsh Sandpiper (0.1% = 100) – four counts in June 2015 (171, 102, 131, & 214 birds), 624 (July 2015), three counts in September 2015 (150, 127, & 103 birds), 223 (October 2015), 219 (November 2015), 246 (March 2016), and 101 (November 2016).
-) Common Greenshank (0.1% = 60) – 71 (March 2016).
-) Black-tailed Godwit (0.1% = 160) – 328 (March 2016).
-) Little Curlew (0.1% = 180) – 276 (March 2016).
-) Red-necked Stint (0.1% = 325) – 348 (June 2015), and 745 (July 2015).
-) Sharp-tailed Sandpiper (0.1% = 100) – 533 (July 2015), 570 (September 2015), 179 (October 2015), 778 (October 2016), and 216 (November 2016).
-) Curlew Sandpiper (0.1% = 18) – 72 (July 2015), 18 (September 2015), and 33 (November 2016).
-) Little Curlew (0.1% = 180) – two counts in October 2015 (1,082 & 186 birds), and two records in October 2016 (210 & 617), and 536 (November 2016)⁴⁴.
-) Oriental Plover (0.1% = 70) – 252 (November 2016).
-) Wood Sandpiper (0.1% = 100) – 104 (November 2016).
-) Long-toed Stint (0.1% = 25) – 50 (November 2016).

3.1.3.2.4. Threatened Species

Four threatened waterbird species, all migratory shorebirds, have been recorded during surveys of the freshwater wetlands of the Legune coastal floodplain. Of these, only the Curlew Sandpiper was recorded regularly during surveys.

Curlew Sandpiper *Calidris ferruginea*⁴⁵ - Recorded during the majority of dry season survey events in 2015 and 2016. The highest (and most significant) count of was derived from surveys of Osmans Lake in July 2015 (72 birds). Smaller numbers were also recorded at Osmans Lake during other surveys when water persisted on the lake, i.e. May, June, & July 2015. Curlew Sandpipers were also recorded from the Alligator Creek wetland system. Typically recorded in small numbers of birds (three birds) during survey events prior to September, then larger counts recorded during the September to November surveys; e.g. 18 birds in September 2015 and 33 birds November 2016). The majority of these records derive shallow margins along the central sections of Alligator Creek (e.g. AC2, AC5 and AC7).

⁴² Note: Given the nature of 2016 wet season aerial surveys, only a proportion of the many shorebirds observed could be identified to species level.

⁴³ EPBC Act Policy 3.21: A wetland is of national importance if it regularly supports 0.1% of the East Asian-Australasian Flyway (the flyway) population of a single species of migratory shorebird.

⁴⁴ In addition to the 1% population count previously listed.

⁴⁵ The Curlew Sandpiper is listed as *Critically Endangered* under the EPBCA, and as *Vulnerable* under the TPWCA.

Lesser Sand Plover *Charadrius mongolus*⁴⁶ - There were three dry-season counts of this species (2015 only) from the surveyed freshwater wetlands – two records (2 & 4 birds) from the most downstream freshwater sections of Alligator Creek (AC1 & AC2), and a single bird observed in a paddock subject to recent inundation from the Forsyth Dam release (IA3). These are atypical habitats for Lesser Sand Plover, and those records are not regarded as significant *per se*.

Bar-tailed Godwit *Limosa lapponica*⁴⁷ - Low numbers of Bar-tailed Godwit were recorded at the freshwater wetland monitoring site AC1 within the downstream section of Alligator Creek with four birds recorded during the November 2015 survey. These are atypical habitats for Bar-tailed Godwit, and this record is not regarded as significant *per se*.

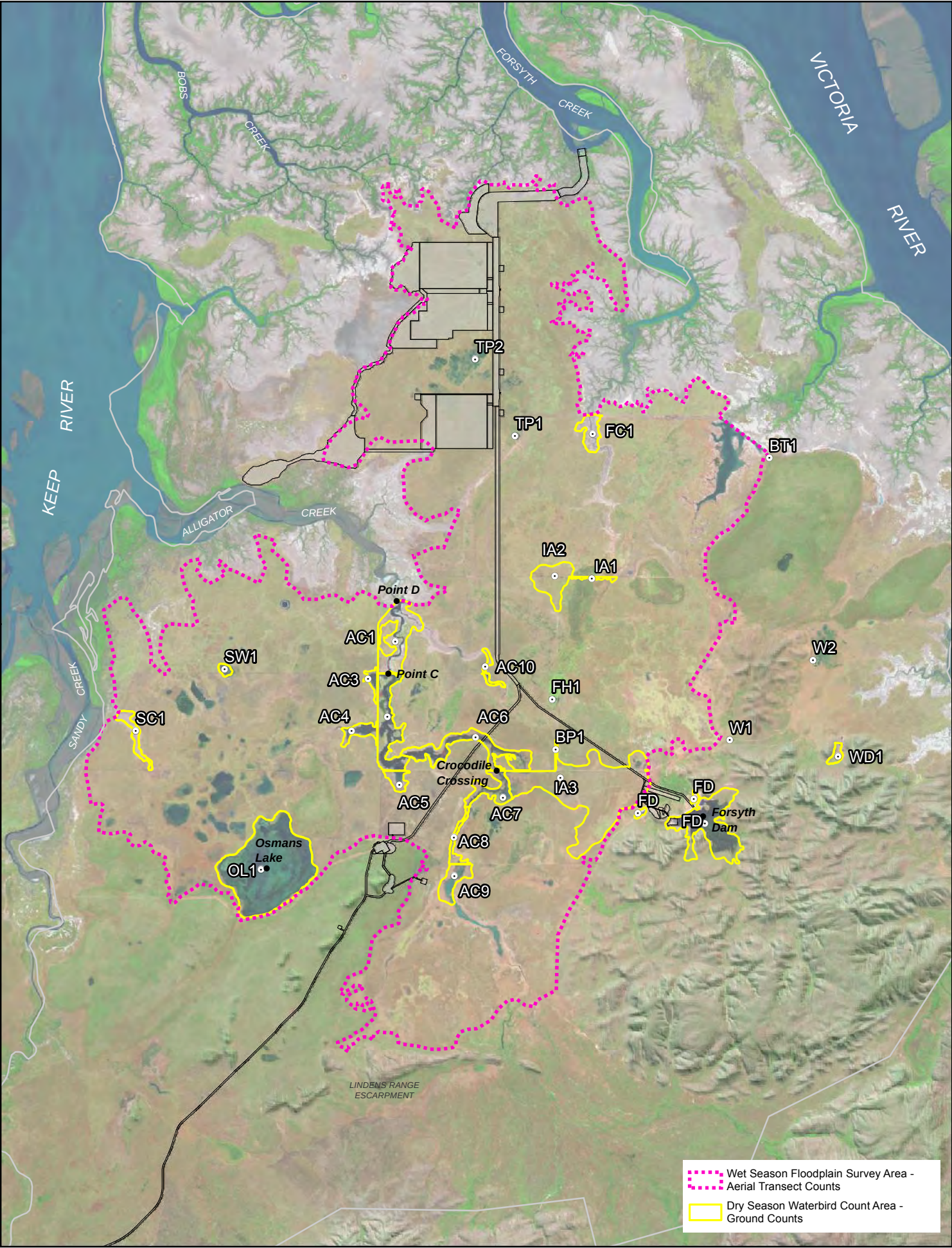
Great Knot *Calidris tenuirostris*⁴⁸ - The Great Knot has only been recorded once – an individual bird at AC1, the most downstream section of the Alligator Creek freshwater wetland system. The Alligator Creek wetland system does not support habitat typically preferred by Great Knots and this record is not regarded as significant *per se*.

Australian Painted Snipe *Rostratula australis* - Whilst no Australian Painted Snipe were recorded during surveys, the site's wetlands support potentially suitable habitat for this species. The location and extent of potentially suitable habitat will vary according to conditions throughout the year. For Australian Painted Snipe, habitat of potentially higher suitability may be associated with beetle grass *Leptochloa fusca* and samphire marshes, particularly those more extensive examples of these habitats observed as part of the Osmans Lake wetland system.

⁴⁶ The Lesser Sand Plover is listed as *Vulnerable* under the TPWCA. Subsequent to the date when the project was determined as a "controlled action" (31 August 2015), the Lesser Sand Plover was listed as a threatened species under the EPBCA (5 May 2016), being included within the category *Endangered*.

⁴⁷ The Bar-tailed Godwit listed as *Vulnerable* under the TPWCA. Subsequent to the date when the project was determined as a "controlled action" (31 August 2015), two subspecies of the Bar-tailed Godwit were listed as a threatened species under the EPBCA (5 May 2016). *Limosa lapponica baueri* was included within the category *Vulnerable*, whilst *Limosa lapponica menzbieri* was included within the category *Critically Endangered*.

⁴⁸ The Great Knot is listed as *Vulnerable* under the TPWCA. Subsequent to the date when the project was determined as a "controlled action" (31 August 2015), the Great Knot was listed as a threatened species under the EPBCA (5 May 2016), being included within the category *Critically Endangered*.



3.1.4. Key Seasonal Wetland Values

During the **dry season and transition periods**, wetland habitats which support the highest values to waterbirds are those associated with Osmans Lake and the lower parts of the Alligator Creek wetland system.

Osmans Lake is the largest natural wetland on the site (app. 1,050ha at full supply level). This shallow (<1m deep) wetland supports surface water longer than other similar, though smaller (and in many cases more heavily vegetated) playa wetlands to the near north. Osmans Lake and the associated mosaic of natural playa wetlands are contained within a catchment separate to the site's predominant catchments of Forsyth Creek and Alligator Creek. Observations in 2015 and 2016 show that surface water of Osmans Lake contracts notably from May onwards and disappearing by late-July. Smaller surrounding playa wetlands to the near north were dry by mid- to late-June (as observed in 2015).

The relatively shallow waters are used by substantial numbers of spoonbills, stilts, and avocets, whilst very shallow water and wet muds either side of the margins of the retreating water's edge have supported significant numbers of smaller shorebirds such as sandpipers and stints⁴⁹. Once large areas of the Lake floor are exposed and develop some herbaceous ground cover (e.g. *Batis argillicola* which was abundant), these habitats have attracted large flocks of brolgas and in turn, notable numbers of Oriental Plovers.

The **Alligator Creek wetland system** supports core refuge habitat in the dry season. This system extends 15-20km upstream from where it is bunded near its tidal limit (Point D)⁵⁰. From July onwards, this system is the only significant source of surface water on the site (estuarine deltaic plain)⁵¹. The Alligator Creek wetland system has consistently supported a high waterbird density and species richness throughout each survey program during 2015 and 2016. The majority of the individual species counts from these survey programs (abundance exceeding either the 1% or 0.1% population thresholds) were derived from the Alligator Creek wetland system. This human modified system supports a variety of conditions and resources and of an extent, not observed elsewhere on the site during the dry season and transition periods.

Under **wet season conditions**, consistent with much of northern Australia, the wetland habitat was much more widespread and the coastal plain supported a range of wetland types, water depths and vegetation characteristics. These wetlands undoubtedly operate as an integrated system, with waterbirds utilising/favouring certain component sub-sites/wetlands for different purposes throughout the wet season and into the transition period (April to early-May).

⁴⁹ During the 2015 survey program, notable counts for Osmans Lake included: Royal Spoonbill (612), Black-winged Stilt (1,314), Red-necked Stint (890), Oriental Plover (231), Red-capped Plover (560), Marsh Sandpiper (624), Sharp-tailed Sandpiper 533, and Curlew Sandpiper (72). In the March 2016 aerial survey, one of the satellite wetlands supported 140 Black-tailed Godwits.

⁵⁰ The series of sites along Alligator Creek supported water throughout the survey program (AC1, AC2, AC6, AC7, & AC8).

⁵¹ The two large dams, Forsyth and Weaner Dams, and various small turkey nest dams scattered across the site do support water throughout the latter part of the dry season, though survey results and habitat assessments indicate that these wetlands support comparatively lower values to those of the Alligator Creek wetland system (see Austecology 2016a).

Count data derived from the March 2016 aerial survey program⁵² demonstrate a comparatively higher average waterbird density for areas within the central part of the survey area which generally coincide with the Alligator Creek wetland system, though also for wetland habitats associated with the Osmans Lake wetland system (Austecology 2016a). Similarly, review of species richness data indicates comparatively higher results associated with the central and southern parts of the survey area, coinciding with the Alligator Creek and Osmans Lake wetland mosaics.

3.1.4.1. Variability in Values

Wet season conditions (rainfall volumes and rainfall pattern) are the primary driver of variability in the extent and persistence of wetland habitat on the site. Water releases from Forsyth Dam also significantly influence the extent and persistence of wetland habitat within the Alligator and Forsyth Creek systems during the dry season.

As described previously, the recent history of releasing water from Forsyth Dam and subsequently inundating part of the Alligator Creek catchment during the latter part of the dry season has profoundly increased habitat values for waterbirds. The 2015 and 2016 survey results show:

-) That the Forsyth Dam release generates a strong influence on overall waterbird abundance and the pattern of abundance throughout the progression of survey event sequence from midway (June-July) through until the end of the dry season (November)⁵³.
-) That variability in overall waterbird abundance and for individual species may, to varying degrees, be explained by potential influences such on-site management practices (e.g. inundation flow controls) which influenced wetland availability in both a spatial and temporal context.
-) That several large waterbird count areas along Alligator Creek, which were not affected by inundation from Forsyth Dam, supported waterbirds throughout the dry season survey programs with significant waterbird numbers recorded, and in some instances, exceeding the Ramsar Criterion 5 significance threshold.

⁵² Including a series of 23 aerial transects that provided survey coverage of 46,452ha of Legune coastal floodplain, and implemented twice in March 2016.

⁵³ The pattern of gross (total) abundance of waterbirds through the survey program sequence was similar in 2015 and 2016, with lowest abundance recorded from the pre-inundation survey (average 35,629 birds), then a significant increase and highest recorded abundance during the 1st post-inundation survey (average 87,443 birds), then a notable decrease in abundance during the remaining two survey events (average 43, 868 birds and 37,719 birds respectively).

3.2. Issues Relevant to Plan Development

3.2.1. Key Features of Waterbird Occurrence and Indicative Variability

Key features of waterbird usage of freshwater wetlands of the site, and their indicative variability (as recorded 2015-2016, and predicted) are as follows:

1. A large diversity of species (71 species) uses the freshwater wetlands.
 -) Variability in species diversity between surveys was low, with changes mainly attributable to vagrants and/or external factors.
2. At least one nationally-threatened waterbird (Curlew Sandpiper: Critically Endangered) occurs within the Alligator Creek wetland system and Osmans Lake.
 -) Low variability in numbers of all four threatened species, based on 2015 and 2016 evidence; low variability in the longer term (once dam releases have ceased) is a possibility. Numbers may decline in the future as a result of threatening processes operating elsewhere in the EAAF (i.e. external to the study site).
3. At least 25 species of waterbirds⁵⁴, listed under the migratory provisions of the EPBCA, occur, with 21 species⁵⁵ which breed in countries of the EAAF, mostly far (e.g. over 10,000 km) beyond Australia.
 -) Low to moderate variability recorded in 2015 and 2016; moderate variability in the longer term is a possibility. Numbers of some species may decline in the future as a result of threatening processes operating elsewhere in the EAAF (i.e., external to the study site). A number of these species have only been recorded once or twice⁵⁶, and for others, the freshwater wetlands of the Legune coastal floodplain do not represent typical habitat for those species⁵⁷.
4. Many species occur in large numbers, e.g. 15 species with site-counts of 1,000 or more individuals⁵⁸.
 -) Low variability in abundance recorded in 2015 and 2016; the situation after dam releases cease in terms of abundances of waterbirds is not easy to predict but there is potential for low variability in the longer term for three of these 15 species (because numbers have been well above 1,000) but for greater variability in the abundance of other species (numbers not far above 1,000).

⁵⁴ i.e. Glossy Ibis, Little Tern, Gull-billed Tern, Caspian Tern, White-winged Black Tern, Little Ringed Plover, Pacific Golden Plover, Lesser Sand Plover, Oriental Plover, unidentified Snipe (assumed to be Swinhoe's), Great Knot, Common Sandpiper, Sharp-tailed Sandpiper, Curlew Sandpiper, Red-necked Stint, Long-toed Stint, Broad-billed Sandpiper, Ruff, Bar-tailed Godwit, Black-tailed Godwit, Little Curlew, Whimbrel, Wood Sandpiper, Common Greenshank, and Marsh Sandpiper.

⁵⁵ 20 shorebirds and White-winged Black Tern, though noting that migratory populations of Little Tern and Gull-billed Tern do breed in Asia.

⁵⁶ i.e. Little Tern, Great Knot, Little Ringed Plover, Pacific Golden Plover, Lesser Sand Plover, Long-toed Stint, Broad-billed Sandpiper, Ruff, and Bar-tailed Godwit.

⁵⁷ i.e. Great Knot, Lesser Sand Plover, Broad-billed Sandpiper, Bar-tailed Godwit, and Whimbrel.

⁵⁸ i.e. Magpie Goose, Wandering Whistling-Duck, Plumed Whistling-Duck, Radjah Shelduck, Green Pygmy-Goose, Pacific Black Duck, Grey Teal, Hardhead, Australian Pelican, Glossy Ibis, Eurasian Coot, Little Curlew, Black-winged Stilt, Sharp-tailed Sandpiper, and Red-necked Stint.

5. Seven species⁵⁹ occur in numbers exceeding 1% of their estimated population size (related to the entire range of occurrence of the population, some of which include overseas countries within the EAAF).
 -) Low variability in numbers recorded in 2015 and 2016; see remarks for point 4 above.
6. 11 species⁶⁰ occur in numbers exceeding 0.1% of their estimated EAAF population size.
 -) Low variability recorded in 2015 and 2016; see remarks for point 4 above; high variability also is possible due to external factors in the EAAF.
7. The total number of waterbirds of all species is high: count totals have exceeded 20,000 waterbirds during all 10 dry season survey events and the only wet season survey event with over 100,000 waterbirds recorded in August 2016.
 -) Low variability because numbers usually were far above 20,000 in each survey through 2015 and 2016; see remarks for point 4 above regarding future variability, but variability once inundated habitat area is greatly reduced could be similar to variability between 2015 and 2016.
8. 71 species have been recorded breeding in the Legune coastal floodplain; this is expected to under-represent the actual number given the cryptic habits of many species when breeding.
 -) Insufficient information to reveal natural variability, but based on wider experience, variability may be high due to the many and complex factors influencing waterbird breeding and challenges finding nests/young of all species present. If wet season inundation remains largely unchanged, breeding values may remain similar to pre-development.
9. A breeding colony comprising at least six species⁶¹ and over a 1,000 breeding pairs occur in woodland within the freshwater wetlands and other smaller colonies (e.g. Pied Heron) possibly also occur.
 -) Variability as for point 7 above; waterbird breeding colonies are renowned for inconsistency in active/inactive status⁶² although generally status is directly related to extent and depth of water (more water equates to more food for colony nestlings). See also post-development comment within point 8 above.

⁵⁹ i.e. Magpie Goose, Plumed Whistling-Duck, Wandering Whistling-Duck, Green Pygmy-goose, Radjah Shelduck, Pied Heron, and Little Curlew.

⁶⁰ i.e. Marsh Sandpiper, Common Greenshank, Black-tailed Godwit, Little Curlew, Red-necked Stint, Sharp-tailed Sandpiper, Curlew Sandpiper, Little Curlew, Oriental Plover, Wood Sandpiper, and Long-toed Stint.

⁶¹ The majority of the birds observed in active colonies and confirmed or assumed to be breeding were small egrets (mainly Cattle Egrets, though also Intermediate Egrets), with many Pied Heron and Australian White Ibis as well. Other species present, and possibly nesting, were Nankeen Night-Heron and Royal Spoonbill.

⁶² e.g. Aerial and ground searches during the 2016 wet season and 2015-2016 dry season survey program did not find any evidence of a colony site associated with the Alligator Springs Colony 76 which had been previously described by Chatto (2000) and where over 500 pairs of breeding waterbirds were recorded. There was no apparent disturbance to habitat fringing the springs or within the locality and vegetation appeared apparently suitable. The reasons for the absence of breeding evidence are unclear. Conversely, the colony recorded in the north-central plain during the 2016 aerial survey program was not previously described by Chatto, though Chatto's report clearly shows that this area was surveyed.

3.2.2. Threats to Waterbirds

3.2.2.1. Water Supply

Ultimately, waterbirds require a place to feed and, either there or elsewhere, a place to breed. Survey results show that the Legune coastal floodplain supports feeding habitat for a large diversity of species, as well as breeding habitat for some species - some proven, some to be confirmed, others being non-breeding visitors.

Threat 1: Reduction of wetland habitats (defined by area of water) that provides food for the expected suite of waterbird species in expected numbers.

Threat 2: Reduction of wetland habitats (defined by duration of inundation) that provide food for the expected suite of waterbird species in expected numbers.

Threat 3: Reduction or loss of wetland habitats (defined, separately to **Threats 1 and 2**, by the vegetation and/or other features of nest site structure) that meet the ecological requirements for waterbirds to breed locally with natural levels of success.

In each of the above cases, the driver for the threat could be human-caused (e.g. damming or diversion of creeks feeding the coastal plain wetlands) or, where water flows have long been modified and birds adapted to that, by subsequent changes to the flow regime. Wetland vegetation, either woody or non-woody, that supports waterbird nests, depends on water supply. For example, grass-sedge communities in which Magpie Geese nest may not grow tall and dense enough nor be suitably inundated if flooding is reduced. Barringtonia trees along watercourses, used for nesting by colonial waterbirds, may die if flows are reduced or stopped.

Change in climate, over shorter (e.g. decadal) time-scales due to natural drought, or over longer time-scales due to global climate change, may also impact the hydrology of the site's freshwater wetlands. These drivers cannot be influenced significantly by the Legune PSDS1 proponent.

3.2.2.2. Food Supply

The particular food items that each waterbird species needs to survive, day-to-day and also during breeding (where applicable locally), are not well known and in impact assessments tend to be assumed from a limited knowledge base. Food resources are linked to area and duration of inundation (see **Threats 1 and 2**), but also to condition of the habitat, especially the water quality and the vegetation that is consumed or that harbours prey. A decline in the quality of available habitat therefore poses a threat as well.

Threat 4: Decline in the condition/quality of water in the wetland habitats.

Threat 5: Decline in the condition/quality of vegetation in the wetland habitats.

Threat 4 is often difficult to relate to waterbird usage because waterbirds commonly occur (often in high numbers) in polluted water bodies, or wetlands with poor water quality (e.g. sewage treatment ponds). **Threat 5** is similar to **Threat 3**.

Drivers of poor water quality include direct contamination (e.g. industrial spills), elevated nutrient levels (e.g. from cattle manure or artificial fertiliser) and high levels of suspended sediment (e.g. from overgrazing in creek catchments).

3.2.2.3. Weeds and Feral Animals

In tropical Australia, large areas of freshwater wetland have been infested with weeds such as the prickly bushes *Mimosa pigra* and *Parkinsonia aculeata* or floating plants such as *Eichhornia crassipes* and *Hymenachne amplexicaulis*. Although these plants do allow some waterbird usage, they tend to choke water bodies and/or surrounds, and can render them inaccessible to waterbirds. Floating plants form mats that can de-oxygenate the water, affecting fish populations – with fish being an important food for many waterbirds. Currently, only *Parkinsonia* has been recorded on the site⁶³. It is being actively managed and is on the decline. Although exotic pasture, including Para Grass *Urochloa mutica* is widespread on Legune Station, currently it seems to present no major threat because the wetlands are seasonal and cattle browse down the Para Grass each year.

Threat 6: Spread and increased density of major weeds of tropical wetlands.

Feral animals including wild pigs occur at the Legune wetlands. At present, the small number of observations throughout the 2015-2016 dry and wet season survey program suggest that feral pigs are uncommon to rare on the site, which is consistent with observations by station management. In the tropical savannah areas, feral pigs have the greatest impacts on biodiversity in ephemeral lagoons and floodplain wetlands. Pigs root up the substrate and eat *Eleocharis* and other tubers, thereby disturbing the soil and depleting food that Magpie Geese and Brolgas favour. They also eat animals such as frogs and freshwater turtles and spread diseases. Other feral animals of concern would include possible introduction of exotic fish such as *Tilapia* (now spreading in Australia), which exclude native fishes.

Threat 7: Spread and increased numbers of exotic animal pests of tropical wetlands, notably feral pigs.

3.2.2.4. Other Threats

Waterbirds can become remarkably tolerant of human activity, especially the passing of vehicles, and also tolerate noise. This response may in some cases depend on an initial familiarisation period. Provided the birds are not shot at or chased by domestic/working dogs, human disturbance is not likely to be a serious threat to waterbirds other than where habitat is altered or destroyed.

Climate change may be impacting rainfall patterns and sea levels, including in the Legune area. Being close to sea-level, on marine plains, the Legune coastal floodplain could become subject to incursion of salt water and/or greater coastal erosion. There is little that can be concluded at this stage in terms of major threats to waterbirds from climate change.

⁶³ Astrebla Ecological Services (2016) notes that sparse stands of *Parkinsonia* were present on the estuarine-deltaic plain in grassland, and is being actively managed and is on the decline. *Parkinsonia* is arguably one of the most serious weed threats having formed extensive stands in riparian and floodplain areas elsewhere across northern Australia.

Dunlop and Brown (2008) identified the key threats of climate change to the northern tropical savannas as:

-) saltwater incursions into freshwater ecosystems
-) changing fire seasons
-) potential for spread of exotic flora and fauna including high dispersal during the wet season
-) more intense storm activity.

3.2.3. Likely Off-site Influences on Waterbird Usage

Interpretation of the results of waterbird monitoring at any site in Australia requires understanding of influences at the local, regional, continental and flyway scales. Influences off-site are important because waterbirds are highly mobile and thus capable of moving away from the site; some exhibit migratory or nomadic (wandering) behaviour.

3.2.3.1. Regional influences – within Bioregion

The site lies within/near the centre of the Victoria-Bonaparte Bioregion⁶⁴, an area of some 7.3 million hectares⁶⁵. Wetlands within or at the edge of this bioregion and which regularly support over 20,000 waterbirds of a similar species composition to the Legune coastal floodplain are the Parry Floodplain (120 km WSW) and Lake Argyle (140 km SSW). Both are Ramsar sites (Hale 2008; Hale & Morgan 2010).

The habitats and waterbird fauna of the Legune coastal floodplain and Parry Floodplain are highly similar whereas Lake Argyle is a vast permanent reservoir that has extensive shallow and deep-water habitats but limited emergent vegetation (*pers. comm.* R. Jaensch 2017). Many of the waterbirds from the Legune coastal floodplain could move to Lake Argyle for refuge if the site's freshwater wetlands are dry or otherwise unsuitable. Given the close proximity and similar rainfall, it is unlikely that the Parry Floodplain would serve as a refuge for waterbirds from the Legune coastal floodplain, and presently it seems that water persists longer and wider at Legune than at Parry Floodplain (*pers. comm.* R. Jaensch 2017).

Concluding comments:

-) Overall, it seems that external wetlands within the bioregion might exert moderate influence on waterbird usage at the site.
-) Surveys of waterbirds at major wetlands within the bioregion appear to be spasmodic, certainly not regular (see Hale 2008), so the scope and scale of influence would have to be inferred from historical data or rainfall/inundation data.

⁶⁴ One of 89 bioregions which describe Australia by way of the Interim Biogeographic Regionalisation for Australia (IBRA). Bioregions are large, geographically distinct areas of land with common characteristics such as geology, landform patterns, climate, ecological features and plant and animal communities.

⁶⁵ <https://www.environment.gov.au/land/nrs/science/capad/2014>

3.2.3.2. Regional influences – surrounding Bioregions

The site is within the tropical savannah or “wet dry tropics” of Australia. Within 1,000 km⁶⁶ of the Legune coastal floodplain, major wetlands with extensive habitat in savannah (and semi-arid) landscapes, are listed in **Table 3-1**.

Of these 10 wetland systems listed in **Table 3-1**, all have at times supported 20,000 waterbirds, at least half have supported over 100,000 waterbirds, and nearly all can support large numbers of migratory waterbirds⁶⁷. Waterbird species present at these sites are much the same as those recorded at Legune. Some of the external wetlands are known to be the major breeding grounds or seasonal refugia for waterbirds, e.g. Magpie Geese (1 million plus) breeding in the Darwin Coastal floodplains; others attract huge numbers of waterbirds when they are seasonally or occasionally inundated, e.g. Barkly Lakes, Sandfire Flats.

Concluding comments:

-) Savannah and semi-arid wetlands within 1,000 km of site in adjoining bioregions are likely to exert great influence on waterbird usage of the site.
-) Surveys of waterbirds at the major wetlands (**Table 3-1**) appear to be generally spasmodic, certainly not regular, so the scope and scale of influence would have to be inferred from historical data or rainfall/inundation data (an exception may be Magpie Goose surveys conducted annually by the NT Government in the Darwin Coastal floodplains).

Table 3-1 Major wetland habitats within 1,000 km of Legune coastal floodplain

Bioregion	Major Wetland ⁶⁸	Distance from Site (km)
Victoria-Bonaparte	Parry Floodplain	120
Victoria-Bonaparte / OVP	Lake Argyle	140
Ord Victoria Plain	Birrindudu Wetlands	370
Great Sandy Desert / Tanami	Lake Gregory system	600
Dampierland	Camballin Floodplain	620
Dampierland	Roebuck Plains and lakes	780
Dampierland	Sandfire Flats – Anna Plains	1,000
Mitchell Grass Downs	Barkly Lakes system ⁶⁹	530 - 780
Darwin Coastal	Top End Floodplains ⁷⁰	130 - 500
Central Arnhem	Arafura Swamp	680

⁶⁶ 1,000 km is an arbitrary distance; waterbirds are capable of much longer movements.

⁶⁷ e.g. Jaensch & Vervest 1990; Morton *et al.* 1991; Jaensch 1994; Environment Australia 2001; Chatto 2006; Hassell *et al.* 2006; Hale 2008; Harrison *et al.* 2009; Bennelongia 2009; Hale & Morgan 2010; BMT WBM 2010; & Rogers *et al.* 2011.

⁶⁸ Information on these wetlands can be sourced from the Australian Wetlands Database, accessible online at: <http://www.environment.gov.au/cgi-bin/wetlands/search.pl?smode=DOIW>

⁶⁹ Lakes Woods, Tarrabool and Sylvester, Eva Downs Swamp and intervening unnamed wetlands.

⁷⁰ Floodplains from the Moyle River to Darwin, and from Darwin to the Alligator Rivers area.

3.2.3.3. Continental influences

It is likely that some waterbirds may travel farther (beyond the abovementioned previous spatial contexts) within Australia to exploit temporarily available and highly productive wetlands, including for breeding purposes (e.g. Kingsford & Norman 2002; Kingsford *et al.* 2010). Some abundant waterbirds such as Hardhead, Grey Teal, Eurasian Coot and Whiskered Tern rarely nest in semi-permanent wetlands of the tropical coasts, but mainly breed in temporary inland wetlands (Marchant & Higgins 1990 & 1993, and Higgins & Davies 1996). Limited evidence from bird-banding and satellite tracking indicate that some waterbirds will venture much farther than 1,000 km when opportunities present, e.g. potentially 1,200 km to the Gulf Plains bioregion, 1,500 km to the Channel Country, or perhaps even 2,000 km or more to the Murray Darling Basin (e.g. Roshier *et al.* 2006).

In regard to the above, additional points of relevance are:

-) Given that there are usually ample wetland areas available for waterbirds somewhere within (much less than) 1,000 km of Legune, it seems likely that wetlands farther afield would be of only low to moderate influence on waterbird usage at the site.
-) An annual aerial survey of waterbirds in part of eastern Australia (University of NSW)⁷¹ gives a snapshot of waterbird abundance in the month October, historically from 1983; this applies to the Murray Darling Basin and parts of the Channel Country though not necessarily at the times of maximum inundation and waterbird numbers. It is one of the few long-running, large-scale survey programs on waterbirds in Australia.

3.2.3.4. Flyway-scale influences

As well as moving around within Australia, migratory waterbirds, notably the shorebirds, migrate annually to their breeding areas in the northern hemisphere. For some species, such as Little Curlew and Sharp-tailed Sandpiper, most of the flyway population is present in Australia in the non-breeding season but others, such as Wood Sandpiper and Black-tailed Godwit, commonly also use wetlands of South-east Asia during that period (e.g. Higgins & Davies 1996; Bamford *et al.* 2008). The proportion in Australia or overseas in mid-summer could vary, year to year. Also, loss of habitat and other threats (e.g. hunting and habitat destruction) in other EAAF countries may impact the numbers arriving in Australia in a given year (e.g. Piersma *et al.* 2016). Furthermore, breeding success of shorebirds in the Arctic regions is known to be highly variable, impacting the proportion of juveniles in non-breeding populations (e.g. Meltofte *et al.* 2007; Minton *et al.* 2016).

⁷¹ In October of each year since 1983, waterbirds in eastern Australia are counted from the air on up to 2,000 wetlands (app. 100 hours flying). Most waterbirds are identified to species and abundance indices for all waterbird species are collected. An area of 2,697,000 km² (approximately 12% of the land in the eastern 3rd of the continent) is systematically sampled with ten survey bands 30km in width, spaced every 2° of latitude from 38°30'S to 20°30'S. <https://www.ecosystem.unsw.edu.au/content/rivers-and-wetlands/waterbirds/eastern-australian-waterbird-survey>

Concluding comments:

-) Flyway-scale influences, such as recent destruction of major areas of habitat outside of Australia, may greatly influence waterbird (shorebird) use of wetlands within the site⁷².
-) Monitoring of shorebirds in highly populated coastal parts of Australia is well placed to advise on trends in numbers of many shorebird species, though not so well placed for others that mainly occur in the north, e.g. Wood Sandpiper.
-) Monitoring of migratory shorebirds in other countries of the flyway is incomplete and patchy but is improving.

In conclusion, external influences are likely to greatly affect waterbird composition and numbers within the site and must be taken into account. Some information will be available to support this analysis but overall the knowledge is highly inadequate and some inferences from other types of data, such as remote sensing of available habitat, may be needed.

3.2.3.5. Long-term Climatic Cycles

The El Niño Southern Oscillation (ENSO) modulates the behaviour of the monsoon and frequency of cyclones experienced (e.g. Hennessy *et al.* 2004). The El Niño phase tends to suppress monsoon and cyclone activity over the Northern Territory, while the La Niña phase tends to enhance this activity. Hence, drier years tend to be El Niño years, whereas the wetter ones are usually La Niña years. Climate variability on longer, decadal time scales has also been suggested (e.g. Power *et al.* 1999), with the Inter-decadal Pacific Oscillation (IPO) shown to be associated with decadal climate variability over parts of the Pacific Basin, and to modulate interannual ENSO-related climate variability over Australia (Salinger *et al.* 2001).

In their study of the Magela Creek floodplain dynamics, Bayliss *et al.* (2008) noted an approximate 20-year decadal variation in rainfall and flow for waterways within the catchment, and that other major rivers across the “Top End” exhibit 20-25 year periodicities in flow volume. Such long term decadal periodicities in rainfall and flow may have important implications for waterbirds in this area. For example, Bayliss *et al.* (2006 & 2008) contend that Magpie Geese across the Northern Territory exhibited approximately 20 year population cycles that were coupled to similar and generally coherent periodicities in flow of the Katherine River, Daly River and Magela Creek (**Figure 3-3**). The authors noted an average response time lag of three to five years between river flow and magpie goose numbers.

⁷² e.g. potential explanatory factor in assessment of reduced summer shorebird counts for Roebuck Bay (Bennelongia 2010; Fuller & Wilson 2010).

Figure 3-3 Relationship between Magpie Goose Abundance and River Flow

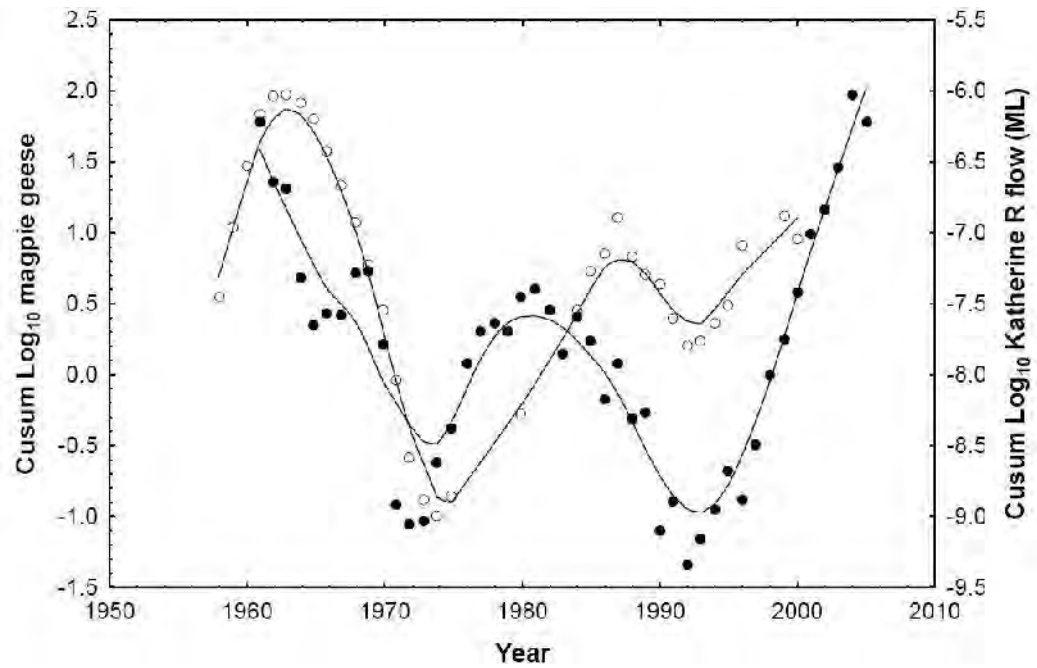


Figure reproduced from Bayliss et al. 2008. Cusum plots (cumulative sum of mean deviations) of magpie goose numbers (white symbols) in the Northern Territory and Katherine River flow (black symbols).

3.3. Establishing Limits of Acceptable Change

Threats to waterbirds at (or external to) a site may cause some change in the diversity and abundance of waterbirds that use a wetland site, though the magnitude or scope of change may, or may not, be significant. In order to systematically assess the seriousness of such change and to respond appropriately, site managers may wish to know the “limits of acceptable change”.

Although promoted through ecological character descriptions for Ramsar Sites (e.g. DEWHA 2008), “limits of acceptable change” is a relatively new concept. SEWPaC (2012) provides the following guidance:

Limits of acceptable change are defined as the variation that is considered acceptable in a particular component or process of the ecological character of the wetland, without indicating change in ecological character that may lead to a reduction or loss of the criteria for which the site was Ramsar listed. Limits of acceptable change can be established for those components and/or processes:

-) For which there is adequate information to form a baseline against which change can be measured;*
-) For which there is sufficient information to characterise variability around the time of listing;*
-) that are critical in determining the ecological character; and*
-) that can be monitored.*

Limits of acceptable change should be evidence based and drawn from the best available quantitative information from relevant monitoring programs, scientific papers, technical reports, or other publications and documented information on the wetland.

For some critical wetland components and processes, there may be insufficient good quality data or information available to be able to determine the natural variation at the time of listing and the limit of acceptable change in a particular wetland feature. Where available information is insufficient to be able to set a limit of acceptable change, a ‘knowledge gap’ may be identified and efforts can be made by site managers to undertake investigations or research, or initiate a targeted monitoring program to provide the required information.

There are several challenges which hinder application of “limits of acceptable change”. The final monitoring plan will address this issue, however the below provides some commentary that may be worthy of consideration during the formulation of the final plan.

1. Inadequate baseline data. For many important wetlands, even those listed as Ramsar Sites, there is insufficient information on waterbird usage to form an adequate baseline. Large, remote or otherwise inaccessible, and erratically inundated wetlands, are inherently difficult to survey and count data tend to be sparse overall (few surveys conducted), with data gaps seasonally and year-to-year. Accordingly, it is difficult to compare present waterbird usage with what might be considered ‘normal’ or ‘typical’ usage.

This limitation may be addressed through maintaining or expanding a regular program of waterbird surveys at the site.

- 2. Poor knowledge of natural variability.** In Australia, knowledge of how waterbird usage varies over time due to natural causes is invariably poor. This reflects the general sparseness of baseline data, especially in remote regions, and where surveys were confined to few years or a broken sequence of years. It also reflects the high level of variability in Australia's climate, with rainfall and thus wetland availability varying considerably, even in areas of high rainfall. Habitat on-site naturally (but somewhat unpredictably) varies greatly year-to-year and this impacts waterbird usage irrespective of on-site threats to waterbirds.

This limitation may be addressed through maintaining or expanding a regular program of waterbird surveys at the site. It may also be addressed by finding ways to predict waterbird usage of wetlands through examination of data on rainfall, river flow and/or wetland depth.

- 3. Influence of other external factors.** All waterbirds, even those of small size and apparently weak flight, are highly mobile and capable of travelling thousands of kilometres, e.g. the Red-necked Stint, weighing only 25 grams fat-free, undertakes round trips of 20,000 km per year between Russia and Australia.

In Australia, direct and indirect evidence, though limited, shows that many waterbirds move from coastal to inland wetlands during times of inland floods; this may be despite having apparently very suitable habitat locally on the coast. For example, it seems likely that several species (e.g. Eurasian Coot) that were common at Legune in 2015, almost totally abandoned the Legune wetlands in the dry season of 2016 due to exceptional conditions widely across inland Australia, with extensive flooding of inland areas attracting waterbirds from far and wide.

In regard to migratory species, loss of habitat, injury/death during travel and/or poor breeding success in the Arctic may result in declines in numbers of such species as detected locally in Australia (e.g. Bennelogia 2010; Fuller & Wilson 2010). Declines in waterbird numbers at Legune may therefore be attributed to external factors as opposed to conditions on site, creating uncertainty as to the cause(s) of observed declines. Surveys/monitoring of waterbird numbers across Australia and the EAAF are therefore important for understanding the cause(s) of declines observed on site.

In regard to migratory species, the following is noted:

-) Surveys of resident waterbirds in Australia, especially in the NT and WA within say 1000 km of Legune, have been sparse and/or geographically restricted, though the results can nevertheless help with interpretation of survey data from Legune. But there are few ongoing survey programs that could helpfully inform the interpretation of survey data at Legune.
-) Survey programs for migratory shorebirds in Australia are relatively active but in northern Australia are sparse or absent outside the Broome to Port Hedland region of WA.
-) Surveys of migratory shorebirds in other Flyway countries are highly localised and by no means adequate, but are improving.

The above limitations may be addressed by maintaining and expanding (and/or promoting the expansion of) waterbird monitoring at key sites within Australia and the EAAF.

4. No guidelines or standards for setting limits. Ideally, managers would like to know what percentage or absolute change in numbers over time would trigger a management response for each waterbird species. However, as the concept of acceptable limits is relatively new, there are few if any published guidelines or standards to help managers quantitatively define the limits of acceptable change. Hence, the limits used are somewhat arbitrary.

) This limitation could be addressed by governments setting regional/national standards and providing guidelines for setting limits of acceptable change.

A variety of northern Australian Ramsar Site Ecological Character Descriptions (ECDs) have been reviewed to assess approaches to establishing limits of acceptable change and monitoring programs. **Attachment B** provides a summary of the relevant key elements of the following Ramsar Site ECDs: Ord River Floodplain (including Parry Lagoons); Lakes Argyle and Kununurra; Kakadu National Park; Eighty-mile Beach; Roebuck Bay; and Cobourg Peninsula.

The reviewed Ramsar Site ECDs within **Attachment B** provide relevant examples which highlight the difficulty in providing confident and robust responses to the abovementioned challenges.

An aspect of this task which serves to provide meaningful results, especially in Australia's highly variable climate, is to look for change within a realistic timeframe. For example, rather than unacceptable change within too few (e.g. 1-3) years, the timeframe should be longer, e.g. 4-10 years. As waterbird observations over a longer term (several decades) may be needed in order to capture most of the natural variability in waterbird usage of Australian wetland sites, 5-10 years might be referred to as 'medium term'. But the lower end of this range would satisfy decision makers far better than the upper.

Due to known or expected high natural variability in numbers and occurrence of many waterbird species, use of a medium term timeframe (five years) may be advisable in setting limits of acceptable change.

4. References

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Attachment A Summary of 2015-2016 Waterbird Surveys – Freshwater & Estuarine Wetlands

Survey Events: Event 1 (4-6 May 2015); Event 2 (12-20 June 2015); Event 3 (8-13 July 2015); Event 4 (14-21 August 2015); Event 5 (11-19 September 2015); Event 6 (9-17 October 2015); Event 7 (11-17 November 2015); Event 8 (7-13 March 2016); Event 9 (1-4 August 2016); Event 10 (30 August to 2 September 2016); Event 11 (1-5 October 2016); and Event 12 (31 October to 4 November 2016).

Survey Event	1	2	3	4	5	6	7	8	9	10	11	12	Comments	Survey Effort (app.)
Season: Dry (D) or Wet (W)	D	D	D	D	D	D	D	W	D	D	D	D		
Year: 2015 (5) or 2016 (6)	5	5	5	5	5	5	5	6	6	6	6	6		
Survey Person Days	3	9	10	16	18	18	14	15	8	8	9	10		138 survey person-days
Systematic monitoring of freshwater wetlands across the site.		x	x	x	x	x	x						Two-person ground-based survey team. Total of 24 wetland survey sites. The number of sites varied each month dependent on seasonal conditions.	36 survey person-days
Systematic aerial transect count of freshwater wetlands across the site.								x					Three-person team (one observer & two counters). A transect total of 306km (23 transects) with an overall survey area of 45,619ha, and repeated on two separate days.	6 survey person-days
Dedicated aerial searches for waterbird breeding colonies.								x					Three-person observer team. Searches conducted along eastern side of Keep River (Sandy Creek to Turtle Point), Turtle Point to Victoria River, along western side of Victoria River to upper Knapp Springs Creek, and surrounds of Forsyth Dam and Alligator Springs.	302 km of aerial survey transects
Systematic monitoring of wetlands throughout the Alligator Creek catchment and several sites within Forsyth Creek catchment.									x	x	x	x	Two-person ground-based survey team. Total of 13 wetland survey sites. The 2016 survey program provided a replication of the survey effort and coverage of the 2015 survey program throughout the Alligator Creek wetland system. The number of sites varied each month dependent on seasonal conditions.	35 survey person-days
Turtle Point high tide roost counts (ground-based).		x			x		x	x					Two-person team. Surveys coincide with highest monthly tides.	28 survey person-hours
Boat-based high & low tide surveys of Forsyth Creek.		x											Two-person team – one dedicated observer.	38 km of boat transects
Boat-based high & low tide surveys of Keep River (true right bank from Turtle Point to Sandy Creek).		x											Two-person team – one dedicated observer	72 km of boat transects

Survey Event	1	2	3	4	5	6	7	8	9	10	11	12	Comments	Survey Effort (app.)
Season: Dry (D) or Wet (W)	D	D	D	D	D	D	D	W	D	D	D	D		
Year: 2015 (5) or 2016 (6)	5	5	5	5	5	5	5	6	6	6	6	6		
Survey Person Days	3	9	10	16	18	18	14	15	8	8	9	10		138 survey person-days
Boat-based surveys of Victoria River (true left bank) & Knapp's Spring Creek.		x											Three-person team – one dedicated observer	31 km of boat transects
Low tide aerial counts of Forsyth, Alligator, & Bob's Creek.							x						Complete survey of each waterway on 2 separate days. Forsyth Creek transect 24km; Alligator Creek transect 14km; and Bob's Creek transect 21km.	118 km of aerial survey transects
High tide aerial counts of Forsyth, Alligator, & Bob's Creek.							x						Complete survey of each waterway on 2 separate days.	118 km of aerial survey transects
High tide aerial counts of Forsyth & Alligator Creek.								x					Complete survey of each waterway.	81 km of aerial survey transects
High tide aerial surveys of Keep River (true right bank from Turtle Point to Alligator Creek).					x		x						Searches for high tide roost sites.	60 km of aerial survey transects
Aerial search for high tide roosts between Forsyth Creek and Bob's Creek.							x	x					4 transects on four separate days - covering area adjacent to northern part of PSD1 footprint (between Forsyth and Bob's Creeks) and around Forsyth Creek intake.	44 km of aerial survey transects

Attachment B Summaries of Ramsar Site Ecological Character Descriptions

Ord River Floodplain ECD			
Surveys Cited	Relevant Ramsar Criterion	LAC	Monitoring
"Paucity of published bird counts". Current knowledge is based on surveys in the 1980s, 1993 and a single survey in 2005.) Surveys conducted prior to 1990 at Parry Lagoons (Jaensch & Vervest 1990).) Other published quantitative count is from 2005 (Hassell et al. 2006).) The abundance and species of waterbirds that regularly use Parry Lagoons in the wet season is considered a knowledge gap.	Criterion 5) Parry Lagoons: exceeded in March 1980; March 1983 and May 1986.) Parry Lagoons: May 1998 (18,900 waterbirds) would equate to >20,000 if birds from other parts of site were included.) Parry Lagoons: 6,400 waterbirds were recorded in 2005. This count was undertaken in the dry season and the wet season count from the same year (total of 1600 birds) occurred at a time when the floodplain was not inundated. Criterion 6) Plumed Whistling Duck and Little Curlew (Known)) Red-kneed Dotterrel and Sharp-tailed Sandpiper (considered Likely).	Preliminary, LAC set based on Ramsar criteria and reason for listing. In the majority of years in which the Parry Floodplain Wetlands is extensively inundated, the system supports:) >20,000 waterbirds) substantial numbers of migratory shorebirds) substantial breeding by waterbirds) large numbers of Plumed Whistling-Duck and Little Curlew) at least occasional (1 in 20year) occurrence of Australian Painted Snipe provided that appropriately frequent, systematic and comprehensive surveys of waterbirds have been conducted at these times. <u>Note:</u> No metrics associated with terms "substantial numbers", "large numbers" or "substantial breeding".	There is no regular on-going bird monitoring within the Ord River Floodplain Ramsar sites. There were surveys conducted in the 1980s, 1993 and 2005 at Parry Lagoons. However, there are no plans for continued monitoring at any sites within the Ramsar site.

Source: Hale, J. (2008). Ecological Character Description of the Ord River Floodplain Ramsar Site. Report to the Department of Environment and Conservation, Perth, Western Australia.

Lakes Argyle & Kununurra ECD			
Surveys Cited	Relevant Ramsar Criterion	LAC	Monitoring
Comprehensive bird survey data for the site are limited. A single count from the 1980s (Jaensch & Vervest 1990) and counts from 2005 (Hassell et al. 2005) and 2007 (Bennelongia 2007) are the only surveys that covered large portions of the site. All are aerial surveys and resulted in summer total waterbird numbers >150,000. Note: Packsaddle Swamp and Lily Lagoon are shallow, vegetated wetland basins that are largely kept permanently inundated by the Kununurra Diversion dam.	Criterion 5 Site operates as a significant dry season refuge with large numbers of birds recorded at the end of the dry / beginning of the wet in November / December. Total recorded abundance:) 181,400 - December 1986) 71,233 - July 2005) 152,105 - November 2005) 244,765 - November 2007 Criterion 6 Ramsar site supports greater than 1% of the relevant populations (flyway or total) of 11 species of birds, including 4 migratory species):) Little Curlew, Wood Sandpiper, Sharp-Tailed Sandpiper, & Oriental Pratincole;) Black-Winged Stilt Red-Capped Plover, Magpie Goose, Wandering Whistling Duck, Hardhead, Eurasian Coot, and Green Pygmy Goose.	Relative confidence levels for LACs (based on the extent and type of data available) have been based on the following scale:) High confidence – where there is sufficient data for statistical comparisons;) Medium confidence – where there is insufficient data for statistical analysis, but sufficient data to allow for considered expert opinion; and) Low confidence – where there is little or no data, but judgements have been made on observations or opinion. Waterbird abundance: total abundance >100,00 during November / December. ECD confidence level for this LAC assigned as Medium. Migratory shorebirds (1% flyway threshold): >1% of flyway population recorded in at least two years in every five year period - Little Curlew, Wood Sandpiper, Sharp-Tailed Sandpiper, Oriental Pratincole. Resident waterbirds/shorebirds (>1% flyway threshold):) Abundance in at least 2 years in every 5 year period o >1,000 Red-capped Plover) Abundance in at least 3 years in every 5 year period o >3,000 Black-winged Stilt o >10,000 Eurasian Coot) Abundance in at least 4 years in every 5 year period o >20,000 Magpie Goose o >20,000 Wandering Whistling-Duck o >20,000 Green Pygmy-Goose o >10,000 Hardhead For each of the above LACs, ECD confidence level assigned as Low.	A comprehensive monitoring program is beyond the scope of an ECD. What is provided is an identification of monitoring needs required to both set baselines for critical components and processes and to assess against limits of acceptable change. It should be noted that the focus of the monitoring recommended in an ECD is an assessment against LAC and determination of changes in ecological character. This monitoring is not designed as an early warning system whereby trends in data are assessed to detect changes in components and processes prior to a change in ecological character of the site. This must be included in the management plan for the site. Assessment against LAC, using abundance and species identifications as Indicators. Surveys in November / December across the entire site.

Source: Hale, J. and Morgan, D. (2010). Ecological Character Description for the Lakes Argyle and Kununurra Ramsar Site. Report to the Department of Sustainability, Environment, Water, Population and Communities, Canberra.

Eighty Mile Beach ECD			
Surveys Cited	Relevant Ramsar Criterion	LAC	Monitoring
Eighty-mile Beach (60km section of coastal beach): - series of summer counts between 2002-2008 heavily relied upon (D. Rogers unpublished data). - Minton et al. 2003, & Sitters et al. 2004; Wade and Hickey 2008. Mandora Salt Marsh (40km inland; temporary freshwater wetlands): - two intense surveys (Graham 1999 and Halse et al. 2005) both related to episodic floods.	Criterion 5 Eighty Mile Beach: - Summer counts (10 – 60km south of Anna Plains) consistently >200,000 birds and winter >20,000 birds. - Summer counts from 2002 to 2008 (10 – 30km south of Anna Plains) >20,000 waders during - Support in excess of 500,000 birds. 2.88 million Oriental Pratincoles February 2004 Mandora Salt Marsh: >20,000 waterbirds in 1997 and 1999. 480,000 – 490,000 waterbirds in 1999 and 2000 aerial surveys. - Waterbird usage linked to episodic inundation events following cyclonic activity. Criterion 6 21 waterbirds including 17 migratory species and 4 Australian residents: - Greater Sand Plover, Oriental Plover, Grey Plover, Bar-tailed Godwit, Red Knot, Great Knot, Red-necked Stint, Sanderling, Sharp-tailed Sandpiper, Curlew Sandpiper, Eastern Curlew, Little Curlew, Common Greenshank, Grey-tailed Tattler, Terek Sandpiper, Ruddy Turnstone, & Oriental Pratincole. - Red-capped Plover, Pied Oystercatcher, Black-winged Stilt, & Great Egret.	Waterbird abundance – Eighty-mile Beach: >200,000 shorebirds during summer and >20,000 waterbirds during winter. Waterbirds (>1% threshold) – Eighty-mile Beach: LAC to apply to subset of species, i.e. those consistently present in numbers sufficient to calculate practical statistics - Bar-tailed Godwits (>35,000); Great Knot (>55,000); Greater Sand Plover (>23,000); Red-necked Stint (>18,000), & Terek Sandpiper (>4,800). Applicable to the above - In an attempt to incorporate the level of variability in shorebird counts, limits are proposed based on mean ± 1 standard deviation. Waterbirds – Mandora Salt Marsh: Data deficient – baseline must be established before limits can be set. Data available is from a single such inundation event in 1999 / 2000. There is no data upon which to assess variability with respect to species composition, abundance or breeding activity.	Annual seasonal waterbird surveys conducted at Eighty-mile Beach to be expanded to include Mandora Salt Marsh.

Source: Hale, J. and Butcher, R. (2009). Ecological Character Description of the Eighty-mile Beach Ramsar Site. Report to the Department of Environment and Conservation, Perth, Western Australia.

Kakadu ECD			
Surveys Cited	Relevant Ramsar Criterion	LAC	Monitoring
Bayliss and Yeomans 1990, Bamford 1990, Morton et al. 1991, Chatto 2000, Chatto 2003a, Chatto 2006.	Criterion 5 Variety of studies show >20,000 birds on an annual basis e.g.:) Peaks in abundance prior to and after the wettest months (January–March).) During peaks, floodplain population estimated to be almost one million birds.) Densities of up to 100 birds per hectare recorded during the late dry season.) >2.5 million waterbirds within Alligator Rivers Region during the late dry season 2001.) >172,000 waterbirds within upstream South Alligator River floodplains during October 2001.) Highest monthly mean for the dry season is 545,000 birds from nine waterbird species and approximately 600,000 birds from five duck species across five floodplains in the Alligator Rivers Region and Boggy Plain. Criterion 6 13 species incl. 4 migratory shorebirds:) Magpie Goose, Wandering Whistling-Duck, Plumed Whistling-Duck, Radjah Shellduck, Pacific Duck, Grey Teal, Brolga, Black-necked Stork, & Australian Pratincole.) Marsh Sandpiper, Little Curlew, Common Sandpiper, & Sharp-tailed Sandpiper.	Waterbird abundance (excl. migratory shorebirds). Acceptable change: Moderate change (short term, individual floodplain context). LAC: Average abundance of the most common species (magpie geese, wandering and plumed whistling-ducks) will not fall below corresponding minimum recorded seasonal values of Morton et al. (1991) for Magela, Nourlangie and East Alligator River floodplains on more than 30% of sampling occasions over a 20 year period. Waterbird species (>1% threshold; excluding migratory shorebirds). Acceptable change: Moderate change (short term). LAC: Insufficient current, systematically collected baseline data. Long-term LAC to be confirmed on completion of data collection as part of the recommended baseline monitoring program. Recommended <u>interim LAC</u>: Average abundance of each species will not fall below the corresponding minimum recorded seasonal values of Morton et al. (1991) on more than 30% of sampling occasions over a 20 year period. Migratory shorebird distribution-abundance. Acceptable change: Moderate change (short and long term). LAC: Insufficient current, systematically collected baseline data. Should an adequate baseline be established, limits of acceptable change could be calculated based on the range of variability. <u>Interim LAC</u>: as a minimum, sites at which each migratory shorebirds have previously been recorded (as per Chatto 2003) will continue to provide habitat for these species. Migratory shorebird (>1% threshold). Acceptable change: Large change (long term). LAC: Average abundance of each species (from at least three annual surveys over a 10-year period) does not fall below the 20th percentile baseline value, or below 1% of flyway population, due to altered habitat conditions within the site. Until completion of a suitable baseline monitoring program (and determination of LACs), <u>interim LAC</u> is recommended: one or more species (whose population is currently known to exceed the one percent threshold) no longer occurs within the site.	For Waterbird abundance and Waterbird species (>1% threshold) excl. migratory shorebirds:) Recommended baseline monitoring program based on aerial survey protocols of Morton et al. (1991).) Based on a ten year cycle with a minimum three annual sampling periods, each separated by at least one year.) Each annual sampling period is comprised of one late dry season and one wet season survey. LAC based on at least three annual surveys measured over a 20 year period from date of ECD preparation. For Migratory shorebird distribution-abundance, recommended baseline monitoring program is:) A combination of aerial and ground surveys.) Representative coverage of primary habitats, i.e. intertidal coastline (including lower estuary areas), floodplain wetlands and grasslands.) A minimum of three annual sampling periods, each separated by at least one year, and within a 20 year period.) Each annual sampling period is comprised of two seasonal survey events, i.e. one during late-March to mid-May (wet season, corresponding to northward migration), and one during mid-September to mid-November (late dry- season, corresponding to southward migration).

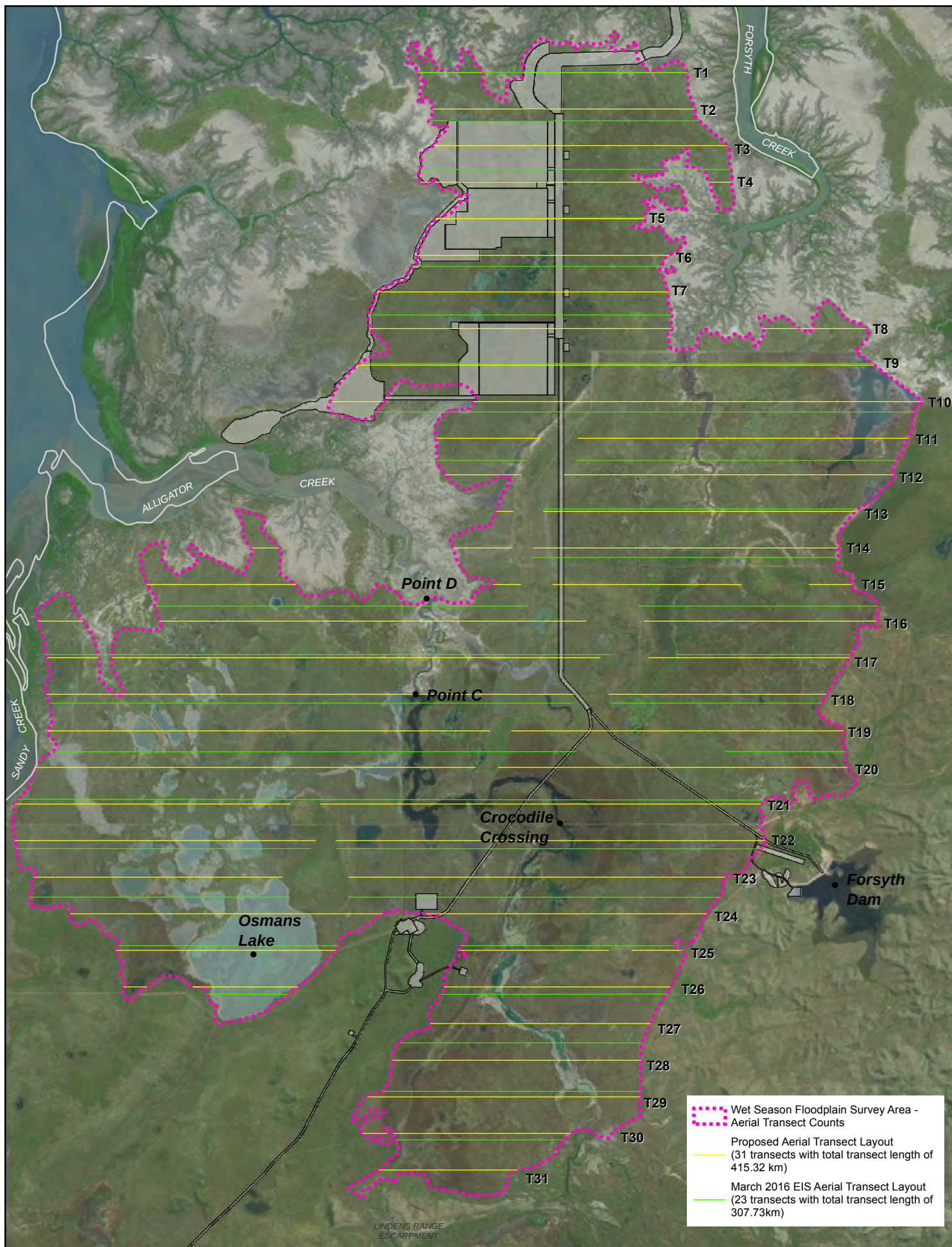
Source: BMT WBM (2010). Ecological Character Description for Kakadu National Park Ramsar Site. Prepared for the Australian Government Department of Sustainability, Environment, Water, Population and Communities.

Roebuck Bay ECD			
Surveys Cited	Relevant Ramsar Criterion	LAC	Monitoring
Rogers et al. 2006d, Collins and Jessop 1997 The Ramsar site itself comprises 34,119 hectares, mostly occupied by intertidal mudflats.	Criterion 5 The site regularly supports over 100,000 waterbirds.) The highest number of shorebirds counted at the site was 170,915 in October 1983) Allowing for turnover, the total number of shorebirds using the site may exceed 300,000 annually.) No other waterbirds (ducks, ibis, herons, gulls, cormorants etc.) occur in sufficient numbers to justify inclusion in the Ramsar criteria. It is appropriate, therefore, to refer to the site primarily in terms of its value to shorebirds.) In the austral winter, shorebird numbers have declined to as low as 50,000 juvenile or non-breeding birds. Juveniles of many species do not return to their breeding grounds for two years. Criterion 6 The site regularly supports 1% of the population of at least 22 wader species (20 migratory and 2 resident species).) Large Sand Plover, Oriental Plover, Mongolian Plover, Grey Plover, Bar-tailed Godwit, Black-tailed Godwit, Red Knot, Great Knot,) Red-necked Stint, Curlew Sandpiper, Sanderling, Eastern Curlew, Little Curlew, Whimbrel, Greenshank, Common Redshank, Grey-tailed Tattler, Terek Sandpiper, Ruddy Turnstone, and Asian Dowitcher (migratory).) Red-capped Plover and Pied Oystercatcher (resident).	Insufficient information to set a reliable baseline for most species. Extend surveys to provide species information. It is suggested that the interim limit for acceptable change in total waterbird abundance for Roebuck Bay should be > 75% of the average number of birds counted (i.e. 99,400 birds). The above approach is intended to monitor whether habitat in Roebuck Bay remains suitable for waterbirds and assumes that numbers in the global Flyway will remain constant.	Annual aerial monitoring count of the whole of Roebuck Bay. Annual monitoring ground count of species west of Crab Creek. Future monitoring of the carrying capacity of the Bay as a staging point for migratory shorebirds should be based on whole of Bay waterbird counts. These should be conducted in early November (and perhaps again in February) when populations are at their most stable. Counts should consist of an aerial survey to count the total number of waterbirds in the Bay and a ground survey to count numbers of individual species of shorebirds. Data from Corner Inlet in Victoria suggest there will be high variability in these counts and that there will be a biased representation of the Bay as a whole. Nevertheless, over time (perhaps with a 5-year rolling averages) it should be possible to detect any declines in individual species.

Source: Bennelongia (2009). Ecological Character Description for Roebuck Bay. Prepared for the Department of Environment and Conservation, Perth.

Coburg Peninsula ECD			
Surveys Cited	Relevant Ramsar Criterion	LAC	Monitoring
Woinarski and Baker 2002, Chatto 2003, Frith and Calaby 1974	Criterion 4 Significant waterbird breeding colonies on Sandy Island #1, Sandy Island #2 (multi-species colony, mainly terns, >6,000 crested terns recorded in 1967), Edwards Point (Port Bremer), Cape Don, Coral Bay, & Warla Island. Criteria 5 and 6 Based on available information, there is presently insufficient information to support these criteria having ever been met. With further survey effort, it may be possible that these criteria are met.) A total of 12,200 shorebirds was recorded around Cobourg Peninsula and southern islands (September/October 1993).) Approximately 5,000 magpie geese recorded in 1961 (Banteng Lagoon).) From the data available, the most populous species, that is those that may approach a one percent threshold, include the Caspian tern, little tern and magpie geese though no documented recordings of these species approaching these population densities.	Identified sites continue to support breeding colonies of a similar waterbird assemblage. Insufficient current, systematically collected baseline data to enable a quantitative LAC to be described. Long-term LAC to be confirmed on completion of data collection as part of a recommended baseline monitoring program.	Recommended baseline monitoring program should be based on aerial survey protocols of Morton et al. (1991) and Chatto (2001). The survey should be systematic and involve repeat sampling over corresponding time periods. Based on a ten year cycle, the recommended program should comprise a minimum three sampling events, each separated by at least one year. Each sampling event is comprised of one late dry season and one wet season survey over the course of one year. LAC based on sampling in at least three years within a 10 year period from date of ECD preparation.

Source: BMT WBM (2011). Ecological Character Description for Cobourg Peninsula Ramsar Site. Prepared for the Australian Government, Canberra.



APPENDIX B AVIAN PREDATION SUBMISSION



**PROJECT SEA DRAGON
STAGE 1 LEGUNE GROW-OUT FACILITY
SUPPLEMENTARY ENVIRONMENTAL IMPACT STATEMENT**

**APPENDIX B AVIAN PREDATION
SUBMISSION**



Avian Predation Management

SEIS Submission

Project Sea Dragon Stage 1 Grow-out Facility

Legune Station, Northern Territory

Prepared for:	CO2 Australia
Prepared by:	Lindsay Agnew, Austecology
Report Status:	Final – 7 February 2017

Table of Contents

1.	Introduction	3
1.1.	Background and Purpose	3
1.2.	Terminology, Nomenclature and Acronyms.....	3
2.	Background and Context	4
2.1.	The Aquaculture Environment.....	4
2.2.	Relevant Aspects of Penaeid Shrimp Ecology.....	4
2.3.	Potential Avian Predators	4
2.4.	Literature Review	10
2.4.1.	Key Findings.....	10
3.	Conclusions and Recommendations	15
4.	References	17

List of Figures

Figure 2-1	PSDS1 Farm Pond Design.....	6

List of Tables

Table 2-1	Summary of Potential Avian Predators of Prawn Stock at Legune Station	7
Table 2-2	Summary of Literature Review – Deterrent Methods	12

List of Attachments

Attachment A	Feeding Habitat and Diet Summary – Recorded Waterbird Assemblage.....	21
Attachment B	Literature Review – Waterbird Deterrent Methods	23

1. Introduction

1.1. Background and Purpose

An Environment Impact Statement (EIS) has been prepared for the Project Sea Dragon Stage 1 Grow-out Facility to be situated on Legune Station in the Northern Territory (hereafter Legune PSDS1). As part of the EIS, Austecology (2016)¹ provided a review of research and literature associated with bird predation and management strategies on aquaculture operations.

Review comments on the draft EIS by the Flora and Fauna Division (Department of Environment and Natural Resources)² sought additional information to augment that previously provided.

This report has been prepared to provide additional information in response to the agency requests as part of the Supplementary EIS.

1.2. Terminology, Nomenclature and Acronyms

Within this report, the following terms and or acronyms are used:

-) **Site or Legune Station** – the area comprising NT Portion 798 and Portion 3222 in the Victoria River District.
-) **Project area** - that part of Legune Station which is within the Stage 1 Legune Grow-out Facility (PSDS1) development footprint.
-) **Legune PSDS1** - Project Sea Dragon Stage 1 Legune Grow-out Facility
-) **Legune coastal floodplain** – the extensive alluvial plain on Legune Station, above the normal influence of tides and containing various freshwater wetlands.
-) **Region or surrounding area** - the lands within the Victoria Bonaparte Bioregion and northern parts of the Ord Victoria Plain Bioregion, both of which encompass land within the Northern Territory and Western Australia (IBRA version 7)³.
-) **Waterbird** - refers to those bird species⁴ which are ecologically dependent upon wetlands (after Kingsford & Norman 2002; and Wetlands International 2016).
-) **Shorebird** - refers to both resident and migratory species⁵ which are ecologically dependent upon shallow wetlands and form a subset of the waterbird grouping (after Geering *et al.* 2007).
-) **sp. and spp.** - Species (singular) and Species (plural).

¹ EIS Volume 5, Appendix 15, Austecology 2016.

² Attachment A, letter dated 23 November 2016 and authored by Luis Da Rocha, Department of Environment and Natural Resources, Northern Territory Government.

³ Interim Biogeographic Regionalisation for Australia, Version 7, 2012. Australian Government Department of Sustainability, Environment, Water, Population and Communities.

⁴ From the following Families: Anseranatidae, Anatidae, Podicipedidae, Anhingidae, Phalacrocoracidae, Pelecanidae, Ardeidae, Threskiornithidae, Ciconiidae, Gruidae, Rallidae, Scolopacidae, Rostratulidae, Jacanidae, Burhinidae, Haematopodidae, Recurvirostridae, Charadriidae, Glareolidae, Laridae and Sternidae.

⁵ From the following Families: Scolopacidae; Burhinidae; Rostratulidae, Haematopodidae; Recurvirostridae; Charadriidae; and Glareolidae.

2. Background and Context

2.1. The Aquaculture Environment

The project includes three farms, with farm 1 comprising 40 ponds and farms 2 and 3 each comprising 36 ponds. Farm ponds will be 10 hectares in size. Pond batters will be earthen, seeded with grass (to assist scour control) and of a slope of 1:3 gradient (vertical to horizontal). A five metre wide road will separate each pond. Each pond will be filled to a depth of at least 1.5m, with a 0.7m additional freeboard to the top of the embankment⁶.

Figure 2-1 describes the key characteristics of the proposed farm ponds

2.2. Relevant Aspects of Penaeid Shrimp Ecology

The farm ponds will be stocked with 15 day old post-larval Black tiger prawns (*Penaeus monodon*).

With few exceptions, Penaeid shrimp are marine, though some spend part of their life cycles in brackish water estuaries (Gutiérrez *et al.* 2016). The life cycle goes through several stages of development: from fertilized egg to nauplius to zoea to mysis to post larva to juveniles and finally to adult (Solis 1988).

Through the larval stages, the nauplius reach juvenile stage while migrating to the shallower coastal waters where vegetation provides nursing grounds for their development. Reaching sub-adult, they return back to the sea to reach sexual maturity and the cycle is repeated (Montgomery *et al.* 2010). Typically, only animals within the early developmental stages occur regularly within the upper part of the water column, with juveniles through to adults tending to spend the majority of their time within the benthic environment (Gutiérrez *et al.* 2016).

Prawns search across the bottom for food with their pereopods, which have chemo-sensory hairs attached (Hall 1962). Generally, prawns prefer a substrate with high mud content (Montgomery *et al.* 2010). Penaeids are generally considered to be omnivores with *P. monodon* in particular preferring slow-moving benthic macroinvertebrates, vegetable matter, polychaetes, and insects, and occasionally small fish (Solis 1988).

2.3. Potential Avian Predators

Wetland surveys across the site during both wet and dry seasons between 2015 and 2016 have collectively yielded records of 71 waterbird species (Austecology 2016a & b), including:

-) waterfowl (ducks and geese) – 11 species;
-) grebes – three species;
-) darter, cormorants and pelican – five species;
-) herons, ibis, egrets, and spoonbills – 14 species
-) storks and cranes – three species;

⁶ Volume 1, Chapter 3, Project Sea Dragon Stage 1 Legume Grow-out Facility Draft Environmental Impact Statement.

-)] crakes, rails and jacana – four species;
-)] shorebirds (non-migratory) – six species;
-)] shorebirds (migratory) – 19 species; and
-)] terns and gulls – six species.

Attachment A presents a high level overview of the above according to the primary feeding habitats and diet⁷. A review of the information summarised in **Attachment A** indicates that, there is a sub-set of the species which could be regarded as predators of the farm prawns (see **Table 2-1**).

However, when the design features of the ponds, and the known species specific feeding behaviours are taken into account, as outlined in **Table 2-1**, it is apparent that there is a negligible to low potential for predation impact associated with the majority of listed waterbirds. A comparatively higher potential for predation impact may be linked to the Cormorants, though also the Australasian Darter.

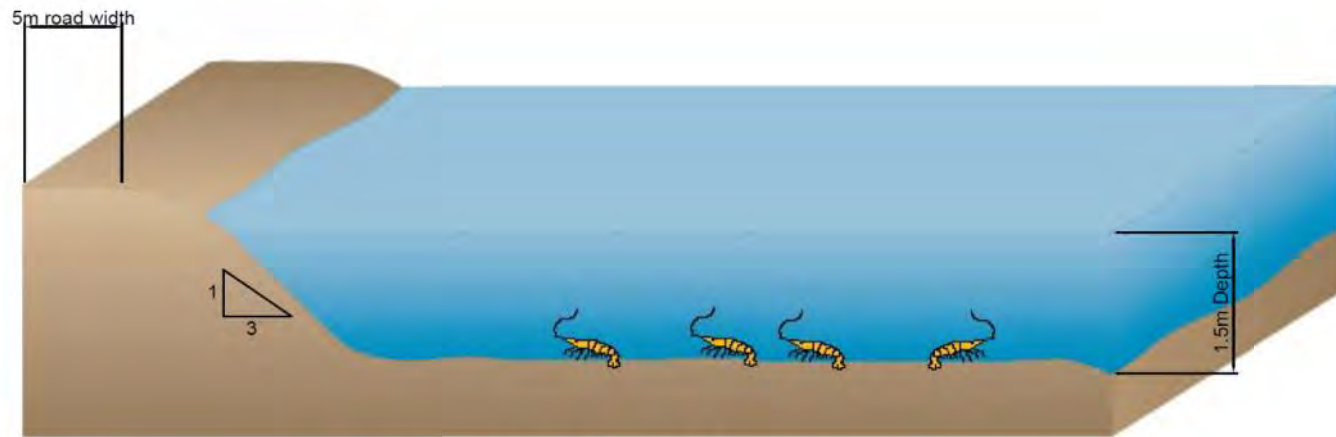
In assessing potential management strategies to minimise potential impacts of predation by Cormorants and the Australasian Darter, the following aspects of their biology are worth considering⁸:

-)] Characteristically, all feeding occurs during the day.
-)] Peak feeding activity is typically during the early morning and late afternoon.
-)] Much of the day is spent loafing and often on open ground – such as banks and spits – adjacent or close to feeding habitat.
-)] Access to a waterbody is typically involves birds landing on a bank beside the water, then entering the water from the bank rather than alighting directly on the water.
-)] Hunting occurs by foot-propelled surface-diving or pursuit-swimming. The Darter is known to dive to depths of ≥60cm.
-)] Species usually forage singly, though may congregate where food is abundant and may form large feeding flocks – Little Black Cormorant and Great Cormorant. Feeding in co-operative rafts appears to be relatively common behaviour for the Little Black Cormorant, and less so for the Little Pied Cormorant.
-)] Co-operative feeding rafts are more likely to be formed in regard to hunting fish. In regard to freshwater crayfish and shrimp, observations suggest that birds feed individually which allows a more stealthy approach required for crustacean prey.
-)] Cormorants (visual predators) are known to take fish from dams with Secchi disc transparency depths of less than 10cm, indicating that they can fish successfully, though perhaps with some difficulty, in turbid water.
-)] Research on fish aquaculture farms shows that farm dams of considerable depth do not provide refuge for fish, with cormorants recorded predating on fish to 4m, and the Great Cormorant known to dive to a depth of 9m.
-)] Of the five species, only the Little Pied Cormorant feeds mainly on crustaceans (≥60% of recorded diet), whereas for the remaining species, almost the same proportion of the diet comprises fish.

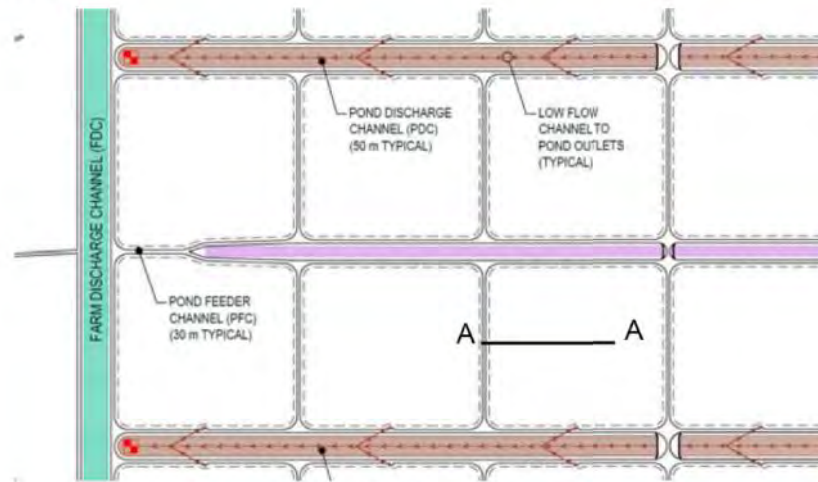
⁷ Though noting that some species may utilise more than one category of feeding habitat and/or are omnivorous.

⁸ Information drawn from the following sources: McNally 1957; Miller 1979; Barlow & Bock 1984; Marchant & Higgins 1990; and as cited in Barlow & Bock 1984 (Madsen & Sparck 1950; Stead 1954; Ransom & Beveridge 1983).

Figure 2-1 PSDS1 Farm Pond Design



Conceptual Cross Section A-A



Overview of farm ponds (part)

Table 2-1 Summary of Potential Avian Predators of Prawn Stock at Legune Station

Common Name	Notes on Known Diet	Presence of Suitable Feeding Habitat within Farm Pond Environment	Predation Impact Potential
Radjah Shelduck	Poorly known, though probably mostly molluscs and other aquatic invertebrates, but also seeds. Few records of crustaceans and worms.	Yes, though likely to be negligible. Constrained by pond design to an almost negligible area of habitat along water margins (sloping embankment resulting in very little "wading zone"). Benthic habit of the prawn stock makes it unlikely for them to be present near the pond edges..	Negligible
Pink-eared Duck	Mostly invertebrates, particularly chironomid larvae, though also seeds. Few records of freshwater shrimp and crayfish.	Yes, though likely to be negligible. Constrained by pond design to an almost negligible area of habitat along water margins (sloping embankment resulting in very little "wading zone"). Benthic habit of the prawn stock makes it unlikely for them to be present near the pond edges.	Negligible
Australasian Grebe	Fish, snails, and aquatic arthropods. Crustaceans known to be consumed, though probably uncommon.	Yes, though enhancement by aquatic macrophytes highly unlikely.	Low - Negligible
Hoary-headed Grebe	Chiefly aquatic arthropods, obtained largely by deep diving. Crustaceans known to be consumed, though probably uncommon.	Yes, though enhancement by aquatic macrophytes will not occur..	Low - Negligible
Greater Crested Grebe	Mostly fish, taken mainly by diving in clear water. Consumption of freshwater shrimps and midge larvae known, though not regarded as a significant contributor to diet.	Yes, though water clarity maybe be a limitation.	Low - Negligible
Australasian Darter	Predominately fish in most habitats. In freshwater habitat, occasionally takes large numbers of crustaceans or insects.	Yes. Batters may be used sunning / roosting habitat.	Low - Moderate
Little Pied Cormorant	Mostly freshwater crayfish and other crustaceans, though also small numbers of fish.	Yes. Batters may be used roosting habitat.	Moderate - High
Little Black Cormorant	Mostly fish, with smaller numbers of freshwater crayfish and other crustaceans.	Yes. Batters may be used roosting habitat.	Moderate
Pied Cormorant	Mostly fish with few crustaceans. Mostly marine, though also large sheets of open water within freshwater environments.	Yes. Batters may be used roosting habitat.	Low - Moderate
Australian Pelican	Mostly fish but an eclectic carnivore and scavenger taking anything from insects and small crustaceans to ducks and small frogs.	Yes, but a surface feeder and near-surface zone is unlikely to be used by sub-adult / adult prawn stock. Observed to be present, but not feeding, within farm ponds in the Seafarms north Qld operations	Low
Black-necked Stork	Diet poorly known, though largely aquatic with a variety of fish, crustaceans and some insects as well as snakes recorded.	Yes, though likely to be negligible. Constrained by pond design to an almost negligible area of habitat along water margins (sloping embankment resulting in very little "wading zone"). Benthic habit of the prawn stock makes it unlikely for them to be present near the pond edges.	Negligible
Black Bittern	Probably largely fish and freshwater crayfish.	Yes, though likely to be negligible. Constrained by pond design to an almost negligible area of habitat along water margins (sloping embankment resulting in very little "wading zone"). Benthic habit of the prawn stock makes it unlikely for them to be present near the pond edges.	Negligible
White-necked Heron	Mainly small aquatic and terrestrial animals, rarely fish.	Yes, though likely to be negligible. Constrained by pond design to an almost negligible area of habitat along water margins (sloping embankment resulting in very little "wading zone"). Benthic habit of the prawn stock makes it unlikely for them to be present near the pond edges.	Negligible

Common Name	Notes on Known Diet	Presence of Suitable Feeding Habitat within Farm Pond Environment	Predation Impact Potential
Eastern Great Egret	Aquatic animals, principally fish but also frogs, insects, and small birds.	Yes, though likely to be negligible. Constrained by pond design to an almost negligible area of habitat along water margins (sloping embankment resulting in very little "wading zone"). Benthic habit of the prawn stock makes it unlikely for them to be present near the pond edges.	Negligible
Intermediate Egret	Aquatic animals, principally fish but also frogs, with lizards and grasshoppers main food in drier habitats.	Yes, though likely to be negligible. Constrained by pond design to an almost negligible area of habitat along water margins (sloping embankment resulting in very little "wading zone"). Benthic habit of the prawn stock makes it unlikely for them to be present near the pond edges.	Negligible
Pied Heron	Aquatic animals, principally insects but also frogs and fish.	Yes, though likely to be negligible. Constrained by pond design to an almost negligible area of habitat along water margins (sloping embankment resulting in very little "wading zone"). Benthic habit of the prawn stock makes it unlikely for them to be present near the pond edges.	Negligible
White-faced Heron	Wide range of aquatic invertebrates and vertebrates.	Yes, though likely to be negligible. Constrained by pond design to an almost negligible area of habitat along water margins (sloping embankment resulting in very little "wading zone"). Benthic habit of the prawn stock makes it unlikely for them to be present near the pond edges.	Negligible
Little Egret	Aquatic animals, principally fish but also frogs and insects.	Yes, though likely to be negligible. Constrained by pond design to an almost negligible area of habitat along water margins (sloping embankment resulting in very little "wading zone"). Benthic habit of the prawn stock makes it unlikely for them to be present near the pond edges.	Negligible
Nankeen Night Heron	Mostly aquatic animals, principally fish but also frogs, freshwater crayfish and insects, but an opportunist that takes any suitable prey when available.	Yes, though likely to be negligible. Constrained by pond design to an almost negligible area of habitat along water margins (sloping embankment resulting in very little "wading zone"). Benthic habit of the prawn stock makes it unlikely for them to be present near the pond edges.	Low - Negligible
Glossy Ibis	Mostly aquatic invertebrates and insects.	Yes, though likely to be negligible. Constrained by pond design to an almost negligible area of habitat along water margins (sloping embankment resulting in very little "wading zone"). Benthic habit of the prawn stock makes it unlikely for them to be present near the pond edges.	Negligible
Australian White Ibis	Small, usually aquatic animals including fish, frogs, freshwater crayfish, crickets, and beetles.	Yes, though likely to be negligible. Constrained by pond design to an almost negligible area of habitat along water margins (sloping embankment resulting in very little "wading zone"). Benthic habit of the prawn stock makes it unlikely for them to be present near the pond edges.	Negligible
Straw-necked Ibis	Wide range of small animals depending on habitat but including freshwater crayfish, frogs, fish, beetles, crickets, and grasshoppers.	Yes, though likely to be negligible. Constrained by pond design to an almost negligible area of habitat along water margins (sloping embankment resulting in very little "wading zone"). Benthic habit of the prawn stock makes it unlikely for them to be present near the pond edges.	Negligible
Royal Spoonbill	In fresh water habitats, mainly fish, though also crustaceans and aquatic insects.	Yes, though likely to be negligible. Constrained by pond design to an almost negligible area of habitat along water margins (sloping embankment resulting in very little "wading zone"). Benthic habit of the prawn stock makes it unlikely for them to be present near the pond edges.	Negligible
Yellow-billed Spoonbill	Mainly aquatic insects, with small numbers of freshwater crayfish, freshwater shrimp and fish.	Yes, though likely to be negligible. Constrained by pond design to an almost negligible area of habitat along water margins (sloping embankment resulting in very little "wading zone"). Benthic habit of the prawn stock makes it unlikely for them to be present near the pond edges.	Negligible
Little Tern	Carnivorous, mainly small fish, but also crustaceans, insects, annelids, and molluscs. Surface/near-surface feeder (plunging and dipping), though also hawking above water.	Yes, but a surface / near surface feeder and the benthic habit of the prawn stock makes it unlikely for them to be present near the surface of the ponds.	Low

Common Name	Notes on Known Diet	Presence of Suitable Feeding Habitat within Farm Pond Environment	Predation Impact Potential
Gull-billed Tern	Carnivorous. Insects, fish, and small vertebrates. Surface/near-surface feeder (plunging and dipping), though also hawking above water.	Yes, but a surface / near surface feeder and the benthic habit of the prawn stock makes it unlikely for them to be present near the surface of the ponds.	Low
Caspian Tern	Carnivorous, almost entirely fish. Dietary records of crustaceans known, though probably form only a minor part of diet. Surface/near-surface feeder (plunging and dipping), though also hawking above water.	Yes, but a surface / near surface feeder and the benthic habit of the prawn stock makes it unlikely for them to be present near the surface of the ponds.	Low
Whiskered Tern	Carnivorous. Insects, crustaceans, fish and other small vertebrates (e.g. frogs). Occasionally seeds, centipedes, and spiders. Surface/near-surface feeder (plunging and dipping), though also hawking above water.	Yes, but a surface / near surface feeder and the benthic habit of the prawn stock makes it unlikely for them to be present near the surface of the ponds.	Low
White-winged Black Tern	Carnivorous. Insects, spiders, and fish. Surface/near-surface feeder (plunging and dipping), though also hawking above water.	Yes, but a surface / near surface feeder and the benthic habit of the prawn stock makes it unlikely for them to be present near the surface of the ponds.	Low

2.4. Literature Review

Austecology (2016a) provided a review of literature relevant to bird predation management strategies. That work has been augmented with a further and more extensive review of deterrent methods herein. The current work also provides a particular focus on studies relevant to aquaculture, the deployment of airborne deterrents, and the target suite of waterbirds described previously in this report.

