Yannarie Solar
a Straits initiative

Response to EPA Service Unit Comments (received 5 April 2007)

Yannarie Solar Environmental Review and Management Programme

January 2008

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1. INTRODUCTION

Straits Salt Pty Ltd (Straits) is proposing to construct and operate a solar saltfield on the eastern margin of the Exmouth Gulf (the Gulf) in Western Australia. Known as the Yannarie Solar Project, the operation will meet the rapidly growing demand for salt stemming from the Asia-Pacific region. The original proposal was for a nominal 10 million tonne per annual (Mtpa) solar salt field, however in response to concerns raised in submissions about the scale of the development, Straits has revised the proposal to reduce the size of the project footprint. Straits now propose to construct and operate a nominal 4 Mtpa solar saltfield.

An Environmental Review and Management Programme (ERMP) was prepared for assessment by the Environmental Protection Authority (EPA) pursuant to Part IV of the *Environmental Protection Act 1986* (EP Act) and the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act). The ERMP described the proposal, characterised the existing environment, examined likely environmental impacts and outlined proposed commitments and management, including management plans for specific issues.

The ERMP was originally subject to a 12 week period of public review following its release on 4 December 2006. The public review period was extended by two weeks, and closed on 12 March 2007. Over 2600 submissions were received by the EPA, of which approximately 2562 were proforma submissions. Twenty-six (26) written submissions were received from organisations, including Government Departments, non-government organisations and associations; and 27 written submissions were received from private individuals. A Response to Submissions report (First Draft) was prepared (July 2007) which provided a response to issues raised in public submissions and a subsequent Response to Submissions report (Second Draft) was prepared (December 2007), which addressed comments provided by the EPA Service Unit (EPASU) on the First Draft.

In addition to the public submissions, the EPASU submitted comments on the Yannarie Solar Project ERMP to Straits on 5 April 2007. This report provides responses to these EPASU comments.

2. DOCUMENT STRUCTURE

This document presents a response to comments submitted by the EPASU on the Yannarie Solar Project ERMP. The comments are presented in Section 4 in a tabular format, as follows:

- Table 10 – Comments on Volume 1 of the ERMP
- Table 11 – Comments on Volume 2 of the ERMP
- Table 12 – Additional EPASU Comments.

Changes that have been made to the proposal since the release of the ERMP, primarily in response to the submissions received to date, are presented in Section 3.

3. CHANGES TO PROPOSAL

3.1 REVISED KEY PROJECT CHARACTERISTICS

As described in the Response to Public Submissions report, a number of changes have been made to the proposal since the release of the ERMP. The most significant change is a large reduction in the size of the proposed development. Straits revised the proposal to reduce the size of the project footprint, in response to concerns raised in submissions about the scale of the development. Straits now propose to construct and operate a nominal 4 Mtpa solar saltfield. The major changes to the proposal are summarised in Table 1, and shown in Appendix 1.

A summary of the revised environmental implications of the changes to the proposal are shown in Table 1.

Table 1 Original and revised key project characteristics

Characteristic	Original ERMP proposal	Current proposal	Environmental implications
Proposal location	Refer Figure 2-2 of ERMP	Refer to Appendix 1	
Production	Nominal 10 Mtpa	Nominal 4 Mtpa	Overall reduced footprint and subsequent environmental impacts
Current reservation of project area	Ministerial Temporary Reserve for potential future solar salt and gypsum production.	Ministerial Temporary Reserve for potential future solar salt and gypsum production.	No change
Site disturbance (ha)			
Terrestrial Vegetation	Approximately 461 ha of terrestrial vegetation to be removed for infrastructure	Approximately 157 ha of terrestrial vegetation to be removed for project related infrastructure.	Reduction in area of terrestrial vegetation disturbed (approximately 157 ha). Refer to Table 2 and Table 3 for revised vegetation clearing estimates.
Mangroves	Approximately 5.4 ha	Approximately 2 ha	Reduction in area of mangroves to be disturbed (approximately 3.4 ha less)
Algal mat	Approximately 30.8 ha	Approximately 17 ha	Reduction in area of algal mat to be disturbed (approximately 14 ha less)
Quarries	Approximately 26.9 ha	Not required (limestone to be sourced from excavation of Hope Point barge harbour)	No disturbance to limestone quarry sites proposed in ERMP (approximately 26.9 ha less)
Salt flat	Approximately 411 km^2	Approximately 180 km^2	Substantial reduction in area of salt flat disturbed (approximately 231 km^2 less)
Concentrator and crystalliser ponds			
Location	Refer Figure 2-2 of ERMP	Refer to Appendix 1	
Quantity	64 crystalliser ponds, 16 concentrator ponds, 1 bitterns management area	About 30 crystalliser ponds, up to 7 concentrator ponds, 1 bitterns management area	Reduced footprint, substantial reduction in area of salt flat disturbed (approximately 231 km^2 less)

Characteristic	Original ERMP proposal	Current proposal	Environmental implications
Levee banks			
Materials	Approximately 5,700,000 m^3 embankment material	Approximately 2,700,000 m^3 embankment material	Reduction in the number and extent of disturbance to clay pans
	Approximately 1,100,000 m^3 rock armour	Approximately 540,000 m^3 rock armour	No disturbance to limestone quarry sites proposed in ERMP
	Approximately 145,000 m^3 road base materials	Approximately 140,000 m^3 road base materials	No disturbance to limestone quarry sites proposed in ERMP
Construction method	Keyed down to clay layer	Not keyed down to clay layer	Less potential disturbances of PASS, potential for subterranean seepage through low permeability sediments
Length	Approximately total of 300 km Seaward facing length of field approximately 70 km	Approximately total of 120 km Seaward facing length of field approximately 30 km	Reduction in area of supratidal salt flat within bunds. Reduction in disturbance to surface hydrology and sediments
Setback from high water mark, as indicated by landward edge of algal mat	Average 40 m	Minimum of 100 m for concentrator and crystalliser ponds	Reduction in potential impacts on algal mats and mangroves from seepage. Structures less affected by potential sea level rise
Prospective quarry sites	Refer Figure 2-9 of ERMP	Refer to Appendix 2 for clay source areas. Noted that limestone quarries are no longer required, as all limestone is to be sourced from excavation of Hope Point barge harbour.	No disturbance to limestone quarry sites proposed in ERMP Reduction in the number of clay pans disturbed
Salt stockpile			
Location	Refer Figure 2-12 of ERMP	Location of stockpile moved to accommodate revised location of diesel fuel farm. Refer Appendix 3.	No significant change
Quantity	Approximately 1 million tonnes	Approximately 1 million tonnes	No change
Length	Approximately 1 km	Approximately 1 km	No change
Duration of the project	>60 years	>60 years	No change
Seawater pump stations			
Location	Refer Figure 2-2, Figure 2-5 and Figure 2-6 of ERMP Hope Point, Dean's Creek, Naughton Creek	Refer to ERMP Figure 2-2 Dean's Creek pump station. For Hope Point pump refer to operational desalination plant, below.	No impact at Naughton Creek on sedimentation, tidal regimes or entrainment of marine fauna
Operational desalination plant			
Type	Reverse osmosis	Reverse osmosis	No change
Location	Main Island	Main Island	No change
Capacity	30 kL/day (supplied by the one reverse osmosis plant)*	30 kL/day	No change
Barge harbour			

Characteristic	Original ERMP proposal	Current proposal	Environmental implications
Area	12 ha	Approximately 16.5 ha (Appendix 4)	Increase in area of disturbance, small additional loss of algal mat (0.3 ha) in this area
Location	Hope Point	Hope Point – change in orientation of barge harbour (Refer to Appendix 3 and Appendix 4)	Reduction in direct disturbance to wader roosting sites
Barge harbour excavation volume	Excavation to include 600,000m^3 limestone	Approximately 1,535,000 m^3 for barge harbour	Eliminates the requirement for limestone quarries
Dredge channel			
Dredge channel length/width/depth	Approximately 1.3 km long, 125 m wide, 3.5 m CD deep	Approximately 1.6 km long, width from 125 m to 143 m, depth from -5.1 to -7.1 AHD (Refer to Appendix 4)	Orientation of dredge channel revised to reduce disturbance to 'reef with algae' and 'reef with algae, corals and sponges' benthic habitat types (Refer to Oceanica 2008, Appendix 11)
Area	16.4 ha (included 15.4 ha channel and 1.0 ha transition zone)	18.5 ha (includes 17.5 ha channel and 1.0 ha transition zone)	See above
Barge channel B excavation volume	20,500 m^3	Approximately 135,000 m^3	Increased volume of tail water may result in temporary increase in suspended sediment concentrations (note that tail water will be held in sedimentation ponds prior to the return of seawater)
Barge channel A excavation volume	284,500 m^3	Approximately 240,000 m^3	No significant change
Transition land excavation zone excavation volume	Not directly identified in ERMP	Approximately 10,000 m^3 (1 ha)	No change
Construction camp			
Size	Modular transportable living quarters for 100 workers	Modular transportable living quarters for 100 workers	No change
Other infrastructure			
Water supply	Refer to Operational Desalination Plant above	Refer to Operational Desalination Plant above	Refer to Operational Desalination Plant above
Sewerage treatment plant	Activated sludge sewage treatment system	Activated sludge sewage treatment system	No change
Power generation (capacity)	8 MW (4 x 2 MW) diesel generators	6 MW (6 x 1 MW) diesel generators (includes SOP Plant)	Reduction in greenhouse gas emissions by approximately 25%
Roads	Primary access road running 55 km from the existing Yanrey Station access road to the site boundary	Primary access road running 55 km from the existing Yanrey Station access road to the site boundary	No change
	General site access roads within Hope Island	General site access roads within Hope Island	No change
Shipping	At full production approximately 3 Panamax ships per week	At full production approximately 1 Panamax ship per week	Reduction in shipping traffic in Gulf, reduction in potential disturbance to marine fauna, reduction in risk of introduction of non-indigenous marine species

Characteristic	Original ERMP proposal	Current proposal	Environmental implications
Barge movements	At full production approximately 19 barge movements per week (6 – 7 movements to fill one 65,000 tonne Panamax ship)	At full production approximately 6 – 7 barge movements per week	Reduction in barge traffic in Gulf, reduction in potential disturbance to marine fauna, reduction in risk of introduction of non-indigenous marine species
Site facilities	Airstrip at Hope Point for general site access and emergency evacuation	Airstrip at Hope Point for general site access and emergency evacuation	No change
	Bunded fuel storage area with a storage capacity of approximately 250 kL located at Hope Point, and a second fuel storage area at Main Island.	Bunded fuel storage area. The diesel fuel farm at Hope Point has been relocated (Appendix 3) to higher ground (8-9M AHD), and decreased in storage capacity from approximately 250 kL to 140 kL. The second fuel farm located at Main Island will have a storage capacity of approximately 220 kL.	Reduction in risk of fuel spill in extreme weather conditions, no disturbance to locally significant *Melaleuca cardiophylla* shrubland community at Hope Point
	Truck service bays and wash, parts store and tyre change and storage	Truck service bays and wash, parts store and tyre change and storage	No change
	Mobile plant workshop	Mobile plant workshop	No change
	Offices and laboratory	Offices and laboratory	No change
Workforce			
Construction	100 personnel	100 personnel	No change
Operation	Up to 190 personnel	Up to 75 personnel	Reduction in site wastes, such as waste water and solid wastes from operations

* In the ERMP it was incorrectly stated that 530 kL of water per day would be produced by the reverse osmosis plant at Main Island. The total volume of water to be supplied by reserve osmosis is anticipated to be 30 kL/day (11 ML/year). Water for dust suppression will not be treated by reverse osmosis.

As outlined in Table 1, the revised proposal has resulted in the area of terrestrial vegetation to be removed for project infrastructure being decreased by approximately 300 ha. The revised estimated clearing of vegetation types, as surveyed by Biota (2005a), are shown in Table 2.

In the ERMP (Table 5-9) the estimated clearing interpolated from Land System Mapping was 298.1 ha (Table 3). In addition to the 161.32 ha of clearing of mapped vegetation, this gave a total of 459.42 ha for the original Yannarie Solar Project proposal. However, the figure used from land system mapping was not confined to vegetation clearing, but included infrastructure footprint, irrespective of whether this involved vegetation clearing or not. The indicative clearing of vegetation for the revised project of approximately 20 ha only relates to vegetation clearing (Table 3). Hence the combined total of clearing of mapped vegetation and unmapped vegetation (derived from land system mapping) is approximately 157 ha.

Table 2 Original and revised estimated clearing of vegetation types (excluding mangroves) surveyed by Biota (2005a) for saltfield infrastructure

Vegetation Type	Total area mapped (ha)	Indicative footprint clearing (ha)	
		Original project	**Revised project**
1a Samphire on Mainland Remnant Margins and Inland saline Flats	420.7	0.7 Access roads 1.0 Conveyor 0.3 Haul roads 11.6 Hope Point 0.1 Southern pump stn 0.8 Crystalliser	0.5 Access roads 1.1 Conveyor 0.5 Haul roads 12.1 Hope Point 0.1 Southern pump stn 1.4 Crystalliser 2.8 Main Island
Total 1a		**14.5 ha**	**18.5 ha**
% disturbance		**3.4%**	**4.4%**
2a Acacia shrubland over *Troidia epactia*	1384.5	4.1 Access roads 1.1 Haul roads 0.2 Crystalliser	1.32 Access roads 0 Haul roads 0 Crystalliser
Total 2a		**5.4 ha**	**1.32 ha**
% disturbance		**0.4%**	**0.1%**
2b *Melaleuca cardiophylla*	2.1	0.02 Hope Point fuel farm	0 Hope Point fuel farm
Total 2b		**0.02 ha**	**0 ha**
% disturbance		**1%**	**No disturbance**
2c Vegetation in Dune Swales and Intertidal Flats	6946.4	22.8 Access roads 0.1 Camp and access 4.9 Conveyor 25.3 Haul roads 39.7 Hope Point 0.1 Southern pump stn 18.9 Quarries 0.6 Crystalliser	25.4 Access roads 0.1 (+ ~ 13 ha inferred) 4.1 Conveyor 0.5 Haul roads 33 Hope Point 0.1 Southern pump stn 0 Quarries 0 Crystalliser 9.5 Main Island 17.0 contingency
Total 2c		**112.4 ha**	**102.7 ha**
% disturbance		**1.6%**	**1.5%**
2d Vegetation longitudinal sand dunes	1945.5	5.6 Access roads 4.1 Haul roads 9.2 Hope Point 8.1 Quarries	5.1 Access roads 0 Haul roads 0.35 Hope Point 0 Quarries Camp and access ~ 3 ha inferred 0.01 Crystalliser 6.7 Main Island
Total 2d		**27 ha**	**15.2 ha**
% disturbance		**1.4%**	**0.8%**
2e Vegetation mobile sand sheet	73.4	0	0
3a bare claypans /fringing vegetation	124.8	0.1 Access roads 1.9 Haul roads 0.003 Quarries	0.02 Access roads 0 Haul roads 0 Quarries

Vegetation Type	Total area mapped (ha)	Indicative footprint clearing (ha)	
Total 3a		**2 ha**	**0.02 ha**
% disturbance		**1.6%**	**0.02%**
TOTAL	**10,897.4**	**161.32* ha**	**137.74* ha**

Note: * indicative clearing as surveyed by Biota (2005a) has decreased from 1.5 % to 1.3 % of the total area within the project footprint

Table 3 Estimated and revised of vegetation types interpolated from Land Systems Mapping for southern saltfield

Rangeland Unit	Area mapped in original project footprint (ha)	Indicative clearing for original project (ha)	Indicative clearing for revised project (ha)
RGEDUN	240	60.3 (25% disturbance)	8.7 (access roads)
RGELIT	41,091.9	222.4 (0.5% disturbance)	7.2 (access roads)
RGEONS	22.3	4.9 (22% disturbance0	3.5 (access roads)
RGEYAN	10.5	10.5 (100% disturbance)	0
TOTAL	**41,364.7**	**298.1**	**19.4**

The estimated quantities of construction materials required have been revised for the new proposal. The original and revised volumes are shown in Table 4 and Table 5 respectively. In total, the volume of material required has been reduced from 8,187,000 m^3 to approximately 5,100,000 m^3. The clay material requirement for construction has reduced from 6,693,000 m^3 to approximately 3,000,000 m^3 (Table 4; Table 5). Clay material will be sourced from 12 claypans (Appendix 2), and the total area of disturbance will be limited to approximately 75 ha.

Table 4 Estimated material quantities for 10 Mtpa saltfield construction (ERMP Table 2-13)

Item	Required embankment material (m^3)	Required armour material (m^3)	Required road base material (m^3)
Seawall, concentrator and crystalliser	5,760,000	1,067,000	141,000
Roads, airstrip, building platform	933,000	133,000	153,000
TOTAL	**6,693,000**	**1,200,000**	**294,000**
Total of all materials	**8,187,000 m^3**		

Table 5 Estimated approximate material quantities for revised saltfield (4 Mtpa)

Item	Required clayfill material (m^3)	Required armour material (m^3)	Limestone basecourse material (m^3)
Levees, concentrator and crystalliser	2,700,000	540,000	140,000
Other infrastructure (Roads, airstrip, building platform, salt stockpile base, maintenance, SOP plant)	300,000	35,000	1,350,000
TOTAL	**3,000,000**	**575,000**	**1,490,000**
Total of all materials	**Approximately 5,100,000 m^3**		

The limestone basecourse material required for ‘Other infrastructure’ (Table 5) has increased due to the inclusion of base material for the salt stockpile. The armour and limestone basecourse material will be sourced from the excavation of the barge harbour at Hope Point, transition land excavation area and the nearshore barge channel A (Appendix 4).

The volumes of materials to be sourced from dredging and excavation of the barge channel and barge harbour been revised. The original and revised volumes are shown in Table 6 and Table 7 respectively. The revised volumes of materials to be sourced from dredging and excavation have increased due to a number of factors:

- revised design of barge channel and barge harbour
- use of batter slopes
- increase in excavation depth
- previously unreferenced volume of barge harbour excavation now included.
- refined calculations of excavated volumes.

Table 6 Dredging and excavation volumes from ERMP

Value	Barge channel B	Barge channel A (nearshore)	Total channel (A + B)	Barge harbour
Volume (m^3)	20,500	284,500 *	305,000 m^3	600,000 m^3 limestone **
Area			16.4 ha***	12 ha
Depth			3.5 m CD	5 m CD
Length			1.3 km	

* This figure was included in ERMP Table 2-11 as excavation volume from the barge harbour – however, it was also included in Figure 6-37 (p.6-72) as nearshore excavation from the barge channel.

** In the ERMP this figure is not given as excavation volume, but as limestone resource

*** The 16.4 ha area of channel A and channel B in the ERMP included 1 ha for the transition land excavation area

Table 7 Revised dredging and excavation volumes

Value	Barge channel B	Barge channel A (nearshore)	Total channel (A + B)	Transition land excavation	Barge harbour	Total excavation
Volume (m^3)	Approximately 135,000 *	Approximately 240,000 *	Approximately 375,000 *	Approximately 10,000 **	Approximately 1,535,000 **	Approximately 1,995,000
Area			~17.5 ha	1.0 ha	16.5	
Depth			-5.1 to -5.4 m (AHD) (3.5 m CD to 3.8 m CD)	-5.4 to -7.1 m AHD) (3.8 m CD to 5.5 m CD)	-7.1 m (AHD) (5.5m CD)	
Length			~1.6 m			
Width	130 m (max)	143 m (max)	130 – 143 m			

* Volume allows for 1:2 batter slopes

** Volume allows for 1:1.5 batter slopes above 1.3 AHD

Fuel and power requirements for the project have been amended based on the revised proposal. A total of six 1 MW diesel generators will be required for the 4 Mtpa facility and will be located at the Main Island.

Fuel farms will be located at Hope Point and Main Island, having capacities of 140,000 L and 220,000 L respectively. The truck refuelling facility at Main Island will be 30,000 L in capacity. A temporary fuel storage facility will be located at Dean's Creek, to provide a temporary power supply during construction. This facility will be a self bunded double skinned fuel tank with a 14,000 L capacity.

In the revised proposal the diesel fuel farm at Hope Point has been relocated to higher ground (8-9 m AHD) in response to concerns about its setback from the coast. This will provide additional protection against storm surge events greater than 1 in 100 year storm event. In addition, the relocation of the fuel farm will prevent disturbance to the *Melaleuca cardiophylla* vegetation at Hope Point (vegetation type 2b).

An operational desalination reserve osmosis plant will be located at Main Island, and have a capacity of producing approximately 30 kL/day of water. Water will be fed to the plant by a line approximately 40-50 mm in diameter, and tailwater from the plant will be pumped into concentrator ponds.

The areas of disturbance to intertidal BPPH, consisting of mangroves and algal mat, in the project area have decreased (Table 8; Table 9) due to revision of the proposal. The total area of BPPH habitat to be cleared for the project has decreased from 36.2 ha to 18.6 ha.

Table 8 Original areas and losses of intertidal BPPH in proposed management units along the east coast of Exmouth Gulf

Draft BPPH management unit	Size (km^2)	Current area (ha)		Losses within units (ha) and (% loss)		Cumulative loss (ha) and (% loss)
		Mangroves	Algal mats	Mangroves	Algal mats	BPPH
M1 – Tent Island to Tubridgi Point	120	3218	2639	3.6 (0.11)	14.5 (0.55)	18.1 (0.3)
M2 – Hope Point to Tent Island	81	1697	1147	1.0 (0.06)	3.6 (0.31)	4.6 (0.16)
M3 – Giralia Bay to Hope Point	160	3987	3377	0.8 (0.02*)	12.7 (0.38)	13.5 (0.18)
M4 – Giralia Bay	47	1763	633	0	0	0
Total		10665	7796	5.4 (0.05)	30.8 (0.4)	36.2 (0.2)
Total (mangrove + algal mats)		18,461		36.2 (0.2)		

Source: Biota 2005c

** The % loss stated in ERMP (0.04) was a miscalculation; the actual % loss is 0.02 %.*

Table 9 Revised areas and losses of intertidal BPPH in proposed management units along the east coast of Exmouth Gulf

Draft BPPH management unit	Size (km^2)	Current area (ha)		Losses within units (ha) and (% loss) Revised Project		Cumulative loss (ha) and (% loss)
		Mangroves	Algal mats	Mangroves	Algal mats	BPPH
M1 – Tent Island to Tubridgi Point	120	3218	2639	No impact	No impact	N/A
M2 – Hope Point to Tent Island	81	1697	1147	1.0 (0.06)	3.6 (0.31)	4.6 (0.16)
M3 – Giralia Bay to Hope Point	160	3987	3377	1.0 (0.02)	13.0 (0.38)	14.0 (0.19)
M4 – Giralia Bay	47	1763	633	0	0	0
Total		10665	7796	**2.0 (0.02)**	**16.6 (0.21)**	18.6 (0.1)
Total (mangrove + algal mats)		18,461		18.6 (0.1)		

Source: Revised from Biota 2005c

3.2 REVISED YANNARIE SOLAR SALT PRODUCTION PROCESS

The following description of the salt production process to be used at Yannarie Solar has been updated from the ERMP in light of the changes to the proposal, as outlined above. The description also includes further information on the bitterns resource recovery process.

Seawater intake and concentration

Seawater will be pumped from Deans Creek at a nominal rate of 143 Mm^3/year into a series of seven (7) concentrator ponds covering an area of approximately 8270 ha. As the seawater (now called brine) flows through the series of concentrator ponds, solar energy evaporates water, increasing both the density of the brine and concentration of the dissolved salts. Calcium salts begin to precipitate out of the brine at an early stage, initially as calcium carbonate ($CaC0_3$) and then as calcium sulphate ($CaSO_4.2H_2O$) in the form of gypsum. The calcium salts remain on the floors of the concentrator ponds increasing the sealing of the ponds.

At the exit point of the final concentrator pond, the brine has achieved a density approaching 1.216 g/ml. At this density the brine is saturated with salt (sodium chloride) and 85% of the gypsum has been removed.

Stage 1 crystalliser ponds

The saturated brine would then be pumped into the Stage 1 crystalliser ponds where salt (predominately sodium chloride) precipitates out as crystals.

The Stage 1 crystalliser ponds will cover an area of approximately 1100 ha and nominally involve a series of 12 ponds arranged in pairs. The brine moves continuously through each of the pairs (via passive movement) and at the exit point of the second crystalliser pond the density of the brine reaches approximately 1.25 gm/ml. At this density about 75% of the sodium chloride and most of the remaining calcium in the incoming brine has been precipitated.

The precipitated salt forms an even bed on the floor of the crystalliser pond and under average meteorological conditions the bed thickness after one year will be approximately 25cm.

Initially, this salt bed will be left in place as a permanent pavement and, subsequently, harvesters and haulage equipment will extract salt that precipitates out on top of this pavement.

Reconstituted brine process (Bitterns recovery phase 1)

Bitterns from the Stage 1 crystalliser ponds are fed through two series of ponds, Desalting Ponds and Secondary Crystalliser Ponds, (nominally 8 ponds) to raise the density from 1.25g/ml to 1.30g/ml.

Salt grown in the Desalting Ponds is periodically redissolved in seawater to produce saturated brine (called reconstituted brine) which is fed into the Secondary Crystalliser Ponds.

Salt grown from the reconstituted brine in the Secondary Crystalliser Ponds is harvested and transferred to the washplant in the same way as the salt from the primary crystallisers.

Bitterns left over after the reconstituted brine process are referred to as Spent Bitterns (Bitterns B). Bitterns B is then processed to produce potassium salts.

Potassium salts recovery process (Bitterns recovery phase 2)

Bitterns B discharged from the reconstituted brine process are fed into a sequence of two new sets of crystalliser ponds called the spent bitterns crystallisers for the potassium salts recovery process.

Salts crystallized from bitterns in the density range of 1.30 to 1.35g/ml provide the feed to a Sulphate of Potash (SOP) process. These mixed salts contain sodium, magnesium and potassium chlorides and sulphates and are deposited from a sequence of ponds of steadily increasing density. The potassium content of the salts varies with the bitterns density. The mixed salts are harvested and put through beneficiation (washing) and blending steps to provide a uniform feed to the SOP facility. There are large circulating flows of mixed salts and brine between the crystallisers and the SOP facility and within the crystallisers. Water, electricity and heat energy are consumed in the SOP process. No other substances are added anywhere in the process so that the residual brine from the SOP plant contains only species from the original seawater.

The SOP process will require about 2 MW which could be provided by diesel generators originally allocated for the northern pump station. However, given the lead in time required, further engineering investigations will consider opportunities for using thermal pond technology to deliver the electricity and heat energy required by the SOP facility. The development of this technology by a saltfield in Victoria has shown enormous potential. The Australian Greenhouse Office (2007) has reported that there are about 60 solar pond energy systems operating around the world.

Bulk SOP product is delivered by ship through existing load out facilities.

Bitterns discharged from the SOP ponds is referred to as End Point Bitterns (Bitterns C) and transferred to the Bitterns Management Area.

End Point Bitterns (Bitterns C)

The bitterns management area is located at the northern end of the proposed salt field and will include a storage pond with a capacity of about 10 Mm^3. This will provide sufficient storage capacity for 10 years at full production. The area of storage available is about 1000 ha and hence to accommodate 10 Mm^3 the bitterns will be stored to a depth of about 1 m. The Bitterns C has potential to be a saleable product for a number of commercial uses, such as dust suppressant, tofu production, de-icing material, or utilisation of Bitterns C for in situ production of algae for biofuels. The evaluation of further bitterns processing will be completed within the first 10 years of operation, well prior to storage capacity being reached.

4. RESPONSE TO EPASU COMMENTS

Responses to EPASU comments are provided in Table 10 to Table 12.

Table 10 EPASU comments on ERMP on Volume 1

No.	Page	Para	Comment	Response
1	1-1	4	Calculations needed on - how much bitterns will be generated per annum. - area and volume of storage required over life of' project if these bitterns cannot be recovered or discharged?; i.e. what area is to be treated as long term 'tailings' storage if residual salts cannot be used or discharged and - how would this area be closed, stabilised and managed for the long term? Precisely what is the proposal for which approval is being sought now, without relying on the outcomes of future technical and economic research?	Under the revised proposal: • The amount Bitterns C that will be produced after the resource recovery process will be approximately 1 Mm^3 annually after about three years. • Use and recovery of magnesium chloride from Bitterns C will be known within first 10 years of production. The intention is store up to a maximum of 10 Mm^3 of Bitterns C. The bitterns management area will be an area of up to approximately 1000 ha. • Closure concept for Bitterns C at this stage may involve a variety of options if discharge of the diluted and mixed Bitterns C to the Gulf, tidal creek or deep aquifers in an environmentally acceptable period of time and manner is not appropriate. The selected option would be subject to approval in the final Closure Plan to be prepared at least 5 years before closure. These options would include; dilution of Bitterns C with seawater and spread between ponds for evaporation; provision of Bitterns C for commercial application as dust suppressant; utilisation of Bitterns C for in situ production of algae for biofuels. • Valuable infrastructure could be utilised for aquaculture following closure or levee walls demolished and material used to backfill quarries used for their construction. If the infrastructure is not to be used, limestone armour and clay fill would be recovered and sold as construction material.
2	1-1	5	What caveats apply to the implementation of proposals to recover bitterns beyond a specific gravity of 1.35?	The only caveat for recovery of Bitterns C is finalisation of market opportunities for magnesium products and/or MgCl feedstock. The recovery of values from Bitterns C will depend on market for magnesium metal and usage of magnesium chloride.
3	2-24	Fig 2-2	Where are the bitterns storage ponds located?	Under the revised proposal, the future bitterns resource recovery area will be located at the northern end of the salt field (refer to Appendix 1). The end product of the recovery process (termed Bitterns C) will not be produced for about the first three years of salt field operation.
4	2-25	Tab 2-11	64 crystalliser ponds listed in Table 2-11 but 50 listed on p2-34 – which figure is correct? Please list in Table 2-11 the range of volumes of seawater to be pumped annually (see p 2-31).	The number of crystalliser and bitterns resource recovery ponds will be determined following completion of detailed design phase of the project. Under the revised proposal, the estimated number of ponds will be about 30 crystallisers ponds, up to 7 concentrator ponds and 1 bitterns management area. The bitterns management area will be an area of up to approximately 1000 ha. Under the revised proposal, the amount of seawater pumped to the salt field from Deans Creek is estimated to be about $143x10^6m^3$ annually.
5	2-25	Tab 2-11	Data in this table indicate that Yannarie will require 0.00411 hectares of disturbed area for operations per tonne of annual production (total 41,100 ha for 10Mtpa). Why is this disturbance to productivity ratio significantly greater than for other, comparable operations based on seawater in WA viz - Pt Hedland 0.0026 ha/t - Dampier 0.0025 ha/t - Onslow 0.0036 ha/t (Lake McLeod is 0.0008 ha but uses naturally concentrated brine as input resource)	In the original proposal an area was allowed for resource recovery from bitterns which is not conducted elsewhere to the extent intended under the Yannarie Solar proposal. This may explain the difference. From an environmental point of view the disturbance salt flat to productivity ratios do not consider resource efficiency factors, or significant environmental impact due to direct loss of algal mats and mangroves. It is also not clear that the disturbance ratios have included the disturbance area of bitterns discharge and also they have failed to include a time weighted factor for bitterns discharge disturbance. Yannarie Solar has a better ratio of disturbed area to loss of mangroves and algal mats. For example, Onslow salt field has involved clearing of 380 ha of algal mat or 19% of project area compared to about 17 ha of algal mat or about 0.2% of the original project area for Yannarie Solar. The Yannarie Solar project has a revised pond depth of 0.8m to facilitate more efficient evaporation and this efficiency factor may also account for differences in the ratio of area to productivity for Yannarie Solar.

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6	2-26	9	Are there current examples of where additional salts are recovered above SG 1.35? Why will this recovery be economic at this location when it does not occur at other locations in WA?	Synthetic magnesium hydroxide production from seawater and bitterns has been practised worldwide for decades, with some plants operating continuously since the 1930's (CSIRO 2004). Bitterns resource recovery is an economically viable process in Israel (Dead Sea Works) and the Great Salt Lake (US) as well as other countries, including Ukraine and Germany (CSIRO 2004). In Australia, SunSalt in Victoria also commercially extract Epsom salts from bitterns (CSIRO 2004). Other salt fields in WA have attempted to institute some recovery and have been granted environmental approval to do so. The Straits proposal has been designed from the outset to recover salts where other fields have not necessarily had the room to retrofit recovery process areas. This may be a substantial reason why some other salt fields have not proceeded with full recovery of further salts from bitterns.
7	2-27	5	For each of the potential applications listed - what is the current market demand vs annual production from Yannarie? - what is the current spot price for each product versus the break-even FOB cost for each from the Yannarie project?	Financial assessment will need to consider market values and trends beyond simplistic current 'spot price'. Product value will also depend on final product quality which will need to be assessed at the time. It should be noted that there is no current spot price for salt.
8	2-34	2	Where is the services corridor between Hope Pt and Main Is illustrated please?	The services corridor is illustrated in the ERMP on page 2-43 and 2-44 (Figures 2-11 and 2-12) and pages 6-46 and 6-47 (Figures 6-19 and 6-20).
9	2-34	5	What is the transmissivity of the salt pavement in the crystallisers?	Following completion of construction, maiden brine is transferred to the crystallisers where salt grows massively on the floor of the pond. Initially a permanent salt pavement (400mm – 600mm) is set down in order to support harvest equipment. The pavement crystallises as a massive, monolithic growth which solidifies (cements) further with annual draining and exposure to the weather. Initially the pavement is virtually impervious, with further consolidation of the deposit with time. Drift salt, a fine non massive deposit which forms at the edge of the levees, is initially pervious. However, exposure of this salt to atmosphere on draining allows the reforming (cementation) of drift salt into a massive deposit which becomes effectively impervious. It is the intention of Straits to use drift salt to further stabilise the levees by increasing the natural clay batter slope from 1.0 m vertical to 1.5 m horizontal with a drift salt infill batter of 1.0 m vertical to 4.0 m horizontal. The salt batter formed effectively seals the perimeter edges of crystallisers, as well as protecting the clay fill / limestone armoured levee and preventing levee clay from contaminating product salt (SSJV pers comm. 2007). Hence the transmissivity of the salt pavement is negligible.
10	2-34	8	Please provide a diagram showing the 0.38m contour on the salt flats. If sea level rises by 0.38m, why won't all areas below that elevation become inundated, regardless of distance inland (unless there is a dike or similar structure to hold the sea back)? Please also provide the outline of the algal mat boundary on the same diagram. What impacts are likely to occur as a result of sediment compaction under the weight of the salt field, or future tectonic activity?	The Yannarie Solar project proposed in the ERMP was to be set back an average of 40 m landward of the algal mat, based on estimated shoreline retreat of 38 m. The 38 m setback was determined using the Bruun Rule, which is considered to be an over conservative estimator of local shoreline response to sea level change, and in the absence of any EPA policies or guidelines on this issue. The Bruun Rule is recognised as the only current 'official' approach to determining shoreline response to sea level rise and has been applied elsewhere in Western Australia by the Department of Planning and Infrastructure. Using a planning horizon of 100 years and anticipating a sea level rise of 0.38 m, a potential shoreline retreat of 38 m was determined. Under the revised proposal the concentrator ponds and crystallisers will be setback a minimum of 100 metres from the landward edge of the algal mat. As the algal mat is generally wet from tidal inundation only 1-3% of the time during regular spring tides the additional setback to a minimum of 100 metres will provide even greater accommodation for extreme tidal events, in addition to potential sea level rise. As acknowledged by the Department for Planning and Infrastructure in their submission on the ERMP, the response of the project area shoreline to sea level rise is likely to be complex. The

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				ERMP (section 2.2.4) points out that mangroves are also excellent land builders and consequently the long term sea level rise will not necessarily result in an inland migration of mangroves. There are many varied opinions on the estimated level of sea level rise predicted to occur by 2100. In this light, Straits undertook a mapping exercise showing three sea level rise scenarios (0.3 m, 0.5 m and 1.0 m) and their potential impact on mangrove and algal mat habitats in the Yannarie Solar project area. The exercise involved extrapolating the known tidal ranges of mangrove and algal mats in relation to sea level rises of 0.3 m, 0.5 m and 1.0 m (Appendix 5) (Note: the green shading represents the tidal range of potential mangrove habitat and brown shading represents the tidal range of potential algal mat habitat). The diagrams show that based on tidal range only, mangroves and algal mats could potentially migrate inland under each scenario. Under the 1.0 m sea level rise scenario, the tidal range in which mangroves potentially occur reaches the edge of the hinterland and there is no suitable area for algal mats. At a Gulf scale, it is evident that the tidal range in which mangroves potentially occur under the 1.0 m sea level rise scenario is extensive (Appendix 5). Straits undertook a drilling program in November 2007, to further investigate the geology and hydrogeology of the supratidal flat. The study included investigations into the geology of the supratidal flats, which allowed for an estimation of the effects of loading (and possible impacts such as sediment compaction) the supratidal flats with the construction of ponds. For more detail refer to Parsons Brinckerhoff 2008 (Appendix 6).
11	2-35	1	What evidence exists to demonstrate that levees will be maintained in a 1 in 25 ARI event? When levees are overtopped by storm surge, what will prevent the retreating water eroding the levees from the top where draining waters concentrate at the inevitable low points along the top of the levee wall?	The exterior levees have been designed in accordance with the Coastal Engineering Manual (U.S. Army Corps of Engineers 2006) and are designed to prevent wave run-up and overtopping for a 1 in 50 year ARI event. For larger storm events overtopping will occur but structural integrity will be maintained. Ponds will be maintained with a freeboard of 200 mm below the top of the levees thereby providing a large buffer volume for any waves that may break over the walls in extreme events. Advice provided to Straits from the Solar Salt Joint Venture (SSJV, pers comm. 2007) is that "It is the authors experience that events at or below those for which the levees were designed to withstand, overtopping of the levees did not occur and damage to the levee armouring was minimal. During events which did not exceed design standards, some overtopping was experienced and some stripping of armour was observed. At no stage did the overtopping continue to the point where brine level in the pond exceeded that of the levee." Levees on the seaward side of the ponds will be armoured with large rocks to prevent erosion of the levee in the same way as armoured in marinas or groynes function. Levee armouring is designed to prevent or minimise scouring events. For instances where some scouring occurs, maintenance works will be carried out on completion of post storm event investigations.
12	2-35	4	What examples exist of where levees at other WA solar salt operations have collapsed, why did they collapse and how will the Yannarie design differ from the failed case(s)?	Properly designed and engineered levee walls have not failed in salt fields in WA. Failures related to inadequate design and construction will be avoided by strict adherence to required standards and best practice levee design and construction.
13	2-37	2	What is the planned area of disturbance to the area required to source clay fill? What percentage of the area of clay pans in the region will this disturbance constitute? What is the regional significance of the clay pans as extended sources of water for wildlife following flooding, as periodic water-bird feeding or breeding habitat or as habitat for other organisms dependent on clay pans?	The area of potential disturbance to claypans has been substantially reduced by the recent amendment to the project. In addition, the proposal has been amended to reduce the number of claypans to be disturbed by greater extraction from a smaller number and extraction from claypans in mainland remnants will be restricted. The estimated quantities construction materials required have been revised for the new proposal. The clay material requirement for construction has reduced from about 14601.992 m^3 to approximately 3,000,000 m^3. Clay material will be sourced from 12 claypans (refer to **Table A** and the total area of disturbance will be limited to approximately 75 ha (Appendix 2).

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Table A: Clay pan borrow pits – approximate parameters
<table>
<tr><th>Location</th><th>Excavation volume (m3)</th><th>Excavation depth (m)</th><th>Area (ha)</th></tr>
<tr><td>A</td><td>480,000</td><td>3.6</td><td>13.3</td></tr>
<tr><td>D,E</td><td>843,000</td><td>4.2</td><td>20.1</td></tr>
<tr><td>F</td><td>288,000</td><td>4.0</td><td>7.2</td></tr>
<tr><td>I,K</td><td>391,850</td><td>4.0</td><td>9.8</td></tr>
<tr><td>M</td><td>302,000</td><td>4.0</td><td>7.5</td></tr>
<tr><td>N</td><td>218,000</td><td>4.0</td><td>5.5</td></tr>
<tr><td>YN</td><td>17,000</td><td>4.0</td><td>0.4</td></tr>
<tr><td>YS</td><td>5,000</td><td>4.0</td><td>0.1</td></tr>
<tr><td>Hope Point</td><td>22,800</td><td>4.0</td><td>0.6</td></tr>
<tr><td>Main Island</td><td>392,000</td><td>4.0</td><td>9.8</td></tr>
<tr><td>TOTAL</td><td>2,986,450</td><td></td><td>74.3</td></tr>
</table>
Straits have undertaken a GIS mapping analysis of claypans in the region to determine the proportion of claypans in the region disturbed by the proposal. The analysis involved sub-sampling two representative 625 ha areas and mapping claypans in detail, then multiplying by broad-scale extent to obtain a figure for the locality. The results of this analysis showed that in one 625 ha area, there was approximately 65 ha of claypans (~10.4%) and in a second 625 ha area there was approximately 98 ha of claypans (~15.7%) (Appendix 7). Therefore based on an average of these two areas, approximately 13% of the region sampled comprised of claypans. Hence the 75 ha of claypans required for the project equates to about 0.58% of claypans in the adjacent 100,000 ha designated as regional context.
At natural population levels, native fauna in the area are not dependent on drinking standing water. Arid zone fauna obtain water pre-formed in food, from dew and other sources and are physiologically adapted to arid conditions without plentiful water supplies. It is therefore unlikely that the clay pans provide any significant ‘extended sources of water’ for native fauna present in the area.
The clay pans in the project area may provide periodic habitat for waterbirds or other fauna. However, these landscape features are extremely widespread and common in the locality, with hundreds of similar intermittently ponded claypans covering the landscape on the immediately adjacent hinterland. It is likely that these numerous, undisturbed claypans would continue to provide periodic habitat to water birds and other fauna in the locality.
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<tr><td>14</td><td>2-39</td><td>Sect 3.93</td><td>There is no text under this heading – what text should appear here?</td><td>No text missing. The heading level shown is in error, the heading number should be 3.10 instead of 3.9.3.</td></tr>
<tr><td>15</td><td>2-40</td><td>Fig 2-10</td><td>Why can't the fuel farm be rotated and consolidated on the higher ground, further from the beach to provide further protection from storm surge events? (See Fig 4-7 for elevation).</td><td>The original location of the Hope Point fuel storage facility was above the 1 in 100 year ARI storm surge event (as indicated by the Cyclone Vance debris line). The fuel farm will be relocated (principally to avoid a vegetation community) alongside the salt stockpile on an elevation of 8-9m AHD, as opposed to the original elevation of 4-5m AHD (Appendix 3).</td></tr>
<tr><td>16</td><td>3-3</td><td>5</td><td>Why is subterranean fauna treated as a minor factor when no data exist to show whether or not subterranean fauna are present?</td><td>The Scoping Document, which has been subject to public consultation and sign off by the EPA sets out what work is required and in so doing, the relative significance of the issue being</td></tr>
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				investigated. Hence the Scoping Document states in relation to subterranean fauna: "While Cape Range, on the western side of Exmouth Gulf, is well recognised for its subterranean fauna, there is little evidence to date that the project area has any significance for this fauna. The majority of the project area is hypersaline mudflats that would not comprise suitable habitat for this fauna." A risk-based approach was taken in this scoping process, considering: • the nature of the project impacts • the nature of the subterranean habitats present • other records of subterranean fauna from the region (G. Humphreys pers comm. 2007). The outcomes of this suggested a relatively low risk that significant subterranean biodiversity values would be associated with the project area, or that these would be compromised in the event that subterranean fauna were present (G. Humphreys pers comm. 2007). Consequently, the Scoping Document required assessment of this issue from a desktop review and liaison with the WA Museum and CALM, based on site geotechnical and hydrogeological investigations and opportunistic sampling "where targeted bores are available." These requirements of the Scoping Document were implemented. On this basis, and relative to other environmental factors associated with the proposal, the factor was considered minor. However, due to concern regarding the lack of subterranean fauna investigations within the project area raised since the sign-off of the Scoping Document, a subterranean fauna investigation was undertaken in late 2007. The subterranean fauna survey programme was designed by Biota Environmental Sciences (Biota) to meet the EPASU requirements for additional data, as part of finalising the EPA assessment of the Yannarie Solar Project. The scope of works were agreed to by DEC and EPASU (G. Humphreys pers. comm. 2007). In selecting the location and number of sampling points for the programme, consideration was given to: • sampling of the key project impact areas (e.g. Hope Point and Main Island, in addition to mainland remnants situated in the centre of the saltfield that may be affected by elevated saline groundwater) • installation of 'control' or reference bores in similar prospective habitats outside of the project impact area, principally to target other potential limestone areas along the coastal portion of the study area that will be undisturbed by the project • requirements of the DEC regarding sampling effort, spatial spread and number of sample locations for subterranean fauna surveys (Biota 2007b). For results of the investigations refer to Biota 2008a (Appendix 8). Any decision on whether additional subterranean fauna work is required will be made after an informed review of the outcomes of these investigations.
17	3-7	6	Why are preservation of native vegetation and rehabilitation of degraded areas treated as offsets, unless they include areas to be protected and rehabilitated over and above what is disturbed by the proposal?	This was not intended to be part of a formal offset package.
18	3-7	7	What examples exist of renewable energy sources that will be viable for this proposal?	Straits reiterate its commitment to using renewable energy where feasible. Straits will investigate the use of various sources of renewable energy, including solar power, wind and solar/thermal ponds. A consortium involving RMIT University and Pyramid Salt Pty Ltd has completed a project using a 3000 m^2 solar pond located at the Pyramid Hill salt works in northern Victoria which can capture and store solar energy using pond water naturally heated up to 80^{o}C (Australian Greenhouse Office 2007).