Table 2-2 provides an inventory and brief account of the key documents reviewed, whilst **Attachment A** provides additional information for each of the key documents reviewed.

2.4.1. Key Findings

Of the various deterrent methods trialled or currently in use, complete enclosure of waterbodies with fencing/netting is the only proven, effective way of eliminating waterbirds from ponds/reservoirs. Numbers of waterbirds frequenting ponds/reservoirs may also be significantly reduced with partial enclosure (using a combination of fencing and overhead wires). Increasing the height of sidewalls and steepness of embankments may also help deter wading birds from using ponds/reservoirs.

The effectiveness of most other deterrent methods is either limited (usually due to habituation) or, as is the case with many existing technologies, poorly documented. A number of newer technologies which appear to show some promise - e.g., the use of modified drones fitted with speakers for broadcasting distress/alarm calls, radio-controlled “robirds”, “sonic nets”, and lasers – but require further testing to determine their effectiveness on waterbirds.

There is general agreement in the literature that the effectiveness of deterrent programs for waterfowl may be increased by integrating multiple techniques and varying the presentation of aversive stimuli, so as to minimize habituation of birds to deterrent methods. A number of authors/studies have indicated that deterrent methods are most effective before birds have become established at ponds - i.e. before birds become regular visitors to a pond/reservoir.

With regard to waterfowl, deterrent methods appear to be more effective when used to deter birds in flight (i.e. before birds come to rest at a pond or reservoir). For this reason radar-activated deterrent systems, which operate only once birds are detected approaching a pond, are more effective at deterring waterbirds. The effectiveness of non-lethal deterrent methods may also be enhanced by occasional shooting/killing of birds.

With regards the use of drones, it appears that, when used alone, conventional drones (in particular multi-rotor drones) have limited utility as a deterrent for waterbirds. The deterrent effect of drones may, however, be increased when used in combination with portable lasers and speakers broadcasting distress/alarm calls.

With regards the use of helicopters, there is clear evidence that low-flying helicopters cause significant disturbance to some waterfowl, with ducks, geese and egrets taking flight when approached. The impact of helicopters on waterbirds, however, is generally short-lived with birds returning soon after a helicopter has passed. Effects on diving species such as

cormorants and grebes appear minimal with birds simply diving underwater and resurfacing once a helicopter has passed.

Table 2-2 Summary of Literature Review – Deterrent Methods

Reference	Industry Application	Airborne Deterrent Methods	Detection Methods for Cormorants	Deterrent Methods - Other
Kevan 1992	aquaculture	manned and radio-controlled aircraft	waterbirds generally	automatic exploders, lights, alarm/distress calls, pyrotechnics (noise bombs, whistlers, rockets, rope crackers), water spray devices, scarecrows, reflectors, streamers and silhouettes, shooting birds, complete and partial enclosure of ponds, and modification of pond design.
Barras and Godwin 2005	aquaculture		waterbirds generally	propane exploders, pyrotechnics (bangers, screamers and cracker shells), effigies of humans/predator (such as the 'scary man' device), dogs, sirens, broadcasting distress or alarm calls, spot lights and strobe lights (to disperse birds feeding at night), and live ammunition.
Swaddle et al. 2016	airfields		gulls & terns	"Sonic net" - spatially controlled noise designed to overlap with the frequency range of bird vocalizations.
Ross et al. 2001	aquaculture		common eider	underwater broadcasts of recordings – distress calls and approaching boats.
Greer & O'Connor 1994	oil spill management	helicopters	waterbirds generally	gas-operated exploders, pyrotechnics, boats, all-terrain vehicles, electronic sound generators, air horn, biosonics, underwater acoustic deterrents, ultrasonic sound, balloons, flags, lights, reflector/reflective tape, human effigies, predator models, trained falcons and hawks, decoys, and coloured dyes.
Russel et al. 2012	aquaculture	radio-controlled airplanes	yes - specifically	commercially produced noise-generating bird scarers (gas cannons & pyrotechnics); shooting to scare and deter birds or reinforce the scaring effect of other deterrents (e.g. human presence, gas guns and pyrotechnics); above- and under- water bio-acoustic deterrents (e.g. 'Cormoshop®'); and high intensity air horns and sirens; human disturbance, static and revolving scarecrows ± "predator eyes"; inflatable "scarey man" device; model raptors; tethered floats to resemble the head of a crocodile/alligator; helium-filled balloons with eyespots; kites and kite-hawks (e.g. 'Helikite™'); flashing/rotating strobe and searchlights; flags, rags and streamers, including reflective silver or Mylar® streamers; lasers; rotating and static high-pressure water jets; dyes, colourants and turbidity; dogs; chemical repellents; netting enclosures; floating anti-predator nets and cages; overhead parallel wiring systems; and floating plastic balls to deter birds landing.
Cleary 1994	aquaculture		yes - specifically	vertically-straightening banks and erecting poultry fencing around ponds; use of overhead exclusion wires/grids and netting; use of frightening/repellent devices including flags, balloons with eyespots, mylar tape, scarecrows, automatic exploders, dogs, shooting, live capture, chemical repellents, pyrotechnics, and broadcasting of distress calls.
Vas et al. 2015	aquaculture	quadricopter drones	waterbirds generally	research limited to airborne deterrents only.
Komenda-Zehender et al. 2003	not specific	helicopters and aeroplanes	waterbirds generally	research limited to airborne deterrents only.
Clarke 2004	not specific		waterbirds generally	scarecrows, bird corpses, kites, bio-acoustic devices, ultrasonic devices, strobe lights, lasers, taste and tactile chemical repellents, wires, spikes, gas cannons, water sprayers, and 'bird blaster' (a Doppler-radar based, autonomous pressurised air deterrent system)
Moerbeek et al. 1987	aquaculture	helicopters	yes - specifically	pistol-flash cartridges and gas cannons.
Stickley et al. 1995	aquaculture		yes - specifically	human effigies, including the 'scary man' device.

Reference	Industry Application	Airborne Deterrent Methods	Detection Methods for Cormorants	Deterrent Methods - Other
Sullivan et al. 2006	aquaculture		yes - specifically	propane canons; lasers; pyrothernics scarecrows; human effigies; Mylar tape streamers; exclusion netting; overhead grid wire systems; and non-lethal shooting.
Read 1999	mining - toxic liquid storages	radio-controlled aeroplanes	waterbirds generally	gas gun and floating, rotating, intermittent beacons (directed at a shallow angle across the water surface).
Nemtsov 2005	aquaculture		yes - specifically	gas cannons and pyrothernics.
McEvoy et al. 2016	not specific	delta-wing and multi-rotor drones	waterbirds generally	research limited to airborne deterrents only.
Curtis et al. 1996	aquaculture	radio-controlled aeroplanes	waterbirds generally	complete fencing/netting of ponds; partially-covered systems (with overhead lines and wires) which interfere with predators feeding behaviour; broadcasting distress calls; use of pyrotechnic devices (cracker shells, whistle bombs and screamer rockets, rope firecrackers, live/blank ammunition); automatic exploders; electronic noisemakers; flashing lights, strobe lights and flood lights coupled with motion detection sensors; scarecrows/effigies; predator models; mirrors/reflectors; streamers; radio-controlled boats; vehicle/human patrols; intermittent use of high-pressure water spray devices; dogs; and lethal control measures.
Stickley & King 1995	aquaculture		yes - specifically	human effigy - the 'scary man' device.
Moertbeel et al. 1987	aquaculture		yes - specifically	overhead nylon string barriers and netting.
Office of Technology Assessment (US Congress) 1995	aquaculture	radio-controlled aeroplanes	yes - specifically	increasing water depth in holding ponds; increasing the height of sidewalls and slope of embankments; removal of perches and feeding platforms located near ponds; broadcasting predator distress calls; automatic exploders; pyrotechnics; sirens; lights; scarecrows and effigies; predator decoys; trained falcons; water spray devices; perimeter fencing and protective netting; overhead wires; and shooting/killing.
Mott & Boyd 1995	aquaculture		yes - specifically	netting barriers, overhead wires, pyrotechnics, human effigies, gas cannons, and live ammunition.
Ronconi et al. 2006	mining, tailing ponds		waterbirds generally	radar-activated, demand-performance bird hazing system.
Bishop et al. 2003	aquaculture	radio-controlled aeroplanes	yes - specifically	gas cannons, pyrotechnics, bioacoustic devices, ultrasonic and high intensity sound, lasers, dogs, human scarers, scarecrows, raptor models, bird corpses, balloons, kites, trained falcons, lights, mirrors/reflectors, tape, flags and streamers, dyes/colourants, taste and tactile repellents, nets and wires, water spray devices and shooting.
Brann 2016	agriculture	drones fitted with audio bird-scarer	terrestrial and aquatic avifauna	research limited to airborne deterrents only.
Andelt et al. 1997	aquaculture		herons	pyrotechnics, rotating lights, and human effigies (including 'scary man').
Baxter 2007	airport wetlands		waterbirds generally	lasers.
Gorenzel et al. 2007	aquaculture	ultralights & radio-controlled airplanes	waterbirds generally	enclosing ponds, use of overhead wires, reflecting tape, eyespot balloons, scarecrows, automatic exploders, pyrotechnics, broadcasting alarm and distress calls, lights, water sprays, ground harassment with vehicle patrols, trapping and shooting.
Stevens et al. 2000	power station ponds		waterbirds generally	radar-activated integrated hazing system - including acoustic alarm calls, pyrotechnics and chemical repellents dispersed as tear gas.
Loon 2006	not specific		waterbirds generally	various watercraft.

Reference	Industry Application	Airborne Deterrent Methods	Detection Methods for Cormorants	Deterrent Methods - Other
Draulans 1987	aquaculture		yes - specifically	relocation, shooting, visual scaring devices (e.g. scarecrows, flags, reflectors, 'flash harries', lights, model airplanes and helicopters), acoustic scaring devices (e.g. gun shots, firecrackers and gas cannons), and biological.
Whisson & Takekawa 2000	oil spill management		waterbirds generally	deployment of drifting buoys broadcasting distress calls.
Seiche et al. 2012	aquaculture		yes - specifically	cage and netting "pond—in-pond" systems; exclusion netting; non-lethal shooting; laser guns (e.g. Cormoshop™); fireworks; gas cannons; scarecrows; and pyrothenics.
Rowland 1995	aquaculture		yes - specifically	hanging gill nets vertically in the water (large diameter mesh enabling fish fry and fingerlings to swim through unhindered, but not cormorants) and harassment patrols (people walking around the ponds to scare off birds).
UK Civil Aviation Authority 2014	aviation			avian radar systems in automatic activation of bird deterrent systems.
Draulans & Van Vessem 1985	aquaculture		herons	systematic foot patrols.

3. Conclusions and Recommendations

The diet and primary feeding habitat for each of the 71 waterbird species recorded on the site has been reviewed in order to determine which species may potentially predate on prawn stock. The findings of that review show that there are a variety of species which could be regarded as predators of prawn stock, though for most, the potential impact is likely to be low.

A comparatively higher potential for predation impact may be linked to a sub-set of waterbirds, particularly Cormorants and the Australasian Darter. In order to assess potential management strategies to minimise potential impacts of predation, the key aspects of species' biology was reviewed.

As part of the assessment of potential management strategies, literature relevant to prevention and control of damage caused by waterbirds was also reviewed. The review targeted studies relevant to aquaculture, the deployment of airborne deterrents, and applicable to the target suite of waterbirds described previously in this report.

Recurrent throughout the review is evidence that the effectiveness of a bird predation control programs can be increased by:

- a) careful consideration of the location, shape and layout of ponds;
- b) ensuring efforts to deter avian predators commence immediately after construction;
- c) frightening diving birds away before they land on the water's surface - since diving birds can avoid exposure to most deterrent measures by diving underwater;
- d) use of a variety of deterrent techniques within an integrated strategy;
- e) changing control measures - as well as the timing/sequencing of different deterrent measures - to minimise habituation; and
- f) use of lethal methods (if necessary) for enhancement of non-lethal measures.

In regard to point f), to be clear, the Proponent will not use lethal methods for enhancement of non-lethal measures.

In regard point a), this has already been included through design as avoidance of creating of habitat for waterbirds was a factor in the engineering of the pond batter slopes, which are as steep as is possible from an engineering perspective

Austecology (2016a) identified that a primary predation management strategy was reliant on the use of a helicopter, where it was proposed to operate the helicopter during daylight hours and be mobilised as required when flocks form on any one of the three farms. A suite of allied strategies were provided to minimise potential disturbance impacts to waterbirds within wetland habitat surrounding the farms. This review has confirmed that the aforementioned strategies are still relevant as potential waterbird deterrents.

In addition, Austecology (2016a) recommended that a series of experimental trials be undertaken during the 2018/2019 wet season to assess responses of waterbirds within wetland habitat adjacent to the farms, to trial operations above the farms. A primary objective of this work would be to investigate practical flight protocols for future operations. This recommendation still stands.

As noted in the literature review, there is clear evidence that low-flying helicopters cause sufficient disturbance for waterbirds to take flight when approached. The review findings also indicate that on-going efforts will be required to minimise waterbird habituation⁹, and that in regard to the cormorants and Darter (diving waterbirds), the most effective strategy is to disperse birds before they land on the pond bank and prior to entering the water.

Austecology (2016a) identified that human disturbance (patrols on foot or in a vehicle) would be implemented as part of the management strategy. As noted in the literature review, there is evidence that human disturbance has been shown to be effective, though the level of effectiveness of this method is linked to implementation frequency.

This method is employed in Seafarms' north Queensland farms where there is generally a regular human presence around the ponds and, as such, personnel are able to actively drive away waterbirds wherever possible. However, it should be noted that, because of the increased scale of operations at Legune it will be more difficult to use human (on ground) presence as a deterrent. Whilst human deterrence is still intended to be a component of a suite of waterbird deterrent methods at Legune, it is important to note that, by virtue of the size of the operation at Legune Station as compared to the Queensland, the aforementioned measures will be less likely to be successful - hence the proposition for aerial measures as a deterrent, which would allow rapid response and coverage of large areas.

The following emerging technologies should also be investigated in developing a potential variety of deterrent methods to be relied upon: modified delta-wing drones fitted with speakers for broadcasting distress/alarm calls; radio-controlled "robirds"; "sonic nets"; lasers, and avian radar systems for automatic activation of fixed position deterrents such as lasers (e.g. Baxter 2007, Vas *et al.* 2015, Brann 2016, McEvoy *et al.* 2016, and Swaddle *et al.* 2016).

In regard to pond design/management and to dissuade cormorants and the Darter, investigate the viability of the following:

-) include a barrier (fixed or floating netting fence) at water's edge; and/or
-) minimise potential perching sites for Darter (and/or modify structures to reduce attractiveness as perches) within/around farm ponds.

⁹ Evidence regarding waterbird habituation to aircraft overflights is mixed, and that the ability of waterbirds to habituate to helicopter activity may be species-specific (e.g. Owens 1977; Derksen *et al.* 1992; Black *et al.* 1984; Conomy *et al.* 1998).

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Attachment A Feeding Habitat and Diet Summary – Recorded Waterbird Assemblage

Table Notes:

Feeding Habitat: FH1 = dense fringing vegetation. FH2 = water's edge; very shallow water (<10cm) +/- wet mud.

FH3 = shallow water; water < 0.5m deep +/- wet mud. FH4 = deeper water; waters >1m deep. FH5 = away from wetlands; terrestrial non-wetland habitats such as grasslands.

Diet: D1 = mainly or exclusively plants. D2 = mainly or exclusively animals. D3 = omnivorous, both plants and animals.

Latinised Name	Common Name	FH1	FH2	FH3	FH4	FH5	D1	D2	D3
<i>Anseranas semipalmata</i>	Magpie Goose			1		1	1		
<i>Cygnus atratus</i>	Black Swan			1	1	1	1		
<i>Dendrocygna arcuata</i>	Wandering Whistling-Duck			1	1		1		
<i>Dendrocygna eytoni</i>	Plumed Whistling-Duck			1		1	1		
<i>Tadorna radjah</i>	Radjah Shelduck		1					1	
<i>Malacorhynchus membranaceus</i>	Pink-eared Duck			1				1	
<i>Nettapus pulchellus</i>	Green Pygmy-Goose				1		1		
<i>Anas gracilis</i>	Grey Teal			1	1		1		
<i>Anas superciliosa</i>	Pacific Black Duck			1	1	1	1		1
<i>Anas rhynchos</i>	Australasian Shoveler			1	1		1		1
<i>Aythya australis</i>	Hardhead				1				1
<i>Tachybaptus novaehollandiae</i>	Australasian Grebe			1	1			1	
<i>Poliiocephalus poliocephalus</i>	Hoary-headed Grebe			1	1			1	
<i>Podiceps cristatus</i>	Greater Crested Grebe				1			1	
<i>Anhinga novaehollandiae</i>	Australasian Darter				1			1	
<i>Microcarbo melanoleucos</i>	Little Pied Cormorant				1			1	
<i>Phalacrocorax sulcirostris</i>	Little Black Cormorant				1			1	
<i>Phalacrocorax varius</i>	Pied Cormorant				1			1	
<i>Pelecanus conspicillatus</i>	Australian Pelican				1			1	
<i>Ephippiorhynchus asiaticus</i>	Black-necked Stork			1				1	
<i>Ixobrychus flavicollis</i>	Black Bittern	1	1					1	
<i>Ardea pacifica</i>	White-necked Heron			1				1	
<i>Ardea modesta</i>	Eastern Great Egret			1				1	
<i>Ardea intermedia</i>	Intermediate Egret			1				1	
<i>Ardea ibis</i>	Cattle Egret			1		1		1	
<i>Egretta picata</i>	Pied Heron	1		1				1	
<i>Egretta novaehollandiae</i>	White-faced Heron			1		1		1	
<i>Egretta garzetta</i>	Little Egret			1				1	
<i>Nycticorax caledonicus</i>	Nankeen Night Heron	1		1				1	
<i>Plegadis falcinellus</i>	Glossy Ibis			1		1		1	
<i>Threskiornis molucca</i>	Australian White Ibis			1		1		1	
<i>Threskiornis spinicollis</i>	Straw-necked Ibis			1				1	
<i>Platalea regia</i>	Royal Spoonbill			1				1	
<i>Platalea flavipes</i>	Yellow-billed Spoonbill			1				1	
<i>Grus rubicunda</i>	Brolga			1		1			1
<i>Grus antigone</i>	Sarus Crane			1		1			1
<i>Porphyrio porphyrio</i>	Purple Swamphen	1	1				1		
<i>Gallirallus philippensis</i>	Buff-banded Rail	1	1					1	
<i>Fulica atra</i>	Eurasian Coot			1	1		1		
<i>Himantopus himantopus</i>	Black-winged Stilt			1				1	
<i>Recurvirostra novaehollandiae</i>	Red-necked Avocet			1				1	
<i>Pluvialis fulva</i>	Pacific Golden Plover		1					1	
<i>Charadrius dubius</i>	Little Ringed Plover		1					1	

Latinised Name	Common Name	FH1	FH2	FH3	FH4	FH5	D1	D2	D3
<i>Charadrius mongolus</i>	Lesser Sand Plover		1					1	
<i>Charadrius ruficapillus</i>	Red-capped Plover		1					1	
<i>Charadrius veredus</i>	Oriental Plover		1			1		1	
<i>Elseya melanops</i>	Black-fronted Dotterel		1					1	
<i>Erythronyx cinctus</i>	Red-kneed Dotterel		1					1	
<i>Vanellus miles</i>	Masked Lapwing		1			1		1	
<i>Irediparra gallinacea</i>	Comb-crested Jacana			1	1				1
<i>Gallinago sp.</i>	a snipe (Swinhoe's ?)	1	1					1	
<i>Limosa limosa</i>	Black-tailed Godwit			1				1	
<i>Numenius minutus</i>	Little Curlew		1			1		1	
<i>Numenius phaeopus</i>	Whimbrel			1				1	
<i>Actitis hypoleucos</i>	Common Sandpiper		1					1	
<i>Tringa nebularia</i>	Common Greenshank			1				1	
<i>Tringa stagnatilis</i>	Marsh Sandpiper			1				1	
<i>Tringa glareola</i>	Wood Sandpiper	1	1					1	
<i>Calidris tenuirostris</i>	Great Knot		1					1	
<i>Calidris subminuta</i>	Long-toed Stint	1	1					1	
<i>Calidris ruficollis</i>	Red-necked Stint		1					1	
<i>Calidris acuminata</i>	Sharp-tailed Sandpiper		1					1	
<i>Calidris ferruginea</i>	Curlew Sandpiper		1					1	
<i>Limicola falcinellus</i>	Broad-billed Sandpiper		1					1	
<i>Philomachus pugnax</i>	Ruff		1					1	
<i>Sternula albifrons</i>	Little Tern			1	1			1	
<i>Gelochelidon nilotica</i>	Gull-billed Tern			1	1			1	
<i>Hydroprogne caspia</i>	Caspian Tern			1	1			1	
<i>Chlidonias hybrida</i>	Whiskered Tern			1	1			1	
<i>Chlidonias leucopterus</i>	White-winged Black Tern			1	1			1	
<i>Chroicocephalus novaehollandiae</i>	Silver Gull		1	1				1	
	Totals	8	24	40	22	13	10	57	6

Attachment B Literature Review – Waterbird Deterrent Methods

Russell et al. 2012

Issues addressed: Strategies for reducing cormorant-fisheries conflict in Europe and Eurasia (including depredation at aquaculture facilities)

Summary: Russell et al. (2012) provide a detailed evaluation of various management strategies/tools for reducing conflict between cormorants and fisheries, including scaring techniques (pyrotechnics, live ammunition, human disturbance, scarecrows, avian predator models, floating models of a crocodile's head, streamers, lasers, water guns, gas cannons, dogs, balloons, mirrors and reflectors), barriers (netting, overhead wires, floating ropes and floats), modified stocking practices (changing the timing, location and frequency of stocking as well as stock size), dyes, habitat modification (e.g., providing additional cover for fish, removing roost/nesting structures), dispersing birds from roost and breeding sites, and shooting/culling cormorants. The costs and benefits of these methods/strategies are explored in some detail. With regards to scaring techniques, Russell et al. (2012) note that gas cannons are only effective over a small area (1.3 – 2 ha); and that cormorants are easily scared by humans if humans are perceived as a threat. With regards to overhead wires and floating ropes, the authors note that ropes/wires should be placed < 8 m apart (the minimum distance required for take-off).

Management Implications & Recommendations: Exclusion of birds (using netting and/or wires) is the most reliable and effective way of reducing conflict between cormorants and fisheries. Scaring techniques may be effective if multiple techniques are used and the location and timing of aversive stimuli is varied. Deterrent techniques are most effective if deployed before or immediately after birds arrive (i.e., before birds become established). Shooting may be used in conjunction with scaring techniques to improve the effectiveness of deterrent programs. Adjustments to the timing, location, and frequency of stocking (and the size of fish introduced to ponds) may also reduce depredation by cormorants, where cormorants are present in large numbers for only part of the year.

Evaluation of Literature: Provides a detailed cost benefit analysis of techniques for reducing depredation by cormorants, with a focus on great cormorants. Considerable emphasis is placed on managing cormorant-fisheries conflict at a broad (continental) scale.

US Fish and Wildlife Service (2003)

Issues addressed: Cormorant depredation of fisheries in the southern US; strategies for managing cormorant depredation and associated impacts on southern US fisheries.

Summary: This report evaluates a number of broad strategies for managing cormorant-fisheries conflicts in the US, with a focus on broader management issues (including stakeholder perspectives and the application of policy). Details regarding impacts and control of cormorant depredation on US fisheries are provided in the Appendices. Methods for dispersing/detering cormorants (including shooting, removal of nests, fencing, overhead wires, propane guns, pyrotechnics, distress calls, scarecrows, repellents, mylar tape, human patrols, balloons, live ammunitions, vehicle patrols) are examined in detail in Appendix 4 of this report. The information provided in this report indicates that exclusion fencing, non-lethal dispersal of night roosts and nest removal/destruction may be effective in reducing cormorant depredation.

Management Implications & Recommendations: Exclusion fencing can be used to exclude cormorants from aquaculture ponds. Overhead wires may also be effective but only when arranged in grids (with the distance separating wires < than the distance required for take-off). Non-lethal scaring methods are generally effective over small areas only and are unlikely to remain effective for long (with animals quick to habituate). The effectiveness of scaring programs can be increased by using a variety of techniques, applying techniques rigorously, and by changing the location of static scaring devices. Non-lethal scaring techniques may also be more effective when used to disrupt nearby night roosts. Repeated removal of nests and the destruction of eggs and nestlings may also help reduce depredation by reducing the number of cormorants occurring locally. Shooting large numbers of cormorants is impractical and ineffective, especially if culled birds are replaced by birds from nearby wetlands.

Evaluation of Literature: Provides some useful information on the effectiveness of various lethal and non-lethal methods for control/reduction of cormorant depredation in the Appendices. The main body of the report is much less informative with regards to the efficacy of control methods.

Sullivan et al. (2006)

Issues addressed: Cormorant-fisheries conflicts in the US; measures for controlling depredation by cormorants.

Summary: Sullivan et al. (2006) provide an overview of issues relating to management of cormorant-fisheries conflict in the US including the use of lethal and non-lethal options for control of cormorant numbers/depredation (i.e., shooting, exclusion fencing/netting, floats, noise scarers, human presence, and visual harassment). With regards to the latter i.e., non-lethal options, the authors note the following: (1) harassment or scare techniques may be effective if applied in an integrated and consistent fashion; (2) shooting of cormorants may increase the effectiveness of non-lethal deterrent programs (by reducing habituation); (3) use of exclusion fencing and wires may significantly reduce cormorant numbers/depredation (though the cost and practicality of using fences may preclude their use). In terms of the overall effectiveness of deterrent programs, the authors note that efforts to deter/exclude cormorants from an area are more effective if alternative foraging areas are available nearby.

Management Implications & Recommendations: Harassment and scarring techniques should be applied in an integrated and consistent fashion with the timing and location of static scaring devices varied (so as to reduce habituation). Occasional shooting of cormorants may increase the effectiveness of scaring/harassment programs. Cormorants may be more easily deterred from ponds if there are alternative foraging areas nearby.

Evaluation of Literature: Not especially informative with regards to methods for controlling depredation at aquaculture ponds.

Cowx (2013)

Issues addressed: Cormorant depredation at aquaculture facilities and open water fisheries in Europe; strategies/methods for reducing cormorant depredation (with a focus on the Great Cormorant).

Summary: Cowx (2013) provides an overview of cormorant-fisheries conflicts in Europe, an assessment of the effectiveness of the measures adopted to address cormorant depredation (including a pan-European management plan) and recommendations regarding a management strategy to reduce the damage caused by cormorants. Measures for control/reduction of cormorant depredation (including killing birds and egg destruction, scaring/harassment, use of exclusion fencing/overhead wires, fish stock management and habitat modification [to reduce the availability and accessibility of prey to cormorants]) are summarised briefly. Limitations of these methods are also discussed.

Management Implications & Recommendations: Depredation by cormorants at aquaculture ponds may be significantly reduced using fencing and overhead wires to exclude birds. Harassment/scaring programs are more effective if: (1) multiple techniques are used to scare/deter birds; (2) scaring/deterring techniques are applied rigorously, and (3) if birds have access to foraging habitat elsewhere.

Evaluation of Literature: The summary table included on page 27 of this report provides a useful overview and evaluation of different methods for reducing cormorant depredation. Though succinct, the appraisal of control methods provided by Cowx (2013) is highly informative with regards to the pros and cons of different measures/approaches to cormorant control.

Carss (2002) (REDCAFE Report)

Issues addressed: Management of cormorant-fisheries conflict on a pan-European scale (with a focus on Great Cormorants).

Summary: Carss (2002) provides an overview of current methods/tools for managing impacts of cormorant depredation on European fisheries. Methods/tools for managing cormorant depredation examined in this report include: modification of fish habitat (to reduce accessibility and availability of prey to cormorants); altering fish stocking practices (timing, frequency, stocking density, fish size and location of smaller, susceptible species); use of exclusion netting and overhead wires; use of submerged

anti-predator nets and covering fyke nets; human harassment; audio scarers (e.g., sirens, vehicle horns, tin plates, gas cannons, pyrotechnics, live ammunition); visual deterrents (static and animated scarecrows and mylar tape); and shooting (to reinforce harassment or reduce numbers at a site). The pros/cons and applicability of control/deterrent methods (including their use at aquaculture facilities) are examined in considerable detail. In reviewing existing control/deterrent methods for cormorants, Carss (2002) notes the following: very few techniques currently in use have proven effective in the long-term (i.e., over years). Methods that have proven effective in the long term include: (1) alteration of fish habitat (to reduce the availability and accessibility of prey to cormorants) and (2) erection of barriers (fencing and overhead wires).

Management Implications & Recommendations: Fencing and overhead wires provide an effective means of reducing cormorant numbers at aquaculture facilities in the long term. Other control/deterrent methods such as scaring/shooting are less effective or unlikely to remain effective in the long term.

Evaluation of Literature: Section 5 of this report includes a detailed evaluation of the pros/cons and applicability of different control/deterrent methods.

Greer and O'Connor 1994

Issues addressed: Deterrent techniques for waterbirds, with a specific emphasis on techniques used/developed for oil spills.

Summary: Greer and O'Connor (1994) summarize information and research on deterrent methods for waterbirds with an emphasis on those used/developed for oil spills, including: gas-operated exploders, pyrotechnics, aircraft, boats, all-terrain vehicles, electronic sound generators, air horn, biosonics, underwater acoustic deterrents, ultrasonic sound, balloons, flags, lights, reflector/reflective tape, human effigies, predator models, trained falcons and hawks, decoys, and coloured dyes. Particular consideration is given to the applicability of deterrent methods to different waterbird species and in different contexts.

Management Implications & Recommendations: Deterrent methods should be used in combination with one another and the type, timing and (where appropriate) location of 'scarers' changed frequently in order to reduce habituation. The effectiveness of deterrents varies with bird species, residency, age, habitat and season, so selection and use of deterrents requires careful planning. The success of hazing/deterrence programs is heavily dependent upon careful planning and dedication of responsible personnel.

Evaluation of Literature: Provides a detailed, thorough evaluation of a range of deterrent techniques for waterbirds. Consideration is given to the applicability of deterrent methods to different waterbird species and in different contexts.

Discussion of un-manned or manned aircraft: The author's note that aircraft (in particular helicopters) can be used to deter waterfowl, gulls and herons, though not all waterbirds will take flight in response to overflying aircraft with some species diving rather than flying when approached.

INTERCAFE 2006

Issues addressed: Cormorant-fishery conflict management in the Hula Valley, Israel, including strategies/methods for reducing depredation at fish-rearing facilities.

Summary: Details are provided of a cormorant management program implemented successfully at a fish farm in Israel. Factors underpinning the success of this project (including organisation and timing) are discussed in some detail.

Management Implications & Recommendations: Cormorant depredation may be significantly reduced through large-scale, co-ordinated disturbance of cormorants visiting aquaculture ponds (with minimal killing). Deterrent measures are most effective when used to deter birds arriving, or recently arrived, at ponds. Efforts to disperse cormorants are more likely to succeed if birds are able to relocate to nearby wetland areas.

Evaluation of Literature: Provides useful insights into a successful cormorant management plan which may have relevance to prawn farms.

Cleary 1994

Issues addressed: Prevention and control of damage caused by waterfowl (including depredation of fish by mergansers and ducks at aquaculture facilities).

Summary: Cleary (1994) outlines various strategies for preventing/controlling damage caused by waterfowl, including depredation at aquaculture ponds. Strategies suggested by Cleary (1994) include: vertically-straightening banks and erecting poultry fencing around ponds; use of overhead exclusion wires/grids and netting; use of frightening/repellent devices including flags, balloons with eyespots, Mylar tape, scarecrows, automatic exploders, dogs, shooting, live capture, chemical repellents, pyrotechnics and broadcasting of distress calls. Specific recommendations regarding the use of these prevention/control measures are also provided.

Management Implications & Recommendations: Some waterfowl may be dissuaded from using ponds by vertically straightening banks or by erecting a poultry wire fence around ponds. Waterfowl may also be excluded from aquaculture ponds by constructing overhead grids of 0.4-0.8 mm stainless steel wire and heavier ultraviolet-protected monofilament line. Where complete exclusion is needed, 2.5-3.75 cm propylene UV-protected netting can be used to exclude waterbirds from ponds. Effective control using scarees requires promptness and persistence. Waterfowl are difficult to disperse once they become established, so frightening devices/repellents should be in place before birds become a problem. The deployment of 'frighteners'/ deterrent devices (in particular exploders) also needs to be planned so as minimise habituation.

Evaluation of Literature: useful review of deterrent measures for waterbirds which includes specific recommendations regarding their use. In comparison with other reviews, discussion of the efficacy of prevention/control measures is limited.

Curtis et al. 1996

Issues addressed: Potential solutions for reducing bird predation at aquaculture facilities.

Summary: Curtis et al. (1996) provide an overview of potential solutions for reducing bird predation at aquaculture facilities. Methods for reducing predation discussed include: complete fencing/netting of ponds; partially-covered systems (with overhead lines and wires) which interfere with predators feeding behaviour; broadcasting distress calls; use of pyrotechnic devices (cracker shells, whistle bombs and screamer rockets, rope firecrackers, live/blank ammunition); automatic exploders; electronic noisemakers; flashing lights, strobe lights and flood lights coupled with motion detection sensors; scarecrows/effigies; predator models; mirrors/reflectors; streamers; radio-controlled aeroplanes and boats; vehicle/human patrols; intermittent use of high-pressure water spray devices; dogs; and lethal control measures. The primary advantages and disadvantages of these deterrent methods are discussed. According to the authors, the use of a single technique/method (other than exclusion fencing) is rarely effective and, in most cases, a combination of methods is needed to reduce or eliminate predation at aquaculture facilities. Modification/redesign of holding structures (increasing the steepness of banks and height of side walls) may also decrease the ability of some species to feed at aquaculture ponds. Removing and/or bird-proofing perches (including handrails, light posts and fence posts) may also be helpful in this regard. However, the only completely effective method for eliminating bird predation at aquaculture facilities is fully enclosing ponds with fencing and mesh/netting.

Management Implications & Recommendations: A range of techniques can be used to reduce predation by waterbirds at aquaculture ponds including barriers, frightening techniques, lethal control measures, and redesign/modification of ponds. In most cases, a combination of techniques will be needed to significantly reduce predation by birds at aquaculture facilities. The only way of completely eliminating predation by waterbirds is to fully enclose ponds with bird proof mesh/fencing.

Evaluation of Literature: Provides a useful evaluation of a range of technologies for minimizing predation at aquaculture facilities.

Office of Technology Assessment (U.S. Congress) 1995

Issues addressed: Effectiveness, costs and benefits of technologies used to minimize predation by birds at aquaculture facilities.

Summary: This document provides an overview and evaluation of measures to minimise predation by birds at aquaculture facilities. Methods/technologies for deterring waterbirds considered in this report include: increasing water depth in holding ponds; increasing the height of sidewalls and slope of embankments; removal of perches and feeding platforms located near ponds; broadcasting predator distress calls; automatic exploders; pyrotechnics; sirens; lights; scarecrows and effigies; predator decoys; model aeroplanes; trained falcons; water spray devices; perimeter fencing and protective netting; overhead wires; and shooting/killing. Details are provided of the costs, effectiveness and limitations of the aforementioned measures.

Management Implications & Recommendations: The effectiveness of bird predation control programs can be increased by: (1) careful consideration of the location, shape and layout of ponds; (2) ensuring efforts to deter avian predators commence immediately after construction; (3) frightening diving birds away before they land on the water's surface (since diving birds can avoid exposure to most deterrent measures by diving underwater); (4) use of a variety of deterrent techniques; (5) changing control measures (as well as the timing/sequencing of different deterrent measures) to minimize habituation; and (6) use of lethal methods (if necessary) for enhancement of non-lethal measures.

Evaluation of Literature: Provides an excellent, detailed evaluation of a range of technologies for minimizing predation at aquaculture facilities.

Discussion of un-manned or manned aircraft: As regards the use of unmanned craft/drones, the authors note the following: Radio-controlled aeroplanes are effective at scaring wading and swimming birds as well as aerial-divers from ponds. Model aeroplanes are most effective when fitted with pyrotechnic launches that haze birds as they attempt to land. Birds already on water may simply dive to avoid harassment. The utility of model aeroplanes is also limited by weather and flight obstructions around ponds.

Clarke 2004

Issues addressed: Costs and benefits of existing bird deterrent systems; development of an effective autonomous bird deterrent system.

Summary: This dissertation provides a detailed evaluation of existing bird deterrent systems, including: scarecrows, bird corpses, kites, bio-acoustic devices, ultrasonic devices, strobe lights, lasers, taste and tactile chemical repellents, wires, spikes, gas cannons, water sprayers, and 'Bird Blaster' (a Doppler-radar based, autonomous pressurised air deterrent system). Deterrent systems ranked the highest in terms of their 'effectiveness' were: strobe light, movement-activated audio deterrent, propane cannon, and rapidly-inflating 'Scarey Man' scarecrow. The use of manned and unmanned aircraft was not considered in this assessment.

Management Implications & Recommendations: The effectiveness of bird predation control programs may be increased by employing more effective deterrent systems such as strobe lighting, movement-activated audio deterrents, propane cannon, and rapidly-inflating 'Scarey Man' effigies.

Evaluation of Literature: Provides a useful cost-benefit analysis of a range of bird deterrent systems.

Barras and Godwin 2005

Issues addressed: Management of depredation at aquaculture ponds using scaring techniques.

Summary: This publication provides an overview of bird frightening techniques with specific recommendations regarding their use in aquaculture. Scaring techniques addressed in this publication include: propane exploders, pyrotechnics (bangers, screamers and cracker shells), effigies of humans/predator (such as the 'Scary Man' device), dogs, sirens, broadcasting distress

or alarm calls, spot lights and strobe lights (to disperse birds feeding at night), and live ammunition. The effectiveness and limitations of these is discussed briefly, with the authors noting that the effectiveness of most techniques in preventing fish loss has not been subject to scientific study. There is no discussion of the use of unmanned or manned aircraft to frighten birds.

Management Implications & Recommendations: Effective management bird predation in aquaculture requires the integration of multiple deterrent methods including non-lethal (hazing) and lethal techniques. Lethal control should be used to reinforce nonlethal methods and to remove or retrain birds that are no longer responsive to non-lethal methods. To counter habituation (and reduce the need for lethal methods), the deployment of scarers should be varied in space and time. In areas with many birds, harassment patrols should be conducted continuously. Where practical, birds should also be deterred from using nearby roosting and loafing areas.

Evaluation of Literature: Provides specific recommendations regarding the use of a range of hazing/harassment techniques.

Bishop et al. 2003

Issues addressed: Efficacy of auditory and alternative bird deterrent devices.

Summary: Bishop et al. (2003) reviewed published and grey literature to evaluate the efficacy of a range of bird deterrents including: gas cannons, pyrotechnics, bioacoustic devices, ultrasonic and high intensity sound, lasers, dogs, human scarers, scarecrows, raptor models, bird corpses, balloons, kites, trained falcons, radio-controlled aircraft, lights, mirrors/reflectors, tape, flags and streamers, dyes/colourants, taste and tactile repellents, nets and wires, water spray devices and shooting. In this review, Bishop et al. (2003) cite a number of studies/reports relating to the use of deterrent devices on waterbirds at aquaculture facilities. Based on their review, the authors concluded the following: Exclusion techniques (fencing, mesh and wires) are the most effective, depending on the degree to which birds are excluded. While generally considered to be effective and environmentally friendly, habitat modification techniques are rarely investigated scientifically. It seems likely, however, that modification of habitat will be shown to be cost-effective in a variety of situations. Lethal techniques are generally considered to enhance other scaring methods, though this remains largely untested. The integration of multiple deterrent techniques/methods is considered to be more effective than techniques applied singly but combinations are rarely scientifically evaluated.

Management Implications & Recommendations: Effective control/elimination of bird predators from aquaculture facilities may best be achieved through exclusion techniques (i.e., fencing and netting). Scaring methods have also been shown to be effective in deterring waterbirds from aquaculture ponds, with an integrated control strategy using a range of deterrent methods likely to be more effective.

Evaluation of Literature: Provides an excellent and thorough assessment/evaluation of a range of bird deterrent strategies, including their effectiveness on waterbirds.

Discussion of un-manned or manned aircraft: With regards to unmanned aircraft, the authors note that radio-controlled model aeroplanes have been used with some success to deter cormorant and herons at aquaculture facilities. Their effectiveness in deterring waterbirds, however, appears to be limited with diving species which simply dive underwater to avoid disturbance.

Komenda-Zehender et al. 2003

Issues addressed: Behaviour of waterbirds in relation to overflying helicopters and aeroplanes.

Summary: The authors of this paper report on a study examining the response of waterbirds (mostly ducks and coot) to helicopters and aeroplanes flying over wetlands in Switzerland. Four to six overflights were performed at 15 minute intervals at successively decreasing altitudes (600-450-300-150-80 m AGL), at a constant altitude (150 or 90 m AGL) or at varying altitude (450-300-150-80 m AGL). Over the course of a month, a total of 326 over-flights were undertaken (179 by aeroplanes and 147 by helicopter). Data from flight series carried out at a constant height showed birds did not habituate to overflying helicopters or aeroplanes. The proportion of birds disturbed by aircraft was found to increase with decreasing altitude, with over 90% of birds disturbed when helicopter flights were conducted at 90m AGL. The duration of disturbance, however, was short-lived with bird behaviour returning to normal within 5 minutes of aircraft passing over. The number of birds in affected areas also remained

constant during trials. Helicopter flights at 450m AGL or higher did not produce a significant increase in the proportion of birds disturbed.

Management Implications & Recommendations: Low-flying helicopters may be used to disrupt feeding waterbirds, however disturbance caused by helicopters is likely to be short-lived. Occasional use of helicopters is therefore unlikely to reduce predation at aquaculture facilities.

Evaluation of Literature: Provides some useful insights into the response of waterbirds to helicopters overflying wetlands at different altitudes.

Discussion of un-manned or manned aircraft: see above.

Brann 2016

Issues addressed: Use of modified drone to deter birds from crops.

Summary: This news report highlights the use of drones to protect seed crops from birds (including magpie geese). According to the report, a drone fitted with an audio bird-scarer is being used successfully by Pacific Seeds to deter birds from feeding on seed crops in the Ord Valley. According to a company representative (Petre Bagely), the drone is working very well and significantly reducing losses. Bird numbers have been significantly reduced with an hour's flying each morning and afternoon. Prior to the drone, bird chasers on quad bikes, helicopter, gas guns and various other devices were used to keep birds away (at an estimated cost of \$2000/day).

Management Implications & Recommendations: Drones fitted with audio scarers emitting a high-pitched distress and raptor calls may provide a more cost-effective way of dispersing birds than other techniques, including low-flying helicopters.

Evaluation of Literature: Provides some useful information on the efficacy and cost-effectiveness of drone use in pest bird management.

Discussion of un-manned or manned aircraft: see above.

Read 1999

Issues addressed: Minimizing waterfowl use of toxic liquid storages.

Summary: Read (1999) documented the use of deterrent measures in conjunction with engineering and management techniques to discourage nomadic waterfowl from landing and remaining on toxic waste water ponds at Roxby Downs mine, South Australia. Use of a gas gun and floating, rotating, intermittent beacon (directed at a shallow angle across the water surface) reduced numbers of ducks by 90% or greater at ponds where beacons were installed. In contrast with ducks, hoary-headed grebe were not deterred from using ponds, with grebes simply diving underwater in response to aversive stimuli.

Management Implications & Recommendations: Operation of a floating, flashing beacon (in conjunction with a gas gun) may help deter waterfowl from visiting ponds at night.

Evaluation of Literature: Provides evidence for the efficacy of flashing beacons as a deterrent for waterbirds moving at night.

Kevan 1992

Issues addressed: Effectiveness of measures/techniques for deterring bird predators from fish farms.

Summary: Kevan (1992) undertook a detailed evaluation of methods used to reduce bird predation on land-based fish farms including: automatic exploders, lights, alarm/distress calls, pyrotechnics (noise bombs, whistlers, rockets, rope crackers), water spray devices, scarecrows, reflectors, streamers and silhouettes, manned and radio-controlled aircraft, shooting birds, complete

and partial enclosure of ponds, and modification of pond design. Disadvantages and advantages of these methods are discussed in some detail.

Management Implications & Recommendations: Complete enclosure of ponds is the most effective and only reliable way of eliminating bird predation at aquaculture ponds. Partial enclosure of ponds may also significantly reduce bird predation and has been used successfully to deter wading birds (including herons). The utility of common deterrent devices such as visual deterrents, water sprayers, automatic exploders, pyrotechnics, light and broadcasting alarm/distress calls is limited and variable (depending on context and frequency of use). The effectiveness of these measures is greatest when used in combination with one another and when the presentation of deterrent stimuli is varied in space and time. The use of deterrent measures should also precede the establishment of birds at aquaculture ponds (i.e., before the visitation of ponds has become a habit).

Evaluation of Literature: Provides an excellent, detailed evaluation of a range of technologies for minimizing predation at aquaculture facilities.

Discussion of un-manned or manned aircraft: With regards the use of helicopters and radio-controlled aircraft, Kevan (1992) notes the following: 'The uses of helicopters, airplanes and radio-controlled aircraft have limited success. There is no long term effectiveness because birds are frightened from the ponds for a short time and then return after the aircraft has left the site, especially when there are no other ponds or suitable wetland areas for the birds to go to. Weather and expense also decreases the effectiveness of scaring off birds. Many trips are needed to keep birds off ponds. Manpower, fuel, maintenance and machinery costs may not make it economically feasible to employ this method..'

Moerbeek et al. 1987

Issues addressed: Effectiveness of different measures/techniques for deterring bird predators from fish farms (including helicopters).

Summary: Moerbeek et al. (1987) examined the effectiveness of a number of deterrent measures, including low-flying helicopters, on great cormorants and fish ponds in the Netherlands. Of the methods trialled, pistol-flash cartridges were found to be the most effective at scaring birds from ponds. Gas cannons had little effect with birds rapidly habituating to the noise produced by cannons. An overflying helicopter scared cormorants from ponds, however large numbers of birds returned to ponds the day after helicopter trials were completed.

Management Implications & Recommendations: Cormorants may be deterred from aquaculture ponds by pistol-flash cartridges. Occasional/short-term use of helicopters may have little impact on predation by cormorants, with birds returning to ponds soon after helicopters have stopped flying.

Evaluation of Literature: Provides some insight into the effectiveness of different deterrent techniques when applied to cormorants at aquaculture ponds.

Vas et al. 2015

Issues addressed: Disturbance of waterbirds by drones.

Summary: Vas et al. (2015) investigated the impact of quadcopter drones on the behavioural responses of mallard ducks in a semi-captive situation, and of wild flamingos and common greenshanks in a wetland area. In this study, the authors conducted 204 approach flights with quadcopter drones approaching at different speeds and angles (20, 30, 60 and 90 degrees). Irrespective of colour and approach speed, birds showed little reaction to drones except when drones approached at an angle of 90°. In less than 80% of trials did drones cause birds to take flight.

Management Implications & Recommendations: Conventional quadcopter drones may have limited use as a deterrent for waterbirds. If drones are used to haze birds, birds should be approached at 90 degrees in order to maximize disturbance.

Evaluation of Literature: Provides some interesting insights into the response of waterbirds to drones.

McEvoy et al. 2016

Issues addressed: Utility of drones in waterfowl surveys; potential disturbance of waterfowl by drones during surveys.

Summary: McEvoy et al. (2016) assessed disturbance of waterfowl by drones of different shapes and sizes on free-ranging waterfowl at sites in eastern Australia. Irrespective of the type or model used, drones caused minimal disturbance to waterfowl. During this study, birds were rarely observed flying away from drones, and only when fixed-wing drones were launched at a flock of birds at low altitude (10-15 m) during takeoff. Birds responded the strongest to delta-wing drones on direct approach and when banking while descending. The response of birds to the arrival raptors, by contrast, was far more pronounced, with large flocks of birds taking flight and flying for longer before resettling.

Management Implications & Recommendations: Conventional drones may have limited value as a deterrent for waterbirds. The use of delta-wing drones (which may frighten birds on direct approach or when banking and descending like a raptor) is recommended over multirotor drones which cause very little disturbance.

Evaluation of Literature: Sheds considerable light into the utility of drones as a deterrent device for waterbirds.

Discussion of un-manned or manned aircraft: see above

Baxter 2007

Issues addressed: Use of laser deterrents to prevent nocturnal use of waterbodies by birds near an airport.

Summary: Baxter (2007) investigated the use of lasers as a means of dispersing seagulls roosting at a large (1.5 km wide) reservoir near an airport. The reservoir with roosting gulls was swept repeatedly with a laser beam at a height of 1.5 m after dusk. Movement of the laser across the water sent roosting gulls wheeling into the air, departing, or moving to another part of the reservoir. With repeated sweeps all gulls were dispersed from the site and no gulls were recorded back at the reservoir for at least 60 minutes. The response of gulls remained the same over the 26 nights which the laser was used indicating little or no habituation. Use of the laser deterrent during the day had no effect on gulls and gulls returned to the reservoir in numbers the following day.

Management Implications & Recommendations: Lasers may provide a useful tool for preventing nocturnal use of aquaculture ponds by waterbirds and could therefore be used to deter nocturnal avian predators such as Nankeen night herons.

Evaluation of Literature: Provides some useful insights into the potential use of lasers as a deterrent for waterbirds.

Gorenzel et al. 2007

Issues addressed: Predation by birds at aquaculture facilities; evaluation of different methods for reducing predation by birds.

Summary: Gorenzel et al. (1994) critically evaluated the efficacy of a range of methods for preventing/controlling bird predation at aquaculture facilities, including: enclosing ponds, use of overhead wires, reflecting tape, eyespot balloons, scarecrows, automatic exploders, pyrotechnics, broadcasting alarm and distress calls, lights, water sprays, aerial harassment with ultralight aircraft and radio-controlled airplanes, ground harassment with vehicle patrols, trapping and shooting. The pros and cons of these methods is discussed in some detail. Methods most often used to control particular waterbird species (including egrets and cormorant species, striated heron, night-heron, and diving ducks) are also identified.

Management Implications & Recommendations: The most effective, reliable way of limiting predation at aquaculture ponds is to enclose ponds with mesh/fencing. Most conventional frightening techniques may only be effective in the short-term. The effectiveness of frightening methods can, however, be increased when multiple techniques are used and methods used are varied over time.

Evaluation of Literature: Provides useful information on control methods applicable to different of waterbird species.

Discussion of un-manned or manned aircraft: With regards the use of unmanned aircraft as a deterrent, the authors note that radio-controlled aircraft may not be effective on species that seek safety by diving underwater.

Swaddle et al. 2016

Issues addressed: Use of a spatially controlled noise or 'sonic net' to deter exclude birds from an airfield.

Summary: Swaddle et al. (2016) investigated the use of a "sonic net" (spatially controlled noise designed to overlap with the frequency range of bird vocalizations) to exclude birds from an airfield. Use of the sonic net resulted in an 82% reduction in bird numbers (including gulls and terns) compared with sites outside the treatment area. Numbers of waterbirds at the study site, however, were low.

Management Implications & Recommendations: Preliminary data from this study suggest sonic nets could help deter some waterbirds from aquaculture ponds.

Evaluation of Literature: Provides insight into a novel method for deterring birds which may have some applicability to waterbirds frequenting aquaculture ponds.

Stevens et al. 2000

Issues addressed: Use of a radar-activated, demand-performance bird hazing system to deter waterfowl from contaminated ponds.

Summary: Stevens et al. (2000) investigated the use of a radar-activated integrated hazing system (including acoustic alarm calls, pyrotechnics and chemical repellents dispersed as tear gas) to deter birds from contaminated ponds at a power plant. Over the course of a year, waterfowl were 12.5 times less likely to fly over, and 4.2 times less likely to land on hazed ponds relative to control ponds. Hazing also altered the direction of and altitude of waterbirds flying over ponds. Unlike timed interval or random activation hazing systems, birds did not habituate to the radar-activated hazing system trialled in this study.

Management Implications & Recommendations: The effectiveness of hazing systems may be greatly improved with the integration of radar enabling activation of hazing equipment when birds approach aquaculture ponds.

Evaluation of Literature: Provides details of a superior radar-activated hazing system.

Ronconi et al. 2006

Issues addressed: Use of a radar-activated, demand-performance bird hazing system to deter waterfowl from contaminated ponds.

Summary: Ronconi et al. (2006) investigated the use of a radar-activated on-demand system of deterrence at tailing ponds in Alaska. Of three deterrence systems trialled (radar-activated, continuously operated, and randomly activated), only the on-demand radar-activated system significantly reduced the likelihood of birds alighting on ponds. Though operational 24 hours a day, the response of birds to this system at night was not assessed.

Management Implications & Recommendations: The effectiveness of hazing systems may be improved with the integration of radar, enabling activation of hazing equipment when birds approach aquaculture ponds.

Evaluation of Literature: Provides details of a superior radar-activated hazing system.

Loon 2006

Issues addressed: Disturbance of waterbirds by boats and other watercraft.

Summary: Long (2006) reviewed studies and reports of motorcraft disturbance to birds to support an assessment of potential impacts of watercraft on birdlife at the Ross Dam Wetlands. Studies/reports cited in Long (2006) show that motor boating causes significant disturbance to foraging waterbirds, especially with loud and fast-moving watercraft. Responses to watercraft documented in this review include reduced feeding time and displacement of waterbirds from feeding grounds (including striated heron, coots and ducks).

Management Implications & Recommendations: Disturbance by motorcraft (in particular loud, fast-moving motorcraft) can disrupt feeding behaviour of waterbirds and, potentially, displace waterbirds from feeding grounds.

Evaluation of Literature: Provides details of a superior radar-activated hazing system.

Draulans 1987

Issues addressed: Predation by birds at aquaculture facilities; evaluation of different methods for reducing predation by birds.

Summary: Draulans (1987) critically evaluated the efficacy of a range of methods for preventing/controlling bird predation at aquaculture facilities, including: relocation, shooting, visual scaring devices (e.g. scarecrows, flags, reflectors, 'flash harries', lights, model airplanes and helicopters), acoustic scaring devices (e.g. gun shots, firecrackers and gas cannons), and biological. Management Implications & Recommendations: Most studies indicate that their effect, if any, was short-term. Broadcasting recorded distress and warning calls on cormorant and heron abundance has proved usually ineffective. Night herons *Nycticorax nycticorax* were deterred by distress calls but only close to the speaker; positive effects on fish stocks are reported but no data are presented to support this. The use of dead birds, model predators and dogs is reported by several authors as almost completely ineffectual. Trained raptors to scare off piscivorous birds seemed effective but this method is expensive. The only practical solution identified to deter birds from fish farms is to make them inaccessible through wiring/netting.

Evaluation of Literature: A comprehensive review of a wide variety of methods to control predation, of which with many continue to be advocated almost 30 years after this landmark review was published.

Rowland 1995

Issues addressed: Cormorant predation of fish stocks and means to minimise predation impacts.

Summary: Rowland (1995) assessed predation by Black cormorants *Phalacrocorax carbo*, little black cormorants *P. sulcirostris* and little pied cormorants *P. melanoleucos* of silver perch *Bidyanus bidyanus* at aquaculture operations in New South Wales. The effectiveness of hanging gill nets vertically in the water (large diameter mesh enabling fish fry and fingerlings to swim through unhindered, but not cormorants) and harassment patrols (people walking around the ponds to scare off birds) was assessed.

Management Implications & Recommendations: Hanging gill nets in the water and harassment patrols were ineffective in deterring cormorant from fishing in the ponds. Survival rates of fry (average weight 0.8g), which might be considered similar to the early stages of the black prawns, was only 0.3%, 0.8% and 3.5% (average 1.5%), and survival of fingerlings (average weight 69.5g) was 0.9%. Little black and little pied cormorants preyed mainly on small fingerlings (3-75g), whilst black cormorants took fish from 55 to 37 g.

Evaluation of Literature: A useful Australian example of issues in regard to the three cormorant species relevant to the current project.

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Key messages

-) Two studies found lower bird mortality or fewer birds rescued from toxic ponds when deterrent systems were used.
-) Four of five studies found that fewer birds landed on pools with deterrents than controls, although one of these found that the effect was weaker for grebes compared to wildfowl and absent for waders. One study that used regular broadcasts of different sounds found that it had no impact on bird behaviour.
-) Two studies investigated different systems and found that radar-operated systems were more effective than systems that worked at random intervals. One of these studies also found that loud noises were more effective than moving peregrine falcons *Falco peregrinus* models.

Supporting evidence from individual studies

A trial of an early design of radar-activated system (that triggered a stereo, fire alarm, propane cannons and firecrackers) aimed at scaring birds from mine tailing facilities in Nevada, USA (Weber & Filas 1993), showed that the system had promise. Subsequent trials of the system are described in (Johansson et al. 1993, Stevens et al. 2000, Ronconi et al. 2004).

Two controlled experiments at a 18.2 ha desulfurisation pond in north-central USA (Johansson et al. 1994) found that significantly fewer birds landed on ponds where a scaring system was in place (autumn and spring 1993-1994: 17 birds used a pond when the system was active for 48 hour periods vs. 125 when it was inactive for 48 hour periods; autumn 1994: 16 of 43,964 bird landings, 2% of the expected number, occurred on the pond with the system). The radar-activated system (a BirdAvert® system) used various deterrents (broadcasts of recordings of e.g. dogs barking, guns firing and falcons screaming; strobe light; plastic falcons with flapping wings, and automated scarecrows).

A randomised, replicated and controlled trial in South Australia in 1996-7 (Read 1999), found that the number of wildfowl on sewerage ponds was 90% lower when a slowly rotating beacon with an intermittent, low-angled beam was floated in the centre of the ponds, compared to control ponds with no beacon (average of approximately 2 ducks/night on experimental ponds vs. 36 ducks/night on control ponds). There was no change in the behaviour of waders, and grebes dived, rather than dispersing. A follow-up, before-and-after experiment found that the number of wildfowl and hoary-headed grebes *Poliiocephalus poliocephalus* on toxic and acidic tailing ponds were over 66% lower in the 12 months following the installation of a slowly rotating beacon with an intermittent, low-angled beam that floated in the centre of the ponds, compared to the 12 months before installation. Over half of the casualties were when the device was not fully operational and mortality rates were reduced to one-sixth of post-installation levels in the 12 months after the device became fully operational. Of the 15 mortalities following installation, four were hoary-headed grebes.

A controlled trial at the Jim Bridger Power Plant, Wyoming, USA, in 1996-7 (Stevens et al. 2000) found that waterfowl were 12.5 times less likely to fly over and 4.2 times less likely to land on two ponds (36.5 and 80.8 ha) when a radar-activated deterrent system was used, compared to an adjacent freshwater pond (93.2 ha) with no deterrent; non-waterfowl were seven times less likely to land. Bird rescues per year decreased by more than 400 (>70% fewer rescues) in the first year of full operation. Between 685 and 714 rescues occurred in preceding years, 859 in the transition year, and 210 in the first year of full operation (mortality reduced by more than 77% relative to previous years). When flying birds were detected, the system broadcast alarm and distress calls of a variety of animals, let off 'screamer' cartridges, and finally a bird aerosol tear gas was triggered (only used if birds were still detected after initial deterrents were activated).

A replicated, controlled trial at two sites in San Francisco Bay, California (USA) found that the Breco Bird Scarer (an orange buoy designed to drift with an oil slick) did not alter waterbird behaviour when it was broadcasting sounds as opposed to non-broadcasting (Whisson & Takekawa 2000). The buoy broadcasts up to 30 different sounds at up to 130 dB at 1 m, at varying intervals (30 sec to 5 min, dependent on how programmed). Alternating 2-day treatment (device 'on') and control ('off') periods

were conducted. No significant deterrent effect was noted on numbers of three common wintering duck species (greater and lesser scaup *Aythya affinis* and *A. marila*, surf scoter *Melanitta perspicillata*) and all other waterbirds.

A literature review (Ronconi et al. 2004) suggests that the use of radar-activated deterrent systems both increases effectiveness at deterring waterbirds at contaminated sites and reduces the cost necessary (compared to conventional methods) to achieve success.

A randomised, replicated and controlled trial at a tar sands mine in Alberta, Canada, in 2003 (Ronconi & St Clair 2006), found that a lower proportion of 372 groups of birds landed on three tailing ponds when an on-demand bird deterrent system was used, compared to control periods when the system was not used or to periods when industry standard deterrents were used (1-5% of bird groups landing with on-demand system vs. 5-16% for industry standard and 8-23% for controls). The on-demand system used radar-activated propane cannons, high-intensity strobe lights, moving models of peregrine falcons *Falco peregrinus* and broadcasts of peregrine calls; the industry standard system used human effigies and cannons that fired at random intervals. A further trial found that birds were significantly more likely to change direction when propane cannons were fired on demand, compared to when a peregrine model was moved and peregrine calls played (11% of 28 bird groups responded when peregrine models were activated vs. 40% of 30 bird groups responding when cannons were used).

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Key messages

-) Two replicated studies from Germany and the USA found that netting or closely-spaced string barriers reduced losses of fish or deterred fish-eating birds from fish ponds. A review concluded that excluding birds was an effective way to reduce damage.
-) A series of tests in the Netherlands found that netting or nylon lines over ponds did not prevent birds from landing, but did alter behaviour, whilst a before-and-after study from the USA found that fewer great blue herons *Ardea Herodias* landed at fish ponds with netting, but that they stayed longer.
-) Two replicated studies from Germany and Israel found that some birds became entangled in netting or closely-spaced string barriers over fish ponds. The Israeli study found that dark, small meshed netting entangled fewer birds than other netting types.

Background information and definitions

Predation by birds at aquaculture facilities (e.g. fish ponds, raceways and shellfish farms) can cause significant commercial loss (Draulans 1987). With increasing protective wildlife legislation, demand for non-lethal, environmentally safe methods of bird exclusion and scaring have increased. Most fish farmers now rely primarily on non-lethal techniques to accomplish control (i.e. to reduce abundance or exclude fish-eating birds in and around the vicinity of fish farms). Control efforts may be optimized by compiling evidence relating to deterrent or exclusion device efficacy, taking into account costs, practicality of use and the possibility of developing integrated strategies (i.e. combining more than one deterrent method). Avian deterrents can be categorised as auditory, visual, chemical, exclusion, habitat modification and lethal (Bishop et al. 2003). Lethal deterrents are not considered here (except where, very rarely, used as part of an integrated approach).

Supporting evidence from individual studies

A replicated trial in the winter of 1962-3 in North Rhine-Westphalia, Germany (Ueckermann et al. 1981), found that using string barriers and netting were effective at deterring grey herons *Ardea cinerea* from fish farms, if strings were 30 cm apart (larger distances being significantly less effective), but that occasional fatalities (entanglement) occurred. String barriers were ropes laid parallel across the water, 0.3 to 2 m apart; netting had 10 cm mesh size; and stumble ropes were also tested. This study also investigated the effects of scaring birds from fish farms, discussed in 'Scare birds from fish farms'.

A series of experiments in Flevoland, the Netherlands, in 1981-3 (Moerbeel et al. 1987) found that nylon lines and ropes did not prevent cormorants from landing on fish ponds, but did change behaviour (from quick incursions by many birds to smaller numbers staying in ponds for longer). Effects on fish stocks are not reported. In 1981 nylon lines (forming 20 x 20 m squares) were placed over a 5 ha pond; in winter 1981-1982, 10 x 10 m squares were tested, and four ponds fitted with 20 x 20 m squares, with an irregular pattern over another; in 1983 over a 5 ha pond, ropes were stretched downwards from 10 m towers in the pond centre to the sides, with spacing between lines of 14-15 m). The effect of scaring birds from fish ponds is discussed in 'Scare birds from fish farms'.

A 1995 review assessed effectiveness of techniques used to prevent double-crested cormorant *Phalacrocorax auritus* predation at aquaculture facilities in the Mississippi delta region, USA (Mott & Boyd 1995), and concluded that excluding birds using netting or wires was an effective way to reduce damage.

A before-and-after trial in trout farms in Colorado, USA, in 1990-2 (Andelt et al. 1997), found that 7 cm nylon netting significantly reduced great blue heron *Ardea Herodias* numbers next to ponds, but they stayed longer to capture fish after netting installation. Netting was 2.3 m long, 0.5 m high and slanted toward the water. The effects of various scaring devices is discussed in 'Scare birds from fish farms'.

A controlled, replicated experiment in 1995-6 at 18 ponds in seven aquaculture facilities in Florida, USA (Avery et al. 1999), found that fish losses from ponds covered in netting were significantly lower (11%) than for uncovered ponds (38%). Main species preying fish were snowy egret *Egretta thula*, green-backed heron *Butorides striatus*, tricolored heron *E. tricolor* and little blue heron *E. caerulea*.

A replicated study in 2000-1 at 101 fish ponds, covered in 20 net types, in two fish farms in Israel (Nemtzov & Olsvig-Whittaker 2003) found that few or no dead birds were found in small mesh sizes with thick or dark-coloured netting. However, the largest numbers of entangled (dead) birds were found in two, thin monofilament net types, even though they had small mesh sizes (35 birds equivalent to 34/ha and 30 birds, equivalent to 25/ha). Ponds with slack, horizontal nets also had fewer dead birds, probably because they were more visible (flapping in the wind) than tight-strung nets. Entrapment within some ponds was attributed to poor net maintenance (e.g. holes/tears). A total of 327 dead (entangled) and 4,575 live birds (under nets) of 31 species were recorded.

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Key messages

-) One before-and-after study from Israel found that the population of pygmy cormorants in the area increased after birds were scared away from fish farms, possibly due to lower persecution.
-) One of two studies that examined fish stocks found that fewer fish were taken from a farm when heron distress calls were played. The other study, a literature review, found no evidence for the effects of scaring birds on fish stocks.
-) Two replicated studies from Belgium and Australia found that using foot patrols to disturb birds from fish farms did not reduce the number of birds present or fish consumption.
-) Ten of eleven studies from across the world, three controlled, found evidence that playing distress calls or using other acoustic deterrents (some with flashes of light) reduced the number of birds at fish farms, or changed bird behaviours. One of these involved underwater broadcasting. One study found effects were only temporary and five found that birds became habituated to noises. Four studies, one replicated and controlled, two before-and-after, found that acoustic deterrents were not effective in scaring birds.
-) Five of seven studies, one controlled, found evidence that visual deterrents (including inflatable 'Scarey Man' scarecrows) reduced the number of birds at fish farms. Three found evidence for habituation to deterrents and three studies found no evidence that visual deterrents were effective.
-) Two studies examined other deterrents, finding that trained raptors were effective but that the effects of helicopters and ultra-light aircraft were either inconclusive or very temporary.

Background information and definitions

Predation by birds at aquaculture facilities (e.g. fish ponds, raceways and shellfish farms) can cause significant commercial loss (Draulans 1987). With increasing protective wildlife legislation, demand for non-lethal, environmentally safe methods of bird exclusion and scaring have increased. Most fish farmers now rely primarily on non-lethal techniques to accomplish control (i.e. to reduce abundance or exclude fish-eating birds in and around the vicinity of fish farms). Control efforts may be optimized by compiling evidence relating to deterrent or exclusion device efficacy, taking into account costs, practicality of use and the possibility of developing integrated strategies (i.e. combining more than one deterrent method). Avian deterrents can be categorised as auditory, visual, chemical, exclusion, habitat modification and lethal (Bishop et al. 2003). Lethal deterrents are not considered here (except where, very rarely, used as part of an integrated approach).

Supporting evidence from individual studies

A trial at a fish pond in western Germany in 1976 (Behlert 1977) found that broadcasting the flight call of a grey heron *Ardea cinerea* during daylight caused herons standing near the pond to take off and deterred flying herons from landing. However, at dawn trials, the majority (ten of 12) of herons were not deterred from landing. Preliminary trials had revealed that distress calls were more effective at scaring herons than heron alarm calls, combined heron and other bird alarm calls or a white-tailed sea eagle *Haliaeetus albicilla* call.

A controlled trial in northern Israel in September and October 1978 (Spanier 1980) found that 88% (1,122 of 1,265) of black-crowned night-herons *Nycticorax nycticorax* feeding at fishpond were scared off when heron distress calls (both adult and juvenile) were played on 12 observation nights. Over the study period there was no apparent habituation to the distress calls, in contrast to when recordings of a gas gun were used, when herons became habituated after only one night (60% of birds remained at ponds after 12 nights). Distress calls also reduced the number of herons perched in nearby trees by approximately 50% and, despite less than 5% of scared herons leaving the area, the scaring significantly reduced fish losses over the study period.

A replicated trial in the winter of 1962-3 in North Rhine-Westphalia, Germany (Ueckermann et al. 1981), tested the effectiveness of visual and acoustic deterrents on deterring grey herons *Ardea cinerea* from fish ponds and found that a 'Flash-Harry' (wind-

powered rotating orange cross on a pole) had no effect, whilst birds quickly became used to streamer bands, broadcasting of bird distress/alarm calls and scarecrows. Shooting guns close to birds proved impractical. This study also investigated the use of netting on ponds, discussed in 'Use netting to reduce fish loss to birds'.

A replicated study from Limburg, Belgium, over 49 nights in 1982-3 (Draulans & Van Vesseem 1985), found that using foot patrols to disturb grey herons *Ardea cinerea* from 12 fish ponds did not necessarily reduce fish consumption. Low frequency disturbance (e.g. 3-5 farmer visits/night) caused a significant decrease in heron numbers but became less effective as heron numbers increased. Reduced numbers did not necessarily reduce fish consumption, as maximum predation occurred soon after bird arrival and disturbance mostly discouraged only well-fed birds from returning.

A 1987 literature review (Draulans 1987) found that there was little evidence that scaring devices at fish farms succeeded in increasing fish stocks/reducing losses. Devices could be classified as visual (scarecrows, flags, reflectors, lights, model etc), acoustic (gun shots, firecrackers and gas cannons) or biological (recordings of distress calls etc). Black-crowned night herons *Nycticorax nycticorax* were deterred by distress calls but only close to the speaker and no data are presented to support any positive effects on fish stocks. The use of dead birds, model predators and dogs is reported by several authors as almost completely ineffectual. Trained raptors seemed effective but expensive.

A series of experiments in Flevoland, the Netherlands, in 1981-3 (Moerbeek et al. 1987) found that pistol-fired flash cartridges (detonation after a light flash, or a flash only) appeared the most effective method of deterring great cormorants *Phalacrocorax carbo* from ponds and scared most birds away (although some alighted on nearby ponds). Gas cannons (producing a bang at regular or irregular intervals) had little effect as birds soon habituated to the noise; an overflying helicopter scared cormorants from ponds but they soon returned (on the day following the 2-day trial large numbers were present). An ultra-light aircraft proved inconclusive.

A before-and-after trial at 25 fish ponds in a catfish farm over 45 days in February and March 1992 in the Mississippi delta region, USA (Stickley & King 1995), found that using a 'Scarey Man' resulted in a rapid decrease in double-crested cormorant *Phalacrocorax auritus* numbers (320 birds/patrol before treatment vs. 8/patrol for the first seven days after erection and 16/patrol for the whole 46 day experiment). Clothing the devices to resemble marksmen, replacing them with actual marksmen and using propane gas exploders (at up to six Scarey Man positions for 23 days) did not further reduce cormorant numbers.

A 1995 review assessed effectiveness of techniques used to prevent double-crested cormorant *Phalacrocorax auritus* predation at aquaculture facilities in the Mississippi delta region, USA (Mott & Boyd 1995), and concluded that there was little good evidence for what worked and what did not. Pyrotechnics, human effigies, gas cannons, and live ammunition have been used with varying degrees of success in frightening cormorants, but the authors warn that birds can become habituated to them.

A replicated trial in New South Wales, Australia (Rowland 1995), found that hanging gill nets in fish ponds and using harassment patrols to deter cormorants *Phalacrocorax* spp. from fish farms was not effective. This study is discussed in 'Use in-water devices to reduce fish loss from ponds'.

A replicated, controlled, paired sites study in winter-spring 1991 at four pairs of catfish farms in the Mississippi delta region, USA (Stickley et al. 1995), found a 71-99% reduction in double-crested cormorant *Phalacrocorax auritus* numbers following the deployment of six 'Scarey Man' devices for 10-19 days. However, signs of habituation became apparent (reduced flush success) within the trial period at three sites.

A before-and-study in May-June 1993 at a trout-rearing farm in Colorado, USA (Andelt & Hopper 1996), found a 48% reduction in black-crowned night heron *Nycticorax nycticorax* numbers following the broadcasting heron alarm/distress calls for 11 days (pre-treatment average 77 birds; treatment 40; post-treatment 69). However, numbers and the proportion remaining increased from nights over the treatment phase, indicating habituation. Great blue heron *Ardea herodias* numbers were unaffected (pre-treatment 15; treatment 13; post-treatment 16). Herons were counted during six pre-treatment (12-13 to 18-19 May 1993), five treatment (21-22 May to 31 May-1 June 1993), and five post-treatment (1-2 to 11-12 June 1993) nights. Calls were broadcast through each night of the 11 day treatment period: 15-sec sequences of night heron calls followed by 14 min without calls, then a similar sequence of great blue heron calls.

A series of before-and-after trials in trout farms in Colorado, USA, in 1990-2 (Andelt et al. 1997), found that pyrotechnics were effective at decreasing the number of black-crowned night-herons *Nycticorax nycticorax* and great blue herons *Ardea herodias* at farms. Firing pyrotechnics for 14 consecutive nights was more successful than doing so for seven nights. Frightening every fifth night was unsuccessful. Rotating lights did not reduce the number of attempted or successful fish captures. 'Scarey Man' reduced heron numbers during the first four nights but numbers of both species subsequently increased substantially to night 18, indicating habituation.

A controlled, replicated before-and-after experiment in January-April and October 1998, and March 1999, in Argyll, Scotland (Ross et al. 2001), found that an underwater playback system (UPS) was effective in deterring common eider *Somateria mollissima* from feeding on mussels *Mytilus edulis* at farms on two sea lochs (47-80% fewer birds feeding after use of the UPS; 2-37 birds feeding before use). Underwater recordings of an approaching 'scare boat' (scaring by boat being a conventional deterrent method) were played via an underwater loudspeaker, and also a 'control' i.e. playback of an unassociated sound. Average return time of eiders after chasing by boat also increased significantly, suggesting that effectiveness was strengthened by UPS.

Replicated ex situ experiments in Ohio, USA (Dolbeer et al. 2002), found that $\mu 10\text{mW}$, 633nm laser did not repel brown-headed cowbirds *Molothrus ater* or European starlings *Sturnus vulgaris* from a perch over three trials with stationary and moving laser beams treating a randomly selected perch. Effectiveness of a 68mW, 650nm laser in dispersing starlings and rock doves *Columba livia* from perches, and Canada geese *Branta canadensis* and mallard *Anas platyrhynchos* from grass plots was also tested. Starlings did not disperse when targeted with the beam, doves dispersed only in the first 5 min of six 80 min treatment periods. An average, 96% of individual geese in six groups of four birds, dispersed from laser-treated plots during 20-min periods (23 replicates). Mallard dispersed (average 57% of individuals) during 20-min treatment periods, but habituated to the beam after about 20 min.

A before-and-after study in northern Israel (Nemtsov 2005) found that pygmy cormorants *Phalacrocorax pygmeus* relocated away from colonies near fish farms during 1999-2002, following the use of gas cannons and pyrotechnics to scare birds before the start of nesting in winters between 1999-2000 and 2002-3. Between 1998 and 2004, the overall number of cormorant nests in the area increased from 60 to approximately 110 (reaching a high of approximately 155 in 2001), possibly due to greater reproductive success with lower levels of persecution following relocation.

At four sites around Lake Como, Italy, a controlled replicated experiment (Gagliardi et al. 2006) found that none of three deterrents (gas cannon detonations, fire crackers and shooting near birds) were effective or practical in deterring great crested grebes *Podiceps cristatus* from areas with commercially important common bleak *Alburnus alburnus* shoals. Grebe behavioural response was recorded during 3-h observation periods when deterrents were or were not, in use. Cannons had little effect. Crackers and shooting caused significant behavioural changes (less time feeding, resting and preening, and more time swimming) compared to control periods, but grebe numbers were only temporarily reduced in the vicinity.

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APPENDIX C 2016 DRY SEASON WATERBIRD COUNTS AND REVIEW OF THE 2015 AND 2016 DRY SEASON SURVEY PROGRAMS



**PROJECT SEA DRAGON
STAGE 1 LEGUNE GROW-OUT FACILITY
SUPPLEMENTARY ENVIRONMENTAL IMPACT STATEMENT**

**APPENDIX C 2016 DRY SEASON WATERBIRD
COUNTS AND REVIEW OF THE
2015 AND 2016 DRY SEASON
SURVEY PROGRAMS**



2016 Dry Season Waterbird Counts and Review of the 2015 and 2016 Dry Season Survey Programs

Project Sea Dragon Stage 1 Grow-out Facility

Legune Station, Northern Territory

Prepared for:	CO2 Australia
Prepared by:	Lindsay Agnew, Austecology
Report Status:	Final – 17 December 2016

Table of Contents

1.	Introduction	4
1.1.	Background and Purpose	4
1.2.	Terminology, Nomenclature and Acronyms.....	5
2.	Methodology	7
2.1.	Field Survey Program.....	7
2.2.	Study Team	7
2.3.	Permits.....	8
3.	Results and Discussion.....	9
3.1.	2016 Survey Program Results	9
3.2.	Comparative Assessment - 2015 and 2016 Survey Program Results	12
3.2.1.	Potential Influences on Survey Results.....	12
3.2.1.1.	Survey Timing and Sequencing	12
3.2.1.2.	Count Techniques and Personnel.....	12
3.2.1.3.	Survey and Seasonal Conditions	14
3.2.1.4.	Forsyth Dam Storage and Release Management Strategies	18
3.2.2.	Waterbird Assemblage Characteristics	21
3.2.2.1.	Species Diversity.....	21
3.2.2.2.	Variation in estimates of Waterbird Abundance	21
3.2.2.3.	Variation in Abundance across Foraging Guilds.....	23
3.2.2.4.	Migratory Shorebirds	26
3.2.3.	Waterbird Count Areas not affected by Inundation.....	27
4.	Conclusions	32
5.	References	34

List of Figures

Figure 3-1	Comparison of Survey Event Timing	12
Figure 3-2	Replicated Dry Season Waterbird Count Coverage – 2015 and 2016.....	13
Figure 3-3	Rainfall Deciles 1 December 2014 to 30 November 2015.....	16
Figure 3-4	Rainfall Deciles 1 December 2015 to 30 November 2016.....	16
Figure 3-5	Rainfall Deciles 1 June to 30 November 2015	17
Figure 3-6	Rainfall Deciles 1 June to 30 November 2016	17
Figure 3-7	Infrastructure Controls Applicable to Forsyth Dam Releases	20
Figure 3-8	Waterbird Species Richness Summary	24
Figure 3-9	Pattern of Overall Waterbird Abundance.....	24
Figure 3-10	Changes in Magpie Goose Abundance	25
Figure 3-11	Changes in Green Pygmy-Goose Abundance	25
Figure 3-12	Changes in Wandering Whistling-Duck Abundance	25
Figure 3-13	Migratory Shorebird Species Richness	29
Figure 3-14	Pattern of Overall Migratory Shorebird Abundance	29
Figure 3-15	Changes in Little Curlew Abundance	29
Figure 3-16	Dry Season 2015 and 2016 Curlew Sandpiper Records.....	30
Figure 3-17	Curlew Sandpiper Abundance – All Count Areas.....	31
Figure 3-18	Curlew Sandpiper Abundance – Alligator Ck Downstream of Crocodile Crossing ..	31
Figure 3-19	Curlew Sandpiper Abundance – Alligator Ck Upstream of Crocodile Crossing	31

List of Tables

Table 1-1	Report Acronyms	6
Table 3-1	Summary of 2016 Waterbird Count Results	11
Table 3-2	2016 Dry Season Curlew Sandpiper Records	11
Table 3-3	2016 Count Data Summary – Waterbird Count Areas not subject to Inundation	28

List of Attachments

Attachment A	2015-2016 Dry Season Waterbird Count Data	37
Attachment B	Waterbird Distribution and Feeding Guild Review	47

1. Introduction

1.1. Background and Purpose

Project Sea Dragon Pty Ltd, a wholly owned subsidiary of Seafarms Group Limited (Seafarms), proposes to develop Project Sea Dragon, a large, fully integrated, prawn aquaculture project located in northern Australia. Project Sea Dragon is a large project with a long development timeline (approximately 7 years) between first operations and full scale operations.

A comprehensive assessment report¹ (Austecology 2016) has previously been prepared as part of the Environment Impact Statement prepared for Stage 1 of Project Sea Dragon being the Grow-out Facility to be situated on Legune Station (hereafter PSDS1).

The Austecology (2016) report included a comprehensive program of waterbird surveys across the extent of freshwater wetlands during the 2015 dry season². That work included coverage of the floodplain wetlands associated with both Alligator Creek and Forsyth Creek, the two major waterway catchments of the site³.

Forsyth Dam was constructed in 2005 to support pastoral operations on the site, including the provision of a single, dry season irrigation event to parts of the floodplain within both the Forsyth Creek and Alligator Creek catchments (Freeland 2004).

Annual dam releases commenced in 2007 (*pers comm.* O. Stacy 2016). Typically, these dam releases occur towards the end of the dry season from July to September, and can prolong inundation of the floodplain downstream by one to two months depending on the volume released (*pers comm.* C. Rasheed 2016). Total estimated storage capacity of Forsyth Dam is 35GL.

The results of the 2015 dry-season waterbird survey program demonstrated that the annual release of water from Forsyth Dam produced a significant positive influence on waterbird abundance within the Alligator Creek wetland system, which was sustained – though with diminishing effect - throughout the remainder of the dry season.

As a result of the modelling of the PSDS1 development requirements, it has been determined that replication of the previous annual release regime will not be possible given the freshwater requirements to sustain the proposed development and other pastoral operational requirements.

In regards to potential impact associated with the cessation of annual releases, the Austecology (2016) report concluded the following:

-) There was sufficient anecdotal evidence to suggest that habitat would persist throughout the dry season within the lower channel sections of Alligator Creek and associated wetlands.

¹ EIS Volume 5, Appendix 15, Austecology 2016.

² A systematic ground-based survey count of all freshwater wetlands implemented during each of six survey events (June to November 2015 inclusive).

³ These catchments have an area of 315km² and 707km² respectively.

Furthermore, that floodplain hydrology modelling indicated that water would remain in upstream sections of Alligator Creek and associated wetlands.

-) There was insufficient information to confidently assess the degree of the assumed decline in waterbird abundance, or whether the site could maintain waterbird abundance above the reviewed significance thresholds (e.g. Ramsar Criterion 5), and thus maintain a key value of the Legune coastal floodplain SCS (DNREaS 2015).
-) That future monitoring of waterbirds within the Alligator Creek system in the dry season, in the absence of a release from Forsyth Dam, would be required to provide adequate data to assess the degree of the predicted decline, and potentially, a basis to assess options if required, to provide what additional corrective actions may be required to sustain waterbird abundance in excess of the threshold for International importance (e.g. Ramsar Criterion 5).

The 2015/2016 wet season conditions produced significantly less storage within Forsyth Dam. The resulting lower volume of inundation (approximately 30% of the 2015 release) was considered to provide conditions similar to a post-development (Stage 1) scenario for water releases, with which to assess the degree of the predicted waterbird decline.

This report, provides the results of the supplementary waterbird survey program undertaken during the 2016 dry season to investigate waterbird usage, particularly in terms of abundance, under these drier conditions.

1.2. Terminology, Nomenclature and Acronyms

Within this report, the following terms are used:

-) **Site** or **Legune Station** – the area comprising NT Portion 798 and Portion 3222 in the Victoria River District.
-) **Project area** - that part of Legune Station which is within the Stage 1 Legune Grow-out Facility (PSDS1) development footprint.
-) **Region** or **surrounding area** - the lands within the Victoria Bonaparte Bioregion and northern parts of the Ord Victoria Plain Bioregion, both of which encompass land within the Northern Territory and Western Australia (IBRA version 7)⁴.
-) **Waterbird** - refers to those species⁵ which are ecologically dependent upon wetlands (after Kingsford & Norman 2002; and Wetlands International 2016).
-) **Shorebird** - refers to both resident and migratory species⁶ which are ecologically dependent upon shallow wetlands and form a subset of the waterbird grouping (after Geering *et al.* 2007).
-) **Threatened** - a common use term to collectively describe species listed as Critically Endangered, Endangered or Vulnerable species under Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and/or the *Territory Parks and Wildlife Conservation Act 2000* and its regulations and amendments.

⁴ Interim Biogeographic Regionalisation for Australia, Version 7, 2012. Australian Government Department of Sustainability, Environment, Water, Population and Communities.

⁵ From the following Families: Anseranatidae, Anatidae, Podicipedidae, Anhingidae, Phalacrocoracidae, Pelecanidae, Ardeidae, Threskiornithidae, Ciconiidae, Gruidae, Rallidae, Scolopacidae, Rostratulidae, Jacanidae, Burhinidae, Haematopodidae, Recurvirostridae, Charadriidae, Glareolidae, Laridae and Sternidae.

⁶ From the following Families: Scolopacidae; Burhinidae; Rostratulidae, Haematopodidae; Recurvirostridae; Charadriidae; and Glareolidae.

-) **Alligator Creek wetland system** – the extent of freshwater wetlands associated with Alligator Creek in the dry season upstream of Point D (the tidal barrage). The extent of this system is the focus of the waterbird survey programs in 2015 and 2016.
-) **Waterbird count area** – a spatially defined part of the Alligator Creek wetland system subject to surveys in 2015 and 2016, e.g. AC1 to AC9, and IA3.
-) **Survey program** – the series of four consecutive survey events implemented within the Alligator Creek wetland system.
-) **Survey event** – one of four surveys of the complete suite of waterbird count areas over consecutive days which form part of the survey program.
-) **Survey** - the activity by which waterbirds are searched for, identified and counted.
-) **Count** - the number of individuals counted for a particular species of waterbird.

Nomenclature used for this study follows Christidis & Boles (2008). Vegetation type descriptions used in this report are based on the structural types described by Astrebla Ecological Services (2016).

The conservation status of a species is described in accordance with the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and/or the *Territory Parks and Wildlife Conservation Act 2000* and its regulations and amendments.

Acronyms used in this report are provided in **Table 1-1**.

Table 1-1 Report Acronyms

Acronym	Name, Term or Expression
DE	Commonwealth Department of the Environment
DLRM	Northern Territory Department of Land Resource Management
EPBCA	Commonwealth Environment Protection and Biodiversity Conservation Act 1999
MNES	Matter of National Environmental Significance (as defined under the EPBCA)
PSDS1	Project Sea Dragon Stage 1 Legume Grow-out Facility
NTEPA	Northern Territory Environment Protection Authority
SEWPaC	Former Commonwealth Department of Sustainability, Environment, Water, Population & Communities
sp.	Species (singular)
spp.	Species (plural)
TSSC	Threatened Species Scientific Committee for the Commonwealth Department of the Environment
TPWCA	Northern Territory Territory Parks and Wildlife Conservation Act 2000
WMA	Northern Territory Weeds Management Act 2001
WoN	Weed of National Significance as listed by the Australian Weeds Committee 2012

2. Methodology

2.1. Field Survey Program

The design and implementation of the 2016 survey program was informed by previous experience in practices which provide consistency with recognised survey guidelines and best practice guidelines, e.g.: DEWHA 2009; DEWHA 2010; Wetlands International 2010; NT EPA 2013; and DE 2015.

The 2016 survey program provided a replication of the survey effort and coverage of the 2015 survey program throughout the Alligator Creek wetland system⁷. The resultant systematic survey of the Alligator Creek wetland system was implemented during each of four survey events (July to November 2016). **Figure 3-2** describes the location and survey extent of each surveyed wetland count areas.

The survey program comprised a pre-inundation survey, with the remaining three events staged to cover post-inundation conditions throughout the remainder of the dry season. The timing of each of the 2016 survey events was determined in order to reflect the temporal relationship of the 2015 survey events and pre/post-inundation conditions. **Figure 3-1** describes the timing sequences of both the 2015 and 2016 survey events.

The following 2015 survey protocols were replicated during the 2016 survey program:

-) The order in which waterbird count areas were surveyed was determined through an on-site field reconnaissance prior to initiating each survey event.
-) Each survey of a wetland count area was completed within the survey day they were started, i.e. no incomplete surveys were “carried over” to the following survey day, and each was typically completed within a few hours.
-) In order to progress surveys efficiently, small grebe and tern species (which often cannot be readily identified to species level) were not counted separately but tallied as “small grebe species” and “tern species”. The presence of individual tern and grebe species was, however, noted to provide species richness totals for each waterbird count area.

2.2. Study Team

The field study team comprised Lindsay Agnew (all four survey events), Dr Ed Meyer (1st and 2nd survey events), Jeff Giddings (3rd survey event), and Roger Jaensch (4th survey event). All members of the study team have experience undertaking waterbird surveys, with LA, EM and RJ having undertaken waterbird surveys on site previously.

Ed Meyer and Roger Jaensch also provided helpful comments in regards to the data interpretation and input to report sections focussed on contextualising waterbird values of the site.

⁷ Other parts of the Legune wetlands complex normally are dry in all but the first months of the dry season.

2.3. Permits

All methods required to implement the field survey work, were employed in accordance with the relevant NT TPWCA scientific research permits (57593 & 51606) and Animal Ethics Committee Approval (DAFF QLD CA2014/07/784).

3. Results and Discussion

3.1. 2016 Survey Program Results

The 2016 survey program encompassed 13 waterbird count areas. Several wetland count areas were surveyed in July, however had dried-out by the following survey event in August (i.e. AC3, AC4, & AC5). As in 2015, other wetland count areas were introduced into the survey program in August after inundation from the release of water from Forsyth Dam (i.e. IA1, IA2, & IA3). Waterbird count areas along Alligator Creek which supported water throughout the survey program included sites AC1, AC2, AC6, AC7, and AC8.

The 1st survey event (1 to 4 August 2016) preceded the release of Forsyth Dam by approximately one week (with the release beginning on 11 August). The 2nd survey event was timed to assess the early influence of the inundation (within 19 to 22 days of the release).

The subsequent 3rd and 4th survey events were timed to assess the progressive decline of the inundation's influence, at similar lag times to the 2015 surveys. These survey events also provided the opportunity to count migratory shorebirds at their peak abundance with the progressive arrival from about September of birds into northern Australia (on their return migration from breeding grounds in the Northern Hemisphere).

Of the four survey events, the highest count total was recorded during the 2nd survey event (101,042 birds) and the lowest during the 4th and final survey event (42,726 birds). The 2nd survey event followed shortly after the inundation from Forsyth Dam. Large numbers of Magpie Geese (71,777) contributed significantly (~71%) to the overall count total for the 2nd survey event. The increase in species richness results for the 3rd survey event can be attributed largely to the arrival of migratory shorebird species. **Table 3-1** provides a summary of the results for each of the 2016 survey events.

Individual counts for four species exceeded the 1% population thresholds (after Wetlands International 2016 or Bamford *et al.* 2008)⁸. Those individual counts⁹ were from the Alligator Creek wetlands, with the exception being the record for Magpie Goose which was derived from the nearby IA3 wetland.

Counts from a waterbird count area, which were robust in minimising any risk of bird movement, and which met thresholds for international importance were:

-) Wandering Whistling-Duck (1% = 10,000) – 13,512 birds (1st survey event);
-) Green Pygmy-Goose (1% = 1,000) – 1,192 birds (1st survey event), 1,567 birds (2nd survey event), 1,664 birds (3rd survey event);

⁸ A globally accepted approach to assessing wetland importance is to compare survey results with criteria adopted under the Ramsar Convention on Wetlands to identify internationally important wetland habitat. In regard to a waterbird species, the relevant threshold being at least 1.0% of the individuals in a population of one species or subspecies of waterbird.

⁹ Note: these counts are based on a single wetland count and do not reflect the overall species count for the survey event. This conservative approach minimises the impact of the inclusion of repeat counts at other wetland count areas included within the survey program.

-) Magpie Goose (1% = 20,000) – 61,840 birds (2nd survey event); and
-) Little Curlew (1% = 1,800) – 3,179 birds (4th survey event).

Apart from the Little Curlew record, there were no count results for any migratory shorebird species from the Alligator Creek wetland system which exceeded the 1% population threshold, i.e. which meet the Ramsar Convention Criterion 6 for International importance.

In regard to migratory shorebirds, EPBC Act Policy 3.21 indicates that if a wetland regularly supports 0.1% of the East Asian-Australasian Flyway (the flyway) population of a single species, then it is regarded as a wetland of National importance (DE 2015). By extrapolation from the data provided in Bamford *et al.* (2008), individual counts¹⁰ from a single waterbird count area, which were robust in minimising any risk of bird movement, and which exceeded the 0.1% threshold during the 2016 dry season surveys were :

-) Little Curlew (0.1% = 180) – 210 birds and 617 birds from separate counts during the 3rd survey event which are in addition to the 1% threshold count previously cited;
-) Sharp-tailed Sandpiper (0.1% = 160) – 778 birds (3rd survey event);
-) Oriental Plover (0.1% = 70) – 252 birds (4th survey event);
-) Little Curlew (0.1% = 180) – 536 birds (4th survey event) and in addition to the 1% count previously listed;
-) Marsh Sandpiper (0.1% = 100) – 101 birds (4th survey event);
-) Wood Sandpiper (0.1% = 100) – 104 birds (4th survey event);
-) Long-toed Stint (0.1% = 25) – 50 birds (4th survey event); and
-) Sharp-tailed Sandpiper (0.1% = 160) – 216 birds (4th survey event).

The Curlew Sandpiper *Calidris ferruginea* was the only threatened species recorded during the 2016 survey program of the Alligator Creek wetland system. This species is listed as *Critically Endangered* under the EPBCA, and as *Vulnerable* under the TPWCA. The Curlew Sandpiper has previously been recorded at a variety of locations within the Alligator Creek wetland system, though also in notable numbers at both Osmans Lake (in the western part of the site) and at Turtle Point roost site (locations not included with the 2016 survey program).

Curlew Sandpipers were also recorded in small numbers during 1st and 3rd survey events (though not recorded during the 2nd event) with the highest individual count of 33 birds recorded during the 4th survey event. That record comprised two groups (~21 and 12 birds) observed foraging with other small shorebirds within an area of very shallow water and exposed mud adjacent to Alligator Creek (near Crocodile Crossing).

Table 3-2 provides a summary of Curlew Sandpiper records, whilst **Figure 3-16** illustrates the location of each of the records.

¹⁰ Note: these counts are based on a single wetland count area and do not reflect the overall species count for the survey event. This conservative approach minimises the impact of the inclusion of repeat counts at other waterbird count areas included within the survey program. Most published counts of waterbirds across a wetland complex take the less conservative approach of adding data from all sectors and thus our results are understated in that context.

Attachment A provides a detailed presentation of the waterbird species recorded at each of the waterbird count areas for each of the four survey events, and provides a comparison with the equivalent 2015 survey data.

Table 3-1 Summary of 2016 Waterbird Count Results

Survey Event	Waterbird Abundance	Waterbird Species Richness
Survey Event 1	44,426	47
Survey Event 2	101,042	46
Survey Event 3	50,780	58
Survey Event 4	42,726	54

Table 3-2 2016 Dry Season Curlew Sandpiper Records

Number of Birds	Survey Event	Waterbird Count Area	Latitude	Longitude	Comments
2	1	AC5	-15.208425°	129.346071°	
3	3	AC2	-15.191650°	129.341441°	
3	3	AC7	-15.213995°	129.377798°	
6	3	AC1	-15.147055°	129.345583°	The combination of birds at distance and heat haze reduced reliability of identification of additional birds - possibly a further 5 birds amongst a larger feeding flock of small shorebirds.
13	3	AC8	-15.226789°	129.370898°	
7	4	AC7	-15.214320°	129.387366°	
33	4	IA3	-15.207340°	129.389548°	Record comprises two general groups (21 and 12 birds). On an area of very shallow water and drying mud adjacent to Alligator Creek - similar count on two subsequent days.

3.2. Comparative Assessment - 2015 and 2016 Survey Program Results

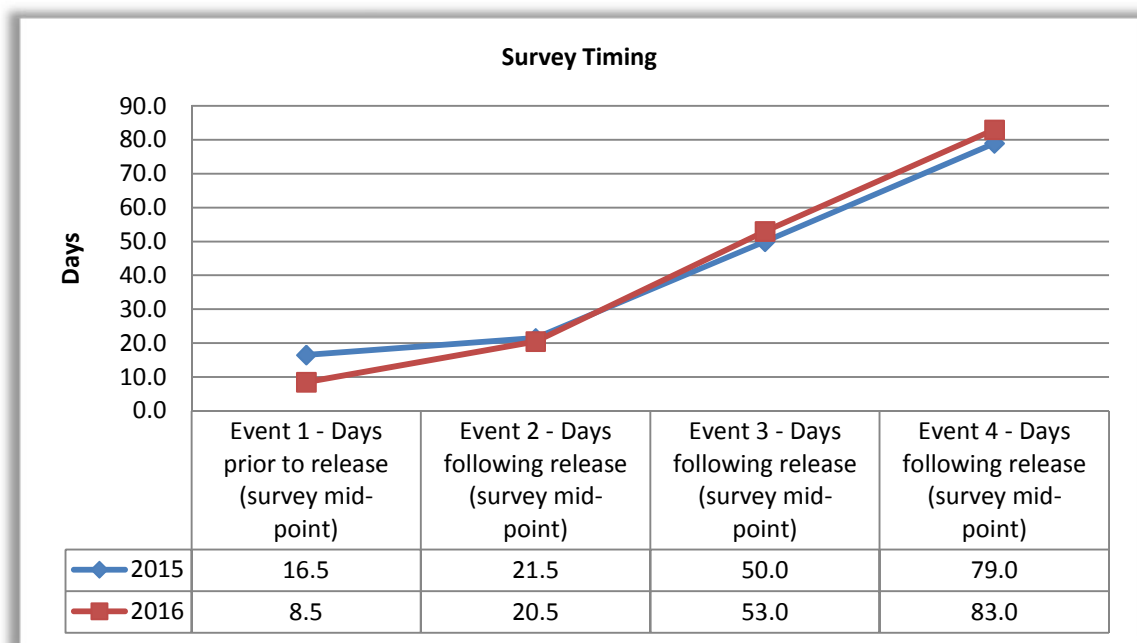
3.2.1. Potential Influences on Survey Results

3.2.1.1. Survey Timing and Sequencing

The 2016 survey replicated the four 2015 dry-season survey events (see **Figure 3-2**). Both survey programs comprised a pre-inundation survey event, with the remaining three survey events staged to sample post-inundation conditions throughout the remainder of the dry season. The timing of each of the 2016 survey events is broadly consistent with the timing of the 2015 survey events.

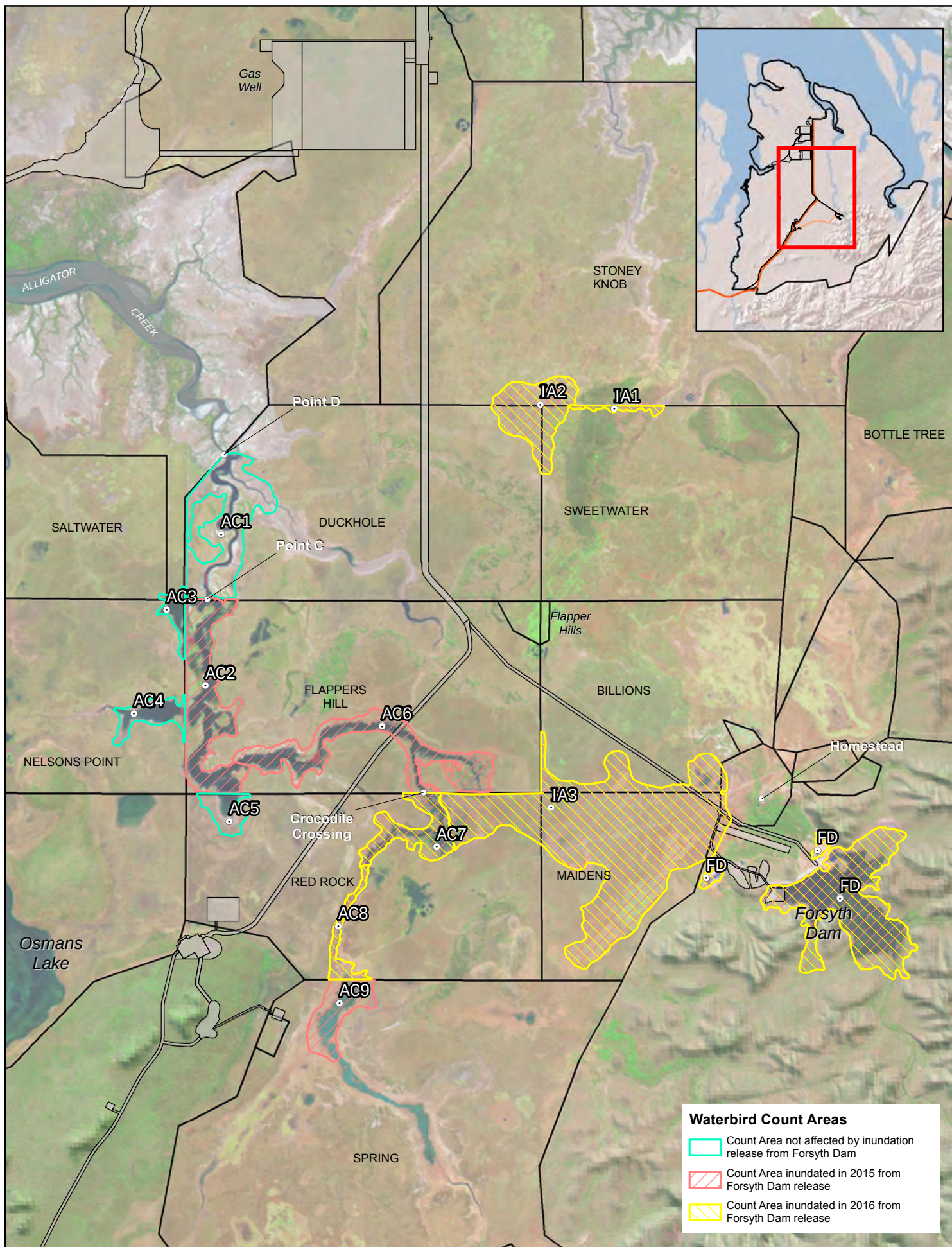
As illustrated in **Figure 3-1**, there is a strong similarity in the timing of each survey event in both survey programs. The strong correlation between the survey programs in this regard, minimises the potential for differences in results arising from having surveyed the waterbird count areas at different times.

Figure 3-1 Comparison of Survey Event Timing



3.2.1.2. Count Techniques and Personnel

Three of the four field investigators had previously implemented waterbird surveys on the site. The author participated in all of the 2015 and 2016 survey events. These circumstances contribute strongly to continuity and consistency in approaches taken for the counting of waterbirds in the 2015 and 2016 survey programs. Hence, the potential for differences in count results which could arise from unfamiliarity with site characteristics and survey protocols, and from personal differences in survey approach, was minimised.



3.2.1.3. Survey and Seasonal Conditions

All of the counts during the eight survey events were conducted under fine conditions – no counts were undertaken during rainfall or storms. Average ambient temperatures between each pairing of 2015 with 2016 survey events were similar (Australian Bureau of Meteorology data).

Data for rainfall has been collected on Legune Station since 1957, providing 55 years of data to date. The data indicates the following:

-) Annual rainfall - minimum of 583mm, median of 1,088mm, and maximum of 1,728mm; and
-) Wet season (December-March) rainfall – minimum of 440mm, median of 938mm, and maximum of 1,923mm.

The following is of relevance in considering potential influences related to differences in the results between the two survey programs:

-) In regard to the 2015 dry season survey program – the preceding wet season provided local rainfall (1,030mm) that was above the median value.
-) In regard to the 2016 dry season survey program - the preceding wet season provided local rainfall (871mm) that was below the median value.

These outcomes indicate that locally, comparatively drier conditions preceded the 2016 survey program. Within a regional context, Australian Bureau of Meteorology data shows a similar pattern, with the 2016 season being comparatively drier. It could be expected that drier seasonal conditions would have a bearing on wetland availability on the site and surrounding region.

As a result of the comparatively poorer wet season conditions, there was significantly less water available for release¹¹ from Forsyth Dam¹² in 2016, i.e.:

-) In August 2015, approximately 23GL of water was available for release from Forsyth Dam (*pers comm.* O. Stacy 2016).
-) In August 2016, the release was limited to approximately 7GL of available water for release (*pers comm.* O. Stacy 2016).

This difference is also borne out in the comparison between the summary of rainfall deciles for the 12-month period December to November of relevance to each survey program (Australian Bureau of Meteorology), i.e. “above average” rainfall conditions of relevance to the 2015 survey program and “average” rainfall conditions of relevance to the 2016 survey program for the site and surrounding region (see **Figures 3-3 and 3-4**).

The period June to August 2016 was characterised by above average rainfall over extensive areas of the continent, with June 2016 ranked as the second-wettest June on record nationally, July the 7th wettest on record, and August rainfall regarded as above to very much

¹¹ It should be noted that in both 2015 and 2016, all available water within Forsyth Dam was released. When release flows cease, there typically remains approximately 1GL on the floor as a result of the design of Forsyth Dam.

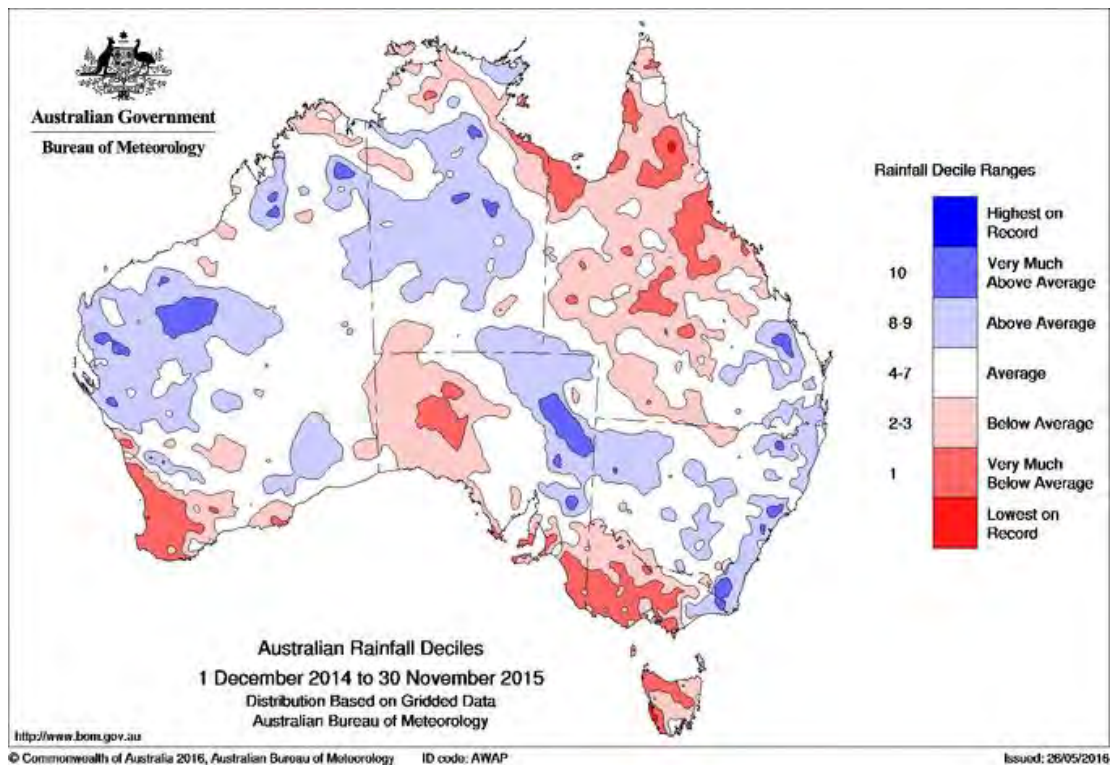
¹² Forsyth Dam has a catchment area of 56km² and holds up to 35GL of water at peak capacity.

above average¹³. Significant rainfall was recorded throughout southern parts of the Northern Territory, western Queensland, and north-western New South Wales. These conditions triggered moderate to major flood levels and increased availability of wetland habitat in inland Australia - particularly within the upper parts of the Lake Eyre drainage basin.

Regional and national climatic conditions are both relevant to the following interpretation of results from the waterbird survey programs.

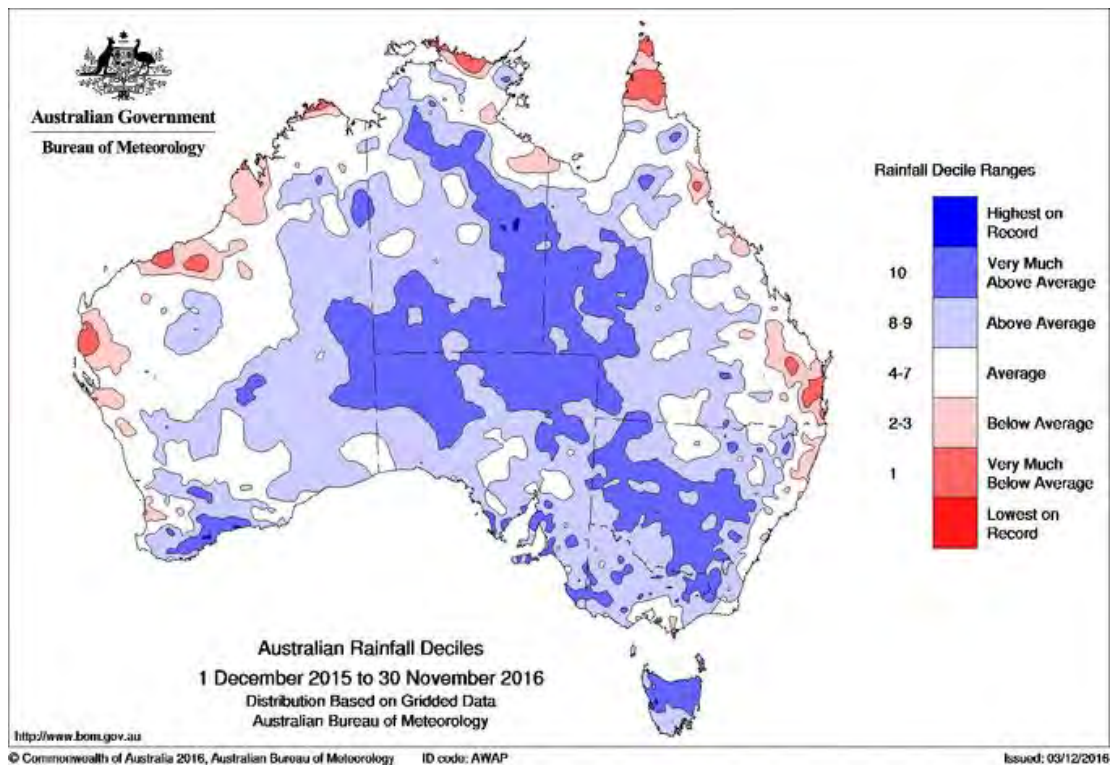
¹³ Data and climate summaries provided within the Australian Bureau of Meteorology's *Monthly Weather Reviews* (May to August 2016).

Figure 3-3 Rainfall Deciles 1 December 2014 to 30 November 2015



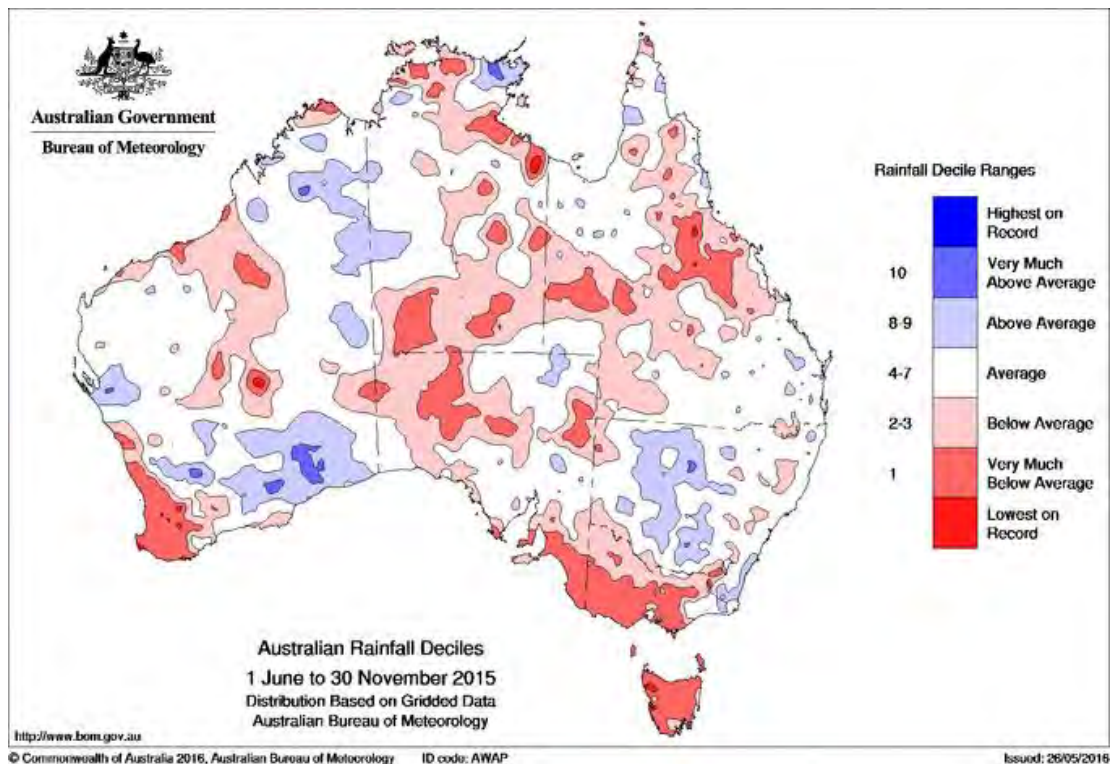
Source: Commonwealth of Australia 2016, Australian Bureau of Meteorology, www.bom.gov.au

Figure 3-4 Rainfall Deciles 1 December 2015 to 30 November 2016



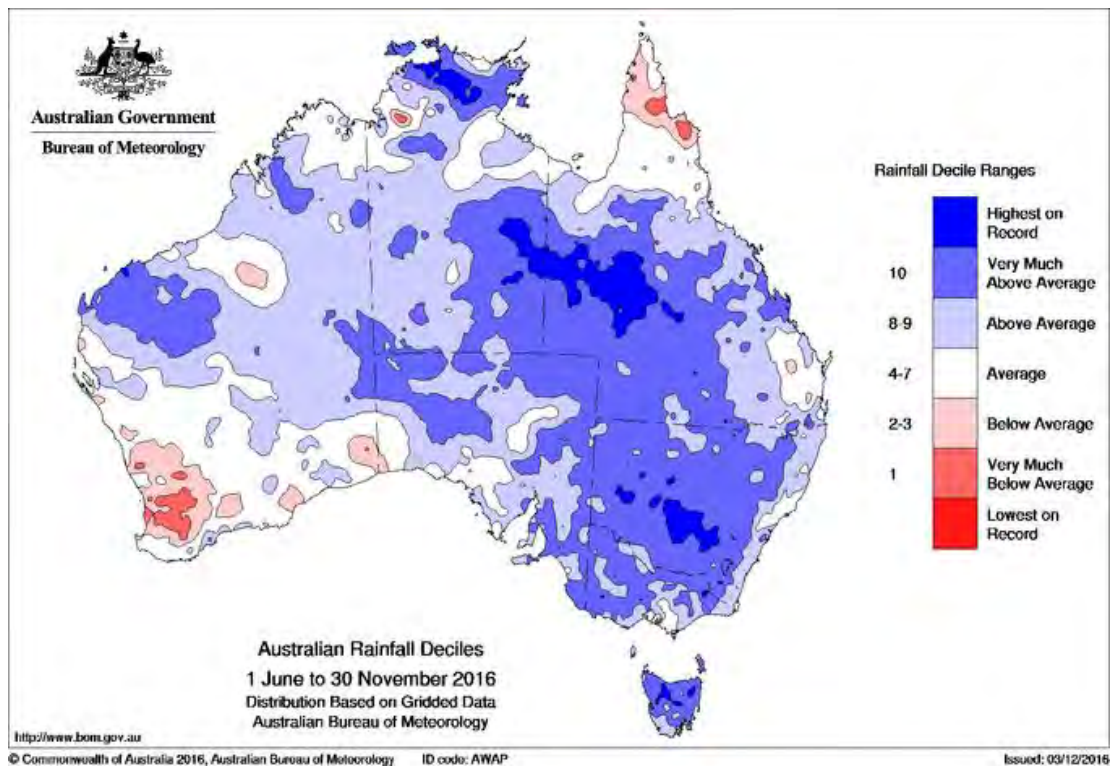
Source: Commonwealth of Australia 2016, Australian Bureau of Meteorology, www.bom.gov.au

Figure 3-5 Rainfall Deciles 1 June to 30 November 2015



Source: Commonwealth of Australia 2016, Australian Bureau of Meteorology, www.bom.gov.au

Figure 3-6 Rainfall Deciles 1 June to 30 November 2016



Source: Commonwealth of Australia 2016, Australian Bureau of Meteorology, www.bom.gov.au

3.2.1.4. Forsyth Dam Storage and Release Management Strategies

As noted previously, the water available for release in 2016 was significantly less than in 2015, i.e. approximately 30% of the water availability in 2015¹⁴. This prompted a different approach by the Legune station managers in 2016, influencing both the geographical spread and temporal duration of inundation. Waterbird habitat at Legune in the dry season thereby differed markedly between 2015 and 2016.

The following summary explores potential influences of differing management of habitat on count results between 2015 and the 2016 survey programs. **Figure 3-7** shows the location of features mentioned.

Following the initial release of water from Forsyth Dam, the first key area to be inundated is Maidens Paddock, with overland flow blocked by the bund on its western side (the boundary with Red Rock Paddock). Secondary flows enter Billions Paddock to the north (direct and via Maidens Paddock), though the extent of inundation is significantly less than that which enters Maidens Paddock.

In 2015, the greater volume of water created extensive deeper water conditions within Maidens Paddock, and as such, did not provide suitable habitat for a diverse or abundant waterbird assemblage during the 2nd survey event (1st post-inundation survey) - see results of IA3 count area (**Attachment A**). In 2016, the lower volume of water created comparatively shallower wetland habitat throughout Maidens Paddock which provided more favourable (and accessible) wetland habitats for a wider suite of species and greater numbers of waterbirds.

The most notable example of this influence is evident in the data for Magpie Goose. Wetland habitat within the south-eastern part of Maidens Paddock, which was heavily inundated in 2015 (deeper water) but only partially inundated in 2016 (shallower water). With more extensive foraging habitat (shallow inundated wetland), the numbers of Magpie Geese were much higher in 2016 with in excess of 61,00 birds counted in this area during the 2nd survey event (September 2016). In 2015 (2nd survey event), Magpie Geese were largely absent from this area, with birds concentrated in similar shallowly inundated wetland (with favoured *Eleocharis* sp. sedge) in downstream parts of the Alligator Creek wetland system - where the highest counts of Magpie Goose (in excess of 41,000 birds) were recorded.

Flows beyond Maidens Paddock continue westwards, via a bund overflow point, into the Alligator Creek system within Red Rock Paddock. Again, the extent of deeper water habitat throughout this part of the system in 2015 was greater than that observed in 2016 which may explain the greater abundance of birds recorded at waterbird count areas AC7 and AC8 during the 2nd survey event in 2016 (see **Attachment A**).

¹⁴ To reiterate, in both 2015 and 2016, all available water within Forsyth Dam was released. When release flows cease, there typically remains approximately 1GL on the floor as a result of the design of Forsyth Dam.

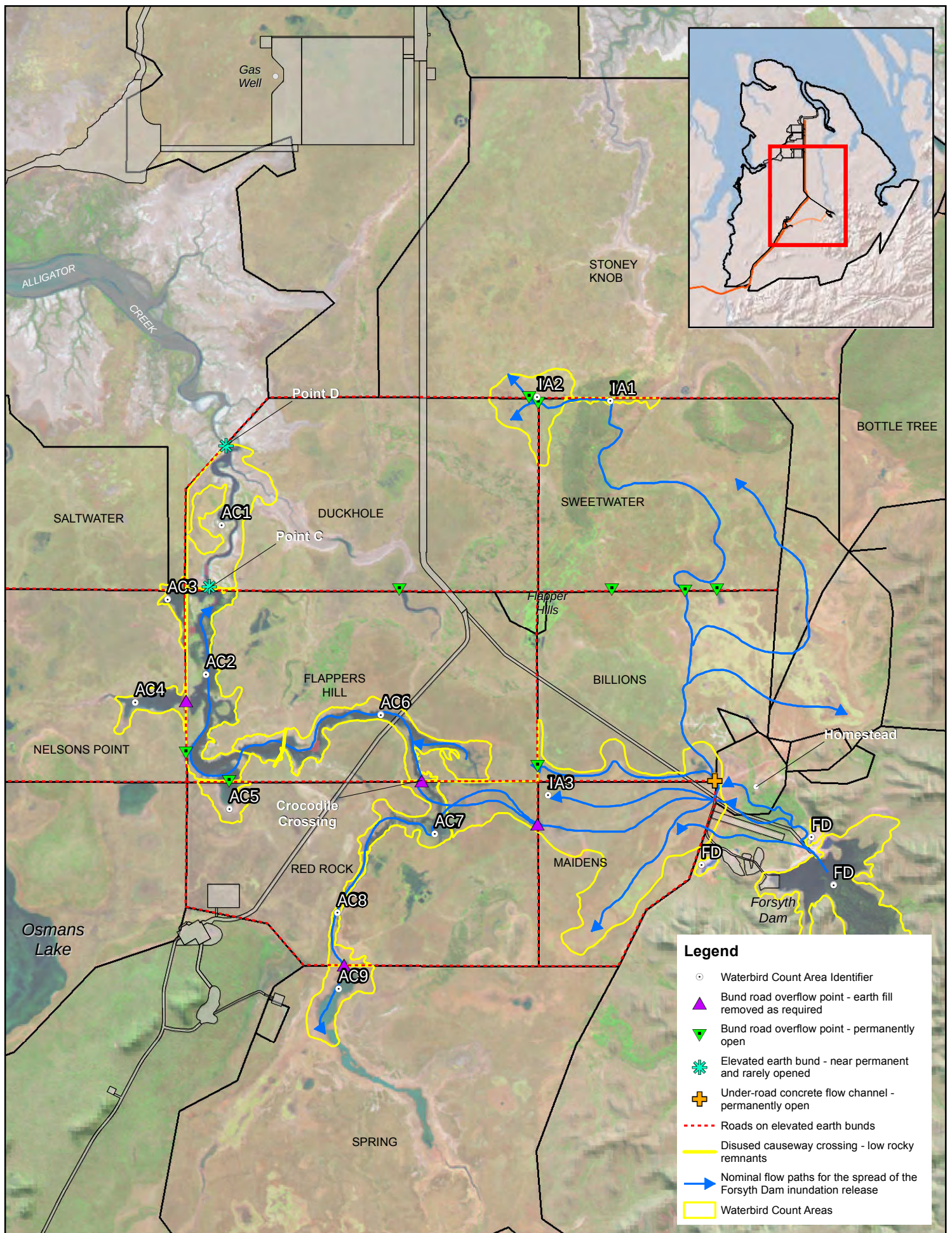
Controls within the bund system undoubtedly have a significant bearing on the timing and extent of inundation, and thus, wetland availability and characteristics¹⁵. An example relates to waterbird count area AC9, the most upstream count area on Alligator Creek. In 2015, the short bund separating this area from wetland habitat further downstream (i.e., at AC7 and AC8) was removed and a large area of shallow wetland habitat was created at AC9 following the release of water from Forsyth Dam. In 2016, however, this bund was left intact and AC9 remained dry following the release of water from Forsyth Dam. Thus, while large numbers of birds (5,285 in total) were counted from AC9 during event 2 in 2015, no waterbirds were recorded from AC9 during dry season surveys in 2016.

A significant flow control point along Alligator Creek is created by the bund at the so-called "Crocodile Crossing" on the main access road to the station homestead. During the 2nd survey event of 2015, the bund was broken and a significant and strong flow into the downstream waterbird count areas of AC6 and AC2 ensured.

Surveys conducted at this time revealed a dramatic increase in the number of waterbirds which accompanied the initial flows, including large numbers of Magpie Geese that foraged within the freshly wetted margins of the expanding shallow edge of the inundation in the eastern (backwater) section of waterbird count area AC6. In 2016, this bund was maintained, preventing the water released from Forsyth Dam reaching count areas AC6 and AC2. Conditions at sites AC2 and AC6 during the 2016 dry season may therefore somewhat reflect conditions in the future, once the release of waters from Forsyth Dam ceases.

It should be noted that in both 2015 and 2016, the bund at Point C (a significant flow control point) was maintained, thus conditions within waterbird count area AC1 were not affected by the release of water from Forsyth Dam. Dry season conditions at AC1 in 2015 and 2016 may therefore also reflect future conditions, with the proposed cessation of annual flows from Forsyth Dam.

¹⁵ These controls are not necessarily large or complex structures.



3.2.2. Waterbird Assemblage Characteristics

3.2.2.1. Species Diversity

Survey programs in the 2015 and 2016 dry seasons collectively yielded records of 71 waterbird species, including:

-) waterfowl (ducks and geese) – 11 species;
-) grebes – three species;
-) darter, cormorants and pelican – five species;
-) herons, ibis, egrets, and spoonbills – 14 species
-) storks and cranes – three species;
-) crakes, rails and jacana – four species;
-) shorebirds (non-migratory) – five species;
-) shorebirds (migratory) – 20 species; and
-) terns and gulls – six species.

There were no major differences in species richness between survey events or between survey programs in 2015 and 2016 (**Figure 3-8**).

3.2.2.2. Variation in estimates of Waterbird Abundance

The pattern of gross (total) abundance of waterbirds through the survey program sequence was similar in 2015 and 2016 (**Figure 3-9**). In summary, lowest abundance was recorded in the 1st survey event (the pre-inundation survey), then increased to the highest abundance during the 2nd survey event (1st post-inundation survey), then decreased through the 3rd survey event through to the final and 4th event. Abundance recorded in the final event remained higher than that recorded during the initial pre-inundation survey. The 2016 survey results reiterate the strong influence that the Forsyth Dam release generates on overall waterbird abundance and the pattern of abundance throughout the progression of survey event sequence.

Whilst the pattern of total abundance through each survey program sequence was similar, total abundance for each of the 2016 survey events was comparatively higher than for each of the corresponding 2015 survey events. The larger number of waterbirds recorded during the 2016 dry season surveys was especially influenced by increased abundance of two species (see **Figures 3-10 to 3-12**):

-) Magpie Goose:
 - o 11,116 (2016) versus 1,482 (2015) – 1st survey event.
 - o 71,777 (2016) versus 48,153 (2015) – 2nd survey event.
 - o 15,657 (2016) versus 8,621 (2015) – 3rd survey event.
-) Wandering Whistling-Duck:
 - o 18,263 (2016) versus 1,736 (2015) – 1st survey event.
 - o 13,406 (2016) versus 466 (2015) – 2nd survey event.
 - o 9,666 (2016) versus 2,447 (2015) – 3rd survey event.
 - o 4,901 (2016) versus 1,343 (2015) – 4th survey event.

In regard to the above, there was no apparent evidence of any significant changes in wetland condition and/or extent within the Alligator Creek wetland system that could be linked to the increase in the abundance of these species in 2016.

In regard to the Magpie Goose, it is possible that the different release management strategy may have rendered a greater area of wetland habitat favourable for a longer period in 2016. This, in and of itself, is however unlikely to account for the higher number of birds recorded during the 1st survey event, or necessarily be a significant contributor to the comparatively higher number of birds recorded during the 2nd or 3rd survey events in 2016 (*cf.* results from the equivalent 2015 survey events).

In regard to both Magpie Goose and Wandering Whistling-Duck, it is considered that regional rainfall patterns may provide a more likely explanation for a large part of the difference between the 2015 and 2016 results for these species. That is, an overall reduction in wetland availability within the wider surrounding region resulting from a comparatively poorer (average to below average) 2015/16 wet season (see discussion in **Section 3.2.1.3**; but also examples provided in Baylis & Yeomans 1990 and Morton *et al.* 1990 & 1991) - which would tend to cause these tropical waterbirds to move to semi-permanent wetlands near the coast, such as at Legune.

In contrast, notable changes in the abundance of some species may be better explained by wider rainfall patterns across central and northern Australia, rather than in regions immediately surrounding (i.e. regional climatic conditions). For example, the count data shows a significant difference (decrease) in abundance of Grey Teal, Hardhead, and Eurasian Coot during dry season surveys in 2016 (*cf.* dry season surveys in 2015) (see **Attachment C**).

This decrease in abundance is particularly noticeable in the data for Eurasian Coot:

-) 17 (2016) versus 4,753 (2015) – 1st survey event.
-) 3 (2016) versus 3,901 (2015) – 2nd survey event.
-) 0 (2016) versus 5,507 (2015) – 3rd survey event.
-) 2 (2016) versus 6,023 (2015) – 4th survey event.

Grey Teal, Hardhead, and Eurasian Coot are representative of the suite of Australian waterbirds that exhibit a more continental distribution - *cf.* Magpie Goose and Wandering Whistling-Duck which essentially maintain a northern distribution (see Frith 1982; and Marchant & Higgins 1990; and **Attachment B** summaries). Grey Teal, Hardhead, and Eurasian Coot are also representative of a suite of waterbirds known to undertake long distance movements in response to the irregular rainfall and flooding cycles which create large areas of, often highly productive, wetland habitat associated with floodplains along inland river systems (see e.g., Roshier 2009; Reid *et al.* 2010; and Kingsford *et al.* 2010). Flooding of inland rivers is capable of producing “boom” conditions resulting in massively increased habitat which can be extremely productive for all feeding groups of waterbirds, often resulting in significant breeding events (see e.g., Costelloe *et al.* 2004; Kingsford & Porter 1999; and Kingsford & Norman 2002).

As highlighted previously, unusually heavy rainfall in southern parts of the Northern Territory, western Queensland, and north-western New South Wales, resulted in significant flooding across inland Australia during June and July 2016 (**Section 3.2.1.3**) (see **Figures 3-5 and 3-6** for comparison of rainfall in 2015 and 2016). The near-absence and/or significant declines of Grey Teal, Hardhead, and Eurasian Coot in 2016 may therefore be attributed to the movement of birds inland to exploit newly-productive wetland habitat in areas such as the upper catchments of the Lake Eyre Basin.

In some cases, differences in abundance between survey programs (and survey events) defy ready explanation, as exemplified by the Plumed Whistling-Duck, numbers of which varied wildly in a seemingly unpredictable manner (see **Attachment A**). This species typically roosts or camps in wetlands by day and disperses to feed on short grass by night, therefore commonly moving camp according to grass availability rather than wetland conditions. Examples of differences in abundance of Plumed Whistling-Duck include the following:

-) 1st survey event – higher abundance recorded in 2015 (5,735 versus 3,448).
-) 2nd survey event - significantly higher abundance recorded in 2015 (12,763 versus 6,826).
-) 3rd survey event - similar abundance for both 2015 and 2016 (7,798 versus 9,688).
-) 4th survey event – significantly lower abundance recorded in 2015 (1,387 versus 10,692).

3.2.2.3. Variation in Abundance across Foraging Guilds

To assist in the assessment of the types of feeding habitat used, and availability of these habitats through to the end of the dry season, waterbirds were categorised according to their primary usage of habitats occurring within - and/or associated with - the Alligator Creek wetland system, i.e.:

-) **Dense fringing vegetation** (tree thickets, bulrush, sedges, dense grass) – eight species; e.g. Buff-banded Rail and Black Bittern;
-) **Waters edge** (very shallow water <10cm and wet mud) – 24 species; e.g. Radjah Shelduck and small shorebirds.
-) **Shallow water** (0.1 – 0.5m) – 40 species; e.g. Little Egret and Red-necked Avocet;
-) **Deep water** (>1m) – 22 species; e.g. Greater Crested Grebe and Pied Cormorant; and
-) **Away from wetlands** (grassland, areas of dry sedgeland away from wetlands) - 13 species; e.g. Plumed Whistling-Duck and Brolga.

Attachment B presents an overview of the species groupings (feeding guilds) according to the primary feeding habitats used – though noting that some species may utilise more than one category of feeding habitat. A review of the survey data indicates that the majority of species within each “feeding guild” were present throughout the progression of the dry-season programs, including the final survey events (almost the transition period into the early wet season).

Notably, the majority (>90%) of species within each “feeding guild” were also present throughout the dry-season survey program, including the final survey event, within those parts of the Alligator Creek wetland system which were not affected by the Forsyth Dam inundation, i.e. waterbird count areas AC1 (2015 and 2016) and AC2 and AC6 (2016).

Figure 3-8 Waterbird Species Richness Summary

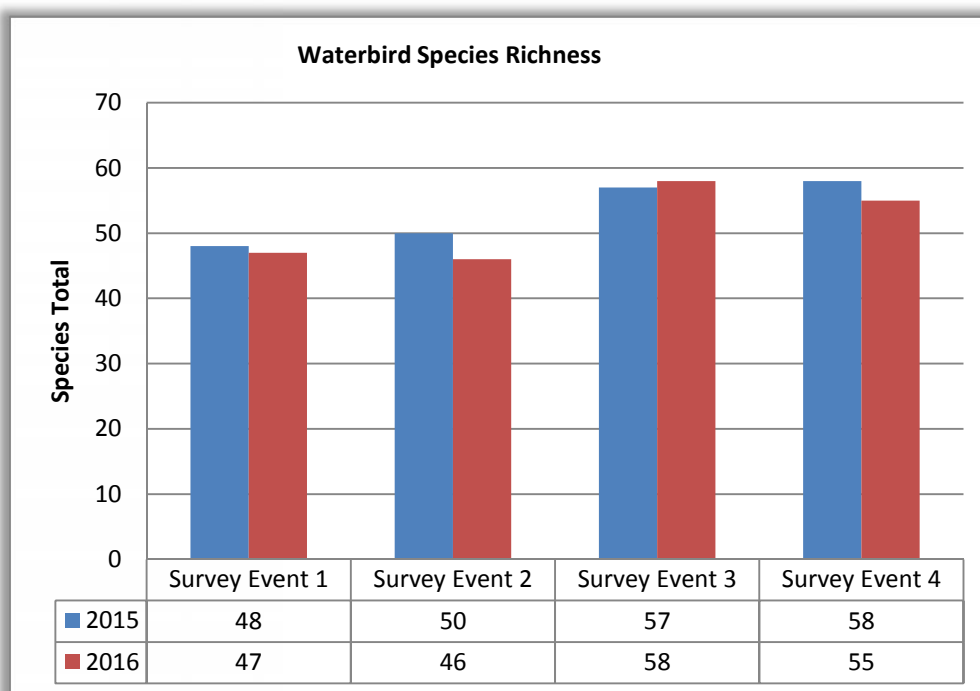


Figure 3-9 Pattern of Overall Waterbird Abundance

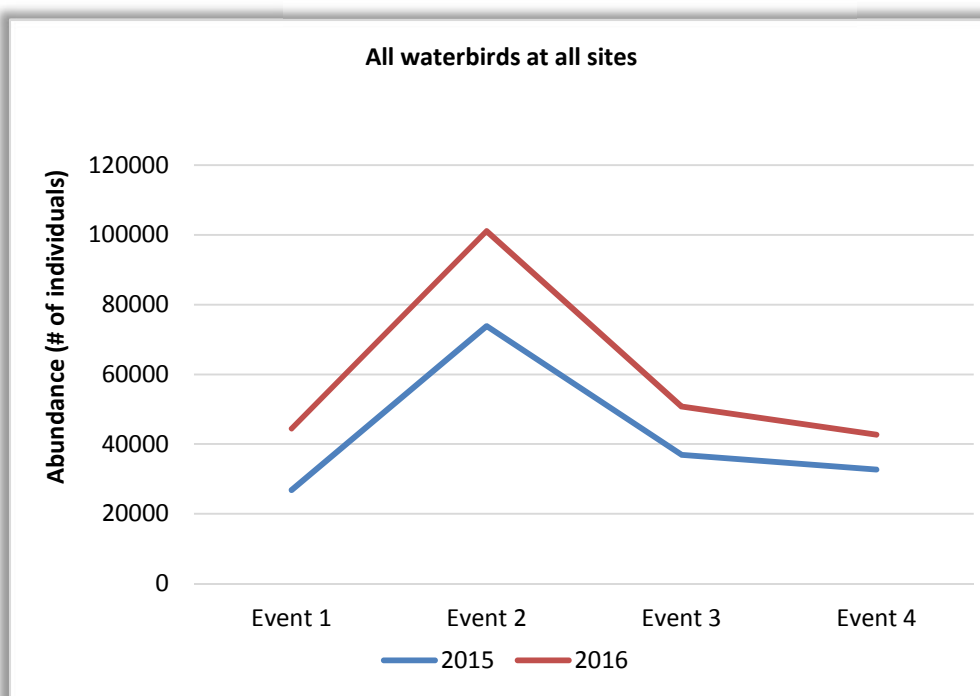


Figure 3-10 Changes in Magpie Goose Abundance

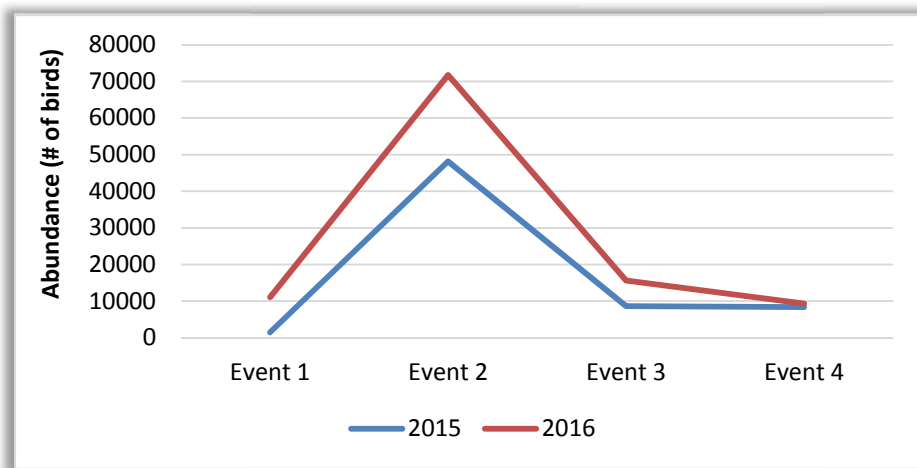


Figure 3-11 Changes in Green Pygmy-Goose Abundance

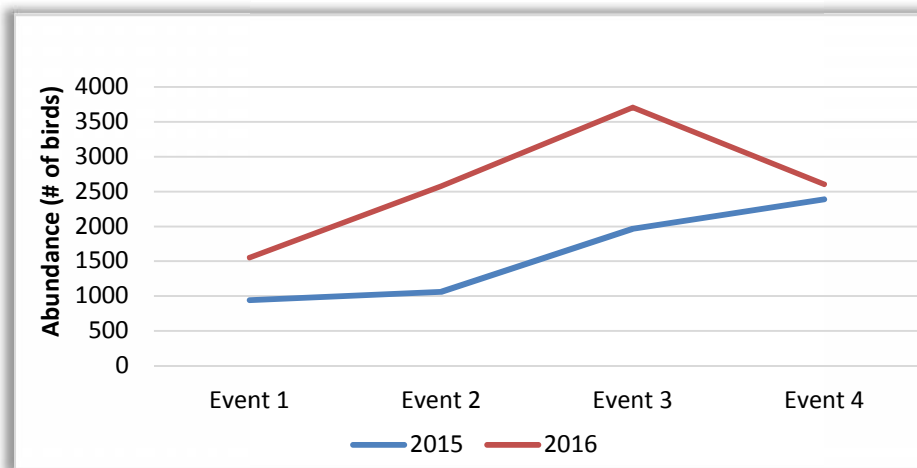
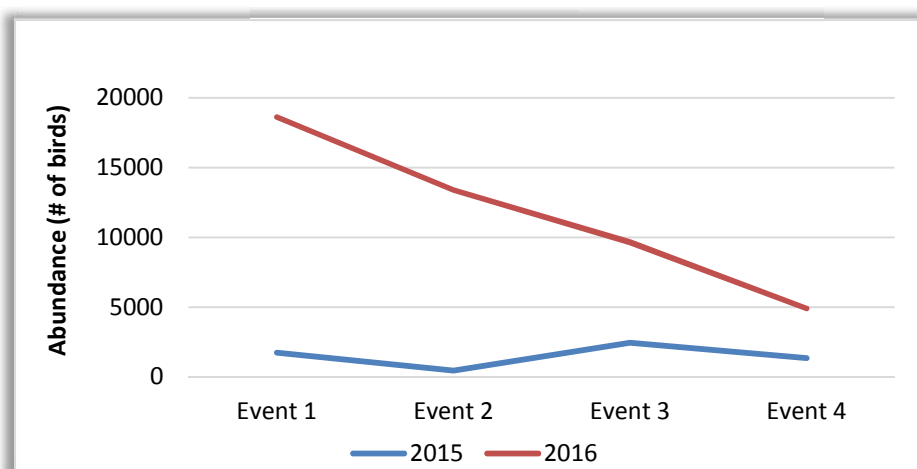


Figure 3-12 Changes in Wandering Whistling-Duck Abundance



3.2.2.4. Migratory Shorebirds

In regard to migratory shorebirds, there were no significant differences in species richness between corresponding survey events in 2015 and 2016 or in overall species richness between the 2015 and 2016 dry-season survey programs (see **Figure 3-13**). The overall pattern of migratory shorebird abundance throughout the progression of survey program sequence exhibited the following:

-) Almost the same overall abundance of birds during the 1st and 2nd survey events for both the 2015 and 2016 survey programs, and the same magnitude of decrease from the 1st to 2nd survey events.
-) A divergence in the abundance data for both the 3rd and 4th survey events, with a significantly higher total abundance recorded in 2016 (see **Figure 3-14**).

Little Curlew was the most significant contributor to the higher total abundance for both the 3rd and 4th survey events (see **Figure 3-15**). This is highlighted by the following:

-) 3rd survey event - 2,602 Little Curlew recorded in 2016 versus 66 birds in 2015.
-) 4th survey event - 3,792 Little Curlew recorded in 2016 versus 1,478 birds in 2015.

The latter was dominated by separate simultaneous counts undertaken during the same survey by two observers: one from the southernmost edge of waterbird count area IA3 (3,179 birds) and the other from the southern part of adjacent AC7 (536 birds). The majority of birds in each case were either drinking/standing in shallow water or within short grassland immediately adjacent to the wetlands. Very hot conditions prevailed at the time of those observations (approximately 40-42°C), probably causing many more Little Curlews to come to shallow water bodies than usual.

Curlew Sandpiper was the only threatened migratory shorebird recorded consistently throughout both survey programs. **Figure 3-16** describes the location and extent of those records. **Figure 3-17** compares Curlew Sandpiper abundance for each of the survey programs for all waterbird count areas, whilst **Figures 3-18 and 3-19** illustrate abundance patterns at of the waterbird count areas downstream and upstream of Crocodile Crossing.

Whilst the small amount of data in regard to the number of records and abundance does not provide a sound basis for detailed assessment, the following general comments are provided:

-) Curlew Sandpipers have been recorded throughout the survey program at locations throughout the extent of the Alligator Creek wetland system.
-) Not surprisingly, abundance increased through the 3rd and 4th survey events, coinciding with a period when birds are arriving in Australia on their return migration from breeding grounds in the Northern Hemisphere.
-) Waterbird count areas where records appear to be clustered include the northern part of AC1, the southern part of AC2, and the northern part of AC7.
 - o AC1 is the most downstream count area, adjacent to the intertidal section of Alligator Creek, and is the only count area in both 2015 and 2016, which was not affected by inundation from Forsyth Dam.
 - o Whilst Curlew Sandpipers were recorded throughout AC2 in both 2015 and 2016, AC2 was not affected by inundation from Forsyth Dam in 2016.
 - o AC7 was inundated during both the 2015 and 2016 count programs.

-) Whilst comparatively higher numbers of Curlew Sandpiper were recorded late in the 2016 count program, there appears to be no material change (improvement) in the extent or condition of the site's wetland habitat during this part of the drawdown cycle which might favour the species.

3.2.3. Waterbird Count Areas not affected by Inundation

Several waterbird count areas along Alligator Creek, which were not affected by the release of water from Forsyth Dam, supported waterbirds throughout the dry season survey programs¹⁶. These waterbird count areas provide useful insight into the potential maintenance of waterbird habitat values under a future scenario when annual release from Forsyth Dam will no longer occur.

One of these areas, waterbird count area AC1, downstream of Point C is situated within the most downstream part of the Alligator Creek freshwater wetland system.

AC1 was effectively isolated from the influence of the Forsyth Dam release in both 2015 and 2016. Average counts and highest counts at AC1 were similar during dry season surveys in 2015 and 2016, with the average count for 2015 survey program around 4,699 waterbirds (vs. 5,358 for 2016). The highest count total for AC1 in 2015 was 8,627, whilst in 2016, the highest count total was 8,116 waterbirds.

Waterbird count areas AC2 and AC6 were also not affected by flows from Forsyth Dam in 2016. Both these count areas were surveyed as part of the 2015 and 2016 survey programs. The following provides a summary of the survey results for each of these waterbird count areas:

-) At AC2 - the average count total for both the 2015 and 2016 survey programs was very similar – 7,995 versus 7,007 respectively.
-) At AC6 – there was a significant difference in the average count total for each program due to significant aggregations of Magpie Geese (41,669) counted during the 2nd survey event in 2015. The average count total for the 2015 and 2016 survey programs were 18,858 and 8,657 waterbirds respectively.

In regard to the results of the 2016 survey program, where AC1, AC2, and AC6 were not inundated, the data demonstrates that significant waterbird numbers were present throughout the dry season, and in some instances, exceeding the Ramsar Criterion 5 significance threshold.

¹⁶ Note: other waterbird count areas were not influenced by the Forsyth Dam releases (AC3, 4, & 5) though had dried by late August and for that reason, were not considered relevant for inclusion in this discussion.

Table 3-3 2016 Count Data Summary – Waterbird Count Areas not subject to Inundation

	AC1	AC2	AC6	Count Total	Count Average
1 st Survey Event	4,526	6,107	10,805	21,438	7,146
2 nd Survey Event	2,140	9,556	11,947	23,643	7,881
3 rd Survey Event	6,651	6,896	5,691	19,238	6,413
4 th Survey Event	8,116	5,469	6,185	19,770	6,590
Count Average	5,358	7,007	8,657	21,022	

Figure 3-13 Migratory Shorebird Species Richness

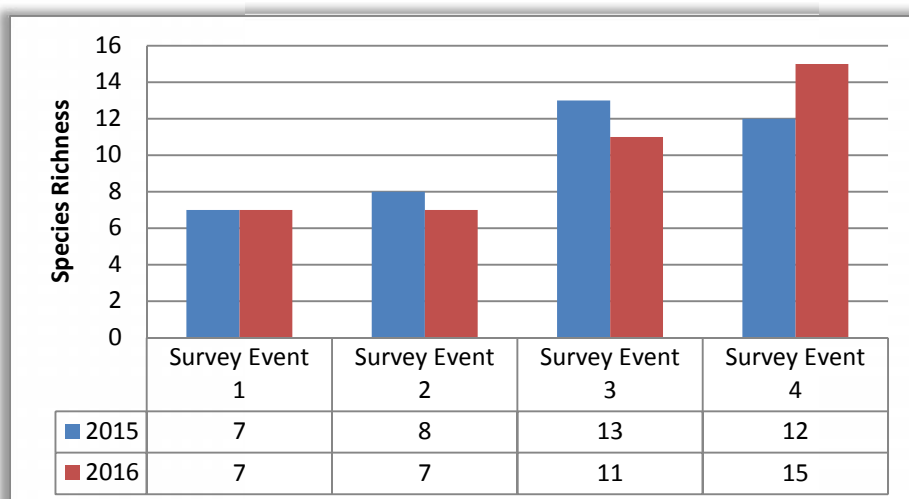


Figure 3-14 Pattern of Overall Migratory Shorebird Abundance

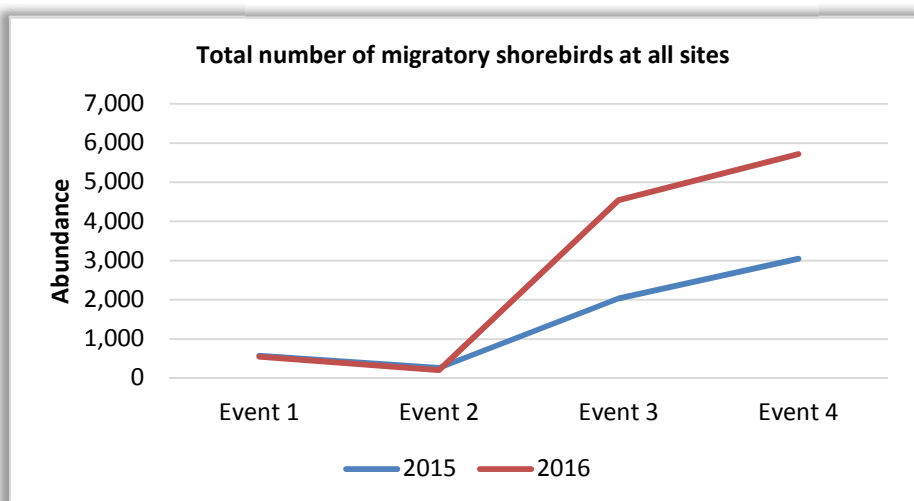
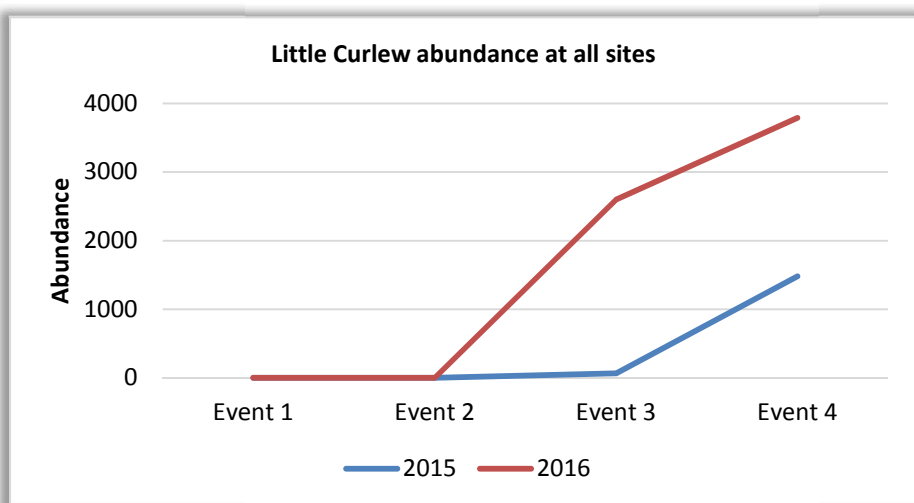


Figure 3-15 Changes in Little Curlew Abundance



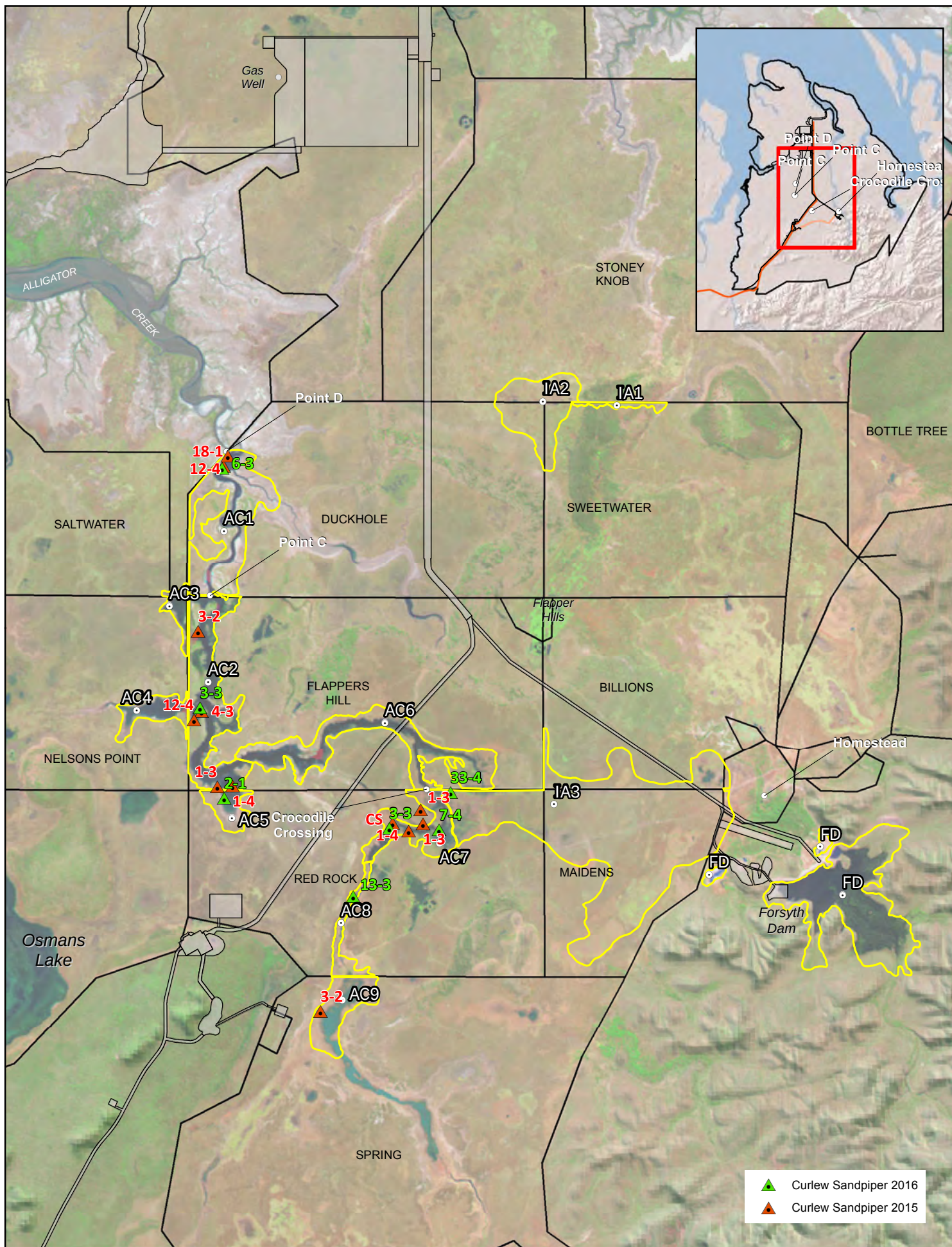


Figure 3-17 Curlew Sandpiper Abundance – All Count Areas

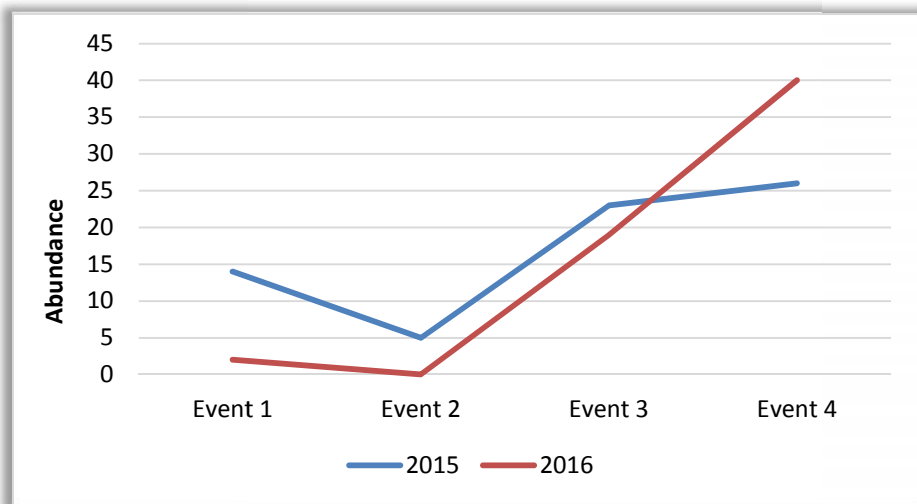


Figure 3-18 Curlew Sandpiper Abundance – Alligator Ck Downstream of Crocodile Crossing

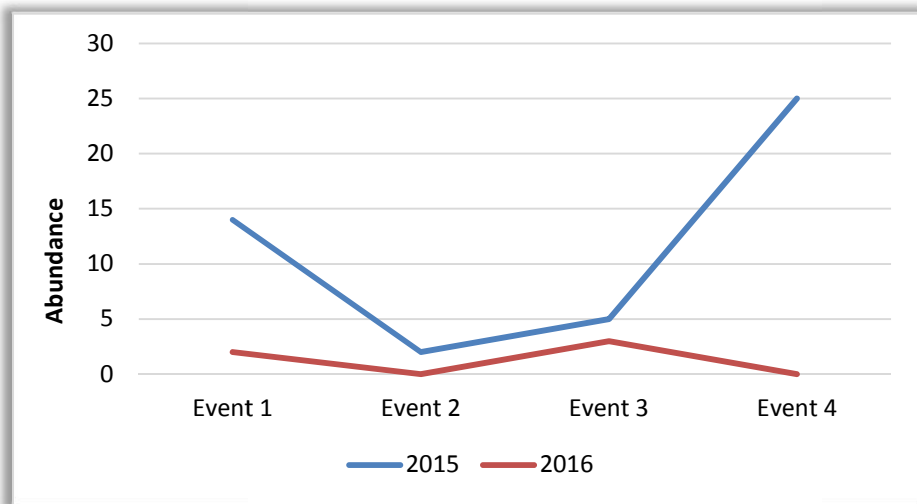
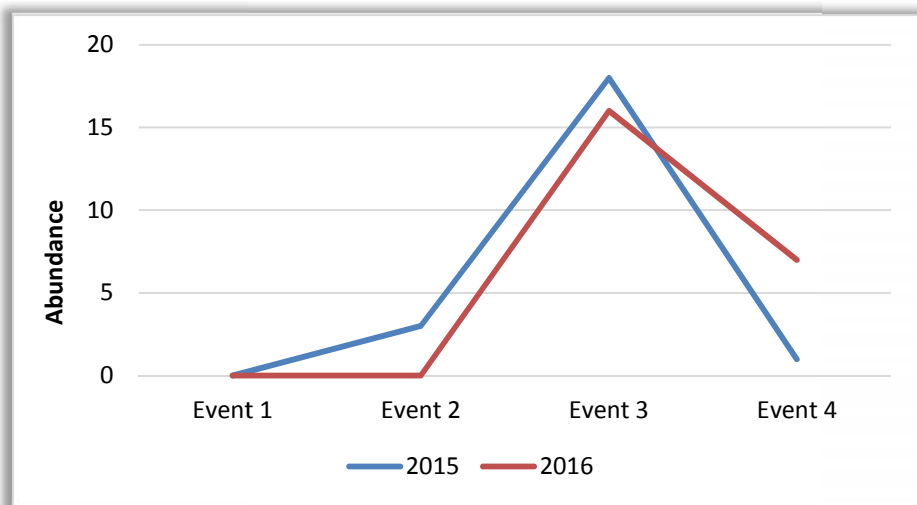


Figure 3-19 Curlew Sandpiper Abundance – Alligator Ck Upstream of Crocodile Crossing



4. Conclusions

Results from the survey program of the 2015 dry season have highlighted the comparatively higher values of the Alligator Creek wetland system for waterbirds, and the positive influence that releasing water from Forsyth Dam had on these values during the latter part of the dry season.

The 2016 wet season conditions produced significantly less storage within Forsyth Dam, resulting in a smaller dry season release (approximately 30% the volume of water released in 2015), and less extensive inundation of the Alligator Creek floodplain. The results of 2016 dry season survey program are therefore informative with regards to the response of waterbirds to reduced inundation of wetland areas with the cessation of annual dry season releases from Forsyth Dam.

The key findings from the 2016 survey program are summarised as follows:

-) A significant number of waterbirds were supported by the Alligator Creek wetland system throughout the survey program, and notably, through late dry season conditions.
-) The overall count total for each survey event exceeded the widely recognised threshold for International importance – Ramsar Criterion 5¹⁷.
-) The Alligator Creek wetland system continued to support individual waterbird species in numbers exceeding 1% population threshold for International importance (Ramsar Criterion 6) - Wandering Whistling-Duck, Green Pygmy-Goose, Magpie Goose, and Little Curlew.
-) The Alligator Creek wetland system continued to support individual migratory shorebird species in numbers exceeding 0.1% population threshold for National importance¹⁸ - Sharp-tailed Sandpiper, Oriental Plover, Marsh Sandpiper, Wood Sandpiper, and Long-toed Stint.
-) The Alligator Creek wetland system continued to support the presence of the threatened Curlew Sandpiper, which was recorded at various locations throughout the wetland system.

The key findings arising from the reviews of the 2015 and 2016 dry season survey program data sets are summarised as follows:

-) Data demonstrates that in two consecutive years, there is persistent use by over 20,000 waterbirds, and that a variety of species have occurred in abundance that exceed their respective 1% population threshold or 0.1% flyway population threshold.
-) Count results show that the majority (>90%) of waterbird species within each “feeding guild” were present throughout the 2015 and 2016 dry-season programs indicating that the full suite of habitat types were available through into the late dry season.
-) In both 2015 and 2016, there was positive influence on wetland availability and a subsequent increase in waterbird abundance during the dry season as a result of annual release of water from Forsyth Dam.

¹⁷ Ramsar Convention on Wetlands Criterion 5: *A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds.*

¹⁸ EPBC Act Policy 3.21: A wetland is of national importance if it regularly supports 0.1% of the East Asian-Australasian Flyway (the flyway) population of a single species of migratory shorebird.

-) The abundance of some waterbird species varies widely between survey events and from year to year, likely due to multiple factors, including some external to the site.
-) Significant changes evident in overall waterbird abundance and for individual species may, to varying degrees, be explained by potential influences such as on-site management practices and/or those beyond site management control – e.g. climatic conditions, be they within a site, regional or continental context.
-) The 2015 and 2016 dry season survey program results demonstrate that significant components of the Alligator Creek wetland system which were not directly affected by the inundation from Forsyth Dam, support:
 - o significant waterbird aggregations – in some instances exceeding the threshold for International importance (Ramsar Criterion 5) – throughout the extent of the survey period and through late dry season conditions;
 - o individual species in abundance that exceeds the 1% population threshold for International importance or 0.1% flyway population threshold for National importance; and
 - o suitable habitat for the threatened Curlew Sandpiper throughout the extent of the survey period and through late dry season conditions.
 - o suitable habitat for the majority (>90%) of waterbird species within each “feeding guild” remained throughout the dry-season program.

The additional information derived from the 2016 dry season survey program, together with the results of the 2015 survey program, improve our understanding of the characteristics of the waterbird assemblage and capacity of the Alligator Creek wetland system to support waterbirds throughout the dry season. The results of the 2015 and 2016 dry season survey programs also indicate that the Alligator Creek wetland system may continue to support waterbird abundances near or exceeding the threshold for International importance without the annual release of water from Forsyth Dam.

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Attachment A 2015-2016 Dry Season Waterbird Count Data

1st Survey Event – Dry Season 2015 and 2016

	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2015	2016	2016
Common Name	AC1	AC1	AC2	AC2	AC3	AC3	AC4	AC4	AC5	AC5	AC6	AC6	AC7	AC7	AC8	AC8	FD	FD	Totals	Spp.	Totals	Spp.
Magpie Goose	156	420	562	2,567							405	4,023	127	2,707	230	1,399	2		1,482	1	11,116	1
Wandering Whistling-Duck		2	1,641	293								4,455	95	13,513					1,736	1	18,263	1
Plumed Whistling-Duck				35								16	5,735	3,397					5,735	1	3,448	1
Radjah Shelduck	129	519	348	122			51				49	62	13	50	12	87	2	2	604	1	842	1
Green Pygmy-Goose		5	872	152							32	1,192	22	162	14	8		35	940	1	1,554	1
Grey Teal	730	21	1,305		4		2				146	10	1,010	25					3,197	1	56	1
Pacific Black Duck	326	1,323	1,125	1,045	13		70				465	417	51	157	25	24			2,075	1	2,966	1
Australasian Shoveler		1																	0		1	1
Hardhead	223		561	198							139	33	98	7			4		1,025	1	238	1
Grebe spp.	69	285	276	123	1						16	73	8				14		384	3	481	2
Australasian Darter	6	28	10	21							3	20	3	8		3	32	15	54	1	95	1
Little Pied Cormorant	17	23	128	15								10		2		3		17	145	1	70	1
Little Black Cormorant	8	166	6	9								20		2			180		194	1	197	1
Pied Cormorant	48	20	177	103							4	3						9	229	1	135	1
Australian Pelican	33	37	68	11							12	16	8	54	3	7			124	1	125	1
Black-necked Stork	2	5	13	12							8	8	1			10	1		25	1	35	1
White-necked Heron	5	14	36	14							11	9	2	3		5	1	3	55	1	48	1
Eastern Great Egret	3	16	12	19			1	1			6	9	4	9	1	13	2	3	29	1	70	1
Intermediate Egret	5	20	12	30	1		2	5			6	12	3	5		7	2	6	31	1	85	1
Pied Heron	39	121	28	93		1						20		12		6		1	67	1	254	1
White-faced Heron	5	4	12	11			1	2		1	1	4	1	1		1	1		21	1	24	1
Cattle Egret		2										2		2					0		6	1
Little Egret	1	8	2							1		4	2	7		6			5	1	26	1
Nankeen Night Heron		1	22																22	1	1	1
Glossy Ibis	102	371	241	507	3	1	8	96	33		66	62	7	20	8	18			468	1	1,075	1

	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2015	2016	2016
Common Name	AC1	AC1	AC2	AC2	AC3	AC3	AC4	AC4	AC5	AC5	AC6	AC6	AC7	AC7	AC8	AC8	FD	FD	Totals	Spp.	Totals	Spp.
Australian White Ibis	13	11	4	30		1	1					4	2	9		4	5	6	25	1	65	1
Straw-necked Ibis	55	86	44	86							41	24	12	11		16	6	4	158	1	227	1
Royal Spoonbill	157	297	76	109	2			17			21	27		9		5			256	1	464	1
Yellow-billed Spoonbill	14		247																261	1	0	
Brolga	252	145	141	187				4			397	41	68	16	67	117			925	1	510	1
Purple Swampphen			2																2	1	0	
Eurasian Coot			2,812	17							1,486		275						4,573	1	17	1
Black-winged Stilt	166	103	380		3				43	13	53	6	12		3				660	1	122	1
Red-necked Avocet		2																	0		2	1
Red-capped Plover	238			2				74	13			4			2				253	1	80	1
Black-fronted Dotterel	2	7		30		2		7	4	8		3		1		1			6	1	59	1
Red-kneed Dotterel	2	9										1							2	1	10	1
Masked Lapwing	34	171	22	79	17	2	9	19	4	6	22	42	23	60	13	31			144	1	410	1
Comb-crested Jacana	19	18	36	76							43	159	29	159	8	13	3		138	1	425	1
Black-tailed Godwit	90	61																	90	1	61	1
Common Greenshank		4	2	5		1			1	4	1								4	1	14	1
Marsh Sandpiper	64	90	72					38	15	4	10								161	1	132	1
Wood Sandpiper	5	1	6																11	1	1	1
Red-necked Stint	275							270		22									275	1	292	1
Sharp-tailed Sandpiper	18							30		13									18	1	43	1
Curlew Sandpiper	14									2									14	1	2	1
Tern spp.	48	109	99	106	2		2	8		4	11	14		25	4	13	42		208	3	279	2
Totals	3,373	4,526	11,400	6,107	46	8	147	571	113	78	3,454	10,805	7,611	20,433	390	1,797	297	101	26,831	48	44,426	47

2nd Survey Event – Dry Season 2015 and 2016

	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2015	2016	2016
Common Name	AC1	AC1	AC2	AC2	AC6	AC6	AC7	AC7	AC8	AC8	FD	FD	IA3	IA3	Totals	Spp.	Totals	Spp.
Magpie Goose	3	302	223	639	41,669	1,262	3,569	3,731	1,355	3,979		24	1,334	61,840	48,153	1	71,777	1
Wandering Whistling-Duck		656	1	5,671	442	5,691		969		396	14		9	23	466	1	13,406	1
Plumed Whistling-Duck					11,530	3,296		2,703	1,110	827			123		12,763	1	6,826	1
Black Swan			1												1	1	0	
Radjah Shelduck	216	252	198	289	74	163		24	11	26	8	4	25	46	532	1	804	1
Pink-eared Duck									47						47	1	0	
Green Pygmy-Goose	222	12	587	1,567	254	894		51		50					1,063	1	2,574	1
Australasian Shoveler		1													0		1	1
Grey Teal		6				16			26				13		39	1	22	1
Pacific Black Duck		53	1	41	11	134	223	2	1,190	56	6		66	757	1,497	1	1,043	1
Hardhead	52		25	4	4	9	139		15				21	24	256	1	37	1
Grebe spp.	74	147	58	73	66	51	14			1	4		22	51	238	3	323	2
Australasian Darter	15	24	3	22	4	11		1			217	95	1		240	1	153	1
Little Pied Cormorant	37	21	1	114		19		3			6	1	4	5	48	1	163	1
Little Black Cormorant		11		13		3		40			324	42		2	324	1	111	1
Pied Cormorant	6	5	6	2		5		2			13	10			25	1	24	1
Australian Pelican	31	48	4	22	6	13	23	1			710	156	4	8	778	1	248	1
Black-necked Stork	3	7	2	9	2	6	1	3		2	6	9	3	4	17	1	40	1
White-necked Heron	3	1		3	2				28		6		4	28	43	1	32	1
Eastern Great Egret	5	10	6	13	3	7	6	10		1	34	8	9	33	63	1	82	1
Intermediate Egret	4	11	2	5	4						114		6	26	130	1	42	1
Pied Heron	8	38	28	57	9	2			75		67	36		34	187	1	167	1
White-faced Heron	3			3									14	3	17	1	6	1
Little Egret	1	3		5		5		1				8			1	1	22	1
Glossy Ibis	39	119	28	328	170	48	43		579	12	46		28	54	933	1	561	1
Australian White Ibis	2	1	1		6	5				1	19	4	1	5	29	1	16	1

	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2015	2016	2016
Common Name	AC1	AC1	AC2	AC2	AC6	AC6	AC7	AC7	AC8	AC8	FD	FD	IA3	IA3	Totals	Spp.	Totals	Spp.
Straw-necked Ibis	3		1	1		9	18		59	1			3	56	84	1	67	1
Royal Spoonbill	98	183	2	92	30	36			11		17	38	29	3	187	1	352	1
Yellow-billed Spoonbill	3								1						4	1	0	
Brolga	6	25		22		17		320	110	44		5	24	391	140	1	824	1
Purple Swampphen				1											0		1	1
Eurasian Coot	321		557	3	2,678		180						165		3,901	1	3	1
Black-winged Stilt		15			27				164				27		218	1	15	1
Red-necked Avocet	14				6				16						36	1	0	
Red-capped Plover	7	5		9		25									7	1	39	1
Black-fronted Plover		16	26	16		1									26	1	33	1
Masked Lapwing	34	115	23	61	14	40		7	19	18	4	9	17	26	111	1	276	1
Comb-crested Jacana	47	4	32	158	43	118	7	4	7	22	17				153	1	306	1
Black-tailed Godwit	15	3			3				31						49	1	3	1
Common Sandpiper		1	1		1										2	1	1	1
Common Greenshank	2	9	1	37		4			1				1	1	5	1	51	1
Marsh Sandpiper	29	27	6	59		12			70				6	6	111	1	104	1
Wood Sandpiper			2						4				1	1	7	1	1	1
Red-necked Stint			36			5									36	1	5	1
Sharp-tailed Sandpiper	31	9	4	18		10			12						47	1	37	1
Curlew Sandpiper			2						3						5	1	0	
Tern spp.			46	199		30		41	340	67	224	2	214	105	824	4	444	4
Totals	1,334	2,140	1,914	9,556	57,058	11,947	4,223	7,913	5,284	5,503	1,856	451	2,174	63,532	73,843	50	101,042	46

3rd Survey Event – Dry Season 2015 and 2016

	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2015	2016	2016
Common Name	AC1	AC1	AC2	AC2	AC6	AC6	AC7	AC7	AC8	AC8	FD	FD	IA3	IA3	Totals	Spp.	Totals	Spp.
Maggie Goose	848	2,558	2,250	1,356	1,378	1,882	2,907	2,901	326	1,572	314	2,118	598	3,270	8,621	1	15,657	1
Wandering Whistling-Duck	1,193	2,782	3	1,296	914	757	108	2,997	276	920	229	5		909	2,447	1	9,666	11
Plumed Whistling-Duck	36	248	320	191	4,777	672	1,918	7,122	328	732	419	48		675	7,798	1	9,688	1
Radjah Shelduck	67	73	172	542	159	336	71	141	29	111	21	4	260	121	779	1	1,328	1
Pink-eared Duck							52								52	1	0	
Green Pygmy-Goose	811	96	633	1,664	253	956	191	650	23	25	53	2	2	310	1,966	1	3,703	1
Grey Teal			25	2	35		94		14				70	3	238	1	5	1
Pacific Black Duck	118	88	861	720	370	682	1,065	236	67	86	6		177	100	2,664	1	1,912	1
Hardhead	1,018		139	8		7			2		2		120		1,281	1	15	1
Grebe spp.	234	105	119	264	49	15		2	7		10		65	18	484	3	404	1
Australasian Darter	14	21	3	14		11		7	2	3	160	122	4	1	183	1	179	1
Little Pied Cormorant	4	47	7	33	1	18	1	2	2		4	9		5	19	1	114	1
Little Black Cormorant	2	8		25				322	7		85	21		1	94	1	377	1
Pied Cormorant	36	16	87	19		11		4			4	4		16	127	1	70	1
Australian Pelican	51	52	12	33	9	12	15	3	3	1	75	9		1	165	1	111	1
Black-necked Stork	2	5	4	6	2	13	3	7			22	3		1	33	1	35	1
White-necked Heron			2							1	4	2	77		83	1	3	1
Eastern Great Egret	3	2	6	8	4	7	4	28	1	2	9		5	12	32	1	59	1
Intermediate Egret	7	8	7	12	4	11	11	72	3	9		4	16	20	48	1	136	1
Pied Heron	9	33	47	24	4	46		16	7	18	2	11	5	28	74	1	176	1
White-faced Heron											5		1	3	6	1	3	1
Little Egret	4	8	1	5		5	1		2	6		1	6	5	14	1	30	1
Nankeen Night Heron															0		0	
Glossy Ibis	115	69	104	35	54	45	83	69	11	25			136	147	503	1	390	1
Australian White Ibis		1	5	2		3	6	2			5	50	22		38	1	58	1
Straw-necked Ibis	3		7	31	2			1	7	1		129	54	16	73	1	178	1

	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2015	2016	2016
Common Name	AC1	AC1	AC2	AC2	AC6	AC6	AC7	AC7	AC8	AC8	FD	FD	IA3	IA3	Totals	Spp.	Totals	Spp.
Royal Spoonbill	50	36	10	21	18	19	58	46	14			2	1	119	151	1	243	1
Yellow-billed Spoonbill	1				1								1		3	1	0	
Brolga	10	114	24	20	65	17	30	116	15	9		27	49	94	193	1	397	1
Purple Swamphen			2	1											2	1	1	1
Eurasian Coot	3,840		242		746		477		47		155				5,507	1	0	
Black-winged Stilt	15	8	111	6	86		61	1	3				147	35	423	1	50	1
Red-necked Avocet	39				9								1		49	1	0	1
Pacific Golden Plover							1								1	1	0	
Little Ringed Plover			1												1	1	0	
Red-capped Plover	3		10	11		2	75		2	7			1		91	1	20	1
Lesser Sand Plover				2									1		1	1	2	1
Oriental Plover							9			3					9	1	3	1
Black-fronted Dotterel	4	6	4	4	1	3	1		5	1	13		15		43	1	14	1
Red-kneed Dotterel							2		2				1		5	1	0	
Masked Lapwing	7	40	16	59	26	37	23	40	18	28	5	49	19	104	114	1	357	1
Comb-crested Jacana	52	74	22	200	137	113	23	35	14	28			2	9	250	1	459	1
Black-tailed Godwit			4				18	47						13	22	1	60	1
Little Curlew							18	1,763		12		210	48	617	66	1	2,602	1
Common Sandpiper	4	4	2	2	1			1					2		9	1	7	1
Common Greenshank	1	6	5	10		5	1	4	2	12	1		5	2	15	1	39	1
Marsh Sandpiper	7	33	150	25	127	4	103	182	7	44			64	183	458	1	471	1
Wood Sandpiper			1					2	1	3			6	10	8	1	15	1
Red-necked Stint		7	181	136	11		198	232		9			7		397	1	384	1
Sharp-tailed Sandpiper			224	42	74		570	778	21	39			136	81	1,025	1	940	1
Curlew Sandpiper			4	3	1		18	3		13					23	1	19	1
Silver Gull		1				2						1			0		4	1
Tern spp.	19	102	158	64	16		6	195	23	13	38	22	8		268	5	396	3

	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2015	2016	2016
Common Name	AC1	AC1	AC2	AC2	AC6	AC6	AC7	AC7	AC8	AC8	FD	FD	IA3	IA3	Totals	Spp.	Totals	Spp.
Totals	8,627	6,651	5,985	6,896	9,334	5,691	8,222	18,027	1,015	3,733	1,641	2,853	2,132	6,929	36,956	57	50,780	58

4th Survey Event – Dry Season 2015 and 2016

	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2015	2016	2016
Common Name	AC1	AC1	AC2	AC2	AC6	AC6	AC7	AC7	AC8	AC8	FD	FD	IA3	IA3	Totals	Spp.	Totals	Spp.
Maggie Goose	2,873	1,999	2,771	1,031	1,073	2,111	1,036	2,058	230	772	361	684		643	8,344	1	9,298	1
Wandering Whistling-Duck	141	733	381	1,624	529	1,022	292	1,117		324		81			1,343	1	4,901	1
Plumed Whistling-Duck		2,961	177	115	467	845	743	4,993		2,881		284			1,387	1	12,079	1
Radjah Shelduck	100	246	380	541	312	164	124	314	12	72	2	8	107	329	1,037	1	1,674	1
Pink-eared Duck			141				33						13		187	1	0	
Green Pygmy-Goose	189	567	1,399	775	731	494	53	599		164	16	3			2,388	1	2,602	1
Grey Teal	39		228	5	115	2	65						58		505	1	7	1
Pacific Black Duck	93	513	1,165	163	467	899	192	632	25	61	8		42	85	1,992	1	2,353	1
Hardhead	19		581		173	6	56	4					3		832	1	10	1
Grebe spp.	213	50	322	129	49	12	28	16				1	38		650	2	208	1
Australasian Darter	3	9	4	8	1	8	1	7		1	119	96			128	1	129	1
Little Pied Cormorant		20	24	41	5	39		23		5	1	2	1		31	1	130	1
Little Black Cormorant	6	27	5	11	1	44		6			217	60	1		230	1	148	1
Pied Cormorant	5	1	71	1	4			9			1	4			81	1	15	1
Australian Pelican	25	373	17	5	5	28		10	3	2	131	4	120		301	1	422	1
Black-necked Stork	5	7	1	11	4	9		6		1	37	3		3	47	1	40	1
White-necked Heron	1		23										46		70	1	0	
Eastern Great Egret	10	6	12	39	5	11	1	16	1	2	9	8	4	37	42	1	119	1
Intermediate Egret	7		9	10	5	11	1	5		8	35		14	7	71	1	41	1
Cattle Egret				2						13				3	0		18	1
Pied Heron	29	79	45	39	4	52		18		6	5	8		59	83	1	261	1
White-faced Heron	2		1					2			3			2	6	1	4	1
Little Egret	7	8	7	19	9	12		21		8	2	1	4	14	29	1	83	1
Nankeen Night Heron													32		32	1	0	
Glossy Ibis	53	56	88	24	31	20	50	32	8	35	520	2	18	60	768	1	229	1
Australian White Ibis	7	3	3	1		4					255	35	2	1	267	1	44	1

	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2015	2016	2016
Common Name	AC1	AC1	AC2	AC2	AC6	AC6	AC7	AC7	AC8	AC8	FD	FD	IA3	IA3	Totals	Spp.	Totals	Spp.
Straw-necked Ibis	1		2	3	2	2		1			532		43		580	1	6	1
Royal Spoonbill	16	13	16	150	3	8	6	175		7	3	5	129	49	173	1	407	1
Yellow-billed Spoonbill			3				1						45		49	1	0	
Brolga	2	4	23	27	86	39	13	27	68	128	10		174	162	376	1	387	1
Purple Swamphen			10					1							10	1	1	1
Eurasian Coot	932		3,388	2	1,180		519						4		6,023	1	2	1
Black-winged Stilt	39	15	129	9	35	4	72	32	3	4	8		21	13	307	1	77	1
Red-necked Avocet	23						3						7		33	1	0	
Pacific Golden Plover														25	0		25	1
Little Ringed Plover		4													0		4	1
Red-capped Plover	9		1		1	2	14		2	1				2	27	1	5	1
Oriental Plover										252			8	1	8	1	253	1
Black-fronted Dotterel	9	1	16	3	5	3	3			2	6	4	22	15	61	1	28	1
Red-kneed Dotterel			7										18	1	25	1	1	1
Masked Lapwing	13	69	51	83	31	45	14	56	3	18	34	59	37	113	183	1	443	1
Comb-crested Jacana	65	92	88	155	57	98	27	69	2	17			2		241	1	431	1
Black-tailed Godwit	19	32		19	2		3	31						20	24	1	102	1
Little Curlew	20	2	11		22	66	1,082	536		9	186		157	3,179	1,478	1	3,792	1
Whimbrel									26						26	1	0	
Common Sandpiper	11	4	6		7				1		4	1	1		30	1	5	1
Common Greenshank	5	26	16	18		19	2	14	1	5	2	4	3	15	29	1	101	1
Marsh Sandpiper	47	22	223	25	31	21	56	33	2	1	4	1	74	101	437	1	204	1
Wood Sandpiper	2	2	4	2	2	2		3		1	1	8	4	104	13	1	122	1
Great Knot		1													0		1	1
Long-toed Stint														50	0		50	1
Red-necked Stint	93		294	283	39	13	107	93	1	1			15	136	549	1	526	1
Sharp-tailed Sandpiper	47	9	179	30	34	22	47	64			3	2	24	216	334	1	343	1

	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2015	2016	2016
Common Name	AC1	AC1	AC2	AC2	AC6	AC6	AC7	AC7	AC8	AC8	FD	FD	IA3	IA3	Totals	Spp.	Totals	Spp.
Curlew Sandpiper	12		12		1		1	7						33	26	1	40	1
Broad-billed Sandpiper			1											9	1	1	9	1
unidentified small waders			16		23		12	115					44	26	95		141	
Tern spp.	151	162	328	66	36	48	72	101	1	15	111	11	24	2	723	6	405	5
Totals	5,343	8,116	12,679	5,469	5,587	6,185	4,729	11,246	389	4,816	2,626	1,379	1,359	5,515	32,712	57	42,726	54

Attachment B Waterbird Distribution and Feeding Guild Review

Table Notes:

Distribution: C = Continental; N = Northern; NE = Northern-eastern; SE = South-eastern; SW = South-western; E = Eastern; CC = Continental Coastal; and I = Inland.