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				Solar pond systems have been installed around the world with about 60 now in operation and the technology is poised for commercialisation (Australian Greenhouse Office 2007). Electricity is generated from the heat stored in the ponds.
19	3-8	1	What is the projected amount of carbon sequestration as a result of algal growth in the concentrator ponds and how does it compare to the increased amount of greenhouse emissions from the proposal? What calculations have been performed consistent with EPA Guidance Statement 12?	EPA Guidance Statement No. 12 and the associated methodology from the National Greenhouse Gas Inventory Committee do not provide methodology for determining carbon sequestration for created marine wetlands. Assessment of Greenhouse Gas Emissions from the project was done according to Australian Greenhouse Office methods (ERMP page 3-7). The amount of greenhouse gases attributable to the original proposal was relatively small (~58,000 tonnes CO_2 equivalent/yr) and was not considered to be a major factor. The greenhouse gases emissions for the revised proposal is estimated to be less than the original proposal (~43,500 tonnes CO_2 equivalent/yr), due to the reduction in power requirements from 8 MW to 6 MW. Nonetheless renewable sources of energy will be assessed and employed where feasible.
20	3-9	7	Troglofauna as well as stygofauna need to be considered. Subterranean fauna may be affected by excavation in limestone habitats and by incursion of brine into limestone 'islands' when the concentrator/crystallises ponds adjoin them. Please provide data to indicate whether or not freshwater lenses occur on top of saltwater below limestone features (as occurs on Barrow Island for example) and data from properly sampled, purpose built bores designed to detect whether or not subterranean fauna are present within limestone features.	A subterranean fauna investigation was undertaken in late 2007. Refer to Item No. 20 Table 10, and for the results of the investigation refer to Biota 2008 (Appendix 8). Hydrological drilling has shown no existence of freshwater lenses. Refer to Parsons Brinckerhoff 2008 (Appendix 6).
21	4-5	4	What number of lettable units already exist in Exmouth? What number of caravan/camping sites exist in the Exmouth area? What number of visitor/nights are recorded in the area? What economic benefit does Exmouth currently derive from tourism annually? What level of employment does it provide?	The information in the ERMP was provided as a broad background and not intended to be comprehensive or economic analysis of the tourism industry and is not an environmental factor. However, the following information was gathered to address these questions. Total number of lettable units (including caravan/camping sites) for Exmouth area (Exmouth, Coral Bay, Giralia Station, Mackerel Islands) is 5375 units (Deb Kezich, Exmouth Visitors Centre, pers comm. 2007). Currently there are a number of tourism developments at the planning stage for the Exmouth region which are expected to provide an additional 816 'visitor units', in addition to the number of visitor units to be finalised for two other developments at planning stage. A further 40 units are currently under construction (Tourism WA 2006a). Exmouth recorded a total of 569,700 visitor nights averaged over 2004 and 2005. This represents a decrease on the number of visitor nights recorded in 2003/2004, 2002/2003 and 2001/2002 (Tourism WA 2006b). The economic benefits or otherwise of tourism is not an environmental factor and no further evaluation of economic costs or benefits will be conducted by Straits.
22	4-5	6	Why is the Woodside Enfield oil production project 30km off North-West Cape not included as an existing petroleum production activity in the Exmouth area? What level of employment and economic activity does it provide to the area?	The socio-economic information in the ERMP was provided as a broad background and not intended to be comprehensive economic analysis of the value of any industry. The project is of little consequence to the Straits revised proposal. The economic benefits or otherwise of the oil and gas industry locally is not an environmental factor and no further evaluation of economic costs or benefits will be conducted by Straits.
23	4-6	2	What level of employment and economic benefit does fishing and aquaculture provide to the Exmouth area?	An overview of fisheries and aquaculture industries in Exmouth Gulf was prepared by Oceanica (2005b). This report was summarised in the ERMP (Sections 1.2.1 and 1.2.2), however unfortunately it was not included as an Appendix in the ERMP documentation. This report was prepared in consultation with Dr Mervi Kangas and Mr Errol Sporer of the Department of Fisheries and was peer reviewed by Dr Rick Scoones (Rick Scoones and

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				Associates) and Dr Mervi Kangas from the Department of Fisheries, and it is provided in Appendix 9. The socio-economic information in the ERMP was provided as a broad background and not intended to be comprehensive economic analysis of the value of any industry.
24	4-8	Fig 4-3 (see also Fig 4-8)	What is the sequence of landform units to the west of those shown in Fig 4-3? Specifically, how do the limestone features (such as at Hope Pt) relate to subsurface geology as shown on Fig 4-8? Are the limestone features essentially isolated 'islands' or are they laterally connected below the surface? These questions bear directly on the likely implications of the proposal for subterranean fauna and hydrology.	Landform units are described on page 5-2 and shown diagrammatically in Figure 4-8 of the ERMP. Halpern, Glick & Lewis (1966) reported the presence of limestone on and under the northern end of the supratidal saltflat in the vicinity of Urala Creek as part of initial investigations for a solar salt field. It was noted that the limestone was composed largely of coral and shells bound together with a calcareous cement and that the pores of this rock have been sealed with silt and clay "which renders it impervious". The 1966 report also stated that "It is evident that when high tides cover any calcareous limestone shelf little pools are left which evaporate and make salt." (Halpern Glick & Lewis 1966). Halpern Glick & Lewis (1966) also noted that the presence of the impervious limestone diminished further south, closer to the Yannarie Solar proposed project site "The central area which has now been chosen as the initial stage in the project differs somewhat from the northern area in geology, surface level and soil type (see holes 61 to 70 and 102 to 110). The limestone outcrops are not nearly so conspicuous except around the islands and seaward edge of the flats. The auger holes generally did not reach rock, nor did they penetrate any poor sandy materials. The surface is much higher and much firmer and the soil at depth is almost invariably a dark brown tough sandy clay which shows every sign of persisting to considerable depth and forming a satisfactory basement without the aid of the limestone." (Halpern Glick & Lewis 1966). The observations presented above also reflect the results of hand auger holes on the supratidal saltflat conducted by Parsons Brinckerhoff and provided in an appendix to the ERMP. The 1966 study by Halpern Glick and Lewis also states; "Evaporation would slowly cause the groundwater to increase in salt content provided it could not leak out of the basin through the bedrock or subsoil. This is borne out by field evidence where in every case groundwater is well above mean sea level and leakage could take place if the area were sufficiently porous. Salinity readings range from 18^o to 20^o Baume' which is only slightly below salting point and these values persist even beneath areas frequently covered by the tide and up to the landward edge of the flats indicating that contamination by lateral flow is negligible." It should be noted that seawater is about 3^o to 4^o Baume and the figure cited of 18^o to 22^o Baume is comparable to bitterns. Investigation drilling was conducted in November 2007 to determine the stratigraphic relationship of surface limestone features. The results of these investigations are provided in Parsons Brinckerhoff 2008 (Appendix 6). Subterranean fauna investigations were also to be undertaken at this time, as described in Item 16, paragraph 5, above. Refer Appendix 8 to for results of the subterranean fauna investigations.
25	4-10	1	What is the current estimate of mangrove recovery since the work of Paling and Kobryn? Following the construction of concentrator ponds at Port Hedland in the mid 1990s, significant mangrove mortalities (hundreds of hectares) have been reported, as recently as 2005, with some more than 1km from the bund wall. The apparent cause of these mortalities has been reported to be the hydrostatic head of impounded water on top of naturally occurring hypersaline groundwater beneath the salt flats. The increased head is reported to have caused a slow migration of hyper saline water towards the	The Paling and Kobryn (2005) work represents the current estimate of mangrove recovery. It was completed in 2005 and only minor changes are likely to have occurred since this time. Straits do not have access to any reports on the alleged mangrove mortality making a specific response difficult. The displacement of the hypersaline water in the salt flat by seepage from the ponds may not occur as suggested in the comment. The very small amount of seepage that may occur under and through the base of bunds may interact with the hypersaline groundwater in the salt flat sediments in a similar way as fresh groundwater discharges to the ocean. In other words, a hypersaline groundwater wedge may form under the base of the bund over which the less

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			mangrove zone, resulting in mortality at the landward edge of the mangrove zone where groundwater is less influenced by tidal variation. What evidence is there to suggest that such an effect would not be likely to be significant on the salt flats at Exmouth? What studies have been undertaken to demonstrate the effect of the increased head created by the salt ponds on groundwater movement beneath the salt flat?	saline concentrator water "flows". This less dense water may continue to flow over the top of the hypersaline layer until it diffuses or is mixed with the hypersaline layer below. The watertable in the sediments varies 0.2 and 1 m below ground level. The salt flat is intermittently recharged by spring tides and flood events from the Yannarie and Rouse river systems but most of recharge to the salt flat is evaporated concentrating the salts in the surfical sediments as halite crust thereby producing hypersaline groundwater. The current hypersaline groundwater discharge from the salt flat is by throughflow into the mangroves and intertidal flats, evaporation and localised baseflow into drainage channels of the Yannarie and Rouse river systems. The scenario of a migration of hypersaline water toward the mangrove zone will be constantly diluted by tidal action. Port Hedland could be a specific case and cannot necessarily be directly compared with the Yannarie Solar proposal because: • the far greater separation distance between the mangrove zone and the field in this project compared with Port Hedland • this phenomenon has not been observed at either Dampier or Onslow salt fields (the latter particularly relevant as more representative of existing geomorphological conditions at Yannarie) • the underlaying clays in the salt flat have a hydraulic conductivity of around $1x10^{-9}$m/sec (ERMP p5-18 penultimate paragraph) according to Parsons Brinckerhoff 2005a. The very impermeable nature of the salt flat sediments will also be enhanced through compaction during construction. The bunds will be constructed of similar material with hydraulic conductivity being no more than 10^{-7}m/sec. The revised Yannarie Solar proposal includes an increase in the setback distance of the ocean facing ponds from the algal mat from an average of 40 m to a minimum of 100 m. This will reduce the potential impact of saline seepage (seepage is anticipated to the very slow) from ponds on algal mats and mangroves. The hydraulic head created by the salt ponds is 0.8 m and the impacts of the hydrostatic head have been studied in seepage investigations (Parsons Brinckerhoff 2004).
26	4-12	2	What evidence exists to indicate that the clay layer is continuous below the salt flat? What evidence is there to suggest that it is continuous below the 'islands' on the salt flat? Are there perched, if thin, freshwater lenses on these islands?	Hand auger investigations (involving 39 holes) were conducted over the salt flat by Parsons Brinckerhoff (2005b) to determine the distribution of the shallow watertable and the distance to the clay layer. In all these holes a clay layer was located. Investigations from a 1966 salt field study by Halpern, Glick and Lewis (1966) also support the statements regarding the continuous clay layer at depth. In addition, the impermeable nature of the lower extent of the superficial aquifer on the salt flat is shown through the field observations from both the 1966 study and recent site visits where seawater pools at the surface and subsequently evaporates to form salt. In addition, Straits undertook a drilling program in November 2007, to further investigate the geology and hydrogeology of the supratidal flat. Straits discussed these investigations with the Department of Water's hydrogeologist Mr Gary Humphreys prior to the program. The investigations to be undertaken are aimed at determining the following: • Stratigraphy of the supratidal flat, including the mainland remnants • Chemistry of the surficial sediments and of the groundwater within the surficial aquifer • The extent, thickness and permeability of the clay/silt layer that has been found beneath the surficial silty aquifer of the supratidal flats • Chemistry of the upper and lower portions of the clay/silt layer • Chemistry and piezometric surface of groundwater within the aquifer beneath the clay/silt layer

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				• The natural groundwater hydrogeological process of the supratidal flat (Parsons Brinckerhoff 2007). The results of the investigations are provided in Parsons Brinckerhoff (2008) (Appendix 6).
27	4-17	Fig 4-10b	What is the key to the colour coding in Fig 4-10b?	Figure 4-10b is sourced from a report by the Centre for Whale Research (2004) (in Appendix 7 of ERMP). There is no key to the shading in the original figure, however it is noted that the maximum depth (darker shading) in the Gulf is approximately 20 m.
28	4-18	6	What is the risk of disturbance or changed hydrology due to the presence of concentrator and crystalliser ponds causing the release or a change in the bio-availability of naturally elevated arsenic concentrations?	The naturally elevated levels of arsenic were noted in marine sediments not in the salt flat. Straits undertook a drilling program in November 2007, to further investigate the geology and hydrogeology of the supratidal flat, including investigation of the chemistry of surficial sediments. Surficial soil samples were collected from the top 0.2 m of sediments, and the samples were analysed for both Australian Standard Leachate Potential and whole rock geochemistry. Each soil sample was analysed for the following: • Major ions/rock forming elements (Na, K, Ca, Mg, Si, Alk, SO_4, Cl) • Trace elements (As, U, Pb, Sr, Ba, Li, Al, Fe, Mn, B, Cd, Cr, Cu, V, P, N, S) • $CaCO_3$ and total carbon (Parsons Brinckerhoff 2007). The results of the investigations are provided in Parsons Brinckerhoff (2008) (Appendix 6).
29	4-18	10	What are the predicted impacts of sediment released during seawall construction and subsequently? Will elevated sediment loads adversely affect the adjacent algal mats?	The seawalls (levees) are situated in a supratidal area and will be constructed as conventional 'dry' earthworks. There will not be any significant sediment release due to the sediment control management measures that will be implemented to account for the potential for rain and runoff during construction, hence sediment impact is not considered to be an issue.
30	4-21	5	What is the substrate beneath the 'mainland remnants'? Could it be limestone, and if so, could it be karstic? If so, is there a groundwater lens present?	Straits undertook a drilling program in 2007, to further investigate the geology and hydrogeology of the supratidal flat, including mainland remnants. Prior to the drilling program Straits discussed these investigations with the Department of Water's hydrogeologist Mr Gary Humphreys. The investigations undertaken were aimed at determining the following: • Stratigraphy of the supratidal flat, including the mainland remnants • Chemistry of the surficial sediments and of the groundwater within the surficial aquifer • The extent, thickness and permeability of the clay/silt layer that has been found beneath the surficial silty aquifer of the supratidal flats • Chemistry of the upper and lower portions of the clay/silt layer • Chemistry and piezometric surface of groundwater within the aquifer beneath the clay/silt layer • The natural groundwater hydrogeological process of the supratidal flat (Parsons Brinckerhoff 2007). The results of the investigations are provided in Parsons Brinckerhoff (2008) (Appendix 6).
31	4-21	6	Saline playas in the Goldfields have been found to support unique spider species. While usually arid, periodic flooding can lead to high productivity (of brine shrimp for example) and significant water-bird use on Goldfields clay pans and salt lakes. Does the same thing occur on the clay pans or salt flat at Exmouth?	There is no available data, as fauna sampling did not coincide with rainfall events, but it is unlikely that any significant intermittent faunal biodiversity values associated with the clay pans will be affected by the project because: • only a small number of clay pans will be excavated for materials sourcing • these features are widespread in the local landscape and apparently hydrologically linked during major flood events. It therefore appears a relatively low risk that there would be any aquatic fauna restricted to individual clay pans. The salt flat is also flooded during major events, so there is no apparent mechanism whereby localised species endemism could arise on this feature • with respect to water birds, the flooding of the salt field is actually likely to improved water

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				bird use aspects of the locality through habitat creation as has been documented at other salt fields along the Pilbara coast • the revised Yannarie Solar project has significantly reduced the area of saltflat to be impacted and hence reduced any risk relating to potential salt flat fauna. Straits have undertaken a GIS mapping analysis of claypans in the region to determine the proportion of claypans in the region disturbed by the proposal. The results of the analysis are discussed in Item No. 13 above.
32	4-21	6	What is the sub-surface geology of the 'mainland remnants' and limestone outcrops (like Hope Pt)? Karstic limestone occurs at Cape Range with freshwater lenses over seawater which is connected to the ocean (e.g. Bunderra Sinkhole with unique subterranean fauna) Does the Giralia range continue below ground under the project site and if so might similar limestone features occur there with similar faunas?	Straits undertook a drilling program in November 2007 to further investigate the geology and hydrogeology of the supratidal flat, including mainland remnants. The results of the investigations are provided in Parsons Brinckerhoff (2008) (Appendix 6).
33	5-9	Fig 5-6	Do limestone cliffs and pavement have any connection with mainland remnants in and around the salt flat? What is the subsurface geology of the proposal site?	Straits undertook a drilling program in November 2007 to further investigate the geology and hydrogeology of the supratidal flat, including mainland remnants. The results of the investigations are provided in Parsons Brinckerhoff (2008) (Appendix 6).
34	5-11	3	What is the area of clay pans to be disturbed and what fraction of the clay pan habitat in the lease area is this?	The area of disturbance to clay pans has been greatly reduced following revision of the proposal from a nominal 10 Mtpa salt field to a nominal 4 Mtpa salt field. In addition, the proposal has been amended to reduce the number of claypans to be disturbed by greater extraction from a smaller number and extraction from claypans in mainland remnants will be restricted. Clay material will be sourced from 12 claypans (refer to **Table A** comment no. 13), and the total area of disturbance will be limited to 75 ha (Appendix 2). Straits have undertaken a GIS mapping analysis of claypans in the region to determine the proportion of claypans in the region disturbed by the proposal, as described above in comment no. 13. The analysis determined that the 75 ha of claypans required for the project equates to about 0.58% of claypans in the adjacent 100,000 ha designated as regional context.
35	5-11	8	What are the geographic limits of the Ashburton Land System? What will the cumulative percentage take of salt flats be when this proposal in added to the Onslow Salt project and any other man-made disturbance of this habitat in the region?	The extent of the salt flat landform within the Ashburton Land System is approximately 1,270 km^2. The disturbance to the supratidal flat landform has been significantly reduced following revision of the project. The original proposal was to occupy an area of approximately 410 km^2 of salt flat at full production which equated to about 32% of the salt flat landform within the Ashburton Land System; however this has been reduced to approximately 180 km^2 of salt flat, which equates to about 14% of the salt flat landform within the Ashburton Land System.
36	5-11	11	What is the 'small' volume in cubic meters of potentially acid generating material to be excavated?	Preliminary acid sulphate soil (ASS) sampling was undertaken by Parsons Brinckerhoff (2005a) and Oceanica (2006) (ERMP Chapter 5, Section 1.4.2; Chapter 6, Section 1.3.3). Due to the large size of the project area, Parsons Brinckerhoff adopted a risk based methodology to identify areas of likely significance for potential ASS disturbance (Parsons Brinckerhoff 2005a). Oceanica (2006) undertook sampling ASS of material offshore of Hope Point, Dean's Creek and Naughton Creek (Oceanica 2006). The results of this sampling showed that the high calcium carbonate content of the sediments lead to an excess neutralising capacity within the sediments, indicating that any acid produced following disturbance is likely to be effectively neutralised by the in situ buffering capacity of the sediments and the open marine waters. A detailed ASS Management Plan has been prepared to address the worst case scenario volume of potentially acid generating material to be excavated. A scope of works for ASS investigations is included in the ASS Management Plan and will be discussed with the DEC prior to sampling.

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37	5-13	1	Soil bores need to be installed to provide data on acid sulphate soils before assessment is complete. When will these data be provided?	Refer above to comment no. 36.
38	5-14	1	What is the environmental significance of the locations to be disturbed? What is the representation of these habitats elsewhere in the region and in secure conservation reserves?	This section of the ERMP is not addressing impacts on habitats but landforms. In any case, this is already addressed in the flora and fauna baseline reports (and the ERMP). There were no TECs, Schedule Fauna, DRF or Priority Flora recorded from the project footprint area. The habitats to be disturbed are generally well represented in the locality, including in Giralia Conservation Park to the immediate south of the project area. The largest landform modification will be associated with construction of the ponds on the supratidal salt flat landform. As discussed in Item No. 35, the disturbance to the supratidal flat landform has been significantly reduced following revision of the project. The original proposal was to occupy an area of approximately 410 km^2 of salt flat at full production which equated to about 32% of the salt flat landform within the Ashburton Land System; however this has been reduced to approximately 180 km^2 of salt flat, which equates to about 14% of the salt flat landform within the Ashburton Land System. The representation of the supratidal landform in conservation reserves should be available to the EPASU through other sections of the Department of Environment and Conservation. Straits support the incorporation of the remaining area of the supratidal flat south of the project and adjoining the Giralia station which owned by DEC into a conservation reserve.
39	5-14	3	What environmental performance standards are proposed for rehabilitation? What is the likelihood of success of rehabilitation in this environment? What examples of success exist that can be referred to?	Most of the area disturbed will not be available for rehabilitation. A preliminary Terrestrial Vegetation Management Plan was prepared and issued with the ERMP. This plan has been updated and will be provided to the EPASU.
40	5-21	4	What risk is there that brine from the salt field would back-contaminate stock bores to the east? Why?	Very low, notwithstanding concentrator pond levels. The seepage from the ponds into the hinterland groundwater will not affect stock watering bores given that: • the hinterland groundwater gradient is toward the supratidal flat to the west and • groundwater is saline for at least 5 km inland.
41	5-22	3	Why would subterranean fauna at Hope Point also be likely to occur at other limestone outcrops? Is connectivity of outcrops demonstrated in such a way as to support this statement?	Due to concern regarding the lack of subterranean fauna investigations within the project area, a subterranean fauna investigation was undertaken in 2007. The subterranean fauna survey programme was designed by Biota Environmental Sciences (Biota) to meet the EPASU requirements for additional data, as part of finalising the EPA assessment of the Yannarie Solar Project. The scope of works was agreed to by DEC and EPASU (G. Humphreys pers. comm. 2007). Results of these investigations will provide an indication of whether subterranean fauna are present and the connectivity of limestone outcrops. Further information on the subterranean fauna investigation is provided in comment no. 16 above. For results of the investigations refer to Biota 2008a (Appendix 8).
42	5-22	5	What evidence is there to support the view that 'it is considered unlikely that vegetation in these areas would be ground-water dependent'?	None of the flora species occurring in the project impact areas are known or putative phreatophytes (Garth Humphreys pers comm. 2007). Field surveys ground-truthing the impact area recorded no evidence of any perennial or intermittent surface water features that might be groundwater driven supporting distinct vegetation types. All of the vegetation types present are dominated by xerophytic and vadophytic flora (soil and surface water dependent). The only areas where groundwater-dependency was indicated based on the floristic components of the vegetation was on the hinterland at the major alluvial system associated with the more inland portions of the Yanrey River.
43	5-23	6	What evidence is there that the clay layer is continuous, particularly below the mainland remnants? If there are 'holes' in the clay layer beneath or extending out from the mainland remnants how would these be isolated from the salt ponds to avoid leakage?	Refer to comment no. 26 above. If such holes were found to exist, the rate of seepage through the sediments would be low given the very low permeability of sediments under the ponds. Any seepage that may reach groundwater at depth would not represent an environmental risk and would not require a management response because: • groundwater eventually discharge to the marine environment at depth

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				• hypersaline water (of greater concentration than the pond water) from the supratidal would be currently discharging through these holes.
44	5-23	6	If the conductivity (tranmissivity?) of the clay layer is $10^{-9}sec^{-1}$, what would the impact of 1.9m of leakage be over the 60 year life of the project?	Straits is not sure how the "1.9m of seepage over the life of the project through the clay layer" was determined by the EPASU. It is assumed that the EPASU has applied the reported hydraulic conductivity over the 60 year life of the project. This result tells us that over the 60 year life of the project, seepage would have travelled a horizontal distance of 1.9 m through the soil (this is less than the width of the pond levees). Parson Brinckerhoff (2005b) conservatively estimated seepage from ponds horizontally through bund walls and underlaying sediments based on the permeability of the sediments but not the highly impermeable clay layer. Clay permeability may be as low as 10^{-10}cm/s. It should also be noted that the permeability of the sediments is expected to be further reduced due to compaction during construction. Vertical seepage from the ponds through the clay layer is expected to be inconsequential over the life of the project. Vertical flow from the concentration ponds was calculated by Parsons Brinckerhoff to be less than 1mm per year and deemed negligible because of the low hydraulic conductivities of the underlaying sediments – generally less than $1x10^{-8}$ m/sec. Parsons Brinckerhoff estimated the amount of seepage loss over the Stage 1 saltfield was about 440,000 m^3/yr through or under 68 km external levees about 24 km of which are on the ocean side of the saltfield. A small proportion (7 km) of the 24 km of seaward levees would be adjoining the crystalliser ponds. The salinity in these ponds would be approaching that in the supratidal flat whereas the salinity in the concentrator ponds will be considerably less. Only about 1.5 km of seaward levees will be constructed in the bitterns processing area because of the presence of mainland remnants on the western side of this area. Seepage may make its way to the surface and evaporate externally to the ponds and in the vicinity of levees as a result of capillary rise and the hydraulic head difference between the supratidal flat and the ponds. Most of the seepage that escapes is expected to evaporate near the levees and would be regularly inundated and washed away by spring tides and rainfall. This process of removal and accumulation of evaporated salts from the supratidal flat in the Gulf occurs naturally and regularly following tidal inundation. If it is very conservatively assumed that evaporation does not occur, the amount of seepage along seaward levees may average about 650 m^{-3}/100 m/yr. Assuming the supratidal flat aquifer is on average about 1.5 m thick, the storage of the aquifer (assuming 0.1 storativity) is about 15 m^3/lineal m/100m. Aquifer storage between the levees and these sensitive areas is approximately at least 7500 m^3/100m meaning that leakage past the levees (assuming no evaporation) is likely to be less than 10 percent of the aquifer storage between the mangroves and the levees.
45	5-24	3	What is the total mass balance of projected seepage through the walls over the 60 year life of the project? What would the environmental consequences of this amount of seepage be, particularly on the adjacent algal mats? Why?	Also refer to comment no. 44 above. The displacement of hypersaline water in the supratidal flat to the mangrove zone from seepage is unlikely to be environmentally significant on the basis of the following: • seaward levees are set back from the mangrove zone by at least 500 m • natural discharge of hypersaline nature of supratidal groundwater at the intertidal fringe (mangrove fringe and tidal creeks) occurs in any case • regular recharge of supratidal flat aquifer by tides is much greater than seepage flows • very low permeability of the supratidal flat sediments and very shallow hydraulic gradient resulting very slow movement of groundwater towards the coast • evaporated salts (from both seepage and tidal inundation) are regularly removed by tidal movement

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				• incident rainfall is very much greater than seepage from the ponds • most seepage will be less saline than the naturally occurring hypersaline supratidal flat groundwater formed from the evaporation of seawater from tidal inundation • likely evaporation of seepage in the vicinity of levees. Similarly algal mats are unlikely to be significantly affected by seepage because of the greater salinity tolerance of these species and the 100 m minimum buffer between algal mats and the seaward levees. It is a likely possibility that the growth of algal mats may be encouraged in areas near levees where seepage occurs as these areas are likely to be attractive habit given the moist conditions. This kind of growth in algal mats has been observed an Onslow (G. Humphreys pers. comm. 2007).
46	5-24	4	What are the likely physical and environmental consequences of stopping the evapo-concentration of groundwater below the salt flat? Why?	Straits undertook a drilling program in November 2007, to further investigate the geology and hydrogeology of the supratidal flat. Straits discussed these investigations with the Department of Water's hydrogeologist Mr Gary Humphreys prior to the commencement of the drilling program. The results of the investigation are provided in Parsons Brinckerhoff (2008) (Appendix 6). The investigations included investigation of the natural groundwater hydrogeological process of the supratidal flat (Parsons Brinckerhoff 2007). Notwithstanding the outcomes of this investigation, the presence of the saltfield on the supratidal flat will lower the salinity of the underlaying hypersaline aquifer over most of the area of the salt field and may create moist areas suitable for algal mats outside levees. The impact of seepage from the saltfield on salinities in the mangroves will be inconsequential when compared with volumes of tidal movement on the remaining area supratidal flat. With less evaporation of seawater over the supratidal flat there may be less input of hypersaline water (even with seepage) as result of the dissolution of evaporated salts on the flat by rainfall and tidal movement to the mangrove and tidal creek zone. This may be of some benefit to the eastern edge of the mangroves depending on the significance of this change. The decreased salinity under the saltfields is not anticipated to significantly mobilise any heavy metals that may be present in the sediments as current inundation and evaporation of seawater and rainfall on the supratidal flat create large variations in the salinity of the groundwater.
47	5-24	6	If saline water from the ponds intrudes into the groundwater lens below the islands, as stated on page 5-23, how will impacts on biota dependent on that groundwater be prevented? What will the significance of such impacts be, particularly on subterranean fauna if it occurs there? What data are being collected to determine the stratigraphy and presence of subterranean fauna beneath these islands?	As already indicated in response to comment no. 42, there is no evidence of groundwater dependent vegetation in the project area. Straits undertook a drilling program in November 2007, to further investigate the geology and hydrogeology of the supratidal flat. The results of the investigation are provided in Parsons Brinckerhoff (2008) (Appendix 6). In addition, a subterranean fauna investigation was undertaken in 2007. The subterranean fauna survey programme was designed by Biota Environmental Sciences (Biota) to meet the EPASU requirements for additional data, as part of finalising the EPA assessment of the Yannarie Solar Project. The scope of works for were agreed to by DEC and EPASU (G. Humphreys pers. comm. 2007). Results of these investigations will provide an indication of whether subterranean fauna are present in the project area, and will specifically target some mainland remnants. Further information on the subterranean fauna investigation is provided in comment no. 16 above. For results of the investigations refer to Biota 2008a (Appendix 8). At present, there is no indication that there is any 'biota dependent on groundwater beneath the islands'. This again pre-empts the outcomes of the subterranean fauna survey that has already been scoped and agreed with DEC. As outlined in the ERMP, the effects of saltwater intrusion will be managed through: • further stratigraphical investigations to identify areas within mainland remnants that are most at risk from intrusion of saltwater

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				• baseline flora and vegetation surveys conducted on mainland remnants • long-term monitoring of flora and vegetation on the mainland remnants to assess changes to species composition, abundance and condition.
48	5-25	1	What evidence is there to show whether episodic (rather than routine) use of clay pans by fauna occurs? See earlier comments about similar environments in the Goldfields.	Refer to comment no. 13 above.
49	5-25	2	Apart from vegetation monitoring, what action will be taken to monitor impacts on subterranean fauna, where present, and what management action will be taken to mitigate any such impact.	Straits undertook a subterranean fauna survey in November 2007. The results of the survey are pending and will be provided to the EPASU when available. The results will be used to determine risk-based management measures for subterranean fauna.
50	5-27	1	Why is it not expected that subterranean fauna taxa will be limited to the proposed quarry locations in the absence of data on their distribution or evidence of connectivity between limestone features?	Refer to comment no. 41 above.
51	5-27	2	How will impacts from oil and fuel spills be prevented once spills occur?	Impacts to groundwater from oil and fuel spills will be minimised by a range of management measures, including provision of spill response equipment, spill response training and implementation of spill response and cleanup procedures. Management measures are detailed in the revised Groundwater Management Plan.
52	5-27	3	What management action will be implemented if monitoring shows that low-lying areas on islands are affected by the salt field? What evidence is there that such management action will be effective? If it is not effective, what is the significance of the likely impacts in the regional context, particularly for subterranean fauna is present?	There are very few low laying areas on mainland remnants as indicated in Figure 5-22 of the ERMP as compared with the Onslow saltfield. This figure shows the 5 m contour illustrating only a small area of the remnants may be affected. The revised proposal will also affect fewer mainland remnants and the potential impact of saline intrusion from the ponds into the mainland remnants has been significantly reduced through the lowering of the proposed pond level from a maximum of 1.5 m to 0.8 m. As indicated in the ERMP (Chapter 5, Section 4), in those areas that may be affected, *Triodia* dominated vegetation, and in these affected areas may die-off and eventually be replaced with samphires (though this would be a very slow process). Currently there are no feasible management options that will prevent this progression. The potential impact of saline intrusion from the ponds into the mainland remnants has been significantly reduced through the lowering of the proposed pond level from a maximum of 1.5m to 0.8m.
53	5-27	4	Why is it considered that the EPA objectives to maintain the quality and quantity of groundwater and to maintain ecosystem function there will be achieved?	The EPA objective is to maintain quality and quantity of water so that existing and potential environmental values including ecosystem function are protected. This objective does not suggest that current quality or quantity need to be maintained but that quality and quantity needs to be maintained such that values are protected. There is no evidence to suggest that the changes (if any) to groundwater quality and quantity in the supratidal flat or the hinterland will result in any significant impact on groundwater dependent ecosystems or environmental values. This consideration is based on site investigations and the results of investigations from the 1966 saltfield study (Halpern, Glick and Lewis 1966) (ERMP Chapter 5, Section 2.3).
54	5-35	1	In what way did the anecdotal observations indicate that the hydrological modelling of the catchments was not completely accurate for the 50 and 100 year flood events? What are the implications of this inaccuracy?	Page 10 of the Parsons Brinckerhoff hydrology report (ERMP Appendix 8) confirmed that the anecdotal observations matched the hydrological modelling results for the Yannarie River. The modelled Rouse Creek flows are conservative when compared to anecdotal observations.
55	5-38	5	Since flows from the river are likely to be delayed for some days after a storm, and associated elevated sea level, has passed, why are river outflows likely to be affected by the associated storm surge?	River outflows are not affected by storm surge. The supratidal flats may be subjected to storm surge; not the river outflows.
56	5-39	2	Given that productivity in Exmouth Gulf is nitrogen limited (ERMP p4-14), why couldn't episodic inflows from the Yannarie River be important contributors to the nitrogen economy of the Gulf?	The definition of episodic events in this comment is assumed to mean those 1 in 20 year ARI events or greater events when discharge from the Yannarie River reaches Exmouth Gulf. The revised proposal will not prevent the discharge from Yannarie South or other creek outlets from reaching the Gulf.

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				Available published and peer reviewed scientific investigations of this issue (Aykai and Miller 1998 and Brunskill *et al.* 2000) describe the nutrient inflow from surface waters as "insignificant". It is noteworthy that the Brunskill *et al.* (2000) estimations of nutrient inflow were based on the constantly flowing major river of the region. However, the Yannarie Solar project area does not include any flowing rivers and the rivers present are only expected to flow with sufficient volume to reach the ocean in a 1 in 20 year ARI event. Calculations of dissolved inorganic nitrogen (DIN) loads to the Gulf have been estimated below (Oceanica 2007):

Source	Estimated loads	Reference	Comments
Hinterland	~30 tpa	Brunskill *et al.* 2001	Estimated that hinterland contribution was equivalent to 0.8 mmol TN per m^2 Gulf Area per annum.
Algal mats/mangroves	~550 tpa	Paling and McComb 1994 & Biota 2005c	68 kg N/ha/yr from mats, 8054 ha of mats. No contribution from mangroves (no numbers for mangroves for DIN, so possibly conservative).
Offshore waters	~7,400 tpa	Oceanica 2006, APASA 2006	Based on measured nutrient concentrations in waters immediately offshore from creek areas in water depths <5 m (average 9.6 ug/l). The exchange is based on the shallow areas (average water depth 2.23 m, area of 9.45×10^8 m^2). Average tidal range is ~1.2 m and occurs ~ twice per day. Therefore annual volume exchange in shallows ~7.71×10^{11}.

'Although the calculations are by nature 'ball-park', it is clear that the tidal exchange between the Gulf and the mangrove coast dominates total load by two orders of magnitude. The concentration of DIN in the waters offshore is very low and the load calculation is dominated by the exchange. Exchange is very high due to the diurnal tidal regime acting in shallows areas, with range on each leg up to 2.5 m with average of around 1.2 m with the waters containing the bulk of the habitat less than 2.5 m deep. This means that volume replacement of these shallow water areas occurs on a daily basis'.

However, production in ecosystems does not respond to loads directly, but to concentrations. The measurements made of DIN and chlorophyll_a for the [ERMP] assessment show a distinct gradient from nearshore up the creeks (Oceanica 2006, Refer to Figure 6-7 of the ERMP).

This completely supports the conceptual model presented in the ERMP, being that the algal mats are a significant source of nitrogen for the marine ecosystem in a nitrogen poor environment. The mats fix nitrogen directly from the atmosphere and then tides carry the nitrogen (as organic detritus or in dissolved form) back into the creeks and mangrove system. This accounts for the higher primary productivity up creeks and then in turn supplies elevated nutrients to the vegetated banks nearshore.

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				Therefore, the important loading is the loading that creates the gradient, being the algal mat source. This is at least one order of magnitude higher than hinterland sources' (Oceanica 2007).
57	5-39	3	What are the objectives of the baseline water quality monitoring program? What contingent management actions are planned to be associated with it?	The overall objective of the baseline water quality monitoring program is to maintain or improve marine water and sediment quality in compliance with sediment and water quality guidelines documented in Australian and New Zealand Water Quality Guidelines (ANZECC 2000). The identified issues and cause effect pathways which underpin the water quality program are: • Creation of turbidity and elevated suspended sediment concentrations through construction activity; and • Potential for contamination, including hydrocarbon pollution near pump station and Hope Point. The project is no longer discharging bitterns nor is it introducing nutrients to the system. *In relation to turbidity* The baseline program will ensure that there are sufficient data to establish background levels for suspended sediment, turbidity and light so that trigger levels may be set for the dredging and construction work to protect any identified sensitive habitats at risk. The baseline sampling program will consider the predictions from the modelling and the location of sensitive habitat and aquaculture leases in locating monitoring sites. *In relation to contaminants* Water and sediment samples will be collected from sites at risk of hydrocarbon pollution and analyse for Polycyclic Aromatic Hydrocarbon (PAH) compounds as part of a regular water and sediment quality program (frequency to be established); Collect sediment samples from sites (numbers and locations to be determined) at risk of pollution and analyse for metals, organotins, particle size distribution (PSD) and total organic carbon (TOC) as part of a regular water and sediment quality program (frequency to be established); and Include any areas where drainage from site may reach the marine environment in the regular sediment quality monitoring program, with sediment samples analysed for PAHs, metals, organotins, PSD and TOC. *Contingency plans* There are no contingent plans associated with the baseline program as the purpose is to gather information to allow trigger levels and levels of existing contamination to be established. Contingency plans will be developed for the construction and operations management programs, and will be detailed in the Surface Water Management Plan.
58	5-40	2	What is the likely change to Deans Creek if flows are directed away from it? What is the likely change to Giralia Bay if flows are directed towards it?	Under the revised proposal flows from Yannarie River South will not be directed away from Giralia Bay, and Deans Creek will receive flow from the Yannarie South.
59	5-40	3	Where does Rouse Creek North discharge? What is the likely effect of diverting these episodic flows out of the current system? If flows are changed by ~90-100% what morphological changes are likely, what impact is this likely to have and is it likely to be significant? Why?	Under the revised proposal and during normal conditions Rouse Creek North will discharge to the Gulf in a similar manner as it does now. The peak discharge during a 1:100 yr event (very little discharge occurs from Rouse North in a 1:20 yr event) will almost double. There will be minimal effect of diverting the Yannarie North's flows to the Rouse system because the channel's characteristics (i.e. very wide and flat channel) has the ability to accommodate the diverted flows without causing any significant changes to the flow velocity or depth (in other words erosion).
60	5-40	4	What will be the likely positive and negative effects on pastures and local pastoral water supplies of ponding Yannarie Creek flows behind the	The predicted flooding backwater has such a localised area of effect on the scale of Yanrey station that it would have a negligible effect on grazing condition and related pastoral values.

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			proposed weir?	
61	5-51	2	Are any locally or regionally restricted or significant vegetation units present? Are any Threatened Ecological Communities present?	There are no TECs present in the project area (as outlined in the ERMP Chapter 5, Section 4.3.4, page 5-60 and Biota (2005a)). There are no regionally restricted vegetation types present. There is only one locally restricted vegetation type present (*Melaleuca cardiophylla* shrubland on Hope Point) and the design of the diesel fuel farm at Hope Point was revised to avoid impacting this unit (Appendix 3).
62	5-51	5	Are vegetation units or flora species which are to be disturbed represented in secure conservation reserves?	There is no comprehensive dataset available for vegetation and flora of conservation reserves in the region, making regional comparisons difficult. As part the scope of work of proposed additional botanical survey work, vegetation data for the Giralia Station will be obtained. While this station has not yet been declared a formal conservation reserve it is owned and managed by DEC for conservation. There are no DRF, Priority Flora, TEC species or communities in the project area (Biota 2005a).
63	5-55	5	If the vegetation type recorded at Hope Point was only found there and is likely to be disturbed, a thorough search should be conducted to locate it elsewhere.	As noted in Biota (2005a) (page 26), the *Melaleuca cardiophylla* shrubland at Hope Point is just the only <u>local</u> record of this vegetation type – it is known from elsewhere in the bioregion, including Cape Range. Regardless, the design of the diesel fuel farm at Hope Point has been revised to avoid impact to the *Melaleuca cardiophylla* shrubland vegetation community (Appendix 3).
64	5-59	5	The ERMP (p5-59) states that bare clay pans have been listed as having a high reservation priority, but also notes that some 15 of them have been targeted for construction materials Under these circumstances, what proportion of clay pans in the region are protected in secure conservation reserves and what proportion in the lease area will not be affected by the proposal?	Refer to comment no. 13 above.
65	5-59	5	If parallel red sand dunes on islands have coastal influences on their floristics which possibly makes them unique, as stated in the ERMP, please indicate where these types are represented in secure conservation reserves and the extent and percentage of these types within the lease area that will not be disturbed.	Most of these dune areas will remain undisturbed and will be too elevated to be affected by saline groundwater. Disturbance to this vegetation type (type 2d) will be limited to approximately 15.2 ha, or 0.8% of the vegetation type in the project area (Table 2).
66	5-60	Tab 5-6	Noting the communities with high conservation priority in Table 5-6, which of these communities are represented in secure conservation reserves and what fraction of each community in the lease area would remain undisturbed and not threatened by other threats like saline water intrusion below islands?	The maximum % disturbance to equivalent vegetation types within the project area are shown in Appendix 10.
67	5-61	2	What management action is planned for weed species, including `sleeper weeds' in the lease area?	Weed management is addressed in the Terrestrial Vegetation Management Plan (ERMP Volume 2). This plan has been revised to reflect the revised proposal and will be provided to the EPA upon completion. Management actions include weed mapping, vehicle and equipment clean-down procedures and weed control as required.
68	5-64	Tab 5-8	Column 3, third last line of Table 5-8 refers to 0 003 ha of disturbance in claypans for quarries. Is this area (30m^2) correct given that some 15 claypans have been targeted for clay construction material?	The 0.003 ha disturbance stated in Table 5-8 is no longer relevant, as it related to disturbance to vegetation type 3a for quarries. The area of potential disturbance to claypans has been substantially reduced following revision of the proposal. In addition, the proposal has been amended to reduce the number of claypans to be disturbed, by greater extraction from a smaller number of claypans and extraction from claypans in mainland remnants will be restricted. The estimated quantities construction materials required have been revised for the new proposal. The clay material requirement for construction has reduced from 3,412,740.1146 m^3 to approximately 3,000,000 m^3. Clay material will be sourced from 12 claypans (refer to **Table A**), and the total area of disturbance will be limited to approximately 75 ha (Appendix 2).

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69	5-65	1	Is 0.07ha correct for the camp and camp access (-70m x 10m)?	The 0.07 ha estimated for clearing for the construction camp and camp access in the ERMP was incorrect. The construction camp and access will comprise approximately 16 ha (Table 2).
70	5-65	3	What fraction of the vegetated area (rather than the total project area) within the project area is to be cleared?	The fractions of vegetation area to be cleared for the project were provided in the ERMP (Table 5-8, Chapter 5, Section 4, page 5-64) and the impact on land systems were also provided in the ERMP (Table 5-9, Chapter 5, Section 4, page 5-65). These figures were updated following revision of the proposal (Table 2 and Table 3). Indicative clearing as surveyed by Biota (2005a) has reduced from approximately 1.5% of the total area within the project footprint (ERMP Table 5-8, Chapter 5, Section 4, page 5-64) to 1.3 % (Table 2) and indicative clearing estimated from Land Systems Mapping has reduced from approximately 0.7% of the total area within the footprint (other than that surveyed by Biota 2005a) (ERMP Table 5-9, Chapter 5, Section 4, page 5-65) to approximately 0.05 % (Table 3).
71	5-65	4	What offsets are planned to compensate for impacts on vegetation?	Straits has committed to rehabilitation of a minimum area of 2 ha of mangroves post construction, to offset the 2 ha of mangroves disturbed by construction.
72	5-66	6	What area in hectares and what fraction of the mainland remnant land unit type within the lease area may be affected by saltwater intrusion? Until sampling shows otherwise, the possibility that these remnants may be important for subterranean fauna dependent on the groundwater within them needs to be considered.	Refer to comment no. 52 above. The potential impact of saline intrusion from the ponds into the mainland remnants has been reduced through the lowering of the proposed pond level from a maximum of 1.5 m to 0.8 m. In addition, fewer mainland remnants will be disturbed by the proposal due to the reduction in its scale. As described in comment no. 26, additional hydrogeological investigations were undertaken in 2007, which will provide information on the stratigraphy and groundwater of mainland remnants. Subterranean fauna investigations were also undertaken in 2007. Results of these investigations will provide an indication as to whether there is the potential for subterranean fauna to be present within mainland remnants. Further information on the subterranean fauna investigation is provided in comment no. 16 above. For results of the investigations refer to Biota 2008a (Appendix 8).
73	5-72	4	What importance do clay pans and floodouts have for waterbirds or other fauna following episodic flood events?	Refer to comment no. 13 above.
74	5-78	3 & 4	Why do the habitat preferences of Australian Bustards and Rainbow Bee-eaters make them unlikely to be affected by the proposal?	Individuals of these two species may be affected at the local population scale, however the species are widespread in the bioregion and extensive habitat suitable for Bustards and Bee-eaters will remain undisturbed by the project in the locality. No changes to conservation status would therefore be expected for either taxon (Biota 2005b), as described in the ERMP (Chapter 5, Section 5, page 5-78).
75	5-83	Fig 5-27	What opportunities exist to re-orient the facilities at Hope Pt to avoid directly affecting the roosting site for waders there?	The design of the barge harbour and channel has been revised (Appendix 4), and the revised orientation of the barge channel will reduce the direct impact to wader roosts located on the north-west tip of Hope Point (ERMP Figure 5-27, page 5-83).
76	5-85	7	What is the significance of the four reptile species not previously recorded from the locality of the project? Do they coincide with project infrastructure and are they widely distributed elsewhere?	None of the reptiles recorded (including the four not previously recorded locally by CALM or the WA Museum) are of any elevated conservation significance (Biota 2005b) (ERMP Chapter 5, Section 5.3.7, page 5-85).
77	5-88	2	Is it possible that the Bilby persists in the 'undeveloped' hinterland north of Yanrey Homestead where there are few to no bores present?	It is not impossible, but it is not relevant to the assessment of this proposal, as it was considered unlikely that this species still persists on the hinterland (Biota 2005b) (ERMP Chapter 5, Section 5.3.10). The hinterland north of the station is well removed from the area to be affected by the salt field development.
78	5-89	1	What action will be taken to manage control fox and cat numbers on the project lease?	A collaborative feral animal programme that integrates feral cat and fox control measures will be developed and implemented consistent with DEC advice. Details of the program will be included in the Terrestrial Fauna Management Plan.