Feeding Guilds: Waters Edge = very shallow water (<10cm) +/- wet mud; Shallow Water = water < 0.5m deep +/- wet mud; Deeper Water = waters >1m deep; and Away from Wetlands = terrestrial non-wetland habitats such as grasslands.

Common Name	Distribution	Dense Fringing Vegetation	Waters Edge	Shallow Water	Deeper water	Away from Wetlands
Magpie Goose	N			1		1
Black Swan	C			1	1	1
Wandering Whistling-Duck	N/NE			1	1	
Plumed Whistling-Duck	N/SE			1		1
Radjah Shelduck	N		1			
Pink-eared Duck	C			1		
Green Pygmy-Goose	N				1	
Grey Teal	C			1	1	
Pacific Black Duck	C			1	1	1
Australasian Shoveler	SW/E			1	1	
Hardhead	C				1	
Australasian Grebe	C			1	1	
Hoary-headed Grebe	C			1	1	
Greater Crested Grebe	C				1	
Australasian Darter	C				1	
Little Pied Cormorant	C				1	
Little Black Cormorant	C				1	
Pied Cormorant	C				1	
Australian Pelican	C				1	
Black-necked Stork	N/E			1		
Black Bittern	N/E	1	1			
White-necked Heron	C			1		
Eastern Great Egret	C			1		
Intermediate Egret	N/E/SE			1		
Cattle Egret	N/E/SE			1		1
Pied Heron	N	1		1		
White-faced Heron	C			1		1
Little Egret	N/E/SE			1		
Nankeen Night Heron	C	1		1		
Glossy Ibis	N/E/SE			1		1
Australian White Ibis	C			1		1
Straw-necked Ibis	C			1		
Royal Spoonbill	N/E/SE			1		
Yellow-billed Spoonbill	C			1		
Brolga	N/SE			1		1
Sarus Crane	NE			1		1
Purple Swamphen	SW/E	1	1			
Buff-banded Rail	E/SW/N	1	1			
Eurasian Coot	C			1	1	
Black-winged Stilt	C			1		
Red-necked Avocet	SE/SW			1		
Pacific Golden Plover	CC		1			
Little Ringed Plover	CC		1			

Common Name	Distribution	Dense Fringing Vegetation	Waters Edge	Shallow Water	Deeper water	Away from Wetlands
Lesser Sand Plover	CC		1			
Red-capped Plover	C		1			
Oriental Plover	CC/I		1			1
Black-fronted Dotterel	C		1			
Red-kneed Dotterel	CC/I		1			
Masked Lapwing	N/E/SE		1			1
Comb-crested Jacana	N/NE			1	1	
a snipe (Swinhoe's ?)	SE/E	1	1			
Black-tailed Godwit	CC			1		
Little Curlew	CC/I		1			1
Whimbrel	CC			1		
Common Sandpiper	CC/I		1			
Common Greenshank	CC/I			1		
Marsh Sandpiper	CC/I			1		
Wood Sandpiper	CC/I	1	1			
Great Knot	CC		1			
Long-toed Stint	CC/I	1	1			
Red-necked Stint	CC/I		1			
Sharp-tailed Sandpiper	CC/I		1			
Curlew Sandpiper	CC/I		1			
Broad-billed Sandpiper	CC		1			
Ruff	CC		1			
Little Tern	CC			1	1	
Gull-billed Tern	CC/I			1	1	
Caspian Tern	CC/I			1	1	
Whiskered Tern	C			1	1	
White-winged Black Tern	C			1	1	
Silver Gull	C		1	1		

APPENDIX D ACCESS AND RECREATIONAL FISHING POLICY



**PROJECT SEA DRAGON
STAGE 1 LEGUNE GROW-OUT FACILITY
SUPPLEMENTARY ENVIRONMENTAL IMPACT STATEMENT**

**APPENDIX D ACCESS AND RECREATIONAL
FISHING POLICY**

CONTENTS

1	Introduction	3
2	Current Context	3
2.1	Access	3
2.2	Fishing.....	3
3	Project Position	4
3.1	Access	4
3.2	Fishing.....	4

1 INTRODUCTION

This Access and Recreational Fishing Policy has been prepared to consolidate and clarify the access and recreational fishing protocols that were proposed as part of the Environmental Impact Statement (EIS) for the Stage 1 Legune Grow-out Facility (the Project).

These access and recreational fishing protocols relate directly to third parties, and personnel who will be working onsite.

Access and fishing arrangements for Native Title Holders is being dealt with separately as part of the Indigenous Land Use Agreement (ILUA).

2 CURRENT CONTEXT

2.1 ACCESS

The only road access to Legune Station is via the Keep River Plains Road (referred to in the draft EIS as the Cave Springs Road) and the Legune Access Road. The Keep River Plains Road services Spirit Hills Station, the Marralum Community and Legune Station and terminates at Legune Station. There is no access from this road into the Keep River National Park.

Direct access to Legune Station via boat is not available given that there are no boat ramps or landing points along the coastline. The estuarine and marine environments surrounding Legune Station, including the Keep and Victoria Rivers, are accessed on occasion by recreational fishers and boaters who launch their boats further upstream in the Keep and Victoria Rivers.

2.2 FISHING

The tenure of Legune Station is a perpetual pastoral lease and as such operates as a private property. Public access is formally not allowed without the permission of the owner or station manager. However, the proponent is informed by the station manager that there is a certain level of land based recreational fishing undertaken predominantly by people from the local area (i.e. not tourists), and predominantly around the deeper freshwater reaches of Alligator Creek.

Native Title is also established across the property and thus the Native Title Holders have unfettered access to the property in order to exercise their Native Title rights, of which fishing is one. In contrast to other native title determinations in which individuals are named, the Native Title Holders are members of estate groups which has meant that a broader group of individuals access Legune Station.

3 PROJECT POSITION

3.1 ACCESS

Legune Station will remain private property under Project Sea Dragon and will be subject to strict biosecurity management requirements. As such, access to Legune will be restricted to authorised personnel only. Access by the Native Title Holders is being negotiated as part of the Indigenous Land Use Agreement (ILUA).

To deter access by unauthorised third parties, a gate will be installed on the Legune Access Road. In addition, in recognition of the likelihood that, for determined individuals, access could be gained from vantage points other than the road, Indigenous Rangers will be employed to monitor and manage any unauthorised parties accessing the station.

The resourcing, training and supervision of Indigenous Rangers is a matter that is being incorporated in the ILUA process.

3.2 FISHING

As described in Section 2.2, a level of recreational fishing by people from the local area currently occurs on Legune Station. The Native Title Holders also fish on the property in accordance with their Native Title rights.

Following the commencement of the Project, access to the property will be restricted and recreational fishing by unauthorised third parties will not be allowed. Access to the property will be restricted through the installation of a gate on the Legune Access Road and the employment of Indigenous Rangers to monitor any recreational fishing activity on the property undertaken by unauthorised third parties.

With regards to recreational fishing by Project Sea Dragon employees and contractors, the following will apply:

- Construction personnel will not be permitted to fish on the property.
- During operations the company plans to restrict access to fishing places if not ban recreational fishing activity on the property altogether for health and safety reasons (e.g. crocodiles, uncharted waters, large tidal variations).

A Recreational Fishing Management Plan will be developed for the Project, however the details of this will not be finalised until the ILUA has been completed. Fishing has been discussed privately with a range of Indigenous stakeholders and a range of views have been expressed. Some Traditional Owners have expressed a desire to curtail or limit fishing activity at Legune Station, while others have indicated a desire for broader access. For this reason the proponent is reluctant to make definitive statements in relation to fishing until an ILUA, which is expected to address matters including access and fishing, has been completed.

APPENDIX E DISSOLVED OXYGEN MODELLING



**PROJECT SEA DRAGON
STAGE 1 LEGUNE GROW-OUT FACILITY
SUPPLEMENTARY ENVIRONMENTAL IMPACT STATEMENT**

**APPENDIX E DISSOLVED OXYGEN
MODELLING**

MEMORANDUM

To CO2 Australia, Att Kate McBean/Natasha McIntosh
From Tony McAlister
Date 23 August 2016
Subject Project Sea Dragon DO Modelling Assistance

This memo describes water quality modelling investigations that were conducted to investigate the potential for dissolved oxygen (DO) sags to develop in Alligator Creek in the event that the chlorophyll/algal carbon content of the proposed prawn farm discharge rapidly decays upon entering the light limited receiving waters.

1 MODEL DESCRIPTION

The DO model was developed using ECOLAB (a DHI product), which was coupled with the MIKE 3D hydrodynamic model of the Alligator Creek system which was developed for the Project Sea Dragon Surface Water Assessment (Water Technology, 2016). The model calculates the changes in DO dynamics as a result of wastewater discharge from the proposed operation to Alligator Creek and assesses how this may relate to overall oxygen cycling processes in the waterway. Waste discharge was assumed to be uniformly distributed at four locations shown in Figure 1.

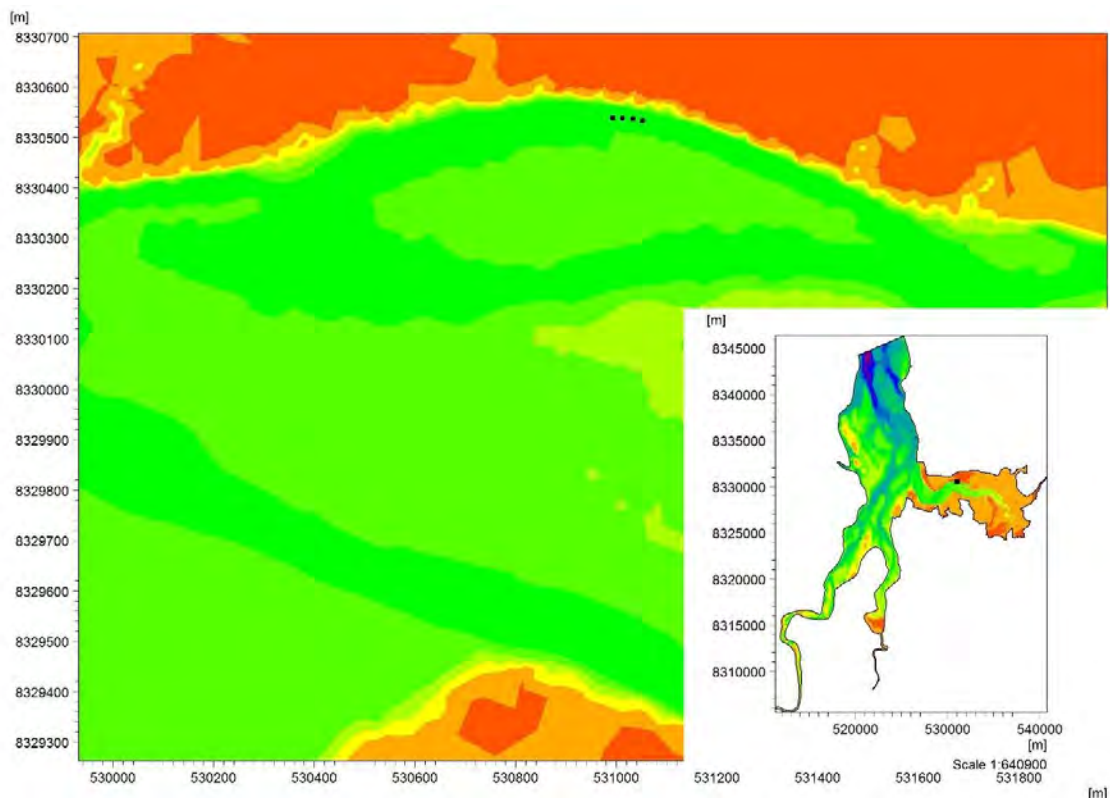


FIGURE 1 MODEL DOMAIN AND DISCHARGE LOCATION

Oxygen depletion is caused by biogeochemical processes associated with the mineralization of organic matter in both the water column and sediments. The rate of mineralization is strongly dependent on a number of factors such as temperature and the nature of the organic matter. Physical processes such as stratification can enhance oxygen depletion in an estuary by preventing mixing. Generally, the extent of oxygen depletion is ultimately determined by the rates of organic matter loading, oxygen production and reaeration. For the current study, we have assumed that oxygen produced by primary production was negligible due to the consistently high turbidity observed in the study area. Therefore, a relatively simple DO model setup as shown in Figure 2 was adopted. Reaeration was calculated using accepted formulae which combine the effects of wind and water currents, and DO saturation levels associated with the ambient temperature climate in Alligator Creek.

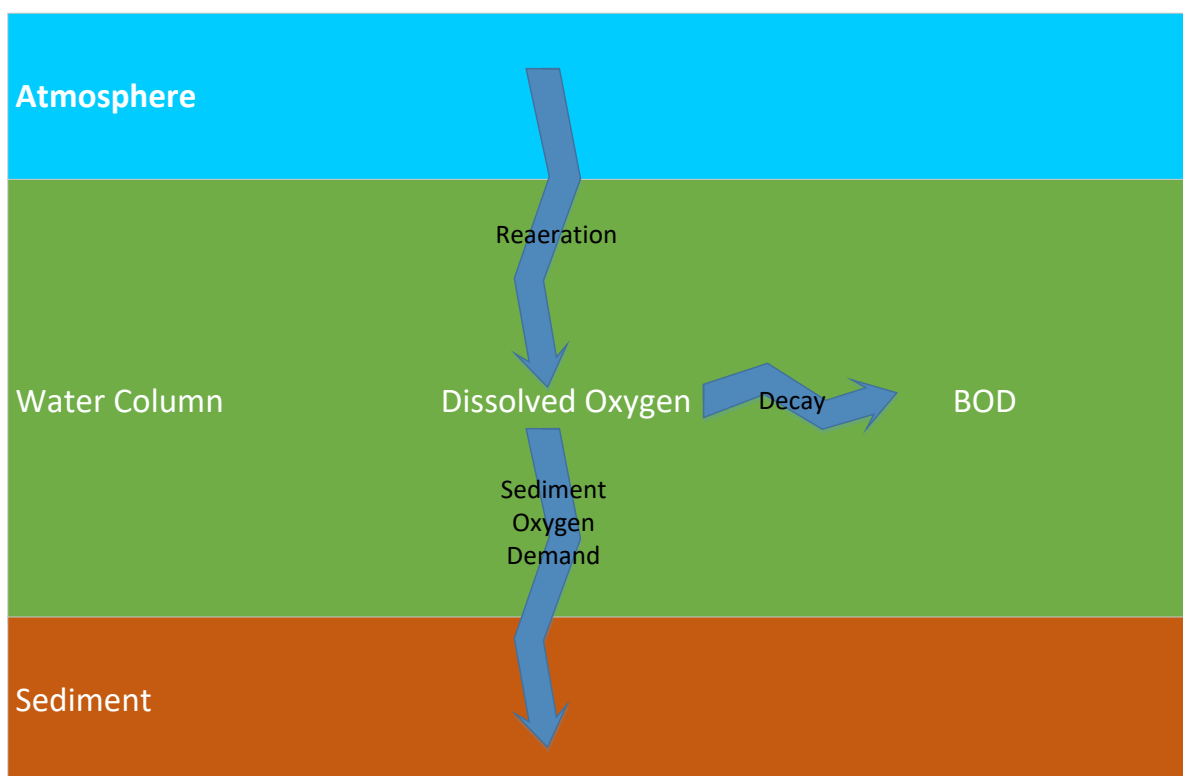


FIGURE 2 DO MODEL SETUP (BOD = BIOLOGICAL OXYGEN DEMAND, DO = DISSOLVED OXYGEN, SOD = SEDIMENT OXYGEN DEMAND)

The model initially formulated the 5-day biological oxygen demand (BOD_5) component of the discharge from the expected particulate carbon in the discharge using the following approach:

- a conversion ratio of 2.67g BOD to 1g carbon;
- the carbon content in the discharge was assumed to be related to chlorophyll a in the ratio of 50:1, that is 50 $\mu\text{g/L}$ carbon for every 1 $\mu\text{g/L}$ chlorophyll a; and
- the discharge was assumed to have a chlorophyll a content of 20 $\mu\text{g/L}$.

This indicates an effective BOD_5 of around 2.7 mg/L. BOD_5 testing of prawn farm wastewater samples undertaken by the Townsville office of the Queensland EPA however indicated that with normal pond management techniques, a BOD_5 concentration of the order of 7 – 12 mg/L could be expected (Environmental Protection Agency, Queensland, 2000). Literature data also indicated that the BOD_5 from Malaysian shrimp

farms ranges between 5.9 and 18.7 mg/L (Nyanti et al. 2011). For this study, a range of BOD₅ concentrations were simulated between 3 to 50 mg/L.

A settling velocity of 0.5m/day was used for the particulate carbon. To be consistent, the term BOD will be used solely in the rest of the document.

The decay of BOD was calculated using a first order oxidation reaction equation. The first order reaction rate constant, K, normally varies between 0.1 and 0.5 /day. The current model adopted a value of 0.23/day for the rate constant. A value of 1.05 was chosen for the temperature dependency coefficient. A constant sediment oxygen demand of 0.5 mg/m²/day was also used. All these parameters are consistent with literature values.

The relevant equation describing DO dynamics in the model is as follows:

$$\frac{dDO}{dt} = \text{Reaeration} - \frac{dBOD_r}{dt} - \text{SOD}$$

Where

- Reaeration = oxygen exchange rate at air-water interface (mg/L/day)
- BOD_r = remaining biological oxygen demand (mg/L)
- SOD = Sediment oxygen demand (mg/L/day)

The decay of BOD was described using first order oxidation kinetics, as follows:

$$\frac{dBOD_r}{dt} = k_{20} \cdot \theta^{(T-20)} \cdot BOD_r$$

Where

- k = first order reaction rate constant at 20 °C (/day)
- Θ = temperature dependency coefficient (-)
- T = temperature (°C)

2 BOUNDARY CONDITIONS

The DO concentration for all model boundaries and discharges was calculated based on temperatures and salinities using the method proposed by Weiss (1970), assuming 100% saturation. There were some total organic carbon (TOC) concentration measurements for the study area (FRC Environmental, 2016); however, there was no information available to establish a correlation between TOC and BOD₅. The Queensland Water Quality Guidelines (2009) had some background levels of BOD₅ in Queensland waters.

The current study adopted a median BOD₅ concentration of 1.2 mg/L as the model boundary condition.

4 SCENARIOS

Four (4) sets of scenarios were simulated for the period between 01/09/2015 and 15/09/2015 (as summarised in Table 1). Discharge rates associated with each of these scenarios are presented in

Figure 3. Scenarios S1 and S3 had a varying discharge rate with wastewater released from 1 hr before each ebb tide until 5.5 hrs before the end of the ebb tide while scenarios S2 and S4 had a constant discharge rate.

Wind plays an important role in oxygen exchange at the air-water interface. For the simulation period, a relatively uniform temporal pattern was found from the wind time series that was used to force the model (Figure 4). In addition to using these data for most scenarios, additional sensitivity tests were conducted on the influence of wind-induced reaeration in the last two scenarios which 'switched off' the wind.

TABLE 1 SCENARIOS

Scenario	Discharge	Wind
S1	Varying discharge rate	wind-induced reaeration switched on
S2	Constant discharge	wind-induced reaeration switched on
S3	Varying discharge rate	wind-induced reaeration switched off
S4	Constant discharge	wind-induced reaeration switched off

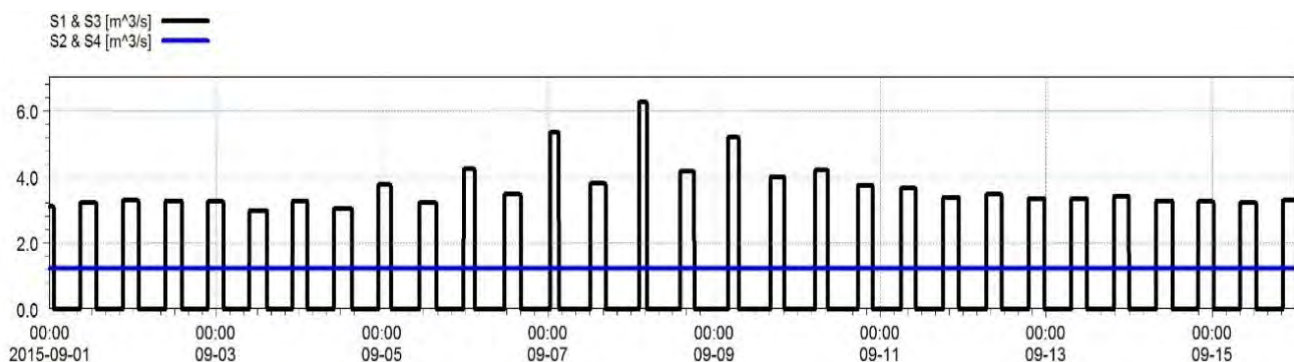


FIGURE 3 DISCHARGE RATES FROM EACH DISCHARGE LOCATIONS

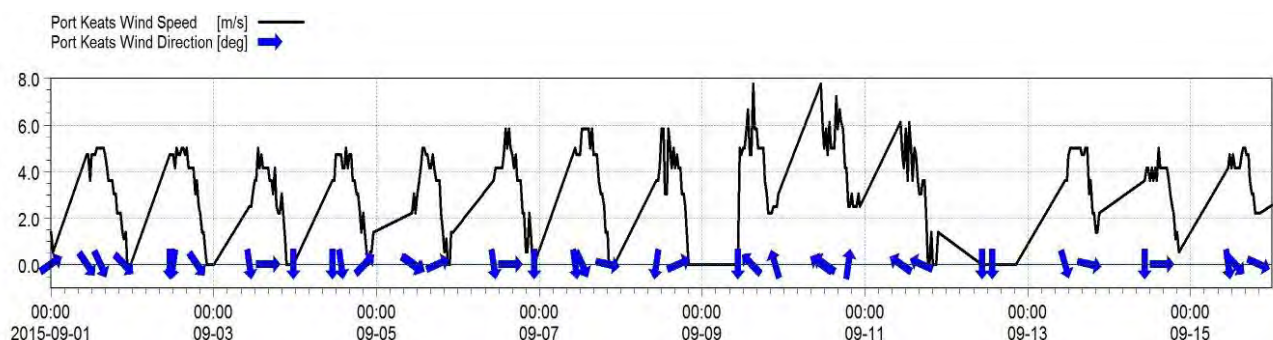


FIGURE 4 WIND SPEED AND DIRECTION AT PORT KEATS

5 RESULTS

Mean, median and minimum surface and bottom DO concentrations and saturation levels at the discharge location are shown in Figure 5 to Figure 7. Varying discharge scenarios tended to produce slightly lower DO concentrations when compared with the constant discharge scenarios. As expected, DO concentrations reduced when wind-induced reaeration was switched off (Figure 8) and the reduction became more obvious as the BOD₅ loading increased.

Generally speaking, there was no significant decrease in DO concentrations for simulations with BOD₅ concentration below 20 mg/L, even when the wind was switched off. This indicates that DO depletion is unlikely to occur in Alligator Creek as a result of wastewater discharged from the proposed prawn farm.

When the lower bound ANZECC median water quality guideline level for DO in tropical estuaries is considered, this being 80% saturation (see the red line in Figure 6), it is apparent that provided BOD₅ levels in the discharge remain below 50 mg/L for all 'with wind' cases, that there is no violation of the guideline value. For the highly conservative 'no wind' case, the threshold BOD₅ value for potential impact becomes typically 30 mg/L, with the exception of bottom DO levels for the varying discharge case where impacts occur for a discharge level of 10 mg/L. As this is a quite extreme case, that is two weeks with no wind, a more realistic recommendation for a maximum BOD₅ in the discharge is between 20 and 30 mg/L. As stated earlier in this regard based on available data, it is expected that the site will discharge at levels more like 7-12 mg/L, and as such no adverse DO impacts are expected.

6 REFERENCES

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- WEISS, R. (1970) The solubility of nitrogen, oxygen and argon in water and seawater. Deep Sea Research and Oceanographic Abstracts. Elsevier, 721-735.

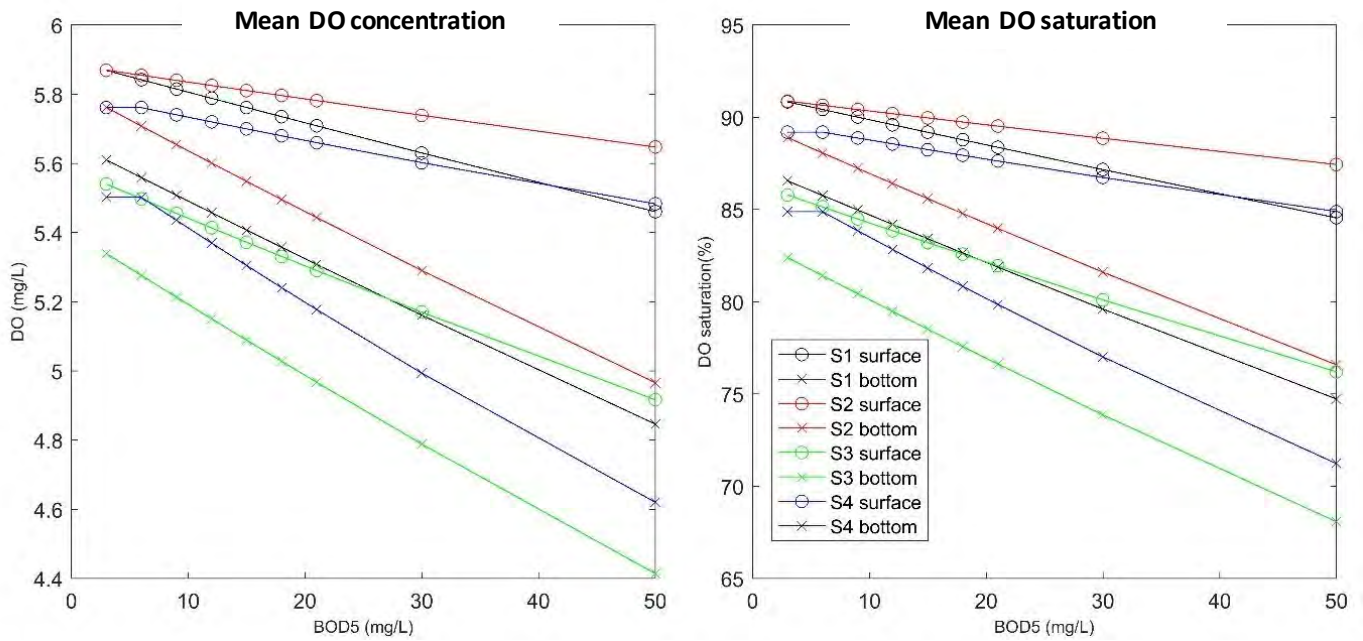


FIGURE 5 MEAN DO CONCENTRATION

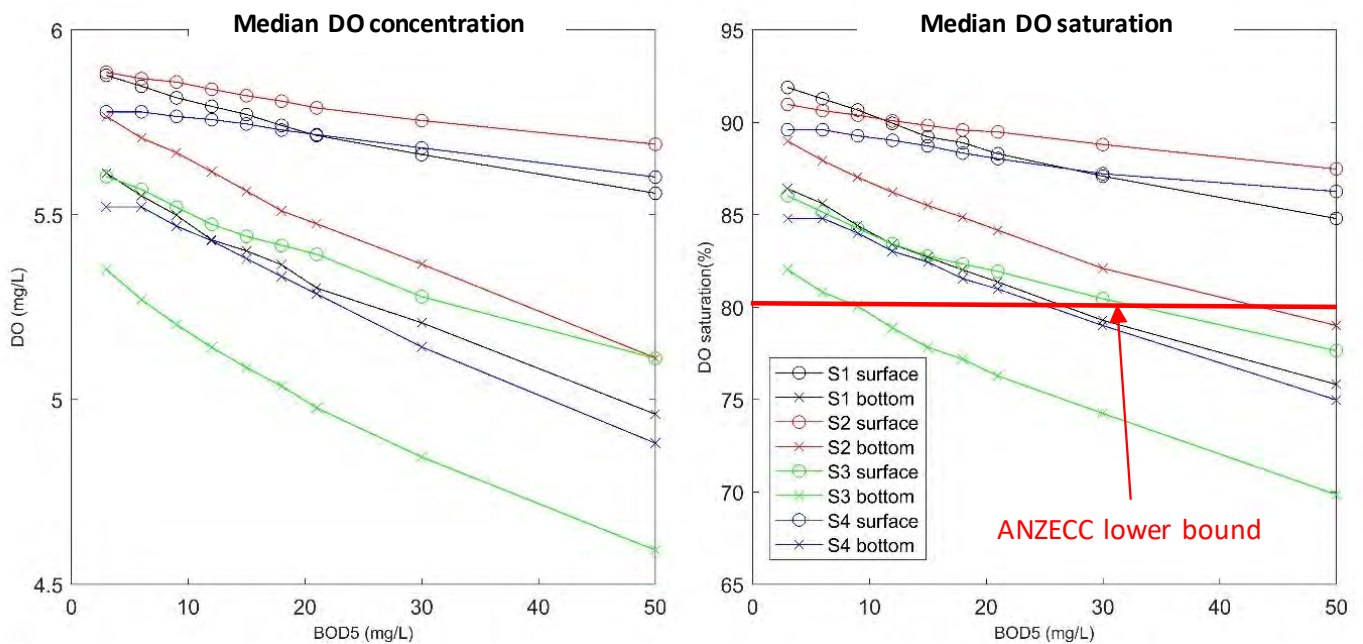


FIGURE 6 MEDIAN DO CONCENTRATION

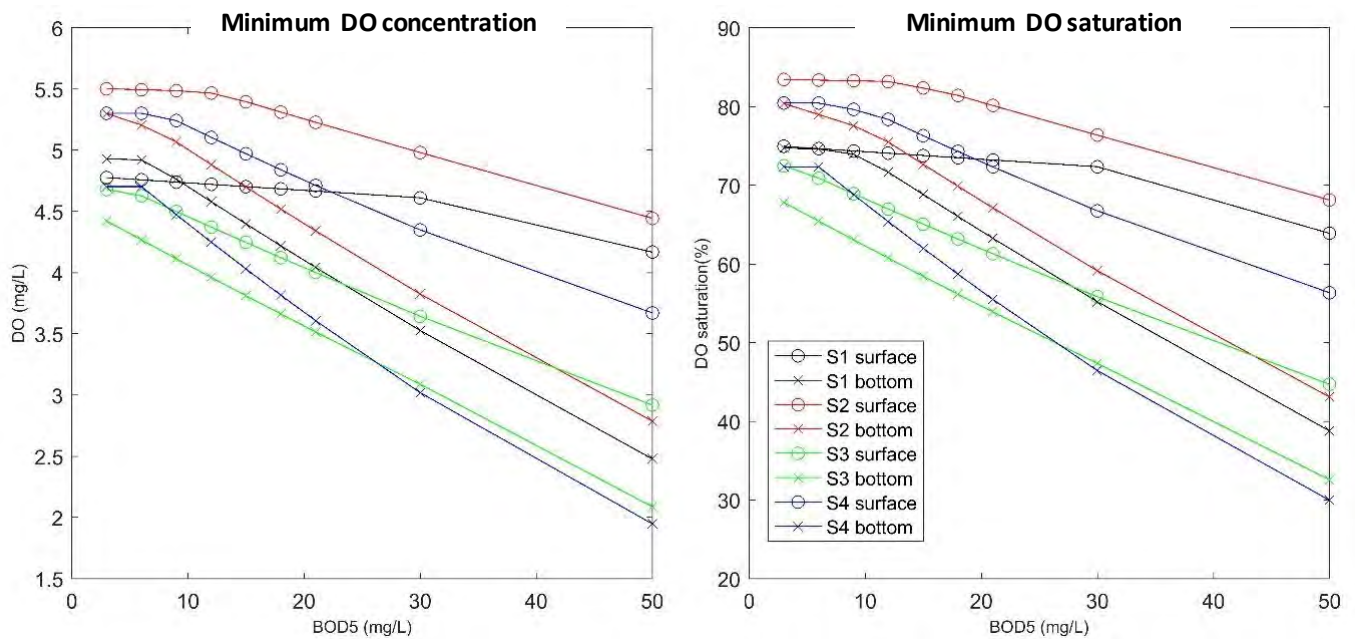


FIGURE 7 MINIMUM DO CONCENTRATION

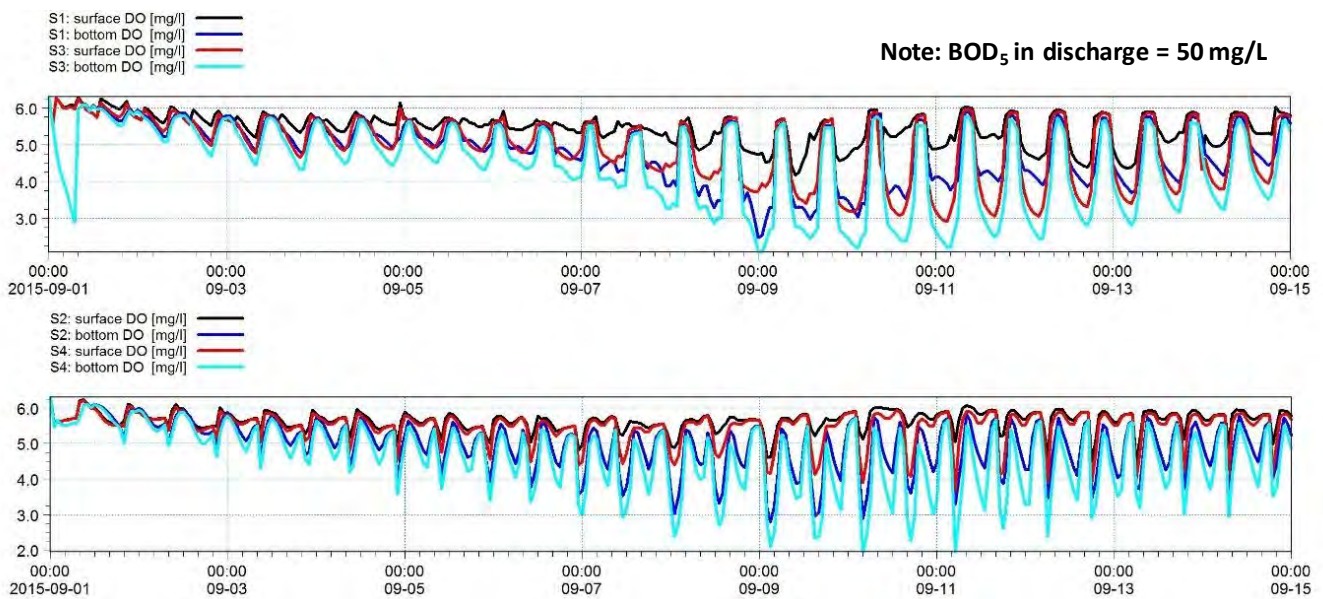


FIGURE 8 SURFACE AND BOTTOM DO CONCENTRATION

APPENDIX F LAND AND SOILS



**PROJECT SEA DRAGON
STAGE 1 LEGUNE GROW-OUT FACILITY
SUPPLEMENTARY ENVIRONMENTAL IMPACT STATEMENT**

APPENDIX F LAND AND SOILS

CONTENTS

1	Introduction	1
2	Site Selection, Investigation and Engineering Design	2
2.1	Site Selection and Investigations	2
2.2	Earthworks Trial	3
2.2.1	Construction and Testwork	5
2.2.2	2016/2017 Wet Season Early Results	8
2.2.3	Ongoing Testwork	11
2.3	Engineering Design	12
2.4	Detailed Design Phase and Further Investigations	14
3	Specific Soils and Engineering Questions Raised in Submissions to the EIS	16
3.1	Dispersive Soils, Stability and Bank Lining	16
3.2	Soil Variability	18
3.3	Soil Permeability	19
3.4	Soil Salinity	20
3.5	Pond Turbulence and Tidal Influences	22
3.6	Embankment Traffic	24
3.7	Stop Logs and Water Controls	25
3.8	Soft Soils on the Coastal Plain	28
3.9	Pond and Channel Waste	28
4	References	30

LIST OF FIGURES

Figure 1	Soils and Lanforms including Soil Sampling Locations	4
Figure 2	Earthworks Trial in Progress	6
Figure 3	Thickness of Suitable Soils	6
Figure 4	Earthworks Trial Infiltration Test	7
Figure 5	Earthworks Trial Dispersion Test	8
Figure 6	Example EMI Investigation Data	15
Figure 7	Mapped Wind Generated Wave Height Results	23
Figure 8	Typical Scour Protection Requirements for Embankment	23
Figure 9	Trafficable Berms in Existing Seafarms' Operations	24
Figure 10	Example of Typical Remotely Actuated Gate	25
Figure 11	Main Discharge Channel - Typical Details	27

LIST OF PLATES

Plate 1	Earthworks Trial in Progress	6
Plate 2	Earthworks Trial Infiltration Test	7
Plate 3	Earthworks Trial Dispersion Test	8
Plate 4	Aerial view of Earthworks Trial, January 2017	9
Plate 5	Embankment Wall Rill Erosion, January 2017	10
Plate 6	Embankment Wall Rill Erosion, January 2017	10
Plate 7	Embankment Wall Rill Erosion, January 2017	11
Plate 8	Embankment Protection Against Erosion, January 2017	11
Plate 9	Trafficable Berms in Existing Seafarms' Operations	24
Plate 10	Example of Typical Remotely Actuated Gate.....	25

LIST OF ATTACHMENTS

Attachment F1	Further Advice Regarding Soil Permeability and Dispersivity Testwork

1 INTRODUCTION

This document provides a consolidated set of information relating to soil and land for the Supplementary Environmental Impact Statement for the Project Sea Dragon Stage 1 Legume Grow-out Facility.

Specifically, this document provides information to address questions and comments on the EIS regarding the soils of Legume Station and the possible engineering design risks, particularly related to the risk of chronic leakage and/or embankment failure, and impacts on surrounding soils. The information in this Appendix covers the site selection process, the studies and observations undertaken of the site, background on the field tests and detailed design phase, and responses to specific land and soil related issues from the submissions

It is important to note that Seafarms is managing the process of engineering and project delivery in parallel to the EIS. This process has been consistent throughout the Concept, Pre-Feasibility and Feasibility studies, and as such, has served to act as a continuing risk management process, to progressively reduce the possible risks to ensure bankability of the project and success of the business.

2 SITE SELECTION, INVESTIGATION AND ENGINEERING DESIGN

2.1 SITE SELECTION AND INVESTIGATIONS

Seafarms undertook a detailed investigation procedure to first select a site, and then to understand the site to determine engineering requirements, particularly in relation to soils. Many properties in northern Australia were inspected, screened and evaluated (refer to the draft EIS, Volume 1, Chapter 4, Section 3), with the critical success factor being both the availability of a large flat floodplain with ready access to seawater and adequate fresh water, and clay soils suitable for building shallow ponds and channels without recourse to prohibitively expensive engineering solutions and environmental controls.

Legume Station met the criteria far better than any other property studied, particularly because of the presence of the deltaic 'black soil' plain (the estuarine-deltaic plain). Around Australia black soil plains have been proven to be ideal for irrigation, channels and ponds. Of particular relevance was the experience in very similar soils by Kimberley Agriculture Investments (KAI) at Ord Stage 2 around 60 km to the south-west.

Seafarms has studied Legume Station for the Grow-out Facility since late 2012. The works can broadly be broken into the following programs:

- 2012 - 2013 Concept Study and preliminary engineering and geotechnical investigations
- Ongoing field observations - wet and dry seasons from 2012 to 2016 (and continuing)
- Technical exchange with KAI in relation to engineering on similar soils in the region
- Detailed geotechnical assessment by Douglas Partners in late 2015 (dry season)
- An earthworks Field Trial supervised by Golders and undertaken in the 2016 dry season
- Continuing observations of the 2016-2017 wet season effects on the trial earthworks structures.

The 2012-2013 Concept Study by SKM (now Jacobs) included preliminary engineering and geotechnical investigations, as well as acid sulfate soils testing, investigating the soils and project risks, amongst many other aspects of the project.

Observations were also made of the 22 turkey nest dams on the property, including how these were constructed, and how they have performed in terms of slope stability, structural integrity, wet season erosion and cattle traffic on the embankments. No signs of structural distress, significant leakage or catastrophic failure were observed or reported, even though it is understood that many of these dams were not engineered or compacted to an accepted engineering standard. In terms of the soil materials, given the locations of many of these structures on the Estuarine-Deltaic Plain, the construction materials can only have been the upper Unit 1 and 2A materials, or at worst the deeper, sandier and less permeable, and generally more sodic soils. Given that the earthworks plan and design has designated Unit 1 and 2A as suitable, with 2B and other soils as unsuitable, the observations show that the available soils are suitable for long term stability.

Sandy soils, which would have higher permeability, and hence result in higher leakage, piping failure and/or structural collapse in the proposed water retaining structures, were not found in any of the areas targeted for the grow-out farms or channels. Areas on the property having overlaying sandy lenses have been excluded from the grow-out farms footprint.

Engineering discussions were held with the Legume Station owners, one of whom runs an earthworks business and also managed the construction of the levees and embankments across Forsyth Creek floodplain and Alligator Creek, as well as the construction of Forsyth Creek dam, between 2002 and 2006.

Ongoing observations have continued of the property over the wet and dry seasons from 2012 through to 2016. This included hydrology, flood areas, and natural erosion of the perimeter of the floodplain.

The technical exchange with KAI was focussed on:

- The degree of compaction of the surface black soils required to create structurally stable embankments and sufficiently low permeability to prevent unacceptable leakage and failure
- The type of equipment most suitable and the construction methodology
- Surface treatment of embankments to minimise wet season erosion
- The necessity or otherwise of lining the silty clay layer under the black soil in deeper channels.

Douglas Partners conducted a comprehensive geotechnical assessment across the Project footprint in 2015 (Volume 5, Appendix 7 of the draft EIS), to provide data and testwork for the engineering design. This work specifically addressed the soil characteristics that are pertinent to the issues raised by respondents to the Legume EIS in the public consultation.

Following these works, a field trial was conducted in 2016, supervised by Golders, and further described in Section 2.2 of this Appendix. An experienced representative of KAI also inspected this earthworks trial.

Other data was available from groundwater bore records, previous salinity investigations by NT government agencies (Tickell & Hill, 2001) and the available soils mapping and information for Legume station and the region (land Systems of the Northern Part of the NT 1:250,000 Mapping (DLRM 2008), Lands of the Ord-Victoria Area, Western Australia and Northern Territory (Stewart et al. 1970) and reconnaissance Land Resource Survey of Auvergne and Sections of Spirit Hills Stations (Brocklehurst et al. 1998)).

Figure 1 shows the soil sampling locations from this work and other available data. The Douglas Partners soil sample site designations and pit descriptions are provided in Volume 5, Appendix 7b, specifically in Section 3.2 and Tables 3 - 5 (soil profiles), Table 8 (clay/silt/sand proportions) and the pit logs in Appendix A to that document. This and the other data is discussed together in Volume 2, Chapter 1, Section 3.3.2 of the draft EIS.

Coastal engineering investigations were carried out by Water Technology Pty Ltd (refer to the draft EIS, Volume 5, Appendix 8 and Volume 2, Chapter 2), to address tides, storm surge, hydrology, sea level rise and erosion regimes for the property. These investigations were utilised in the engineering design of the farms, channels, intake and outfall structures, and other infrastructure. This included the observation that the structures built by the current Legume Station owners have had the effect of slowing the rate of erosion of the deltaic floodplain.

2.2 EARTHWORKS TRIAL

One of the risks for the project is the development of successful methodologies for the pond and channel earthworks construction and maintenance at the Grow-out Facility. To assist managing this risk an earthworks trial and test work was undertaken in June 2016. The Douglas Partners geotechnical report (Volume 5, Appendix 7 of the draft EIS) recommended that any propensity for the soils to be dispersive should be managed by compaction in the first instance, and therefore the trial was designed in part to prove, or otherwise, that compaction alone would be sufficient.



2.2.1 Construction and Testwork

The trial comprised:

- Trial embankments, to simulate shallow pond construction, with several configurations of plant and compaction methods representative of the most likely selection; and
- Trial excavations, to simulate the recycling ponds and other deeper channel construction.

A contract for the trial works was awarded to a local earthworks company experienced in these soils, utilising selected earthworks plant from Kununurra and Darwin. The trial was supervised by Golders, and carried out in the Northern part of Legume Station, adjacent to the first aquaculture farm that is intended to be built in Stage 1 of PSD (refer to Figure 1 which includes the location of the earthworks trial and test pits). It consisted of:

- Two ponds, to represent a scaled-down part of a farm, and
- A part of an adjacent drainage channel, to represent a deep Pond Drainage Channel (PDC).

The two ponds had perimeter embankments constructed from the surface clay in the floor of the ponds. Each embankment was constructed with different degrees of compaction and moisture content, to test and trial the required methods that will best be applied to the earthworks, recognising the seasonal variability in shallower surface soil moisture content.

The adjacent drainage channel was trialled with two different types of excavation, to determine the optimum earthworks fleet for the deepest channels on the project. Productivity was measured throughout the trial, and the soil moistures and achieved compaction was progressively tested.

Plate 1 Earthworks Trial in Progress shows the trial in progress, exposing the underlying silty-clay layer. This was conducted to represent the deepest channels, in an area that represented some of the thinnest zones of the surface black soil, thus representing a "worst case" scenario.

The trial also included a further 12 test pits within the footprint of Stage 1 farms, to further the knowledge of materials that are 'suitable' or 'unsuitable' for the construction of embankments, and develop recommendations for encapsulation within the farms of any unsuitable material that must be excavated to achieve the required cut-fill balance. One embankment was constructed in the trial with a core of 'unsuitable' material, covered by 'suitable' black soil. This embankment formed part of the compaction testing and moisture control.

Reference to the earlier soil exploratory works showed these soil profiles to be consistent with the profiles expected in these areas, both in terms of soil types, and presence/absence of acid sulfate soils (refer to the draft EIS, Volume 2, Chapter 1, Section 3.8).

Golders used this information to develop an indicative soils model using a Kriging algorithm, for the inferred base of the black soil and contact between 'suitable' and 'unsuitable' materials. An example of one layer of this 3 layer model is shown in Figure 2.



PLATE 1 EARTHWORKS TRIAL IN PROGRESS

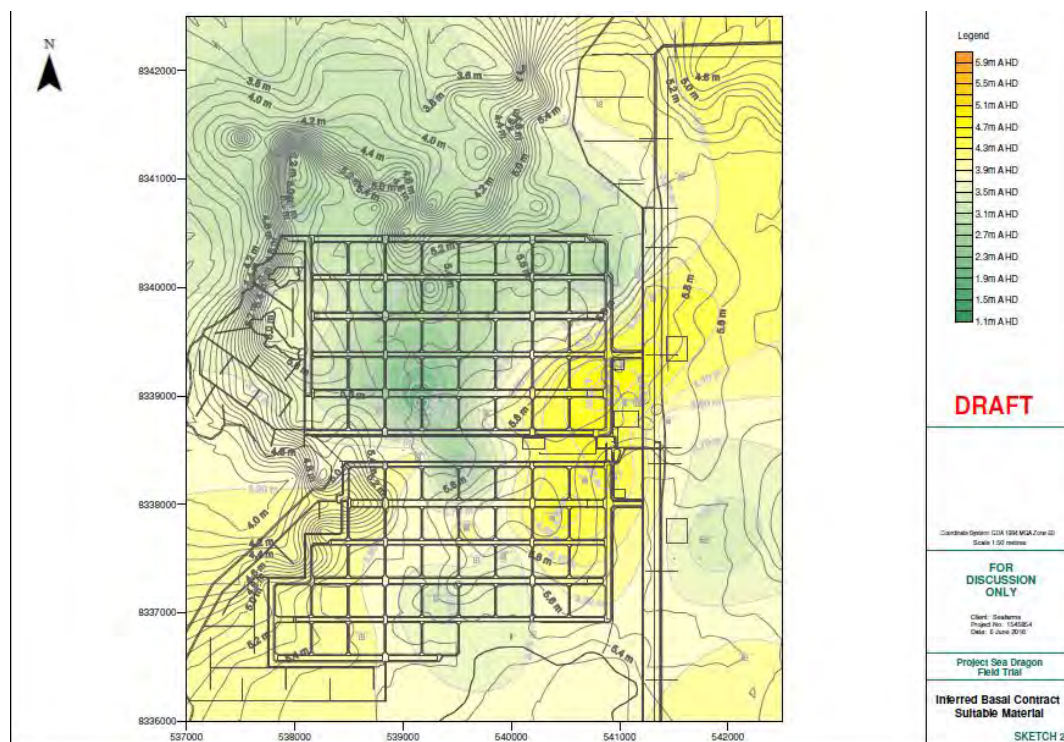


FIGURE 2 THICKNESS OF SUITABLE SOILS

The key findings of the trial related to soils performance included:

-  The silty-clay materials underlying the black soil proved more workable than first thought, with high in-situ stiffness in the Unit 2A materials, proving that the designed embankment slopes were conservative.

- Laser buckets will achieve satisfactory productivity in this material in a range of moisture contents. This will obviate the need for much of the truck and excavator methods in the deeper channels, which can be more sensitive to soil moisture.
- The stiff silty-clays (Unit 2A) are stable on slopes, and have sufficient impermeability to perform well without the need for channel lining, and thereby providing minimal seepage losses and impacts to the water table (refer to Section 3.3 for further information).
- The ideal optimum moisture content range for the placement of material (embankment construction) is OMC to +2.5 OMC.
- Compaction of 95% at OMC to +2.5 OMC is considered the minimum compaction standard that will achieve the required stability and safety against failure of embankments. KAI advised that in their black soils this is achieved with just 4 passes of a Cat 825 compactor per 200mm layer thickness. Seafarms has conservatively budgeted for 7 passes at this stage of the planning.

PLATE 2 EARTHWORKS TRIAL INFILTRATION TEST

shows an infiltration test performed for 6 days in the silty-clay layer at the base of the trial channel, to determine the permeability. Three trenches were excavated, two at different depths of base, and a 3rd observation trench. This photo was taken at Day 3 of the test. After 6 days no seepage was encountered in the observation trench, indicating low horizontal hydraulic conductivity (i.e. no lateral seepage to surface soil layers).



PLATE 2 EARTHWORKS TRIAL INFILTRATION TEST

A CRUDE TEST WAS CONDUCTED BY JETTING THE NATURAL SILTY-CLAY LAYER ON THE 3:1 SLOPE OF THE DEEP CHANNEL, TO OBSERVE ANY PROPENSITY FOR DISPERSION, EROSION OR SLUMPING, AS SHOWN IN PLATE 3 EARTHWORKS TRIAL DISPERSION TEST

. The silty-clay material remained stable for the duration of the test, with minimal erosion. This was undertaken to provide in-field observational data to back up the laboratory data described further in Section 3.1, and while indicative only, does match the general findings in that section.



PLATE 3 EARTHWORKS TRIAL DISPERSION TEST

2.2.2 2016/2017 Wet Season Early Results

The earthworks trial site was visited in late January 2017, and photographs taken to assess the performance of the ponds over the 2016 - 2017 wet season. Over the intervening 6 months, the trial had been utilised by the existing pastoral operations, with water being pumped into the ponds, and supplied back from the ponds to cattle in the nearby area.

The following plates show key photos of the site, as follows:

- Plate 4 - An aerial view of the trial, showing the two ponds and the trial channel to the right and rear. Note the extensive natural revegetation growth
- Plate 5 - A view showing the pond embankment wall. While good growth is found on the top and part of the sides, rill erosion has occurred along the slope. Note no embankment slumping or failure
- Plate 6 - similar view showing both the inside and outside of pond embankment
- Plate 7 - closer view of internal pond embankment erosion
- Plate 8 - View of channel embankment wall, which included shale armouring protection, showing no evidence of rill erosion (the drums are for the pump, utilised by pastoral operators in transfer of water into and out of the structure for cattle watering).

Overall, while the results are preliminary, the following can be said regarding the trial, soils and the stability of the structures:

- Rapid revegetation occurred over the structures, without any formal revegetation having been applied to the structures (showing effective natural re-colonisation). This shows revegetation measures have a high chance of success where surface soils remain stable

- Rill erosion occurred along embankment walls, to a greater and lesser degree in different areas. The cause of this is unknown, however as noted in Section 2.2.1 above, different construction methods and levels of moisture and compaction effort were utilised, which may explain these differences. Importantly, suitable vegetative cover and use of gravel or rock armouring (or similar) would protect against the erosion observed
- No embankment slumping or structural failure was noted and no catastrophic failure was found for any of the structures, even though they were constructed using less than optimal techniques (i.e. to test different methodologies) in different areas.

It is important as well to note that the structures were filled with fresh water, which would be substantially different in action to salt water, in terms of dispersivity, where the saltier water would tend to support soil structure more than freshwater.



PLATE 4 AERIAL VIEW OF EARTHWORKS TRIAL, JANUARY 2017



PLATE 5 EMBANKMENT WALL RILL EROSION, JANUARY 2017



PLATE 6 EMBANKMENT WALL RILL EROSION, JANUARY 2017



PLATE 7 EMBANKMENT WALL RILL EROSION, JANUARY 2017



PLATE 8 EMBANKMENT PROTECTION AGAINST EROSION, JANUARY 2017

2.2.3 Ongoing Testwork

The earthworks trial is ongoing, in that the trial ponds will be used over the 2016-2017 wet season and early part of the 2017 dry season to carry out further tests, including:

- Draining the first pond and subjecting the second (full) pond to the full hydrostatic head difference. Observations will then be made on the permeability of the centre embankment, which was deliberately

constructed with the least (minimum standard) compactive effort. This is expected to help find the point of collapse, and therefore indicate a lower bound figure for the required compactive effort (with an applied Factor of Safety). Tests to determine the line of phreatic surface will be made, with piezometer measurements.

- Tests for seepage/leakage where an installed water pipe was built into the base of an embankment, as a means of inducing a point of weakness.
- Solar drying of the pond floor, once drained, to simulate the end of a harvest, and thereby determine the length of time it will take before wheeled earthmoving equipment can commence re-grading and shaping the pond floor in the fallow period.

2.3 ENGINEERING DESIGN

The engineering design has been conducted by experienced civil engineering consultants Aurecon and Golders, utilising the data provided by Douglas Partners and the earthworks trial described in Section 2.2. This design has been supported by Seafarms' own engineers and aquaculture operations personnel experienced in the design, building, operating and maintaining of prawn farms in clayey and silty soils. A comprehensive Basis of Design is controlled and managed by Seafarms for this project.

The engineers and geotechnical consultants were well aware of the potential for the Unit 1 and Unit 2A soils to be dispersive, and understand the measures required to accommodate such soils both in-situ and in structural embankments (refer to Section 3.1 for further information). As such, a number of design principles were applied to minimise potential for dispersion. These are described below, along with other design principles that minimise the potential for other environmental impacts.

- The area of the farms was deliberately situated where the floodplain elevation is highest and the black soil is thickest, hence providing the greatest possible resource (i.e. unit 1 and 2A soils) for use in constructing the ponds and channels, and assuring that these structures would not contain more permeable base soil layers
- These soils were noted to be saline, increasing with depth (due largely to groundwater salinity as shown in Section 3.5.1 of Volume 1, Chapter 1 of the draft EIS), and as evidenced by the sparsity of deep rooted vegetation and dominance of shallow, seasonal grasses.
- Apart from the short intake channel, a part of the settlement pond and a section of the outlet structure in Alligator Creek, all the farms and channels will be constructed above RL 5.0m AHD, thereby minimising exposure to tides, storm surge and sea level rise. These structures are more than 8 km from the Keep River, Victoria River and the open ocean. The aforementioned structures that will be below RL 5.0m AHD and may be exposed to the infrequent peak water levels will be armoured to provide wave scour protection.
- The ponds, channels and IFRP have been designed to be as shallow as possible, to better target the structures within the low permeable (and most suitable) black soil, minimising the use of the underlying silty clays, as well as avoiding Potential Acid Sulfate Soil (PASS) materials. This will be achieved by only excavating to shallow depths (within the unit 1 and 2A soils) and using the excavated material to construct raised embankments.
- Channel widths have been designed to convey water at low velocities, in the range 0.4 - 0.7 m/s. This will avoid scour, but is sufficient to minimise sediment deposition.

- There was little topsoil¹ evident in the targeted area of the farms, thus minimising the need for extensive pre-stripping and stockpiling of the top layer of the soil, and also meaning that the depth of construction could be minimised to the top 300 mm (i.e. without the need to strip the top 200-300mm just for topsoil as found in many other sites). The Douglas geotechnical report in Volume 5, Appendix 7b and findings from the earthworks trial indicates topsoil of up to 0.05m in some parts, which (where present) will be stockpiled as a windrow adjacent to the excavation, as was undertaken in the bulk earthworks trial.
- The embankments have been designed for structural integrity, and are therefore covered by engineering controls on slope stability, compactive effort, moisture content at placement, and geometry. Soils testing and quality control will apply to the construction activities.
- The embankments will be subject to operating traffic in the wet. The road surfacing materials have been selected to maintain a high level of operability, allowing for the quarry materials available on the property. Seafarms has experience in maintaining the same type of unsealed roads on its prawn farms in Queensland, and has a maintenance manual established to ensure operations and harvesting are not impacted by the wet season conditions.
- The hydrology of the property has been studied carefully, and the footprint of the Grow-out Facility chosen to:
 - Not impede the floodways of the Forsyth Creek and Alligator Creek systems, the two main overland flow systems on Legume.
 - Not alter the existing interface between the freshwater wetlands and the saltwater wetlands, noting that these interfaces have been substantially altered by the current proprietors over the past few decades by holding (bundling) and moving water across the property to support pastoral operations (i.e. implementation and use of ponded pastures).
 - Retain the incident rain within the farms and control the release of excess water, thus exercising control of erosion off the edge of the floodplain.
 - Control surface water flows in the biosecurity zones between farms, Main Farm Channel (MFC) and Freshwater Channel (FWC).
- A Water Balance model has been developed for all water movement design. This takes into account the expected losses through pond and channel walls and floor, based on the measured permeability data and design criteria for compaction of the soils (refer to Section 3.3).
- The farm ponds, settlement pond and channels will be large bodies of water and as such, under certain meteorological conditions, may be subject to wind-generated waves. The design of these ponds and channels has allowed for these conditions with the calculated potential waves having been considered in the criteria for slopes, compaction and material selection. Observations have been made of the wind-generated scour that occurs on the inner face of Forsyth Creek dam, a water body that has considerably greater fetch than any of the water bodies that will be constructed by the project. No scour protection such as rip-rap or artificial materials is recommended for the internal slopes, as the annual pond and

¹ Topsoil is the upper part of the soil horizon where most plants, roots, earthworms, insects and microorganisms are active, usually referred to as the A horizon. This is different to the upper soil profile on the site (the 'black soils') which contains (in places) a thin topsoil only, around 0.05m thick.

channel maintenance is expected to be able cope with any trimming or regrading as part of the planned maintenance between crops.

2.4 DETAILED DESIGN PHASE AND FURTHER INVESTIGATIONS

Geotechnical work in the upcoming detailed design phase is planned to provide further information and refinement of the data regarding the soil horizons (black soil/ silty-clays/PASS) ahead of the farm and channel construction works. The work will comprise further test pitting for calibration of the earthworks model, and is expected to be accompanied by electromagnetic mapping methods. This will allow for refinement of the soil and geotechnical model, including allowing delineation of PASS material and testing requirements ahead of construction and fine tuning of the earthworks production plan.

Interest has been raised in some of the submissions on the EIS regarding the lower number of test pits in Farm 3 and compared to those undertaken in Farms 1 and 2. As part of the aforementioned upcoming work, Seafarms commits to further test pitting, testing and mapping of soils for Farm 3 during the detailed design phase.

The planned non-invasive electromagnetic induction (EMI) agriculture surveys noted above provide a rapid high saturation of data. Figure 3 provides an example agricultural application (by VNET Precision Farming Pty Ltd) used in Queensland Vertosol clay soils (the Legume estuarine-deltaic plain soils are also Vertosols).

This technique measures changing electrical conductivity at multiple depths in the soil profile, and will detect changes in physical, chemical and moisture characteristics. The data collected will interface with the project digital terrain model, which is based upon the highly accurate LiDAR survey developed for the project.

This new data will be used to refine the Golders soil profile model referred to in Section 2.2 above.

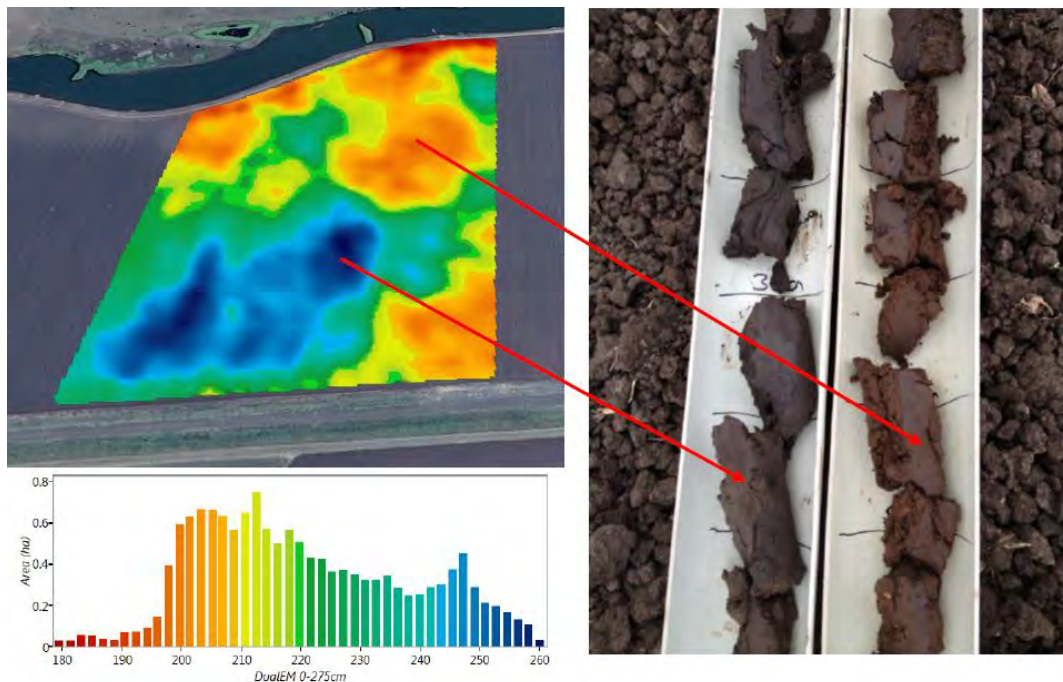
Deep soil drilling at the intake site for piling design was not undertaken in the late 2015 geotechnical investigation. Accordingly a conservative design was assumed for the jetty piling, until testing for the detailed design phase is commenced. The conservatism in the design included the assumption that the soils will be low strength marine muds, and that no end-bearing capacity will be achieved, and that friction capacity would be generated by long pile lengths. This design will be improved by including deep borehole testing during the above monitoring works.

Specific control measures for specific areas, such as sheet piles and culverts, will be developed during this stage as required.

The project Basis of Design commits to adherence to Australian codes and standards, and will continue to confirm appropriate standards for both design and testwork. Ongoing testwork results and investigation/supervision results will be included in the engineering / earthworks quality control documentation.

Generally all design shall be completed using the most appropriate State design methods (Northern Territory, or either Western Australia or Queensland where Northern Territory standards are not available), and shall take into consideration the relevant strength, stability, serviceability, durability and fire requirements in accordance with the relevant Australian Standards. The Regulatory Approvals Map for Project Sea Dragon prepared by the Australian Government sets out these requirements (refer to the draft EIS, Volume 1, Chapter 6).

These commitments will be carried forward into the construction phase through the Project Execution Plan and design specifications.



- Higher ECa readings at depth in the profile have identified subsoils with much higher clay contents (that was not evident from surface inspection).

FIGURE 3 EXAMPLE EMI INVESTIGATION DATA

All design work has been completed by professional engineering consultants, working to Australian Standards; the Environmental Code of Practice for Australian Prawn Farmers (Donovan, 2001) and guided by the ASC Shrimp Standard (ASC, 2014).

All soils tests in the 2015 geotechnical program were carried out in Douglas Partners' NATA accredited laboratory in Darwin, to the AS 1289 Methods of testing soils for engineering purposes series of standards, with soils classified to AS 1726 Geotechnical Site Investigations. Piling will be designed to AS 2159 Piling - Design and Installation, and "The behaviour of laterally loaded piles" (Poulos, 1971).

The Queensland Department of Primary Industries and Fisheries Guidelines for constructing and maintaining aquaculture containment structures (DPI&F, 2007) has been referenced and considered in:

- Assessment of clay layer thickness, permeability and acceptability of risk of leakage from ponds
- Containment structures design
- Freeboard
- Dispersivity management.

Importantly, the DPI&F (2007) guidelines use the above Australian standards for earthworks (AS1289). The Project engineers also use AS3798 Guidelines on earthworks for commercial and residential developments, which provides for guidance on control testing of earthworks and associated site preparation works, and on the interpretation and application of the relevant test methods specified in the AS 1289 standard.

3 SPECIFIC SOILS AND ENGINEERING QUESTIONS RAISED IN SUBMISSIONS TO THE EIS

3.1 DISPERSIVE SOILS, STABILITY AND BANK LINING

The potential for clay soils to undergo shrink/swell cycles and to be dispersive in certain circumstances was understood prior to the advent of the site investigations, and was taken into account in the design of the water retaining structures. Seafarms decided to address the risks associated with these soils by a practical combination of geotechnical testwork and field trials, coupled with local experience and observations. Advice from Ord Stage 2 work done for the Western Australian Water Corporation was taken also into account. Seafarms have taken a conservative approach in designing for a worst-case scenario in which all soils are assumed to be dispersive and sodic. This section describes the finding of the testing and explains why this conservative approach adopted by Seafarms is more than adequate to ensure that treatment of the soils during construction and operation will ensure the long term stability and impermeability of the ponds.

It is important to note that laboratory testwork for dispersion is indicative, but is not conclusive in its own right (Foundation Engineering Handbook, Fang 1991) because of the influence of:

- The state of aggregation of the clay particles,
- The formation, i.e. film of fine fraction (clay particles) adhering to the coarser fraction (silty sand particles).
- The degree and strength of the physicochemical interaction with the coarser fraction.
- The nature and salinity of the soil-water matrix.

Thus Seafarms has utilised multiple lines of evidence in reaching its conclusions. Dispersion and sodicity is discussed further in the EIS - Volume 2, Chapter 1, Sections 3.5, 4.2.5 and 5.1.1, and in Volume 5 Appendix 7b. To provide further clarify, Attachment 1 to this document also provides recent advice from Golders after reviewing the available dispersion data, with the following two key findings:

- Emerson and pinhole dispersion tests showing a range of results from dispersive to non-dispersive for the unit 1, 2A and 2B soils at Legune. Based on the results and the variability, Golders finds a variable risk of dispersion but overall a relatively low risk for the Project.
- Similar testing at the Ord Stage 2 project and the Kununurra Wastewater Treatment Plant (both on similar soils) showed non-dispersive to potential (intermediate) dispersion, indicating similar issues, though at a slightly lower risk level than at the Legune site.

The laboratory work by Douglas Partners included Emerson Class and Pinhole Dispersion tests, with further testing on disturbed and remoulded samples in the laboratory to be undertaken as part of the detailed design phase. These tests are not likely to cause any significant adjustments to the farm designs, but may be used to refine definition of the required compactive effort and Optimum Moisture Content (the moisture level required to achieve suitable compaction) settings for construction.

Dispersion, including the mechanisms involved, is described in the draft EIS, Volume 2, Chapter 1, particularly in Section 3.5. Results indicate patchiness in the dispersive characteristics of the Legune soils (with some of the Legune soils with similar characteristics being sodic, and others non sodic). However, at this stage of the Project, all design has been undertaken assuming soils are dispersive and sodic (a worst case and conservative approach).

It is generally understood that dispersion may be suppressed by the pond and channel saline water², but may occur with inundation from high rainfall events. The design presented in the EIS is based on the use of the black soils and unit 2A soils, and the available laboratory evidence and information from 4 years of observations, similar soils at nearby sites, anecdotal information from site operators and the specific earthworks trial conducted in 2016 (refer to Sections 2.1, 2.2, 3.2 and 3.3 in this Appendix). All of the information, both that provided in this section and appendix, along with experience in clay soils in Seafarms' existing operations, supports that the soils will be suitable for pond and channel structures without the need for artificial lining or stabilisation. It is considered that any variability in the soils and any propensity for dispersion can be economically handled by the engineering methods described further below (and in Section 5.1 of Volume 1, Chapter 1 of the draft EIS) and through construction planning and best engineering practice in monitoring and maintenance.

The farm designs allow for the deeper channels (PDC, FDC) to be dug into the stiff upper layer of the silty-clays (Unit 2A), in areas where the structural strength of the bottom section of the slope is high and remains undisturbed. Any use of the silty-clay material in embankments above natural ground level would be in a disturbed state, and therefore laboratory testing must reflect the degree of compaction which would be applied. The cut-to-fill calculations and farm levels have been designed to avoid using any low stiffness soils for the structural embankments and slope surfaces, and if 'unsuitable' material (generally Unit 2B, soft silty-clays, and below) is generated it would be encapsulated within embankments and in general fill areas.

As noted by Douglas Partners (draft EIS, Volume 5, Appendix 7), any risk of dispersion can be mitigated by the following methods:

- Compaction and moisture control during placement, or
- Gypsum treatment during placement, or
- Lining batter slopes with a filter material, or
- Incorporation of a filter within the embankment.

Compaction and moisture control is by far the most practical and economical method, for construction and for maintenance, as it benefits not just resistance to dispersion of soils, but provides the impermeability required for seepage control. This applies to the base of ponds and channels, as well as embedded items in the embankments, including pipes and concrete drainage structures.

Early results from the earthworks trial are discussed in Section 2.2.2 showing that, while rill erosion was evident (though not ubiquitous), the embankments remained stable and no catastrophic leaks or failures were evident, and shale armouring of parts of the wall were successful in stopping this erosion. This was despite the fact that the embankments were subject to varying compaction standards (for testing purposes) and not formally revegetated (again to test natural re-colonisation) or armoured. No tunnelling or other signs of sodic soil deterioration were noted, even though ponds and the channel were filled with fresh, not saline, waters.

Surface protection through armouring and revegetation is explicitly included in embankment designs, as shown in the draft EIS (refer to figures 11 - 13, 15 and 22 in Volume 1, Chapter 3).

² Dispersion occurs due to an expanded hydrated radius for sodium ions causing separation of the diffuse double layer (though repulsion of like charges) when hydrated (i.e. in the presence of water). Saline waters have the effect of removing water from this layer through osmotic potentials, therefore avoiding the hydration and subsequent dispersion.

Farm maintenance will however allow for tunnelling potential in the embankments, and will monitor and react with surface compaction and corrective measures if shrinkage cracks and other defects arise.

If scour is evidenced in the channels due to instability, dispersion of clays or higher than expected velocities, the areas of scour will be rectified during the annual maintenance or maintenance periods during the fallow periods. However, it needs to be reiterated that scour is not expected due to design considerations that have taken this risk into account (see above). Each farm will be dried out after harvest, allowing inspection of embankments and channel bases.

Any uncovered unstable materials will be covered with a layer of compacted suitable soil as part of routine maintenance works. The tops of embankments will be provided with a 2% cross-fall for control of surface water drainage, and settlement of embankments will be monitored, with fill materials added to the tops of embankments where necessary to maintain freeboard, etc.

3.2 SOIL VARIABILITY

Variability in soil conditions across the footprint were noted in the draft EIS. However, the soils of the estuarine-deltaic Plain, where the earthworks will take place, were found to be quite uniform. This is not surprising given the similar geology and soil formation history and processes across the plain, and the high energy environment, notably the wet season rain and floods. The 'black soils' (unit 1) and underlying silty clays (Unit 2A) showed little variability in depth across the Project footprint, which is best visualised by reference to Figure 2 in this Appendix.

Variability was primarily noted for:

- Dispersivity and sodicity
- Salinity, where surface salt scaling and saline groundwater expression provided for elevated surface salinity, and
- Potential Acid Sulfate Soils, where existing or remnant tidal channels, or the presence of sand lenses (outside of the Project footprint) and rock outcrops resulted in different presences/absences for PASS.

However, and importantly to the design:

- All soils were accepted as sodic/dispersive for the purposes of design
- Saline groundwater generally evens out the salinity in subsoils below the salt scalded zones (refer to Volume 2, Chapter 1, Section 3.5.1 and Tickell & Hill (2001) referenced in that section)
- PASS was not encountered in the depths subject to excavation depths required for the Project. Furthermore, PASS would not be found in the soil layers that will be used for construction since both the geological origin of the soils and the weathering that those soils have undergone are not precursors to PASS.

Importantly, the presence of the soil units (Unit 1, Unit 2A, etc.) that have been identified as suitable for construction was highly repeatable across the geotechnical test pits conducted between late 2012 and early 2016. Areas of the site where the soil Units did not support the construction of the farms and channels have been avoided.

Given the relative uniformity of the soils in the development footprint, the mapping of the variability of soils across the site that has taken place to date is sufficient for the preliminary design, the Feasibility Studies and

the EIS. The draft EMP (Volume 4, Chapter 3 of the draft EIS) has been formulated based on the worst case conditions, particularly relevant to dispersion and acid sulfate soils.

The exact treatments required in different areas will be refined during the detailed design phase through further testwork (refer to Section 2.4). This will result in more efficient design where more favourable conditions exist, rather than adopting the current conservative approach across the entire Project based on worst case conditions (although suitable factor of safety and conservative design will still be adopted). The farm designs allow flexibility, such that the number of ponds and farm shape could be adjusted for local effects, such as excessive 'unsuitable' soils. However, the evidence collected shows that major adjustments will not be necessary.

3.3 SOIL PERMEABILITY

There were a number of comments received to the draft EIS in relation to soil permeability. The key issues raised were:

- A perceived lack of permeability test data, or lack of good synthesis of permeability data
- Questions regarding the suitability of the local topsoil for pond lining, and therefore the need for synthetic liners
- Lack of seepage testing and ambiguity about likely frequency of chronic leaks, as well as a query regarding the use of embankment foundation preparation to reduce seepage.

The draft EIS stated that suitably low permeability would be achieved (refer to Volume 1, Chapter 3, Section 5.3), however the data was only explicitly available in the geotechnical report, Volume 5, Appendix 7b of the draft EIS. This provided test results on the permeability of materials to be used for embankments and ponds, namely the 'black soils' (described as Unit 1 soils) and underlying clay and clayey silty soils (described as Unit 2A and 2B soils) across the estuarine-deltaic plain. In particular, Table 11 in that report provides permeability test results across a number of sites, showing quite consistently results of lower permeability than $1 \times 10^{-9} \text{m/s}$ can be achieved through sufficient compaction (these results simulate a compacted clay liner). This low level of permeability is commonly adopted for these types of structures, and is the lowest (i.e. most stringent) requirement outlined in the *Guidelines for constructing and maintaining aquaculture containment structures* (DPI&F, 2007).

Further work on soil permeability was derived from similar sites and soils, and also conducted during the earthworks trial, confirming the above findings. Golder Associates have provided a more recent synthesis of existing permeability evidence and data, included in Attachment 1. This information shows:

- Very low achievable permeability of the unit 1, 2A and 2B soils through sufficient compaction
- Low permeability of in-situ soils (units 2A and 2A-sandy or 4A) without compaction, although requiring some compaction to reach suitably low permeability for ponds and channels (as evidenced by above laboratory tests)
- Very similar soils at the Ord Stage 2 project, showing similar laboratory permeability, but higher field permeability than found at the Legume Stage 1 site (i.e. more favourable at Legume). Importantly, similar soils and permeability levels were used in the Ord Stage 2 project to successfully construct engineered clay liners, even though the Ord Stage 2 project showed this higher field permeability.

Due to issues associated with variable shear strength (refer to Section 3.8), unit 2B materials have been characterised as unsuitable for use in the Project structures. As such, only the Unit 1 and 2A materials will be

utilised. The above data, evidence and information, as well as findings from the observational study of existing structures (refer to Section 2.1), shows that satisfactory impermeability in pond and channel embankments can be achieved in these materials.

Advice in the Douglas Partners geotechnical report (Volume 5, Appendix 7b in the draft EIS) as confirmed in the field in the earthworks trial (refer to Section 2.2) has been used to confirm the minimum layer thicknesses and compaction standard required for these Unit 1 and 2A materials. By comparison with the successful experience of water retaining structures at the Ord Stage 2 project, and with reference to the DPI&F (2007) Guidelines, the following design standards have been adopted:

- A minimum 300mm thickness of compacted clay liner to be utilised for all saltwater containing structures (to be confirmed, by playing off compactive effort with liner thickness)
- Maximum daily infiltration rate of 2mm/day, consistent with that successfully adopted for water retaining structures in the Ord Stage 2 project. Note that experience in the Burdekin Irrigation Scheme in Queensland (where clays have some similarity to the Ord area) also shows that channels designed and constructed using this 2mm/day criterion have performed successfully over a 20 year life span (Golder Associates, pers.comm, January 2017).

The permeability value and liner thickness achieved may differ from place to place (depending on thickness, in-situ moisture and workability), but the overall infiltration can be controlled by balancing liner thickness against permeability, as is also adopted in the DPI&F (2007) guidelines.

During construction, and during pond maintenance in the fallow periods the in-situ base materials will be ploughed, re-graded to the required contours, moisture conditioned and surface compacted with a drum roller to maximise the impermeability. If the channel intersects unsuitable materials, these will be replaced with a compacted liner of Unit 1 or 2A materials to the design thickness (although areas of unsuitable soils have generally been avoided). The detailed design and earthworks plan will enable efficient planning of soil thicknesses and compaction requirements, through the existing data and additional field testwork committed to in Section 2.4.

In terms of the need for pond liners, the above data shows that suitably low permeability can be achieved without the need for additional liner material in the ponds and channels. Sections 2.2.2 and 3.1 further show that pond liners will not be required to control dispersivity, with the vegetation, armouring/protection and compaction to be adopted.

Finally, the adopted approach to manage embankment foundation preparation to further reduce seepage is to firstly clear and grub any surface vegetation, principally grasses, then scarify the base and condition the soil by water truck, to key in the first layer of compacted embankment fill. If poor substrate is evident, then that material would be stripped back and stockpiled for re-use in a non-structural application. This is expected to be sufficient to control seepage at the base of embankments.

For the structures such as the settlement ponds and intake channel that are necessarily situated on the poorer soils on the coastal erosion plain, the Aurecon designs in the draft EIS clearly show that keyways have been recommended. Refer to Volume 1, Chapter 3, Settlement Pond - Figure 12, and MDC - Figure 22.