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79	5-92	2	What significance is the salt field likely to have as a barrier to fauna moving from the hinterland to the mangroves? What measures could be taken to avoid creating a continuous barrier to faunal movement between the mangrove zone and the hinterland? What likelihood is there that fauna will fall into the ponds and become trapped or adversely affected by high salt concentrations?	The great majority of the fauna species recorded during surveys of the area do not move between the hinterland and mangroves under the current natural conditions. There would therefore be no barrier to fauna movement for most species present (Garth Humphreys pers comm. 2007). The only species likely to be affected would be kangaroos and emu that occasionally traverse the salt flat between mainland remnants. As these are widely dispersing and distributionally widespread taxa, it is very unlikely that any significant population subdivision would arise. There is therefore no requirement for a fauna corridor or similar. Experience at the nearby Onslow salt field indicates that terrestrial fauna do not become trapped in the ponds and that egress is possible on shallow banks approaching the mainland remnants (Garth Humphreys pers comm. obs). The revised proposal results in a reduction in the area of salt flat disturbed from approximately 410 km^2 to 180 km^2. The length of the seaward facing length of the field has been reduced from approximately 70 km to 30 km. The potential barrier that the salt field represents has therefore been substantially reduced. The movement of feral fauna (such as foxes and cats) from the hinterland to the mangroves may be reduced due to the barrier provided by the salt field. In addition to limiting this movement, Straits will undertake a feral animal control program which will include baiting.
80	5-93	4	What noise modelling has been undertaken and what is the footprint of noise emissions from the main sources for this proposal?	Noise modelling and management is included in the ERMP pages 6-127 to 6-131.
81	Note	Bitterns	Approach to bitterns implies that either bitterns will be able to be re-used or long term storage will be necessary. Alternatively, discharge will be required in future. Given that reuse is not yet certain, the prospect that either long term storage or future discharge would be acceptable needs to be evaluated. To evaluate the storage option, detail is required on how long term storage and rehabilitation would be achieved for what would essentially be permanent tailings dams for bitterns, so that the EPA can assess this issue now. Key questions are:- - Calculations suggest there could be millions of cubic metres of bitterns produced each year once pond floors are developed. How and where could this volume of bitterns be effectively retained, how long would it take to evaporate, what area would be required to accommodate the extra evaporation ponds needed and what residual volume of salts would require long term storage if those salts could not be re-used? - How would bitterns storage dams be stabilised/rehabilitated long term? - What would the erosion rate of stabilised/ rehabilitated dams be long term? - What would the release rate of' bitterns be long term?* - What impacts would such a release rate have and are those impacts acceptable? - What are the credible failure modes for the storage structure, what contingencies would be put in place to manage them and are the consequences acceptable? * noting that tailings dams eventually leak. With regard to the possibility of discharge: What would be the impact on the proposal of a condition requiring that no bitterns be discharged to the ocean for the life of the project? If a future stage of the proposal required the respective annual volumes of the various forms of bitterns described in the ERMP to be discharged to	Question 1 – About 1 M m^3 of Bitterns C (end point bitterns) will be produced per year after about three years of production. The bitterns will be contained in the area specifically designated for bitterns management, to the north of the revised project area (Appendix 1). The area set aside for the containment of about 10 M m^3 of end point bitterns is about 1000 ha. This will allow for the containment of 10 M m^3 of end point bitterns at a depth of 1 m. Complete natural evaporation of Bitterns C will depend on the depth at which the material is stored. Hence, evaporation can be facilitated at a shallower depth than the gross storage depth of 1 m. No additional area for evaporation ponds is required and instead the proposed bitterns management area will be designed to facilitate storage and evaporation. Question 2 – Bitterns storage ponds will be stabilised and rehabilitated according to the decommissioning plan. The project is only seeking approval for the containment of about 10 M m^3 of end point bitterns (10 years worth of bitterns). Question 3 –The erosion rate of rehabilitated pond infrastructure is expected to be negligible. The armoured levees are designed to last >60 years. Maintenance of pond infrastructure will be based on regular inspections, particularly following any cyclonic events. Question 4 –Straits is not intending to discharge bitterns / release and seeks no approval to do so. If, within 10 years of approval and investigation of total bitterns reuse identifies that there is a need to discharge bitterns then application for discharge will be made to the EPA. Straits will consider discharge of bitterns through the barge harbour, tidal creeks and hypersaline groundwater in order to determine the option with the most acceptable environmental implications. The long term release rate for bitterns would therefore only be equivalent to the estimated seepage rate, although over time this seepage rate is expected to be reduced through the build up of massive salt deposits on the floor and slope of the levee walls. The permeability of the saltflat in the vicinity of the crystallisers ranges from 1.4 x 10^{-7} (about 4.4 mm/year) to 1.3 x

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			Exmouth Gulf; what area of influence would they have (i.e. over what area could elevated salt levels be detected) and what area of likely impact would they have (i.e. over what area would eco-toxic concentrations of salts be present) for spring and neap tides respectively? What level of dilutions would be required to render the various forms of bitterns non-toxic to 99% of species? If bitterns were discharged, what combination of weather, tide or other conditions could result in poorly diluted, dense bitterns moving down gradient and collecting in the deeper parts of Exmouth Gulf? How likely are these weather conditions on an annual basis? What impact would such collection of dense bitterns be likely to have on organisms, including prawns in those deeper areas? What impacts are likely on ephemeral seagrasses or other benthos in the near-shore mixing zone if bitterns were discharged to Exmouth Gulf?	10^{-9} (about 0.04 m/year). Question 5 – The expected low rate of release of bitterns over the long term is not expected to have any significant environmental impacts. Firstly, the surrounding saltflats are naturally hypersaline. The horizontal seepage rate in the vicinity of the crystallisers is expected to be generally less than 4.4 m/year. The setback of pond infrastructure from the algal mat is a minimum of 100 metres and tidal cycles (including Spring Tides) regularly inundate the algal mats and flush any stored evaporates in the soil back into the ocean. It is expected that additional to regular tidal cycles, minor 2 year ARI storm events would be expected to inundate the saltflats beyond the algal mat resulting in flushing of any evaporates stored in the soil. Question 6 – The credible failure modes relate to significant storm surge events and wave run-up impacts (> 1 in 50 year ARI event). These would be addressed through regular inspections after such significant storm events. Question 7 –*Impact of condition requiring no discharge to the ocean for the life of the project* – This will not affect the project as the project is not seeking approval for discharge to the ocean. Should discharge be identified as the only feasible option for bitterns management later in the life of the project, Straits would apply for an amendment to that condition and would undertake an impact assessment as required. Question 8 – The proposal does not propose to discharge Bitterns A, B or C so this would require a referral to the EPA with supporting evidence to back any variation to the proposal. Only Bitterns C value adding is dependent on further investigations. Results of the dispersion modelling for Bitterns C were provided to the EPASU in December 2007 (Appendix 13). Question 9 – The level of bitterns dilutions required to protect 99% of species is dependent on ecotoxicological studies. As requested by the EPA, dispersion modelling was provided to the EPA (Appendix 13) and on the basis of these results consideration will be given to any potential need for ecotoxicological studies. Question 10 – Environmental conditions that could result in poorly diluted dense bitterns collecting in the deeper part of the Gulf are unknown at this stage. The results of dispersion modelling were provided to the EPA as requested in December 2007 (Appendix 13). However, due to the diurnal tidal system, naturally occurring hypersaline discharge from the creeks is not currently considered to be accumulating in the deeper part of the Gulf. Question 11 – Should discharge be identified as the only feasible option for bitterns management later in the life of the project, Straits will undertake further dispersion modelling and ecotoxicity testing to assess impacts on ephemeral seagrasses or other benthos in the nearshore mixing zone. However current dispersion modelling (APASA 2007) has shown that bitterns can be contained within the barge harbour to within the 95th percentile of naturally occurring magnesium levels (Appendix 13).
82	6-3	6	What protection levels apply adjacent to Shark Bay Salt?	Straits is unsure of the relevance of this question to the Yannarie Solar project. It is assumed this question is asking what level of ecosystem protection was applied to the coast adjacent to the Shark Bay Salt Joint Venture solar salt mine. There was no information available in relevant EPA Bulletins regarding levels of ecosystem protection applied to Shark Bay Salt.

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83	6-5	5	Noting that storm surges can be 4-6m above mean sea level (p65) and overtopping may be expected (p6-16), how would the water drain away from overtopped, earthen walled ponds without erosion initiating at the lowest point on the dam wall, leading to cutting through the wall, emptying of the brine/bitterns and scorning out of the salt pavement?	Refer to comment no. 11 above.
84	6-8	Fig 6-4	What would the implications be for an oil or other pollutant spill on the eastern side of the Gulf, given the long lag in tidal flushing there?	There is no 'long-lag' in tidal flushing (Oceanica pers comm. 2007). The tides are diurnal (twice daily) with average variation in the order of 1 to 2 m each tide (ERMP Chapter 6, Section 1, page 6-5). Therefore, tidal flushing is likely to be highly efficient. The extent of impact of a spill will depend on the size of the spill. Implementation of the Oil Spill Contingency Plan will ensure any impact is minimised.
85	6-9	8	What are the concentrations of arsenic and how do these compare to the environmental quality guideline limits? What are the implications of disturbing sediments with these arsenic levels during dredging?	This information is provided in Table 6-5 in the ERMP (Chapter 6, Section 1, page 6-12). Given the background levels are elevated and the bioavailability of arsenic (As) in the sediments is likely to be low, dredging is not anticipated to adversely affect environmental values of the Gulf.
86	6-11	Tab 6-2	What are the units for this table?	The units for this table are mg/kg.
87	6-16	2	What is meant by "increasingly smaller volumes of bitterns and hence more rapid dilution back to seawater" when the stated intention is not to discharge bitterns? Given that progressively smaller volumes are a result of increasing concentration (that is, the same amount of salts are present despite the decreasing volume) what is the practical effect of this statement?	This proposal does not include the discharge of bitterns. Straits are confident of achieving full resource recovery. However, the final assessment of options for recovery of Bitterns C (end point bitterns) will be made within the first ten years of operation of the Yannarie Solar project if approved. While Straits is not seeking approval to discharge bitterns, three discharge scenarios were assessed, as described in the ERMP (Appendix 1) to provide information on the range of possible outcomes, and an investigation into mixing and dilution of Bitterns C was completed in December 2007 (APASA 2007, Appendix 13).
88	6-16	3	Where exactly will the bitterns storage ponds be located? How will they be protected from storm surge? Why won't they be eroded from the lowest point of the wall as overtopping water drains back out to sea? What contingency plans are in place to deal with such events? How will bitterns storage ponds be stabilised/ rehabilitated in the long term? Given the potential need for long term storage of bitterns, answers to the questions above are required prior to the EPA completing its assessment. The "proposed security of bitterns storage" (p6-16) needs to be clearly demonstrated.	Under the revised proposal the bitterns management area will be located at the northern end of the salt field (refer to Appendix 1). The end product of the recovery process (termed Bitterns C) will not be produced for about the first three years of salt field operation. The bitterns management area is situated in this location as it is well protected by mainland remnants to the west. These remnants are up to approximately 13 m AHD. The levee walls containing and protecting the bitterns management area will be designed to withstand, at a minimum, a 1 in 50 year ARI storm event in terms of wave run up to prevent overtopping. Levees will be protected with a blanket of rock armour designed to prevent displacement and erosion during storms.
89	6-17	7	The Dredging Management Plan needs to be available for assessment prior to the completion of the EPA's assessment. Will limestone or other rock require dredging? If so, what will be the environmental implications?	Straits will provide the Dredging Management Plan to the EPA prior to completion of its assessment of the project. Dredging will be limited to the Hope Point barge channel.
90	6-18	1	What performance indicators and levels are proposed for water quality during dredging? What are the environmental implications at these levels of water quality?	Performance indicators, targets and management responses will be described in the Dredging Management Plan (Refer to Item No. 89 above). These parameters will be derived on the basis of additional benthic habitat mapping and assessment of sensitive habitats, which was undertaken in 2007 (Oceanica 2008, Appendix 11).
91	6-31	3	Which nutrients are supplied from "offshore sources" and what is the percentage contribution from offshore given the statement on p 6-33 that "algal mats are the key source of nitrogen to the nitrogen-limited Exmouth Gulf' What contribution is microbial activity within the sediments of the saline flats (additional to activity in the algal mats above the sediments) likely to make to nutrient inputs to Exmouth Gulf' and what impact is the proposal likely to have on any such activity?	Offshore sources refers to the supply of nutrients from the open ocean. Brunskill *et al.* 2001 described the relative inputs from marine and terrestrial sources, as follows: "Based upon a small amount of chemical data from the adjacent Ashburton River (P. Callahan, SWRIS, 1984), and extrapolation to Exmouth Gulf, total nitrogen (particulate and dissolved) inputs from the terrestrial catchment to Exmouth Gulf surface area would be 0.8 mmol/m^2 yr, and total phosphorus inputs would be about 0.4 mmol/m^2/yr. Note that the N: P ratio of terrestrially supplied nutrients is also very low, probably indicating a large fraction of inorganic and particulate phosphorus. This nutrient supply rate from the terrestrial catchment is insignificant, compared to the much larger inputs from tidal volumes from the Indian Ocean." As described in Item No. 56, calculations of dissolved inorganic nitrogen loads to the Gulf were estimated at approximately 30 tpa from the hinterland, 550 tpa from algal mats and

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				mangroves and 7400 tpa from offshore waters (Oceanica 2007). Therefore the percentage contribution of dissolved inorganic nitrogen from offshore sources is approximately 92.7 %. The results of the Chlorophyll-a and phaeophytin investigations (Biota 2005) of the supratidal flat indicate very little photosynthetic activity and found no active cyanobacterial mats occurring on the supratidal flat outside recognised areas of algal mat activity.
92	6-41	1	Please provide a map of the extent of vegetated habitat on the seabed, together with contours, referred to in the text in various places.	Straits undertook additional benthic habitat mapping in 2007 to further characterise the benthic habitat offshore from Hope Point. Maps showing depth contours and the extent of vegetated habitat are provided in Appendix 11 (Oceanica 2008).
93	6-41	9+	Please provide a map showing the limits of habitats referred to in the text, including those periodically covered by seagrass and algae, together with the substrate in those habitats.	Refer to comment no. 92 above.
94	6-46	Fig 6-19	What provision has been made to ensure that tidal flows will continue to reach portions of the tidal channels and flats that may be cut off by the conveyor formation or intake channel seawall?	Tidal channels are not proposed to be "cut off". The effects of the proposal on water flows in the intertidal region and the waters immediately offshore were modelled by Worley Parsons (2005a, 2005b). Modelling showed that only small changes in velocities were anticipated near the bund for the conveyor leading out to Hope Point and the culvert leading out to the Dean's creek pumping station, as shown in ERMP Figure 6-31.
95	6-51	6	Given the low gradients present, what reduction in area inundated would result from the 2cm reduction in the depth of water on the landward side of the infrastructure corridor to Hope Point?	Given the tidal range (about 1.8m under mean spring tidal range) the 2cm reduction in depth under these maximum tidal conditions (will be less under lower tides) will be of no consequence to nearby mangrove communities or algal mats.
96	6-60	3	What management actions will be taken if monitoring detects changes in sedimentation patterns?	Contingency actions, which will be implemented in the event that monitoring detects changes in sedimentation patterns attributable to the project, are outlined in the Marine Management Plan. Contingency actions will address the following: 1. Investigate the cause of the change. 2. Review the seawater pumping regime. 3. Implement an appropriate corrective action programme in consultation with the DEC. 4. Monitor the effectiveness of the corrective action to ensure the corrective action is suitable.
97	6-63	9	What are the proposed limits of acceptable change to creek cross-sectional areas? What will be done if changes are detected?	With the revised proposal there will only be one seawater intake pump station, located at Dean's Creek, where it is anticipated that there will be no significant impact on the sediment dynamics of the creek (ERMP Section 2.6.5). The Marine Management Plan addresses performance targets and proposes contingency actions if targets are not met.
98	6-68	1	What is the hardness and extent limestone to be dredged and what will be the effect on turbidity generated by dredging?	The detailed geotechnical work for the barge harbour and channel is yet to be completed. Turbidity will be managed as per the Dredging Management Plan, which addresses the sensitive local marine environment and outline appropriate management measures and trigger values for management responses.
99	6-68	4	The Marine Management Plan (like many others in the ERMP) is mainly a plan for monitoring rather than management action What standards or limits of acceptable change will be adopted for each item that is monitored? What contingency plans are in place to deal with unacceptable changes detected during monitoring? Statements such as "a corrective action programme may be proposed and implemented" do not have adequate certainty that potential problems are well understood, a contingency plan is in place and appropriate and effective action can and will be taken to remedy any significant problem.	The Marine Management Plan has been updated to take into account these comments, and this plan will be submitted to the EPA Service Unit.
100	6-69	8	What is the salinity tolerance limit for algal mats and how does this compare with the salinity in the concentrators, crystallisers and bitterns storage areas?	Algal mats have a higher salinity tolerance than mangroves and it is believed that algal mats may colonise seepage areas near the seaward levees because of favourable moisture conditions. Salinities in the concentrator ponds will be less than that of the current groundwater in the supratidal flat. Refer also to response to comment no. 45 above.

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101	6-70	1	The ERMP states that there will be no impact on mangroves from leaks (p6-69) or small scale changes in surface hydrology (p6-70) but what impacts may occur to algal mats, given their importance to the nitrogen supply in the Gulf?	Refer to response to comment no. 45 above.
102	6-70	5	Will all dredged material, including entrained water, be piped to shore and settled and deposited there, in a manner in which turbid overflows can be managed on-shore, or will overflow from hopper barges or other activity generate turbidity at sea?	All dredged material will be pumped onshore and stored in sedimentation ponds at Hope Point prior to the return of seawater. The sedimentation ponds will be located directly behind the barge harbour on the site of the future salt stockpile.
103	6-71	3	Why will dredging take 4 months to remove the small quantity of ~20,000m^3 of sediment, given that the bulk of the barge harbour (~284,000m^3) will be excavated by land based earthmoving equipment?	The four month dredging period stated in the ERMP was the maximum window of dredging anticipated for the project, which was specified to coincide with the period of seagrass dormancy and when light requirements of benthic habitat are naturally at a minimum. Since the release of the ERMP, the volume of material to be dredged been revised due to a number of factors including use of batter slopes, increase in excavation depth and refined calculations of the volumes (Refer to Section 3). The volume to be dredged from barge channel B has increased from ~20,000 m^3 to ~135,000 m^3 and the volume to be excavated from barge channel A has decreased from 284,500 m^3 to ~ 240,000 m^3. It is still anticipated that dredging will be completed well within four months. It is very important that the DEC recognises that the 'dredge campaign' is insignificant in terms of volumes compared to other campaigns currently proposed in the Pilbara (of order 50-100 times smaller of the volume of these larger campaigns) and that therefore the risks of long-term adverse impacts are similarly insignificant. Modelling of dredge plumes has already been completed (APASA 2005c, Appendix 12) and demonstrates that impacts from turbidity plumes will be insignificant.
104	6-71	5	What data are available to demonstrate that the volume of potentially acid generating soil is "relatively small compared to the total volume of soil"? What is the amount of potentially acid generating soil that will be disturbed and how will it be managed?	Data used to determine worst case scenarios for volumes of acid generating soil and potentially acid generating soil are included in the Acid Sulphate Soil Management Plan.
105	6-72	Fig 6-37	What are the limits of Dredge Area A and B? Where is the HWM and the limestone/ sand interface relative to HWM in the cross-section?	The limits of Dredge Area A and B are shown in Appendix 4. The definition of the limestone /mud or sand interface along the dredge channel has yet to be confirmed by detailed geotechnical investigation but is currently believed to be at -2.0 m CD.
106	6-77	2	What data are available to indicate that limestone will be capable of being broken by an excavator? What will the impacts be if a rock breaker or blasting are required to break the limestone? Can a coffer dam be built around the excavation works to prevent sediment being lost to the marine environment?	Detailed geotechnical investigations have yet to be completed to confirm the hardness of the limestone. Blasting is not anticipated but the Dredging Management Plan addresses excavation contingencies. Sediment curtains will be used to contain sediment plume within the dredging area.
107	6-83	1	How much salt may be spilt, how often and what assumptions have been used to reach the conclusion that "spills will be negligible"?	The spillage of salt during loading is difficult to quantify but should spillages occur they are likely to be small volumes associated with barge loading and unloading, conveyors transfer points on and truck loading. Spills from the loading of barges will be contained in the barge harbour and as indicated in the ERMP, barges will be constructed with high sides to avoid spillage from over-filling. To minimise the risk of salt spillage during loading, loading will not occur under adverse weather conditions.
108	6-88	7	What is the estimated area likely to support new colonies of mangroves?	Given the scale of the project and the patchiness with which colonisation is likely to occur, it is next to impossible to put any accurate prediction on the estimated area likely to support new colonies of mangroves (Garth Humphreys pers comm. 2007).
109	6-124	1	What is the additional level of "predation" on the prawn populations as a result of the pumping? What is the ecological significance of the extra level of predation? Why?	The "predation" referred to is assumed to mean 'by-catch' from seawater harvesting. The revised Yannarie Solar project now has only one seawater pumping station instead of two. The total volume of seawater pumped per year has been reduced by about 70%. The

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				revised seawater intake for Deans Creek is about 143 Million m^3/yr. The revised intake for Deans Creek represents about 3% of the tidal prism (the volume of water that flows into an area between high and low tide) in the creek and about 0.35% of the tidal prism for the region from Giralia Bay to Hope Point. The prawn species most likely to be affected by seawater pumping is the banana prawn which is the only prawn species in the Exmouth Gulf to use the mangrove creeks as juvenile habitat (Kenyon, R.A & Loneragan, N.R, 2004). Juvenile banana prawns utilise mangrove habitats all year round (Travers 2006). Given the very small proportion of the tidal prism being pumped into the ponds on a regional basis (0.35%) there is no grounds to presume that there will be a significant impact on banana prawns. The ecological relevance of the by-catch from Yannarie Solar can be given a context by comparison to the Exmouth Gulf Prawn Fishery by-catch which has been assessed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) against the guidelines for the Ecologically Sustainable Management of Fisheries. With respect to the by-catch from the Exmouth Gulf Prawn Fishery, the Department of Fisheries has estimated (DoF 2006) that the by-catch of dead and discarded non-commercial fish is between 2 and 5 times the annual prawn catch. This means that in 2004 when the total prawn catch for the Exmouth Gulf was 1,346 tonnes (DoF 2005) the resultant by-catch of discarded fish was up to 6,730 tonnes. In addition to the by-catch of discarded non commercial fish, there is also by-catch of sharks and rays, turtles, sea snakes and seahorses. The DoF estimate of cumulative other by-catch for the Exmouth Gulf Prawn Fishery is between 2 – 13 tonnes per season. The DoF has stated (DoF 2006) that: “The impact on the environment, by removing the sum of all retained and discarded species was considered to be unlikely to even cause a moderate change to the ecosystem hence it was only a minor risk on the Exmouth Gulf environment.” “The information used to come to this conclusion includes: • Prawns have a very high natural mortality rate such that a large percentage of the yearly recruits would already be removed from the system (either from death or predation) by the end of the season regardless of fishing. As a result of the natural variation of prawn populations being very high, the effect of removing prawns through fishing would be masked. • There are no known obligate prawn predators, which are likely to be directly impacted upon by the removal of adult-sized prawns. Most prawn predators are opportunistic and/or scavengers and therefore not dependent on any one species. A variety of other small crustacean, invertebrate and fish species live in these areas. Consequently, it is not likely that the commercial take of prawns significantly impacts on the upper trophic levels within the Exmouth Gulf ecosystem. • The cumulative take of other by-product species is relatively low, ranging from 2 to 13 tonnes per season. The impact of the take of by-product species on the environment was considered to be ‘negligible’ as the amount of each by-product species, and the total by-product amount is insignificant and likely to be less than the natural background variation in abundance. • Exmouth Gulf is considered to be a highly productive system and as such the removal of this level of biological material is not likely to be detectable. • Trawling only occurs in a relatively small area of Exmouth Gulf (35%) and only for a period of 8 months (April to November).”

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				Given that the State and federal Governments have both accepted the DoF rationale for ecologically sustainable management of the Exmouth Gulf Prawn Fishery, and given the substantial biomass of by-catch from what is described as "a relatively small area of Exmouth Gulf (35%)", the ecological significance of the Yannarie Solar by-catch is certainly less than a "minor risk".
110	6-126	1	What is the practical feasibility of reducing the pumping rate, especially in summer when evaporation is likely to be highest?	Reducing summer pumping is not feasible as this is the time of the year when evaporation is at a maximum and top pumping is required more than at other times.
111	6-132		Will the 75% P contour plot for dugong also be avoided during the peak use period?	Applying a 1.5 km buffer from 75% preferred habitat area for dugongs is not feasible in the vicinity of the barge harbour, however a 1.5 km buffer from the 5-0% preferred habitat area can be met. Straits will apply a buffer of 1.5 km from the preferred habitat (50% preferred habitat area) for humpback whales contour rather than the 75% contour as suggested in the ERMP.
112	6-135	6	AQIS requirements are essentially minimum standards. Given the importance of the eastern part of Exmouth Gulf, what measures beyond the minimum AQIS requirements is the proponent willing to commit to to ensure non-indigenous marine species are not introduced to the area?	The AQIS requirements are the relevant national standard and considered to be generally effective for boats originating from international ports, especially ballast water exchange protocols (EPA 2006). However, the EPA draft State of the Environment Report identified that the major source of future introduced marine pests in WA is likely to be other Australian ports (EPA 2006). Straits have liaised with the Department of Fisheries (DoF) to obtain additional guidance on management of marine pests and diseases. The DoF advised that there is currently no information available on the Department's website in relation to marine pest or marine disease management (Dr Stephanie Turner pers. comm. 2007). The DoF are currently working towards preparing drafting instructions for the regulations which will address these issues under the new Biosecurity and Agriculture Management Bill (WA), which is anticipated to be enacted in 2008. The DoF has provided Straits with a draft Marine Pest Management Strategy, which focuses on management measures for dredges. Management measures proposed in this strategy have been incorporated into the Marine Management Plan.
113	6-139	4	While the ERMP states that the Marine Management Plan will "identify" management controls for vessels, what action will be taken to ensure effective control actions are implemented rigorously and monitored for compliance and effectiveness?	Environmental audits will be undertaken on a regular basis to assess the compliance of the proponent with regards to implementation of management actions and effectiveness of the actions in the Marine Management Plan.

Table 11 EPASU comments on ERMP on Volume 2

No.	Page	Para.	Comment	Response
1	1-4	2	When is it intended that the CEMP will be produced? Will it be available prior to the completion of the EPA's assessment? What evidence is available to indicate that the level of monitoring and management necessary to support the level of environmental commitments in the ERMP will be supportable throughout the life of the project, particularly during periods of low salt prices?	Straits has provided a formal commitment to prepare a Construction Environmental Management Plan (CEMP) on advice from DEC before the construction commences (refer Commitment 1 in the Executive Summary of the ERMP). Irrespective of market conditions monitoring will be conducted in accordance with the CEMP and Operational Environmental Management Plan (OEMP).
2	1-4	4	The hierarchy of CEMS, CEMP, OEMS, OEMP with regard to `system' and 'plans' is not clear – paragraph 2 refers to "above management plans" when the paragraph above refers to the "management system" Paragraph 4 refers to the OEMS containing procedures that can by used by construction contractors when it appears to relate to the operational phase Please clarify the hierarchy of documents intended to be produced and when they are planned to be produced.	The Construction Environmental Management System (CEMS) and Operational Environmental Management System (OEMS) will detail the environmental aspects and impacts of the proposal and management controls to be implemented during construction and operation respectively. The CEMP and OEMP will contain more detailed requirements that can be used directly by construction contractors and operational personnel. As stated on page 1-4 of the ERMP (Volume 2, Management Programme), the CEMP and OEMP will be submitted to the EPA for approval prior to works commencing on site. The “management plans” referred to in paragraph 2, refer to the list of plans in Section 2.1 (page 1-3). These include: • Terrestrial Vegetation Management Plan • Terrestrial Fauna Management Plan • Marine Management Plan • Groundwater Management Plan • Surface Water Management Plan • Acid Sulphate Soil Management Plan • Aboriginal Sites Management Plan (to be re-named Cultural Heritage Management Plan) • Preliminary Closure Plan.
3	1-4	6	Following discontinuation of work, what will be the criteria for recommencing work?	Should work be discontinued following an incident, work will recommence following approval from the site manager or delegate. Work will not recommence unless it is safe to do so.
4	1-5	3	Who will the Project Manager 'recommend environmental objectives too? Who will be responsible for signing off on those recommendations?	This comment will be addressed in the preparation of the CEMP.
5	1-5	5	If the Operations Manager will 'set' environmental objectives, who will sign off on them and then oversight their achievement?	This comment will be addressed in the preparation of the OEMP.
6	1-6	6	DoIR should be added to the agencies to be involved in the preparation of the Audit Plan.	Noted. DoIR will be included in the list of agencies to be involved in the preparation of the Audit Plan.
7	1-7	1	Reporting of incidents and breaches should be added to the list.	Reporting on environmental performance (as listed in this paragraph) will include reporting of environmental incidents and breaches.
8	1-7	2	Who are the three parties making up the Tripartite Stakeholder Liaison Group?	The Tripartite Stakeholder Liaison Group will be referred to as the Stakeholder Reference Group. Meetings of the Stakeholder Reference Group will be open to the public and the group will include representatives from: • community environment organisations • local Government • Government agencies • Chamber of Commerce and Industry • Recreation fishing sector

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				• Commercial fishing sector • Tourism • Straits Resources.
9	1-7	7	Noting that the CEMS will be 'continually' reviewed, how frequently will it be formally updated?	This CEMS will be updated continually as new procedures are prepared or amended.
10	1-7	8	The use of 'should' and 'can' ought to be replaces with 'will'.	Noted. The updated plans will use the word "shall" which has more force than "will". Amendments will be made to the plans, as appropriate.
11	2-1	1	What process will be used to decide the practicability of implementing actions to deal with impacts on vegetation and flora?	Management actions to address impacts on vegetation and flora are included in the Terrestrial Vegetation Management Plan. Actions were reviewed to ensure practicality of implementation.
12	2-2	1	The potential for hydrological changes caused by redirection of surface flows to affect vegetation should also be acknowledged.	This comment has been addressed in the revised Terrestrial Vegetation Management Plan.
13	2-2	Tab 2-1	The Performance Indicators listed in Table 2-1 (and most others listed in other tables in this volume) are not effective indicators of performance. Numeric limits or targets, like those listed in the third column of Table 2-11 are suitable indicators against which the performance of the project can be assessed. Examples of performance indicators for clearing might be "no clearing outside approved areas" or "no incidents of clearing without a valid vegetation clearing permit"	This comment has been addressed in the revised Terrestrial Vegetation Management Plan.
14	2-3	1.2	To what level of detail will surveys be conducted, noting that Guidance Statement 51 lists a number of levels? Will surveys be undertaken on mainland remnants?	This comment has been addressed in the revised Terrestrial Vegetation Management Plan.
15	2-3	3.2	What process will be used to design in advance what tracks will be required, for what duration, so that track numbers are strictly controlled? How practical are scrub-rolled tracks likely to be in an environment where tyre staking is a high probability?	This comment has been addressed in the revised Terrestrial Vegetation Management Plan.
16	2-3	3.4	Topsoil should either be windrowed for re-use in the short term or used to rehabilitate some other area. Long-term stockpiling (recognising the 60 year nominal life of the project) will not result in viable topsoil.	This comment has been addressed in the revised Terrestrial Vegetation Management Plan.
17	2-3	3.7	The Vegetation Clearing Permit should have "including Mangroves and Algal Mat" added to the main heading to indicate that all vegetation types require a permit.	This comment has been addressed in the revised Terrestrial Vegetation Management Plan.
18	2-3	3.13	What will happen to cleared vegetation?	This comment has been addressed in the revised Terrestrial Vegetation Management Plan.
19	2-3	3	An annual register of areas cleared and rehabilitated, with a cumulative balance of area disturbed, should be maintained.	This comment has been addressed in the revised Terrestrial Vegetation Management Plan.
20	2-4	1.1	By when will weed mapping be undertaken?	This comment has been addressed in the revised Terrestrial Vegetation Management Plan.
21	2-4	1.2	What will happen to weed infested soil?	This comment has been addressed in the revised Terrestrial Vegetation Management Plan.
22	2-4	1	An annual report of weeds found and management action taken to control them should be prepared and submitted to DEC.	This comment has been addressed in the revised Terrestrial Vegetation Management Plan.
23	2-5	1	The numbered statements are commitments but do not constitute completion criteria. Please specify what criteria will indicate when rehabilitation is complete (e.g. Plants/m^2, % cover, diversity index etc). Soil function should also include stability.	Noted. Detailed completion criteria will be developed throughout the operational phase of the project and after adequate consultation with stakeholders has been undertaken.
24	2-5	3	Presumably the 'AER' referred to is an Annual Environmental Report – where is a commitment made to produce such a report and what will it contain?	AER stands for Annual Environmental Report. Straits will produce an AER on an annual basis, and will include relevant environmental information, such as a summary of environmental monitoring results.

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25	2-6	1	After cessation of activity, what re-start criteria will apply? Rehabilitation work is an operational matter that should be to the satisfaction of DEC.	Contingency actions have been reviewed and are included in the revised Terrestrial Vegetation Management Plan.
26	2-7	4	Additional impacts include the disturbance to claypans and quarries which may be habitat to water borne fauna and subterranean fauna respectively. The potential for light emissions to affect fauna should also be listed here, noting that it is covered in later parts of this section.	This comment has been addressed in the revised Terrestrial Fauna Management Plan.
27	2-8	Tab 2-3	The items in column 3 are not indicators of performance. An example would be "Actual area cleared to be less than or equal to area shown on approved plan" for example. Landform impacts (as well as vegetation composition) should also be addressed (i.e. What is likely to be the impact of excavating clay for numerous claypans, when this habitat is limited in the area). The prospect of unvegetated, as well as vegetated, sites comprising habitat should also be planned for.	This comment has been addressed in the revised Terrestrial Fauna Management Plan.
28	2-14	2	Specific targets and performance indicators need to be provided by the proponent for the important Marine Management plan before the EPA completes its assessment.	The revised Marine Management Plan (with targets and performance indicators) will be provided to the EPASU prior to completion of its assessment of the project.
29	2-14	4	What provisions are being made in bund design to allow for overtopping by storm surges and subsequent safe drainage of the overtopping waters in a way which will not erode the bunds at their lowest points?	This comment will be addressed in the updating of the Marine Management Plan (refer to response in Table 10, number 11 above).
30	2-15	2	When will the baseline sampling for the location of sensitive habitat (including benthic habitat mapping) be completed? This information is required prior to the EPA completing its assessment.	Additional benthic habitat mapping was undertaken in late 2007. The results are provided in Appendix 11 (Oceanica 2008).
31	2-15	3.3	Monitoring of the continued health and vigour of ephemeral primary producers is also required, particularly since ephemeral vegetation is essential to grazers.	This comment has been addressed in the revised Marine Management Plan.
32	2-15	4.2	Baseline survey of biota needs to cover the annual cycle, given the variability in habitat usage by species such as prawns.	Travers (2006) undertook a review of the fish and crustaceans that use the mangrove habitats in Exmouth Gulf throughout the annual cycle. The review suggested that juveniles of the mangrove jack, gold-spotted rockcod, black-spotted rockcod and the white banana prawn are abundant in the mangroves throughout the year (Travers 2006). The review also suggested that it is likely that the larvae of various fish species and the juvenile stages of the green mud crab would be most abundant in the mangrove habitat of Exmouth Gulf during the spring and summer period when water temperatures are at their highest (Travers 2006). The results of Travers investigations were considered when updating of the Marine Management Plan.
33	2-15	4.4	What can be done to screen out larval stages of important organisms, such as prawns?	Refer to comment no. 109, Table 10. Although entrainment of small biota/larvae will not be preventable through screening and is not considered to be ecologically significant, there are measures that can be investigated for introduced in response to entrainment concerns. Entrained fish may be managed by the following methods: • Internal bunding: Molony and Parry (2002) reported that a solar salt producer at Shark Bay installed a system to encourage fishes to leave the first pond. A bund wall inside the first pond, enclosing an area of approximately 1 ha, was constructed. The wall is lower than the external bund walls and is overtopped by water during pumping. This allows fish within the first pond to move towards the pumps, into the 1 ha area. However, when pumping ceases, the water level within the first pond reduces and the water (and fish)

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				within the 1 ha area becomes isolated from the rest of the pond. This water (and the fish) is then drained out of the system back into adjacent waters via large diameter culverts fitted with one-way valves. • Targeted removal: many of the fish aggregate around the pumping stations during the pumping process. This is most likely due to feeding opportunities created by small fauna being pumped into the system and is likely to be a learned response. This behaviour can be exploited to reduce fish biomass within the concentration ponds through capture with nets, especially of predatory fish. • Improving the success of targeted removal and fish release/escape can be further enhanced by screening the connections between the initial concentration pond and subsequent ponds. • Exploitation of the fish resources within the concentration pond: There is the potential to allow local aquaculture operators to use sections of the initial concentration pond for commercial aquaculture activities. • Recreational use of the ponds: Given the potentially large biomass of fishes within the first concentration pond and the fact that larger fish will concentrate around the pump station. The pump station areas could be enhanced to allow recreational fishing access. Management of entrainment will employ some or all of the above methods. A programme of monitoring and research will also be implemented, this programme will comprise of the following key elements: • Prior to commencement of operations, baseline surveys of biota in four creeks on the east coast (Dean's Creek and one other creek selected as a control), with the aim of building information on the species present and the stages of their life cycle they are present. • Design of a monitoring program for operation to record the fauna within the ponds and the impacts on Dean's Creek. • Design of programs to assess the effectiveness of management methods employed. • Collaboration with the Department of Fisheries and the Department of Environment and Conservation in all of the above, designing the sampling programs, refining management methods and interpreting the results.
34	2-16	1.1	The presence and distribution of acid sulphate soils needs to be determined well before dredging commences so that an appropriate plan for proper disposal can be developed and approved.	ASS testing of offshore sediments was undertaken by Oceanica (2006).
35	2-16	1 3	Dredging needs to be suspended, not just reassessed if wind speed and wave height exceed the operational parameters of the dredge. A plan also needs to be in place for the suspension of dredging operations if water quality limits are exceeded.	Noted. The Marine Management Plan and Dredging Management Plan have been amended to reflect this.
36	2-16	1.7	Targets and performance indicators for the Dredging Management Plan need to be provided by the proponent before the EPA completes its assessment.	Noted. The Dredging Management Plan will be provided to the EPA prior to completion of its assessment of the proposal. The plan has been prepared in accordance with Department of Environment (DoE) 2006 *draft Compliance Monitoring and Reporting Guidelines for Proponents, Preparing Environmental Management Plans* and includes targets and performance indicators. Oceanica and Msicence (coral experts) will review information and provide advice on appropriate coral stress thresholds (if required).
37	2-16	3.1	Remote sensing images need to be provided before, during and after dredging and barging operations to enable a proper assessment of performance.	This comment has been addressed in the revised Marine Management Plan.

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38	2-17	1.2	How will "exceptional" environmental sensitivity be defined?	This comment has been addressed in the revised Marine Management Plan.
39	2-18	1.1	When will baseline data for PAH and hydrocarbon levels be collected?	This comment has been addressed in the revised Marine Management Plan.
40	2-18	2.2	Will mangrove and algal mat clearing require the use of the form at Appendix 1 of Volume 2 of the ERMP? It would be helpful for the title of the form to include "mangroves and algal mats" to make it clear to operators that these areas are covered by the need to have a permit.	This comment has been addressed in the revised Marine Management Plan.
41	2-18	2.4	What will the "management procedures and actions" relate to?	This comment has been addressed in the revised Marine Management Plan.
42	2-19	2	What does "minimising the potential for vessel avoidance" mean? Should this read "vessel strike" rather than "vessel avoidance"?	Vessel avoidance covers vessel strike as well.
43	2-19	2	The list of actions under Vessel Avoidance focuses on whales. What specific actions will be taken to avoid vessel strike to dugong, recognising that smaller vessels will be involved but that dugong are slow moving, poor at taking evasive action, constrained by the shallow depth of water they typically feed in and that there are likely to be more small vessel movements than large vessel movements?	The same management procedures already suggested for humpback whales are based on Hinchenbrook Island procedures and will be applied to dugongs. These procedures involve the specification of vessel speed and designated routes. Dugongs are expected to mostly occur to the south of the dredge channel and in shallow water and are unlikely to be significantly affected by shipping or barge vessels.
44	2-19	2.6	Will an annual update of the 75% P contour plot be undertaken to best define the actual distribution of animals each year?	This comment has been addressed in the revised Marine Management Plan.
45	2-19	2.10	Will a similar level of research effort be applied to dugong given that they are more confined in their distribution and more highly dependent on the waters adjacent to the proposal than whales are?	Straits will support the development and implementation of an Exmouth Gulf Research Project, which includes a 2 year dugong survey programme and funding for a PhD project to investigate the linkages between benthic habitat and dugong survey results.
46	2-20	3	Recognising that AQIS guidelines are typically minimum standards developed to avoid undue impediment to shipping and trade, what additional quarantine procedures such as compulsory exchange of ballast water outside State waters, is the proponent prepared to adopt to provide the level of NIMS control appropriate to the eastern side of Exmouth Gulf?	Straits is not aware that AQIS standards are minimum developed to avoid undue impediment to shipping and trade. Does DEC have evidence that current standards are insufficient for shipping Exmouth Gulf? The draft State of the Environment Report (EPA 2006) expresses confidence in the AQIS requirements, especially ballast water exchange protocols. However, the EPA identified other Australian ports as the major source of future introduced marine pests in WA. The discharge of high-risk ballast water in Australian ports or waters is prohibited. Ships that contain high risk ballast water are required to exchange 95% (or better) volumetric exchange of high risk ballast water outside the Australian 12 nautical miles limit. Ballast water exchange logs are checked by AQIS inspectors upon arrival to Australian waters (AQIS 2007). Prevention measures are being developed with the Commonwealth Department of Agriculture, Fisheries and Forestry (DAFF) and the States, to minimise marine pest incursions and translocations for commercial shipping and non-trading commercial vessels (DAFF 2006). See comment 112 in table 8 above.
47	2-20	3.3	Recognising the potential benefit of anchoring outside the Gulf, how practical is this requirement?	Anchoring outside the Gulf is not practicable.
48	2-20	3 4, 3.6	To whose satisfaction will monitoring of ship's captains performance and NIMS inspections be carried out? What provisions will be made for the transparent reporting of the results of these actions?	This comment has been addressed in the revised Marine Management Plan.
49	2-21	1	Some birds may also be attracted/disoriented by lights. What consideration will be given to managing this potential impact?	This comment has been addressed in the revised Marine Management Plan and Terrestrial Fauna Management Plan. Management measures will include minimising the use of direct upward lighting where appropriate.
50	2-21	5	When will investigations on techniques to reduce or manage entrainment be conducted, especially for the larval stages of important species? It is important that this data be available in time for the EPA to be able to complete a proper assessment of the risks of entrainment.	Refer to comment no. 109, Table 10. Entrainment is not considered an ecologically significant issue. No data on potential management responses to potentially insignificant entrainment issues will be available prior to completion of assessment.
51	2-24	Tab 2-5	Will shoreline change be monitored at the seawater intake points? Will	Yes and the Marine Management Plan has been updated accordingly.

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		Row 3	monitoring occur after significant events like cyclones/ storm surges?	
52	2-25	3.1	Following the cessation of dredging or ship and barge movements, what will the criteria be for the recommencement of these activities?	This comment has been addressed in the revised Dredging Management Plan.
53	2-25	5	What amelioration responses are contemplated for detrimental effects to marine water and sediment quality? Essential elements of the Dredging Management Plan, particularly related to targets and performance criteria need to be provided by the proponent prior to the EPA completing its assessment.	This comment has been addressed in the revised Dredging Management Plan.
54	2-26	1	What is the proposed target level for collisions with humpback whales (or any other marine mammals)?	The proposed target level is for zero collisions. This has been addressed in the revised Marine Management Plan.
55	2-26	1.2	NIMS response should occur if NIMS are found to have spread to any new locations within the Gulf, particularly the eastern Gulf, rather than response being confined to cases where NIMS are new to the Gulf as a whole.	This comment has been addressed in the revised Marine Management Plan.
56	2-26	2	What are feasible examples of responses to recurring entrapment of marine fauna?	This comment has been addressed in the revised Marine Management Plan.
57	2-27	3	It should be noted that seepage may potentially also affect algal mats, as well as mangroves.	Seepage is not expected to affect algal mats other than to potentially increase their abundance in seepage areas near levees.
58	2-27	4	Targets and performance indicators are required from the proponent prior to the EPA completing its assessment.	Targets and performance indicators are being addressed in the updating of the Groundwater Management Plan.
59	2-28	1.1	Noting the intention to establish baseline groundwater levels, prior to construction, why could these bores not be drilled now to assist in understanding the hydrogeology of the area prior to the EPA completing its assessment?	Hydrogeological investigations are underway and will provide further information on hydrogeology of the area.
60	2-28	1.3	Sampling for subterranean fauna needs to be conducted prior to the EPA completing its assessment.	Subterranean fauna investigations were undertaken late 2007 as part of the scope of work agreed with DEC. For results of the investigations refer to Appendix 8 (Biota 2008a).
61	2-28	2.2	What does "turbidity less than mean background levels" mean in the context of discharges to dry surfaces?	To reduce turbidity of run off.
62	2-28	2.3	Acid sulphate soil mapping needs to be completed prior to the completion of the EPA's assessment.	Worst case scenarios for ASS mapping in areas to be disturbed have been addressed in the revised Acid Sulphate Soil Management Plan.
63	2-28	3	How will fuel storages within the storm surge zone be protected from such storm surges?	The main fuel storage area located at Hope Point has been repositioned to a height well above the 1:100 yr storm event.
64	2-29	Table 2-6	What will be done to monitor the impact of dewatering on any subterranean fauna present?	This comment speculates that stygofauna are present and should await the results of the proposed sampling program. Subterranean fauna investigations were undertaken late 2007 as part of the scope of work agreed with DEC. For results of the investigations refer to Appendix 8 (Biota 2008a).
65	2-30	2	The Groundwater Management Plan should be prepared in consultation with the Department of Water.	Consultation will be undertaken with the Department of Water during the preparation of the final Groundwater Management Plan.
66	2-36	Table 2-8	Why do the ASS risks differ for the Barge harbour and Barge channel?	This was an error – both the barge channel and barge harbour were rated as moderate risk of ASS in the preliminary assessment undertaken by Parson Brinckerhoff (2005).
67	2-36	2	Baseline ASS surveys need to be completed prior to the completion of the EPA's assessment.	Baseline ASS surveys have been completed for Deans Creek, the barge channel and supratidal flat.
68	2-37	1.7	Why is only one in ten soil bores proposed for testing for acid generating capacity? Where there are field indications of ASS, all bore sites should be tested to provide a comprehensive map.	This question has been superseded by the revised Acid Sulphate Soil Management Plan.
69	2-38	1.3	How will stockpiled ASS be managed?	This comment has been addressed in the revised Acid Sulphate Soil Management Plan.
70	2-28	3	What are the likely effects of placing ASS in limestone pits if there are	This question has been superseded by the revised Acid Sulphate Soil Management Plan.

No.	Page	Para.	Comment	Response
			subterranean fauna there?	
71	2-46	Table 2-12	Borrow pits – what are completion criteria? Should be done as part of Terrestrial Vegetation Rehabilitation plan.	Preliminary closure objectives for borrow pits are stated in the Preliminary Closure Plan. Detailed completion criteria will be developed throughout the operational phase of the project and after adequate consultation with stakeholders has been undertaken.
72	2-47	Table 2-13	Scenarios involving complete removal of all embankments should also be planned for as the base case. Borrow pits and clay pans should not be backfilled with material from the salt field – salt contamination will not be acceptable in these environments.	This comment has been addressed in the revised Preliminary Closure Plan.
73	2-50	1	Completion criteria to an appropriate level need to be provided prior to the EPA completing its assessment.	This may not be practicable at this stage as details of site-specific topsoil assessments and mapping and pre-existing vegetation survey of the site to develop completion criteria will be required.

Table 12 Additional EPASU comments on ERMP

No.	Comment	Response
1	**Terrestrial issues**	
2	**Flora and vegetation**	
3	The proposed monitoring of vegetation using NDVI methodology needs to be further described (Table 2-2, page 2-5 of Environmental Management Programme). It also needs to be clarified whether the annual monitoring proposed in Table 2-2 is to be undertaken using imagery analysis, or physically by a botanist. Vegetation should be assessed annually at plots or specific locations by an experienced qualified botanist, to determine whether, for example, increases in percentage foliage cover are not in fact growth of introduced species, or whether decreases in percentage foliage cover indicate significant plant deaths.	Both methods would be employed (remote sensing and ground-truthing by a botanist at representative sites). Details have been provided in the revised Terrestrial Vegetation Management Plan.
4	Plans for rehabilitation location and vegetation type should be indicated in the Environmental Management Programme. The landform features of the area that are expected when the project potentially reaches the 'closure planning phase' should be detailed, for example expected soil salinity levels, and the landform/scaping works that will be undertaken to remove bunds/pond walls, and create drainage lines.	Previously addressed in comments 71, 72, 73 of Table 11.
5	If this project were to proceed, closure and rehabilitation would be expected to be many decades into the future Rehabilitation planning would need to be consistent with the best practice standards of the time (currently EPA Guidance 6 Rehabilitation of Terrestrial Ecosystems), and to the satisfaction of the minister, on the advice of the DEC. The statement that 'Rehabilitation will be consistent with current best practice' (page 5-65 of ERMP) should reflect that there will be evolving standards, and that the project would comply with those. As stated on page 12 of EPA Guidance 6; 'Definitions that are not readily auditable include: to a high standard, best practicable, world's best practice, etc. (Table 3). To overcome these problems it is recommended that a more precise definition of rehabilitation be used.'	As stated in the Preliminary Closure Plan, closure planning process is dynamic and will require regular review and further development throughout the life of the operation. The Preliminary Closure Plan will be periodically updated, to incorporate changing legislative requirements, technical improvements, cost increases, changes to the needs of stakeholders and changes to environmental best practice techniques. It also allows for future negotiations on end land use and completion criteria suitable for the location. In addition, the continued improvement of the Terrestrial Vegetation Management Plan will occur in response to environmental incident resolutions and audit findings and changes to environmental best practice techniques.
6	The flora and vegetation technical report is of a good quality, and appears to meet the requirements of EPA Guidance Statement 51 for Terrestrial Flora and Vegetation of the area surveyed. However, it does not cover the full extent of environments to be impacted by this project. Nor does it place the areas impacted into regional context. Given this limitation, it is not possible to fully assess the vegetation values and impacts of the proposal, It is understood that the proponent is required to undertake further works in relation to flora and vegetation. This further work is expected to include establishment of additional vegetation plots in areas of impact not yet surveyed due to expansion of the proposed project area, and in areas outside the proposed project area, to provide context of vegetation representation for the survey. The results of these additional works are expected to be published as a supplementary report, and a final assessment of the adequacy of the flora and vegetation surveys will need to be made at this time.	Noted. Further botanical survey work, as agreed with the DEC, was undertaken in November 2007. These surveys included areas of disturbance that were not originally surveyed and reference areas outside the project footprint. This included part of the hinterland at the eastern margin of the Onslow Plain (a small area which may be affected by flood backwater behind planned diversion dams and materials sourcing locations) and associated mainland remnant land masses extending across the saltflats toward the eastern margin of Exmouth Gulf. Refer to Biota 2008b (Appendix 14) for results.
7	The flora and vegetation technical report states that 'There is little data available to determine the uniqueness of the vegetation associated with these claypans, and very few detailed botanical surveys appear to have been completed in the sub-region, particularly the eastern part of it' (Biota 2005, page 27). This point reemphasises the need for further survey, to define context and representation of communities within and surrounding the project area.	Further botanical survey work, as agreed with the DEC, was undertaken in November 2007. These surveys included areas of disturbance that were not originally surveyed and reference areas outside the project footprint, to provide regional context. A quantitative comparison was completed of floristic data from all quadrats within the project impact area (including those from the original survey) and those outside in the immediate locality. Additionally, a PATN analysis was also completed (a method based on floristic composition that groups quadrats from similar vegetation types together) to the meet the key EPASU requirement. Refer to Biota (2008b) (Appendix 14).