3.4 SOIL SALINITY

The key issue raised in the submissions in regards to soil salinity was in terms of saline waters in ponds affecting soil salinity through seepage and leaks from ponds and channels

The construction methods call for very shallow excavation to gain the material for the pond wall construction. This is made possible because both because the ponds require only shallow water depths, hence low walls (1.3m + 0.7m freeboard); and also because the large size of the ponds means a large volume of material can be gained from relatively shallow excavations.. This is similar for channels (5m high embankments but 100m wide channels) resulting in a generally low hydrostatic head relevant to the surrounding plains. Constructing any of the structures with the base in highly permeable sands is not proposed. As such, and given the achievable permeabilities (refer Section 3.3) and the monitoring commitments (Section 2.4), as well as the engineering controls outlined in above sections, there is considered highly unlikely that large scale leaks would form. Regardless, early warning and mitigation measures have been adopted as part of the risk management system in the EMP, namely (from Appendix C8 of the draft EMP, Volume 4, Chapter 3 of the draft EIS):

- Implement procedures for rapid response to identified large pond and channel leaks. These will include:
 - Early detection of leaks through groundwater monitoring of tracers and/or fingerprinting of waters (anion/cation mixes, etc.)
 - Integrity testing of areas with the potential to leak
 - Rectification of leaks, by in-situ repair works, with emptying of the pond in extreme situations

The investigation works and design in relation to pond impermeability, described in more detail above, provide for the primary mitigation against leaks to groundwater from the ponds, along with the above early warning and rapid response procedures. Appendix C8 of the EMP (Volume 4, Chapter 3 of the draft EIS) also provides corrective actions should a leak be identified. While not explicitly described, these corrective actions (to 'Rectify leaks as soon as practicable once identified') can include emptying of a pond to allow reprofiling, compaction and plugging of any identified leaks in extreme circumstances.

In terms of the surrounding plains, the area the grow-out ponds will be situated upon do not contain freshwater environments, other than ephemeral floodplains during the wet season. In terms of saline influences, many areas on the site are frequently subjected to naturally derived soil salinisation, which can grow and reduce depending on natural conditions, particularly due to a run of above average wet seasons causing saline groundwater expression, as noted in Section 4.5.1 in Volume 2, Chapter 1 of the draft EIS. Given the salinity levels found on the surface, and the salinity profiles through soils, salts are also rapidly flushed through the soil profile by wet season rains. Tickell & Hill (2001), referenced in the above draft EIS section, noted that this widespread salinisation has been a long running occurrence on Legume station, waxing and waning due to climatic influences over time.

As such, given both this and the aforementioned low potential for leakage as a result of the very high impermeability (see Section 3.3. above), there is limited potential for any saline water to impact freshwater environments on the site.

A detailed description and assessment of groundwater dependence was also made of the vegetation on the site, finding that, in fact, the grasses on the black soil plains do not rely on the groundwater table, which is generally 2.5 - 3m below the surface in the dry season (S. Danielsen pers. comm). As these grasses are not deep rooted, with root zones extending at most 0.5 - 1m below the surface, the groundwater table is not generally accessible during the dry season. The grasslands on the estuarine-deltaic plain may be seasonally reliant on the wet season rain saturating the soil, which because of the high clay content is held in the upper layers of the soil and on the surface for long periods of time. However this is soil and surface water, not groundwater, and any changes to groundwater (notwithstanding the above) would be highly unlikely to affect the surrounding grasslands, noting that it does reach very high salinities naturally.

As noted in Volume 2, Chapter 4 of the draft EIS, there are some vegetative systems on the site that may make facultative use (i.e. they make use of, but do not depend upon) of groundwater, however these are associated with the low hills and rises on the plains (the ranges landform residuals extending through the plains), which are not present in the vicinity of the grow-out farms. Surface expression from these areas are often saline, and often associated with salt scalding rather than providing fresh water (refer to Tickell & Hill, 2001 referenced in the above chapter).

Overall, infiltration and leaks can be suitably controlled, and:

- no permanent or semi-permanent freshwater environments will be infiltrated by saline waters as part of the project
- grasslands are not groundwater dependent, relying at best on soil water retained from the wet season within the surface clay soils, and with no ability to reach any groundwater proper in the dry season. The saturation of, and retention within, the surface clay soils of the wet season rainfall will not be affected by the project.
- groundwater is already saline with no useable shallow freshwater aquifers.

As such, soil salinity is not anticipated to be affected by, nor present a problem or a risk from or to, the Project.

3.5 POND TURBULENCE AND TIDAL INFLUENCES

As part of the engineering design for the Feasibility Study, wave set-up and the potential risk of damage to ponds and channels were examined. Recognising the required design winds speeds for this Category 'C' area, significant wave heights (Hs) generated by wind were calculated for each of the water retaining structures, and used to determine the need for scour protection inside the structures.

This same body of work examined the likely wave scour effects on the outer face of earthen structures (embankments) exposed to the design storm events, tides, storm surge and sea level rise (determined in Appendix 8 and Appendix 10 of Volume 5 of the draft EIS). The analysis considered an average of the 50yr ARI event (present day) and 'future climate 2060' having consideration for the structure design life of 25+ years. A peak water level of +5.3m AHD was adopted.

The results of part of this investigation (Hs levels and wave height assessment) is shown in Figure 4.

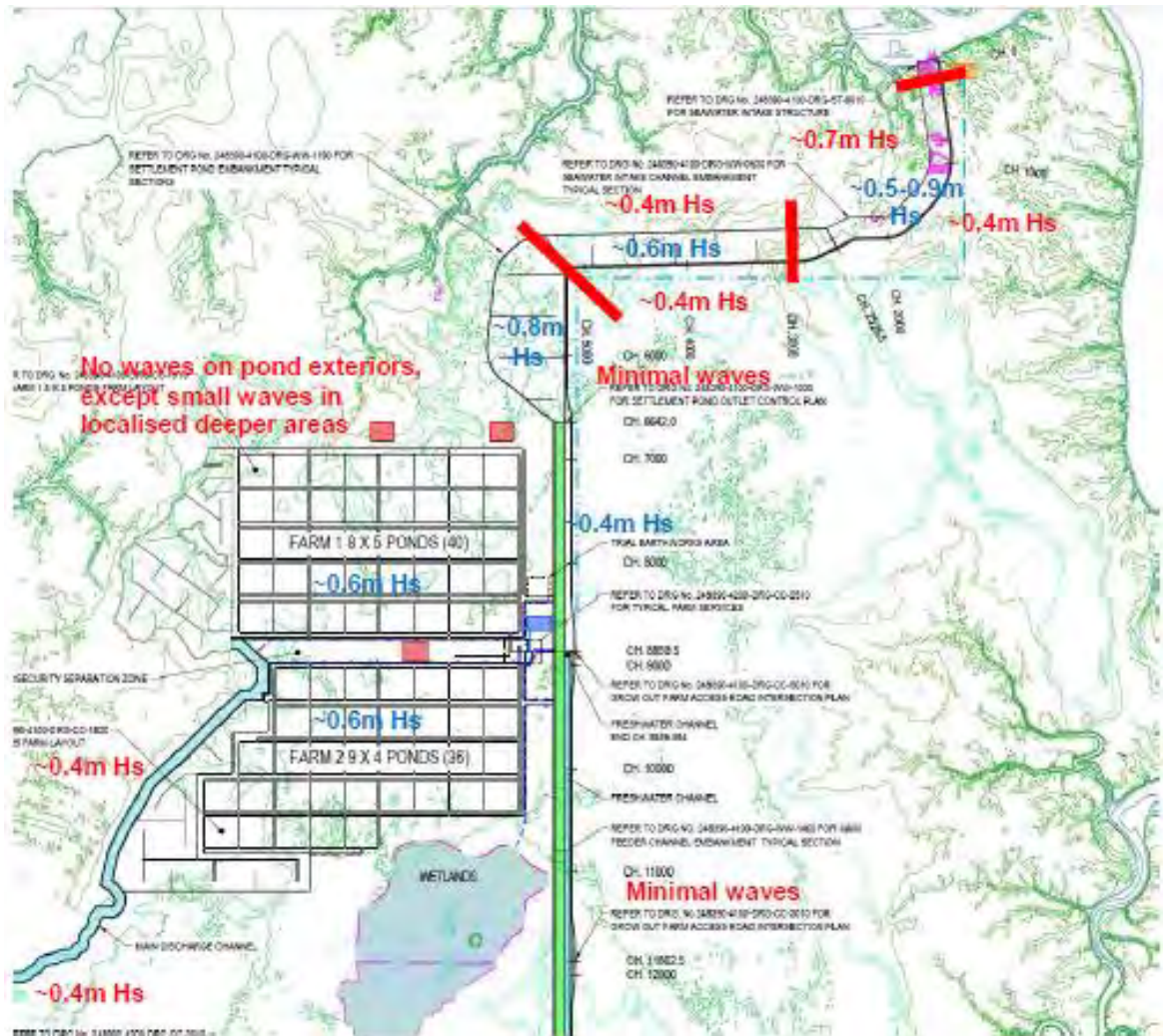


FIGURE 4 MAPPED WIND GENERATED WAVE HEIGHT RESULTS

Based on these investigations and in accordance with the evidence, the recommended treatment for scour protection was incorporated into the design and capital costing, as shown on the sketches incorporated in the draft EIS (Volume 1, Chapter 3), and also shown in Figure 5 below. Limited internal scour is an accepted risk in aquaculture ponds, and the predicted scour for the Grow-out Centre is considered manageable under routine maintenance, typically rectified using silts and waste from the pond itself (refer to Section 3.9 regarding this material).

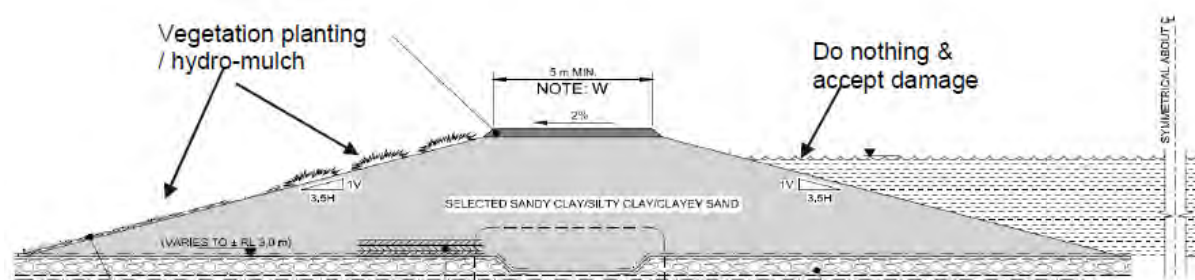


FIGURE 5 TYPICAL SCOUR PROTECTION REQUIREMENTS FOR EMBANKMENT

Comparison was made with the scour that occurs on the inside face of Forsyth Creek dam, which has not required maintenance action since it was commissioned in 2006. Forsyth Creek dam is a much larger body of water than any of the proposed ponds and channels, with a correspondingly much longer fetch. The inside face consists of quarry-run, -75mm shale only, and no armouring.

In the event that any particular structure suffers unacceptable scour, sufficient coarse shaley materials will be available at the project quarry with which to apply armour or coarse material, as a corrective measure only.

Scour protection for the external faces of the intake channel, settlement pond and EPZ outfall structure having infrequent exposure to shallow water waves and currents will be armoured by a combination of rock rip-rap, sacrificial roads and hydro-mulching.

3.6 EMBANKMENT TRAFFIC

Concern was raised by the Northern Land Council regarding traffic on ponds and the potential for damage and instability, which deserves particular mention in this Appendix. Trafficable embankments around the ponds and channels will be sheeted with compacted road base material, as recommended by Douglas Partners in the geotechnical report, and as incorporated into the designs by Aurecon/Golders (refer also to the draft EIS, Volume 1, Chapter 3). Base and sub-base materials will be generated from the lateritic and shaley borrow pits on the property. Experience on the property with these particular materials is sufficient to demonstrate that they perform well in the wet season when compacted to the required standard and elevated with good drainage.

The traffic intensity around farms is low, and so unsealed pavements will suffice if the road base material is used and compacted to the specification. Roads will be generally be maintained in the dry season, by grading, and if necessary, re-sheeting and compacting. See Plate 9 Trafficable Berms in Existing Seafarms' Operations for an example of a Seafarms pond road in the wet season.



PLATE 9 **TRAFFICABLE BERMS IN EXISTING SEAFARMS' OPERATIONS**

Traffic intensity on the access roads between farms and the Central Facilities will be higher, with highway axle loadings. Accordingly, the design geometry and pavement design was based on the Austroads Guide to Road Design publication, for 80kmh operating speed, sealed pavement, 100 year ARI event for floodways and 2 year ARI event for relief culverts. Axle equivalencies in the design adopted the recommendations of the Main Roads Western Australia (2013) Road Note No.9 - Procedure for the Design of Road Pavements. Roads will be elevated above the plain, and no black soils will be used for road embankments or pavement materials.

3.7 STOP LOGS AND WATER CONTROLS

Concern was raised in the submissions with respect to:

- How stop logs will work during high intensity rainfall events when all ponds are approaching maximum capacity.
- Whether the ponds have a designed spillway to maintain integrity of bund walls.
- Freeboard height of walls.
- Management of prawn escapes from potential stormwater release.

Ponds have been designed with a 700mm freeboard. Exchange of water through the farms is a daily event, as is the balancing of the water volume in the total farm, and indeed the volume in the entire intake and discharge system. Stop logs and control gates will be remotely actuated and monitored, as well as having local control and actuation. Manual actuation of gates will be possible in the event of failure of distributed power and failure of the local standby fixed and mobile generators.

All devices will be instrumented with level sensors and connected to the control system at each farm services area by a combination of proprietary SCADA, fibre-optics and Wi-Fi systems, according to the reliability required.

Plate 10 shows an example of a typical remotely actuated gate, supplied by Rubicon Pty Ltd, for a single pond discharge (non-prawn farm picture). Fixed mesh screens will be inserted upstream of all pond discharge gates to prevent the movement of prawns into the PDC's and downstream channels.



PLATE 10 EXAMPLE OF TYPICAL REMOTELY ACTUATED GATE

For storm events greater than the 10 year ARI but less than the 50 year ARI stormwater will be managed by controlled release drainage through the downstream weir structures from PDC, FDC, IFRP and then to the MDC/EPZ. For storm events > 50 year ARI a lined swale has been provided in the berm of the outermost channel (PFC or PDC) facing the biosecure zone, for planned and controlled release to the environment. In such events the salinity of the water being released is expected to be very diluted by the rainfall event.

The release from the EPZ to Alligator Creek will have approximately 21m length of Rubicon style of gates, sized to handle the peak release volume, as shown in Figure 6 (and described in Section 6.14.1 in Volume 1, Chapter 3 of the draft EIS). Each individual gate will be sized so that it can be manually actuated, in the event of power failure, with local hand-wheel control. Note that

The 700mm of freeboard for ponds and channels forming the discharge route was sized to:

- Hold up to the ≤ 10 year ARI storm event.
- Allow a buffer time and hence volume in the system, for the water releases to be managed by the attendant staff.

The system is not planned to be regularly operating at water levels within the freeboard zone. Weather patterns and storm predictions will be taken into account in the daily management of the farms and water system. Water levels can be lowered ahead of forecast storm events, in order to accommodate the predicted rainfall input, for events such as cyclones. The seawater intake pumps would be the first level of control of the volume of water in the system, ahead of predicted high intensity rainfall.

All ponds are internal to the farm, surrounded by channels with water level controls. No ponds will be externally facing the environment, in the event of failure of a pond embankment. As such, any overflow (although there are not expected to be any unplanned overtopping events due to water management controls) will be retained within the farm water management system, inside ponds, farm channels and ultimately the IFRPs and MDC.

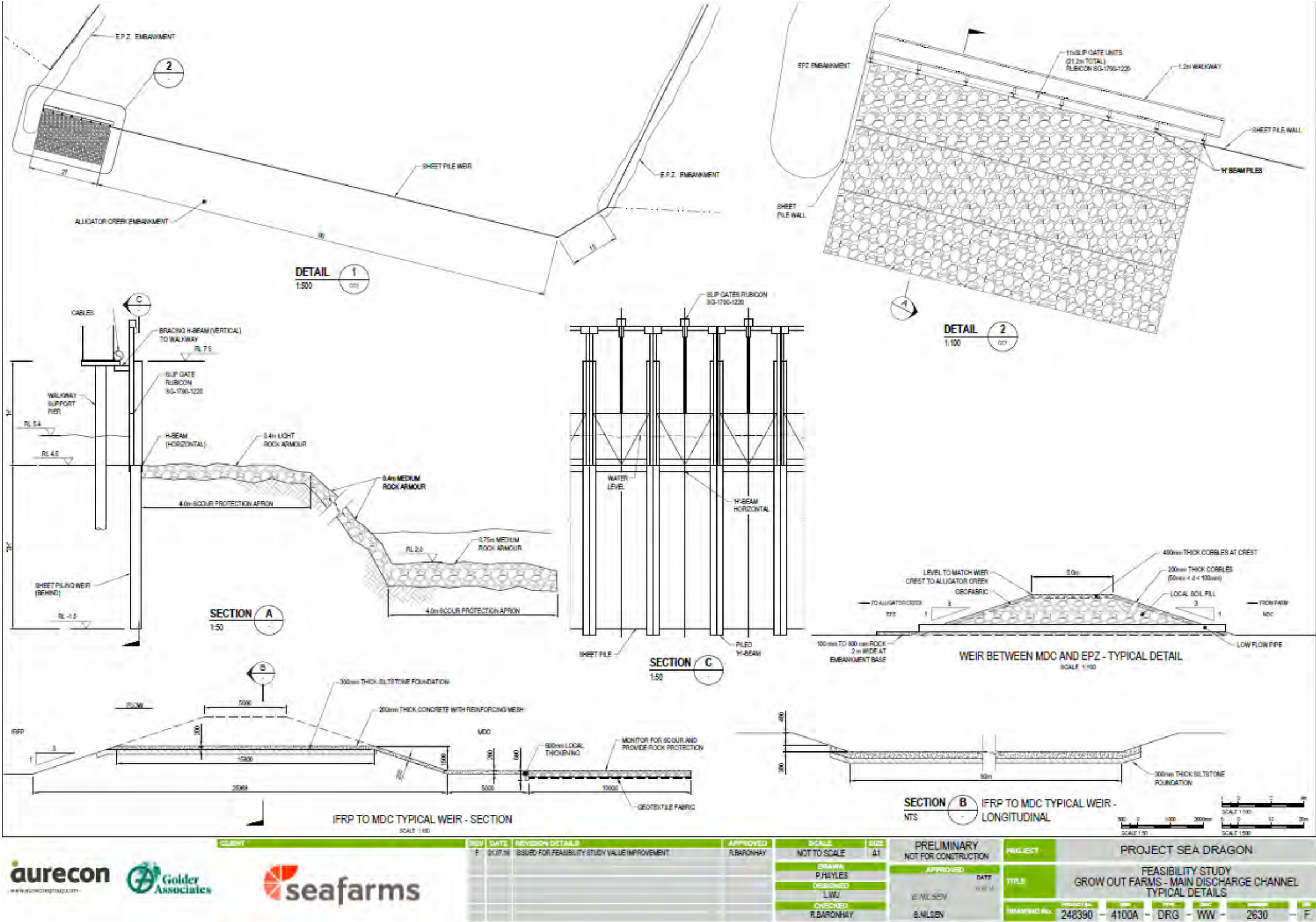


FIGURE 6 MAIN DISCHARGE CHANNEL - TYPICAL DETAILS

3.8 SOFT SOILS ON THE COASTAL PLAIN

Concerns were expressed by the NT EPA in one submission regarding how recommendations made in the geotechnical report (Volume 5, Appendix 7 of the draft EIS) have been incorporated into the project commitments, design and management, particularly regarding:

- Soft surface clays in the northern parts of the site within the coastal plain, etc.
- Penetration into the Unit 2B very soft to firm clays
- Further monitoring and soil delineation.

Seafarms and its consultants adopted very conservative designs for the structures on the coastal plain, with batter slopes as flat as 3.5: 1 to avoid slip-circle failure of embankments. Piling designs were also conservative, assuming very low strength marine sediments. Geotechnical drilling in the detailed design phase will confirm the in-situ conditions and allow adjustment of designs if necessary (refer Section 2.4), however, Seafarms do not expect significant changes.

Seafarms acknowledges that the Unit 2B materials will be quite variable in shear strength, and accordingly have been assumed to be classed 'unsuitable' for channel lining and embankment construction. In other words, the Unit 2B materials will not be used for channel lining and embankment construction, which is reflected in the proposed design and lay-out.

3.9 POND AND CHANNEL WASTE

As detailed in Section 8.1.10 of Volume 1, Chapter 3 of the draft EIS the waste material is composed of silt and organic matter (algal matter and prawn faeces). This material will be combined with the waste material from the upstream ponds and channels (sediment dam, seawater channel) which will be benign, allowing for strategic mixing of the materials as needed.

The material itself is described in Section 3.6 of Volume 2, Chapter 9 of the draft EIS as initially an 'anoxic material with elevated nutrients, and a high proportion of mineral soil from the pond walls'. However this material is found to rapidly gain oxygen when exposed to air and dried, as found in Seafarms' Queensland operations. This material, once leached of salt (see below), offers the opportunity for use on the site as a fertiliser enriched soil (with some micronutrient adjustments perhaps required).

The material has been identified by the NT EPA as a listed waste, specifically 'Prawn pond sediment and detritus, filtration waste is considered a listed waste under the Waste Management and Pollution Control (Administration) Regulations' (NT EPA Comment 45) - see the main Supplementary EIS document). Presumably this is the 'Animal effluent and residues (abattoir effluent, poultry and fish processing waste)' listed waste in Schedule to the regulations. According to the NEPM Controlled Waste Code, this listing is as a 'Putrescible/organic waste'. Due to the high percentage of inert sediment/silt in the product, it is arguable whether this product could be considered a putrescible or organic waste. We propose to discuss this further with the department, and to adopt the more conservative approach at this stage of assuming the material is a listed waste, requiring licensing under the Act. However, management will not change (mitigation measures in place are suitable to the material rather than its listing as such).

The material is to be solar dried and aerated in a designated area between farms 1 and 2. Its primary purpose will be use within the ponds and pond embankments, where required, which will retain the material inside the farm water system. On initial removal, the material will be rolled out and compacted, with bunding and vegetation used to control erosion and sediment loss of this material. Once leached of salt (the material will be

spread in thin layers of <1m depth in any season, suitable for flushing of salts over a small number of wet seasons), this material, with its high levels of organic material, can be used to help revegetate pond and channel banks. This will be in accordance with relevant guidelines and standards, with the intent to comply with the Environmental Code of Practice for Australian Prawn Farmers requirements (Donovan, 2001, pp19-20) which requires these areas to have the following properties:

- if sediment is stockpiled for extended periods, the floor of the designated storage area must be compacted sufficiently to minimise nutrients leaching into groundwater [refer to permeability discussions for the upper soils in Section 3.3]
- Methods (such as perimeter bunds), must be used to prevent overland flow from entering the designated storage area (or crop/pasture area) and resulting in unacceptable levels of sediment/top soil erosion
- Methods must be used to reduce erosion of the sediment from within the storage area (or crop/pasture area) and subsequent siltation of waterways (such as using cropping, hay bales or sediment traps).

These will all be adopted.

The Commonwealth Department of Environment and Energy queried the use of this material outside of farm areas in regards to water pollution. Volume 1, Chapter 3 of the draft EIS noted that the material may be used in selected areas outside the farm to assist with scour erosion or included in the construction of new berms. This use is nominated as the material presents a resource highly useful for vegetation stabilisation, given the available organic matter and nutrients, equivalent to a fertiliser enriched soil (once leached of salt and aerated, with micronutrient addition if required). However, as noted above it will be mostly used inside the farm areas, and so any washoff would be maintained within the farm water system, and captured in ponds, channels or the IFRP for later removal (although as stated the use of this material is intended to aid in revegetation and stabilisation).

While provision has been made for use in select locations on the site outside of the farms, this would not be in such a way as to cause pollution (it would be similar to topsoiling and fertilising areas for revegetation), and there will not be any anticipated impacts to water quality in the areas it may be used.

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ATTACHMENT 1 FURTHER ADVICE REGARDING SOIL PERMEABILITY AND DISPERSIVITY TESTWORK

DATE 12 January 2017

REFERENCE No. 1545845-003-M-Rev0

TO Owen Stacy
Seafarms Group Limited

CC Brett Nilsen and Paul Western - Aurecon

FROM Doug Stewart

EMAIL dpstewart@golder.com.au

**COMMENTARY ON HYDRAULIC CONDUCTIVITY AND DISPERSION
PROJECT SEA DRAGON**

1.0 INTRODUCTION

This memorandum provides commentary on hydraulic conductivity and dispersion characteristics of soils derived from testing completed to date for project Sea Dragon and provides a comparison against data from other selected projects in the region.

2.0 TESTING FOR SEAFARMS PROJECT

The commentary provided here concentrates on Units 1, 2A and 2B as defined in the Douglas Partners geotechnical investigation report referenced below.

2.1 Hydraulic Conductivity and Field Infiltration Testing

Two types of tests to assess water flow through soils have been completed to date:

- Saturated hydraulic conductivity tests were carried out by Douglas Partners as part of the geotechnical investigation. The test were carried out in the laboratory on heavily compacted samples (98% of Modified maximum dry density which would be expected to be approximately equivalent to about 100% standard maximum dry density). These test values are indicative of the hydraulic conductivity of a uniform saturated heavily compacted clay liner placed under closely controlled conditions with no shrinkage cracks or defects.
- Field infiltration tests were carried out by Golder Associates on undisturbed in situ materials. The nature of these tests is that the infiltration rate measured is not necessarily equivalent to the hydraulic conductivity since the hydraulic gradient is unknown and the degree of saturation varies as a wetting front penetrates the soil below the test area. The infiltration test values are indicative of the vertical rate of seepage through the undisturbed in situ soils under low hydraulic head conditions including the effects of any shrinkage cracks, soil structure or variability in soil composition.

The test results for Project Sea Dragon are summarised in Table 1 below.

Table 1: Summary of Hydraulic Conductivity and Infiltration Testing for Project Sea Dragon

Source	Unit	Saturated Hydraulic Conductivity (m/s)	Field Infiltration Rate (m/s)	Number of Tests	Test Type and Conditions
DP report	1	4×10^{-10} to 9×10^{-10}	NT	5	Laboratory saturated hydraulic conductivity test on sample remoulded to OMC and compacted to 98% MMDD
	2A	6×10^{-10} to 6×10^{-9}	NT	4	
	2B	4×10^{-10}	NT	1	
AG report	2A	NT	4×10^{-7} to 1×10^{-6}	1 with multiple test stages	Field infiltration test on in situ undisturbed material
	2A-sandy or 4A	NT	1×10^{-7} to 5×10^{-7}	1 with multiple test stages	

Notes:

DP report = Douglas Partners geotechnical investigation report, Ref. 78232.00.R.001 dated February 2016.

AG report = Aurecon/Golder report on earthworks field trial, Ref. 1545845 Rev0 dated July 2016. Quoted results ignore value from first filling.

NT = Not tested

OMC = Optimum moisture content

MMDD = Maximum dry density using Modified compaction

2.2 Dispersion Testing

Laboratory dispersion test results contained in the DP report for Project Sea Dragon are summarised in Tables 2 and 3 below.

Table 2: Summary of Emerson Class Dispersion Testing for Project Sea Dragon

Unit	Emerson Class Number	Description	Number of Tests
1	2	Some dispersion	5
	4	No dispersion	4
2A	4	No dispersion	2
2B	2	Some dispersion	1
	4	No dispersion	7

Table 3: Summary of Pinhole Dispersion Testing for Project Sea Dragon

Unit	Designation	Description	Number of Tests
1	PD1	Potentially dispersive	5
	PD2	Potentially dispersive (intermediate)	1
	D1	Highly dispersive	1
2A	PD2	Potentially dispersive	1
2B	D1	Highly dispersive	2

3.0 PREVIOUS TESTING FOR OTHER PROJECTS IN THE REGION

Golder has reviewed the results of testing carried out for the following projects in the region of the Project Sea Dragon site:

- Ord Irrigation Expansion Project Phase 2
- Proposed Kununurra wastewater treatment plant.

The results of the testing are contained in various reports prepared by Golder and others.

3.1 Ord Irrigation Expansion Project Phase 2

The various reports subdivide the near surface soils into:

- Surficial Black Soils or Kununurra Soils, generally black or grey in colour – these materials are inferred to be essentially equivalent to Unit 1 at the Project Sea Dragon site.
- Alluvial clayey soils, generally red-brown in colour and underlying the above material – these materials are inferred to be essentially equivalent to Units 2A and 2B at the Project Sea Dragon site.

3.1.1 Hydraulic Conductivity Testing

Saturated hydraulic conductivity tests were carried out using the following methods:

- Laboratory tests on compacted samples (98% of standard maximum dry density). These test values are indicative of the hydraulic conductivity of a uniform saturated compacted clay liner placed under closely controlled conditions with no shrinkage cracks or defects.
- Field hydraulic conductivity tests in boreholes following seven days of saturation. These test values are indicative of the horizontal rate of seepage through the undisturbed in situ soils including the effects of any shrinkage cracks, soil structure or variability in soil composition.

Hydraulic conductivity test results for the Ord Irrigation Expansion Project Phase 2 are summarised in Table 4 below.

Table 4: Summary of Hydraulic Conductivity Testing for Ord Irrigation Expansion Project Phase 2

Unit	Saturated Hydraulic Conductivity (m/s)	Test Type and Conditions
Black Soils	1×10^{-10}	Laboratory saturated hydraulic conductivity test on sample remoulded to OMC and compacted to 98% SMDD
	6×10^{-3} to 6×10^{-2}	Field saturated hydraulic conductivity test on in situ undisturbed material within a borehole
Red-brown alluvial clayey soils	1×10^{-11} to 1×10^{-9}	Laboratory saturated hydraulic conductivity test on sample remoulded to OMC and compacted to 98% SMDD
	3×10^{-4} to 1×10^{-1}	Field saturated hydraulic conductivity test on in situ undisturbed material within a borehole

Notes:

OMC = Optimum moisture content

SMDD = Maximum dry density using standard compaction

3.1.2 Dispersion Testing

Laboratory dispersion test results for the Ord Irrigation Expansion Project Phase 2 are summarised in Tables 5 and 6 below.

Table 5: Summary of Emerson Class Dispersion Testing for Ord Irrigation Expansion Project Phase 2

Unit	Emerson Class Number	Description
Black Soils	Generally 4 to 6 (Range = 1 to 6)	Generally no dispersion. Occasional tests indicated dispersion.
Red-brown alluvial clayey soils	Generally 4 to 6 (Range = 1 to 6)	Generally no dispersion. Occasional tests indicated dispersion.

Table 6: Summary of Pinhole Dispersion Testing for Ord Irrigation Expansion Project Phase 2

Unit	Designation	Description
Black Soils	ND1	Not dispersive
Red-brown alluvial clayey soils	ND1 and PD2	Not dispersive to potentially dispersive (intermediate)

3.2 Proposed Kununurra Wastewater Treatment Plant

The report subdivides the near surface soils into:

- Surficial Black Soils, generally black or grey in colour – these materials are inferred to be essentially equivalent to Unit 1 at the Project Sea Dragon site.
- Alluvial clayey soils, generally red-brown in colour and underlying the above material – these materials are inferred to be essentially equivalent to Units 2A and 2B at the Project Sea Dragon site.

Hydraulic conductivity testing was not carried out during this investigation.

3.2.1 Dispersion Testing

Laboratory dispersion test results for the proposed Kununurra wastewater treatment plant are summarised in Table 7 below.

Table 7: Summary of Emerson Class Dispersion Testing for Kununurra WWTP

Unit	Emerson Class Number	Description
Black Soils	Range = 2 to 5	Partial dispersion to no dispersion.
Red-brown alluvial clayey soils	Generally 2 to 4 (Range = 2 to 5)	Partial dispersion to no dispersion.

4.0 COMMENTARY

A brief commentary on the above information is provided below:

- 1) As expected, laboratory tests on remoulded samples indicate a significantly lower rate of seepage than field tests on undisturbed material since the laboratory test simulates conditions applicable to an engineered clay liner.
- 2) Laboratory tests on remoulded samples of Units 1, 2A and 2B indicate saturated hydraulic conductivity values that are comparable to those on similar materials that were used successfully to construct engineered clay liners for the Ord Irrigation Expansion Project Phase 2.

- 3) The limited field infiltration testing completed to date (one location) indicates a lower rate of seepage through the material type that was tested than was found on undisturbed in situ soils for the Ord Irrigation Expansion Project Phase 2.
- 4) The dispersion testing completed to date indicates a variable risk of dispersion, although based on the spread of test results and the experience on the Ord Irrigation Expansion Project Phase 2, generally the risk could be considered relatively low.
- 5) The dispersion test results have a similar spread of values compared to the other two projects referenced above, although the testing to date suggests that the risk of dispersion may be slightly higher for the Project Sea Dragon site.
- 6) Further testing of materials is recommended during the detailed design phase to provide improved definition of material properties and their variability or distribution across the relevant parts of the project site.

We trust this information meets your current requirements. Please contact the undersigned if you wish to discuss the information presented.

Yours faithfully

GOLDER ASSOCIATES PTY LTD

Doug Stewart
Principal Geotechnical Engineer

DPS/DMS/dps

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APPENDIX G BIOSECURITY ASSESSMENT



**PROJECT SEA DRAGON
STAGE 1 LEGUNE GROW-OUT FACILITY
SUPPLEMENTARY ENVIRONMENTAL IMPACT STATEMENT**

APPENDIX G BIOSECURITY ASSESSMENT

Meghan Farr
Consultant
CO₂ Australia Pty Ltd
S5 Level 2, 12 Browning Street
West End, QLD, 4101
Australia



July 30th, 2016

Re: Project Sea Dragon
Biosecurity Assessment – Request for Proposal
Biosecurity/Disease aspects – Environmental Impact Statement

Dear Meg

Thank you for your invitation for Panaquatic Health Solutions Pty Ltd (“Panaquatic”) to undertake an additional piece of work for the Environmental Impact Statement (EIS) that addresses the risks to the environment surrounding the Legume Grow Out Facility posed by the escape of prawn stock and the transmission of pathogens and/or diseases from the project facilities.

Please find attached a final report of the work conducted as per your request.

Yours sincerely

A handwritten signature in black ink, which appears to read 'Paul Hardy-Smith'. The signature is stylized and fluid.

Paul Hardy-Smith BVSc(Hons), MANZCVSc(Aquatic Animal Health), GradDip(Aquaculture)
Managing Director, Panaquatic Health Solutions Pty Ltd

Contents

1	Introduction	3
2	Location of Legume Grow-out Facility: Joseph Bonaparte Gulf.....	3
3	Identification of diseases of concern	3
3.1	Clinical Disease and mortalities in wild populations of prawns.....	4
4	The steps by which disease could get from farmed prawns to wild prawns in JBG	5
4.1	Farmed prawns being grown in ponds at LGOF must themselves be infected with one of more of the disease agent(s) of concern.	8
4.1.1	Development of domesticated prawns stocks, free of all major diseases of concern	8
4.1.2	Health monitoring and surveillance.....	8
4.2	Viable disease agent(s) must travel from within the ponds/facilities at LGOF to the environment surrounding LGOF.	9
4.3	The presence of susceptible wild prawns in the JBG environment;	10
4.4	Persistence of viable disease agent in the environment;	11
4.5	Exposure of susceptible wild prawns to sufficient quantities of the viable disease agent(s);	11
4.6	Shedding of sufficient quantities of viable disease agent(s) by wild prawns to propagate infection and disease, thereby resulting in environmental impact.....	12
5	Conclusions	13
	References	15
	Appendix A – Prawn diseases of concern – background information	16

1 Introduction

Seafarms Group Limited (Seafarms) is developing Project Sea Dragon (PSD), a large, fully integrated, prawn¹ aquaculture project located in northern Australia. PSD will be delivered as an integrated production system, providing reliable, long-term, high quality and large scale production of Black Tiger prawns (*Penaeus monodon*). Its key grow out facility will be located on Legune Station in the north-western Northern Territory.

Panaquatic Health Solutions Pty Ltd (Panaquatic) understands that the Stage 1 Legune Grow-out Facility is being assessed via an Environmental Impact Statement (EIS) under the Bilateral Agreement between the Commonwealth and the Northern Territory Governments. CO₂ Australia Pty Limited (CO₂ Australia), a fully owned subsidiary of Seafarms, is managing the EIS process.

The NT Government have prepared a 'Terms of Reference for the Preparation of an Environmental Impact Statement' (ToR) to guide the development of the EIS for the project. The ToR require that the EIS contains detail about the biosecurity requirements of the project. Specifically, the ToR require an assessment of the risks to the surrounding environment posed by the escape of prawn stock and the transmission of pathogens and/or diseases from the project facilities.

Panaquatic has been asked by CO₂ Australia to assess these risks and this assessment is provided in this report. Panaquatic has considered the impacts of disease transfer only to wild prawn populations and not to other species of wild crustaceans such as crabs. While the transfer of exotic prawn diseases such as white spot disease from farmed prawns to other species of crustaceans such as crabs is possible and has been shown to occur (OIE 2016), Panaquatic is not aware of any example of such transfer in endemic disease agents and the likelihood of such transfer and its consequences are considered to be very difficult to quantify. It is also, though, considered likely to be very low.

2 Location of Legune Grow-out Facility: Joseph Bonaparte Gulf

The Legune Grow-out Facility (LGoF) will be situated on a promontory between the Keep River and Victoria River adjacent to the southern reach of the Joseph Bonaparte Gulf and approximately 30 km east of the NT/WA border. As such, of concern with respect to the escape of disease agents from LGoF is the Joseph Bonaparte Gulf, or JBG geographic region.

For the purposes of this report and in accordance with the Interim Marine Coastal Regionalisation of Australia (IMCRA 2006), JBG is considered to encompass the IMCRA mesoscale regions of Bonaparte, Cambridge-Bonaparte and Anson-Beagle which also incorporates Darwin harbour and Bynoe Harbour.

3 Identification of diseases of concern

There are a number of potential disease agents that could infect domesticated *Penaeus monodon* prawns being grown in ponds in the Northern Territory. For the purposes of this report and based on previous consideration of prawn disease agents which have the potential to impact farmed prawns

¹ The term "prawn" is used in the report to denote marine crustaceans belonging to the family Penaeidae in the suborder Dendrobranchiata. These are often referred to as penaeid prawns. The terms "shrimp" and "penaeid shrimp" are synonymous terms.

growing at LGoF, a total of 12 disease agents were identified. These disease agents are listed in Table 1. More detail on each of these disease agents is provided in **Appendix A – Prawn diseases of concern**.

The criteria used to identify these 12 disease agents were as follows:

- i. Whether the disease is confirmed² in Joseph Bonaparte Gulf (i.e. endemic); and/or
- ii. An infectious primary pathogen; and/or
- iii. Notifiable under NT and / or WA legislation; and/or
- iv. Capable of causing disease with significant potential adverse impact on commercial fisheries, aquaculture or the environment.

It is important to note that prawn diseases considered exotic to Australia were not considered as part of this assessment. This acknowledges the fact that Australia has a robust and sophisticated biosecurity system. Australia's legislation strictly prohibits the importation into Australia of live prawns without a permit. There are also considerable restrictions placed on the importation of non-viable (dead) prawns and prawn products into Australia for human consumption as these too are considered to pose a potential risk of bringing disease into Australia. Through these processes the risk of and exotic disease being imported into Australia through the importation into this country of non-viable prawns and prawn products has been reduced substantially.

Viruses	Yellowhead virus genotype 6 (YHV-6)
	Yellowhead virus genotype 7 (YHV-7)
	Hepatopancreatic parvo-like virus (HPV)
	Infectious hypodermal and haematopoietic necrosis virus (IHHNV)
	Mourilyan Virus (MOV)
	Spawner isolated mortality virus (SMV)
Bacteria	<i>Vibrio alginolyticus</i>
	<i>Vibrio damsela</i>
	<i>Vibrio harveyi</i>
	<i>Vibrio parahaemolyticus</i> (<i>P. monodon</i> mortality syndrome)
	<i>Vibrio</i> spp.
Fungi	<i>Lagenidium</i> sp.

Table 1 – List of 12 disease agents of prawns in Australia that are considered in this report.

3.1 Clinical Disease and mortalities in wild populations of prawns

Although there are many instances where disease agents have been identified in wild prawn populations, reports of actual clinical disease or deaths due to these disease agents in the wild prawn populations that they have been identified from are rare.

A review of the literature revealed only one such case, in which clinical disease and mortalities due to the Taura Syndrome virus in wild adult *Penaeus vannamei* ("white shrimp") were reported (Briggs et al 2005).

² Some of the diseases of concern have been reported as occurring in Joseph Bonaparte Gulf (see Table 2) but not confirmed.

The scarcity of such reports is, however, likely due to the fact that it is very difficult to document disease in wild prawns, as wild prawns that become diseased are unlikely to survive for any length of time due to predation.

Deaths of large populations of fish, however, are more regularly reported. Many fish “kills”, where large numbers of fish die over a short time period, are due to environmental factors (for example, lack of oxygen in the water, blooms of toxic algae) and not due to disease. One possible exception was the death of large numbers of pilchards (*Sardinops sagax*) in the 1990s off southern Australia. A herpes virus was isolated from fish that were dying. Why the deaths occurred and whether or not the herpes virus was introduced are still points of conjecture.

4 The steps by which disease could get from farmed prawns to wild prawns in JBG

Though obvious, it is still important to point out that if farmed prawns growing at the Legume Grow-out Facility (LGoF) are free of a particular disease agent, then there is no possibility of that disease agent being released to the environment. As noted in LaPatra (2003), the most cost effective way to effectively limit the impact of significant animal pathogens being released to the environment is to prevent their introduction into the facility in the first place. Keeping PSD farmed prawns free of any diseases of concern is therefore not only important to the overall PSD production strategy but also is a very important way to reduce any potential environmental impact that may result from release of a disease.

In addition, there are diseases being carried by wild prawns in the JBG region that the farmed prawns will be susceptible to. A number of disease agents known and reported in wild prawn populations and in wild prawns that were originally captured in JBG are listed in Table 2.

Such endemic diseases can be potentially amplified within a farming system such as LGoF, but are unlikely to have the potential impact on the surrounding environment that a non-endemic disease(s) may have. Consideration of endemic versus non-endemic diseases is included in the consideration of which prawn diseases have been identified as being of concern from an environmental perspective (see Section 3).

Having said that, if farmed prawns growing at LGoF are affected by a disease(s) that is not endemic to the JBG region, in order for that disease agent(s) to impact wild prawns in the environment, the following steps are necessary:

1. Domesticated prawns being grown in ponds at LGoF must themselves be infected with the disease agent(s).
2. Viable disease agent(s) must travel from within the ponds/facilities at LGoF to the environment surrounding LGoF. This may occur in a number of ways i.e.
 - i. Through movement of infectious disease agents being released either as free particles or attached to organic matter from LGoF in, for example, water that is released; and/or
 - ii. By infected farmed prawns escaping from LGoF (or being carried by, for example, birds) and carrying within or on them viable infectious disease agent(s).

3. There must be wild prawns that are susceptible to the disease agent(s) present in the local environment;
4. Viable disease agent(s) which has been released from LGoF must persist in the environment for a sufficient time to come into contact with susceptible wild prawns;
5. Susceptible wild prawns must be exposed to sufficient quantities of the viable disease agent(s) so that they become infected with the disease agent (s) and develop disease;
6. Diseased wild prawns must then shed sufficient quantities of the disease agent(s) to infect other wild prawns and propagate infection and disease, thereby resulting in environmental impact.

This is shown diagrammatically in Figure 1.

Table 2 Disease agents reported as being present in wild prawn populations in JBG – this includes a number of the disease of concern

Disease Agent	Considered present in wild prawn populations, Joseph Bonaparte Gulf
Viruses	
Yellowhead virus genotype 2 (GAV/LOV)	Confirmed
Yellowhead virus genotype 7	Reported ¹
Monodon-type baculoviruses	Confirmed
Hepatopancreatic parvo-like virus (HPV)	Reported ¹
Infectious hypodermal and haematopoietic necrosis virus	Reported ¹
Mourilyan Virus	Reported ¹
Spawner isolated mortality virus	Reported ¹
Isopods	
<i>Parapenaeon expansa</i>	Confirmed

¹ Disease agents identified in wild prawn broodstock sampled from Queensland hatcheries. These prawns had been collected in JBG so there is a possibility that the disease agent had come from JBG but this has not been confirmed.

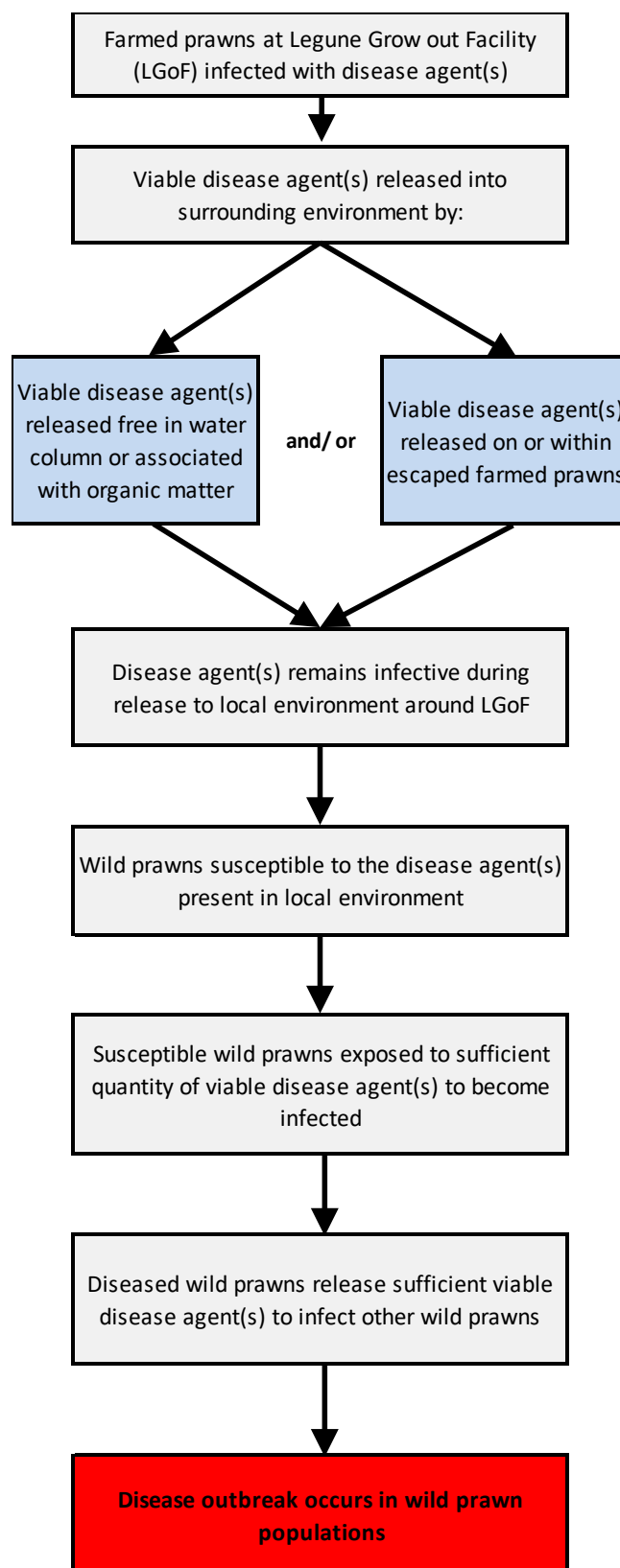


Figure 1 - Necessary steps for there to be environmental impact from release of disease agent(s) from the Legume Grow Out Facility.

4.1 Farmed prawns being grown in ponds at LGoF must themselves be infected with one of more of the disease agent(s) of concern.

For farmed prawns being grown in ponds at LGoF to become infected with one or more of the 12 diseases of concern, it must be introduced in some way to the prawn population.

4.1.1 Development of domesticated prawns stocks, free of all major diseases of concern

Seafarms plans to develop domesticated prawns stocks, free of all these diseases of concern shown in Table 1. The initial development of these stocks will occur at the Founder population Centre located at Exmouth. Wild prawns will initially be collected from a number of locations including the north-west coastal waters and the Gulf of Carpentaria and through a comprehensive screening program only eggs and post larvae that have been derived from wild prawns shown to be free of any of these diseases will be kept for future broodstock. These post larvae will themselves be further screened for any evidence of disease.

After three generations prawns that have gone through extensive disease screening during each generation (and confirmed to be free of any of the diseases of concern) will be transferred to the Core Breeding Centre and Broodstock Maturation Centre. Hence the initial stock from which production post larvae prawn will be derived and sent to populate ponds at the Legume Grow out Facility (LGoF) will be prawns that are certified free of any of the major diseases of concern i.e. Specific Pathogen Free prawns. If any diseases of concern are detected in prawns being used to produce post larvae for stocking of production ponds, the post larvae will not be sent to the LGoF production ponds.

In addition, Seafarms will have a comprehensive biosecurity plan operating across the entire LGoF. This plan addresses the potential for disease transfer to occur through pathways such as staff and equipment movements and has in place mitigation measures to reduce any potential for disease agents to be transferred through such pathways.

Such strict biosecurity aims to ensure that the likelihood of farmed prawns being exposed to a disease of concern and becoming infected with such a disease are minimised.

4.1.2 Health monitoring and surveillance

Growing in an area such as Legume Station, where water is being pumped from the local environment, it is possible that viable disease agents may be introduced with this water and these disease agents may infect farm prawns and cause disease.

Hence, in addition to the comprehensive biosecurity program operating across LGoF, there will also be a health monitoring and surveillance program in place, the aim of which will be to rapidly identify any disease, should such a disease somehow gain entry to the ponds at LGoF. An early detection mechanism for disease is critical to successful farming.

If there is evidence of clinical disease in any of the farmed prawns growing in ponds at LGoF, immediate investigation of the problem will focus on determining the cause of the clinical disease, and in particular determining whether or not the cause is due to a disease of concern.

If there is evidence of a disease of concern, it is likely immediate steps will be taken to contain the disease to the pond(s) in which it has been identified. Such steps will include preventing any water from being released from the pond. If the prawns are large enough, emergency harvest may be undertaken. If the disease is a notifiable disease, government authorities will be immediately informed. Any further steps taken will likely be under the direction of government authorities.

The response by government will take into account whether the diseases is considered endemic to the environment around the LGoF (for endemic diseases, refer to Table 2).

All such steps will ensure that the amount of viable disease agent that potentially enters the environment is minimised.

4.2 Viable disease agent(s) must travel from within the ponds/facilities at LGoF to the environment surrounding LGoF.

There are two ways in which viable disease agents, if present, may travel from within the production ponds at LGoF and out into the environment:

- i. Through movement of infectious disease agents being released either as free particles or attached to organic matter from LGoF in, for example, water that is released; and/or
- ii. By infected farmed prawns escaping from LGoF (or being carried by, for example, birds) and carrying within or on them viable infectious disease agent(s).

There is the potential for disease agents escaping from prawn ponds in effluent water to serve as a source of infection for prawns in the wider environment. The environmental impact of such an event is, however, difficult to define. There are uncertainties regarding the distribution of the disease agent in the environment, the environmental fate of the disease agent (for example, how long it remains in a viable form and in sufficient numbers to cause infection) and host susceptibilities in aquatic ecosystems (La Patra 2003). La Patra (2003) also notes there are no reliable, standardized or validated methods for testing effluents for aquatic animal disease agents and so it is very difficult to quantify what levels of viable disease agents may be in effluent water if farmed prawns contract a disease.

Diseased prawns may escape from a pondage and may also serve as a source of infection for prawns in the wider environment. Prawns may escape by a number of means including (1) lack of screening at outlets, (2) via predators (e.g. birds), (3) accidental release during harvesting and (4) flood events (Briggs et al 2005).

Escapee prawns with clinical disease are unlikely to survive for long in the aquatic environment. However, if escaped prawns were not clinically infected but latently infected, the escapee prawns potentially may transmit the disease agent to their progeny.

Diseased farmed prawns could also be deposited in the local environment through being carried there by predators such as birds. It is quite likely that the disease agent will remain viable in the diseased prawn, even if it is dead, for a period of time (hours to days). A diseased farmed prawn, if deposited into the local environment, would be itself consumed quickly. It is difficult to predict what animal will be most likely to consume this prawn. There are many possibilities in the local environment including a multitude of finfish species, other crustaceans (e.g. crabs) and wild prawns.

While of concern, the deposition of a diseased farmed prawn into the local environment would be unlikely to immediately come in contact with a wild prawn. Determining the possibility of this happening and infection of the wild prawn resulting from this contact is not possible. However, it is considered to be very low.

Other specific measures that will be in place to actively prevent the escape of farmed prawns to the environment include:

Measures that Seafarms would put in place to actively prevent the escape of farmed prawns include:

- Installation of mesh screens of suitable size over all pond outlets;
- Installation of a cage with mesh screens of a suitable size inside the monk (the outlet structure) during harvesting;
- Control of birds predating on prawn stock. A number of different bird control methods are being considered by Seafarms including human disturbance and the use of helicopters and drones. A Bird Predation Management Strategy will be developed and experimental trials will undertaken to determine the most effective method/s prior to operations.

As previously mentioned, a key method of reducing the risk of viable disease agent traveling from within the ponds at LGoF to the environment is ensuring that farmed prawns do not have disease in the first place.

It is quite likely that should a disease infect farmed prawns growing at LGoF, it will come in from the local environment i.e. it will be an endemic disease. A key consideration for Seafarms will be to minimise the impact such a disease has on its own stock. By doing this, the possibility of amplification of the disease agent will be reduced. This will therefore reduce the potential for release of increased numbers of viable endemic disease agent back out into the environment.

4.3 The presence of susceptible wild prawns in the JBG environment;

For disease to transfer from farmed prawns out into the local environment and the JBG, there must be susceptible wild prawns present in the environment that could be exposed to viable disease agent and potentially become infected.

There are at least nine species of prawn are endemic to the JBG. A number of these are known to be susceptible to one or more disease agents of concern. These are listed in Table 3.

There are therefore wild prawn species which are known to be susceptible to a number of the disease agent of concern in the JBG. However, as has also been mentioned a number of these disease agents have been confirmed or reported in wild prawns collected from this region.

Wild prawn species	Diseases of concern to which prawns are known to be susceptible
<i>Fenneropenaeus indicus</i>	
<i>Fenneropenaeis merguensis</i>	HPV, IHNV, SMV
<i>Marsupenaeus japonicus</i>	HPV, MOV
<i>Melicertus latisulcatus</i>	HPV

<i>Melicertus longistylis</i>	
<i>Metapenaeus ensis</i>	IHHNV
<i>Penaeus esculentus</i>	HPV, Vibrio spp.
<i>Penaeus monodon</i>	YHV-6, YHV-7, HPV, IHHNV, MOV, SMV, Vibrio spp. PMMS, Lagenidium
<i>Penaeus semisulcatus</i>	

Table 3 - . Species of prawns endemic to Joseph Bonaparte Gulf and reported occurrence of diseases of concern

4.4 Persistence of viable disease agent in the environment;

The persistence of a number of exotic prawn diseases in the water column has been determined. For example, the disease agent that causes White Spot Disease, a virus in the genus *Whispovirus* within the *Nimaviridae* family (which is exotic to Australia) is viable for at least 30 days at 30°C in seawater under laboratory conditions (Momoyama et al., 1998); and in ponds for at least 3–4 days (Nakano et al., 1998). Yellowhead virus Type 1, another exotic disease agent, remains viable in aerated seawater for up to 72 hours (Flegel et al., 1995).

Information regarding the viability of disease agents of concern in the environment, which all occur in Australia, is however scant. Some assumptions have been made in the background detail given in Appendix A to this report.

As with all agents, particularly viruses, once they are outside the host viability generally reduces relatively quickly.

As far as Panaquatic is aware, there are no published studies in crustacea that have quantified or qualified the risk factors of crustacea contracting disease through exposure to disease agents being released in effluent water from an infected farm. In a study conducted on fish, Jarp and Karlsen (1997) conducted a matched case-control study of the risk factors associated with infectious salmon anaemia (ISA), a disease of Atlantic salmon (*Salmo salar*) in Norwegian salmonid sea sites. The causal agent of ISA is also a virus from the family Orthomyxoviridae.

The study of Jarp and Karlsen (1997) concluded that the risk of a 'clean' farm contracting the disease was increased by 8 times if the site was situated closer than 5km to another ISA-positive site as compared to the risk when the site was more than 5km away. In addition, the risk of a 'clean' farm contracting the disease was 13 times greater when the farm was located less than 5km from a facility slaughtering and processing salmonids where the waste water from that facility was not being disinfected. The study noted that disinfecting the waste water from the slaughtering and processing facilities seemed to prevent transmission of ISA.

However, this study involved fish that were being grown in sea cages. This is a very different scenario than prawns which are being grown in ponds on land.

4.5 Exposure of susceptible wild prawns to sufficient quantities of the viable disease agent(s);

Wild prawns growing in the local environment to the LGoF would need to be exposed to sufficient quantities of viable disease agent for them to become infected. It is not known what that quantity is. It is however reasonable to say that if measures are in place at LGoF to rapidly detect disease in

farmed prawns stocks and rapidly respond to such disease by minimising the number of farmed prawns affected and minimising the potential release of disease agents into the environment then the possibility of wild prawns being exposed to sufficient viable disease agent to infect those prawns and cause disease is significantly reduced.

4.6 Shedding of sufficient quantities of viable disease agent(s) by wild prawns to propagate infection and disease, thereby resulting in environmental impact.

Having noted that the potential for wild prawns to be exposed to sufficient quantities of viable disease agent is difficult to quantify but considered low, and also having mentioned that a diseased prawn in the wild is unlikely to remain in the water column very long as it will be quickly predated, then the possibility of diseased wild prawns shedding sufficient viable disease agent to propagate infection is also considered low.

5 Conclusions

This report has considered the potential for disease to transfer from farmed prawns being grown at the Seafarms Legume Grow-out Facility (LGoF) to wild prawns in the local environment, which is the Joseph Bonaparte Gulf (JBG).

The report has focused on 12 key diseases of concern, all of which are endemic to Australia and a number of which have been reported, but not confirmed, as coming from JBG. This report has not considered prawn diseases which are exotic to Australia.

As described in this report, there are a number of steps that need to occur for viable disease agents to transfer from prawns being farmed at the LGoF to the JBG, and further steps that need to occur for such viable disease agents to infect wild prawns and cause disease.

It is a fundamental truth that if farmed prawns growing at LGoF are not infected with any of the diseases of concern then there is no possibility of any disease agents of such diseases being released to the environment.

For there to be any risk to the environment, farmed prawns must first be infected with a disease of concern. A key strategy of Seafarms is to maintain healthy populations of prawns at LGoF, free of any of the diseases of concern. This will be achieved by stocking only post larvae (PLs) that are derived from a comprehensive domestication program, which produces Specific Pathogen Free (SPF) domesticated *Penaeus monodon* prawns. If there is any evidence that PLs are not healthy at the time that they are destined to be transferred to LGoF, then they will not be transferred.

In addition to stocking SPF PLs, Seafarms will also be farming these prawns in a manner to optimise their health and productivity. Healthy prawns are less susceptible to disease and grow better, thereby improving profitability and sustainability.

In addition, Seafarms will not only stock SPF PLs but also have in place mitigation measures to reduce the risk of their farmed prawns being exposed to a potential disease agent. Such measures are documented in a comprehensive biosecurity plan.

One mechanism by which disease could gain entry is through the intake water, drawn from the local environment, coming into the ponds. There are mitigation measures will be put in place to reduce the risk of disease entry via this route. Such measures include utilising settlement ponds to hold water for a period of days prior to it entering the grow-out ponds and physically filtering the water. However, if a disease agent were to gain entry by the intake water, it would likely be an endemic disease agent. While this is not desirable for the farmed prawns, provided that the amplification of such a disease agent is minimised and Seafarms has in place measures to prevent release of the amplified disease agent back out to the environment, then the impact to the environment should be minimal to negligible, acknowledging that the disease agent has come from the environment in the first place.

Seafarms will have an early detection mechanism operating across all its production ponds to ensure that any disease, if it occurs, will be rapidly identified and appropriate control or eradication measures implemented. Measures will be in place to minimise escape of farmed prawns and release

of effluent water in the event that any evidence of disease is observed in farmed prawns as has been described in this report.

It is acknowledged that there are a number of wild prawn species living in the JBG that are susceptible to one or more of the diseases of concern. These are listed in this report. Having susceptible species present in the JBG does not automatically mean that they will become diseased if disease is detected in farmed prawns growing at LGoF. As described in this report, the following key steps have to occur for that to happen:

1. Viable disease agent(s) must travel from within the ponds/facilities at LGoF to the environment surrounding LGoF. This may occur in a number of ways i.e.
 - iii. Through movement of infectious disease agents being released either as free particles or attached to organic matter from LGoF in, for example, water that is released; and/or
 - iv. By infected farmed prawns escaping from LGoF (or being carried by, for example, birds) and carrying within or on them viable infectious disease agent(s).
2. There must be wild prawns that are susceptible to the disease agent(s) present in the local environment;
3. Viable disease agent(s) which has been released from LGoF must persist in the environment for a sufficient time to come into contact with susceptible wild prawns;
4. Susceptible wild prawns must be exposed to sufficient quantities of the viable disease agent(s) so that they become infected with the disease agent (s) and develop disease;
5. Diseased wild prawns must then shed sufficient quantities of the disease agent(s) to infect other wild prawns and propagate infection and disease, thereby resulting in environmental impact.

Given the use of SPF PLs in the ponds, the biosecurity measures in place while growing these prawns, the early detection mechanism for disease, the mitigation measures to reduce the risk of prawn escapes and the endemic nature of many of the potential disease agents that farmed prawns may be affected by, then the risk to wild prawns in the environment posed by the Legume Grow - out Facility is considered very low.

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Appendix A – Prawn diseases of concern – background information

Yellowhead virus Genotype 6 (YHV-6)

Background and pathogenic significance

Yellowhead virus genotype 6 (YHV-6) was recently identified on the basis of PCR assay by Cowley et al (2015). Cowley et al (2015) reported that the virus is most closely related to GAV (YHV-genotype 2). Although no specific disease or pathology has been attributed to the virus, given its close relationship with YHV-2 (GAV), a pathogenic role cannot be excluded.

Geographic distribution, host range and prevalence in Australia

YHV-6 was identified in 7/60 (11.7%) of wild-harvested mature *P. monodon* from Etty Bay, North-east coast, Queensland. Examination of *P. monodon* from other regions in north-east Queensland, the Gulf of Carpentaria and Joseph Bonaparte Gulf by Cowley et al (2015) failed to identify the virus. It appears therefore that YHV-6 may be restricted to *P. monodon* in a localised region in north-east Queensland.

Re-examination of archived sequences derived from PCR products from *P. monodon* from north Queensland by Cowley et al (2015) indicated that YHV-6 has existed in this region since at least the early 2000s.

In Australia, YHV-6 has only been described in *P. monodon* (Cowley et al 2015).

Detection methods

Cowley et al (2015) described the detection of GAV using a nested PCR assay on samples of RNA extracted from gill/pleopod tissue from mature *P. monodon* from northern Australia. Cowley et al (2015) observed that the closeness of the sequence of YHV-6 to GAV may have resulted in failure to detect this genotype, implying that YHV-6 may have been identified as GAV in earlier, less sensitive PCR assays.

Stability of disease agent

It is assumed that the stability of YHV-6 is the same as YHV-1, i.e., the virus remains viable in aerated seawater for up to 72 hours (OIE 2016a). Heating at 60°C for 15 minutes is reported to inactivate the virus as well as treatment with chlorine at 30 ppm (OIE 2016a).

Transmission

For the purposes of this assessment, it is assumed that YHV-6 may be transmitted both vertically and horizontally as for other YHV genotypes (Cowley et al 2002; DAFF 2012; OIE 2016a; Spann et al 2003).

Yellowhead virus Genotype 7 (YHV7)

Background and pathogenic significance

Yellowhead virus genotype 7 (YHV-7) was recently described on the basis of PCR assay by Cowley et al (2015) as a separate genotype within the YHD complex. Although the pathogenic significance of YHV-7 remains uncertain, however, YHV-7 was identified in broodstock *P. monodon* undergoing elevated mortalities with histopathological lesions of neuropathy of the eye, antennae, ventral nerve cord and segmental ganglia of the pereopods and a retinitis, and with lymphoid organ spheroids indicative of virus infection (Mohr et al 2015). These changes are similar to those described by Callinan et al (2003) for acute GAV infection, strongly indicating that YHV-7 is a significant pathogen of *P. monodon* at least.

Geographic distribution, host range and prevalence in Australia

Cowley et al (2015) reported the presence of a new genotype of YHV-7, in 25/271 (9%) of broodstock *P. monodon* originating from Joseph Bonaparte Gulf and sampled following importation into a Queensland hatchery, indicating that the source of infection was from Joseph Bonaparte Gulf, as the prawns were maintained in quarantine on arrival. YHV-7 was also identified in 1/67 (1%) of broodstock *P. monodon* from the Gulf of Carpentaria and in 3/155 (2%) of *p. monodon* from northeast Queensland. Mohr et al (2015), however, in describing the new GAV-7 in *P. monodon* introduced into a north Queensland hatchery from Joseph Bonaparte Gulf, indicated that the source of infection might be either Joseph Bonaparte Gulf or Queensland.

Cowley et al (2015) recommended that, as YHV-7 was detected and confirmed by sequence analysis from broodstock and grow-out prawns from north Queensland, targeted surveillance of farms in Queensland is required to determine the true prevalence and distribution of this genotype.

Uncertainty exists as to whether YHV-7 is present in *P. monodon* in Joseph Bonaparte Gulf. Mohr et al (2015), in reporting the new YHV-7 genotype in *P. monodon* broodstock introduced into a north Queensland hatchery from Joseph Bonaparte Gulf, indicated that the source of infection might be either from Joseph Bonaparte Gulf or Queensland. Similarly, Cowley et al (2015) questioned whether the detection of YHV-7 in prawn farms in Queensland was due to recent introductions with broodstock sourced from Joseph Bonaparte Gulf or was due to YHV-7 already being present in Queensland prawns. Thus, at this point in time, it is not possible to state with any certainty if *P. monodon* populations in Joseph Bonaparte Gulf are infected with YHV genotype 7 but there is the possibility.

Detection methods

Cowley et al (2015) described the detection of YHV-7 using a TaqMan real-time PCR on RNA extracted from gill/pleopod tissue from mature *P. monodon*

Stability of disease agent

It is assumed that the stability of YHV-7 is the same as for YHV-1, i.e., the virus remains viable in aerated seawater for up to 72 hours (OIE 2016a). Heating at 60°C for 15 minutes is reported to inactivate the virus as well as treatment with chlorine at 30 ppm (OIE 2016a).

Transmission

It is assumed that YHV-7 may be transmitted both vertically and horizontally as for other YHV genotypes (Cowley et al 2002; DAFF 2012; OIE 2016a; Spann et al 2003).

Hepatopancreatic parvo-like virus (HPV)

Background and pathogenic significance

Numerous strains of Hepatopancreatic parvovirus (HPV) are recognised globally (Safeena et al 2012) and multiple identifications of HPV have occurred in prawns in Australia. Sequence analysis of an Australian HPV isolate from *P. merguensis* by La Fauce et al (2007) showed this strain, identified as PmergDNV, to be a separate strain, but sharing the highest nucleotide similarity (87%) with Korean and Thai HPV isolates and the lowest similarity (83%) with an Indian HPV isolate. The relationship of PmDNV with HPV in other Australian penaeid species remains uncertain.

Prawns infected with HPV generally show non-specific gross signs including atrophy of the hepatopancreas, anorexia, slow growth and increased cuticular and gill fouling (Dhar et al 2014) and may present as moribund post-larvae (Spann et al 1997). Infection may be associated with high mortalities in post-larval *P. monodon* and *M. japonicus* (Ketterer 1992) and with poor growth, hepato-pancreatic atrophy and opaque abdominal musculature (Spann and Lester 1997).

Infection is characterised by presence of large, spherical, basophilic intra-nuclear inclusion bodies in hepatopancreatic epithelial cells, with nuclear hypertrophy, margination of the nuclear chromatin, displacement of the nucleolus and necrosis (Paynter et al 1985; Spann et al 1997). Owens and Hall-Mendelin (1990) described inclusion bodies as more prevalent in older prawns with infection in some cases resulting in marked hypertrophy and vacuolation of hepatopancreatic cells containing masses of eosinophilic material.

Geographic distribution, host range and prevalence in Australia

In Australia, HPV appears to be widespread and was first described on the basis of histopathology in wild-harvested *P. esculentus* from Moreton Bay by Paynter et al (1985), in growout ponds in

unspecified species by Owens et al (1988) and HPV has subsequently been reported in *P. esculentus*, *P. monodon*, *M. japonicus* and *F. merguensis* (Cowley et al 2015; Jones 2003; Ketterer 1992; Owens and Hall-Mendelin 1990; Paynter and Lester 1987; Roubal et al 1989; Spann et al 1997).

HPV was initially reported on the basis of characteristic inclusions in juvenile, wild harvested *P. esculentus* from the south-east coast by Paynter et al (1985). Subsequently, HPV was reported in hatchery reared post-larval *P. monodon* and *M. japonicus*, in juvenile and adult wild-harvested *F. merguensis* from the north-east coast (Ketterer 1992; Owens and Hall-Mendelin 1990; Roubal et al 1989) and in hatchery reared post larval *M. japonicus* from the south east coast (Spann et al 1997).

On the basis of prominent intranuclear inclusion bodies supported by electron microscopy, Jones (2003) reported HPV in *M. latisulcatus* and in *F. merguensis* from the North-west Coast (Exmouth Gulf, Onslow) and in *P. esculentus* from the South-west Coast (Shark Bay).

Cowley et al (2015) reported positive PCR assays for HPV in *P. monodon* from the Gulf of Carpentaria and northeast Queensland. Cowley et al (2015) also reported the detection of HPV in 5% of 136 mature wild harvested *P. monodon* originating from Joseph Bonaparte Gulf following their introduction into a Queensland hatchery, suggesting that HPV may be present in populations of *P. monodon* in Joseph Bonaparte Gulf.

Uncertainty exists, however, as to whether HPV is present in *P. monodon* in Joseph Bonaparte Gulf as it is plausible that the source of infection of broodstock imported into Queensland from Joseph Bonaparte Gulf was from Queensland, being endemic in Queensland waters. Thus, at this point in time, it is not possible to state with any certainty if *P. monodon* populations in Joseph Bonaparte Gulf are infected with HPV. It is potentially possible though.

Detection methods

Detection may be based on the presence of characteristic large, spherical, basophilic intra-nuclear inclusion bodies in hepatopancreatic epithelial cells, accompanied by nuclear hypertrophy, margination of the nuclear chromatin, displacement of the nucleolus and necrosis (Paynter et al 1985; Spann et al 1997).

Cowley et al (2015) described the use of a modified nested PCR assay to detect HPV on samples of DNA was extracted from hepatopancreas in cases where this tissue was available and from samples of gill/pleopod tissue in cases where hepatopancreas was unavailable.

Stability of disease agent

No specific data can be identified.

Transmission

Transmission of HPV is both vertical and horizontal. Eggs may be easily contaminated during spawning when coming into contact with water and faecal material from infected females (OIE 2007a). Horizontal transfer via the oral route has been demonstrated in *P. monodon* post larvae (Dhar et al 2014). Vertical transmission is reported in *P. chinensis* and supported by presence of HPV infection in hatchery larvae of *P. monodon* (Dhar et al 2014).

Infectious hypodermal and haematopoietic necrosis virus (IHHNV)

Background and pathogenic significance

The situation with regard to IHHNV in Australia is somewhat confusing, with little distinction being made between the presence of genomic sequences in Australian *P. monodon* sharing homology with known strains of IHHNV and the occurrence of complete viral particles or disease.

Apart from the description of the disease IHHN in juvenile hybrid hatchery-reared *P. monodon* x *P. esculentus* prawns by Owens et al (1992), there are no further clinical or pathological descriptions of the occurrence of the disease IHHN in farmed or wild-caught *P. monodon* or other penaeid species in Australia.

International reporting has failed to clarify the situation. Although there is no evidence of the disease IHHN in Australia in *P. monodon* or other penaeid species, OIE annual reports from 2003 to the present time unequivocally identify the presence of IHHN in Australia under the heading “Crustacean Diseases Prevalent in the Asia Pacific Region” without further discussion. The first of the NACA Quarterly Aquatic Animal Disease (QAAD) Reports (July-September 1998 quarter) clearly states under the heading “Crustacean diseases” that IHHN did not occur in Australia. It appears that the earlier report by Owens et al (1992) was overlooked.

In October 2003, in the NACA QAAD report for October to December, Australia reported under the heading “Crustacean diseases”, the presence of IHHN in *P. monodon* broodstock originating from Queensland on the basis of a PCR assay. A comment against the listing of the disease identified that none of the 126 prawns tested showed clinical signs or histological lesions of IHHN virus infection and that on sequence analysis, there was a high identity with the Madagascar strain of IHHN virus.

Subsequently, up until 2008, IHHN was listed as a “Crustacean disease” occurring in Australia, reported principally in *P. monodon*, but also on one occasion in *P. japonicus*, with comments against the listings referring to the presence of IHHN virus in the absence of clinical disease or pathology.

After 2008, although the QAAD reports continued to identify that IHHN virus was known to have occurred previously in Queensland and the Northern Territory, no further comment was presented

relating to the absence of disease: No disease occurrences are described, however, and no reference is made in the QAAD reports to advice received by OIE that infectious strains of IHNV viral genome have been identified in Australian *P. monodon*, as described by Saksmerprom et al (2010).

As far as can be ascertained, it appears that two different genomic sequences are recognised in Australian *P. monodon* that share homology with IHNV virus.

1. A genomic sequence identified as Type 3A by OIE, a DNA sequence integrated into the genome of *P. monodon*, present in a high proportion of *P. monodon* in Australia (>80%), and showing a high degree of homology with genomic sequences from Madagascar (OIE 2016a).

2. Sequences apparently not integrated into the *P. monodon* genome (the non-Type 3A sequence) that show a high degree of homology with sequences from known strains of IHNV virus and lesser homology with the Type 3a sequence discussed above. The description of the non-Type 3A genomic sequence was based on Australian *P. monodon* shipped to a Thailand laboratory (Saksmerprom et al 2010). OIE announced on 11 July 2008, presumably on the advice of the Australian Government, positive test results for the infectious type of IHNV virus in *P. monodon* from two sites in Northern Queensland: Proserpine with 3% of samples positive in April 2008 and Cardwell with 5% of samples positive in March 2008 (Saksmerprom et al 2010). This status appears to have been retained to the present without modification as OIE (2016a) states “Infectious IHNV was detected for the first time in farmed prawns in Australia in 2008”.

No meaningful transmission studies can be identified to verify if Australia does in fact have a genomic sequence in *P. monodon* capable of producing infectious virus particles that may cause disease in that species or be transferred to other prawns resulting in IHNV disease. The only reference to transmission studies with an “Australian strain of IHNV” appears to be those of Tang and Lightner (2006) who challenged SPF *P. monodon* with extracts of prawns containing a viral sequence with negative results, noting that, in the absence of complete infective viral particles, transmission of disease would be unlikely.

Geographic distribution, host range and prevalence in Australia

IHNV has been recorded in *P. monodon*, *F. merguensis*, *M. ensis* and in *P. monodon* x *P. esculentus* hybrids from Queensland waters (Owens et al 1992; Krabsetsve et al 2004; Owens and Hall-Mendelin 1989). More recently, Cowley et al (2015) demonstrated that IHNV was present in *P. monodon* from the Gulf of Carpentaria and from northeast Queensland.

Cowley et al (2015) also reported that IHNV was detected in 4/136 (3%) *P. monodon* originating from Joseph Bonaparte Gulf and introduced into a Queensland hatchery prior to sampling and

testing, raising the possibility that IHHNV was present in populations of *P. monodon* in Joseph Bonaparte Gulf.

Thus, at this point in time, it is not possible to state with any certainty if *P. monodon* populations in Joseph Bonaparte Gulf are infected with IHHNV. It is possible, though.

Detection methods

Apart from the clinical disease described by Owens et al (1992), the majority of reports of IHHNV in Australian have been based on PCR assay (Krabsetsve et al 2004). The presence of Cowdry Type A inclusions consistent with IHHNV have also been reported in *F. merguensis*, *P. monodon*, and possibly *M. ensis* from north Queensland (Owens and Hall-Mendelin 1989).

More recently, PCR assays were used by Cowley et al (2015) to detect IHHNV in which the assay was designed to only detect IHHNV and not the non-infectious IHHNV-like homologues integrated in the genome of a high percentage of Australian *P. monodon*.

Stability of disease agent

No specific data can be identified, however, IHHNV is believed to be the most stable virus of the known penaeid shrimp viruses (OIE 2016a).

Transmission

IHHNV is transmitted vertically in *P. vannamei* (Dhar et al 2014). Eggs of infected females show poor development and nauplii produced from infected broodstock show IHHNV (Dhar et al 2014). Horizontal transmission occurs through cannibalising of moribund or dead shrimp or through contaminated water (Dhar et al 2014).

Although no information can be identified describing the modes of transmission of the Australian IHHNV genomic sequences, given the prevalence of IHHNV in *P. monodon* at least, and given an absence of disease, it can be assumed that transmission may well be vertical.

Mourilyan Virus (MoV)

Background and pathogenic significance

MoV may cause generalised infection with the development of spheroids in the lymphoid organ and gill in advanced cases. Necrotic debris and vacuolation in spheroids increase in relation to severity of infection (OIE 2007b). In severe infections, ectopic spheroids may also be detected in gill and in connective tissue associated with various cephalothorax organs (OIE 2007b).

MoV in healthy *P. monodon* and *M. japonicus* was restricted mainly to spheroids in the lymphoid organ, implying that it can exist as a subclinical infection in both species (Cowley et al 2005). MoV has been associated with mid-crop mortality syndrome in *P. monodon* (Oanh et al 2011; OIE 2007b)

and has been associated with idiopathic mortalities and poor survival in *M. japonicus* (OIE 2007b, Cowley et al 2005).

Histopathological changes of epineurial hyperplasia and thickening of the midgut basement membrane resembling those described in gut and nerve syndrome (GNS) reported by Lightner et al (1984) in *P. japonicus* were variably present in *P. monodon* exhibiting MOV in nerve, muscle and mid-gut tissues (Cowley et al 2005). A causal association between MOV and GNS could not be established.

Geographic distribution, host range and prevalence in Australia

MOV was first identified in 1996 in diseased *P. monodon* from a farm near the township of Mourilyan in northern Queensland (Cowley et al 2005). Subsequently, MoV has been demonstrated in progeny of farmed *M. japonicus* produced from wild *M. japonicus* from Mackay Harbour (Cowley et al 2005a). Sellars et al (2006) described MOV in mature *M. japonicus* from the Logan River area, southern Queensland. MOV is now considered endemic along the east coast of Queensland and is present at low levels in Gulf of Carpentaria (Cowley et al 2009).

Cowley et al (2015) reported that MOV was detected in 3% of 150 *P. monodon* originating from Joseph Bonaparte Gulf and introduced into Queensland hatcheries prior to sampling and testing, raising the possibility that MOV is present in populations of *P. monodon* in Joseph Bonaparte Gulf.

Thus, at this point in time, it is not possible to state with any certainty if *P. monodon* populations in Joseph Bonaparte Gulf are infected with IHNV. It is possible, though.

Detection methods

Cowley et al (2005) described an RT-nested PCR test that can reliably detect between 2 and 6 copies of a synthetic MOV. More recently, TaqMan RT-qPCR assays were used by Cowley et al (2015) to detect MOV in broodstock *P. monodon* from samples of gill/pleopod.

Stability of disease agent

No specific data can be identified.

Transmission

Horizontal transmission is likely via ingestion of infected tissue (OIE 2007b), however, vertical transmission not reported but cannot be excluded (OIE 2007b).

Spawner-isolated mortality virus (SMV)

Background and pathogenic significance

Spawner-isolated mortality virus is described as a cause of epizootic mortalities with lethargy, failure to feed, redness of the carapace and pleopods in infected spawners of *P. monodon* (Fraser and

Owens 1996), with widespread degenerative changes in organs and tissues. SMV has been associated with mid-crop mortality syndrome (Owens et al 1998, 2003) which caused significant mortalities among cultured juveniles and sub-adults of *P. monodon* cultured in Australia from 1994 to 1996.

Geographic distribution, host range and prevalence in Australia

Spawner-isolated mortality virus (SMV) was initially reported in association with epizootic mortalities in captive *P. monodon* (Fraser and Owens 1996) and was subsequently identified in both *P. monodon* and *F. merguensis* spawners (Owens et al 2003) from Queensland. More recently, the virus was reported at a low prevalence in *P. monodon* from northeast Queensland but not from the Gulf of Carpentaria (Cowley et al 2015).

Cowley et al (2015) also reported that SMV was detected in DNA samples of *P. monodon* originating from Joseph Bonaparte Gulf and introduced into two Queensland hatcheries prior to sampling and testing, raising the possibility that SMV was present in populations of *P. monodon* in Joseph Bonaparte Gulf.

Thus, at this point in time, it is not possible to state with any certainty if *P. monodon* populations in Joseph Bonaparte Gulf are infected with SMV. It is possible, though.

Detection methods

PCR assays were used by Cowley et al (2015) to detect SMV in samples of gill/pleopod from broodstock *P. monodon*.

Stability of disease agent

No specific data can be identified

Transmission

SMV was readily transmitted to experimental *P. monodon* by inoculation (Fraser and Owens 1996). Evidence for vertical transmission exists as the virus is found in gonads (Owens et al 2003) but the virus is present in faeces and transmission may be via faecal contamination. Infection is reported early after stocking or in first week implicating hatcheries as source of infection (Owens et al 2003).

Vibrio spp (V. harveyi, V. damsela, V. alginolyticus)

Background and pathogenic significance

Bacteria belonging to the family Vibrionaceae are ubiquitous and are commonly isolated from clinically normal individuals as well as in association with specific disease syndromes. Infections are commonly reported in larval or juvenile prawns and are associated with septicaemia and mortalities.

Geographic distribution, host range and prevalence in Australia

Vibrio alginolyticus was reported from moribund post-larval *P. esculentus* from the NW coast by Jones (2003) and was identified as a putative cause of “white pleura disease” in unspecified wild-harvested prawns from the NE coast by Owens et al (1988).

Vibrio damsela was reported as a cause of disease in larval, hatchery-reared *P. monodon* in north Queensland by Owens and Hall-Mendelin (1989).

Vibrio harveyi was also reported as a cause of disease in larval, hatchery-reared *P. monodon* in north Queensland by Owens and Hall-Mendelin (1989). The organism was also associated with disease in broodstock *P. esculentus* from the NE coast by Owens et al (1992).

Vibrio spp. are reported as a cause of low-grade disease in larval, hatchery-reared *P. monodon* in north Queensland by Owens and Hall-Mendelin (1989). *Vibrio* spp. have also been reported from moribund post-larval *P. esculentus* from the NW coast by Jones (2003).

Vibriosis is reported in wild harvested *P. monodon* following capture from the Northern Territory (K. Dyrting pers comm.). *Vibrio*-like bacteria were reported by Paynter and Lester (1987) in diseased laral *M. plebejus* from Northern NSW.

Detection methods

Bacterial culture is the usual method of detection.

Stability of disease agent

No specific data can be identified.

Transmission

Vibrio spp are readily transmitted horizontally.

Vibrio parahaemolyticus (P. monodon mortality syndrome)

Background and pathogenic significance

An acute disease characterised by hepatopancreatic necrosis and known as *P. monodon* mortality syndrome (PMMS) has recently been reported (OIE 2016b). At this time, it is believed that the disease is caused by infection with a toxigenic member of the *Vibrio harveyi* clade, i.e., *V. parahaemolyticus*.

Geographic distribution, host range and prevalence in Australia

The disease is associated with on-going mortalities in farmed *P. monodon* from two localities in Queensland, Cardwell and Bundaberg.

Transmission

Vibrio spp are readily transmitted horizontally.

Lagenidium sp.

Background and pathogenic significance

Lagenidium sp. has been associated with egg and larval mycoses of P. monodon and M. plebejus (Owens and Hall-Mendelin 1990; Paynter and Lester 1987, 1988). Owens and Hall-Mendelin (1990) described the presence of aseptate, highly branching hyphae that failed to elicit a cellular host response and which destroyed eggs.

Geographic distribution, host range and prevalence in Australia

Lagenidium sp. was reported in farmed broodstock and larval P. monodon from the northeast coast (Owens and Hall-Mendelin 1990) and in eggs and larvae of M. plebejus from NSW (Paynter and Lester 1987).

Detection methods

Culture and microscopic examination are usual methods of detection.

Stability of disease agent

No specific data can be identified .

Transmission

Lagenidium is considered to be transmitted horizontally.

References for Appendix A

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APPENDIX H DRAFT ENVIRONMENTAL MANAGEMENT PLAN



**PROJECT SEA DRAGON
STAGE 1 LEGUNE GROW-OUT FACILITY
SUPPLEMENTARY ENVIRONMENTAL IMPACT STATEMENT**

**APPENDIX H DRAFT ENVIRONMENTAL
MANAGEMENT PLAN**

Project Sea Dragon: Stage 1, Legume Grow-out Facility

Environmental Management Plan

Project Sea Dragon Pty Ltd

Revision History

Revision	Date	Description	Author	Reviewer	Status
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B	5-Feb-2017	Minor Updates	MW		DRAFT

Authorisations

Document approved and released for distribution

Position	Name	Signature	Date

* Note that electronic copies are uncontrolled.

Key Contacts

Contact	Contact Details
Proponent	Project Sea Dragon Pty Ltd Address: Level 11, 225 St Georges Terrace, Perth WA 6000 Australia Postal Address: PO Box 7312 Cloisters Square, Perth WA 6850 Australia Phone: +61 8 9321 4117 Fax: +61 8 9321 4411 Website: http://seafarmsgroup.com.au/project-sea-dragon/ Primary Contact: Chris Mitchell, Executive Director – Seafarms Group Limited Postal Address: U6 Ground Floor, 31-47 Joseph St Blackburn North VIC 3130 Phone: +61 3 9928 5111 Fax: +61 3 9928 5199 Email: chris.mitchell@seafarms.com.au
Construction Manager	
Site Manager, OH&S contact	
Environmental Manager	
Community / Communications Manager	
Seafarms Ltd	
Pollution Incidents	
Boat Strike or other Marine Fauna Incident	Marine Wildwatch hotline 1800 453 941
Indigenous Cultural Heritage	
Environmental Information	CO2 Australia Ltd
Bushfires, medical and other emergencies	000 (or 112 from a mobile phone)

CONTENTS

1	Introduction	1
1.1	Purpose and Scope	1
1.2	Project Sea Dragon Overview.....	1
1.3	EMS Framework	4
2	Project Description	5
2.1	Legume Station Grow Out Facility - Stage 1.....	5
2.2	Construction	7
2.2.1	Site establishment	8
2.2.2	Construction works	8
2.3	Operations.....	9
3	Objectives and Targets.....	13
4	Implementation.....	14
5	Social and Environmental Context	15
5.1	Overview	15
5.2	Environmental Context	15
5.2.1	Significant Sites or Features	15
5.2.2	Climate	15
5.2.3	Geology, Geomorphology and Soils	16
5.2.4	Hydrology	19
5.2.5	Surface water and sediment quality	22
5.2.6	Groundwater.....	24
5.2.7	Terrestrial Vegetation and Flora	26
5.2.8	Terrestrial Fauna and Avifauna	29
5.2.9	Introduced and Pest Species	30
5.2.10	Aquatic Ecosystems.....	32
5.2.11	Waste Management.....	35
5.2.12	Air Quality.....	37
5.2.13	Climate Change Assessment	38
5.2.14	Noise and Vibration.....	38
5.3	Socio-economic context.....	39
5.3.1	Socio-economic	39
5.3.2	Historic and Cultural Heritage	40
5.3.3	Traffic and Transport.....	41
5.3.4	Amenity	41
6	Environmental Management	43
6.1	Environmental Management Strategies	43

6.2	Monitoring and Review	48
6.3	Contingency Plans	48
7	References.....	50

LIST OF TABLES

Table 1	Recommended Preliminary Separation Distances - Sewage Treatment Plants	37
Table 2	Environmental Management Strategies	44

LIST OF FIGURES

Figure 1	Integrated Project Framework.....	2
Figure 2	Project Component Locations.....	3
Figure 3	EMS Framework.....	4
Figure 4	Key Components of the Stage 1 Legume Grow-out Facility.....	5
Figure 5	Project Layout.....	6
Figure 6	Grow-out Centre Flow Diagram.....	10
Figure 7	Monthly Climate Statistics, BOM Stations 014850, 014825	16

1 INTRODUCTION

1.1 PURPOSE AND SCOPE

This Draft Environmental Management Plan (EMP) is the site specific EMP document for construction and operation of the Project Sea Dragon Stage 1 Legume Grow-out Facility, and exists under the Project Sea Dragon (PSD) Environmental Management System (EMS).