No.	Comment	Response
8	The flora and vegetation technical report states that some flora, that were recorded at the northern or western end of their distribution were 'not considered to be of special conservation significance'. It also states that several species were recorded at the southern end of their distribution, but no comment is made on the conservation significance of these species (page 33, Biota 2005).	As also stated in the technical report, none of the flora recorded were of DRF or Priority status (Biota 2005a) (ERMP Chapter 5, Section 4.3.4). Other than being at their southern range limits, none of the species referred to were therefore of special conservation significance.
9	The flora and vegetation technical report states that 'the timing of the survey was not ideal for sampling' the vegetated claypans of Eucalyptus victrix Low Woodland over Grassland, and that 'It is likely that there are many more species present in these claypans than were identified during this survey' (page 20). Further survey of these claypan areas and the 'Bare pans with *Triodia epactia*, herbs and grasses on fringe' communities (page 20) should be undertaken after substantial summer rain, in order to determine whether species of significance occur.	The completion of these surveys is dependent on the area experiencing a significant rainfall event. An additional botanical survey was undertaken in November 2007, however this survey did not adequately record species responsive to summer or winter rain (Biota 2008b, Appendix 14). It is however worth noting that the majority of the vegetated claypans were actually on the hinterland and would not be affected by the project clearing footprint.
10	As stated in the flora and vegetation technical report, the CALM 2002 Biodiversity Audit showed that 26 ecosystems were considered to be under threat in the Cape Range Sub-region by regional ecologists; 'These included floodplain and samphire, which occurred in the survey area' (page 27, Biota 2005). In addition, Biota comments that 'intact Coolibah communities' which are under threat across the Eremaean province of Western Australia from pastoral activities and introduced animals' are of 'high conservation significance'. The technical report also mentions `The fact that the mainland drainage features within the survey area are still in good condition means that they have high conservation significance' (page 27, Biota 2005), Community types such as those mentioned above do not appear to have been avoided or protected in planning shown in the Environmental Review document. Consideration should be given to these community types, particularly with reference to the knowledge that limited listing of Threatened Ecological Communities may reflect the limited survey work undertaken to date in the region.	The latter two vegetation units are situated on the hinterland and were included in the original survey spatial extent as an access road was being considered at the time. These will not be impacted by clearing for the project under the current design.
11	**Fauna**	
12	The fauna and fauna assemblage technical report is of a good quality, and appears to meet the requirements of EPA Guidance Statement 56 for Terrestrial Fauna Surveys for Environmental Impact Assessment.	Noted.
13	Additional information is required for Figure 5-26 and 5-27 Wader roost sizes and the preceding text on Wader roosts (page 5-81).	The classification of wader roost sizes are as follows: Class 1: 0-50 individuals Class 2: 50-100 individuals Class 3: 100-500 individuals Class 4: 500-1000 individuals Class 5: >1000 individuals.
14	Figures 5-26 and 5-27 require a key which should indicate the size of the different roost classes	Refer to comment no. 13 above.
15	Dot point 1: Wagtail Island is referenced in the text in Figure 5-26 but is not identified on Figure 5-26	An error was made in cross-referencing in dot point 1. Wagtail Island is shown on Figure 5-27, not Figure 5-26.
16	Dot point 2: refers to Hope Point and '... with smaller roosts recorded…' The meaning of smaller in this context should be qualified.	This dot point includes a cross reference to Figure 5-27, which shows the size of roost classes recorded during January 2004, March 2004 and August 2004. Figure 5-27 shows that in August 2004 a class 5 roost was recorded at Hope Point, compared to class 3 roosts in March 2004, and class 1 and 2 roosts in January 2004.
17	Figure 5-26 where available the locations where roosts have been identified should be included on the map.	Coastlines dominated by fringing mangroves such as the eastern Exmouth Gulf provide limited potential roosting sites for waders (Garth Humphreys pers comm. 2007). Figure 5-26 of the ERMP (page 5-82) shows all potential wader roosts identified during the Biota (2005) survey. It can be seen that there are limited roost sites in this area compared with areas further north (refer to ERMP Figure 5-27, page 5-83).

No.	Comment	Response
18	Figure 5-27 refers to four different area names based on their location on Trent Island. There needs to be consistency of use between the names on Trent Island referred to in the text and those on Figure 5-27.	Noted. Dot point 6 and 7 respectively should read 'North-east Tent Island recorded a roost in all months, although it was much smaller in March than in August or January' and 'North-west Tent Island recorded a consistently large roost area'.
19	**Subterranean fauna**	
20	As previously advised, we concur with advice from the WA Museum on subterranean fauna and would expect these limestone quarry sites to be surveyed, along with appropriate sites not proposed to be quarried, to provide context of subterranean fauna presence outside proposed quarry sites.	The limestone quarry sites proposed in the ERMP (Figure 2-9, page 2-38) are no longer required, as all limestone material will be sourced from excavations at Hope Point.
21	A decision on the proposed limestone quarries (Figure 2-9) should not be made prior to additional work on subterranean fauna being undertaken in these locations to determine whether these areas support subterranean fauna and the significance of the fauna and impacts on the fauna.	This comment is no longer relevant, as the limestone quarry sites proposed in the ERMP (Figure 2-9, page 2-38) are no longer required, as all limestone material will be sourced from excavations at Hope Point.
22	**Fauna Management Programme**	
23	Table 2-3 (Environmental targets and performance indicators for terrestrial fauna) needs to be expanded to include management actions and adaptive management. The performance indicators listed do not demonstrate that the objectives have been met, for example Table 2-3: Objective 1 'protect fauna consistent with provisions of the Wildlife Conservation Act 1950' Performance indicator 1 'Fauna surveys, construction plan and correspondence' A fauna survey is not a performance indicator; it does not establish a measurable target level of protection or demonstrate that fauna have been protected A fauna survey is the management tool that can be used to determine whether the objective has been met., The performance indicator is a report with accompanying data demonstrating that under the provisions of the Act fauna have not been impacted. Where fauna have been impacted adaptive management/contingencies can be put into action.	Noted. This comment has been addressed in the revised Terrestrial Fauna Management Plan.
24	**Climate change**	

No.	Comment	Response
25	The impacts of the proposal arising from predicted rise in sea level have not been addressed. The proposal is located on extremely flat land immediately landward of the algal mats that are a measure of tidal extent. It is reasonable to assume that the sea level rise will cause a landward migration of intertidal communities, including the very significant mangal environments along this coast. The impact of the proposal in blocking this capacity to adjust to the sea level rise, potentially constraining future mangrove and other intertidal habitat needs to be addressed in a comprehensive manner.	On what basis does the EPA assume that sea level rise will cause a landward migration of intertidal communities in the project area? The DPI have noted in their submission on the ERMP that the response of the project area shoreline to sea level rise is likely to be "complex". The Bruun Rule is recognised as the only current 'official' approach to determining shoreline response to sea level rise and has been applied elsewhere in WA by the Department of Planning and Infrastructure. Using a planning horizon of 100 years and a sea level rise of 0.38 m, a potential shoreline retreat of 38m was determined. As detailed in the ERMP (page 4-11); "Stive *et al.* (1991) note that the Bruun Rule is over simplistic and suggests that the rate of shoreline retreat with sea level rise is time dependent. They note that the Bruun Rule may actually over-predict shoreline retreat rates. For sea level rise rates of approximately 0.2 m/100 years the shoreface processes are largely compensatory and there is no shoreline retreat. For rates greater than 0.6 m/100 years it is expected that shoreline retreat may become significant. Cox and Horton (1999) note that the Stive *et al.* (1991) model has been qualitatively confirmed for the New South Wales coast, where over the past 100 years with a sea level rise of approximately 0.1 m there has been effectively no overall shoreline retreat." "Further, Cahoon and Lynch (1997) reported that in muddy coastal environments, mangroves are excellent land-builders and by way of example, provided evidence that mangrove elevations in south-west Florida had kept pace with sea level rises over the previous 70 years (rise of 10–20 cm from 1930 to 1990). The implication is that long-term sea-level rise in the Exmouth Gulf will not necessarily result in an inland migration of the mangrove system from its current position." The setback of the concentrator and crystalliser ponds has increased in the revised proposal, from an average setback of 40 m from the landward edge of the algal mat to a minimum of 100 m. This increase in setback will allow more area for algal mat migration, should this occur due to an increase in sea levels. Refer to Table 10 Item No. 10.
26	Note that mangal communities represent rare closed forest habitat in this region and support habitat restricted faunal assemblages including mangrove dependent avifauna (for example Dusky Gerygone, Mangrove Golden Whistler, White-breasted Whistler, Mangrove Grey Fantail and Yellow White-eye) that will be restricted to this environment in the region. The loss of this habitat would thus have significant terrestrial as well as marine impacts.	This is noted, however the current footprint of the project would result in a very small proportion of local and regional mangrove habitat being cleared (approximately 2 ha in total). It would appear unlikely that this would alter the conservation status of any of the mangrove dependent terrestrial species listed here.
27	**General**	
28	With reference to page 19, Section 4.1.1 of the executive summary, incorporating energy saving initiatives into the design of the project is not actually an offset, it is just reducing energy use. Real offsets should be investigated and discussed with the DEC Greenhouse Unit.	Noted. Straits was not seeking formal offsets but rather was providing a description of measures that would reduce greenhouse gas emissions from the project. Notwithstanding this, under the Kyoto Protocol and associated programs countries may achieve offsets or credits to meet their greenhouse gas obligations by investing to increase energy efficiencies of developing countries.
29	**Marine issues**	
30	**General comment**	

No.	Comment	Response
31	The ERMP documentation specifically states that discharge of bitterns to the marine environment is not part of this development proposal. The proponent goes on to say that a bitterns resource recovery strategy is being investigated to recover additional salts from the bitterns and prevent the need for any discharge off-site. It is a significant concern that it may become necessary to discharge bitterns to Exmouth Gulf' in the future, particularly if additional recovery of salts is not feasible. The discharge of bitterns from a solar salt project of this magnitude could have serious ramifications for the marine flora and fauna in the Gulf and if there is any possibility that bitterns management will include discharge to the marine environment then the potential impacts of this option should be fully addressed in this ERMP. If the development is approved without consideration of a bitterns discharge then approval of a discharge at some later stage may be considered a fait accompli. Note: A bitterns discharge would need to be considered within the context of the environmental quality management framework for the Pilbara coastal waters (DoE, 2006). When assessing the bitterns discharge against Exmouth Gulf seawater in the maximum ecological protection zone the proponent will need to use an indicator such as magnesium rather than salinity because of the different ionic composition of the bitterns.	This proposal does not include the discharge of bitterns. Straits are confident of achieving full resource recovery. However, the final assessment of options for recovery of Bitterns C (end point bitterns) will be made within the first ten years of operation of the Yannarie Solar project if approved. As requested by the EPASU, Straits undertook further dispersion modelling of Bitterns C, to assess the dispersion of Bitterns C within and around the barge harbour at Hope Point. The modelling estimated the mixing and dilution of bitterns that were pre-diluted with seawater before discharge into the barge harbour at Hope Point. The results were provided to the EPASU in December 2007 and are provided in Appendix 13 (APASA 2007).
32	It is understood that the Yannarie Solar Salt development will be a staged project.. Some aspects of the proposed management plans currently do not reflect this staged approach to the development and will need to be updated to take this into account. For example, under the heading 'Proposed Management' on page 6-68 monitoring to assess any changes or trends in creek morphology will only be done intensively for the first 2 years The .justification given is that the greatest period of pumping will be in the first two years after commissioning. If the project is in fact a staged development then it would be reasonable to assume that pumping rates might increase with each stage.	The revised proposal does not include a staged development. Straits are seeking approval for a nominal 4 Mtpa salt field.
33	**Specific comments**	
34	Chapter 4, Section 2.2.4. The proponent has estimated long-term sea level rise by taking the mean of the latest models of the latest Assessment Report of the Intergovernmental Panel on Climate Change Working Group. There are two concerns with taking this approach. Firstly, by taking the mean there is a high probability (approx. 50%) that the project and associated infrastructure will be under designed for actual sea-level rises experienced in the future. Secondly, the most recent interpretations of global warming effects are suggesting that changes, including those that could lead to sea-level rise, are happening at a much faster rate than was previously anticipated 'The Yannarie development should be designed based on worst case sea level rise estimates.	The setback of the concentrator and crystalliser ponds has increased in the revised proposal, from an average setback of 40 m from the landward edge of the algal mat to a minimum of 100 m. This increase in setback is more than that required by the worst case modelling of sea level rise by the IPCC.
35	Chapter. 5, Sections 2.4.2 and 2.4.3: Three additional potential impacts need to be addressed by the proponent. 1. Lateral intrusion of saline groundwater into the adjacent algal mat and mangrove habitats from the supratidal salt flats caused by the hydraulic head of the concentrator and crystallises ponds. Given the low hydraulic conductivity of' the soils this will be a slow (10 years plus) process, but could eventually lead to salinities greater than the tolerances of the adjacent algal mat communities or the nearby mangroves. Groundwater salinity under the supratidal salt flats (i.e. under the proposed ponds) is 120,000 – 263,000 AS/cm. Mangroves typically survive in groundwater salinities of 70,000 –150,000 AS/cm. The ERMP does not provide typical salinities in the algal mat habitat. This potential impact also needs to be considered in Section 2.6.4 of Chapter 6. 2. Similarly, intrusion of saline groundwater into the adjacent dunefield system caused by the hydraulic head of the concentrator and crystalliser ponds and consequent effects of the associated vegetation. 3. 3. Effect of surface flow ponding along the salt plain/dune field interface caused by the salt pond bund walls and diversion of Yannarie Creek flows.	Point 1 – Refer response to comment no. 45 in Table 10. Point 2 – Saline intrusion into the hinterland will not be significant as: • the hydraulic head of the concentrator pond is small (of the order of 1 m) • the permeability of subsurface clays in the Carnarvon Dune field is very low • the hydraulic gradient cause flow to the coast (refer Figure 4.8 in ERMP) • the hinterland is 5 m or more above the supratidal flat (refer Figure 5.22 in ERMP). Consequently there is anticipated to be no significant impact on hinterland vegetation. Point 3 – An additional vegetation survey was undertaken in November 2007 (Biota 2008b), and included assessment of the impact area of the diversion weir, to ascertain impact of inundation. The results of the vegetation survey are provided in Appendix 14. Ponding against bunds will be limited on the eastern side of the saltfield as bunds will be absent from the eastern side of the concentrator ponds.

No.	Comment	Response
36	Chapter 5, Section 3: This section does not clearly show the flow route that runoff from Yannarie and Rolls Creeks will take to reach the Exmouth Gulf following construction of the proposed Yannarie Solar Salt project. Any new areas where run-off is likely to pond should be mapped. The predicted recurrence probability for flow events that are expected to reach the Gulf under the new regime should be provided. There are likely to be impacts on vegetation, including mangroves, from the altered freshwater inundation patterns and erosion impacts along the new flow lines. The proponent should therefore be requested to provide relevant information for assessing the potential impacts and any management commitments considered appropriate.	Under the revised proposal the flows of Rouse North and Yannarie South creeks will not be blocked and there will be no significant change to the recurrence probability of these creeks reaching the Gulf. Yannarie North will be diverted to Rouse North doubling the peak flow rate under the 1:100 ARI. There is unlikely to be any significant indirect 'impact' on mangroves from the revised proposal. Surface water hinterland flows are not sustaining mangroves but the tidal regime is the predominant factor in maintaining the mangrove communities.
37	Chapter 6, Section 1.2.1: The description of guideline trigger values and how they are applied is a little confused and does not indicate a good understanding. ANZECC & ARMCANZ (2000) does not provide two levels of guideline trigger value.	Straits will apply ANZECC guidelines to assess the performance of its operation and as described in the Marine Management Plan.
38	Chapter 6, Section 1.2.2: It should be noted that the Western Australian Government's State Water Quality Management Strategy No 6 provides the basis for the environmental quality management framework developed by the EPA for Exmouth Gulf.	Noted.
39	Chapter 6, Section 1.4.2: The potential environmental impact on the nearshore marine environment should there be a catastrophic pond wall failure of' the concentrator, crystalliser and/or bitterns storage ponds has not been addressed. The proponent has argued that catastrophic failure of' the bitterns storage pond walls does not need to be considered because they are the same design as the crystalliser pond walls and gross failure of these walls is not known to have occurred previously. Given the size of the proposed development, the sensitivity and the economic and conservation importance of the Gulf environment and the uncertainty associated with climate change (e.g. cyclone frequency and intensity and sea level rise) it is essential that the risks associated with this issue are considered and discussed.	The risk is reduced under the revised proposal compared with the original proposal. The circumstances under which a catastrophic failure of bunds and levee would occur are hard to imagine. Catastrophic failure could occur under the impact of a catastrophic event. This could include such events as a tsunami generated by meteorite impact or earthquake/volcanic activity. While there is conjecture over where and when such catastrophic events have occurred in the geological record, it is considered that such events are possible, although the natural variables are too many and too complex to reasonably consider. However, the expected coastal impact from such an event would involve significant catastrophic failure of a range of regional coastal infrastructure as well as physical damage to the environment. On this scale, the release of concentrated seawater from the revised Yannarie Solar project would be insignificant on the Gulf scale of inundation, catastrophic mixing and physical damage to seagrass, mangroves, algal mats and coastal morphology. The risk of failure is very remote and does not warrant further investigation.
40	Chapter 6, Sections 1.4.3 and 1.6: Collection of baseline data is not an activity that should be left until construction activity has started. Any baseline data collection should be undertaken for a period of at least one year prior to construction. Ideally baseline data collection should have already been undertaken prior to preparation of this ERMP so that the environmental condition of the potentially affected areas are fully characterised for the assessment.	Baseline data will be collected before the relevant construction activities are commenced. Much data has already been collected (benthic PPH, marine fauna and coastal water quality) and is available for the EPA assessment process.
41	Chapter 6, Sections 1.4.3, 1.6 and 2.6.9: The development of criteria that will be used to protect any identified sensitive marine environments should not be left to the management plan. These are essential to fully understanding the environmental impacts of the proposed development and should be provided up font during the assessment process for EPA endorsement. Environmental quality criteria for the protection of the rest of the marine environment (ie areas other than identified sensitive areas) will also be required along with management strategies that will be implemented if the criteria are exceeded.	The development of environmental quality criteria (EQC) is not the role of the proponent, especially when the EQO itself (Maximum Level) has not been agreed (refer EPA Bulletin 1078, which sets out who has to do the various tasks). The amount of data required to develop EQC is not trivial.
42	Chapter 6, Sections 1.4.3 and 1.6: It is not clear where and how the dredge spoil will be dumped and how impacts such as turbidity from slurry water will be managed. This discussion seems to be missing from the document and needs to be addressed by the proponent.	Dredge spoil will be pumped onshore into sedimentation ponds which will be located in the future salt stockpile storage area prior to the discharge of entrained seawater. Management measures are described in the Dredging Management Plan.

No.	Comment	Response
43	Chapter 6, Section 1.4.3 and 1.6: Dredging campaigns generate large volumes of suspended sediment. Firstly, there is disturbance of sediments at the dredge head. Secondly (and more importantly), overflow from the dredge spoil barge can be a very significant and on-going source of suspended material, particularly the fine clay and silt particles. The sediment particles settle out at different rates according to their size and density and models generally predict that the finer particles are carried away from the area by currents. However, observations from recent large dredging programs has been that the fines do settle out in the vicinity of the dredged area and that they form a fairly cohesive clay like layer that can smother relatively large areas. This layer of fine sediment can be up to > 0 5m thick, smothers the original sediment and appears to be devoid of benthic invertebrates. More recently, an environmental consultants sediment sampling report prepared for a dredging program reported that cored sediments from an area adjacent to some dredging activity "had two distinct profiles, consistent with fresh fine sediment deposited over a more consolidated sediment". It is highly likely that this is a common and consistent impact of dredging programs that has not been recognised in the past, but which should be considered by proponents in fixture dredging campaigns. This will need to be addressed as part of this assessment.	Refer response to comment no. 42 above. It is very important that the DEC recognises that the 'dredge campaign' is insignificant in terms of volumes compared to other campaigns currently proposed in the Pilbara (of order 50-100 times smaller of the volume of these larger campaigns) and that therefore the risks of long-term adverse impacts are similarly insignificant. Modelling of dredge plumes has already being completed and demonstrates that impacts from turbidity plumes will be insignificant.
44	Chapter 6, Section 2.5.2: A detailed benthic habitat map has not been provided. It is essential to fully understand the potential environmental impacts of this proposal.	Straits undertook additional benthic habitat mapping in 2007 to further characterise and map the benthic habitat offshore from Hope Point, as described in Table 10 Comment no. 92. For results of the investigations refer to Oceanica (2008) (Appendix 11).
45	Chapter 6, Section 2.6: Management Units have been identified for the benthic primary producers for assessment in accordance with EPA Guidance Statement 29 (GS29). Management Units are identified for inter-tidal benthic habitats separately from sub-tidal habitats. The inter-tidal management units range in size from 47 km^2 to 160 km^2, whereas GS 29 recommends units of approximately 50 km^2. Consideration should be given to reducing the size of these management units. The intertidal primary producer habitats should be assessed as category A habitats rather than category B because these mangroves were identified as Guideline 1 areas in EPA Guidance Statement 1, Guideline 1 areas are considered by the EPA to be of very high conservation value and are to be afforded the 'highest degree of protection with respect to geographical distribution, biodiversity, productivity and ecological function'.	The intertidal management units have been developed and presented in the ERMP (Chapter 6, Section 2.6.1). As described below, these management units were revised following additional benthic habitat mapping undertaken in 2007. It was determined that the location of benthic primary producer management unit O4 would be more appropriate if relocated slightly to the south, to include the full extent of the modelled turbidity extent, and the extensive reef platform located to the southwest of Hope Point (Oceanica 2008, Appendix 11). The revised marine management units are described in Oceanica 2008 (Appendix 11). As described in Biota 2005c, 'EPA Guidance Statement No. 29 recognises that there is no established scientific method for identifying management units. The Guidance also notes that units of larger than the nominal 50 km^2 could be considered by the EPA with appropriate justification (EPA 2004). Guidance Statement No. 29 states that in this context, the size of BPPH management units should be informed by consideration of: • Spatial scales of ecological interaction • Geomorphological linkages and boundaries • Similarity of habitat types • The dispersal capabilities of the benthic primary producers in question.' Biota (2005c) also reviewed the boundaries and spatial scales adopted by earlier studies that identified ecologically and geomorphologically similar mangrove zones along the coast. These studies included: • 'Semeniuk (1986) – classified the Pilbara coast into five integrated geomorphic zones, each of which was in the order of 100 km in length • MPRWG (1994) (the 'Wilson Report') – identified a proposed marine reserve management area covering the entire extent of the eastern side of Exmouth Gulf (an area of approximately 400 km^2) • EPA (2001) – Guidance Statement No. 1 (and supporting review by Semeniuk 1999) identified the same size area as the Wilson Report as an integrated area of mangroves of the conservation classification, again an area of approximately 400 km^2) • Pedretti and Paling (2001) – divided the eastern side of the Gulf up into four areas, each of which were approximately 120 km^2 in size.