In this document, the term Project (capitalised) is defined as Stage 1 of the Legume Grow-out Facility.

On approval of the Project, this Draft EMP will be updated to reflect approval requirements and implemented on the Project site along with the overarching EMS. The EMS Manual (EM-00-MN-0001) documents the overarching policies and procedures for the management of impacts on the environmental values for the whole of the PSD project, provides project wide commitments and details continual improvement measures. This EMP builds on these procedures by detailing the specific targets to meet the PSD project wide objectives mitigation measures and monitoring requirements, during the construction and operational phases.

The Draft Environmental Impact Statement (EIS) includes detailed description of the existing environment assessment of impacts, and mitigation measures relevant to this EMP, which are summarised herein. This EMP is limited to the Project scope outlined in Section 2, and has been prepared with reference to:

- NT EPA Guideline for the Preparation of an Environmental Management Plan (NT EPA, 2015)
- Commonwealth Environmental Management Plan Guidelines (DoE, 2014)
- AS/NZS ISO 14001:2004 Environmental Management Systems - requirements with guidance for use
- AS/NZS ISO 14004:2004 Environmental Management Systems - general guidelines on principles, systems and support techniques.

1.2 PROJECT SEA DRAGON OVERVIEW

Project Sea Dragon is a large-scale, integrated, land-based prawn aquaculture project in northern Australia designed to produce high-quality, year-round reliable volumes for export markets for Black Tiger prawns (*Penaeus monodon*).

It is a staged development of up to 10,000 hectares of produce ponds, with the development of a series of facilities across northern Australia, including:

- The Grow-out Facility, the subject of this EMP
- Quarantine, Founder Stock Facility and Back-up Breeding Centre – proposed to be located at Exmouth (WA)
- Breeding Program - proposed to be located at Point Ceylon at Bynoe Harbour (NT)
- Hatchery Site – proposed to be located in the Darwin (NT) environs
- a Processing Plant – proposed to be located near Kununurra in Western Australia (WA), and
- Export Facilities – proposed to be located at either or both Wyndham and Darwin.

An overview of the integrated project is shown in Figure 1 and the location of key components in Figure 2.

The main operations will be at the Grow-out Facility located on Legume Station, an operating NT pastoral lease located approximately 106 km north-east of Kununurra on the western border of the Northern Territory, with an ultimate design for approximately 10,000 ha of production ponds over 27 farms.

Stage 1 of the Legume Grow-out Facility comprises three grow-out Farms over 1,120ha and associated supporting infrastructure, and is described in more detail in Section 2.



FIGURE 1 INTEGRATED PROJECT FRAMEWORK

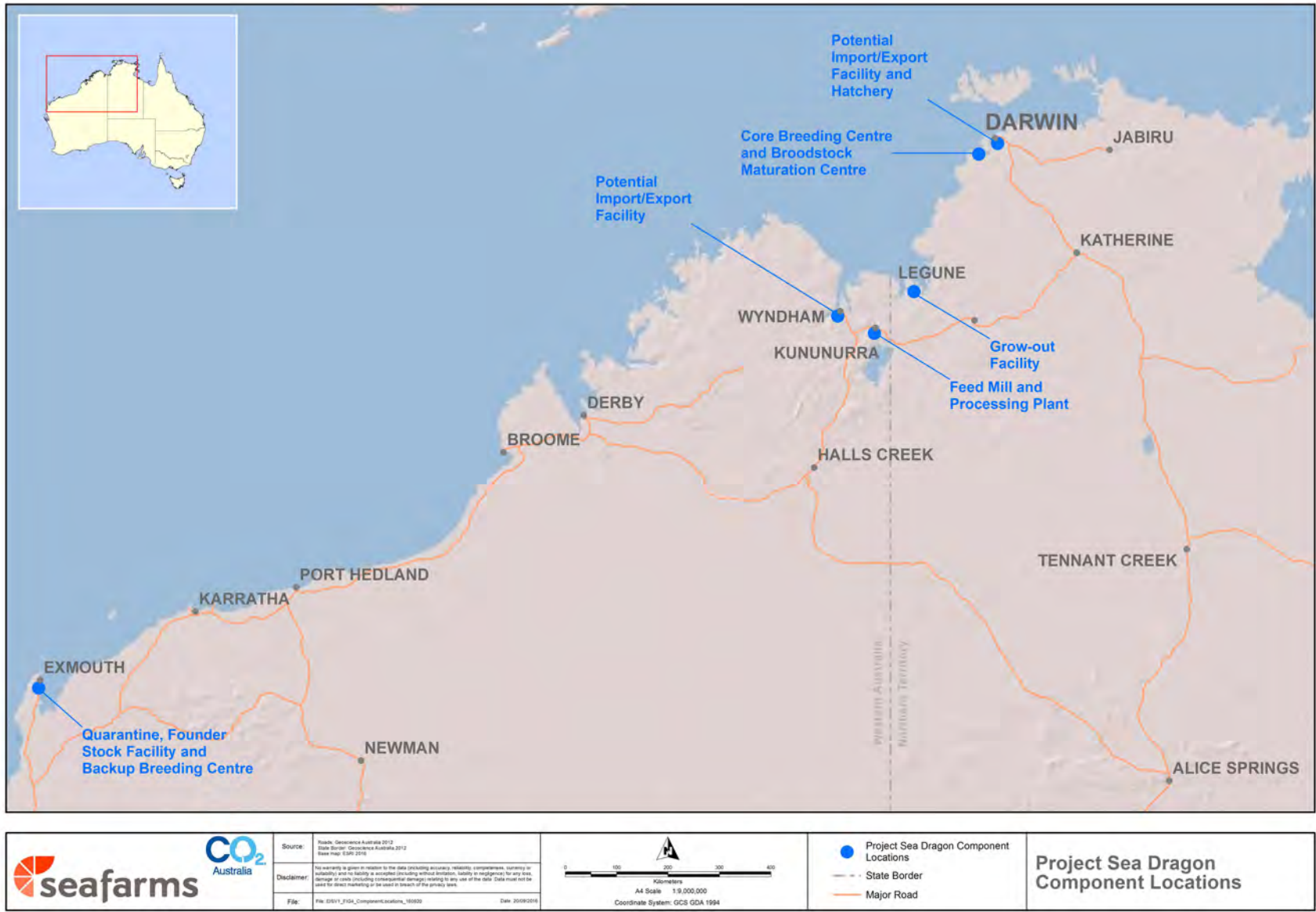


FIGURE 2 PROJECT COMPONENT LOCATIONS

1.3 EMS FRAMEWORK

The EMS is organised into the overall framework shown in Figure 3. The system is primarily site focused, and implemented on a site by site basis, other than policy setting and high level review. The EMS manual defines the overall management system components relevant to all sites, with additional site specific information contained in site specific management plans and documents.

Legume Station is designated as Site 01.

Documentation relevant to the EMS, including site specific documents, is shown in EM-00-RG-001 Document Register.

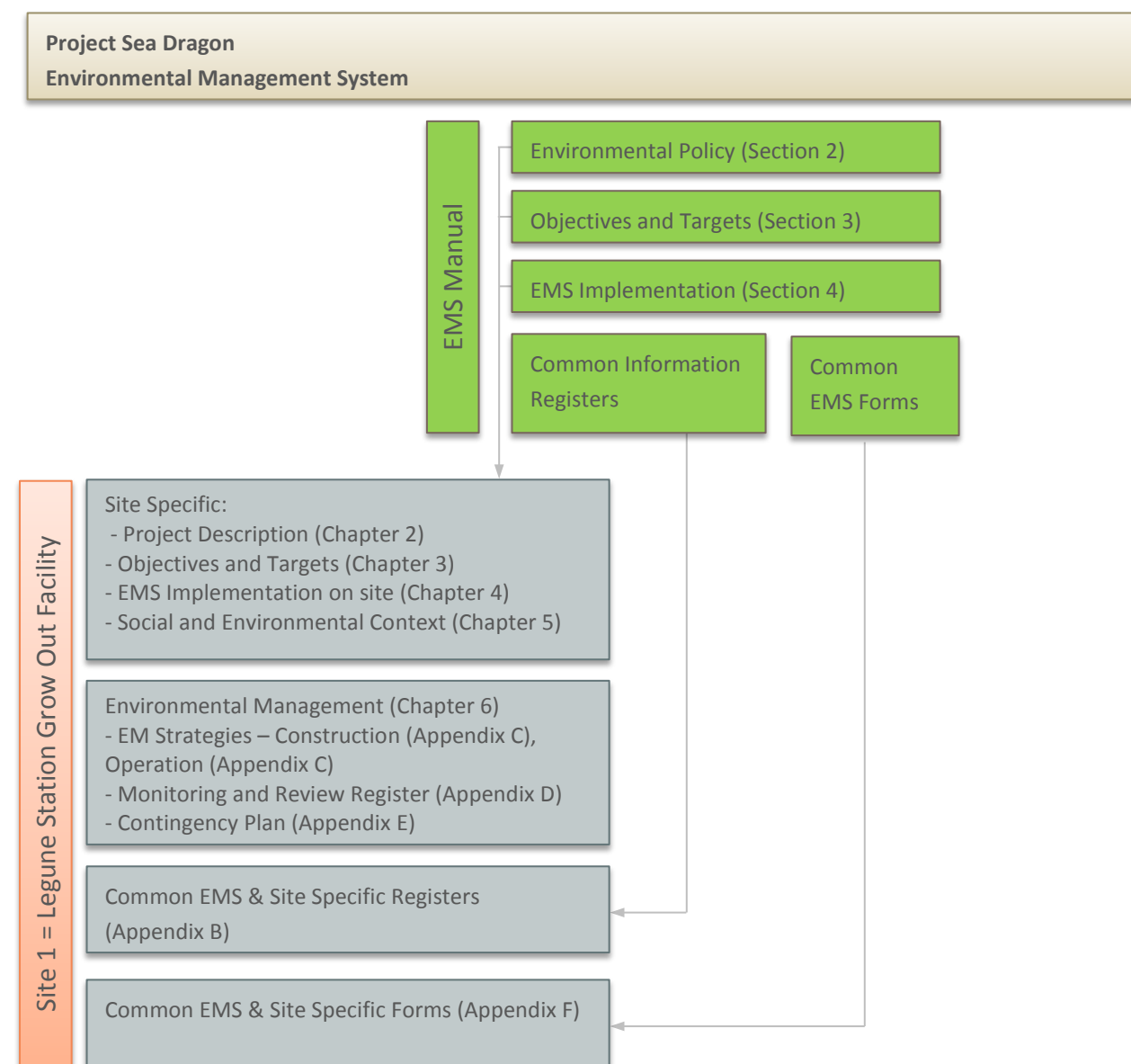


FIGURE 3 EMS FRAMEWORK

2 PROJECT DESCRIPTION

2.1 LEGUME STATION GROW OUT FACILITY - STAGE 1

The Project has been designed in accordance with the Aquaculture Stewardship Council Shrimp Standard and the Environmental Code of Practice for Australian Prawn Farmers. It will also use husbandry practices that are well accepted by government and industry as outlined in the Australian Prawn Farmers' Manual.

The main operations for Project Sea Dragon will be at the Grow-out Facility located on Legume Station, located approximately 106 km north-east of Kununurra near the western border of the Northern Territory. The Stage 1 Legume Grow-out Facility will produce nominally 14,000 tonnes of prawns per annum and consists primarily of the Grow-out Centre, plus the supporting infrastructure as illustrated in Figure 4. The Project layout is shown in Figure 5.

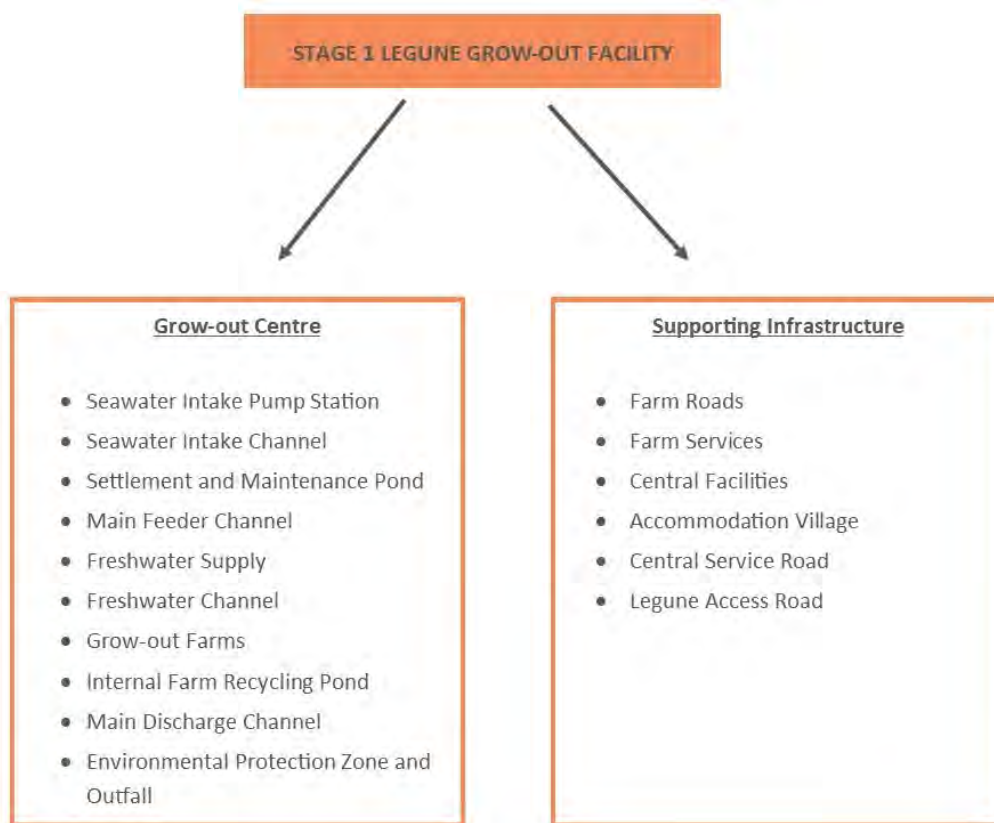
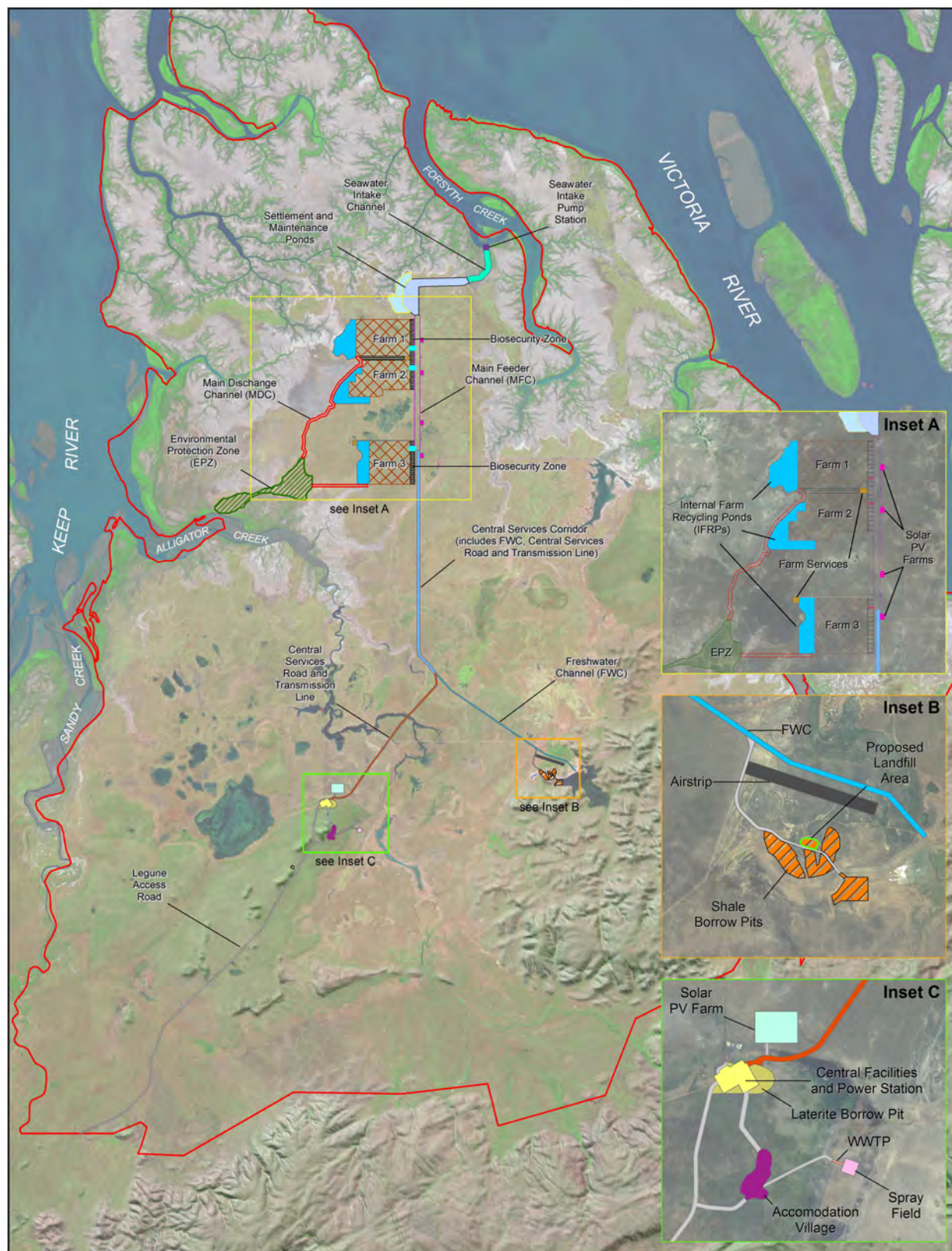


FIGURE 4 KEY COMPONENTS OF THE STAGE 1 LEGUME GROW-OUT FACILITY

Specifically, Stage 1 involves:

- Three farms with a total productive area of 1,120 ha, each consisting of up to 40 ponds, of 10 ha each. These are each serviced by feeder and discharge channels, an internal gravity fed Internal Farm Recycling Pond (IFRP) for storage, settlement and return of water to the farm feeder channel (FFC) for re-use, and supporting infrastructure



	Source: Legume Station: NT Land Information Services 2015 Project Master Plan: Australian 2016 Landfill: Geoscience Australia 2005 Disclaimer: No warranty is given in relation to the data (including accuracy) resulting from the use of the data (including accuracy) or any liability is accepted (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damages) resulting to any use of the data. Data must not be used for direct marketing or be used in breach of the privacy laws. 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FIGURE 5 PROJECT LAYOUT

- A common water intake, comprising pump station and intake channel at Forsyth Creek for seawater supply, rotating drum filters to screen the intake, a settlement pond, a Main Feeder Channel (MFC) and a freshwater channel (FWC) (freshwater will be sourced from the existing Forsyth Creek Dam).
- A Main Discharge Channel (MDC), feeding into an Environmental Protection Zone (EPZ) - a wide, shallow retention area designed primarily to control outflow timing and velocity, but also expected to allow settlement of suspended solids and nutrient reduction before outfall to Alligator Creek
- Project supporting infrastructure, including:
 - Accommodation, offices and laboratory
 - Vehicle wash bays, workshops
 - Stores for fuel, oil and chemical and liquid waste (oil and chemicals)
 - A potable water treatment plant
 - Wastewater Treatment Plants (WWTP) and Land Application Areas (LAA), comprising one system for Central Facilities, and another larger system for the Central Village, plus small systems for the farm services areas
 - A landfill for putrescible and non-putrescible waste, constructed in a depleted gravel pit
 - Drainage and flood mitigation works, such as culvert and drainage channels
 - A central diesel power station, consisting of multiple dual fuel generators with a capacity of 17.5MW, and distributed solar PV generation of approximately 17.5MW
 - A 132KV transmission overhead line to transmit power to the farms and pump stations, distribution switchyards and step down transformers. Critical loads such as the pump stations will have self-contained standby diesel generating sets located adjacent to the Motor Load Centres.
 - All weather, unsealed gravel-sheeted in-farm access roads to and from the ponds, and unsealed access tracks to connect farms with other facilities

The main Project area is the Grow-out Centre, which will be situated on the estuarine-deltaic plain of Legume Station (i.e. the floodplain, above 4.5-5 m AHD), utilising the largely grassed areas currently used for cattle operations. The Grow-out Centre will be constructed on these areas to provide flood immunity, storm surge and sea level rise immunity, and to avoid the coastal erosion plain (nominally below 4.5-5 m AHD) containing wetlands, potentially acid-sulfate soils, and areas of environmental, heritage and cultural sensitivity.

Section 2.2 and 2.3 below summarise the construction and operational phases of the development, described in more detail in Volume 1, Chapter 3 – Project Description, of the Draft EIS.

2.2 CONSTRUCTION

Construction is proposed to begin in July 2017, however, this is dependent upon receiving all necessary Project approvals. It will involve site establishment, earthworks and construction, and site commissioning. Additionally, the commencement and duration of construction will be heavily influenced by wet season constraints and the provision of road infrastructure by the WA and NT governments outside of the Project footprint.

2.2.1 Site establishment

Site establishment will involve preparing the site for earthworks to commence, involving laydown areas, access roads, and similar works. Two laydown areas will be developed, with one at the Central Facilities location, and the other at the Inlet Settlement Pond area. Construction of linear or distributed infrastructure (service corridor, roads, etc.) will be developed using the appropriate laydown and service areas above, with minor storage of raw materials along the route as required. Basic amenities, wash bays, wastewater treatment systems, potable water treatment plant, diesel power station, waste storage, spill management, fuel storage, chemical/oil and supply/equipment storage areas will also be developed at this time and unsealed access tracks will be upgraded where required to obtain access to all construction areas.

2.2.2 Construction works

Following site establishment, construction of the Grow-out Centre and the supporting infrastructure will commence.

2.2.2.1 Grow-out Centre

- The farm areas will be control burned of pasture prior to commencement of earthworks, and trees removed and mulched
- Ponds, channels and berms will be constructed via a cut-to-fill operation to the designed levels
- The embankment walls for the ponds and the channels will be above-ground earthen structures. Farm walls will be ~2.0m above the natural ground level. Embankment walls for channels will be ~1.0- 5.0m above natural ground level
- Ponds and channels will not be lined with any other materials, as the surface soils (the black clay soils on the estuarine-deltaic plain) provide the impermeability needed to retain the water for operations
- Batter slopes will be designed to be suitable to obtain the required stability and re-vegetation of the batters will be encouraged by seeding with grasses to assist in achieving stability
- The tops of most berms will be sheeted with roadbase material and compacted for maintenance access, or where relevant will be incorporated into the site access roads (such as the central service road)
- Procedures will be followed to provide for appropriate management of PASS material that may be encountered, to avoid oxidation and acid production
- The intake will utilise a piling rig to install the required steel tubular piles for the structure, with access to the site will be via an earthen access ramp from the floodplain out onto the coastal erosion plain to Forsyth Creek (reclaimed after use)
- The EPZ will be constructed on the estuarine-deltaic plain by placing minor bunds to direct flow within the EPZ where required
- A weir will be constructed at the outfall to Alligator Creek to guide the flow from the EPZ.

The major equipment utilised during the construction of these elements includes:

- Earthmoving equipment (Laser buckets, tractors, scrapers, trucks, excavators, compactor, graders, dozers, water carts)
- Cranes
- Trucks (delivery of materials, bitumen top-coat).

Once the earthworks have been completed, construction of the associated structures (inlet, outlet, filters, culverts, on- farm facilities, electrical and controls, trenching) will commence.

2.2.2.2 Supporting Infrastructure

In-farm access roads will be constructed on the trafficable bunds forming the ponds, channels and IFRPs.

Other works include the outlet to the existing dam on Forsyth Creek Dam, which will be modified to provide for seasonal control of outflows, by an additional valve and modified weir box on the downstream face of the wall.

Borrow pits on the site will be used for roadbase, and other construction materials.

The Central Facilities, Farm Services and the Accommodation Village will comprise vegetation clearing and bulk earthworks, followed by underground services, concrete foundations, building placement or erection, building fitout, electrical and controls and finishing civil works. Buildings will be prefabricated, transportable buildings that will come to site broken down in transportable sized units and then assembled on site.

A landfill will be established on the site at the location of the existing borrow pits near the Legume Station homestead. This, and the establishment of the Hazardous Waste Facility, and the Waste Transfer Facilities, will occur as soon as practicable during construction, to minimise issues with waste handling during construction.

2.3 OPERATIONS

Project Sea Dragon will grow black tiger prawns (*Penaeus monodon*) bred in an in-house captive breeding program. The prawns will be delivered from the commercial hatchery, proposed to be located in the Darwin environs, to Legume by truck, and stocked into the Grow out Ponds located in the Grow-out Centre, comprised of the three farms and associated services.

The flow of water through the Grow-out Centre is illustrated in Figure 6, from the supply of water through the intake channels, recirculation within the system, to the subsequent discharge of water at the outfall into Alligator Creek. Ponds are fed by the Pond Feeder Channel, which takes seawater from Forsyth Creek (after settling), freshwater from Forsyth Dam, and recirculated water from the Internal Farm Recycling Pond (IFRP). The water is conditioned to achieve the correct pH balance and mix of pond biota (chiefly algal species) before being stocked with juvenile prawns.

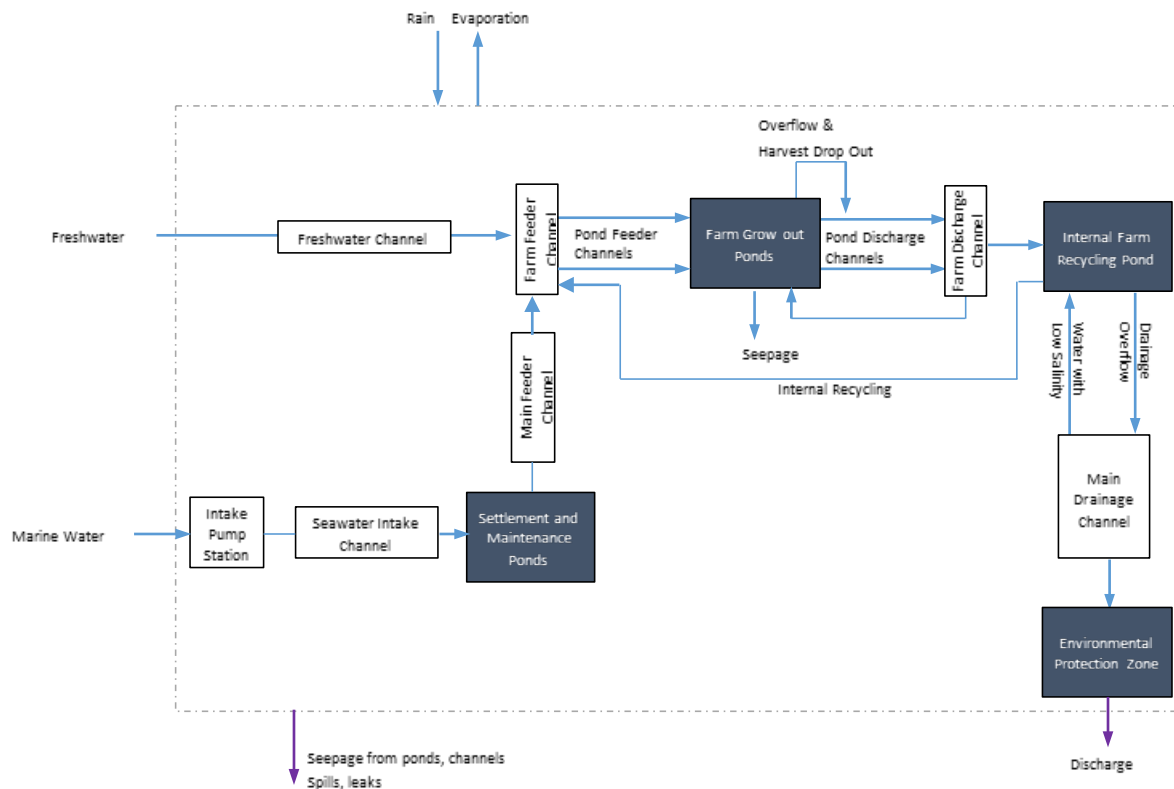


FIGURE 6 GROW-OUT CENTRE FLOW DIAGRAM

Water quality is controlled by:

- internal exchange (recirculation) of farm water via the IFRP to manage pond water nutrient levels and microalgae growth
- application of sea water and fresh water (from the Main Feeder Channel and the Freshwater Channel) to manage pond volumes and salinity levels
- drainage of water from the farms to the Main Discharge Channel to manage pond volumes and salinity levels
- aeration to manage levels of dissolved oxygen in the water

Prawns are fed a formulated feed diet to optimise growth and animal health, supplied by feed trucks equipped with blowers. Several times per day a truck will drive around each pond perimeter and project the prawn feed up to 20 – 30 m in from the edge of the pond. The feed sinks to the pond bottom where it is eaten by the prawns. The amount of feed eaten by the prawns is monitored to minimise feed wastage, and the feeding regime is continually updated to reflect prawn feeding requirements and behaviour.

Harvest involves draining the pond via the outlet structure. The bottom of the pond is shaped and sloped to allow harvest drainage within a 12 hour period. While water can recirculate within the farm, prawns are confined to the pond they are stocked in. Prawns are grown to marketable weight (typically 20+ grams) and harvested.

The water flow carries the prawns into the outlet structure where they are captured in a cage at the drainage point, lifted with a fish pump into a dewatering tower, and then deposited into ice slurry. The ice slurry both euthanizes and preserves the prawns for transport to the Processing Plant.

After harvest, the floor of the pond may be dried out as a fallow measure. This allows the pond floor to be cleaned, the soil conditioned with application of lime, and drainage grades re-cut for the next crop. The centre mound of pond spoil, generated from silt, algal matter and prawn faeces, can also be removed from the pond to a remediation stockpile. This material, with its high levels of organic material, can be used to help revegetate pond banks once leached of salt.

Supporting infrastructure and services will include:

■ Farm services, Central Facilities and Accommodation Village:

- The functions to be carried out at the Central Facilities broadly include: harvest equipment storage and maintenance; harvest handling; vehicle washing and maintenance; slurry ice-making; equipment maintenance and warehousing; power generation and switchyard; energy storage and fuel dispensing; management, administration, fire, security, safety and paramedic; communication and systems controls; security and biosecurity control and laboratory
- two Farm Services areas will be constructed to service Farms 1, 2, and 3. Each farm services area includes administration; accommodation and laboratory buildings (manager's house, short-term accommodation units, common mess and living areas for day and night shift staff, administration office and laboratory); a wash bay for vehicle washing between biosecurity zones; workshops for light farm vehicles and aerators; fuel, chemical, molasses and other material and waste stores; transport of post larvae tub storage; a wastewater treatment facility and spray field for discharge of treated water; potable water treatment and storage, for human consumption electrical substations
- the permanent Accommodation Village will be located approximately 1 km south of the Central Facilities comprising: accommodation units; mess, wet mess and the recreation building; laundry units; central toilet facilities and BBQ areas.

■ An integrated waste management system, comprising:

- distributed waste receptacles and some sorting of waste at source
- A Waste Transfer Facility, located at the Accommodation Village, and used to further sort waste prior to disposal at landfill or removal off-site (for recycling, reuse, or disposal)
- An on-site landfill, for the disposal of general (non-recyclable) and putrescible waste.

■ Wastewater management, including:

- oil-water separator waste, and other liquid chemical waste which will be stored in the Hazardous Waste Facility before removal off-site, or removed directly from the sump or separator system off-site
- effluent from farm services, Central Facilities, or Accommodation Village, which will be treated by on-site package treatment plants and irrigated into designated land application areas.

- Storage of chemicals and other hazardous materials in dedicated, spill proof (bundled, and depending on size roofed) stores. Minor quantities will be stored in accordance with AS 1940—Storage and handling of Flammable & Combustible Liquids.
- Airstrip - allowance has been made to extend the length of the existing unsealed runway to handle larger turbo-prop aircraft, in the event that flights to and from Kununurra and Darwin are justified.

3 OBJECTIVES AND TARGETS

The following terms are adopted for this EMP:

- Objectives are defined as the overall goals for environmental management, consistent with the environmental policy, that are set by the organisation to achieve.
- Targets specify measureable elements to determine whether objectives are being met. They should be objective, verifiable and reproducible.

The overarching objectives and targets for Project Sea Dragon are described in the Environmental Management System Manual (EM-00-MN-0001), with the specific environmental objectives and targets listed in each of the Environmental Strategies in Appendix C in this EMP (refer Section 6.1).

4 IMPLEMENTATION

This EMP has been prepared as a sub-plan under the overarching PSD Environmental Management System (EMS). The PSD EMS Manual (EM-00-MN-0001) details general EMS and EMP implementation including:

- Risk Assessment
- Relevant Legislation and Statutory Requirements
- Roles and Responsibilities
- Training and Awareness
- Communication
- Supplier and Sub-contractor Management
- Monitoring and Review
- Non-compliance and Corrective Action
- Complaints Management
- Documentation and Records
- Reporting.

The following site specific elements have been prepared to supplement the above:

- A risk assessment has been conducted specific to the development and design of the Legume Station Grow Out Facility Stage 1, in order to define site and phase specific risks, and develop appropriate mitigation and management measures. This is shown in the Draft EIS, in Volume 1, Chapter 8.
- The Legislation and Approvals requirements are described in the Draft EIS, Volume 1, Chapter 6. A summary will be included in the legislation register for the site (EM-01-RG-0002, with a template shown in Appendix B) following approval.
- Roles and responsibilities have been updated in Appendix A to this document, specific to this site and phase of works. Additional responsibilities are also outlined in Attachment 1.
- Monitoring requirements are shown in the Environmental Management Strategies for each element in Appendix C. These will be used in conjunction with the EMS monitoring and review requirements to prepare a site and phase specific monitoring and review schedule following approval of the Project (refer to template in Appendix D)
- Complaints Management will remain as per the EMS Manual (EM-00-MN-0001), with the inclusion of site details for lodgement of complaints, to be updated after Project approval and prior to works starting.

5 SOCIAL AND ENVIRONMENTAL CONTEXT

5.1 OVERVIEW

The Draft EIS provides a detailed overview and assessment of the existing environmental and social aspects, potential impacts, and mitigation measures, in Volume 2 – Environmental Assessment. This Section of the EMP summarises the key social and environmental context of the Project, including the key potential impacts.

5.2 ENVIRONMENTAL CONTEXT

5.2.1 Significant Sites or Features

Legume Station is bordered by the Keep River to the west, and Victoria River to the east, with the Project footprint situated within the Legume Coastal Floodplain Site of Conservation Significance.

The Legume Wetlands are also situated on Legume Station, and are recognised as a Nationally Important Wetland. The proposed services corridor and one of the proposed roads intersect the Legume Wetlands. Other significant natural features include seasonal / intermittent freshwater lakes and ponds, and swamps, floodplain lakes and ponded pastures; and the northern territory coastline.

Assessment of these features is detailed in the Draft EIS, Volume 2 - Environmental Assessment, and summarised in Section 5.

Other nearby sites or features that will not be impacted by the Project, but that were considered include:

- The Keep River National Park, located 80 km southwest of the Project, with an extension proposed that would extend it to be approximately 17 km south of the nearest Project element
- The Spirit Hills Wilderness Conservation Area, which falls within the Keep River National Park extension
- The Joseph Bonaparte Gulf Marine Reserve, around 25km seawards from Turtle Point
- World Heritage Properties (nearest 250km south west) and National Heritage Places (nearest 130km west)
- No public or private reserves are located within or near the Project area, and the area is not designated as a conservation zone under a planning scheme
- The project area is not mapped as a storm surge zone.

5.2.2 Climate

The climate is tropical monsoonal, consisting of two predominant seasons:

- The dry season (April to September) influenced by easterly winds generated over inland Australia, resulting in dry and warm conditions, with very little rainfall and low relative humidity.
- The wet season (October to March) influenced by high humidity and thunderstorm activity caused by steady west to north-west winds, bringing moisture and consequent rainfall from the Timor Sea.

The closest long-term weather station to Legume is Timber Creek (BOM Station No. 014850) located 135 km south east of Legume. Temperature and rainfall statistics from the Timber Creek weather station are presented in Figure 7. Evaporation from the Victoria River Downs weather station (BOM Station No. 014825) is also shown (the closest available evaporation data).

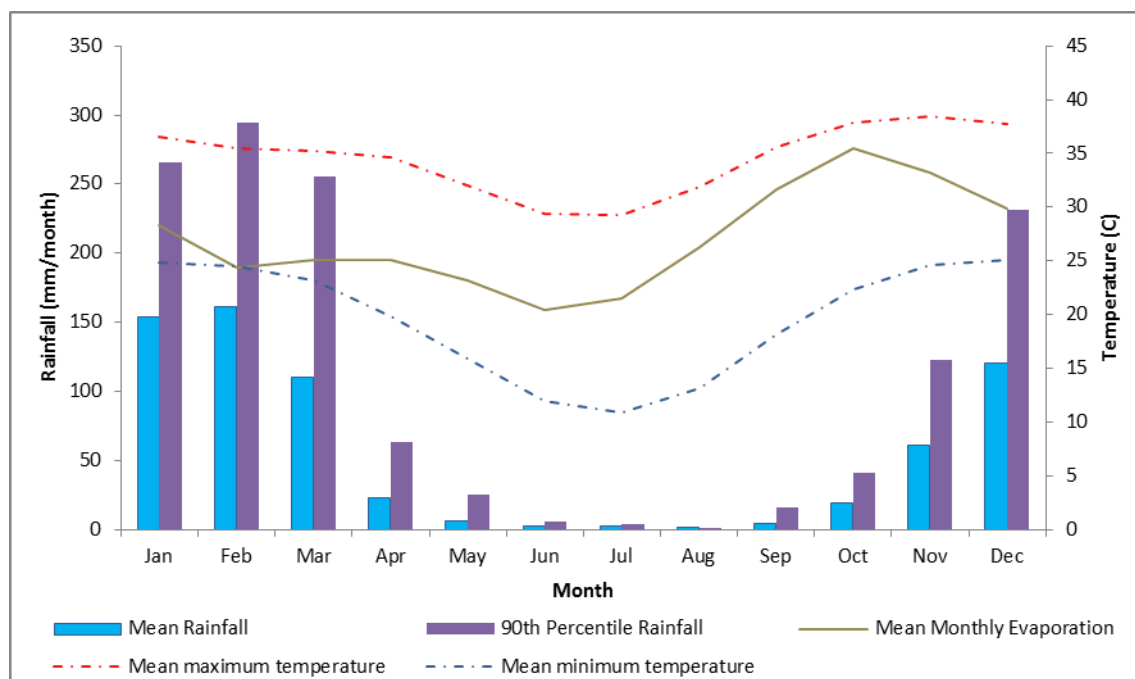


FIGURE 7 MONTHLY CLIMATE STATISTICS, BOM STATIONS 014850, 014825

5.2.3 Geology, Geomorphology and Soils

5.2.3.1 Existing Environment

Legune Station is located at the junction of two geological basins – the Bonaparte Basin in the north and west of Legune (where most of the Project is located), and the Fitzmaurice Basin in the south east. The surface geology of Legune Station is comprised primarily of the Cockatoo, Langfield and Kulshill Groups, with the Legune Formation present as the Legune Range, in the southeast of Legune Station, associated with Forsyth Dam.

In terms of soils and landforms, the Project footprint traverses four plain ‘tiers’, as it moves from north to south across Legune Station. The plains extend from the delta between the mouths of the Keep and Victoria Rivers to the foot of the Legune ranges and Spirit Hills, with the land systems and soils characterised as below:

- The Coastal plain, an area of tidal flats and low closed mangrove forest / samphire forbland vegetation, between sea level up to 4.5-5 m AHD. Soils are hydrosols - poorly drained silty clays and muds. Only the intake structure, intake channel, and part of the discharge structure are located on this plain
- The Estuarine Deltaic Plain, located between 4.5-5 m and 10 m AHD, with scattered residuals up to 30 m, comprised of poorly drained clay soils (Vertosols - self mulching cracking clays) with sandstone residuals, and grassland, open woodland and wetland/swamp areas. This area contains freshwater and tidal estuarine systems, typically saline shallow groundwater (~2-3m depth) and some deeper productive bores. The bulk of the Project infrastructure is located on this plain.
- The Coastal Erosional Plain is characterised as lateritic plains and rises, situated between 10 and 50 m AHD, with residuals rising to 100 m. Soils are Tenosols - Deep red and yellow sands and sandstone residuals, with Sclerophyll woodland, and minor wetland areas around playas. Only the Central Facilities, Accommodation Village and Legune Access Road are located in this land system. Minimal surface water systems are in proximity, although some productive or potentially productive bores are located in the vicinity.

- The Legume Access road traverses a fourth plain system, known as the Flood-out Plain. This plain is located below the Ranges and inland from the Coastal Erosional Plain, representing washout and deposition from local river systems. It is comprised of Hydrosols - Yellow podzolics and yellow earths (sandy clay loam, sandy loam).

The Ranges are located as the backdrop to the above systems, with only the Forsyth Dam, some borrow pits and scattered residuals being included in this land system. Soils are Lithosols, shallow sandy soils and rock outcrop on sedimentary rocks. Some productive groundwater bores, and surface freshwater systems are located in proximity to the works.

5.2.3.2 Acid Sulfate Soils

The Northern Territory Acid Sulfate Soils Risk 1:2M spatial mapping identifies most of the site within the medium risk area for Acid Sulfate Soils (ASS). Areas within the mapped high risk areas include the inlet, sediment pond and maintenance pond in the north, and the Main Discharge Channel (MDC) from farms 1 and 2, the Internal Farm Recirculation Pond (IFRP) in Farm 2 and the Environmental Protection Zone (EPZ).

The airstrip, dam and borrow pit, and the road south of the central facilities and the associated borrow pit are mapped as no risk, though the central facilities area itself is in the medium hazard area.

Sampling has shown that widespread and shallow Actual Acid Sulfate Soils (AASS), being ASS that have oxidised and are producing acidic leachate, are not present at the site, in the areas investigated. Results do confirm the presence of Potential Acid Sulfate Soils (PASS - could potentially oxidise) at a number of locations at or below 2.5 - 3m depth below ground level. In relation to reduced levels (relevant to Australian Height Datum, AHD) this equates to:

- ~1.3m AHD at the location of the intake channel and settlement/maintenance ponds, and the edges of the farms (soil site was northwest of Farm 1), where excavation is anticipated to end more than 2 metres above the PASS in this location, at ~3.7m AHD
- ~2.4m AHD along the MFC, with excavation expected to extend to no lower than 4.7m AHD, which is 2.3 m above the PASS in this location
- PASS material was encountered at 1.7 - 2.7m AHD within the farm areas, and an implied level from the MFC and a site northwest of farm 1 at 1.3 - 2.4m AHD. Excavation is expected to extend to no lower than 4.2m AHD, thus will be at least 1.5 m above any PASS material

Generally, this indicates that PASS is likely present across the site, but is below the level of proposed excavation at ~1.3 m AHD along the Coastal Plain / Estuarine-Deltaic plain boundary, and up to ~2.7 m AHD within the Estuarine-Deltaic plain. Specifically, the farm discharge channels (PDC and FDC), where the deepest excavations will occur, have been hydraulically designed by width, slope and depth (and hence farm shape) to avoid PASS and to minimise construction cost.

Results also indicate that where PASS was found, it naturally has sufficient Acid Neutralising Capacity to result in no Net Acidity (i.e. no chance for PASS to produce acid leachate or runoff), based on groundwater records and soil sampling results (this needs confirmation on a case by case basis).

5.2.3.3 Soil Salinity and Sodicity

Sampling and site observations on Legume Station indicate that the soils in the region of the proposed farm infrastructure and much of the Estuarine-deltaic and Coastal Plains, are saline-sodic, evidenced by elevated salinity and Exchangeable Sodium Percentage (ESP), although sodicity is somewhat patchy and does not show a

clear pattern, other than stronger associations closer to the Coastal Plain. Sampling also indicates that some soils are potentially dispersive, though this is also relatively patchy.

The saline and sodic nature of soils in this area are a direct result of marine influence on these plains, which are subject to alternating drying out and large freshwater pulses onto, over, and through soils each wet season. Salinity profiles indicate generally increasing salinity with depth associated with a shallow, saline groundwater table, and relatively rapid leaching of salts through the profile. This is sourced from both tidal waters and saline deposits (from geologically recent deposition).

More generally, site soils appear naturally habituated to the salt/fresh cycle, without apparent breakdown. In particular, site investigations found no evidence of current dispersion or breakdown of sodic soils, even in areas that have previously been excessively worked such as turkey nest dams, embankments, roadways and channels.

5.2.3.4 Contaminated Land

Potentially contaminating past activities on the site include an operating landfill near the Legume homestead, cattle yards and one known cattle dip, all located outside of the Project footprint. Waste infrastructure on the site is limited to the existing landfill, off-site removal of other wastes, and the potential for unexpected findings of residual waste materials during construction, as a result of the long history of pastoral operations on the site. However, a site contamination assessment did not identify any residual contamination within the Project footprint.

5.2.3.5 Environmental Values

The key environmental values are:

- The ability of undisturbed land systems to be self-supporting, sustainable and stable soil-vegetation systems
- The ability of the soils and landforms to provide a stable landform and infrastructure, both during construction and post-construction
- The in-situ topsoils as a resource for land stabilisation and rehabilitation
- Ability of the land to continue to support pastoral uses during operation of the Project
- Post-Project beneficial landuses, notably pastoral uses

5.2.3.6 Potential Risks and Impacts to Environmental Values

Based on the above, the key potential risks can be summarised as:

- Direct disturbance of soils and landscapes through earthworks and traffic
- Soil erosion from vegetation clearing and batter / channel works, and bare or imperfectly stabilised surfaces
- Disturbance and oxidation of acid sulfate soils
- Soil contamination from leaks and spills, treated effluent land application areas
- Soil structural decline from working and exposure of sodic sub-soils, treated effluent land application areas
- Salinization and sodification of soils subject to saline Project waters (ponds, farm channels)
- Revegetation problems with poor rainfall infiltration and soil structure for plant root growth

- Instability, settlement / consolidation, and poor trafficability from weak soils or unsuitable embankment, berm and supporting materials
- Deterioration of in-situ concrete structures and footings from aggressive soils
- Sterilisation of potential economic mineral resources.

Dust generation and management is further discussed in Section 5.2.12 (Air Quality). Design has been undertaken in regards to geotechnical constraints, and is detailed in the Draft EIS, Volume 1, Chapter 3 - Project Description.

5.2.4 Hydrology

5.2.4.1 Freshwaters and Floodplains

Freshwaters of Legume Station largely comprises freshwater creeks, Osmans Lake, ephemeral wetlands, spring-fed waterholes and man-made dams. The Forsyth and Alligator Creek catchments are the two major waterway catchments of the site. The floodplain hydrological conditions of both catchments have been substantially modified over time as part of the pastoral operations. Alligator Creek is bunded at several locations, and both Forsyth and Alligator Creeks are bunded such that there is no connectivity between the freshwater and estuarine reaches in the dry season. Since 2006, rainfall from the Forsyth Creek headwaters has been captured by Forsyth Creek Dam. The dam has altered the natural hydrology of the system, capturing wet season rainfall that would normally reach Forsyth Creek, and modifying dry season conditions through an annual release of water within both Forsyth and Alligator Creek catchments.

In the wet season, much of the lower plains (estuarine-deltaic plain and lower) are inundated, and as such the freshwater water bodies of the area are characteristically ephemeral, filling in the wet season and drying out in the dry season. While there are extensive floodplains in the wet season, in the dry season, surface water is confined to the bunded areas of Alligator Creek, small channels, billabongs and swamps. With the exception of the bunded areas of Alligator Creek, these water bodies gradually evaporate, becoming stagnant and commonly drying out. Storms in the early wet season result in turbid 'flushes' from surface run-off from the catchment, from stagnant pools in the riverbed, and from previously dried up water bodies. These flushes are further characterised by high concentrations of decayed organic matter, high bacterial pollution and low oxygen content, often resulting in a rapid deterioration of water quality and fish deaths.

A water quality sampling program was implemented between June 2015 and March 2016 to establish the baseline water quality across the site and to allow for future assessment of Project construction and operation on freshwater water quality. The results of the baseline sampling program showed water quality in the creeks on Legume Station was relatively poor and characterised by low dissolved oxygen (i.e. lower than the Australian Water Quality Guidelines), high turbidity and high nutrients in the dry and pre-wet seasons. In Forsyth Creek Dam water quality was poorest in the pre-wet season, with low dissolved oxygen and higher nutrients at this time. Water quality in the ephemeral wetlands was poor to moderate, and characterised by low dissolved oxygen and high turbidity, particularly in the remaining water in the dry season.

Direct impacts from the Project could include intersecting drainage lines and causing changes to flooding, flowpaths, flow velocities and volumes, and providing barriers to fish movement. These will generally be minor drainage lines, other than a crossing of Alligator Creek. However, all affected areas will be subject to culverts and floodways to mitigate any changes, and, with these in place, no significant changes are expected to floodplain hydrology.

The Project will also require that the Forsyth Creek Dam water be used solely to support farming operation. As such, the releases from Forsyth Dam that have occurred in the dry season for the past 10 years will to support

pastoral operations will no longer occur, leading to a return to more natural dry season conditions in catchments that have received this water in the dry season.

In regard to freshwater quality, given the existing poor water quality of Legume Station and the implementation of the mitigation measures outlined in this EMP, it is concluded that construction and operation of the Project will not further impact the freshwater water quality within the Project Area and its surrounds.

5.2.4.2 Estuarine and Marine Waters

The Project site is located in the lower part of Joseph Bonaparte Gulf, a relatively shallow marine area with a coastline dominated by sand banks, extensive mudflats, mangrove systems, tidal creeks and the estuaries of the Victoria River and Keep River systems. In the Joseph Bonaparte Gulf generally:

- Estuaries are well-mixed, macro-tidal (tides > 4m), with little or no vertical water column stratification
- There are extensive shifting unvegetated intertidal flats dominated by relatively fine sediment material
- The waterways typically experience high levels of bed and bank erosion due to strong tidal and wind generated currents
- Water is extremely and chronically turbid due to the large tides (~8 m) and periodic flow of sediment-laden water from the Victoria and Keep Rivers.
- While nutrient concentrations can be relatively high, the concentration of chlorophyll a (an indicator of phytoplankton biomass) and the phytoplankton count are relatively low.
- In the wet season, freshwater lenses may develop above the saline estuarine water, and variations between tidal cycles may be greatest, as there will be the greatest potential for interaction between fresh and tidal waters.
- Estuaries are typically lined with mangroves and extensive areas of hypersaline saltmarsh and saltflats. These flats tend to trap terrigenous sediment

The Project is intimately associated with the marine environment surrounding the site, with the inlet taking water from Forsyth Creek, treating it and using it in the farms, and discharging (again treated) water through the EPZ to Alligator Creek.

In general, Forsyth Creek has a meandering channel form, comprising a single main channel with smaller tidal creeks joining along its length. At the proposed intake location on Forsyth Creek, this changes to split into a series of channels forming a more braided morphology along this 3 km section. Upstream of the divided channels, the creek reverts to a single flow path, however the channel centreline follows a more meandering form than the downstream channel indicating lower current speeds are present.

The intake is to be located on the outside bend of the southern channel, which is significantly deeper than the central or northern channels and conveys the majority of the flood and ebb tide flows. Bank scour in this region has been estimated at around 15 m per year.

Alligator Creek is comprised of a series of sub-channels separated by braid bars, essentially low tide flats, which are flooded at high tide, and are highly dynamic with significant changes occurring over relatively short timeframes. The banks are typically sloping over much of the tidal range, transitioning abruptly to a near vertical bank at the channel margins.

In terms of hydrology, the volume of water extracted from Forsyth Creek and subsequently discharged to Alligator Creek represents a small percentage of the tidal prism. The extraction or discharge of water will be unlikely to impact water levels or current speed within the waterways.

The temperature of the discharge water may be elevated above the natural levels in Alligator Creek due to retention in the EPZ. As the volume of water compared to the tidal prism is minimal and as this discharge will be rapidly mixed into receiving waters, no adverse consequence of this temperature differential are expected.

5.2.4.3 Sediment Transport

The banks and beds around the project site are in a constant state of flux with channel migration and bank erosion observed at a number of locations. Accretion of the bank was also observed with juvenile mangroves extending seaward in places and thereby consolidating progressive bank migration. Tidal currents are the key driver of bed and bank erosion, although the macro tides result in the opportunity for wave erosion to occur across a large vertical profile of the bank.

Sediments in the region are typically a combination of muds, sands and gravels. Bed material at the site is a combination of very fine sands and muds. Banks around the site are the source of much of the mud material, with clay and silt banks in various states of erosion around the site. Tidal shoals within the waterways have a higher sand content than the banks as the larger and heavier particles of sand are more likely to settle than the fine clay and mud which remains in suspension, leading to the high turbidity found in the region.

5.2.4.4 Water Balance

A water balance was developed for the Project, described in the Draft EIS, Volume 1, Chapter 4. The water balance was undertaken to track water and salt balances within the Grow-out Centre, and to determine the amount of inflow, outflow and reliability of water supply.

The modelling found that, while water and salt flows vary throughout the year, and from year to year, a steady state system (for simplification) would require a water exchange of 1.4% of maximum dry season total system volume, which represents an average 575ML/day inflow of seawater from Forsyth Creek, and 410 ML/day discharge into Alligator Creek.

The 35GL Forsyth Creek Dam was found to be suitable to reliably supply freshwater to the Project, with a dry season inflow of ~35ML/day.

5.2.4.5 Environmental Values

The key values to be protected are:

- Marine, estuarine and freshwater aquatic and floodplain ecosystems
- Water supplies for future pastoral uses (general water uses, stock drinking water)
- Recreation and aesthetics, in relation to water quality and fisheries resources in areas adjacent to the site for public use
- Human consumers (primarily for fish species, crabs and other fauna)
- Cultural and spiritual values of marine and estuarine waters, fresh waters and floodplains, including ecosystems and biota
- Suitable freshwater supply to support the Project, primarily related to the Forsyth Dam supply.
- Suitable salt water supply to support the Project (primary industries, aquaculture), primarily related to the intake waters.

5.2.4.6 Potential Impacts to Environmental Values

The key potential risks can be summarised as:

- Physical changes to the tidal areas and hydrodynamics associated with the Forsyth Creek inlet
- The proposed wastewater discharge from the EPZ into Alligator Creek, in terms of the amount and rate of flow.
- Potential erosion and changes to coastal landform and bathymetry in the vicinity of the proposed intake and discharge points
- Direct impacts from the Project intersecting drainage lines and causing changes to flooding, flowpaths, flow velocities and volumes, and providing barriers to fish movement. These will generally be minor drainage lines, other than a crossing of Alligator Creek (though all affected areas will be subject to culverts and floodways to mitigate any changes)
- Potential loss of ephemeral wetlands. Impacts would be associated with removal of temporary habitats for aquatic biota, although this occurs during the dry season when these systems dry up
- Lack of releases from Forsyth Dam, leading to extension of dry season conditions in catchments that have had dry season flows each year since the dam's construction 10 years ago

5.2.5 Surface water and sediment quality

5.2.5.1 Freshwaters

Freshwater water bodies in the area are characteristically ephemeral, filling in the wet season and drying out in the dry season. While there are extensive floodplains in the wet season, in the dry season, surface water is confined to the bunded areas of Alligator Creek, small channels, billabongs and swamps. With the exception of the bunded areas of Alligator Creek, these water bodies gradually evaporate, becoming stagnant and commonly drying out. Storms in the early wet season result in turbid 'flushes' from surface run-off from the catchment, from stagnant pools in the riverbed, and from previously dried up water bodies. These flushes are further characterised by high concentrations of decayed organic matter, high bacterial pollution and low oxygen content, often resulting in a rapid deterioration of water quality and fish deaths.

The Keep and Victoria River catchments, immediately adjacent to Legume Station, are subject to high fluctuations in salinity, turbidity and nutrient concentrations between and within the seasonal changes of dry and wet seasons. Electrical conductivity and turbidity in the Victoria River catchment at times exceeds AWQG.

In the wet season, water from the catchment enters the estuarine receiving environment from high flows created by heavy rainfall. This catchment run-off transports freshwater, sediment loads and detritus that have built up during the dry season. Within the freshwater and sediments, nutrients are transported and deposited further downstream. Despite nutrient availability, high turbidity limits primary production.

Freshwaters are generally characterised by:

- low dissolved oxygen
- high chlorophyll a
- high concentrations of ammonia

Water quality was generally poorest in the pre-wet season, when dissolved oxygen was typically low, and chlorophyll a concentrations high. Total Petroleum Hydrocarbons were below criteria, but were detected at several freshwater sites during surveys.

5.2.5.2 Estuarine and Marine waters

Estuarine and marine environments were generally turbid, with high concentrations of total phosphorus and oxides of nitrogen. Forsyth Creek and Alligator Creek in particular have extremely high levels of turbidity and suspended solids at all times. In addition, turbidity increased with depth in the wet season in Forsyth Creek.

In the dry season, currents driven by stronger offshore winds suspend the sediment, increasing turbidity and limiting primary production even further.

The high phosphorous but low total nitrogen load is consistent with a system which has low existing inputs of nitrogen and considerable particulate phosphorus sources, likely to be bound to the sediment and as such, related to the high rates of sediment re-mobilisation occurring in the system due to the high tidal energy which dominates mixing and transport processes.

Sampling at different depths indicated that water quality was well mixed throughout the water column, with little variation between surface and deep water at any of the sites. Salinity was relatively stable at most sites, and but was lower in the wet and late wet season at sites in Forsyth Creek, as would be expected.

The concentration of potential toxicants was generally low, although there were some elevated levels of some total metals (dissolved metals were below the laboratory limit of reporting). However, the results indicated that Forsyth Creek can supply source waters to the operation without concern for metals or metalloids in the waters to be used in the farming process. Given that none of these substances will be present in the proposed discharge, it is also considered that Alligator Creek can receive wastewater flows with no associated environmental impact concerning metals and metalloids.

Sediments were dominated by silt / clay with sand, with nutrient levels consistent with other sites in the Keep River estuary, and metals and metalloids, and pesticides being generally low or below the laboratory limits of reporting. Hydrocarbons in the C15-C36 fraction were detected at most sites in June 2015; however, concentrations were mostly below laboratory limits of reporting in March 2016. While the C15 to C36 fractions include diesel, fuel oils and lubricating oils, they are also found in vegetation. Given the highly dynamic nature of these environments, and that none were not detectable in March 2016, the source of hydrocarbons in this survey were most likely natural.

5.2.5.3 Forsyth Creek Intake

The key potential impacts in this area would relate to construction phase works, however the construction methods used will avoid machinery contact with marine muds and clays, and given the short duration and small area of disturbance, overall impacts will be minimal. The intake bell-mouth at the inlet to the pump will be fitted with a 100 mm aperture mesh grille, to exclude all but small debris and aquatic fauna. This will be regularly cleaned of marine fouling by raising the pump assembly up and onto the jetty platform, so that personnel access can be afforded safely and the fouling wastes collected without any need for floating plant.

The intake pumps will terminate in the water at a level between Mean Low Water Neap and Mean Low Water Spring, and will only operate between mid to high tide daily. The operation of intake itself will have a negligible impact upon the local coastal morphological and sediment transport processes.

5.2.5.4 EPZ and Alligator Creek Discharge

The primary function of the EPZ is to regulate the flow of discharge water by reducing the velocity and holding the water so that discharge can be timed and discharged at a constant rate during ebb tides. The majority of the discharge will flow through a 100 m wide channel in the centre of the EPZ, but the EPZ is sized for 'overflow' of this channel, to enable it to hold the peak discharge and water from storm events, up to the 50

year ARI event. It is expected that this 'overflow' and the margins of the channel itself will be colonised by local samphire and/or mangrove species, which will assist in nutrient uptake.

Effluent from the farms will be discharged into the main drainage channel (MDC) before passing through the EPZ to the bank of Alligator Creek. Scour protection on the downstream side of the Alligator Creek weir will be provided by a rock blanket. An outflow weir (100 m wide and set back 30 m from the existing bank) will enable control of discharges.

The impacts on water quality from the proposed wastewater discharge from the project are primarily limited to the local waterway of Alligator Creek. Optimisation of the discharge flow regime has shown that timing discharges to the ebb tides can effectively mitigate impacts into these waters. There are unlikely to be any unacceptable changes to nutrient, chlorophyll a or suspended sediment concentrations within Alligator Creek as a whole and there will be no detectable changes in the Keep River or the waterways beyond.

Suspended sediments and turbidity is likely to be either the same, or even lower, than receiving waters, as such, no impacts in relation to sediment and turbidity as a result of the operation of the Project, are anticipated.

5.2.5.5 Environmental Values

The key values to be protected are:

- Marine, estuarine and freshwater aquatic and floodplain ecosystems
- Primary industries - water supplies for future pastoral uses (general water uses, stock drinking water)
- Recreation and aesthetics, in relation to water quality and fisheries resources in areas adjacent to the site for public use
- Human consumers (primarily for fish species, crabs and other fauna)
- Cultural and spiritual values of marine and estuarine waters, fresh waters and floodplains, including ecosystems and biota

5.2.5.6 Potential Impacts to Environmental Values

The key potential risks can be summarised as:

- Changes to estuarine water quality due to discharges into Alligator Creek, both planned and unplanned
- Runoff of sediment laden water during construction, from erosion and sediment loss from exposed surfaces
- Leaching of oxidising acid sulfate soils into freshwaters (unlikely to be large enough volumes even at worst to significantly affect estuarine and marine tidal areas)
- Leaks and spills into fresh, estuarine and marine waters

5.2.6 Groundwater

5.2.6.1 Hydrogeology

Legume Station is primarily located in the Bonaparte Gulf Basin groundwater aquifer, with the south eastern section of the property in the Victoria River Basin aquifer. Groundwater generally flows from the ranges towards the coast in sandstone, fractured rock and sand / colluvial deposits, with a corresponding but opposite flow of saline water from coasts back inland, each balanced by the relative hydraulic head. Local recharge

zones exist around low hills and rises on the plains, which become saline near the foot of these hills, after passing through saline deposits, or forcing saltier watertables to the surface.

Some deep aquifers are located across the site, with recharge from the sandstone and shale hills and rises, and subcrops, particularly on the Coastal Erosional Plain areas. A shallow saline watertable is located at ~3m depth in the dry season, and up to ground level in the wet season across the Estuarine-Deltaic and Coastal Plains, fed by tidal waters and surface rainfall.

Almost the entire Project area (with the exception of minor service corridor areas) is located in an area mapped as containing saline groundwater.

5.2.6.2 Groundwater Dependent Ecosystems

Soils on the coastal erosional plains are sandy and permeable, receiving large amounts of freshwater recharge during the annual wet season. The resulting high head of pressure keeps groundwater in the vicinity of these elevated landforms fresh, with freshwater fronts in similar systems in the Keep River plain area found up to one kilometre from the edge of these outcropping sandstone plains. However, these systems can (and generally do) abut the relatively impermeable black soils on the estuarine-deltaic plains. This higher groundwater head can force more saline waters to express at the foot of these hills, as the saline water table is elevated or fresh waters pass through more saline deposits.

As such, species regularly found in lower positions on the fringe of the coastal erosional plain (where it meets the estuarine-deltaic plain and where groundwater is known to move laterally towards the estuarine-deltaic plain) may have a facultative dependence on groundwater (i.e. they make use of, but do not rely upon, groundwater). Other areas where facultative dependence on groundwater may occur include perennial springs on the margins of the ranges and flood out plain, and fringing forest/woodland communities along creeks and downstream of Forsyth Dam. Given that the project will have very minor impacts upon groundwater, no impacts that will affect the ability of these communities to use of groundwater are expected.

A number of springs are also known to occur at the foot of the Legume ranges (for example, Alligator Springs, located in the upper Alligator Creek catchment), where recharge from fractured rock aquifers discharges into creeks. One such spring was observed outside Legume Station, approximately five kilometres south west of Linden's bore, where it waters a sometimes lush fringing open forest community.

5.2.6.3 Environmental Values

The key environmental values for groundwater are:

- the ability of groundwater resources as a water supply for pastoral operations, in the locations, depths and at the quality currently found at the site
- the ability of ecosystems dependent on groundwater to continue to be functionally and ecologically sustainable

5.2.6.4 Potential Impacts

Potential impacts to groundwater are expected to be minimal, but could include:

- Impacts to productive aquifers due to lowering of groundwater, where excavation in borrow pits or other excavations extends below groundwater levels
- Direct contamination of groundwaters, from general spills and leaks, and leakage of saline and nutrient rich waters from farm dams and other infrastructure
- Contamination of groundwater from wastewater irrigation areas

- Changes to hydrology, affecting recharge zones and therefore groundwater recharge
- Interactions with the shallow saline water table on the estuarine-deltaic and coastal plains, with impacts possible to Project infrastructure, and to shallow groundwater (refer contamination above).

5.2.7 Terrestrial Vegetation and Flora

5.2.7.1 Threatened Species and Ecological Communities

A search of the Commonwealth Protected Matters database did not predict the presence of any threatened ecological communities, and nor were any identified during field surveys. A search of the Commonwealth Protected Matters database and the online NT Maps database found three flora species of conservation significance predicted to occur on the site, all of which are listed as vulnerable:

- Craven's native hibiscus (Commonwealth and NT)
- *Platysace saxatilis* (NT)
- *Zeuxine oblonga* (NT)

However all three are considered unlikely to be on the Project site, due to their highly restricted and localised ranges and rarity, the lack of suitable habitat, and the fact that no individuals were found during field investigations.

In addition, two species listed as 'near threatened' under the TWPC Act were recorded in Legume Station during the surveys:

- Fine-leafed Kimberley fan palm (*Livistona lorophylla*)
- *Turraea pubescens*.

Both of these are near threatened due to the threat from inappropriate fire regimes, which may interfere with recruitment and kill adults if fires occur too often (more than every 5 years for *Livistona lorophylla*).

Livistona lorophylla was found to occur in the Legume Ranges and low ranges near the Marralam community. *Turraea pubescens* was recorded from a small residual on the estuarine-deltaic plain outside of the Project footprint where it was an uncommon element of the vine thicket community. Neither species will be directly affected by Project works. It is therefore the fire regime on the site that presents any risk of impacts to these species.

A further four species listed as 'data deficient' under the Territory Parks and Wildlife Conservation Act (TWPC Act) were recorded in Legume Station during the surveys:

- *Eleocharis acutangula* - a sedge recorded from Legume Station in Melaleuca low woodland on the flood-out plain, in the vicinity of the proposed Legume Access road
- *Ptilotus capitatus* - a woody herb recorded within Legume Station from Darwin stringybark/Darwin woollybutt woodland on the coastal erosional plain
- *Spermacoce gibba* - a herb found within Legume Station in Darwin stringybark/Darwin woollybutt open forest on the coastal erosional plain
- *Triodia triticoides* - a 'spinifex' hummock grass recorded from the ranges open woodland vegetation community on sandstone of the Legume formation, where it was moderately common

Species listed as data deficient are those whose conservation status cannot be accurately categorised from available information. All of the above species, other than *Tridonia triticoides*, were located in habitats that will be impacted by clearing for the Legume Access road. These species are relatively widespread in other Australian states, and *E. acutangula* is considered likely to be more widespread within the NT than current records indicate. None of these three data deficient species were widespread within Legume Station, all of them being represented by a few records each. Given all were recorded from habitats that are well represented within Legume Station and within the bioregion and NT generally, impacts on these species from clearing for the Project are expected to be minor.

5.2.7.2 Other species of note or indigenous cultural significance

One species identified in past surveys of the region was identified on the site as being rare, of conservation significance, or otherwise noteworthy - *Brachychiton tuberculatus*. This is a relatively common species on the coastal erosional plain within Legume Station, however, it has a restricted distribution primarily clustered on the lower Ord River valley.

Two other species of note were recorded on the site:

- Giant spear grass (*Heteropogon triticeus*) – a least concern species which is at its most westerly distribution in Legume Station, was recorded from ranges open woodland.
- *Acacia praelongata*, an NT endemic (also least concern), was recorded from two small populations on low residuals on the coastal erosional plain, approximately two kilometres north-west of Linden's bore. The distribution of this species is centred on Darwin and the Litchfield National Park with one previous record from the Victoria-Bonaparte bioregion.

As advised by the Northern Land Council, plant species identified as being used by the Jaminjung, Ngaliwuru and Nungali people are considered to constitute flora species of indigenous cultural significance. A total of 98 flora species of cultural significance to indigenous people in the region were recorded within Legume Station. Of these:

- 65 species are associated with food, including flora species closely associated with fauna utilised for food, and plants that indicate the changing of seasons or seasonal availability of resources
- 47 species have material cultural significance (e.g., as a source of glue/resin, fibre, soap, insect repellent etc.)
- 42 species are utilised for weapons or have a technological use, including musical instruments, pipes, fish poison, shields, spears etc.
- 21 are utilised as source of medicine.

5.2.7.3 Local Vegetation Communities

Clearing of less than 5% of a vegetation communities extent at the local scale is considered to have a minor to negligible impact on that community overall. Only three of the 16 vegetation communities mapped within the Project footprint will require clearing of more than 5 % of the extent at the local scale (i.e. within Legume Station):

- Wild plum low open woodland (9%)
- Northern rice grass (*Xerochloa imberbis*) grassland (8%) and
- Canegrass (*Ophiuros exaltatus*) grassland (6%).

Wild plum low open woodland is primarily located on the estuarine-deltaic plain in one large patch dominated by one species, wild plum, and is unique within the Project area, and may be a rarely occurring community. However it is not protected, and does not contain threatened species or their habitats, or any species that are otherwise noteworthy. Other wild plum areas exist on the site, though lacking the large mature trees.

The clearing of northern rice grass and canegrass grasslands for the Project will have a minor impact on vegetation community diversity at the local level, as large areas of this community will still be retained (92% of rice grass and 94% of canegrass grasslands in the Project area, assuring they will still be well represented at the local scale).

5.2.7.4 Vegetation Loss at the Bioregional and NT scale

Two vegetation units are impacted by the Project where clearing will comprise >1% of the total unit/class area in the bioregion, namely:

- Xerochloa (ricegrass) grassland (unit 104) – clearing will remove 2,920 ha, which equates to 4% of its bioregional extent and 3% of its NT-wide extent, and
- Mixed closed-grassland/sedgeland (seasonal floodplain) (unit 54) – clearing will remove 186 ha, which equates to 4% of its bioregional occurrence and 0.02% of its NT-wide extent.

For the purpose of assessing impact for the Project, clearing impacts of one percent or less at a bioregional and NT-wide scale have been assessed as negligible.

As such, the impact of the proposed clearing of northern rice grass grassland at a bioregional and NT-wide scale will be minor, since ~96% of the total extent at the bioregional level and ~97% at the NT level will remain, ensuring it continues to maintain its representation at these scales. Similarly, the retention of 96% of the bioregional extent and over 99% of the NT-wide extent of mixed closed-grassland/sedgeland indicates that clearing impacts on this vegetation unit will be minor at the bioregional scale and negligible at the NT-wide scale.

5.2.7.5 Environmental values

Given that threatened ecological communities and Protected Plants have not been found, and are unlikely to be present, the key environmental values in relation to terrestrial flora are therefore:

- Vegetation community diversity, at a local, bioregional or NT-wide scale
- Flora species diversity, primarily at a local scale
- Habitat for flora and fauna
- Land / soil stability (potentially degraded after clearing).

5.2.7.6 Potential Impacts

The key potential impacts are:

- Reductions in vegetation community and flora species diversity, at a local, bioregional or NT-wide scale, through additional or unintentional clearing or damage to flora outside clearing limits
- Loss of habitat for flora and fauna (impacts to fauna are discussed in Section 5.2.8)
- Land degradation from acid sulfate soils, upslope land clearing or runoff leading to vegetation die-back
- Decreased volume of surface water released from the dam in the late dry season which may affect floodplain vegetation communities

- Impacts to groundwater dependent flora and communities (though this is considered unlikely without changes to groundwater hydrology, also considered unlikely)
- Removal of woody or deep rooted vegetation resulting in the rising of the water table, and surface soil salinity, although again impacts from this source are considered unlikely.
- Dust deposition on vegetation and communities (considered minor given existing dust impacts at the site)
- risks to near threatened species under NT legislation (Fine-leaved Kimberley fan palm (*Livistona lorophylla*) and *Turraea pubescens*) from changes to fire regimes that do not take into account the needs of these species
- impacts to data deficient species, which due to this factor the local and bioregional impacts are not well defined
- Introduced flora and weeds from vehicles, machinery, personnel, resulting in a negative change to community diversity

5.2.8 Terrestrial Fauna and Avifauna

5.2.8.1 Legume Coastal Floodplain Site of Conservation Significance

The Legume coastal floodplain has been identified by the Northern Territory Government as a site of conservation significance because it supports internationally and nationally significant numbers of some waterbird species and exceeds internationally significant thresholds for some shorebird species. This was confirmed based on dry and wet season surveys for the Project.

An extensive terrestrial fauna and avifauna field survey program was implemented over a 12 month period between May 2015 and May 2016. The survey program involved more than 130 survey person days and was implemented by a team of eight highly experienced biologists. The surveys focussed on waterbirds and shorebirds of both estuarine and freshwater habitats, and on the identification of records and habitat for listed threatened and migratory species under the EPBC Act and the TPWC Act. Understanding how waterbird usage changes over time, in response to changes in freshwater resources, was a particular focus of the survey effort.

The results of the assessment concluded that the construction and operation of the Project, when undertaken in accordance with the mitigation measures outlined in the EIS, will not result in a significant impact to nationally important aggregations of waterbirds, or other listed threatened and migratory species under the EPBC Act and TPWC Act.

5.2.8.2 Waterbirds and shorebirds

The surveys identified a variety of habitats across of the site of importance to waterbirds. Osmans Lake and the lower parts of Alligator Creek were found to support the highest values for waterbirds during the dry season and transition periods. In the wet season, consistent with much of northern Australia, wetland habitat was widespread and the coastal plain supported a range of wetland types, water depths and vegetation characteristics. The estuarine wetlands (Alligator Creek, Bob's Creek and Forsyth Creek) were found to not support a high species richness or abundance of waterbirds and there were no significant or notable congregations of birds (at roost) at these locations. Turtle Point was found to support nationally important habitat for migratory shorebirds, and in comparison to the other estuarine sites on Legume Station, provides important habitat for a variety of migratory shorebird species.

Freshwater wetland species considered to be present in significant numbers were magpie goose, plumed whistling-duck, radjah shelduck, green pygmy-goose, wandering whistling-duck, pied heron, marsh sandpiper, red-necked stint, sharp-tailed sandpiper, curlew sandpiper, little curlew, black-tailed godwit and common

greenshank. Estuarine wetland species considered to be present in significant numbers at Turtle Point only were the greater sand plover, lesser sand plover, black-tailed godwit, bar-tailed godwit, whimbrel, eastern curlew, terek sandpiper, grey-tailed tattler, ruddy turnstone, red-necked stint and curlew sandpiper. Importantly, the survey results showed that the lowest density of waterbirds, and lowest waterbird species richness, was generally associated with the northern-most survey transects, where the majority of clearing is proposed to occur for the construction of the farms.

5.2.8.3 Non-waterbird species

The surveys identified 10 threatened species listed under the EPBC Act and/or the TPWC Act that are known to occur on the site (bare-rumped sheath-tailed bat, lesser sand plover, greater sand plover, bar-tailed godwit, eastern curlew, great knot, red knot, curlew sandpiper, Gouldian finch and grey falcon), one that is likely to occur (Australian painted snipe), six that may possibly occur (northern quoll, Mertens' water monitor, Mitchell's water monitor, yellow-spotted monitor, red goshawk and water mouse), three that are unlikely to occur (pale field-rat, vrd blacksoil ctenotus and masked owl (nth)) and six that are highly unlikely to occur (partridge pigeon, purple-crowned fairy-wren (western), brush-tailed rabbit-rat, plains death adder, northern crested shrike-tit and night parrot). Field surveys also identified 40 listed migratory species under the EPBC Act that are known to occur on site and one that is considered likely to occur.

5.2.8.4 Environmental Values

The Environmental Values for the site can be summarised as:

- Vegetation community diversity, at a local, bioregional or NT-wide scale
- Flora and fauna species diversity, particularly threatened or near threatened species.
- Important wetland habitat, particularly associated with the Alligator Creek wetlands and Osman's Lake wetlands (though the latter will not be affected by the Project)
- Nationally and internationally significant, listed threatened and near threatened, and listed migratory species.

5.2.8.5 Potential Impacts

The potential impacts of the Project in regard to impacts to nationally important aggregations of waterbirds, and listed threatened and migratory species were identified, these were:

- vegetation clearance leading to habitat loss or mortality
- changes in floodplain hydrology leading to changes in wetland fauna habitat characteristics
- changes in receiving environment water quality, due to increases in nutrient content and total suspended solids, leading to changes in estuarine shorebird habitat
- disturbance associated with noise and visual stimulation
- disturbance due to bird predation management strategies
- degradation of habitat value or mortality due to introduced species

5.2.9 Introduced and Pest Species

5.2.9.1 Weeds

One Class A declared weed was detected in Legume Station – gamba grass (*Andropogon gayanus*). Two individuals of this species were found in one location, in a fenced enclosure for a pump at the Linden's bore

yards. It is not accessible to stock and it does not appear to be spreading. Two other Class A weeds have been identified as potentially occurring on the site, though neither were recorded during the field survey, namely:

- chinee apple (*Ziziphus mauritiana*),
- and Mimosa (*Mimosa pigra*).

The following plants designated as Class B weeds under the Northern Territory Weeds Management Act 2001 were observed during the vegetation and flora surveys:

- Neem (*Azadirachta indica*)
- Caltrope
- Flannel weed (*Sida cordifolia*)
- Olive hymenachne
- Hyptis
- Parkinsonia
- Sicklepod
- Spinyhead sida

Caltropis procera is also common but it is only declared in Northern Territory where it occurs south of 16°30' S (Legume is 15°23' S).

In the Northern Territory, all Class A and B weeds are also Class C weeds. No additional Class C weeds were observed.

The majority of these weeds are spread primarily by grazing animals. The proliferation of these weeds is then encouraged by the preferential grazing of palatable species, which reduces competition for the non-palatable weed and allows it to proliferate. The two exceptions are neem, whose seeds are spread by birds and bats, and olive hymenachne, which is spread by water and animals.

Of those weeds found in Legume Station, the species of most concern from an ecological viewpoint (in terms of damage being done currently) are parkinsonia and hyptis. Parkinsonia is prevalent in patches on the estuarine-deltaic plain within the grassland mosaic, and unless actively managed in future it could continue to spread, with the potential to significantly change the structure of the grasslands. Hyptis is a particular issue in sclerophyll woodland, where it is generally found in the more accessible areas near dams, stock yards, and roads. Here, it often dominates the ground layer, partially or completely replacing native grasses and herbaceous species. Hyptis has no grazing value and so as grazing continues and palatable species are suppressed, hyptis increases.

5.2.9.2 Pest and Introduced Species

Grazing of the wetlands and floodplains of Legume Station by cattle has also been undertaken for many decades. Of the other species, the fauna survey program provided evidence of five pest animals:

- cane toad (*Rhinella marina*) - this represents arguably the greatest potential threat, however it appears to be well established, at least in parts of the site. Anecdotal observations indicate that toads are of lower abundance (and in parts, absent) in the woodlands within the southern part of the site
- feral pig (*Sus scrofa*) - uncommon to rare on the site

- feral cat (*Felis catus*) - present but apparently not prevalent
- feral dog (*Canis familiaris*) - present but apparently not prevalent
- house mouse (*Mus musculus*) - may be uncommon on the site, although an ongoing baiting program is in place at the homestead complex for mouse control.
- In addition, three native species considered to be pests are present on the Project site - agile wallaby (*Macropus agilis*), red-tailed black-cockatoo (*Calyptorhynchus banksii macrorhynchus*), and sulphur-crested cockatoo (*Cacatua galerita*).

Pest animal species are not expected to gain a significant benefit from either the construction or operational phase of the development.

5.2.9.3 Environmental Values

The key environmental values relate to those of the existing ecosystems, primarily terrestrial ecosystems, namely:

- Vegetation community diversity, at a local, bioregional or NT-wide scale
- Flora species diversity, primarily at a local scale

5.2.9.4 Potential Impacts

The potential impacts of introduced and pest species include:

- Weed spread may result in reduction in the quality of residual grazing land, and consequent economic consequence to current, and potential future grazing potential on the site
- Weeds, introduced and pest species (flora and fauna) may cause changes in natural systems diversity and community structure. Introduced flora may potentially out compete species and communities, and introduced fauna may outcompete and over predate on native fauna (particularly protected or important)

5.2.10 Aquatic Ecosystems

5.2.10.1 Estuarine and Marine Ecology

There are extensive areas of mangroves and saltmarsh/saltflats in the surrounding estuaries, which provide habitat for a variety of both avian and aquatic species, including species that are commercially and recreationally important, species that are of conservation significance, and species of cultural significance.

In the wet season, water from the catchment is flushed into the estuarine receiving environment from high flows created by heavy rainfall. This catchment run-off transports freshwater, sediment loads and detritus that have built up during the dry season. Within the freshwater and sediments, nutrients are transported and deposited further downstream. Despite nutrient availability, high turbidity limits primary production.

In the dry season, currents driven by stronger offshore winds suspend the sediment, increasing turbidity and limiting primary production even further.

Desktop investigations and field sampling found that:

- There are no seagrass or large macroalgal beds in the surrounding estuaries, likely due to the chronic turbidity and extreme tidal range.
- Coral has not been recorded in the vicinity and primary productivity of phytoplankton is limited, both due to the high turbidity.

- Benthic macroinvertebrate communities have relatively low abundance and diversity, and are dominated by polychaetes and crustaceans, with few filter feeders. These communities are limited by high turbidity, high sediment mobility, and long exposure periods
- *Avicennia marina* var. *eucalyptifolia* was the dominant mangrove species at most survey sites and was present at all sites, and mangrove communities were found to be in good health, indicating unimpacted communities
- Several commercial and recreational fisheries operate in the region, targeting prawns, mud crabs, barramundi, threadfin salmon and a variety of other estuarine and pelagic species. Seafood from the Territory is marketed as being from a pristine environment, and from heavily regulated fisheries.
- There are 15 aquatic species listed as threatened under the EPBC Act and/or the TPWC Act in the region. Of these, nine - northern river shark, spear-tooth shark, dwarf sawfish, green sawfish, freshwater sawfish, green turtle, hawksbill turtle, olive ridley turtle and flatback turtle were considered to have high or moderate likelihood of occurring in the estuarine environment surrounding the Project.
- The desktop assessment identified 18 aquatic species listed as migratory under the EPBC Act within the region. Of these, eight - green turtle, hawksbill turtle, olive ridley turtle, flatback turtle, estuarine crocodile, dugong, Australian snubfin dolphin and Australian humpback dolphin were considered to have high or moderate likelihood of occurring in the estuarine environment surrounding the Project.

The key risks to these species are related to entrainment or impingement in the intake structure, water quality changes due to site discharges, particularly the main controlled releases from the EPZ, escape of prawns and prawn diseases into wild stocks, noise and light impacts, and boat impacts. However, the results of the impact assessment found that these risks are unlikely to cause a significant impact to any threatened or migratory species.

5.2.10.2 Freshwater Ecosystems

The freshwater aquatic habitats of Legume Station include freshwater creeks, Osmans Lake, ephemeral wetlands, spring-fed waterholes and man-made dams. Forsyth Creek and Alligator Creek catchments are the two major waterway catchments of the site, and both have been substantially modified over time as part of the pastoral operations. This appears to have resulted in the aquatic habitat of these systems being generally low to moderate.

Osmans Lake is the largest natural wetland feature on Legume Station, with the riparian vegetation highly disturbed due to grazing. However, the Project will not result in any direct or indirect impacts on Osmans Lake given it is outside of any impacted catchments. The aquatic habitat value of ephemeral wetlands was found to be of low value, limited in structure to aquatic plants and detritus. Waterholes and springs provide some refuge areas for fauna in an otherwise seasonally dry environment. Aquatic habitat within Forsyth Creek Dam was minimal and limited to aquatic plants, detritus and rock faces, with some trailing root vegetation depending on water levels.

Water quality in the creeks on Legume Station was relatively poor and characterised by low dissolved oxygen, high turbidity and high nutrients in the dry and pre-wet seasons. Cattle on the property contribute to poorer water quality through the input of excess nutrients and disturbing the in-stream bed sediments. Sediments were predominantly fine, and the concentration of most metals and metalloids were low. The abundance and diversity of freshwater macroinvertebrate communities across sampled sites were relatively low, and typical of disturbed ephemeral waterbodies with relatively fine sediment. There is little structure, such as in-stream or riparian vegetation, to provide varied habitat for macroinvertebrates.

All aquatic flora species recorded on the site are commonly occurring aquatic plants, many of which are typical of disturbed ecosystems (e.g. cumbungi and azolla). No listed threatened species or declared pest aquatic plants species were recorded during field surveys, nor are any expected to occur.

The fish communities in the water bodies on Legume Station are likely to have been impacted both by the installation of roads, bunds and artificial dams that prohibit fish passage and by clearing and cattle grazing. The removal of trailing roots, overhanging vegetation, shading of the waterways and the lack of large woody debris has reduced habitat availability. Despite these conditions, there are considered likely to be diverse fish communities in the water bodies on the station, and water bodies such as Alligator Creek, Forsyth Creek Dam and Osmans Lake are likely to provide refugial habitat in the dry season for a variety of species. No threatened fish species were recorded during field surveys. All species recorded are relatively common in northern Australia and appeared to be healthy, with no lesions, abrasions or parasites.

To date, there have been no records of any freshwater turtle species on Legume Station; however, surveys in the area are likely to be minimal. No freshwater turtles were caught or observed on Legume Station during the field surveys for the Project. While turtles, and in particular the northern long necked turtle, are likely to occur on site, water bodies on Legume Station are unlikely to provide substantial significant habitat. In-stream habitat (i.e. woody debris and trailing tree roots) is limited and would provide little protection from predators (i.e. crocodiles) and potential breeding areas are likely to be disturbed by cattle.

Freshwater and estuarine crocodiles are known to occur on Legume Station, they are considered common and locally abundant, and have been recorded throughout the Victoria and Keep River catchments, and are unlikely to be significantly impacted by the Project.

Finally, no threatened aquatic flora species, ecological communities or aquatic fauna species, listed under the EPBC Act or TPWC Act, are present within the Project Area and therefore will not be impacted by the Project.

5.2.10.3 Environmental Values

in relation to estuarine, marine and freshwater aquatic ecosystems, the primary environmental value is the protection of these aquatic Ecosystems. This includes protection and maintenance of:

- community and species diversity
- threatened and near threatened species, and
- aquatic habitat.

5.2.10.4 Potential Impacts

The potential impacts to estuarine and marine ecologies have been identified as:

- Direct disturbance of habitat for aquatic flora and fauna from vegetation clearing and earthworks
- Changes to floodplain hydrology as a result of changes to the terrain and blocking of flood waters (although these will be engineered away), and the cessation of dry season flows from Forsyth Creek
- The creation of waterway barriers in freshwater waterways
- Entrainment or impingement of aquatic fauna at the seawater intake pump station on Forsyth Creek.
- Changes in water quality resulting from:
 - vegetation clearing and earthworks
 - discharge of waste water from the grow-out facility

-  Spills of hydrocarbons or other contaminants, including oxygen reducing substances (such as cement) and treated or untreated effluent wastewater directly to waterways
-  Proliferation of pest plants, more so to freshwaters
-  Escape of prawn stock and/or diseases and pathogens from the grow-out facility.
-  Disturbance, including physical presence, noise and/or impacts to food chain for estuarine crocodiles
-  Increased risk of boat strike, and interruption of movement, for turtles and other large slow moving surface marine creatures, although boat movements are expected to be minimal, particularly for fast moving vessels – limited primarily to environmental monitoring work
-  Increase in plastic litter and debris resulting in ingestion and entanglement.
-  Loss of access to fishing grounds and/or loss of species of significance to indigenous communities
-  Increased site access, increasing habitat disturbance and direct take of aquatic fauna (primarily fish).

5.2.11 Waste Management

5.2.11.1 Existing Site Waste

Past activities on the site include an operating landfill near the Legume homestead, cattle yards and one known cattle dip, all located outside of the Project footprint. Waste infrastructure on the site is limited to the existing landfill, off-site removal of other wastes, and the potential for unexpected findings of residual waste materials during construction, as a result of the long history of pastoral operations on the site.

5.2.11.2 Waste Characterisation

The project will produce a number of different solid and liquid wastes during both construction and operations. The key waste types and the potential quantities have been identified and a management strategy to deal with them has been devised (refer Appendix C9).

5.2.11.3 Waste Management Strategy

Waste Minimisation

The overarching strategy to be implemented on the site is one of minimisation, in the following order of preference (with those listed first preferred over each of the following practices): avoid, reduce, reuse, recycle, recover, dispose. The following sections describe how this strategy will be implemented

Waste Infrastructure

A site wide integrated waste management system will be developed on the site, with the key elements to be initiated as soon as practicable during construction. Until all elements are installed and operational, construction waste will be dealt with by nominated waste storage locations on-site, prior to removal off-site to licensed landfills or recycling / reprocessing facilities.

The overall waste strategy involves the following key infrastructure:

-  Transfer of general, recyclable and other non-listed and non-hazardous wastes to a Waste Transfer Facility at the Accommodation Village, or temporary storage at farm services and Central Facilities prior to transfer to this Waste Transfer Facility

- Transfer of listed and hazardous wastes to a Hazardous Waste Facility located at the Central Facilities, before removal off-site by licenced transporters to licenced facilities for reuse, recycling, recovery or disposal
- Drainage of washwaters and rainfall from putrescible bin storage areas into the wastewater treatment plants, via appropriate trash rack screens and sumps in the floor of these areas
- Disposal of general and inert waste at an on-site landfill.

Solid Waste Management

Solid wastes will be managed as part of the waste infrastructure described above, and management will include the identification of waste types, quantification of waste tonnage and volumes, and both on and off-site measures for recycling, recovery or disposal.

Wastewater Management

Wastewater on the site will comprise:

- Non-sewage wastewater:
 - Waste oils and oil/fuel contaminated water from oil-water separators, from refuelling areas, workshops and vehicle wash down
 - Waste liquid chemicals or water/chemical mixes, from laboratories, workshops and vehicle wash down
- Sewage wastewater: from the Accommodation Village, Central Facilities and farm services.

Sewage wastewater will be treated in package wastewater treatment plants on-site, and irrigated in designed land irrigation areas. Non-sewage wastewater will be either treated in the on-site wastewater treatment plants, or removed to the hazardous waste facility for later removal from the site.

5.2.11.4 Environmental Values

The environmental values in relation to waste are:

- The quality of air, land and water environments
- The quality and aesthetic value of the environment, including social and culturally significant sites and landscapes.

5.2.11.5 Potential Impacts

The potential impacts of inappropriate waste management can range from nuisance impacts from noise, odour and dust, through to land and water contamination, attraction and breeding of pests, and human health impacts due to landfill gas asphyxiation or explosion.

Inappropriate handling and storage of waste can result in a range of impacts, including:

- Release of dust and odour, causing nuisance impacts to nearby sensitive receptors, primarily the construction camp and work areas
- Breeding of vermin, with impacts to the natural environment, and nuisance impacts to site workers (flies, rats)

- Contamination of groundwater from inappropriately stored or disposed waste, particularly putrescible and/or chemical (oil, fuel, other chemicals) waste.

5.2.12 Air Quality

Air quality in the Project Area is strongly influenced by the predominating wet and dry seasons. The dry season is characterised by moderate temperatures, low humidity and dry conditions, with strong winds from the east and south-east. Conversely, the wet season is characterised by high temperatures and humidity, with predominant winds coming from the north and north-west. Tropical cyclones, thunderstorms and monsoon rains are common during the wet season.

Based on the available air quality data for a representative site near Darwin (the closest such site), in general air quality can be said to be excellent in the wet season and poor during the dry season. The Northern Territory Ambient Air Quality Monitoring Report produced by the NT EPA states that the primary air pollutant in the Darwin region are particulates generated by bushfires and fuel reduction burns. It is expected that this would also be the case in Project Area due to the large areas of vegetation surrounding the site.

Other existing sources of air pollutants which may potentially affect the air quality of the Project Area include:

- sea-salt as an aerosol from the surrounding coastal environment
- dust from land clearing activities.

The primary emissions generated during the construction of the Project will be dust, through mechanical disturbance from vehicles and equipment, and wind erosion of exposed, disturbed soil surfaces.

Emissions from the operation of the Project will result primarily from the operation of the power station located at the central facilities. The power station will consist of 12 CAT3516C diesel generators, operating concurrently. The capacity of thermal engines is expected to be 17.5 megawatts (MW).

5.2.12.1 Sewage Treatment Plant Odour

Odorous emissions could also occur from sewage treatment plants, though generally only when the plants are not operating efficiently, as long as a suitable off-set distance is applied. The Recommended Separation Distances for Industrial Residual Air Emissions (EPA Victoria, 2013) recommends a separation distance based on the equivalent population, with results shown in Table 1, for 'mechanical/biological wastewater treatment plants'.

TABLE 1 RECOMMENDED PRELIMINARY SEPARATION DISTANCES - SEWAGE TREATMENT PLANTS

Location	Flow (L/day)	EP	Separation Distance (m)
Accommodation Village	122 kL/day	610	~100
Central Facilities	Average 2.5 kL/day	12.5	~30
Farm Services	Average 3.6kL/day	18	~30

These offset distances will be applied, unless more detailed analysis shows a lower distance can be managed without impacts.

5.2.12.2 Environmental Values

As the Project Area is remote, the only potentially sensitive receptors in relation to air quality are the Legume Station homestead and the proposed accommodation village. The Legume Station homestead is located over

15 km from the grow-out centre. The accommodation village which will be constructed as part of the Project will be located approximately 18 km from the grow-out centre.

5.2.12.3 Potential Impacts to Environmental Values

The only potential impacts on air quality are from dust emissions, most notably PM10 during construction and emissions from the power station during the operation of the Project, and odour emissions from the pond waste stockpiles and wastewater treatment plants during operation.

As Legume Station is remote, the only potentially sensitive receptors to these emissions are the Legume Station homestead and the proposed accommodation village. Given the distance between the Project and the Legume Station Homestead and the proposed accommodation village there will be no impact on air quality or odour at either of these potentially sensitive receptors.

5.2.13 Climate Change Assessment

The assessment of climate change impacts to the Project involved:

- The calculation of GHG emissions for the Project based on the methodology outlined in the National Greenhouse Accounts Factors
- a desktop review of relevant literature on potential climate change impacts to the Project
- the development of numerical models including hydrodynamic, wave and transport models to enable the simulation of the tides, waves, and extreme events on physical processes.

5.2.13.1 Potential Impacts

GHG emissions

- The Project's estimated average annual GHG emissions (72,075 t CO₂-e) equate to approximately 0.01% and 0.58% of total 2014 emissions for Australia and the Northern Territory, respectively. The annual emissions exceed the 25 kt threshold listed in the Commonwealth National Greenhouse and Energy Reporting Act 2007 (NGER) Act.

Climate Change Assessment

The key threats to the Project from climate change are sea level rise and increases in tropical cyclone intensity and frequency. These climate change impacts are likely to result in:

- shoreline recession
- increase in storm tide elevations
- higher maximum wind speeds generating larger waves and associated wave set-up on the coastline
- higher maximum wind speeds and lower central pressures generating larger storm surges.

The Project components at risk from climate change impacts include the intake and discharge infrastructure and the land based facilities situated on the estuarine-deltaic plain (i.e. the farms and channels).

5.2.14 Noise and Vibration

Noise levels at the Legume Station homestead were found to be typical of a rural environment with negligible levels of transport noise, but higher background noise levels recorded during the day and evening periods. The noise levels at the proposed grow-out farms were representative of an extremely quiet area with little or no artificial sources of noise, but higher background noise levels during the evening period attributed to insect noise.

Areas close to station access tracks currently experience higher levels of noise due to vehicle traffic than at the proposed grow-out farms.

5.2.14.1 Environmental Values

As the Project Area is remote, the only potentially sensitive receptors in relation to air quality are the Legume Station homestead and the proposed accommodation village. The Legume Station homestead is located over 15 km from the grow-out centre. The accommodation village which will be constructed as part of the Project will be located approximately 18 km from the grow-out centre.

5.2.14.2 Potential Impacts

As Legume Station is remote, the only potentially sensitive receptors to noise generated by the construction and operation of the Project are the Legume Station homestead and the proposed accommodation village.

Based on the results of the modelling, noise levels at the Legume Station homestead will be well below the noise criteria during both the construction and operational phases of the Project.

Construction noise criteria will be exceeded at the accommodation village during the construction of the accommodation camp itself and nearby infrastructure (i.e. roads and the central facilities area). As the majority of the inhabitants of the accommodation village will be part of the construction workforce, any noise impacts will be expected by those affected and will occur during working hours. Noise levels at the accommodation village during operations will be well below the operational noise criteria.

5.3 SOCIO-ECONOMIC CONTEXT

5.3.1 Socio-economic

The project area is remote with the nearest population centre being the town of Kununurra in Western Australia, approximately 106 km to the south-west. The closest population centre to the project in the Northern Territory is Timber Creek, approximately 135 km to the south-east.

The town of Kununurra is located in the Shire of Wyndham – East Kimberly and is the major commercial centre for the region. The town was created in the early 1960s to service the development of the Ord River Irrigation Scheme and has experienced steady population growth since its establishment.

The Shire of Wyndham – East Kimberly has an estimated permanent population of approximately 8,500 people. The majority of the population is based in the towns of Kununurra and Wyndham with the remaining inhabitants scattered through several Aboriginal communities, pastoral stations and mining camps. The population of the shire can increase by over 25% with the arrival of tourists during the dry season.

Aboriginal people comprise of about 35% of the total population of the area. The traditional owners of the project area have been identified and consultation is underway to ensure the traditional uses and activities of the area are taken into consideration.

Dominant industries in the region are agriculture including pastoral industries and irrigated agricultural operations, mining, tourism and fishing. The labour force participation rate in the region is 67%, which is similar to Australia as a whole (65%). Unemployment however is much higher within the Aboriginal population (8%) than non-Aboriginal people (4%).

The Project will create significant local employment with over 100 staff and contractors employed at Legume and additional workforce required in the vicinity of Kununurra during Stage 1. The intention is to maximise local and indigenous employment within the Project.

5.3.1.1 Social and Community values

Social and Community values relevant to the Project include:

- Indigenous employment and business opportunities within the region
- Local employment and business opportunities within the region
- Recreational fishing and tourism and
- Community safety.

5.3.1.2 Potential Impacts

During construction, potential negative social impacts may arise, including:

- Negative community relations, due to insufficient communication and community involvement on the progress of the Project
- Failure to meet Indigenous and general local community employment and business expectations
- Restriction of community access to fishing, camping and other recreational and tourism activities
- Damage to locally significant areas, particularly in relation to fishing areas, and other areas that have been commonly accessed or can be seen by the public
- Inadequate attention to community safety, particularly in relation to product transport on public roads.

5.3.2 Historic and Cultural Heritage

No non- indigenous heritage sites are listed on the Commonwealth Heritage Database or on the NT Heritage Register as occurring on Legume. However, a number of sacred sites protected under the Aboriginal Sacred Sites Act (NT) have been registered and recorded on Legume. The NT archaeological database also lists ten Aboriginal archaeological sites and artefacts on Legume, though these were identified as a result of two surveys only in the south-west corner of the property. Large areas of Legume have not been subjected to archaeological survey and as such the NT archaeological database may not record all Aboriginal sites and artefacts present in the area.

Some of the project infrastructure including roads, quarries and accommodation village will be situated on the Cockatoo land system, which has a very high likelihood of archaeological sites. These are most likely to be located on sandstone outcrops and may include rock art and artefact scatters.

However, the majority of the project footprint is located on the Legume and Carpentaria land systems, comprised of tidal mudflats and seasonally inundated coastal floodplains with poorly drained clayey soils. These land systems are considered unlikely to host Aboriginal archaeological sites, although shell middens and mounds are possible around the margins of these areas.

The area of proposed works on Legume Station has also had Native Title Determination, and the Project is seeking to discuss and negotiate an Indigenous Land Use Agreement (ILUA) with Traditional Owners, gain their support for the Project and establish and maintain a sustainable legacy benefit to them. Discussions with the broader indigenous community are planned and such discussions will encompass opportunities the Project may bring. The Project has also submitted applications to the Aboriginal Areas Protection Authority and will seek further advice and will consult with custodians to determine any further constraints that may apply to the proposed project areas. The applications for clearance cover all proposed ground disturbing works, including those incorporated in the environmental baseline work and any temporary works needed in the Feasibility Study.

More broadly, the site selection for the Project has taken into consideration potential impacts to these sites, and the majority of the Project has been located on land which has low archaeological potential and impacts on known heritage sites will be avoided and/or minimised where possible. Additionally, consultation will continue to be undertaken with the Traditional Aboriginal Owners to ensure any impacts to cultural heritage from the development of the project are avoided and/or minimised.

5.3.2.1 Cultural values

The Cultural heritage values requiring protection as part of the Project works include:

- Indigenous objects, sites or places of cultural heritage value, including important songlines
- Non-indigenous historically important sites and objects that may be discovered during site investigations or construction
- Land access by local indigenous people for fishing, hunting and for cultural reasons.

5.3.2.2 Potential Impacts

The potential impacts to cultural heritage values mainly occur due to the removal and/or damage of cultural items or sites, associated with ground disturbing activities conducted during the construction phase. This may occur to known objects or sites, or to chance finds discovered during construction works.

Construction (and operation) also has the potential to limit important site access by Traditional Owner / local indigenous persons, particularly for fishing and hunting activities, or accessing culturally important sites. The degree of impact in this regard (as well as mitigation) will depend on ongoing discussions and negotiations with local indigenous people.

5.3.3 Traffic and Transport

The Project is located approximately 100 km north of Kununurra. Road access is via a single route made up of the Legume Access Road, Cave Springs Road and Moonamang Road. From Moonamang Road, heavy vehicles and trucks heading to the Processing Plant for the Project and/or the Victoria Highway will bypass Kununurra via Stock Route Road, Research Station Road and Ivanhoe Road. Light vehicle traffic heading to Kununurra and/or Victoria Highway will use the Weaber Plain Road.

5.3.3.1 Potential Impacts

Traffic generation estimates have been made for the construction and operational phases of the Project. The forecast total generation of 30 vehicles per day and 42 vehicles per day during construction and operation, respectively, will not have a significant impact on the road network.

5.3.4 Amenity

The focus of the amenity assessment was on visual amenity and the potential impacts of increased access.

The visibility of these Project components was considered and assessed from potentially sensitive viewpoints which included key vantage points, publically accessible areas and/or areas of significance.

5.3.4.1 Potential Impacts

Visual

Given the remote location of the Project on private property, the only potentially sensitive viewpoints from which the Project may be visible will be the estuarine environment and the residual outcrops and ranges to the south of Legume Station. The Project will not have a significant impact on the visual amenity of the area from these viewpoints given:

- Views of the Project from the estuarine environment will be limited to the intake and outfall structures. These views will be limited to parts of Forsyth and Alligator Creeks that are within the immediate vicinity of the structures. Mangroves along the banks of Forsyth and Alligator Creeks will help screen the intake and outfall structures and reduce the level of visual impact.
- The grow-out farms and intake and outfall structures will not be visible from the ranges and residual outcrops in the south of Legume Station given the intervening distance and the low profile of the bund walls.
- The accommodation village and central facilities will not be visible from the ranges and residual outcrops as the buildings will be lowset and screened by the surrounding bushland.

Access

The amenity of the area may be impacted by increased the numbers of recreational visitors to the area resulting from the upgrade of part of Moonamang Road, the Cave Springs Road and the Legume Access Road.

6 ENVIRONMENTAL MANAGEMENT

6.1 ENVIRONMENTAL MANAGEMENT STRATEGIES

Environmental management strategies have been prepared based on the environmental risks identified in the Draft EIS, Volume 1, Chapter 9 - Risk Assessment, and potential impacts, mitigation measures and monitoring identified in the Draft EIS, Volumes 2 - Environmental Assessment and 3 - Social, Economic and Cultural Assessment. These environmental management strategies consolidate and summarise the commitments made as part of the EIS, and will be used to develop site specific management procedures after approval of the Project.

Table 2 shows the potentially impacting aspects of the Project and the relevant environmental management strategy to manage each. Construction and operational impacts are grouped together and management strategies are contained in Appendix C. During operations, all construction type works (earthworks, excavation, etc.) will continue to operate under construction phase controls where relevant.

The strategies are as follows:

- C1 - Erosion and Sediment Control
- C2 - Land and Soils Management
- C3 - Acid Sulfate Soil Management
- C4 - Vegetation Management
- C5 - Weeds and Pests
- C6 - Fauna Management
- C7 - Surface Water Management
- C8 - Groundwater Management
- C9 - Waste Management
- C10 - Air and Noise Management
- C11 - Effluent Management
- C12 - Hazardous Materials Management
- C13 - Bushfire Management
- C14 - Traffic Management
- C15 - Social Impact Management
- C16 - Cultural Heritage Management

The Biosecurity Plan will be developed during the detailed design, and is further discussed in the Draft EIS, Volume 5, Appendix 16 - Biosecurity Assessment.

TABLE 2 ENVIRONMENTAL MANAGEMENT STRATEGIES

Potential Impact/Effect	Environmental Management Strategies
Geology, Geomorphology and Soils	
Earthworks and traffic disturbance	C1 - Erosion and Sediment Control C14 - Traffic Management
Soil erosion	C1 - Erosion and Sediment Control
Disturbance and oxidation of acid sulfate soils	C3 - Acid Sulfate Soil Management
Soil contamination from leaks and spills, excessive treated (or poorly treated) wastewater application	C2 - Land and Soils Management C12 - Hazardous Materials Management C11 - Effluent Management Spill Management (Appendix E, Contingency Management)
Salinity and sodicity	C2 - Land and Soils Management C11 - Effluent Management
Geotechnical issues and stability	C2 - Land and Soils Management Addressed in design, Volume 1, Chapter 3 of Draft EIS
Sterilisation of potential economic mineral resources.	Addressed in design, Volume 1, Chapter 3 of Draft EIS and explored in Volume 2, Chapter 1 - Geology, Geomorphology and Soils
Hydrology	
Physical changes to hydrodynamics at Forsyth Creek inlet	C7 - Surface Water Management
Physical changes to hydrodynamics at Alligator Creek discharge point	C7 - Surface Water Management
Erosion and coastal landform and bathymetry changes at the proposed intake and discharge points	C7 - Surface Water Management
Direct impacts from the Project altering floodplain hydrology, and providing barriers to fish movement.	C7 - Surface Water Management Addressed in design, Volume 1, Chapter 3 of Draft EIS
Potential loss or damage to ephemeral wetlands	C1 - Erosion and Sediment Control C7 - Surface Water Management Addressed in design, Volume 1, Chapter 3 of Draft EIS
Lack of releases from Forsyth Dam, leading to changes to hydrology	C7 - Surface Water Management

Potential Impact/Effect	Environmental Management Strategies
Surface water and sediment quality	
Changes to estuarine water quality due to discharges into Alligator Creek	C7 - Surface Water Management
Erosion and sedimentation of waterways	C1 - Erosion and Sediment Control
Leaching of oxidising acid sulfate soils into freshwaters	Acid Sulfate Soil Management
Leaks and spills into fresh, estuarine and marine waters	C1 - Erosion and Sediment Control C7 - Surface Water Management C12 - Hazardous Materials Management Spill Management (Appendix E, Contingency Management)
Groundwater	
Impacts to productive aquifers due to lowering of groundwater	C8 - Groundwater Management
Spills and leaks leading to direct contamination of groundwaters	C8 - Groundwater Management C12 - Hazardous Materials Management Spill Management (Appendix E, Contingency Management)
Contamination of groundwater from wastewater irrigation areas	C8 - Groundwater Management C11 - Effluent Management
Changes to hydrology, affecting recharge zones and therefore groundwater recharge	C8 - Groundwater Management C7 - Surface Water Management
Impacts from and to shallow saline groundwater on Estuarine-Deltaic Plain	C8 - Groundwater Management
Terrestrial Vegetation and Flora	
Reductions in vegetation community and flora species number and diversity through additional or unintentional clearing or damage to flora outside clearing limits	C4 - Vegetation Management
Land degradation from acid sulfate soils, upslope land clearing or runoff leading to vegetation die-back	C1 - Erosion and Sediment Control C3 - Acid Sulfate Soil Management
Decreased volume of surface water released from the dam in the late dry season which may affect floodplain vegetation communities	C7 - Surface Water Management
Impacts to groundwater dependent flora and communities	C8 - Groundwater Management
Removal of woody or deep rooted vegetation resulting in the rising of the water table, and surface soil salinity.	C4 - Vegetation Management C8 - Groundwater Management
Dust deposition on vegetation and communities	C1 - Erosion and Sediment Control

Potential Impact/Effect	Environmental Management Strategies
Bushfire Risk if elevated due to Project works	C13 - Bushfire Management
Introduced flora and weeds resulting in a negative change to community diversity	C5 - Weeds and Pests
Terrestrial Fauna and Avifauna	
Vegetation clearance leading to habitat loss or mortality	C4 - Vegetation Management C6 - Fauna Management
Changes in floodplain hydrology leading to changes in wetland fauna habitat characteristics	C6 - Fauna Management C7 - Surface Water Management
Changes in receiving environment water quality, due to increases in nutrient content and total suspended solids, leading to changes in estuarine shorebird habitat	C7 - Surface Water Management C6 - Fauna Management
Disturbance associated with noise and visual stimulation	C6 - Fauna Management C10 - Air and Noise Management
Disturbance due to bird predation management strategies	C6 - Fauna Management
Degradation of habitat value or mortality due to introduced species	C5 - Weeds and Pests
Introduced and Pest Species	
Introduced flora and weeds resulting in a negative change to community diversity, impacts to pastoral operations	C5 - Weeds and Pests
Establishment or spread of pest fauna, particularly cane toads, impacting on existing flora and fauna values, particularly threatened and near threatened species	C5 - Weeds and Pests
Aquatic Ecosystems	
Direct disturbance of habitat from vegetation clearing and earthworks	C4 - Vegetation Management C6 - Fauna Management
Changes to floodplain hydrology from changes to flood patterns, and the cessation of dry season flows from Forsyth Creek, and the creation of waterway barriers in freshwater waterways	C7 - Surface Water Management C6 - Fauna Management
Entrainment or impingement of aquatic fauna at the seawater intake pump station on Forsyth Creek	C7 - Surface Water Management C6 - Fauna Management
Changes in water quality from vegetation clearing and earthworks; discharge of grow-out facility wastewater; spills, leaks or waste/litter movement off-site; or discharges of treated or untreated effluent wastewater directly to waterways	C7 - Surface Water Management C12 - Hazardous Materials Management Spill Management (Appendix E, Contingency Management) C11 - Effluent Management
Proliferation of pest aquatic plants	C5 - Weeds and Pests

Potential Impact/Effect	Environmental Management Strategies
Escape of prawn stock and/or diseases and pathogens from the grow-out facility	Biosecurity Plan
Noise and light disturbance	C10 - Air and Noise Management C6 - Fauna Management Design as outlined in the Draft EIS, Volume 1, Chapter 3 - Project Description
Loss of access to fishing grounds and/or loss of species of significance to indigenous communities	C6 - Fauna Management C16 - Cultural Heritage Management
Increased site access, increasing habitat disturbance and direct take of aquatic fauna (primarily fish).	C6 - Fauna Management C15 - Social Impact Management
Waste Management	
Nuisance impacts from noise, odour and dust, land and water contamination, attraction and breeding of pests, and human health impacts due to landfill gas asphyxiation or explosion.	C9 - Waste Management C1 - Erosion and Sediment Control C7 - Surface Water Management C8 - Groundwater Management C8 - Air and Noise Management C12 - Hazardous Materials Management Spill Management (Appendix E, Contingency Management)
Air & Noise	
Excessive dust and noise emissions from construction	C10 - Air and Noise Management C1 - Erosion and Sediment Control
Excessive noise and air quality impacts from operations	C10 - Air and Noise Management
Excessive odour from pond operations	C10 - Air and Noise Management
Excessive odour from sewage treatment plants	C10 - Air and Noise Management C11 - Effluent Management
Climate Change Assessment	
Excessive generation of greenhouse gases from the Project	Ecologically Sustainable Development, outlined in the Draft EIS, Volume 1, Chapter 7 C10 - Air and Noise Management
Sea level rise and increases in tropical cyclone intensity and frequency	This has been incorporated into design elements, outlined in the Draft EIS, Volume 1, Chapter 3 and discussed in Volume 2, Chapter 11
Socio-economic	

Potential Impact/Effect	Environmental Management Strategies
Negative community relations	C15 - Social Impact Management
Failure to meet Indigenous and general local community employment and business expectations	C15 - Social Impact Management Discussed in the Draft EIS, Volume 1, Chapter 3 and Volume 3, Chapter 1
Restriction of community access to fishing, camping and other recreational and tourism activities	C15 - Social Impact Management
Damage to locally significant areas, particularly in relation to fishing areas, and other areas that have been commonly accessed or can be seen by the public	C15 - Social Impact Management
Inadequate attention to community safety, particularly in relation to product transport on public roads	C15 - Social Impact Management C14 - Traffic Management
Historic and Cultural Heritage	
Removal and/or damage of cultural items or sites, associated with ground disturbing activities	C16 - Cultural Heritage Management Unexpected Findings Protocol (Appendix E, Contingency Management)
Limiting important site access by Traditional Owner / local indigenous persons, particularly for fishing and hunting activities, or accessing culturally important sites	C16 - Cultural Heritage Management
Traffic and Transport	
Risks associated with traffic accidents, road kill, etc.	C14 - Traffic Management
Amenity	
Increased the numbers of recreational visitors to the area resulting from the upgrade of part of Moonamang Road, the Cave Springs Road and the Legume Access Road	C15 - Social Impact Management C14 - Traffic Management

6.2 MONITORING AND REVIEW

A monitoring and inspection program has been developed to measure the performance of the works in relation to this EMP, described in each management plan above. A monitoring checklist template (EM-01-RG-0003) is shown in Attachment E, to be updated following approval of the Project.

All results of monitoring and environmental inspections must be documented and be made available to the administering authority upon request.

6.3 CONTINGENCY PLANS

Attachment F contains a contingency response plan that shall be carried out in the event of unexpected incidents or occurrences on the site (e.g. chemical or fuel spills). It is intended as a guide only, and actual responses must be tailored to the incident and situation.

A detailed site disaster management plan is to be prepared and utilised where appropriate, overriding this contingency plan where required.

Health and Safety concerns will always take precedence when managing an incident. If a situation is not safe, personnel will not enter the area. Emergency response is to be undertaken in accordance with a site OH&S Management Plan (refer to the Draft EIS, Volume 3, Chapter 3 - Human Health and Safety for more information). Environmental Emergencies not identified within the contingency plans are to be dealt with as soon as practical to avoid or minimise environmental harm.

7 REFERENCES

IECA (2008). Best Practice Erosion and Sediment Control 2008. International Erosion Control Association.
<http://www.austieca.com.au/>

DLRM (2016). Soil management, erosion and sediment control information. Department of Land and Resource Management. Accessed 12 September 2016 at <https://nt.gov.au/environment/soil-land-vegetation/soil-management-erosion-sediment-control>

DNREAS (2010) Land Clearing Guidelines. Technical Report No. 20 / 2009D, Department of Natural Resources, Environment, The Arts and Sport, Northern Territory.

APPENDIX A ORGANISATIONAL CHART

[To be developed following Project approval, and engagement of management and construction teams]

APPENDIX B EMP IMPLEMENTATION

PROJECT SEA DRAGON DOCUMENT REGISTER

Number	Title	Revision Number	Revision Date	Document Owner	Status
EMS Documents					
EM-00-MN-0001	Environmental Management System Manual	B	9-May-2016		DRAFT
EM-00-CT-0001	Project Sea Dragon Organisational Chart				Not prepared
EM-00-RG-0001	Document Register	B	9-May-2016		DRAFT
EM-00-RG-0002	Legislation and Approvals Register (template)	B	17-Apr-2016		DRAFT
EM-00-RG-0003	Monitoring and Review	A	5-May-2016		DRAFT
EM-00-RG-0004	Incident / Complaint / Improvement Register	A	5-May-2016		DRAFT
EM-00-RG-0005	Cultural Heritage Register (template)	A	6-Jun-2016		DRAFT
EM-00-FO-0001	Training Needs Analysis	A	2-May-2016		DRAFT
EM-00-FO-0002	Incident / Complaint / Improvement Form	A	5-May-2016		DRAFT
01-Legune Station Grow Out Facility					
EM-01-MP-0001	Legune Station Stage 1 EMP	A	28-Sep-2016		DRAFT

Project Sea Dragon - Site Legislation and Approvals Register

[illegible]

* Definitions are as follows:

DoE Commonwealth Department of the Environment

PROJECT SEA DRAGON INCIDENT / COMPLAINT / IMPROVEMENT REGISTER

Record of all incidents, near misses and complaints

Date of incident / complaint	Brief Description	Form No.	Raised by	Actions Required	Assigned to	Assigned Close out date	Close out Date	Remarks / Improvement Opportunities
01/05/16	Near miss – spillage of waste oil from waste oil storage bund due to bund failure. Cleanup contained spill	NC001	Joe Bloggs	Repair Bund Wall [also consider EMS or EMP revisions]	Jane Doe	15/05/16	14/05/16	Waste storage tank bund repaired

APPENDIX C ENVIRONMENTAL MANAGEMENT STRATEGIES

C1

EROSION AND SEDIMENT CONTROL STRATEGY

TABLE C1.1 - EROSION AND SEDIMENT CONTROL STRATEGY

Element	Detail	
Applicable site activities		
Site establishment		
Vegetation clearing and earthworks		
Site stabilisation and rehabilitation		
Aim		
Ensure that land, soil and water resources are protected both now and in the future, such that the ecological health and land uses, and the health, welfare and amenity of people are maintained		
Objectives	Targets	Key Performance Criteria
Undertake and complete works in compliance with statutory environmental requirements	No statutory infringements No breaches of licence/approval conditions	Number of infringements Number of breaches
Minimise erosion and sediment loss by minimising vegetation clearing, stabilising exposed surfaces as soon as possible, and capturing eroded sediments	No evidence of erosion or sediment loss from the site, due to site construction activities	Number of erosion and sediment control failures Area cleared, damaged or deteriorating outside of areas on vegetation clearing plans
Responsibility	Construction: Construction Manager Operations: Site Manager	
Actions / Mitigation Measures	Construction <u>Erosion and Sediment Control Approach</u> The overall approach will focus on three main areas of control: - Access and Traffic Controls - to minimise the impact of traffic on site soils, particularly where fragile, and manage movement of soil and weeds on and off-site through targeted entry and exit points from the site - Drainage Controls - management of runoff volumes and velocity, to control erosion through concentrated flows forming rills and gully erosion, including diversion of clean upslope waters - Erosion Controls - minimising and protecting exposed surfaces to reduce erosion through raindrop impact and surface water flows, using vegetative or other ground covers - Sediment Controls - trapping and settling / retaining sediments that have become mobile, before movement off-site Prior to site works starting, detailed ESCPs will be prepared for all areas of ground disturbance. These are to detail the measures to be utilised, their locations, and any details required for their installation and maintenance. These will include: - an overview and key map of the entire development site, and specific maps for	

Element	Detail
	particular areas ■ location, area and boundaries of vegetation clearing and other disturbance areas on the site, and no go areas on the site (no clearing, or no access or both) ■ the location of any significant features, waterways and natural drainage features ■ natural contours and identification of any high risk erosion areas ■ erosion and sediment controls, including type, location and any other particulars required Erosion and Sediment Controls to be used on the site are provided in Table C1.2. Generally: ■ the location of laydown areas, exit and entry points to the site, and trafficable areas of the site will be defined prior to works starting ■ The ingress to and egress from the site will be confined to a minimum number of stabilised access points required for the works ■ Divert clean water around disturbance areas where possible, or provide least resistance and controlled drainage through disturbance areas ■ Form contour banks, ditches or similar across cleared slopes to direct run-off towards surrounding vegetation or sediment dams, and away from waterways ■ Unstable exposed surfaces, particularly batter slopes must be stabilised by sufficient surface roughening and topsoil application followed by vegetation (locally native vegetation preferred), or alternatively by utilising jute mesh, rip-rap or similar. This to be initiated as soon as practicable following final forming of the surface <u>Site Establishment</u> Ground-truth the location of material stockpiles and erosion and sediment controls shown in the above detailed site plans and adjust if necessary. Nominate areas for parking, storage of materials, areas to avoid disturbing, and other similar matters. All erosion and sediment controls to be installed and operated according to concepts in IECA (2008) and DNREAS (2010), and this management strategy Site works will not start until the erosion and sediment control works outlined herein are installed and functional All weather access roads will be constructed before the start of the wet season for key access areas required during wetter periods <u>Vegetation Clearing and Earthworks, General Construction</u> Vegetation clearing, earth works and stockpiles of soil are minimise where possible Progressively stabilise exposed areas as works progress - areas that are cleared for construction, but not required to be cleared for operations should be rehabilitated as soon as practical. Utilise native vegetation where possible Protect stockpiles from erosion, particularly topsoils to be used for rehabilitation <u>In-stream Works and Waterway Crossings</u> Access tracks/roads through waterways will be undertaken in the dry season (both clearing and construction)

Element	Detail
	Where the works cross flowing waters (or waters that may flow during the works), controls will be installed to avoid erosion and blocking streamflow, which may include: ■ Dam and pump systems – bund upstream and pump waters past the works (a second downstream or semicircular bund encompassing works may be needed). More suitable to smaller stream systems where works are of short duration only. A fish screen will be required for the pump inlet. ■ Dam and divert systems –similar to the above, except that flows are safely passed from upstream to downstream in a diversion system, comprising an earthen channel, or pipe. ■ Temporary watercourse diversions –divert watercourse around a worksite through temporary drainage structures, allowing works within the main channel prior to reinstatement ■ Stabilised outflow structures or flow spreaders to avoid downstream erosion ■ Installation of sediment fencing on the edges of the construction zone, and silt curtains in standing downstream waters where there is a risk of sediment movement into these waters <u>Dewatering</u> Dewatering of temporary waterway crossing controls (see above) and excavation works may be required. These to be managed as follows: ■ Where practicable, decant surface clean waters first. If clean, discharge to the environment, preferably over vegetated areas. Where not clean, dewater to sediment retention structure ■ Pump remaining waters to sediment retention structure ■ Stabilise entry to the retention structure to avoid erosion, allow sediment to settle out, and test prior to release to the environment ■ Where possible, reuse waters on-site (e.g. for dust suppression) Operation Adopt the construction phase controls for construction, earthworks and similar activities Otherwise, mitigation and monitoring during the operational phase will involve inspection and maintaining existing structures from erosion, instability / cracking. Continued erosion control and rehabilitation will be required after each wet season, including topping up and reshaping works. Topsoils may be replaced with stabilised pond spoil (mixed with coarser sandier materials where required) to reform topsoil where required for vegetation growth. Training and Awareness Adopt the training and awareness, communication and incident management controls outlined in the PSD Environmental Management System
Monitoring	Construction Monitoring will include: ■ Regular (weekly) site inspections to ensure erosion and sediment controls are in

Element	Detail
	place, and to identify any rectification works required - Site inspections to be undertaken also after any rain event to check for integrity and maintenance requirements for erosion and sediment controls, and other site features - Check any stream diversion structures for trapped fish or other aquatic wildlife - An incident-complaint register including for all spills and leaks, reviewed regularly, to keep track of and where required improve spill management on the site Operation - Regular visual monitoring of the site will be conducted, with potential issues identified and entered into the corrective action system for rectification.
Reporting	Visual site inspections will be recorded in the Site Manager's logbook, or the site visual inspection form in Appendix E (or similar) Any non-conformance, incident or potential incident will be recorded on the incident-complaint form in Appendix E (or similar) and entered into the incident-complaint register for rectification and follow up All monitoring results (soil, water quality, etc.) will be retained, with an annual monitoring review conducted and report prepared for reporting to the Seafarms environmental management team Audit reports will be prepared and maintained, with copies to the Seafarms management team
Corrective Actions	Corrective Action Triggers will include: - Sediment loss from the site, including turbid waters or plumes in receiving waters or drainage lines (due to construction works) - Damaged or failing erosion and sediment controls, including breaches in drainage controls, sediment fences or sediment ponds - Excessive sediment build-up in sediment ponds or other structures (including sediment fences, drains) - Evidence of loss of litter and other contaminants from the site Corrective Actions: - Repair erosion and sediment controls, stabilise exposed surfaces and reinstate drainage or other controls - Drain and dig out accumulated sediment in sediment controls, and dispose of material in an area that will not re-erode and move off-site - Undertake general site housekeeping to tidy up loose rubbish, ineffective stockpile controls, etc. - Review the Erosion and Sediment Control Plans
References IECA (2008). <i>Best Practice Erosion and Sediment Control 2008</i>. International Erosion Control Association. http://www.austieca.com.au/ IECA (2008b). <i>Best Practice Erosion and Sediment Control 2008, Volume 4 - Design Fact Sheets and Volume 6 -</i>	

Element	Detail
	<i>Standard Drawings</i>. http://www.austieca.com.au/publications/best-practice-erosion-and-sediment-control-bpesc-document DLRM (2016). <i>Soil management, erosion and sediment control information</i>. Department of Land and Resource Management. Accessed 12 September 2016 at https://nt.gov.au/environment/soil-land-vegetation/soil-management-erosion-sediment-control DNREAS (2010) <i>Land Clearing Guidelines</i>. Technical Report No. 20 / 2009D, Department of Natural Resources, Environment, The Arts and Sport, Northern Territory. Leersnyder, H., Bunting, K., Parsonson, M., and Stewart, C. (2016). <i>Erosion and sediment control guide for land disturbing activities in the Auckland region</i>. Auckland Council Guideline Document GD2016/005. Prepared by Beca Ltd and SouthernSkies Environmental for Auckland Council.

TABLE C1.2 - EROSION AND SEDIMENT CONTROLS TO BE USED ON-SITE

Aspect	Control ¹
Access and Traffic	Stabilised site access and egress points - define access points to the site, and stabilise to avoid movement of soil / weeds on or off-site Traffic control plan - define trafficable and no-go areas on the site All weather access tracks, and road/track drainage
Drainage Controls	Diversion Banks - locate upslope of construction areas, stockpiles and hazardous material storage locations Open Drains - to control drainage paths and directions on the site Contouring - use on long overland flow paths on slopes to avoid rill and gully erosion Check Dams - install in drainage channels to slow runoff velocity in drains to minimise erosion Controlled Discharge - stabilised discharge points, energy dissipater or flow spreaders to avoid erosion in discharge points
Erosion Controls	Surface Roughening - short term surface control Revegetation - longer term stabilisation Synthetic materials, relatively small high risk areas (e.g. jute mesh) Drainage protection – geofabric, jute mesh, HDPE liner, rock armouring to protect against high velocity erosive flows
Sediment Controls	Sediment fences - to guide runoff into other control structures, and to hold water and allow sediment to drop out. Suitable for small areas, or at the foot of stockpiles Sediment ponds and basins located to capture sediment runoff and settle out sediments Vegetated areas to slow flows and capture sediment (not suitable for high value conservation species/areas)
Works near or in Waterways	Dam and pump: In-stream dam bunds, sump / pump inlet control, fish screens, pump and pipeline, stabilised outflow or flow spreader Dam and divert: In-stream dam bunds, diversion channel or pipe(s), stabilised outflow or flow spreader

Aspect	Control ¹
	Temporary waterway diversion: stabilised diversion channel, lined with geotextile cloth, HDPE liner or similar; non-erodible dam in upstream and downstream ends of existing channel (sandbags, sheet piles, lined earthen banks, etc.); controlled inlet and outlet points; rehabilitation of in-stream morphology Coffer dam diversions: non-erodible dam structure (sand bags, sheet piles, lined earthen banks) Dewatering: all of the above structures may require dewatering (see below)
Dewatering	Pump and sump system, including surface decant where clean surface waters can be removed first Sediment retention structure – skip bin or tank, sediment fencing, earth bunded area for small works, sediment ponds for larger works Energy dissipation, flow spreaders etc. for inflow to above structures (where required to control erosion)

Table notes:

1 refer to IECA (2008) Design Fact Sheets (Volume 4) and Standard Drawings (Volume 6); DLRM (2016) Technical Notes; Leersnyder et al (2016) guideline and example design drawings

C2

LAND AND SOILS STRATEGY

TABLE C2.1 - LAND AND SOILS STRATEGY

Element	Detail	
Applicable site activities		
Site establishment		
Vegetation clearing and earthworks		
Site stabilisation and rehabilitation		
Operations, particularly for saline ponds and channels, and in relation to leaks and spills		
Aim		
Ensure that land and soil resources are protected both now and in the future, such that the ecological health and land uses, and the health, welfare and amenity of people are maintained		
Objectives	Targets	Key Performance Criteria
Undertake and complete works in compliance with statutory environmental requirements	No statutory infringements No breaches of licence/approval conditions	Number of infringements Number of breaches
Protection of non-impacted site soils and land systems (i.e. outside of the project footprint) to enable stable, self-regulating soil-vegetation environments (management of cover, fertility and contamination)	No damage to vegetation outside of areas identified on vegetation clearing plans Monitoring of vegetation abundance and health over time shows no impacts to vegetation outside of areas identified on vegetation clearing plans No traffic outside of defined roadways	Comply with Vegetation Management Plan Area disturbed by traffic outside of defined Project footprint
Avoid soil contamination	No significant releases of chemicals, spills All unexpected findings notified, works stopped and addressed prior to works proceeding (refer to Effluent Management Strategy in relation to wastewater)	Number of incidents involving leaks, spills or soil contamination Number of contamination incidents reported, and number not addressed as required and in the timeframes outlined
Appropriate engineering design to ensure long term stability and integrity of worked landforms and infrastructure	Engineering design by registered professional engineer, following advice of registered professional geotechnical engineer	Number of defects, failures
Post-closure plans for rehabilitating site soils to allow beneficial post-closure land use (pastoral uses)	Post closure plans prepared and available Rehabilitation methods determined to be suitable, acceptable and achievable	Refer to Decommissioning and Rehabilitation Management Strategy

Element	Detail
Responsibility	Construction: Construction Manager Operation: Site Manager
Actions / Mitigation Measures	Construction <u>Topsoils</u> Topsoils where encountered will be stockpiled for later use (top dressing or stored for rehabilitation works). Topsoil stockpiles are to be a maximum of 2m high, protected from erosion through erosion controls identified in <i>C1 - Erosion and Sediment Control Strategy</i>. In locations with very thin to non-existent topsoils, the above will be impractical and topsoils for rehabilitation constructed through amelioration of existing soils as required (refer to the draft EIS, Volume 1, Chapter 3, Section 11). <u>Soil Contamination</u> Implement the Hazardous Materials Management and Waste Management Strategies, and Spill Response in the Contingency Management Strategy (Appendix E). <u>Geotechnical</u> Engineering design, and construction techniques will be adopted to overcome identified constraints for the site and Project infrastructure, as outlined in the design (Volume 1, Chapter 3) and based on geotechnical advice. <u>Soil Dispersion and Sodidity</u> The risk of dispersion will be managed by adopting a suitable level of compaction, and using gypsum ameliorant, internal batter liners or filters internally within embankments (sandy gravel materials, geofabrics such as Bidim or equivalent). Close attention will be paid to pipes and culverts through embankment walls, including seepage control measures, filters, backfill to limit the risk of dispersion and erosion due to seepage along these pipes. Operation Adopt the construction phase controls for construction, earthworks and similar activities. Otherwise, mitigation and monitoring during the operational phase will involve monitoring and maintaining existing structures from erosion, instability / cracking, and avoidance of soil contamination or structural decline. Continued erosion control and rehabilitation including topping up and reshaping works after each wet season. Topsoils may be replaced with stabilised pond spoil (mixed with coarser sandier materials where required) to reform topsoil where required for vegetation growth. Liaison with the owner of the Manbarrum Zinc-Silver Project will occur to ensure that, should that project proceed, the two projects can coexist cooperatively. Training and Awareness Adopt the training and awareness, communication and incident management controls outlined in the PSD Environmental Management System

Element	Detail
Monitoring	Pre-Construction Representative sampling of soil profiles for fertility characterisation, salinity and sodicity will be undertaken prior to earthworks commencing for the purpose of characterising soils for impact assessment during operations, and rehabilitation post-closure (should this be required). A pre-construction site reconnaissance inspection will be undertaken for all construction areas. This will include identifying: ■ Unstable, shallow or otherwise problematic soils, or evidence of soil contamination ■ Drainage lines and watercourses, and other prominent site features ■ Excavation test pits or bores (after vegetation clearing) to the depth of excavation + 0.5m to confirm soil depths and types to be encountered. Number of pits based on uniformity of the land type, and type of works to be conducted, and at the discretion of the construction manager (inadequate survey will cause delay to construction works rather than potential for environmental harm) Construction Monitoring will include: ■ Regular (weekly) site inspections to identify any signs of land or soil deterioration or contamination, and any rectification works required ■ An incident-complaint register including for all spills and leaks, reviewed regularly, to keep track of and where required improve spill management on the site ■ Regular tank integrity testing for all large fuel, oil, chemical and waste storages. ■ Ongoing geotechnical inspection of works to confirm the subgrade conditions and construction quality against design, and the requirements for subgrade or other amelioration ■ Implementation of the Unexpected Findings Protocol provided in the Contingency Management Strategy (Appendix E). Operation ■ Regular visual monitoring of the site will be conducted, with potential issues identified and entered into the corrective action system for rectification. ■ Ongoing groundwater monitoring will be undertaken to test for leaks from ponds and channels, and annual inspections / audits of dam and channel walls will be conducted to ensure ongoing integrity and stability.
Reporting	Visual site inspections will be recorded in the Site Manager's logbook, or the site visual inspection form in Appendix E (or similar) Any non-conformance, incident or potential incident will be recorded on the incident-complaint form in Appendix E (or similar) and entered into the incident-complaint register for rectification and follow up All records of tank integrity testing, soil or other testwork, waste removal, etc. will be retained A report will be prepared confirming that the project infrastructure has been built to an appropriate engineering standard and soil testing was conducted in accordance with

Element	Detail
	relevant Australian Standards on completion of construction. Preliminary versions of this report will be prepared on a quarterly basis throughout construction. All monitoring results (soil, water quality, etc.) will be retained, with an annual monitoring review conducted and report prepared for reporting to the Seafarms environmental management team Audit reports will be prepared and maintained, with copies to Seafarms management team
Corrective Actions	Corrective Action Triggers will include: ■ An Unexpected Finding of contamination or other soil issue during construction (typically vegetation clearing / earthworks) ■ Evidence of structural failure, erosion (particularly tunnel erosion) ■ Dispersing soils, evidenced by excessively cloudy runoff or ponding waters, surface crusting and waterlogging (beyond what is currently found on the site) ■ Spills or leaks of potential contaminants Corrective Actions: ■ Stop works and implement the Unexpected Findings Protocol provided in the Contingency Management Strategy (Appendix E) ■ Implement the Spill Management process within the Contingency Management Strategy (Appendix E) ■ Instigate repair works, which may require harvest and draining of a pond in worst case situations ■ Investigate the source of any pollution or dispersive soil runoff, ameliorate surface soils by application of ameliorant (e.g. gypsum), surface planting, stabilisation and/or compaction. ■ Review the land and soils management strategy
References ANZECC & ARMCANZ (2000). <i>Australian and New Zealand Guidelines for fresh and marine water quality, The guidelines – Volume 1 – Chapter 4 Primary Industries</i> [sodicity and salinity] DERM (2011). <i>Salinity Management Handbook</i>. Queensland Department of Environment and Resource Management, Second Edition NT Government (2016). <i>Managing Pastoral Land</i>. https://nt.gov.au/industry/agriculture/farm-management/managing-pastoral-land NT EPA (2016). <i>Assessment for Site Contamination</i>. https://ntepa.nt.gov.au/waste-pollution/contaminated-land	

C3

ACID SULFATE SOIL MANAGEMENT STRATEGY

TABLE C3.1 - ACID SULFATE SOIL MANAGEMENT STRATEGY

Element	Detail	
Applicable site activities		
Site Establishment (minor)		
Earthworks, particularly channel construction		
Aim		
Ensure excavation works involving acid sulfate soils are appropriately managed to minimise the risks of environmental pollution and that land and soil, surface and groundwater resources are protected both now and in the future, such that the ecological health and land uses, and the health, welfare and amenity of people are maintained		
Objectives	Targets	Key Performance Criteria
Undertake and complete works in compliance with statutory environmental requirements	No statutory infringements No breaches of licence/approval conditions	Number of infringements Number of breaches
No oxidation of acid sulfate soils on the site as a result of site activities	Excavation below 2m depth or 2.5m AHD (whichever is the highest absolute elevation) on Estuarine-Deltaic and Coastal Plains includes additional ASS testing or re-internment (within 12 hours) Identified ASS are avoided, contained or adequately neutralised	Number of exceedances of water quality results for pH in leachate, runoff and receiving waters Number of laboratory neutralisation results showing net acidity remaining after treatment
Responsibility	Construction: Construction Manager Operations: Site Manager	
Actions / Mitigation Measures	Construction No excavation below 2m depth or 2.5m AHD (whichever is the lesser) without testing for ASS (refer Monitoring - pre-construction below). Alternatively, where ASS are likely to be encountered and the total quantity for a location is <100m ³ , the material can instead be re-buried within 12 hours, and below the layer where they were excavated (without mixing of layers), without pre-testing. The material should be limed at a nominal rate of 240 kg CaCO ₃ / m ³ soil to be disturbed (as per Dear <i>et al</i> , 2014). Manage acid sulfate soils as follows: 1. Acid sulfate soils are to be avoided, and groundwater level not lowered in their vicinity, OR 2. The neutralising capacity of any exposed acid sulfate soil (after treatment) must exceed the existing plus potential acidity of the soil, with a Factor of Safety of 1.5, AND 3. Acid Neutralising Capacity, whether naturally available or added, must be	

Element	Detail
	sufficiently fine to counteract oxidation and acid generation, as outlined in Dear <i>et al</i> (2014) Any placement of ASS is to be in a place such that future exposure of the material to oxidising conditions is prevented, unless the material is validated as having been neutralised Where ASS neutralisation treatment is required: 1. A laboratory test of the material is to be conducted in accordance with the Queensland Acid Sulfate Soil Technical Manual: Soil Management Guidelines (Dear <i>et al</i>, 2014) 2. An assessment of the bulk density of the soil will be required to determine the rate of lime addition required in kg CaCO₃/m³ of soil (from kg CaCO₃/t soil) 3. A subsequent determination of the liming rate per m² to allow determination of lime addition required in kg CaCO₃/m² (or other measure such as acre or hectare as appropriate) 4. Spreading of lime (preferably fine agricultural lime – ‘aglime’) at a rate exceeding that identified above per tonne soil to be disturbed or removed and ploughing or ripping of spread lime into soil ensuring that lime is distributed throughout the topsoil layer. This management is valid for shallow excavations / stripping affecting at most the top 700mm only (without intercepting groundwater and with a 500mm safety factor to the limit of investigation). A factor shall be applied to the liming rate depending on the equivalent CaCO₃ of the neutralising agent used. This shall be applied by calculating 100 / %CaCO₃ equivalent and multiplying this factor by the liming rate / tonne of soil (or m³ of soil) to achieve the required rate in CaCO₃.
Monitoring	Pre-Construction Pre-construction monitoring will be conducted for all areas of excavation below 2m depth or 2.5m AHD (whichever is the highest absolute elevation) on Estuarine-Deltaic and Coastal Plains. This will involve testing to the depth of disturbance + 0.5m in accordance with Dear <i>et al</i> (2014) (field and oxidised pH at 0.25m intervals, chromium reducible sulfur suite analysis at 0.5m intervals). Alternatively, soils that can be reinterred within 12 hours and where the volume at the location is <100m³ will be recorded (these will be reinterred with a nominal liming rate applied)(see above). Construction Implement pre-construction monitoring where excavation depths exceed the threshold depths above, or where blue/grey estuarine soils are encountered during the works. Testing of receiving and ground waters in accordance with Surface Water and Groundwater Management Strategies for pH to provide warning of possible acidic leachate Identified ASS to be tested before and after any liming / neutralisation treatment, such that no net acidity remains and no chance of oxidation can occur in-situ.

Element	Detail
Reporting	All test results shall be retained on-site and electronically by PSD In particular, a tracking system is to be implemented in the form of an ASS register as follows: ■ All areas of potential ASS presence to be recorded in the register ■ All of these areas to be subjected to testing (other than reinternment areas), and the key results recorded in the register with full results linked to from the register. Key results are total sulfur acidity (S%), Acid Neutralising Capacity (ANC) and fineness factor, net acidity (S%) liming rate (kg CaCO₃ / t soil) ■ Time from exposure to reinternment or treatment recorded as start date time, or if addressed on the same day, just the date of exposure and treatment/reinternment ■ Post treatment key results and link to full results recorded in the register. The key results will be Acid Neutralising Capacity (ANC) fineness factor, liming rate, net acidity post treatment ■ The location of all ASS – where they were excavated from, where treated, and where disposed to will be recorded. This register will be recorded electronically and easily accessible from the site. A hardcopy version may also be made available, and/or used for primary data collection prior to transfer to the electronic version Any non-conformance, incident or potential incident will be recorded on the incident-complaint form in Appendix E (or similar) and entered into the incident-complaint register for rectification and follow up
Corrective Actions	Correction Action Triggers: ■ Excavation below 2m depth or 2.5m AHD (whichever is the highest absolute elevation) on Estuarine-Deltaic and Coastal Plains ■ Excavation uncovers blue/grey estuarine deposits ■ Water sampling (surface/groundwater) indicates a drop in pH ■ Runoff waters exhibit iron staining, or pools and receiving waters are excessively clear (indicative of low pH) ■ Identified sites on the register (refer to Reporting above) have not been sampled, treated or reinterred (or entry was not marked in the register) Corrective Actions: ■ Implement testing regime, or record reinternment plan in the register (and implement the reinternment plan) ■ Implement monitoring and sampling as soon as possible to identify the source of any oxidising PASS material ■ Determine if register was not properly filled out. If data is not available, instigate testing as soon as possible to determine if acid sulfate soils were disturbed, and whether ASS are present, and/or the net acidity (accounting for ANC fineness factor) is suitable to avoid oxidation
References	

Element	Detail
	Ahern, C.R., Ahern, M.R. and Powell, B. (1998) Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils (ASS) in Queensland 1998. QASSIT, Department of Natural Resources, Resource Sciences Centre, Indooroopilly. Dear S.E., Ahern C.R., O'Brien L.E., Dobos S.K., McElnea A.E., Moore N.G. and Watling K.M. (2014). Soil Management Guidelines in Queensland Acid Sulfate Soil Technical Manual (QASSIT), Department of Science, Information Technology, Innovation and the Arts, Queensland Government, June 2014. DLRM (2016). Soil management, erosion and sediment control information. Department of Land and Resource Management. Accessed 12 September 2016 at https://nt.gov.au/environment/soil-land-vegetation/soil-management-erosion-sediment-control

C4

VEGETATION MANAGEMENT STRATEGY

TABLE C4.1 - VEGETATION MANAGEMENT STRATEGY

Element	Detail	
Applicable site activities		
Site Establishment		
Vegetation Clearing and Earthworks		
Site stabilisation and rehabilitation works		
Aim		
To maintain the conservation status, abundance, diversity, geographic distribution and productivity of flora and fauna at species and ecosystem levels through the avoidance or management of adverse impacts on the Project area and on adjacent areas that may be impacted.		
To minimise the risk of Significant Impacts to threatened species and communities, and migratory species listed under the EPBC Act, and species listed under the TPWC Act.		
Objectives	Targets	Key Performance Criteria
Undertake and complete works in compliance with statutory environmental requirements	No statutory infringements No breaches of licence/approval conditions	Number of infringements Number of breaches
Minimise the area of clearing to the minimum necessary for the construction and operation of the Project	No damage to vegetation outside of areas identified on vegetation clearing plans	As-cleared area and location of clearing compared to vegetation clearing plans
Maintain the health of flora and vegetation communities not directly impacted by vegetation clearing	No deterioration in flora and vegetation community health in areas of retained vegetation Clearing or damage to rare or important flora, vegetation communities and wetland areas is avoided or minimised	Degree of changes to vegetation abundance and health in areas outside of vegetation clearing plan areas Number and/or area of rare or important flora and vegetation communities cleared/damaged
Responsibility	Construction: Construction Manager Operations: Site Manager	
Actions / Mitigation Measures	Pre-construction A pre-construction survey will be conducted as outlined in Monitoring below, the results of which are to be included with vegetation clearing approvals (or the results otherwise advised) to the NT government / Pastoral Land Board Based on detailed design and vegetation clearing approvals, site specific Vegetation Clearing Plans will be developed, with the extent of clearing and 'no go' areas clearly defined Boundaries of clearing and 'no go' areas will be clearly pegged/flagged on the ground prior to clearing starting. Training for all personnel will include information on identifying these marked areas	

Element	Detail
	Vegetation Clearing Vegetation clearing will only commence after receipt of vegetation clearing approvals for the site Clearing within 100m of identified threatened or near threatened species or communities, or populations of data deficient species shall only occur after explicit approval or written advice from the NT government / Pastoral Land Board Vegetation clearing will be minimised where possible, particularly for: ■ wild plum low open woodland on the estuarine-deltaic plain ■ ephemeral wetland and northern ricegrass grassland ■ Other permanent wetland or waterway areas, including riparian vegetation No lay down areas or materials storage will be located within wetland areas or areas of retained vegetation Vegetation clearing and earthworks will be conducted during the dry season, with areas stabilised as much as practicable prior to wet season rains. Clearing activities must avoid damage to the roots, trunks and canopy of adjacent retained vegetation. Cleared vegetation will be pushed into a series of windrows within the disturbed area and either chipped for reuse in rehabilitation areas or burnt. Burning will only occur after receipt of a Permit to Burn. This will include notification of the date, time and location of the controlled burn to relevant parties, including Air North, NT Bushfire Council, traditional owners, and the Legume Station Pastoral Lease Manager. Topsoil Management Where topsoil is not utilised in earthworks, it should be dispersed onto prepared landscaping and revegetation areas immediately to minimise deterioration of soils. Where topsoil is to be stockpiled: ■ Stockpiles should have a maximum height of 2m; ■ Stockpiles should be revegetated to prevent soil erosion and weed invasion and to maintain soil microbes; and ■ Stockpiles should be located well away from works areas, access paths and overland flow paths. Topsoil should be dispersed onto landscaping and revegetation areas, evenly spread and ripped to bind soil layers and avoid compaction. Implement the Weeds and Pests Strategy Fire Regimes The Bushfire Management Plan to be prepared for the site will take into account recommended fire regimes for the near threatened species, <i>Turraea pubescens</i> and <i>Livistona lorophylla</i> Operation Maintain rehabilitated areas of the site, with endemic species where possible
Monitoring	Pre-construction survey

Element	Detail
	■ A pre-construction survey will be conducted of clearing areas + 100m outside of these areas for the identified data deficient flora species <i>Ptilotus capitatus</i>, <i>Spermacoce gibba</i> and <i>Eleocharis acutangula</i> within the Darwin stringybark/Darwin woollybutt woodland on the coastal erosional plain, and Melaleuca low woodland and flood-out plain wetland on the flood plain. This to be in a suitable season (i.e. April-May). ■ Further survey effort will be required where data deficient or other conservation significant species are detected, to identify the population characteristics and risks from the proposed clearing ■ These surveys are to identify the entire local population within the clearing area (+100 m buffer), including quantifying, mapped and clearly marking populations on the ground ■ The results of the above survey will be collated into a Significant Flora Species Survey report, and lodged with vegetation clearing approvals for subsequent clearing in these areas (or where no data deficient/conservation significant species are found, the results are accepted by the NT government / Pastoral Land Board as being acceptable to clear) Vegetation Clearing Regular inspections will be undertaken of cleared area extents to ensure retained vegetation is not being directly or indirectly impacted by construction activities Weekly monitoring shall be conducted of retained vegetation to detect any damage or decline in the health and condition of retained vegetation within the construction site and adjacent sites Weed mapping will be completed as identified in the Weeds and Pests Strategy All topsoil will be tracked unless used locally in the course of cut to fill earthworks, to ensure that the source and fate of all topsoils across the site are known – where topsoil is removed from weed infested areas, this will not be spread across the site, to limit spread of weed seeds.
Reporting	Any non-conformance, incident or potential incident will be recorded on the incident-complaint form in Appendix E (or similar) and entered into the incident-complaint register for rectification and follow up Any clearing of vegetation outside approved clearing areas shall be reported to the approving authority (Pastoral Land Board)
Corrective Actions	Correction Action Triggers: ■ Clearing has occurred outside of the approved and marked clearing areas ■ Vegetation die-back or deterioration is found in areas outside of the clearing footprint ■ Fire regimes are changed on the site to that occurring pre-construction ■ Changes to threatened or near threatened species list at the Commonwealth, Northern Territory or local level ■ Finds of significant species on the site (not previously identified)

Element	Detail
	■ Poor vegetation health in rehabilitation / replanted areas Corrective Actions: ■ Notify the approving authority of clearing outside approved boundaries (Pastoral Land Board) ■ Rectify training, ground truth marking, reinstate controls, review vegetation clearing plans and this Vegetation Management Strategy ■ Investigate the potential cause of vegetation die-back and rectify. This may be related to a number of causes including but not limited to soil related (fertility, salinity/sodicity, acid sulfate soils, loss of topsoil); surface water runoff (toxicants, salinity, waterlogging, or lack of water through changed runoff paths) ■ Review site operations and Vegetation Management Strategy to determine whether changes can be made to lessen or avoid impacts to significant species
References PLB (2010). Northern Territory Pastoral Land Clearing Guidelines 2010. Northern Territory Government, Pastoral Land Board. DNREAS (2010) Land Clearing Guidelines, Department of Natural Resources, Environment, The Arts and Sport, Darwin. Northern Territory.	

C5

WEEDS AND PESTS STRATEGY

TABLE C5.1 - WEEDS AND PESTS STRATEGY

Element	Detail	
Applicable site activities		
Construction activities, particularly:		
transport of equipment, vehicles and materials to site clearing, stockpiling and movement of topsoil on the site, particularly from where weed species were present		
Operational phase of the Project, for natural or other (grazing, vehicles, etc.) spread and movement of weeds on the site		
Waste handling including on-site landfill, changes to landuse and management (relating to pest fauna species)		
Aim		
To maintain the conservation status, abundance, diversity, geographic distribution and productivity of flora and fauna at species and ecosystem levels through the avoidance or management of adverse impacts on the Project area and on adjacent areas that may be impacted.		
To minimise the risk to pastoral operations (concurrent and potential future) as a result of the spread of weeds and pests		
Objectives	Targets	Key Performance Criteria
Undertake and complete works in compliance with statutory environmental requirements	No statutory infringements No breaches of licence/approval conditions	Number of infringements Number of breaches
Eliminate / avoid presence of Class A declared weeds on the site Minimise weed and pest introduction or spread on the site Avoid the creation of favourable environments for new or to sustain existing populations of invasive pests	No Class A weeds present on the site. No increase in the distribution and number of weed and pest species on the site No new weed or pest species identified on the site	Number of each weed and pest species identified on the site Location and distribution of each weed and pest species identified on the site
Responsibility	Construction: Construction Manager Operations: Site Manager	
Actions / Mitigation Measures	General Weed classes and required actions are as follows: Class A weeds - to be eradicated Class B weeds - growth and spread to be controlled Class C weeds - not to be introduced into the NT Weeds are to be controlled as per the requirements of statutory weed management plans for particular species where available (refer to References at the end of this table).	

Element	Detail
	Weed management requirements are to be defined explicitly for each weed potentially or actually present on the site, based on the above, the Weed Management Handbook, and advice from experienced weed control experts and the Weed Management Branch of the Department of Land Resource Management. This strategy is to be updated with these measures following Project approval but prior to any works commencing on-site. Training to include identification of key weeds and pests on the site. Instructive materials are to be displayed around the site identifying key weeds and pests that require control to aid in employee reporting. Pre-Construction Prior to construction commencing, a weed survey will be conducted in the Project footprint + 200m buffer as outlined in Monitoring below. This will be used to prepare a weed map of the site, used for tracking changes over time. Construction Plant and machinery brought to the site will be subject to weed wash-down. All weed washes will be documented and evidence maintained of weed wash-downs on or off-site. All contractors bringing vehicles/plant onto the site will be required to complete a Weed Declaration Form, in which they formally declare that all required weed hygiene measures have been taken and that their vehicles/plant are free of weed material (in particular, weed seeds). Particularly high risk situations include: ■ Plant or vehicles imported from other states, in particular northern Queensland. ■ Plant or vehicles, particularly including boats, that have been in other wetland areas – weeds of high concern to wetlands and associated areas, and that are not currently present on the Legume delta wetlands, include (but are not limited to) these declared species: a. Bathurst burr (<i>Xanthium spinosum</i>*) b. Cabomba (<i>Cabomba</i> spp. *) c. Noogoora burr (<i>Xanthium strumarium</i>*) d. Water lettuce (<i>Pistia stratiotes</i>*) e. Pond apple (<i>Annona glabra</i>*) f. Prickly acacia (<i>Acacia nilotica</i>*) g. Salvinia (<i>Salvinia molesta</i>*) h. Water hyacinth (<i>Eichhornia crassipes</i>*) i. Water mimosa (<i>Nilotica plena</i>* and <i>N. oleracea</i>*). Topsoil Management Removal, stockpiling and movement of topsoil on the site will be tracked, particularly where the topsoil contained weed species. Top soil from weed infestation areas (as identified in the pre-construction mapping) will be carefully stockpiled and if moved, not stored or reused in areas where those weeds are not present.

Element	Detail
	Operation During the operational stage, weed monitoring will be undertaken within the Project footprint, particularly service corridors subject to road traffic, with weeds eradicated where observed in new areas, completed at an appropriate time in the lifecycle of the weed (and as early as possible). Weed Control Weed control will be undertaken where Class A weeds are present, where new weeds are found, or where existing weeds have spread in the Project footprint. Control methods will follow the recommended approaches from the Northern Territory Weed Management Handbook (DLRM, 2014) and Weed Management Plans (NT Government, 2016) for the specific weed species, or on advice from a suitably experienced and qualified weed control person/officer. Locations of removed weeds will be recorded in the weeds and pests register and monitored after every wet season for the emergence of seedlings, which should be hand-pulled, sprayed or otherwise removed as appropriate. Pest Control Implement management strategies within both the Central Facilities and Accommodation Village to control the spread of cane toads into this part of the site, such as application of suppression pheromones, baited funnel traps to catch toad tadpoles, permanent traps around facilities, and exclusion barriers to farms and drains Implement an ongoing baiting program for feral dogs and pigs. Any application of 1080 poison must be authorised via a 1080 Pest Animal Management Authorisation and accompanying Permit to Take Protected Wildlife. Implement an on-going, rodent baiting program around built facilities. Minimise available food sources for introduced rodents around buildings and within the Central Facilities and Village. Implement an on-going cat baiting program around built facilities using proprietary baits such as Curiosity® with the toxin PAPP (para-aminopropiophenone).
Monitoring	Pre-Construction Prior to construction commencing, a weed survey will be conducted within the Project footprint + 200m buffer, to determine the location and extent of weeds within the Project footprint (including all areas to be accessed by construction personnel and equipment). The Weed Management Branch of the Department of Environment and Natural Resources will be consulted prior to the commencement of this survey. This will be used to prepare digital mapping and combined with a register of weeds identified on the site which will include: ■ Population locations of each weed species in the project footprint ■ For each discrete population, density observations and a representative photographic record.

Element	Detail
	Construction and Operation During construction and for a period of at least two years post-construction, weed monitoring will be conducted to ensure that high risk weeds have not been introduced. This will focus on wetland areas associated with Alligator and Forsyth Creeks, all construction impacted areas and those areas adjacent to construction areas. During the operational stage, weed monitoring within the Project footprint, particularly service corridors subject to road traffic, will be undertaken by a suitably qualified professional (somebody able to identify weeds both present on site, and other declared weeds in the NT) on an annual basis. The above surveys will update the weeds and pests register.
Reporting	The pre-construction survey will develop a spatial map of weeds and pests presence on the site, and a register of pertinent information in relation to weed and pest distribution, numbers and control requirements. This register will be updated with each new survey, siting, incident or complaint that occurs involving weeds and/or pests. Where alterations are made to the register, beyond only adding new entries, a copy of the register will be archived with the archive date. All weed wash documentation and Weed Declaration Forms to be maintained on-site. Where a new declared weed (Class A - C) is identified on the site, the Weed Management Branch of the Northern Territory Department of Land Resource Management must be notified of its presence within 14 days. Any non-conformance, incident or potential incident will be recorded on the incident-complaint form in Appendix E (or similar) and entered into the incident-complaint register for rectification and follow up. Updates to this strategy, particularly in developing the weed management plan for implementation, will be undertaken with consultation with the Weed Management Branch of the Department of Environment and Natural Resources.
Corrective Actions	Correction Action Triggers: ■ Presence of Class A, B or C weeds ■ Spread of existing weeds or pests, or introduction of new pests or weeds to the site ■ Plant or equipment being brought to the site shows signs of carrying weed seeds ■ Plant or equipment being brought to the site has not weed wash certificate ■ Plant or equipment leaving site shows signs of weeds or weed seed presence Corrective Actions: ■ Initiate control measures as outlined in this strategy for control of the identified weeds to eliminate Class A, control the spread of Class B, and avoid importation of Class C weeds into the Northern Territory ■ Initiate control measures to stop the spread and where practicable eradicate pests on the site ■ Stop plant / equipment from entering the site without appropriate weed wash documentation. If required, subject plant/equipment to weed wash prior to entry

Element	Detail
	 Plant / equipment to be subject to weed wash prior to leaving the site.
References <u>Weeds</u> DLRM (2014). Northern Territory Weed Management Handbook. Weed Management Branch, Northern Territory Department of Land Resource Management. NT Government (2016). Weed Management Plans - https://nt.gov.au/environment/weeds/weeds-and-the-law Statutory weed management plans and other guidance material that may be available, including:  Weed Management Plan for Gamba Grass (<i>Andropogon gayanus</i>). https://nt.gov.au/environment/weeds/list-of-declared-weeds-in-the-nt/gamba-grass  Weed Management Plan for Mimosa (<i>Mimosa pigra</i>). https://nt.gov.au/environment/weeds/list-of-declared-weeds-in-the-nt/mimosa  Weed Management Plan for Neem (<i>Azadirachta indica</i>). https://www.nt.gov.au/environment/weeds/list-of-declared-weeds-in-the-nt/neem  <i>Preventing Weed Spread is Everybody's Business</i> . https://landresources.nt.gov.au/rangelands/publications/weed-management-publications <u>Pest Fauna</u> DLRM (2015) Guidelines for the management of the pest animals of Legume. A report extract from Crowley, G.M. and Hill, B. M. (eds.) (2011) Management Practices for Wildlife Conservation in the Northern Territory. Version 1. Charles Darwin University, Darwin. Generated from www.infonet.org.au on 18 May, 2015. NT Government (2016) Controlling wild dogs and pest animals with 1080 poison. Last updated 19 April 2016. Available from: https://nt.gov.au/industry/agriculture/farm-management/controlling-pest-animals-wild-dogs-with-1080-poison	

C6

FAUNA MANAGEMENT STRATEGY

TABLE C6.1 - FAUNA MANAGEMENT STRATEGY

Element	Detail	
Applicable site activities		
Site Establishment		
Vegetation Clearing and Earthworks, Construction		
Operation		
Aim		
To maintain the conservation status, abundance, diversity, geographic distribution and productivity of flora and fauna at species and ecosystem levels through the avoidance or management of adverse impacts on the Project area and on adjacent areas that may be impacted.		
To minimise the risk of Significant Impacts to threatened species and communities, and migratory species listed under the EPBC Act, and species listed under the TPWC Act.		
Objectives	Targets	Key Performance Criteria
Undertake and complete works in compliance with statutory environmental requirements	No statutory infringements No breaches of licence/approval conditions	Number of infringements Number of breaches
Minimise the impacts of clearing and construction on flora and fauna	Comply with the Vegetation Management Strategy No harmful incidents involving wildlife	Number of breaches against Vegetation Management Strategy Number of fauna incidents
Minimise impacts of operations on fauna	No barriers to fish passage erected in waterways	
Responsibility	Construction: Construction Manager Operations: Site Manager	
Actions / Mitigation Measures	Waterbird Monitoring Program Implement the waterbird monitoring program Pre-Clearing Pre-clearance surveys will be undertaken in areas identified as potential habitat for threatened species, prior to commencement of clearing. In areas where these surveys indicate the presence of habitat features observed to (or with the potential to) provide habitat for these species, an experienced fauna spotter-catcher will be engaged to accompany clearing crews. Pre-demarcated habitat features identified during the pre-clearance survey will be thoroughly checked by a fauna spotter-catcher prior to clearing. The spotter-catcher will be required to hold a Permit to Take or Interfere with Wildlife. Vegetation Clearing Comply with the Vegetation Management Strategy, in particular to minimising vegetation clearing, and clearing only within the approved bounds	

Element	Detail
	In addition: - Undertake vegetation clearing sequentially so as to encourage fauna to disperse towards adjacent habitats that will remain intact - The spotter-catcher is to be in attendance during clearing operations to implement fauna relocation and protocols for injured wildlife. The fauna spotter-catcher will provide site specific fauna management protocols suitable for use on the site - Where possible, retain large trees with hollows and hollow logs on the ground to provide nesting opportunities for native species. - Where practical, temporary fencing will be erected around excavations to exclude mobile animals from vegetation clearing areas. - Work areas will be checked before work commences each day for fauna that may have become trapped. If any pits/trenches are to remain open after daily site works have been completed and are not in fenced areas, they will be securely covered by an impenetrable barrier, if possible, or fauna ramps (e.g. log ramps or wooden planks) will be put in place to provide a potential means of escape for trapped fauna. - Site inductions are to include education regarding the local fauna of the site and protocols to be undertaken if fauna are encountered. Traffic Vehicles will be required to stay on pre-determined routes and must comply with speed limits. Speed limits will be clearly signposted so as to minimise the potential for road kill. This will also apply to vessels operating on fresh and estuarine/marine waters. Where there is a fauna-vehicle interaction which results in a mortality, the animal will be relocated to the edge of the road immediately, and subsequently removed as quickly as practicable to reduce potential for scavengers to be subsequently struck. Boats will generally not be used on the site. In the rare circumstances they are, the key control will be speed reduction in areas where strike is a potential issue for marine megafauna, including turtles, dolphins, dugong and crocodiles. In the very unlikely event of an impact, contact the Marine Wildwatch hotline to determine the next steps. Hydrology and Aquatic Ecology Comply with the Surface Water Management Strategy, in particular to avoid changes to floodplain hydrology, and estuarine hydrology in receiving waters. Comply with the Erosion and Sediment Control Strategy to protect water quality during construction, and the Surface Water and Hazardous Materials Management Strategies during operation. Implement the Effluent Management Strategy on-site. Waterway Barriers Comply with the Erosion and Sediment Control Strategy for In-stream Works and Waterway Crossings during construction. For the operational stage, all waterway crossings are to contain suitable flood and low flow passage to avoid creating barriers to fish passage. Impingement and Entrainment of Aquatic Fauna at Intake Structure

Element	Detail
	Comply with the Surface Water Management Strategy Noise Disturbance Comply with the Noise Management Strategy. In addition: - Temporary noise barriers will be installed where construction works are within 100m of the main crossing of Alligator Creek, should impacts be shown to occur from initial avifauna monitoring in this location (refer Monitoring below). Visual Disturbance Implement the following measures where construction works are within 150 m of either Forsyth Creek or Alligator Creek: - Maximise the retention of existing woody vegetation (natural screening) - Develop construction schedules which minimise the period required to complete works - Design and implement temporary measures for visual buffer/screening between works areas and adjacent intertidal feeding habitat. - Investigate the viability of establishing a band of trees and shrubs along either side of the Alligator Creek infrastructure corridor extending up to 150 m either side of the crossing point to provide for permanent screening of movement activity within this part of the transport corridor. Bird Predation Management Strategies For the use of helicopters for bird predation management: - Restrict low altitude helicopter movements (i.e. <450m AGL) to airspace above the farm footprint - When transiting between farms, constrain routes to airspace above the Project footprint. - When transiting from the farm complex to other parts of the site, or off-site, maintain an altitude of >450m AGL and restrict movement to airspace above the Project footprint (e.g. infrastructure corridor). - When transiting between farms or from the farm complex to other parts of the site, or off-site, operate flights procedures which minimise the incidence and duration of rotor blade slap noise. Increased site access leading to increased take of important species Increased site access will be mitigated via the installation of gates on the access road and signs to discourage off road access.
Monitoring	Waterbird Monitoring Program Develop, refine and finalise the waterbird monitoring program prior to works starting on the site, as determined by the Scientific Advisory Group, based on the waterbird monitoring framework included in the Project Sea Dragon Stage 1 Legume Grow-out Facility, Supplementary Environmental Impact Statement, Appendix A. Implement the waterbird monitoring program. Construction

Element	Detail
	Implement Vegetation Management Strategy and Weeds and Pests Strategy monitoring, particularly in relation to inspection of clearing limits and potential damage to retained vegetation, and presence of weeds and pests on the site Pre-clearance surveys by a qualified and experienced spotter-catcher will be undertaken in areas identified as potential habitat for threatened species, prior to commencement of clearing. Monitor all work areas before work commences each day for fauna that may have become trapped. Monitoring of avifauna will be undertaken during initial construction works within 100m of the main crossing of Alligator Creek. Monitoring will record avifauna responses to determine whether noise barriers are required. Operation A series of experimental trials will be undertaken during the 2018/2019 wet season to assess responses of waterbirds to bird predation mitigation strategies within wetland habitat adjacent to the farms. A primary objective of this work will be to investigate practical flight protocols for future operations. Regular inspections of the intake structure, the intake channel and settlement ponds will be undertaken for signs of fauna being drawn into the system. In particular, the presence of threatened or near threatened species is to be noted and actions taken to return these to the wild. Increased Site Access Implement monitoring to detect changes in use of the site by employees or the community, and apply rectification measures where required, in accordance with the Cultural Heritage and Social Impact Management Strategies
Reporting	Record all incidents and complaints related to fauna on the incident-complaint form in Appendix E (or similar) and enter into the incident-complaint register for rectification and follow up
Corrective Actions	Correction Action Triggers: ■ Clearing outside of approved areas, or clearing where a spotter-catcher has not inspected or was not present ■ Flooding changes due to the works, or blockages to waterways ■ Aquatic fauna found trapped or entrained in the intake structure, channel or settlement pond ■ Noise or light disturbance occurs in proximity to turtle nesting sites, due to the Project ■ Boat strike or other injury to marine megafauna ■ Complaints regarding access to fishing grounds Corrective Actions: ■ Engage spotter catcher to inspect site as soon as possible to identify any injured fauna or fauna in distress to relocate or manage ■ Implement drainage controls and construct or rectify fish passages

Element	Detail
	- Remove fauna from intake structures and return to the wild, although only if safe to do so - Alter lighting and restrict noisy activities (refer Noise Management Strategy) to avoid impacts to nesting sites - If marine fauna are injured, contact the Marine Wildwatch hotline to determine the most appropriate actions. Do not approach crocodiles or enter the water where crocodiles are present without expert advice and assistance - Address complaints through the Cultural Heritage and Social Impact Management Strategies
References ANZECC & ARMCANZ (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality, National Water Quality Management Strategy EPBC Act Policy Statement 3.21—Industry guidelines for avoiding, assessing and mitigating impacts on EPBC Act listed migratory shorebird species (Policy 3.21)	

C7

SURFACE WATER MANAGEMENT STRATEGY

TABLE C7.1 - SURFACE WATER MANAGEMENT STRATEGY

Element	Detail	
Applicable site activities		
Intake of seawater from Forsyth Creek		
Management of waters within farms		
Earthworks and effects on floodplain hydrology		
Discharge of water from farms through the EPZ and to Alligator Creek		
Activities with the potential for spills, leaks or other discharges to surface waters		
Aim		
Ensure surface waters, including estuarine and marine waters, wetlands and floodplains, are protected both now and in the future, such that the ecological health, and the health, welfare and amenity of people are maintained.		
Ensure a safe and sustainable fresh and saltwater supply for the Project.		
Objectives	Targets	Key Performance Criteria
Undertake and complete works in compliance with statutory environmental requirements	No statutory infringements No breaches of licence/approval conditions	Number of infringements Number of breaches
Protection of marine, estuarine, freshwater and floodplain aquatic ecosystems	Design and Development Maintain post-development floodplain hydrology similar to pre-development levels Construction Implement the Erosion and Sediment Control and Acid Sulfate Soil Strategies, with:  No evidence of erosion or sediment loss from the site due to site construction activities  No oxidation of acid sulfate soils on the site due to site activities  No leaks or spills Implement the Fauna Management Strategy for maintenance of fresh and marine biota Operation No changes in intake and discharge hydrology, bathymetry, bank erosion, etc. Discharges comply with the proposed discharge criteria in Table C7.2. Outside of the initial mixing zone, waters comply with	Number of incidents or breaches of the Management Strategies Hydrology, bathymetry, bank erosion changes compared to reference sites Number of flood incidents from altered hydrology Number of complaints
Maintenance of the cultural and spiritual values of marine, estuarine, freshwater and floodplain waters, including ecosystems and biota		
Protection of human consumers, primarily for fish species, crabs, etc.		

Element	Detail	
	the interim site specific water quality trigger values shown in Table C7.3.	
Protection of water supplies (general water uses, stock drinking water) for existing and future pastoral uses	Existing water supplies are not impacted where possible (i.e. outside of Project footprint) - no negative changes to existing beneficial uses of surface waters where possible Develop a Post-Closure plan to ensure suitable water supplies to support an agreed level of pastoral operations	Number of exceedances of supply criteria - stock watering, drinking water (Table C7.3) Refer to Draft EIS, Volume 1, Chapter 3
Maintenance of existing public recreation and aesthetics, in relation to hydrology, water quality and fisheries resources	No complaints No unauthorised access	Number of complaints Number of incidents related to site access
Suitable freshwater supply to support the Project, primarily related to the Forsyth Dam supply	Potable water supplies are all treated prior to use on-site Potable water supplies are reliable with a supply volume sufficient for site operations	Number of freshwater exceedances (potable quality, Table C7.3; farm supply, as required by operations)
Responsibility	Construction: Construction Manager Operations: Site Manager	
Actions / Mitigation Measures	General Implement the Erosion and Sediment Control, Vegetation and Fauna Management Strategies Clearing and earthworks undertaken in the dry season, particularly in proximity to watercourses or estuarine areas Design, construct and maintain suitable erosion control, such as rock armouring and scour protection, particularly on structures and banks subject to tides and storm surge Avoid construction equipment traversing soft marine and floodplain sediments Appropriately placed and designed culverts and channel works on infrastructure to reduce upstream ponding and maintain waterway connectivity. Design crossings and culverts to allow for fish passage Intake Where possible, reduce the amount of seawater extracted from Forsyth Creek during neap tide periods. Assess the potential to delay or extend the seawater extraction period Discharge Comply with the discharge criteria outlined in Table C7.2. Minimise discharge of wastes (improve water quality) by efficient farm management - better feed conversion (less feed used), sufficient aeration (dissolved oxygen, reduce	

Element	Detail
	biochemical oxygen demand), water exchange rates and internal recycling, etc.
Monitoring	A baseline monitoring program has been developed, which will be continued up until the start of construction. From that point, construction and operational phase monitoring will be conducted, as follows: Baseline (pre-construction) monitoring Monitoring of surface waters at the sites and frequencies, and for the parameters nominated in Table C7.4, and shown in Figures C7.1 and C7.2 Visual monitoring to include pegging of banks to provide a baseline for further erosion and scour monitoring and protection works, particularly at the inlet and outlet Construction Visual monitoring in accordance with the Erosion and Sediment Control Strategy Construction and Operation Continue monitoring at the baseline monitoring sites as per Table C7.4, and Figures C7.1 and C7.2, in the dry season and the post-wet season on neap tides Continue visual monitoring of banks for erosion and scour, noting changes in relation to placed pegs (and replacing where necessary), particularly at the inlet and outlet. Regular site inspections along with erosion and sediment control inspections to include rock armouring, scour and erosion protection associated with banks and structures The parameters and sites monitored will be reviewed after 2 years of operation, and a revised monitoring plan prepared if required. Intake and Discharge Monitoring In addition to the water quality sampling identified above, conduct routine visual monitoring and inspections of the intake and outlet structures and banks for signs of erosion, fouling, injury to marine organisms, etc. Monitoring to be undertaken on a monthly basis at a point representative of discharge waters (as they are released to the environment) during operation, as outlined in Table C7.4.
Reporting	Prepare quarterly internal monitoring summary reports, summarising: ■ All monitoring data, particularly related to discharge and receiving water quality, exceedances and potential issues ■ Recommended rectification measures (if any) or changes to the monitoring program The analysis will adopt appropriate statistical analyses and the Before-After Control-Impact (BACI) experimental design. For the purposes of this monitoring program analysis, reference sites would be considered control sites An annual summary report will be prepared and provided to the NT government (NT EPA, etc.) on request Any non-conformance, incident or potential incident will be recorded on the incident-complaint form in Appendix E (or similar) and entered into the incident-complaint register for rectification and follow up

Element	Detail
Corrective Actions	Correction Action Triggers: ■ Injury or harm to fresh or marine biota ■ Excessive erosion at intake or discharge locations ■ Exceedance of discharge water quality triggers ■ Receipt of complaint due to access restrictions Corrective Actions: ■ Implement the fauna management strategy for fresh and marine biota where required ■ Instigate bank stabilisation works to protect against erosion ■ Initiate immediate follow up investigation of: ▲ The results - are they representative, errors at the laboratory or sampling? ▲ Re-sample and investigate potential sources of exceedances ▲ If re-sampling shows exceedances, undertake mitigation works, inside the farm (or other source), or alter discharges ■ Review the complaint, and contact the complainant to discuss. If this cannot be simply resolved, determine in accordance with Social Impact and Cultural Heritage Management Strategies
References ANZECC & ARMCANZ 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality, National Water Quality Management Strategy, Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand DERM 2010. Monitoring and Sampling Manual 2009 Environmental Protection (Water) Policy 2009 Version 2 September 2010. Department of Environment and Heritage Protection, Brisbane. Simpson, S. L., Batley, G. E., Chariton, A. A., Stauber, J. L., King, C. K., Chapman, J. C., Hyne, R. V., Gale, S. A., Roach, A. C. & Maher, W. A. 2005. Handbook for Sediment Quality Assessment, CSIRO, Lucas Heights, NSW. Simpson, S. L., Batley, G. B. & Chariton, A. A. 2013. Revision of the ANZECC/ARMCANZ Sediment Quality Guidelines. CSIRO Land and Water Science Report 08/07. CSIRO Land and Water.	

TABLE C7.2 PROPOSED DISCHARGE WATER QUALITY CRITERIA

Parameter	Mean	Maximum
Total Nitrogen (mg/L)	0.8	3.0
Total Phosphorus (mg/L)	0.1	0.3
Chlorophyll a (µg/L)	20	100
Total suspended solids (mg/L)	20	100

TABLE C7.3 INTERIM WATER QUALITY TRIGGER VALUES

Parameter	Proposed Interim Trigger
Marine and Estuarine Waters	
Total nitrogen	0.31 mg/L
Total phosphorus	0.20 mg/L
Chlorophyll a	3.2 µg/L
Total suspended solids	490 mg/L
Turbidity	450 NTU
Freshwaters	
Collect sufficient baseline data, and compare results to baseline	
Other	
Potable Water	Latest edition of the Australian Drinking Water Guidelines
Stock Water	ANZECC & ARMCANZ (2000) Guidelines for Fresh and Marine Water Quality
Other (other agricultural types, industrial, etc.)	

TABLE C7.4 MONITORING SITES (LOCATIONS IN TABLE C7.5)

Site	Description	Parameters and Frequency
Freshwaters		
F01	Alligator Creek upstream of tidal influence, important for waterbirds	2 times per year: late dry season and late wet season Physical and chemical stressors (nitrogen and phosphorous speciation, turbidity, pH, dissolved oxygen, conductivity) Chlorophyll a Recoverable hydrocarbons, and Pesticides.
F02	Ephemeral wetland	
F03	Turkey’s nest dam	
F14	Forsyth Creek, upstream of direct tidal influence, used by waterbirds	
F17	Alligator Creek, upstream site that is important to waterbirds	
F18	Forsyth Creek Dam. Water from the Dam is released in the late wet season.	
Estuarine and Marine Waters		
Forsyth Creek		Dry season and the post-wet season at estuarine receiving environment and reference sites
I05	Upstream of proposed intake pipe: comparative site not influenced by proposed discharge	

Site	Description		Parameters and Frequency
WT07	Mid estuary at site of intake pipe		on neap tides for: ■ electrical conductivity ■ pH ■ turbidity ■ dissolved oxygen ■ total suspended solids ■ total nitrogen ■ ammonia ■ oxides of nitrogen ■ Kjeldahl nitrogen ■ total phosphorus ■ reactive phosphorus ■ total organic carbon ■ chlorophyll a
I08	Offshore of mouth of Forsyth Ck		
Keep River			
I34	Keep River, offshore of the mouth of Alligator Ck		
Alligator Creek			
I27	Mouth of Alligator Creek, 7.75 km downstream of the proposed discharge		
I28	Mid estuary of Alligator Ck		
I29	Upstream in Alligator Ck		
Sandy Creek			
I30	Upstream reference site		
Victoria River			
I11	Reference site on the Victoria River		
I35	Reference site on the Victoria River		
Distant Reference Site			
I22	Distant reference site		
Benthic macroinvertebrates			Sample annually in the dry season
Creek	Intertidal	Shallow subtidal	
Forsyth Creek	I05	I06, I07, WT07	
Keep River	I10, I33, WB1	—	
Alligator Creek	I27, I28, I29, WB2, WB3	I09	
Distant Reference Sites	I11, I22, I23, I24	—	
Mangrove / estuarine sites I02, WT07, I27, I28, I29, I30, I10, I33, I21 and I22 Review satellite imagery (NDVI) for monitoring the health of vegetation			Annually monitor for: ■ Distribution and ecological health of mangrove and saltmarsh communities (satellite imagery with ground truthing), and ■ δ15N signature of mangroves

TABLE C7.5 MONITORING SITE LOCATIONS (MONITORING REQUIREMENTS TABLE C7.4)

Site	Latitude	Longitude
Discharge		

Site	Latitude	Longitude
D1	TBA	TBA
Freshwater		
F01	-15.1706	129.3435
F02	-15.0822	129.3931
F03	-15.0824	129.3918
F14	-15.0746	129.4193
F17	-15.2066	129.3845
F18	-15.2197	129.4614
Estuarine and Marine		
I02	-14.9685	129.2904
I05	-14.9712	129.4353
I06	-14.9519	129.3976
I07	-14.9162	129.382
I08	-14.8857	129.3849
I09	-15.096	129.2526
I10	-15.0278	129.2532
I11	-15.128	129.6127
I21	-14.8862	129.2602
I22	-14.6791	129.6201
I23	-14.5779	129.639
I24	-14.5699	129.5764
I27	-15.089	129.2358
I28	-15.1179	129.269
I29	-15.1019	129.2921
I30	-15.1682	129.2244
I33	-15.1566	129.1929
I34	-15.0745	129.2199
I35	-15.1379	129.6783
WB1	-15.1631	129.1988
WB2	-15.1145	129.2799
WB3	-15.1023	129.2423
WT07	-14.9738	129.4118



FIGURE C7.1 MARINE MONITORING LOCATIONS



FIGURE C7.2 FRESHWATER MONITORING LOCATIONS

C8

GROUNDWATER MANAGEMENT STRATEGY

TABLE C8.1 - GROUNDWATER MANAGEMENT STRATEGY

Element	Detail	
Applicable site activities		
Construction activities which intersect groundwater		
Activities with the potential to cause spills and leaks		
Operation of the site, particularly the saline farm ponds		
Aim		
Ensure groundwater resources are protected both now and in the future, such that the ecological health and land uses, and the health, welfare and amenity of people are maintained		
Objectives	Targets	Key Performance Criteria
Undertake and complete works in compliance with statutory environmental requirements	No statutory infringements	Number of infringements
	No breaches of licence/approval conditions	Number of breaches
Avoid groundwater contamination, maintain the quality of groundwater used for water supply	No leaks or spills	Number of incidents
	No negative change in the quality (chemistry) of a groundwater resource due to project operations Existing bore beneficial uses retained Implement Effluent Management Strategy	Number of exceedances of beneficial use criteria Table C8.2) Compliance with Effluent Management Strategy
Avoid oxidation of acid sulfate soils and generation of acidic leachate resulting from these soils	Implement Acid Sulfate Soil Management Strategy	Compliance with Acid Sulfate Soil Management Strategy
Ensure the protection and resilience of groundwater dependent ecosystems (GDEs)	No change in seasonal groundwater level in the vicinity of GDEs due to project operations	Degree of change in groundwater level, flow in GDE
	No negative change in the quality (chemistry) of groundwater in the vicinity of GDEs due to project operations	Degree of change in groundwater quality in GDE
Responsibility	Construction: Construction Manager Operations: Site Manager	
Actions / Mitigation Measures	Implement Hazardous Materials, Waste, Acid Sulfate Soil and Effluent Management Strategies	
	Manage excavation depths in borrow pits and monitor groundwater levels to avoid lowering groundwater and damaging productive aquifers / bores	
	Ensure that stormwater diversions and flood management does not change the flow	

Element	Detail
	into and out of groundwater recharge zones - pre and post construction flooding levels to be as similar as practicable, using culverts and floodways to avoid excess ponding and allow for continuity of flow. Avoid impacting or drawing from pastoral use bores and borefield areas (freshwater supply will be from Forsyth Creek Dam via the Freshwater Channel) Implement procedures for rapid response to identified large pond and channel leaks. These will include: - Early detection of leaks through groundwater monitoring of tracers and/or fingerprinting of waters (anion/cation mixes, etc.) - Integrity testing of areas with the potential to leak - Rectification of leaks, by in-situ repair works, with emptying of the pond in extreme situations
Monitoring	The monitoring program outlined in Table C8.3 will be undertaken for the Project. Monitoring will involve: - A baseline monitoring round of all monitoring bores for the stated parameters, repeated each quarter until operations begins - Continued monitoring of groundwater bores on a 6-monthly basis for the first 2 years of operations, and annually thereafter. - Logged water level will be collected and analysed monthly for the first 2 years in the vicinity of the farm ponds, particularly the piezometers installed around the farm area. Additional water level loggers will be installed in any productive bores in proximity to ponds and channels, and areas of excavation (i.e. borrow pits). - Groundwater quality will be sampled in the farm area for in-situ parameters (pH, electrical conductivity) and for a suite of anions and cations, to allow identification of leaks (by matching groundwater changes to the 'fingerprint' from pond/channel water if possible). - Productive bores will be monitored to ensure their existing beneficial uses are not impacted, by comparison with the criteria in Table C8.2. - Visual monitoring of Groundwater Dependent Ecosystems as part of vegetation monitoring program (refer Vegetation Management Strategy). Monitoring bores are shown in Figure C8.1.
Reporting	A review of monitoring results and findings will be conducted annually, and a summary report prepared. This will be provided to the Seafarms Environmental Management team, and to authorised NT Government and officers on request. Any non-conformance, incident or potential incident will be recorded on the incident-complaint form in Appendix E (or similar) and entered into the incident-complaint register for rectification and follow up
Corrective Actions	Correction Action Triggers: - Bore monitoring results show elevation in salinity in proximity to grow-out ponds and channels, while reference / background sites do not - Potentially impacted productive bore levels dropping while reference bores are not

Element	Detail
	- Other contamination detected in groundwater aquifers, particularly associated with effluent irrigation areas (nutrients, BOD, E.Coli), pond or channel areas (nutrient impacts) or large leaks or spills (various) Corrective Actions: - Identify the source of leaks, spills or contamination by: - Undertaking a review/inspection of the site and incident-complaints register for recent events that may explain the findings - Performing a water balance on potential sources of leaks - Comparing the water quality fingerprint (anions, cations), and/or - Applying a non-toxic tracer compound - Rectify leaks as soon as practicable once identified. - Cease works which are drawing from productive bores (dewatering in borrow pits, or drainage from borrow pit walls most likely, but very unlikely to occur) - Engage a suitably qualified and experienced hydrogeologist to assess the site and provide amelioration measures for contaminated aquifers (such as pump and treat, cutoff trenches, etc.)

References

NT Government (2016). Groundwater. <https://nt.gov.au/environment/water/groundwater>

NT Government (2016). Water data portal. <https://nt.gov.au/environment/water/water-data-portal>

Tickell, S.J. (2013). Groundwater of the Northern Territory, 1:2,000,000 scale map. Department of Land Resource Management, Northern Territory.

Tickell, S., (2008), Explanatory notes to the Groundwater Map of the Northern Territory.

Northern Territory Government Department of Natural Resources the Environment The Arts and Sport, Technical Report No. 12/2008D

Tickell, S.J. and Rajaratnam, L.R. (1995). Water Resources Survey of the Western Victoria River District, Legume Station. Power and Water Authority, Water Resources Division. Report 31/1995D, June 1995

TABLE C8.2 - WATER SUPPLY CRITERIA

Water Supply Type	Reference
Potable Water	Latest edition of the Australian Drinking Water Guidelines
Stock Water	ANZECC & ARMCANZ (2000) Guidelines for Fresh and Marine Water Quality
Other (other agricultural types, industrial, etc.)	

TABLE C8.3 GROUNDWATER MONITORING PROGRAM

ID	Easting	Northing	Total Depth (mbgl)	Slotted Range (mbgl)	Aspect	Monitoring

ID	Easting	Northing	Total Depth (mbgl)	Slotted Range (mbgl)	Aspect	Monitoring
Piezo 1	541643	8338152	3.0	1.5 to 3.0	Farms (Piezos 3 and 5 will be within ponds during operation, and will no longer be monitored)	Logged water level Water chemistry
Piezo 2	542258	8342899	2.81	1.31 to 2.81		
Piezo 3	540822	8341687	3.0	1.5 to 3.0		
Piezo 4	537957	8340712	3.0	1.5 to 3.0		
Piezo 5	539683	8337478	3.2	1.7-3.2		
RN027014	542131.5	8331961	20	nd		Water level (preferably logged, but not necessary) Water chemistry
RN005135	539131.5	8335161	39.6	nd		
RN038543	538158	8333350	24	Aquifer 9 -24m		
RN027012	547831.5	8316211	60	nd	Water level associated with Forsyth Dam Borrow Pits	Water level (preferably logged, but not necessary)
RN029730	549031.5	8316411	38.6	22.6 – 34.6		
RN005484	548731.5	8316561	22.3	nd		
RN005180	549837.5	8317497	36.6	nd		
RN005133	549231.5	8319261	50	nd		
RN004118	548431.5	8318261	120.4	nd		
RN025202	536565.5	8314901	36	28 - 33	Water level associated with Central Facilities Borrow Pits. Select the one most promising bore of these three	Water level (preferably logged, but not necessary)
RN005313	536566.5	8314936	28	nd		
RN029936	536566.5	8314961	24.48	nd		
New Bore 1	TBD	TBD		Shallow, deep nested	Central Facilities Land Application area, up and down gradient (for groundwater flow)	Water level Water chemistry, nutrients, E.coli, BOD
New Bore 2	TBD	TBD		Shallow, deep nested		
New Bore 3	TBD	TBD		Shallow, deep nested	Accommodation Village Land Application area, up and down gradient	Water level Water chemistry, nutrients,
New Bore 4	TBD	TBD		Shallow, deep nested		

ID	Easting	Northing	Total Depth (mbgl)	Slotted Range (mbgl)	Aspect	Monitoring
					(for groundwater flow)	E.coli, BOD
New Bore 5	TBD	TBD		Shallow, deep nested	Farm Services Land	Water level
New Bore 6	TBD	TBD		Shallow, deep nested	Application area, up and down gradient (for groundwater flow)	Water chemistry, nutrients, E.coli, BOD
Reference / background Sites	TBD	TBD	Sufficient reference and unimpacted sites to allow comparison of results from the above for (primarily) salinity and groundwater level impacts. These will show similar historical results to monitored bores, and/or be in similar hydrogeological locations, but their aquifers isolated from Project impacts, or up-gradient from the Project (to detect changes with distance).			

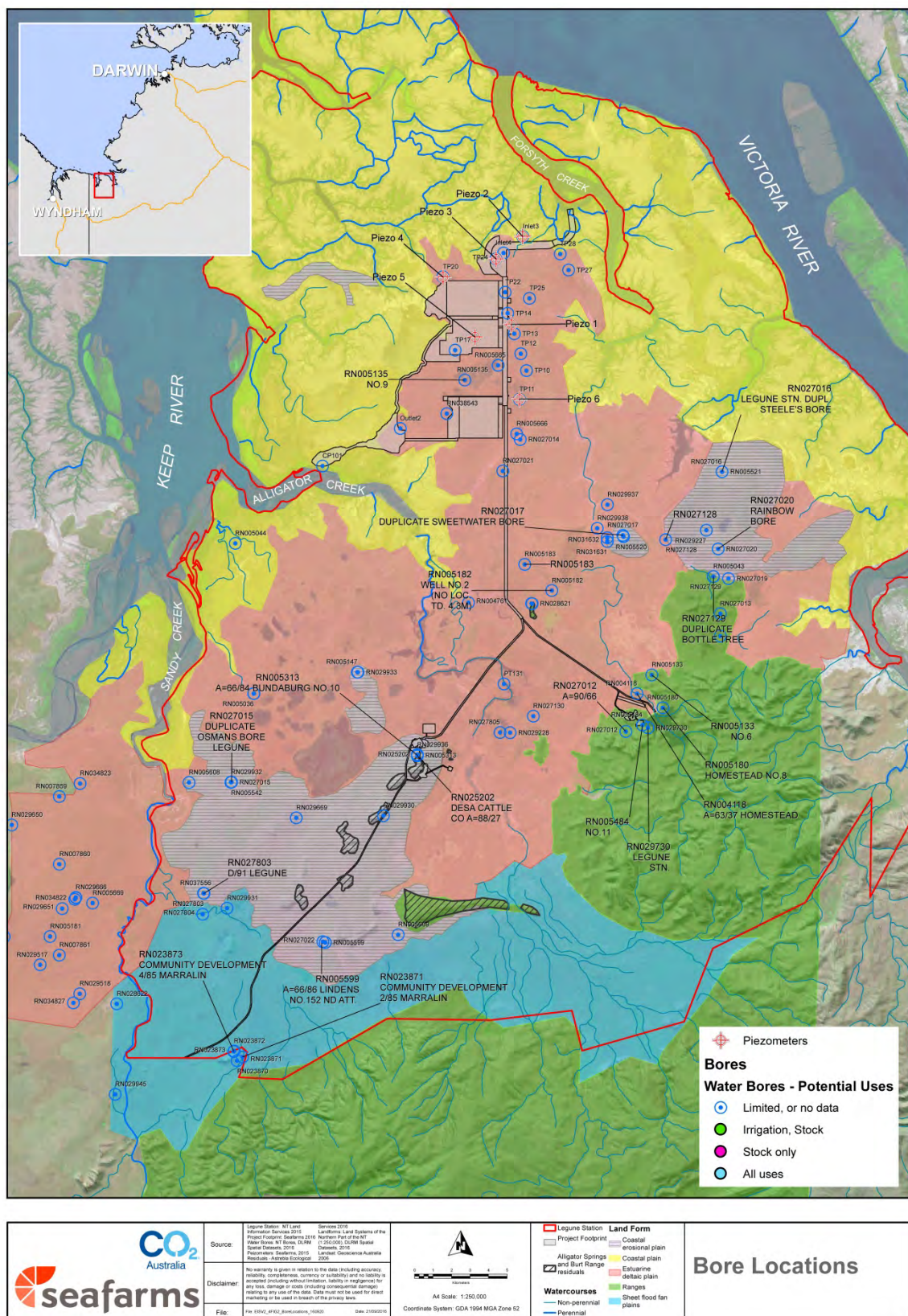


FIGURE C8.1 - MONITORING BORE LOCATIONS

C9

WASTE MANAGEMENT STRATEGY

TABLE C9.1 - WASTE MANAGEMENT STRATEGY

Element	Detail	
Applicable site activities		
All construction and operational activities generating, managing or interacting with waste.		
Excludes discharges through the EPZ into Alligator Creek of farm water (refer Surface Water Management Strategy)		
Aim		
Ensure wastes generated by the Project, both solid and liquid, are appropriately managed in accordance with the waste management hierarchy to minimise the risks of environmental pollution and public health nuisances.		
Objectives	Targets	Key Performance Criteria
Undertake and complete works in compliance with statutory environmental requirements	No statutory infringements No breaches of licence/approval conditions	Number of infringements Number of breaches
Protection of environmental ecosystems, quality and amenity	No leaks or spills No uncontrolled waste on the site All putrescible waste removed within 7 days either to landfill or for soil / waste conditioning on or off-site No hazardous or potentially contaminating wastes, including waste drums or containers, are stored outside of nominated areas Hazardous wastes removed from site or fully contained under cover and above flood levels before the wet season	Number of incidents Number of breaches in site visual inspections Post-storm site condition assessment failures
Minimisation of Waste disposed to on or off-site landfill	Waste targets met. 100% of recyclables are recycled No circumstances of inappropriate waste segregation	Assessment against waste targets Number of non-compliances
Waste Hierarchy		
<u>Avoid and Reduce (1, 2)</u>		
This element involves effective choices and management in procurement and site practices, to limit the amount of waste actually generated.		
<u>Reuse and Recycle (3, 4)</u>		
Reuse and recycling are the next best waste management options, avoiding disposal by maintaining the material in a productive state. The preferred approach is reuse of materials without further processing, being lower energy and material intensive, followed by recycling, where materials may be turned into other materials, potentially with different uses.		
<u>Recover (5)</u>		
Recovery refers to recovery of energy or other materials from a waste stream prior to it going to disposal, or		

Element	Detail
	rectifying a waste so that it doesn't ultimately require disposal, such as on-site soil conditioning. <u>Dispose (6)</u> Disposal is the least preferred option, and the waste management system will seek to minimise as much as practicable disposal of waste, either in the on-site landfill, or off-site landfill sites, by using the above more preferred approaches.
Responsibility	Construction: Construction Manager Operations: Site Manager
Actions / Mitigation Measures	General All permanent and temporary storage facilities are to be designed and operated according to appropriate Australian Standards or guidelines. Store hazardous materials in accordance with the Hazardous Materials Management Strategy Maintain products and dispose of all wastes in accordance with their MSDS Implement the waste hierarchy above to preference practices at the top of the hierarchy (avoid, reduce, reuse) below those lower down (recycle, recover, dispose). This to include: ■ Use care in ordering of products and materials to minimise waste ■ Provide segregation of wastes at source where practicable ■ Ensure bins containing putrescible waste are fitted with lids and closed at all times ■ Look for opportunities to reduce, reuse or recycle materials on site. Dispose of wastes as described in Table C9.2. Update Table C9.2 as required to ensure it remains current, and includes all waste streams. Locate waste storage and collection areas away from overland flow paths and direct stormwater away from these areas. Listed Waste (defined in the Waste Management and Pollution Control Act), shall be collected and removed from the site by a licensed contractor, to a licenced site. All litter and waste materials to be stored or transported from the site shall be covered to prevent spillage or loss of materials. Construction Temporary waste collection facilities will be provided, and waste streams sorted as much as practicable at source prior to removal from site. Waste will be regularly removed from site by appropriately licensed contractors, to appropriately licensed facilities. Putrescible waste will be removed at least weekly. Waste separation facilities (including recycling facilities) shall be provided in an area accessible to collection vehicles. Implement the operational waste controls as soon as practicable during construction. Operation Implement the waste strategy described in this EMP, including:

Element	Detail
	■ Waste receptacles located at source, including at source sorting into general waste, recyclables, and listed wastes ■ Transfer of general, recyclable and other non-listed and non-hazardous wastes to a Waste Transfer Facility at the Accommodation Village, or temporary storage at farm services and Central Facilities prior to transfer to this Waste Transfer Facility ■ Transfer of listed and hazardous wastes to a Hazardous Waste Facility located at the Central Facilities, before removal off-site by licenced transporters to licenced facilities for reuse, recycling, recovery or disposal ■ Drainage of washwaters and rainfall from putrescible bin storage areas into the wastewater treatment plants, via appropriate trash rack screens and sumps in the floor of these areas ■ Disposal of general and inert waste at an on-site landfill. Interstate Transfer Transfer of waste interstate will require a number of authorisations from relevant authorities, either by Seafarms or the transport company. All authorisations are to be in place and a copy maintained on-site for any interstate transfer.
Monitoring	General The waste inventory outlined in this EMP will be updated and maintained during construction and operational phases to record all waste types, quantities produced, and management measures used for each. An annual review will be conducted, and waste targets set for the coming year. Each annual review will assess the progress against the waste targets, and identify opportunities (and constraints) for continued waste minimisation and optimisation. Landfill Monitoring Program The landfill will be subjected to a monitoring program including: ■ Daily visual inspections of the site for signs of the loss of waste materials from the site, erosion, odour, dust, and pest animals and weeds ■ Groundwater bores around the perimeter of the landfill, to provide early warning of any potential leaching or loss of leachate from the landfill into groundwater. Bores will be located up and down gradient of the landfill ■ Routine landfill survey to determine the existing utilised and remaining capacity within the engineered landfill.
Reporting	The waste produced on the site and the ultimate end-point will be recorded and summarised annually, to determine opportunities for waste minimisation. Transfer of wastes from the site will be recorded, either by the retention of a receipt from waste transporters, or in the case of listed wastes the quantity removed, transporter, destination, and treatment/disposal method will be recorded in a register, along with the receipt from the transporter. Any non-conformance, incident or potential incident will be recorded on the incident-complaint form in Appendix E (or similar) and entered into the incident-complaint register for rectification and follow up

Element	Detail
Corrective Actions	Correction Action Triggers: ■ Inappropriate disposal of wastes, either into the environment, or disposal of wastes that can practicably be recycled ■ Uncontrolled waste disposal ■ Listed wastes removed from the site without appropriate waste tracking, and/or by an unlicensed person, and/or to an unlicensed site Corrective Actions: ■ Implement this waste management strategy where site procedures are non-compliant. Review and revise this strategy if required ■ Clean up and appropriately dispose of any waste as needed ■ Ensure only licensed waste transporters are utilised to transport listed wastes.
References LGANT (2010) Waste Management Guidelines for Small Communities in the Northern Territory. Effective from Local Government Association of the Northern Territory, 1 January 2010 NT EPA (2013) Guidelines for the Siting, Design and Management of Solid Waste Disposal Sites In the Northern Territory. Northern Territory Environmental Protection Authority, January 2013 NT EPA (2015) Waste Management Strategy for the Northern Territory 2015 - 2022. Northern Territory Environmental Protection Authority, July 2015 NT EPA (2013). Guideline for Disposal of Waste by Incineration. Version 2.0, Northern Territory Environment Protection Authority, November 2013 NT EPA (2016). Listed Waste Company Summary https://ntepa.nt.gov.au/data/assets/excel_doc/0006/285720/listed_waste_company_summary.xlsx National Environment Protection Measures (NEPM). <u>Interstate Transfers:</u> NEPM Movement of Controlled Waste between States and Territories (1998) Western Australian Environmental Protection (Controlled Waste) Regulations 2004, which requires a controlled waste tracking form and Consignment Authorisation (CA) from the Department of Environment Regulation, along with a Waste Transport Certificate (WTC) from the Northern Territory. Queensland Environmental Protection Regulation 2008, which requires a WTC from the Northern Territory and CA from the Department of Environment and Heritage Protection	

TABLE C9.2 - SUMMARY OF WASTE MANAGEMENT APPROACH FOR WASTE STREAMS

Waste Source	Waste Classification	Management Strategy
Construction		
Vegetation Clearing	Green Waste	Minimise vegetation clearing areas (1, 2); burning of grassland areas avoiding generation of waste for disposal (1, 2); mulching of woody vegetation for reuse in revegetation,

Waste Source	Waste Classification	Management Strategy
		soil stabilisation and rehabilitation (3), or burnt on-site (6)
Excavated Soils	Inert Waste	Waste soils will be minimised by adopting a cut/fill balance (1); any topsoils remaining will be stockpiled for reuse on-site in revegetation, soil stabilisation and rehabilitation (3)
Concrete, rock, inert C&D waste	Inert Waste	Procurement and concrete batching to be managed to reduce material wastage (1, 2); material to be reused as fill (structural or otherwise), or scour protection (3); excess material to be disposed to landfill (6)
Steel, metal waste, offcuts	Recyclables	Waste metal bins to be provided at relevant locations across the site, primarily workshops and maintenance areas. Recycling bins will also be provided next to all general waste receptacles to allow for sorting at source. All recyclable wastes removed to the Waste Transfer Facility for ultimate removal off-site to the receiving station at Kununurra for recycling (4)
Asbestos Containing Materials (ACM) (unexpected findings)	Listed Waste	If found, the site will be isolated and a site investigation will be initiated and site stabilisation and/or cleanup initiated. ACM will generally be double wrapped and removed by licenced operators to a licenced facility for disposal by burial (6)
Construction and Operation		
Batteries	Listed Waste	Vehicle batteries will be removed to the Central Facilities and stored in a bunded area within the Central Hazardous Waste Facility, before removal off-site by a licenced transporter to a licenced facility for recycling (4) and material recovery (5)
Tyres	Listed Waste	Tyres will be stored on the site in small quantities, and sent off-site prior to representing a fire hazard for re-treading (3) or recycling (4) where possible, or disposal (6). Removal will be by a licenced transporter to a licenced facility, to the receiving station at Kununurra.
Used oil/fuel filters, waste oil, oil-water mixtures, oily rags, absorbent and oil spill cleanup products (spent)	Listed waste	Liquid waste of this type will be stored at various locations across the site (at source), in waste oil drums, oil-water separators, and similar, and either: ■ Removed periodically to the Central Hazardous Waste Facility, for later removal off-site by a licenced transporter, or ■ Removed periodically from each source by a licensed transporter. Solid material such as oily rags, oil filters and spent absorbent will be stored in drums under cover until removal

Waste Source	Waste Classification	Management Strategy
		to the Central Hazardous Waste Facility, for later removal from the site by a licenced transporter. Material removed from the site will be processed to recycle (4) or recover (5) oils for reuse, with residual material, including solids, disposed to licenced landfill facilities (6).
Empty chemical and hazardous materials drums and containers	Potentially Listed Waste if containing the residue of a Listed Waste	Waste containers will be stored within bunded areas, in the temporary hazardous waste storage areas across the site, or inside the Hazardous Waste Facility. Alternatively, containers double rinsed with fresh or salt water may be stored as non-hazardous materials (not in bunded or roofed areas) prior to removal off-site.
Oil contaminated soil	Listed Waste	This is expected to be very minimal. Where it is quite small, this can be removed with spent absorbent material as described in the above row for disposal off-site to a licenced facility (6). If larger quantities are involved, on-site soil conditioning will be used where practicable, involving laying out, turning and fertilisation (potentially with nutrients from pond waste) to allow microbes to break down hydrocarbons in the soil (5). Regular soil testing will be undertaken to determine when the soil can be considered 'clean' for reuse (as fill) back on the site (this is not anticipated to be required, however if it is, an approval from NT EPA would be sought prior to undertaking on the site).
Paints and solvents	Listed Waste	These materials will be stored in sealed drums at source, and regularly removed to the Central Hazardous Waste Facility for later transport off-site by licenced transporter to a licenced facility. Recovery (5) or disposal (6) may then occur off-site.
Plastics (classes)? Such as poly pipe, offcuts,	General Waste	This material, where it cannot be reused on the site (3), will be disposed of to landfill (6) with general waste.
Personal Protective equipment and small items:  Gloves  Hardhats  Safety glasses  Boots, biosecurity gear  Water coolers	General Waste	This material will likely be in small quantities relative to the general waste stream, and will be disposed of to landfill with general waste (6).
Vehicle washbays - wash	Listed Wastes	Washbays will produce oil-water mixtures, and biocide

Waste Source	Waste Classification	Management Strategy
waters, first flush runoff		containing waters for disposal. An oil-water separator will separate oily water from the treatable water that will be pumped to the on-site package wastewater treatment plants (5), with the oil-water residue treated as described below.
Workers on-site, accommodation including: - putrescible wastes - Non-class 1, 2, 5 plastics	General wastes	This material will be disposed of to the on-site landfill (6).
- Aluminium and steel cans - Class 1, 2, 5 plastics - Cardboard - Paper	Recyclable wastes	A separate recycling bin will be provided at source, regularly removed to the Waste Transfer Facility and, where practicable, further sorted (e.g. into cans, recyclable plastics, cardboard). This material will be removed off-site for recycling (4).
Wooden Pallets	Green waste (untreated) Listed waste (treated)	Pallets will be stored at the Waste Transfer Facility. Those that can be re-used will be trucked to the Processing Plant at Kununurra where they will be washed and re-used for product transport or bagged feed.
Sewage effluent	Sewage Effluent	Effluent will be treated by package on-site wastewater treatment plants, and disposed of by land disposal systems. This is nominally number (6) in the hierarchy, although effective treatment and disposal will be much more benign than would be waste disposal to landfill.
Sewage Sludge and Grease Trap waste	Listed waste	This material will be stored at and accumulate at various locations across the site (at source), and will be removed periodically from each source by a licensed operator, and transported off-site to a licenced facility for soil conditioning and recovery (5) or disposal (6).
Waste from on-site paramedics, nursing/first aid station	Listed Waste (Clinical waste)	A portion of this material may be clinical waste, requiring off-site disposal to a licenced facility. This may include sharps (stored in a sharps container prior to removal), dressings and pharmaceuticals (typically able to be disposed of to landfill unless in large quantities, unlikely to occur on the Project site)
Operation		
Feed bags	General or Recyclable Waste	Feed bags will generally be a woven polypropylene bulka bag. This will be either reused by filling with sand/cement mix and using as armour for scour protection (3), removed from site for recycling where possible (4), or disposed of to

Waste Source	Waste Classification	Management Strategy
		landfill (6). Reduction of this waste stream (1, 2) is achieved through improving the Feed Conversion Ratio in ponds, related to pond management, and will be an ongoing refinement process for economic and environmental reasons.
Waste (spoiled) feed	General Waste, or if in large quantities, Listed Waste	In small quantities, this material might be used as fertiliser to assist with the growth of vegetation (landscape or stabilising vegetation) under cover to avoid attracting pests, or disposed of to landfill with general waste (6). In larger quantities (an unlikely and emergency type situation), this material can be conditioned with farm/settlement pond waste (soil composting). This would be undertaken in windrows adjacent to the landfill site until the material is suitably benign to use as topsoil dressing or fertiliser on the site (5)
Channel and settling ponds silt and sediments	Inert Waste	This material can be stockpiled for reuse on-site in revegetation, soil stabilisation and rehabilitation (3), including in soil improvement for higher organic load material such as farm pond spoil, and in soil conditioning or windrowing activities
Pond sludge / waste, including organic material from prawn farming	Inert waste after stabilisation	This material is initially anoxic, but upon drying and stabilisation is an inert waste, although high in nutrients. The material is likely to be useful for topdressing berms and embankments for re-vegetation, and may represent a useful and valuable resource (3). It may also be mixed with other organic wastes to improve soil conditioning if undertaken on the site (5). Where not able to be used on the site, the material will be stockpiled and compacted into a low stable landform (6).
Dead prawns	General Waste (putrescible waste)	This waste will generally be of small quantities, and disposed of to landfill (6) or composted on the site (5). In large quantities, on-site landfill disposal with lime covering would be adopted (5), or off-site transport for conditioning or disposal (5, 6). Where major quantities arise as part of a notifiable disease outbreak, this will be handled by the official regulatory process, involving development of a plan by the Department of Fisheries and the proponent, covering shutdown of parts or all of the Grow-out Centre, agreed treatment and disposal of prawns. Disposal would be via a method guaranteed to avoid spread of disease / prawn remains, odour, etc.

Waste Source	Waste Classification	Management Strategy
Laboratory waste	Listed Waste General Waste	General waste will be disposed of to landfill (6). Clinical waste would be expected to be minimal (if any), and if required will be appropriately packaged, stored within the hazardous waste facility, and transported off-site by licenced transporter to a licenced site for disposal (6).

Table notes: (1) Avoid; (2) reduce; (3) reuse; (4) recycle; (5) recover; (6) dispose

C10

AIR AND NOISE MANAGEMENT STRATEGY

TABLE C10.1 - AIR AND NOISE MANAGEMENT STRATEGY

Element	Detail																			
Applicable site activities																				
Primarily construction, particularly intake pile driving operations, earthmoving machinery, dust generation from vegetation clearing and earthworks																				
Operational phase power generation																				
Aim																				
Protect the health, welfare and amenity of people due to noise and air quality impacts.																				
Objectives		Targets		Key Performance Criteria																
Undertake and complete works in compliance with statutory environmental requirements		No statutory infringements No breaches of licence/approval conditions		Number of infringements Number of breaches																
No dust, odour or air quality impacts to sensitive receptors on the site (refer Table C10.2 and Figure C10.1)		No complaints Air quality at sensitive receptors does not exceed the following due to the Project: 50 µg/m2 for PM10 (24h averaging period) 30 µg/m2 for PM10 (annual averaging period) 2 g/m2/month (annual averaging period) 246 µm/m3 for NO2 (hourly averaging period) 7 odour units, Legune Station homestead 4 odour units, Accommodation Village		Number of complaints Number of exceedances																
No noise impacts to sensitive receptors		No complaints Noise levels at sensitive receptors does not exceed the following due to the Project: Construction <table><tr><td>7 am to 7 pm (Mon - Sat)</td><td>Background + 5dB</td></tr><tr><td>9 am to 6 pm (Sun or public holiday)</td><td>Background + 5dB</td></tr><tr><td> Legune Station</td><td>58dB</td></tr><tr><td> Accommodation Village</td><td>51dB</td></tr></table> Operation <table><tr><td>Time Period</td><td>Amenity Criteria (dBA)</td><td>Intrusive Criteria (dBA)</td><td>Project Specific Criteria (dBA)</td></tr><tr><td>Day</td><td>50</td><td>43</td><td>43</td></tr></table>		7 am to 7 pm (Mon - Sat)	Background + 5dB	9 am to 6 pm (Sun or public holiday)	Background + 5dB	Legune Station	58dB	Accommodation Village	51dB	Time Period	Amenity Criteria (dBA)	Intrusive Criteria (dBA)	Project Specific Criteria (dBA)	Day	50	43	43	
7 am to 7 pm (Mon - Sat)	Background + 5dB																			
9 am to 6 pm (Sun or public holiday)	Background + 5dB																			
Legune Station	58dB																			
Accommodation Village	51dB																			
Time Period	Amenity Criteria (dBA)	Intrusive Criteria (dBA)	Project Specific Criteria (dBA)																	
Day	50	43	43																	

Element	Detail			
	Evening	45	43	43
	Night	40	41	41
Responsibility	Construction: Construction Manager Operations: Site Manager			
Actions / Mitigation Measures	Dust Water will be applied periodically to unsealed road and construction area surfaces used for mobile plant and vehicle traffic. Speed limits will be enforced for all vehicles on unsealed roads. Vegetation clearing will be limited and exposed areas revegetated, where possible. Construction water will be pumped close to earthworks, to minimise traffic and long road hauls. Temporary camps and construction laydown areas will be located as close to earthworks as practicable. Weather reports will be checked daily to enable action to be taken immediately if conditions change. Control measures will be implemented in a way that also controls for dust while the site is unattended, e.g. at night or on weekends. A site 'shut down and cover up' policy will be implemented during periods of extreme weather conditions. Additional dust control methods that can be employed where required to control impacts include: - Physical barriers around dust generating activities (dust fences) - Dust suppressants on stockpiles or berms / slopes Odour Pond sediment will be allowed to dry sufficiently prior to disturbance Sediments that are likely to be odorous will not be disturbed when wind direction and speed are likely disperse the odour toward any sensitive receptors (i.e. not on poor dispersion light wind days). On-site sewage treatment plants will be operated efficiently so as to minimise or eliminate odour (well run plants typically do not produce excessive odour). Implement the Effluent Management Strategy. Noise Undertake works with the potential to affect noise sensitive areas only between the hours of: 7 am to 7 pm Monday to Saturday 9 am to 6 pm Sunday or Public Holidays			

Element	Detail
	All equipment will be selected to minimise noise emissions Equipment will be fitted with appropriate silencers and be in good working order All engine covers will be kept closed while equipment is operating The height at which material is dropped into or out of trucks will be minimised as far as practicable Vehicles should be kept properly serviced and fitted with appropriate mufflers. The use of exhaust brakes will be minimised, where practicable Machines found to produce excessive noise compared to industry best practice will be removed from the site or stood down until repairs or modifications can be made. To reduce the annoyance associated with reversing alarms, broadband reversing alarms (audible movement alarms) will be used for site equipment where working near sensitive areas.
Monitoring	As part of regular site inspections (weekly during construction and operation), observations will be made of dust, odour, air quality and noise from site works. Any unacceptable noise will be recorded in the Site Manager's logbook, or the site visual inspection form in Appendix E (or similar) for follow up and rectification. Monitoring will be conducted at sensitive receptors where a complaint (non-vexatious) has been made, where evidence is required against air quality criteria, with the monitoring selected as follows: ■ Dust: PM10 and dust deposition ■ Odour: H2S monitoring as an indicator, or odour unit sampling if required ■ Noise: According to AS 1055.1 - 3: Acoustics
Reporting	Any non-conformance, incident or potential incident will be recorded on the incident-complaint form in Appendix E (or similar) and entered into the incident-complaint register for rectification and follow up. Any monitoring results will be retained and summarised into annual monitoring / environmental performance reporting.
Corrective Actions	Correction Action Triggers: ■ Noise, dust or odour complaint ■ Observed excessive noise, dust or odour emissions ■ Odours in proximity to sewage treatment plants Corrective Actions: ■ Respond to the complaint on the same day if possible and determine the time, location and possible source ■ Rectify any problems identified if practicable, and if non-vexatious, consider monitoring to determine whether air or noise quality criteria are being exceeded. ■ Follow up on complaints after rectification works to determine if they have been successful ■ For sewage treatment plants, inspect the plant, and determine if system needs maintenance, such as sludge pumping or other works to ensure efficient operation.

Element	Detail
	Additional odour control systems may be required to be retrofit.
References NT EPA (2014) Noise Guidelines for Development Sites in the Northern Territory. Northern Territory Environment Protection Authority, May 2014 New South Wales (NSW) Industrial Noise Policy DEC (2005). The Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales. NSW Department of Environment and Conservation EPA Victoria (2013) Recommended Separation Distances for Industrial Residual Air Emissions. EPA Victoria, Publication Number 1518, March 2013. AS 1055.1-1997: Acoustics – Description and measurement of environmental noise, Part 1 General procedures AS 1055.2-1997 Acoustics – Description and measurement of environmental noise, Part 2 Application to specific situations AS 1055.3-1997 Acoustics – Description and measurement of environmental noise, Part 3 Acquisition of data pertinent to land use	

TABLE C10.2 SENSITIVE RECEPTORS

Sensitive Receptor (see Figure C10.1)	Distance from Project	Potentially impacting activities
Legume Station homestead	15 km from the grow-out centre	Landfill, borrow pit, Forsyth Dam are the closest, though all too far away to have any impact)
Proposed Accommodation Village	18 km from the grow-out centre	Accommodation Village works, Central Facilities works, traffic

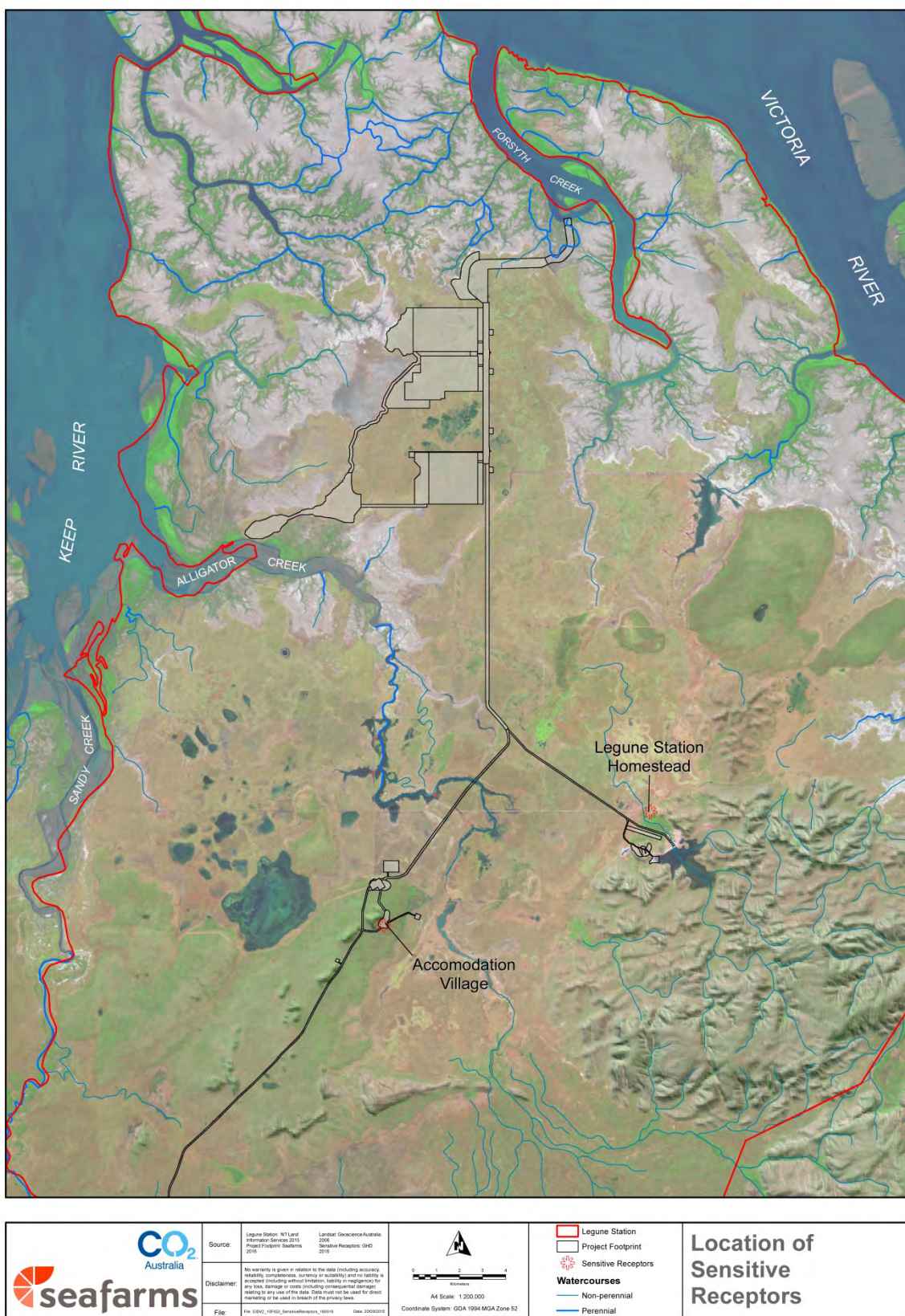


FIGURE C10.1 SENSITIVE RECEPTORS

C11

EFFLUENT MANAGEMENT STRATEGY

TABLE C11.1 - EFFLUENT MANAGEMENT STRATEGY

Element	Detail	
Applicable site activities		
Construction and Operation activities producing sewage effluent		
Aim		
Ensure sewage effluent generated by the Project is appropriately managed, treated and disposed so as to minimise the risks of environmental pollution, human health impacts, and public health nuisances.		
Objectives	Targets	Key Performance Criteria
Undertake and complete works in compliance with statutory environmental requirements	No statutory infringements No breaches of licence/approval conditions	Number of infringements Number of breaches
Protection of environmental ecosystems, quality and amenity	Efficient and safe operation of sewage treatment plants No overflows Effluent quality meets reuse criteria (refer Table C11.2)	Compliance with Hazardous Materials Management Strategy
Sustainable long term irrigation schemes operated at the site	No deterioration of groundwater due to irrigation scheme No deterioration of soil quality or structure, due to irrigation scheme No damage to flora or vegetation communities due to irrigation scheme	Degree of change to groundwater quality in proximity to irrigation areas, particularly for salinity, nutrients, pathogens (E.Coli indicator) Degree of changes to soil quality, particularly for salinity, nutrients, heavy metals, pathogens (E.Coli indicator) Changes to irrigation area vegetation health
Responsibility	Construction: Construction Manager Operations: Site Manager In both cases, appoint a Wastewater Officer with responsibility for managing and maintaining (directly or by subcontract) the sewerage treatment schemes	
Actions / Mitigation Measures	Source Control Only effluent suitable for treatment in the sewage treatment plant to drain into the sewer. Quality dependant on STP type and manufacturers / suppliers recommendations Provide warning signs in kitchens, toilets, etc. warning of what not to flush to avoid overloading or destabilising the treatment plants. Treatment Plant and Irrigation Area Wastewater treatment plants and Land Application Areas will be sized appropriate to	

Element	Detail
	the hydraulic load and the soils to avoid overwatering, by: ■ matching hydraulic load to the hydraulic capacity of the soils ■ matching nutrient application rates to the nutrient assimilation capacity of the soil/vegetation system, and ■ managing salinity buildup, by using a salt leaching fraction (if required). Flow meters will be installed to measure the daily amount of irrigation water applied to each separate irrigation area, recorded on a daily basis to ensure that the scheduled volume of recycled water is not exceeded. Adopt suitable buffers between irrigation areas and sensitive receptors, as outlined in DoH (2014). Adopt a default buffer of 100m for the Accommodation Village treatment plant, and 50m for other plants to sensitive receptors. Review buffer distances at detailed design to ensure no odour nuisance will occur. Erect appropriate signage indicating that recycled water is not suitable for drinking at every outlet from the treated effluent distribution system. Signs shall be easily visible and maintained regularly. Signage shall also be provided and maintained at the irrigation area informing of the use of treated effluent for land irrigation Piping and fittings shall be installed and colour coded in accordance with AS/NZS 1547:2012 On-site domestic wastewater management, AS 3500 National Plumbing and Drainage Code, and AS 1345-1995 Identification of the contents of pipes. Any fittings/valves accessible by public must be appropriately secured to restrict access Alarms and Contingency An alarm system shall be installed on the treatment plant to warn of system malfunctions, high level alerts and potential overflows before they occur (strobe light or similar). Telemetry linked into the Project control system is recommended. All pump stations to be similarly alarmed. Maintenance Do not drive or park vehicles, or build structures or create shade on land application areas. Maintain diversion bunding to keep overland flow water from running across land application areas. Regularly mow and remove excess grass from land application areas. Do not allow trees or large vegetation to grow in this area where roots may disrupt subsurface drip irrigation systems. Ensure system is maintained in accordance with manufacturer's instructions, including routine flushing of irrigation pipework, and cleaning of filters
Monitoring	Systems are to be routinely visually inspected to ensure they are not overflowing and irrigation areas are not being overloaded, that no excessive odours are being generated, and that treatment plants are operating efficiently and effectively. Implement groundwater monitoring program in relation to land irrigation areas Regular visual monitoring of land irrigation areas for signs of: ■ Soggy ground with or without ponding evident on the land application area

Element	Detail
	■ Patchy vegetation growth (or limited growth) indicating blockages or preferential flow pathways to deeper soils ■ Drains and toilets running slowly, which may indicate a blockage in the pipework or treatment system ■ Excessive effluent odour (both land application and sewage treatment systems) which may indicate the system is not performing adequately. One baseline and thereafter 2 yearly soil monitoring in disposal areas, to include monitoring for nutrients, major anions and cations, pH, salinity, and heavy metals. Weekly sampling of water quality, and monthly E.coli. After 2 years, if levels are stable, reduce to quarterly sampling.
Reporting	All monitoring results are to be maintained on-site, and inspected by a person with sufficient knowledge of on-site sewerage treatment plants Compile all results into an annual monitoring report for internal dissemination, and provision to authorised government officers, on request Any non-conformance, incident or potential incident will be recorded on the incident-complaint form in Appendix E (or similar) and entered into the incident-complaint register for rectification and follow up
Corrective Actions	Correction Action Triggers: ■ Excessive odour generated from the treatment plant (whether complaints are received or not) ■ High level alarm is triggered ■ Water quality exceedances ■ Evidence of decline of irrigation area soils Corrective Actions: ■ Inspect and undertake repair or maintenance of treatment plant ■ Check for blockages or pump failures. If required, pump out to temporary holding tank before reintroduction back to plant at a later time, or organise for a licenced contractor to pump out system and remove off-site ■ Investigate source of issue with plant, and undertake repair or mitigation. If necessary, additional plant or equipment may be required ■ Where irrigation soils are showing signs of decline, improve water quality from the plant (better process control, additional equipment), reduce irrigation rates, or allow irrigation area to rest (irrigate alternative location).
References DoH (2014). Draft Guidelines for Wastewater Works Design Approval of Recycled Water Systems. Northern Territory Department of Health, 9 July 2014.	

TABLE C11.2 RECYCLED WATER CRITERIA

Recycled Water	End Uses	Treated water quality criteria

Class		
Class C (DoH, 2014)	Irrigation	Conductivity: <1,600 $\mu\text{S}/\text{cm}$ BOD5: <20 mg/L Total Suspended Solids: 30 mg/L pH: 6.0 - 8.5 E.Coli < 1,000 cfu/100 mL Nutrients: Limits as determined by nutrient balance modelling, during detailed design of irrigation fields

C12

HAZARDOUS MATERIALS MANAGEMENT STRATEGY

TABLE C12.1 - HAZARDOUS MATERIALS MANAGEMENT STRATEGY

Element	Detail	
Applicable site activities All activities involving storage of hazardous chemicals, substances or waste. May include storage, handling or transport of: - fuels in minor quantities and in bulk tanks - hydrogen peroxide in bulk tanks (up to 10,000L) - pesticides and herbicides (minor quantities) - Waste oils/water, hydrocarbons/water mixtures, emulsions - Lead Acid Batteries, Paints and solvents - Grease Trap waste and Sewage sludge - Clinical and laboratory waste - Wastes of any of the above. Storage will generally involve minor storage quantities across the site, other than some bulk stores at the farms/farm services, and a central chemical storage facility at the Central Facilities		
Aim Ensure hazardous substances are appropriately managed to minimise the risks of environmental pollution and that land and soil, surface and groundwater resources are protected both now and in the future, such that the ecological health and land uses, and the health, welfare and amenity of people are maintained		
Hazardous Substances Hazardous goods are substances that have the potential to cause harm to people, property and the environment. This includes: - dangerous goods, classified as having the potential to cause immediate harm to people, property or the environment due to their explosive, corrosive, toxic, oxidising or flammable nature. - Chemicals if they are listed on the national Hazardous Substances Information System and are above the concentration level which is harmful to human health. This management strategy covers both hazardous chemicals and dangerous goods, all of which are termed here hazardous substances, whether products to be used, or wastes to be stored and disposed.		
Objectives	Targets	Key Performance Criteria
Undertake and complete works in compliance with statutory environmental requirements	No statutory infringements No breaches of licence/approval conditions	Number of infringements Number of breaches
No release of hazardous substances causing or having the potential to cause environmental harm or impacts to human health and wellbeing	No releases of hazardous substances outside of containment areas or off-site All rags, absorbents, soils, or containers containing hazardous substances contained on the site Removal of waste or surplus hazardous substances from site by licenced transporters to licenced sites	Number of incidents Number of failures recorded in site inspections Waste Tracking documentation - number of failures to track and breaches of requirements

Element	Detail
Responsibility	Construction: Construction Manager Operations: Site Manager
Actions / Mitigation Measures	Major Hazard Facility Where hazardous chemicals exceed the threshold quantity detailed in Schedule 15 of the WHS Regulations by 10%, NT Work Safe must be notified, and a licence may be required. General All staff to be trained in the safe handling, storage, use and disposal of hazardous substances and chemicals All plant, containers or other equipment used for the storage, handling, or transporting of dangerous or hazardous goods to be maintained in a safe condition Disposal of potentially hazardous substances or chemicals to be undertaken in accordance with the requirements in the MSDS. This includes any spill absorbent material, rags, containers, soil, etc. contaminated with the material All hazardous materials shall be stored and handled in accordance with the requirements of the MSDS All substance containers to be correctly labelled Site storage and containment requirements Store dangerous goods and hazardous materials and wastes (including material which could cause environmental harm) in designated storage areas to appropriate Australian Standards (refer end of table for examples). These require as a minimum: <u>Construction</u> ■ internally banded fuel tanks, with spill kits on hand. Permanent installations will be externally banded around fuel dispensing areas. Chemicals and other hazardous substances to be stored in temporary (or permanent once built) hazardous storage facilities <u>Operation</u> ■ an impermeable base (concrete typically) ■ bunding so that the total banded storage meets the bunding requirements of relevant Australian Standards (see references below for some examples) ■ roofed, or provision to remove or treat all stormwater as contaminated water through oil water separators ■ sumps and pipework to allow the area inside the bund to be completely drained ■ no breaks through the bund - all pipes to go over the bund wall, trafficable sections to go over the height of any bund ■ specific storage containers or sections for specific items, ensuring separation of incompatible chemicals (refer to MSDS, AS1940, etc.) ■ a detailed site plan to be prepared for each storage location to include layout plan, location of spill kit, emergency exit, any emergency/contingency measures

Element	Detail
	(emergency stops etc.), location of PPE, and location and direction of any overflow discharges (if they were to occur) and receiving environment for these discharges - MSDS for all substances stored at the storage location to be included with the above plan Fuel transfer and refuelling operations <u>Construction</u> - Adopt operational controls when they have been constructed - Small or day tanks to be double lined and/or stored in suitable containers to mitigate the risks of spills or leaks - Store all other quantities and bulk hazardous substances within suitably bunded areas - Spill control equipment is to be deployed prior to the transfer of fuel or oil within 30m of a drainage line or the pond, and refuelling is to be attended at all times <u>Operation</u> All bulk transfer and regular re-topping or refuelling points to be bunded to contain the largest likely spill Refuelling locations to also contain: - automatic wet weather diversion, to capture all flows while refuelling, plus the first flush (typically 15mm) after refuelling stops, triggered by the refuelling hose - emergency stops in prominent locations to close off all valves and pipes to tanks - auto shut off valves Fuel will be stored within impermeable and bunded areas (and double skinned storage tanks where required), with refuelling areas being either a built for purpose bunded, concreted refuelling area (larger central storage), or smaller bunded refuelling location (permanent or temporary). Chemicals and waste chemicals, fuel and oil, oil-water mixtures, and waste drums or containers, will be stored within designated roofed and bunded chemical and waste storage facilities. Spill Response Ensure spill response equipment of a suitable type and capacity is located on-site at easily accessible locations. These are to include material for spill clean-up within waterways where waterways could be affected Spills of hazardous materials must not be hosed. Dry cleanup procedures shall be employed as appropriate to the substance Spill Response Procedures are located in the Contingency Management Strategy (Appendix E) Health and Safety Comply with the site Health and Safety Plan. In particular, ensure that workers and others are not exposed to risks to health or safety arising from the Project, based on risk assessment and management of risks.

Element	Detail
Monitoring	Weekly visual inspections shall be conducted of refuelling/servicing areas and hazardous material containment areas to detect leakages or spills Inspect spill kits monthly and following each use of a spill kit to ensure they are appropriately stocked Monthly inspections of containment bunds to ensure bund integrity, and rectify any issues found Annual tank integrity testing for all bulk hazardous or dangerous goods storage tanks
Reporting	Details of all regulated waste transfers onto and off the site are to be recorded, including the date, quantity, type, name of transporter, source and intended treatment or disposal destination. Records are to be maintained of the quantity of waste material removed from the site, and chemicals stored on the site that are dangerous goods, hazardous materials, or those with the potential to cause environmental harm All chemicals or potentially hazardous substances (products or waste) stored on the site to be subject to a risk assessment to identify the level of risk, and thereafter appropriate controls if required (e.g. using Chemaalert or similar). Any new chemicals purchased for use to be subject to this risk assessment prior to use Implement a chemical storage register, to identify types and quantities of chemicals, storage details and location on site, etc. The above risk assessment is to be included with or form part of the register. Any non-conformance, incident or potential incident will be recorded on the incident-complaint form in Appendix E (or similar) and entered into the incident-complaint register for rectification and follow up
Corrective Actions	Correction Action Triggers: ■ Hazardous substance located outside of containment facility ■ Leaks or spills of any substance (hazardous or otherwise, assuming at first it is hazardous) ■ Structures found to be in need of repair, or potential for spill, leak or breach of containment identified Corrective Actions: ■ Initiate spill response (refer Spill Response in the Contingency Management Strategy (Appendix E)) ■ Rectify leaks, defects or potential for leaks or spills, ensuring first it is safe to do so, and appropriate personnel and PPE are utilised
References AS 1940 The storage and handling of flammable and combustible liquids AS 3780 The storage and handling of corrosive substances AS 4326 The storage and handling of oxidizing agents AS 3961 Liquefied natural gas—Storage and handling AS 4332 The storage and handling of gases in cylinders	

Element	Detail
	AS/NZS 1596 The storage and handling of LP Gas AS/NZS 3833 - The storage and handling of mixed classes of dangerous goods, in packages and intermediate bulk containers National Standard for the Storage and Handling of Workplace Dangerous Goods. http://www.safeworkaustralia.gov.au/sites/swa/about/publications/pages/ns200103storageandhandling Australian Dangerous Goods Code. http://www.ntc.gov.au/heavy-vehicles/safety/australian-dangerous-goods-code/ Hazardous Substances Information System (HSIS). http://hsis.safeworkaustralia.gov.au/ NT Work Safe (2016). Dangerous Goods Laws. http://www.worksafe.nt.gov.au/LawsAndCompliance/Pages/Dangerous-Goods-Laws.aspx

C13

BUSHFIRE MANAGEMENT STRATEGY

TABLE C13.1 - BUSHFIRE MANAGEMENT STRATEGY

Element	Detail	
Applicable site activities		
Construction and Operation, Land management		
Aim		
To minimise the risk of adverse impact from bushfire on life, property and the environment.		
Objectives	Targets	Key Performance Criteria
Undertake and complete works in compliance with statutory environmental requirements	No statutory infringements No breaches of licence/approval conditions	Number of infringements Number of breaches
Reduce the number of human-induced bushfire ignitions that cause loss of life and/or property and the environment	No human-induced bushfire ignitions that cause loss of life, and/or damage to property and the environment	Number of human-induced bushfire ignitions that cause loss of life, and/or damage to property and the environment
Manage fuel loads to reduce the rate of spread and intensity of bushfires, while minimising environmental/ecological impacts.	Maintain fuel management zones including low fuel loads in asset protection zones (e.g. assets, fire access trails and property boundary) Maintain adequate separation distances between hazardous vegetation and Class 1-3 and 10a buildings in accordance with AS 3959-2009 – Construction of buildings in bushfire-prone areas (Standards Australia 2009). Manage fuel loads taking into consideration ecological impacts on listed species known to be fire-sensitive.	Measured fuel loads within identified fuel management zones, including asset protection zones Number of confirmed losses of listed fire-sensitive species attributable to fuel management activities
Reduce the community's vulnerability to bushfires by improving its preparedness	Prepare, maintain and review detailed Bushfire Management Plan	Availability and familiarity of Bushfire Management Plan to all employees and contractors Review of Bushfire Management Plan annually and after every bushfire event
Responsibility	Construction: Construction Manager Operations: Site Manager	
Actions / Mitigation Measures	A detailed Bushfire Management Plan for the site will be prepared in consultation with Bushfires NT. This will include preparation of risk-based maps to prioritise and evaluate fuel management zones and mitigation activities, including those within asset	

Element	Detail
	protection zones. Burning of cleared vegetation, if required, will be undertaken in consultation with Bushfire NT with approval under the Bushfires Act 1980.
Monitoring	All staff and contractors will be briefed about the impacts of bushfires and burning in asset protection zones and other sensitive areas. Fire-fighting equipment will be made available during construction and operation to prevent fires spreading, with all vehicles to be fitted with fire extinguishers The site manager will be responsible for liaison with the local authorities (e.g. Bushfires NT, Northern Territory Bushfires Council) on severe bushfire hazard days Site inspections will be undertaken of fuel management zones. This will include annual assessment of fuel loads prior to the fire season, especially within asset protection zones. The confirmed location of fire-sensitive species will be identified on fuel management maps in order to minimise impacts (or loss) of fuel management activities on those species.
Reporting	A report will be prepared following all bushfires on the property, including details of location, source and management actions (if any). Annual reports will be prepared outlining implementation of the bushfire management activities identified in the Bushfire Management Plan. Any non-conformance, incident or potential incident will be recorded on the incident-complaint form in Appendix E (or similar) and entered into the incident-complaint register for rectification and follow up
Corrective Actions	Correction Action Triggers: ■ Bushfire deemed to have ignited as a result of human action ■ Bushfire encroaching into asset protection zones ■ Elevated fuel loads within asset protection zones ■ Confirmed losses of fire-sensitive species as a result of fuel management activities Corrective Actions: ■ Review Bushfire Management Plan to ensure no breaches of management strategies including monitoring of fuel loads ■ Ensure Bushfire Management Plan is made available and familiar to all employees and contractors ■ Survey and identify location of fire-sensitive species within fuel management zones
References <i>AS 3959-2009 Construction of buildings in bushfire-prone areas.</i>	

C14

TRAFFIC MANAGEMENT STRATEGY

TABLE C14.1 - TRAFFIC MANAGEMENT STRATEGY

Element	Detail	
Applicable site activities		
Construction and Operation, vehicles on public roads, and on-site roads		
Aim		
To minimise risks of accidents on-site and off-site, and reduce the impacts of traffic on site receptors (environmental and social).		
To minimise impacts and maintain productive use of site and off-site roads		
Objectives	Targets	Key Performance Criteria
Undertake and complete works in compliance with statutory environmental requirements	No statutory infringements No breaches of licence/approval conditions	Number of infringements Number of breaches
Minimise impacts from traffic on and off-site	No complaints No accidents on-site No increase in accidents off-site	Number of complaints Number of accidents on-site (by severity) and off-site involving site vehicles or staff
Responsibility	Construction: Construction Manager Operations: Site Manager	
Actions / Mitigation Measures	Reduce total vehicle travel where practicable, by developing logistics to reduce overall travel distance / time on-site, and for workers travelling to and from the site Implement fatigue management procedures, to include driving time (as part of the Health and Safety Plan) Monitor site roads for signs of failure and undertake pre-emptive repair works to avoid accidents or delays Observations from drivers recorded and communicated to NT government on the state of external roads. Liaison to be undertaken to maintain trafficability on these roads Implement speed limits on site to: Reduce dust generation Reduce the potential for fauna injury or death, and consequent vehicle damage and human injury (or death) Ensure safe vehicle operation on the site.	
Monitoring	All accidents and near misses on-site to be recorded in the incidents-complaints register. All off-site accidents involving Project drivers, employees and/or vehicles to be recorded in the incidents-complaints register. Encourage reporting of near misses. Monitor road pavement condition on-site, and undertake visual observations of external haulage routes	

Element	Detail
Reporting	Any non-conformance, incident or potential incident will be recorded on the incident-complaint form in Appendix E (or similar) and entered into the incident-complaint register for rectification and follow up In the case of a vehicle accident, an incident form will be required under the site Health and Safety Plan. Undertake an investigation to determine whether future accidents of this type can be reasonably avoided, and implement measures to do so.

C15

SOCIAL IMPACT MANAGEMENT STRATEGY

TABLE C15.1 - SOCIAL IMPACT MANAGEMENT STRATEGY

Element	Detail	
Applicable site activities		
Construction and Operation		
Aim		
The overall aim is to monitor and manage the intended and unintended social and economic consequences, both positive and negative, of the Project.		
Objectives	Targets	Key Performance Criteria
Undertake and complete works in compliance with statutory environmental requirements	No statutory infringements No breaches of licence/approval conditions	Number of infringements Number of breaches
Minimise negative social impacts on the surrounding area during construction	No road traffic incidents resulting in injury to employees, contractors or the public No complaints	Compliance with Traffic Management Strategy Number of Complaints
Maximise local opportunities, particularly with regards to employment, up-skilling and business opportunities	Minimum local and indigenous employment targets No complaints No workforce disputes	Review employment data against annual workforce targets Number of complaints or disputes
Maintain positive community and workforce relations	No complaints Recreational fishery access maintained where possible without jeopardising community safety, company operations, security or biosecurity	Number of complaints
Responsibility	Construction: Construction Manager Operations: Site Manager	
Actions / Mitigation Measures	Establish and work towards achieving targets for Indigenous employment, training and skills development Establish Indigenous Employment, Training and Business Policy. Establish targets for contracting and sub-contracting of Indigenous businesses Establish Project Sea Dragon Local Community Reference Group (PSDLCRG) for annual review of Project Sea Dragon social impacts and progress against targets and management actions. The suggested membership for the group is as follows: ■ 2 x Traditional Owners ■ 1 x SWEK ■ 1 x VDRC	

Element	Detail
	1 x KCCI 2 x General community 1 x NT Government 1 x WA Government 1 x Project Sea Dragon. Establish the following policies and targets: - Community Grievance Policy incorporating public complaints register - Local Employment Policy and targets - Local Content Policy and targets. - traineeships, apprenticeships and other employee development opportunities. - private property Recreational Fishery Access Policy, balancing public access with biosecurity and other farm management concerns - Driver Safety and Fatigue Management Policy for employees and contractors. - OHS policies as required under law - Implement the Traffic Management Strategy
Monitoring	The monitoring associated with the social and community aspects of the Project will involve: - Project Sea Dragon Local Community Reference Group (PSDLCRG) annual review of social impacts and progress against targets and management actions - Internal social impact reviews - Maintenance and follow up on complaints register, and annual review
Reporting	Any non-conformance, incident or potential incident will be recorded on the incident-complaint form in Appendix E (or similar) and entered into the incident-complaint register for rectification and follow up Provide an annual summary report of community and workforce relations, complaints and any incidents.

C16

CULTURAL HERITAGE STRATEGY

TABLE C16.1 - CULTURAL HERITAGE STRATEGY

Element	Detail	
Applicable site activities		
Construction, particularly excavation and vegetation clearing		
Operation, associated with sacred sites and possible unexpected finds		
Aim		
To identify and protect items or places which have historic and/or cultural heritage values, and to minimise impacts on cultural heritage values, places and practices.		
Objectives	Targets	Key Performance Criteria
Undertake and complete works in compliance with statutory environmental requirements	No statutory infringements No breaches of licence/approval conditions	Number of infringements Number of breaches
No damage or disturbance to objects or sites of cultural significance	No physical disturbance or damage to significant cultural heritage sites and objects	Number of incidents of damage occurring
Maintain Access to sites of cultural significance	No breaches of ILUA requirements Minimise disruption to site access for local indigenous persons, in line with the negotiated ILUA Traditional Owners have access to the Project area to monitor progress and impacts upon cultural heritage where necessary, and monitoring indicates no unacceptable impacts. No complaints	ILUA developed and entered into by PSD. Number of breaches of ILUA requirements Number of complaints
Responsibility	Construction: Construction Manager Operations: Site Manager	
Actions / Mitigation Measures	PSD to facilitate Native Title holders, AAPA and NLC are to conduct detailed heritage surveys in the dry season prior to works starting on-site. This heritage survey will be summarised into a cultural heritage register for the Project, noting the key details about each site including location (as MGA zone 56 GDA 94 coordinates), the nature of the site, relevant contact person or organisation, and condition. Obtain AAPA certification for the proposed project area prior to construction works commencing Develop an Indigenous Land Use Agreement (ILUA) Develop and implement a Traditional Owner site access agreement under the ILUA, to include access for cultural business and project inspections	

Element	Detail
	Establish a Traditional Owner Land Access Policy as per the ILUA Implement the Unexpected Findings Protocol in the Contingency Management Strategy (Appendix E) for cultural heritage finds (indigenous and non-indigenous) Continue to engage with Traditional Owners in the management of potential heritage impacts, and to ensure access is not an issue
Monitoring	Following the initial detailed cultural heritage surveys noted above, ongoing monitoring involving visual inspections and confirmation of exclusion zones around cultural sites will be undertaken. Project inspections will also be undertaken by Traditional Owners according to agreements within the ILUA. These inspections will be made against the cultural heritage register, updating the register where relevant. Complaints and any other issues raised in relation to cultural heritage issues will be recorded on the incidents-complaints form and entered into the incidents-complaints register.
Reporting	Any non-conformance, incident or potential incident will be recorded on the incident-complaint form in Appendix E (or similar) and entered into the incident-complaint register for rectification and follow up Provide an annual summary report of cultural heritage interactions, relations, finds, and sites Prepare a heritage register, to be updated with any new finds, and any changes to sites, artefacts or heritage requirements (such as ILUA requirements)
Corrective Actions	Correction Action Triggers: ■ Cultural heritage artefact or site found during construction works ■ Complaint received regarding cultural heritage values or access Corrective Actions: ■ Implement the Unexpected Findings Protocol in the Contingency Management Strategy (Appendix E). Record the location of the find on the heritage register ■ Implement the grievance policies within the ILUA and other policies and agreements
References ICOMOS (2000). The Burra Charter: The Australia ICOMOS Charter for Places of Cultural Significance. The Australian National Committee of International Council on Monuments and Sites. Available at: http://australia.icomos.org/publications/charters/	

APPENDIX D MONITORING AND REVIEW REGISTER

PROJECT SEA DRAGON MONITORING AND REVIEW REGISTER

Corporate / EMS level Monitoring and Review Requirements. To be updated following approval with site specific requirements

Description	Details	Responsible Persons	Frequency	Remarks
Annual EMS Review	Annual review of EMS to include: - performance against objectives and targets, including from individual sites - review of new or updated legislation and standards - Documents and Records (refer below) Reporting: in PSD annual internal report Records: store written results of audit maintained in records	Environmental Manager	Annual	Corporate level EMS review, including review of site specific annual audit / review reports
Board level reporting requirements	Regular reporting for board meetings required in relation to meeting Objectives and Targets and other policy commitments	Environmental Manager	As required	
Annual Site Audit/review	Annual audit of sites to include: - Site performance against objectives and targets - General site walkover and assessment of issues and opportunities	Site Managers	Annual	
Energy Audits	Annual accounting of energy use against energy and energy intensity targets. Review annual accounts and identify opportunities for improvement	Site Managers	Annual 5-yearly	Include in site annual reports
Waste and Recycling Audits	Annual accounting of waste production against waste and recycling targets Review annual accounts and identify	Site Managers	Annual 2-yearly	Include in site annual reports

Project Sea Dragon

Description	Details	Responsible Persons	Frequency	Remarks
	opportunities for improvement			
Training Needs Analysis	Annual review of personnel and training needs, training conducted. Conducted at corporate level and site specific Reporting: QL-00-FO-0001 Training needs analysis form Records: Store dated copy of form in Records	Environmental Manager Site Managers	Ongoing Annual review	Ongoing as needed Included as part of annual audits / reviews
Document Control	Document register to be updated for all new documents and revisions of existing documents. Annual review / audits to include review of available documentation, ensuring new documents or revisions are captured, and available documents (print and electronic copies) are up to date.	Environmental Manager Site Managers Document Author(s)	Ongoing Annual review	Included as part of annual audits / reviews
Update following approval with site specific requirements				

APPENDIX E ENVIRONMENTAL CONTINGENCY PLAN

E1

CONTINGENCY RESPONSE

E1.1 PURPOSE AND SCOPE

This draft contingency strategy aims to outline a basic set of actions to follow when responding to an incident to ensure the correct containment, cleanup and reporting is undertaken for incidents occurring on-site.

E1.2 HEALTH AND SAFETY

Health and Safety concerns will always take precedence when managing an incident. If a situation is not safe, personnel will not enter the area unless they are:

- Properly fitted with Personal Protective Equipment (PPE) and trained in its use;
- Sufficiently experienced to deal with the situation; and
- Acting under an approved Safety Management Plan or Procedure.

The site health and safety management procedures will take precedence in the case where danger to human health and safety exists.

E1.3 ASSESSMENT OF IMPORTANCE OF INCIDENT – ENVIRONMENTAL

The general category of incident should be rapidly assessed to determine the correct course of action. The categories are outlined below.

- High Impact - applies to any one or more of the following:
 - where there is an immediate threat to human life and property
 - where the incident could be associated with significant harm to native fauna and flora
 - creates an immediate observable harm to environmental receptors
 - where it occurs in water catchments for supply of the Project or other site (or off-site) uses, or
 - where the incident has the potential to seriously contaminate soil or water resources.
- Moderate Impact - applies to any one or more of the following:
 - where there is significant (but not immediate) threat to human life and property
 - where the incident may result in chronic or long-term harm to native fauna and flora, or
 - may have a long term (but not immediate) observable impact on environmental receptors.
- Low Impact - applies to any one or a combination of the following:
 - where there is no perceived threat to human life or property
 - where the incident is outside sensitive environments
 - where the incident poses no immediate or long term threat to environmental receptors.

E1.4 INCIDENT RESPONSE – ENVIRONMENTAL ASPECTS ONLY

Table E1.1 below shows the minimum responses to be undertaken based on a rapid assessment of the category of incident as above.

TABLE E1.1 INCIDENT RESPONSE – MINIMUM RESPONSE RECOMMENDED

Impact class	Clean up	Initial Notification	Written notification	Review EMP / Site procedures	Environmental monitoring
High	Immediate	As soon as practicable	Within 14 days	Yes	Yes
Moderate	Immediate	48 hours	Within 14 days	Yes	Decide on effectiveness of clean-up
Low	Within 4 hours	None	None	No	No

Generally, the control methods should follow the Control, then contain, then cleanup hierarchy of approaches, whereby the source of the spill is (safely) controlled, the spill itself contained so as to minimise or avoid its movement into the environment, and cleanup undertaken.

E1.5 NOTIFICATION

The Site Manager or the delegated site environmental manager/officer must be notified of all incidents as soon as practicable. Following this, relevant Government authorities must be notified of any incident with actual or potential significant off-site impacts on people or the biophysical environment as soon as practicable for high impact events and within a maximum of 48 hours after the event for moderate impact events (“initial notification”).

Following initial notification, written details (“written report”) of the incident must be submitted to the relevant Government authorities within 14 days of the date on which the incident occurred, to include the following information:

- the location and time of the event
- the time site staff and the Site Manager became aware of the event
- the suspected cause and a description of the resulting effects of the event
- actions taken to mitigate any environmental harm or nuisance caused by the event, and
- proposed actions to prevent a recurrence of the event.

E1.6 TRAINING

Training of staff will include spill response specific to the types of spills that may occur - oil and liquid waste spills, larger spills to land and to water, including use of absorbents, floating booms and skimmers, and notification procedures.

E1.7 WET SEASON AND EXTREME WEATHER

Prior to the start of the wet season, the site will be prepared by ensuring all waste materials, receptacles and storages are properly contained and stable, and will be able to withstand wet season rainfall without leaching or other loss of contaminants. A site audit will be conducted prior to each wet season with the results provided internally in written form.

A similar process will occur prior to forecast storms or other extreme weather events, whereby all wastes are contained and restrained so as to avoid loss of materials during the event. The landfill will have the day's cover applied and compacted, if sufficient time allows (for safety), with any loose materials secured.

E1.8 RECORDS

All incidents shall be recorded on the incident / complaints or similar and maintained as a register of incidents on the site.

E1.9 REVIEW

This contingency plan is to be reviewed and updated prior to works starting on the site, and periodically thereafter, at a minimum annually.

TABLE E1.2 - CONTINGENCY RESPONSE

Element	Detail
Receipt of Complaint	Record details of the complaint in the incidents-complaints register Investigate and determine whether the complaint is vexatious or not Further investigate the cause and possible rectification for non-vexatious complaints
Spill or leak	Define the spills severity by type and scale of the incident (major, moderate, minor) (Table E1.1) Adopt the following spill response process: ■ Assess: determine if the spill can be safely controlled, or if other or external help is required (if so seek this help as soon as safely possible) ■ Control: if safe to do so, stop the spill, for example by turning off supply, righting barrels, etc. ■ Contain: apply containment measures, such as spill booms, absorbent material, or by scooping small spills by shovel, etc. ■ Cleanup: clean up the spill by sweeping, shovelling, scooping or otherwise cleaning up the spill. Dry methods are preferred over washing ■ Notify: the spill will be recorded and appropriate persons notified ■ Review: an incident will be logged, and opportunities for improvement identified where practicable.
Unexpected Findings (contamination, archaeology, heritage)	Implement the Unexpected Findings Protocol (UFP) as follows: Contaminated Soil ■ If contaminated or potentially contaminated material is found, actions should include, but not be limited to, the following: ■ immediately stop work in the area of concern ■ contact the Site Manager or their designated authority ■ erect temporary barricading to prevent access, and warning signs as required ■ provide cover or suitable suppressant if odorous ■ provide erosion and sediment control measures as required, and ■ contact appropriate organisations to provide specialist advice/support. Heritage Finds

Element	Detail
	■ If any cultural heritage items are found, a similar process will occur as for contaminated soil, and in line with the ILUA and other heritage agreements: ■ immediately stop work in the area of concern ■ contact the Site Manager or their designated authority ■ erect temporary barricading to prevent access, and warning signs as required ■ Advice will be obtained from the Aboriginal Party for the area to determine the nature of the find (in conjunction with an archaeologist/anthropologist as required). If a genuine cultural heritage find, the cultural heritage register will be updated with the find ■ Set up a temporary exclusion zone and develop a strategy for protection and custody of the find. Works may not recommence in the exclusion zone until a strategy is agreed for protection and custody of the find. The UFP should be integrated with a site specific emergency response plan. If the unexpected findings present an immediate hazard, then the emergency response plan should take precedence over the UFP
Other contingencies	Refer to the relevant Management Strategy, or the site Health and Safety Plan

APPENDIX F ENVIRONMENTAL FORMS

PROJECT SEA DRAGON RESPONSIBILITY AND TRAINING NEEDS ANALYSIS FORM

For persons identified within the EMS, identify responsibilities, determine their competency, identify training needs, and plan for training. *Examples given in red*

Role / Position Title/Position no.	Name	Responsibilities	Qualifications/ competency	Training needs	Planned dates	Training details
<i>Chief Operating Officer</i>		<i>Participate in Management review Set Policy Review Objective & Targets Resource allocation</i>		<i>EMS awareness (in house)</i>		
<i>General Manager – Health, Safety and Environment</i>		<i>Over-all responsibility for system implementation Participate in Management review Monitoring and measurement of environmental performance Corporate level training</i>		<i>EMS awareness (in house)</i>		
<i>Internal Auditor</i>		<i>Develop internal audit program Conduct internal audits</i>	<i>Certified (RABQSA) lead auditor</i>			
<i>Site Managers</i>		<i>Site management, comply with EMS and site specific plans where relevant</i>		<i>EMS awareness (in house)</i>		
<i>Site Environmental Role - Site Manager, or delegate</i>		<i>Implement EMS on site Develop and update site specific plans Training of new staff, environmental performance of the</i>				

Project Sea Dragon

Role / Position Title/Position no.	Name	Responsibilities	Qualifications/ competency	Training needs	Planned dates	Training details
		site				
<i>General Staff</i>		<i>Awareness of EMS and environmental policy Spill and contingency response</i>	<i>N/A</i>	<i>EMS awareness (in house) Spill response training (2 yearly)</i>		

NC-	Form QL-00-FO-0002 Incident / Complaint / Improvement	
Date: Name: (Person filling out form)		
☐ Incident ☐ Complaint ☐ Improvement		
Nature of Incident / Complaint (tick one): ☐ water ☐ air ☐ land ☐ other		
Details		
Name and Address of person or company complaining / reporting incident (or anonymous) Phone:		
If company, person lodging complaint / notification:		
Time of Incident / Complaint:		
Nature of Contact (phone, letter, personal, email, etc.):		
Location of Incident:		
Description		
.....		
Actions Taken	Date Acted On	Signed
.....		
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.....		
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APPENDIX I ESTIMATE OF TRAFFIC ON KEEP RIVER ROAD/CAVES SPRINGS ROAD



**PROJECT SEA DRAGON
STAGE 1 LEGUNE GROW-OUT FACILITY
SUPPLEMENTARY ENVIRONMENTAL IMPACT STATEMENT**

**APPENDIX I ESTIMATE OF TRAFFIC ON KEEP
RIVER ROAD/CAVE SPRINGS
ROAD**



Memorandum

09 December 2016

To	Kate McBean		
Copy to	Nicole Conroy, Chris Hall, David Eames		
From	E Wanka	Tel	08 89820130
Subject	Estimate of Traffic on Keep River Road/ Caves Springs Road	Job no.	43/22380/05

1 Background

The Project Sea Dragon EIS is currently on public consultation and a query has been received from the Department of Infrastructure Planning and Logistics (DIPL) regarding the assumptions in GHD's Report - Legune Grow-out Facility EIS Traffic and Transport Impact Assessment July 2016 in relation to the traffic data on Cave Springs Road (which DIPL are referring to as Keep River Road or Legune Access Road).

The issue raised is that the data used is not representative of the actual road numbers. It was suggested that a vehicle count be carried out on Keep River Road for one or two months to gather more accurate data. However, this was then modified to suggesting that an "educated assessment" of traffic numbers should be prepared (to include local community numbers, fishermen and traffic from Legune Station).

At a joint teleconference involving representatives from CO2, DIPL and GHD on 29 November 2016, it was agreed that an estimate of the daily traffic for the road would be provided and a risk assessment be undertaken.

A contract variation for GHD to undertake an assessment and estimate the daily traffic on Keep River Road was entered into on the 5 December 2016.

2 Methodology

To estimate the number of vehicle per day (ie determine the trip generation for the Keep River Road), the following users were contacted where available to determine a reasonable daily traffic figure or range.

Marralum Community – GHD contacted the NLC and Department of Chief Minister to ensure estimate of the traffic generated by the community is based on best information available.

Legune Station – CO2 provided the number of daily trips the station would generate and types of vehicle undertaking the trips. Legune Station was also able to provide advice on other users who frequent the Station such as fishers, Government Service Authorities.

NSW Road Transport Authority Guide to Traffic Generating Developments October 2002 was reviewed to determine if it was applicable for estimating trip generation (trip generation modelling) on rural remote roads servicing pastoral properties and Aboriginal Communities (ie. land use adjoining the road) which is the situation for the Keep River Road. The review found that the Guide did not cover the situation of the Keep River Road.

43/22380/05/CO2

It was determined the most appropriate approach to estimating the traffic would be best based on information gathered from the users and provide an estimated range for the daily traffic and do a comparison of traffic on other similar roads in the NT road network from the 2015 Annual Traffic Report. The resulting estimate would then allow CO2 to undertake a risk assessment for the road.

2.1 Report on Traffic Use from Local Sources

Marralum Community

CO2 received advice that no-one lives at the Marralum Community. Sometimes a family stays there when they go fishing on the weekends, but typically there is no-one there.

GHD received advice from Northern Land Council (NLC) Anthropologists through a Department of Infrastructure Planning and Environment Officer seconded to the NLC that on average there is only about 20 people who live there but on weekends only.

No further information was able to be obtained on Marralum Community.

Legune Station

The following information was provided by CO2 that was obtained from Legune Station direct.

For a typical week during the dry season April to November, traffic crossing the boundary would consist of:

- Station traffic, namely:
 - 2-3 road trains
 - 2 trucks – stores and possibly fuel
 - 20 personal and work vehicles
 - 8-10 bore runner vehicle (small truck)
 - Possible government agency staff
- Then non-station traffic, namely:
 - say 70 fishermen
 - say 50 indigenous

A typical week would see about 150-160 return vehicles per week resulting in about 300-320 single trips per week.

Caveats:

- If the fish are on, then the fisher numbers jump up.
- These numbers do not include the likes of PSD staff and contractors, or Beach Energy ditto.
- These numbers decline in the lead up to the wet as road trafficability decreases, and cease during the wet until the road is trafficable again.

Traffic Analysis

Based on the information provided by Legune Station, the peak traffic in the dry season is likely to be in the range of 40 to 45 vehicles per day. From information on the Marralum Community, the figure of 50 trips per week (about 7 vehicles per day for the Marralum Community) would seem to be on the high side.

The traffic numbers will drop off considerably in the wet season so the Average Annual Daily Traffic will be less than the peak daily figure provided.

The Department of Transport now DIPL 2015 Annual Traffic Report was checked to compare the above estimate for the Keep River Road with traffic on similar roads in the NT road network. It was difficult to find appropriate roads to compare with but some examples are as follows;

- Finke River Road (Unsealed local road servicing Apatula Community and cattle stations but much greater distance from Alice Springs to Legune Station from Kununurra and not affected by wet season river closures) = 20 vehicles per day (vpd).
- Gardens Road (Unsealed local Road servicing cattle property and tourists close to Alice Springs but not affected by wet season river closure) = 22 vpd.
- Lajamanu Road (unsealed secondary local road servicing a reasonably large Indigenous Community and a cattle station (Cattle Station has alternate access to Katherine or Alice Springs) but some distance from Katherine) = 51 vpd.

In terms of adjusting the peak monthly daily traffic figures to AADT, the traffic figures for roads like the Carpentaria Highway (AADT of 71 vpd versus a peak daily figure of 126) and Tablelands Highway (AADT of 48 vpd versus a peak daily figure of 85) gives the AADT as 56% of the peak daily counts. These roads are sealed rural arterial roads with bridges. The Central Arnhem Roads is also a rural arterial road but is impacted by river closure during the wet season and is mainly an unsealed road and the AADT is about 30 % of the peak daily counts.

From this assessment, the estimate of 40 to 45 vpd for the Keep River Road is likely to be high and an AADT estimate is likely to be about 40 % of these figures 16 to 20 vpd.

If the risk assessment is undertaken using the peak daily traffic of 40 to 45 vpd day, it will be a worst case scenario for the road.

The Construction Traffic Management Plan will need to address the road safety risks to the local users and the upgraded road will greatly improve accessibility for these users.

Regards



E Wanka

Principal Civil Engineer