No.	Comment	Response
		Some guidance can also be obtained from previous EPA decisions on the size and parameters for other BPPH management units identified in the relatively recently implemented policy context provided by Guidance Statement No. 29. The two most recent EPA assessments that have addressed this issue for BPPH on the Pilbara coast have been the Fortescue Metals Group port proposal at Port Hedland (FMG 2005) and the Dampier Port Expansion (URS 2005). The sizes of the Guidance Statement No. 29 BPPH management units determined by the EPA for these proposals were approximately 154 km^2 and 200 km^2 respectively. Proposed draft management units for mangrove BPPH along the eastern margin of Exmouth Gulf were developed and took into account the above considerations. These proposed units reflect the smallest spatial scale of any of the studies that have examined the geomorphology, mangrove community variation, conservation significance and management areas along the Pilbara coast (that of Pedretti and Paling (2001). The proposed management units were based on separating the east Exmouth Gulf coast by the only major geomorphic features present that may also indicate local connectivity in mangrove populations, tidal hydrodynamics and other relevant aspects. From south to north, these features are: • The relatively enclosed and low wave energy environment of Giralia Bay, which marks the local southern limit of mangroves at Sandalwood Peninsula • Hope Point – the next major headland, marking the southern boundary of the limestone barrier islands and associated creek systems, which also marks the general southerly limit of the more species rich and complex mangrove association • Tent Island – the next major headland south; this stretch of coast also includes a series of limestone barrier islands (Semeniuk 1993) sheltering more complex creeks; and • Tubridgi Point – a clear boundary margin, representing the first expanse of sandy beach and the northern end of the mangrove habitats in east Exmouth Gulf (Biota 2005c).' The relocation of management unit O4, such that the reef platform units characteristic of the Hope Point area are included, is in-line with this guidance. Hope Point forms a distinct bio-geomorphic transition point between southern and northern habitat types. The original Hope Point management unit was skewed to capture northern habitat types, as it was felt that the plume from dredging would extend north while the southern boundary of the unit was created by simply extending the existing fish habitat protection boundary east and was not based on any benthic features. The current mapping shows that contiguous reefs starting at Hope Point extend south. On the basis of this, the marine management units have been revised so that these reefs are captures which also picks up the southern extent of the dredge plume without losing any important areas north (Oceanica 2008, Appendix 11). Straits disagree that the intertidal BPPH should be considered as category A habitats. There is clearly a conflict between the policy documents produced by the EPA. Straits consider this area should be considered as a category B habitat, considering that category B specifically identifies Wilson report areas as its area of application.
46	Chapter 6, Section 2.6.4: Figure 6-28 does not have a scale so it is difficult to determine how much of the mangrove habitat is likely to experience significant changes in tidal wetting time. An interpretation is that about 1 km^2 of mangrove habitat will experience approximately 20% less tidal inundation in Naughton Creek as a result of pumping (a reduction in percent time wet of'8% (i.e. a change in tidal inundation from 40% to 32% of the time) is a 20% reduction in tidal inundation). This is significant, but the likely impacts are unknown The proponents prediction that there will be no indirect impacts on mangrove habitat is not substantiated.	Under the revised proposal, there will not be a pump station at Naughton Creek.

No.	Comment	Response
47	Chapter 6, Section 2.6.5: Inflows into Naughton Creek will increase by 60% because of pumping. Corresponding effects on current speeds in the channels are likely to change scour patterns and may impact mangrove habitat. These potential impacts have not been fully characterised so that impacts on benthic primary producer habitat can not be assessed.	Under the revised proposal, there will not be a pump station at Naughton Creek.
48	Chapter 6, Section 2.6.6: Using the seepage rate for salt water through the bund walls, approximately 7 litres of water will seep out per metre of wall per day, This water will be evaporated over some distance from the wall and salinity levels in these adjacent sediments will increase over time. The proponent should consider this issue and provide sufficient information to predict the impact on adjacent algal mat communities in the long-term.	Refer to response to comment no. 45 in Table 10.
49	Chapter 6, Section 2.6.7: In this section the proponent commits to capturing and discharging the salt stockpile runoff back into the salt field. No details are provided on how this will be done. Runoff from the salt stockpile should not be allowed to enter the nearshore marine environment.	This comment will be addressed in the updated Marine Management Plan.
50	Chapter 6, Sections 2.6.8 and 2.6.9: Detailed benthic habitat mapping has not been provided in the vicinity of potential impact sites, in particular the proposed dredged channel, so that potential direct and indirect losses of these communities can only be considered in general terms. The actual location of any sensitive biota, biota of high conservation value or important benthic communities are not known and therefore can not be given specific protection.	Straits undertook additional benthic habitat mapping in 2007 to further characterise and map the benthic habitat offshore from Hope Point, as described in Table 10 Comment no. 92. Following the results of the benthic habitat mapping, Straits revised the location of the barge channel, to minimise disturbance to the 'reef with algae' and 'reef with algae corals and sponges, which were mapped offshore from Hope Point. Refer to Oceanica 2008 (Appendix 11) for detailed discussion.
51	Chapter 6, Section 2.6.9: The proponent needs to identify the areas where benthic primary producers will be permanently lost, the zone where reversible losses will occur and the zone where there will be physiological stress to benthic primary producers but not loss. This requires an understanding of the tolerance of the benthic primary producers to the stressors (i.e. sedimentation and turbidity). This has not been demonstrated in the ERMP documentation. Some modelling of the plume associated with the dredging of the channel has been undertaken, but no information has been provided on the inputs to the model or on model calibration or validation. The credibility of the model outputs can not be determined. The Dredging Monitoring and Management Plan needs to include management strategies that will be triggered if environmental quality criteria are exceeded. The Dredging Monitoring and Management Plan also needs to include a strategy for determining whether smothering of adjacent benthic habitat from sedimentation is an issue and for minimising these impacts. There needs to be a monitoring and management plan that addresses benthic habitat impacts associated with on-going barge haulage between ship and shore.	The ERMP has identified those areas of permanent benthic primary producer loss (dredge channel) as well as the area of influence (80^{th} percentile of background turbidity). Given the very small dredging volume, the naturally elevated turbidity of the area and the capacity of the benthic primary producers to rapidly recolonise after minor catastrophic events such as Cyclone Vance, significant dredging impacts are not expected beyond the area of the dredge channel. A copy of the APASA 2005c report *Yannarie salt farm project for Straits resources; Phase 2 Report; fate of sediments suspended by dredging, 2005* is provided in Appendix 12. Straits undertook additional benthic habitat mapping in 2007 to further characterise and map the benthic habitat offshore from Hope Point, as described in Table 10 Comment no. 92. The impacts to BPPH were re-calculated and included assessment of direct permanent losses, reversible losses (within zone of turbidity of 95^{th} percentile of background) and physiological stress (within zone of turbidity of 80^{th} percentile of background) (Oceanica 2008) (Appendix 11). Results of the habitat mapping have been used to develop management strategies for the Dredging Management Plan and Marine Management Plan.
52	Chapter 6, Section 2.6.11: Ideally the oil containment boom should be sufficiently long to shut off the entrance to the barge harbour in case of an oil spill in the harbour.	This comment has been addressed in the revised Hydrocarbon Spill Contingency Plan.

No.	Comment	Response
53	Chapter 6, Section 2.6.12: The inter-tidal primary producer habitats should be assessed as category A habitats rather than category B because these mangroves were identified as Guideline 1 areas in EPA Guidance Statement 1. Guideline 1 areas are considered by the EPA to be of very high conservation value and are to be afforded the 'highest degree of protection with respect to geographical distribution, biodiversity, productivity and ecological function'. The cumulative loss threshold for category A habitats is no loss of BPPH. The sub-tidal BPPH could be considered as category B (cumulative loss threshold of I% loss of BPPH). Because detailed habitat mapping has not been undertaken the assessment of direct losses of sub-tidal benthic primary producer habitat are only indicative and not well substantiated. The estimated loss of inshore BPPH (0 8%) and offshore BPPH (0 2%) have been based on the footprint of the dredged channel compared against the total area of the management units. The proponent has predicted that there will be no indirect loss of any sub-tidal or inter-tidal BPPH., However, because there is a lack of information on many of the processes that could indirectly impact on the BPPH (e.g. effect of hydraulic head of the ponds on local groundwater hydrology, effect of altered outlet flow from the Yannarie and Rous Creek systems, no benthic habitat map and no delineation of the zone where dredge plumes may impact benthic primary producers) this conclusion can not be supported. The proponent should undertake more work on the processes that could lead to indirect losses and better delineate those areas, providing a worst case, most likely and best case assessment of indirect losses.	Refer to Items No. 45, 50 and 51 above (Table 12).

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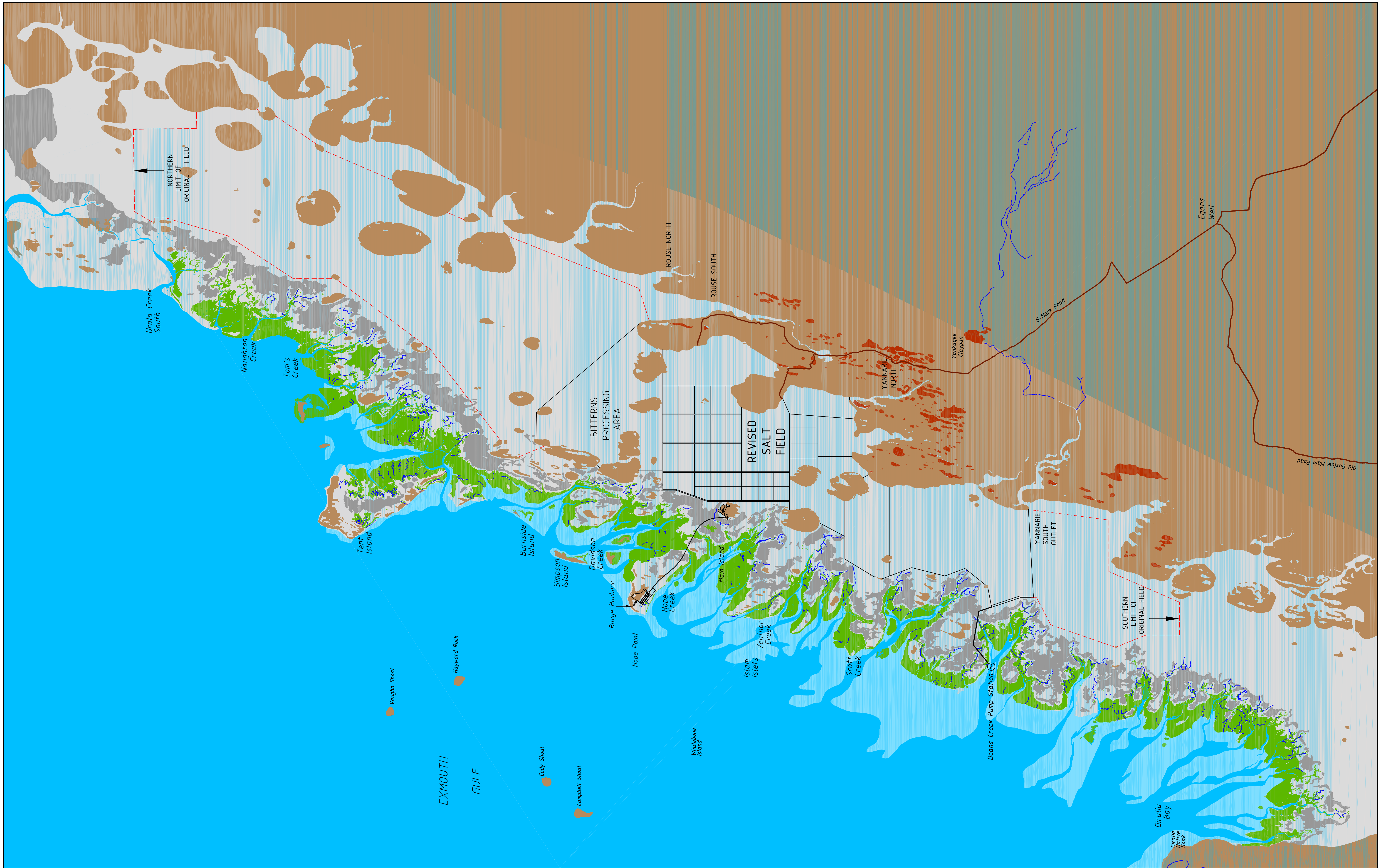
Appendix 1
Yannarie Solar Project
revised salt field layout



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			B	03JUL07	HATCH REMOVED	JB	JB	
			A	19JUN07	ISSUED FOR INITIAL ISSUE	JB	JB	
REFERENCE DRAWINGS			REVISIONS					

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CHKD.	NAME:	SIGN: DATE:	DATE1
DESIGN	NAME:	SIGN: DATE:	DATE2
DESIGN CHECK	NAME:	SIGN: DATE:	DATE3
DESIGN APP.	NAME: J.BARRIE (YS)	SIGN: DATE:	DATE4
PROJECT MGR.	NAME: J.BARRIE (YS)	SIGN: DATE:	DATE5

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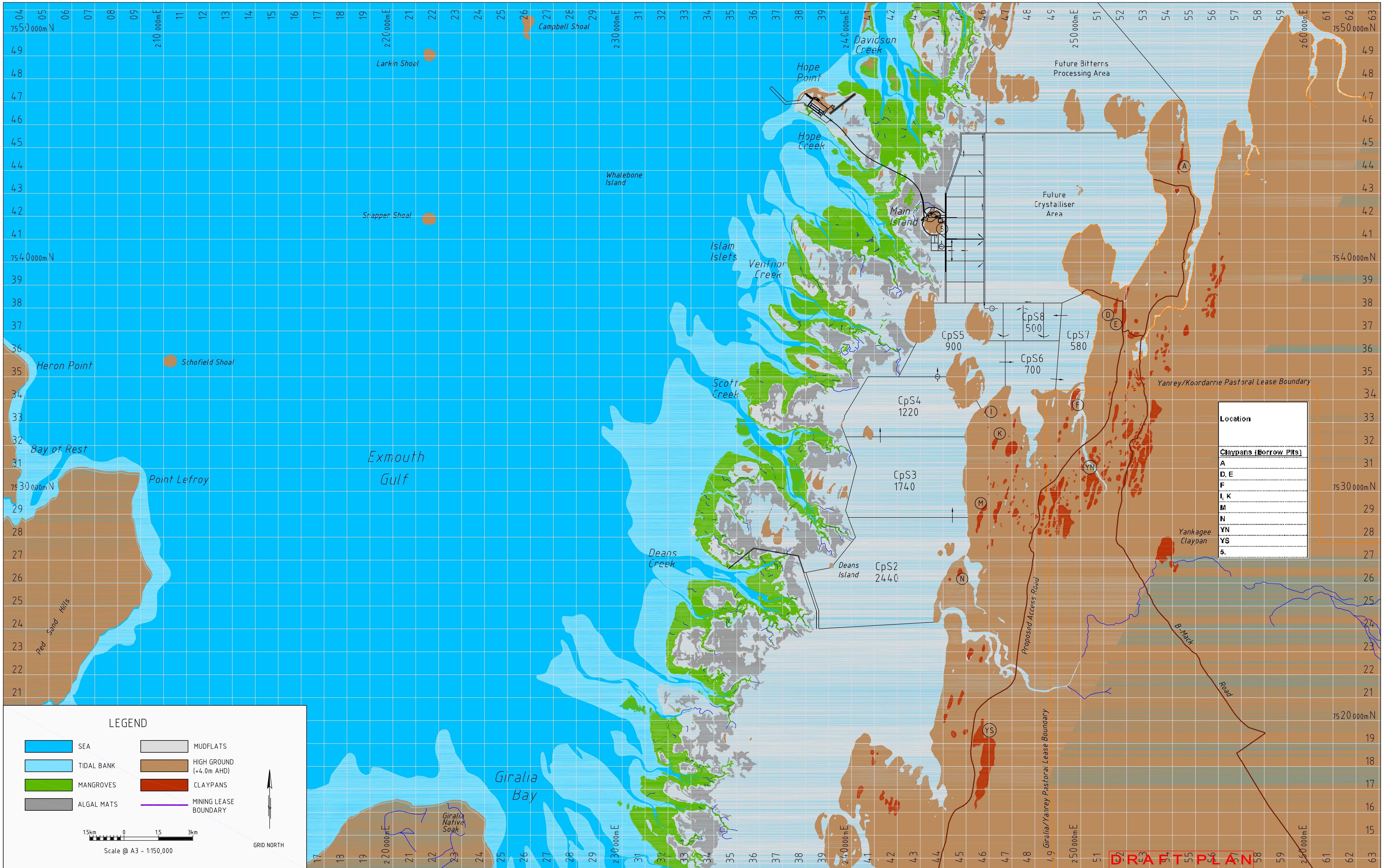
Appendix 1: Yannarie Solar Project revised salt field layout

DRAWING NUMBER: YSPS-0000-SK-020

SCALE: 1:200,000(A3) | REVISION: B
DRN: VP | DATE: 03/07/07

Appendix 2
Locations of claypan borrow pits



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1	14/01/08	BARGE CHANNEL RELOCATED	VP	JB	
0	3/7/07	NEW DRAWING: INFORMATION TAKEN FROM DRAWING YSPS-0000-GA-042 Rev C	MWJ	JB	

REVISIONS

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DESIGN	NAME: SIGN: DATE:	
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DESIGN APP.	NAME: SIGN: DATE:	
PROJECT MGR.	NAME: J.BARRIE (YS) SIGN: DATE:	

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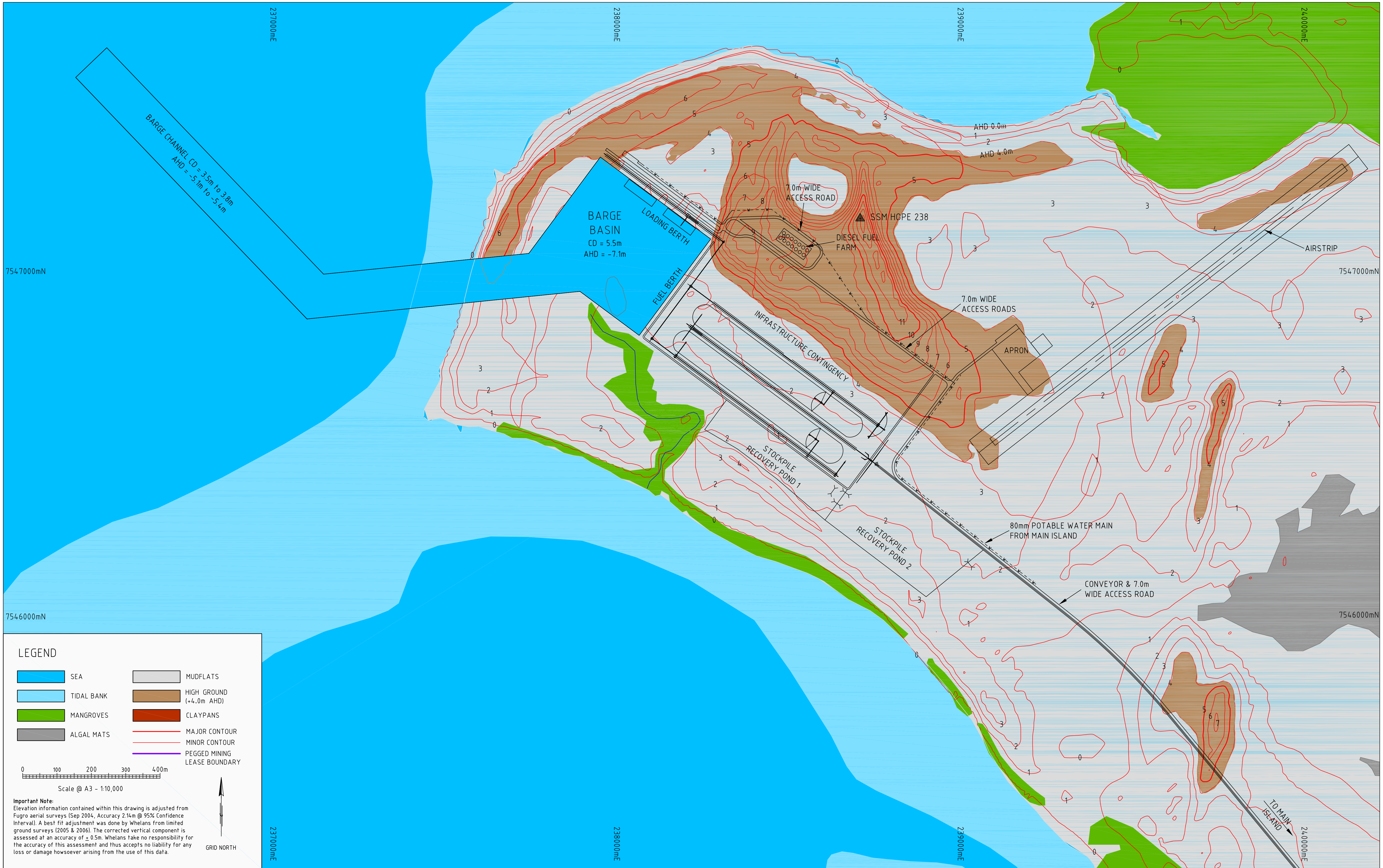
Appendix 2: Locations of clay pan borrow pits

DRAWING NUMBER: YSPS-0000-SK-023

SCALE: 1:150,000(A3) REVISION: 1
DRN: VP DATE: 14/01/08

Appendix 3
Revised general arrangement of Hope Point infrastructure



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No.	DRAWING NUMBER	TITLE
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REVISIONS

No.	DATE	DESCRIPTION	BY	CHKD.	ENGR.
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A	30/08/07	FOR USE	VP	RB	

ORIGINAL DRAWING APPROVAL

CHKD.	NAME: SIGN: DATE:
DESIGN	NAME: SIGN: DATE:
DESIGN CHECK	NAME: SIGN: DATE:
DESIGN APP.	NAME: SIGN: DATE:
PROJECT MGR.	NAME: SIGN: DATE:

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HOPE POINT GENERAL ARRANGEMENT

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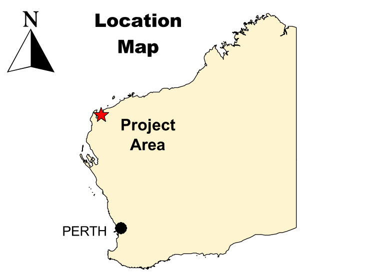
SCALE: 1:10,000 (A3) | REVISION: B
DRN: VP | DATE: 11/01/08



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3	YSPS-0000-SK-027	HOPE POINT GENERAL ARRANGEMENT
2	MOSAIC.ECW	AIR PHOTOGRAPH
1	base plan_GA_INFRASTRUCTURE_RevC.TAB dated 11/01/08	

REFERENCE DRAWINGS

No.	DATE	DESCRIPTION	BY	ENGR.	APPR.
3	11/01/08	BARGE CHANNEL RELOCATED, SAMPLE HOLES REMOVED	V.P.	J.B.	J.B.
2	30/11/07	SUBTERRANEAN FAUNA SAMPLE HOLES ADDED	V.P.	J.B.	J.B.
1	27/09/07	NOTES ADDED	V.P.	J.B.	R.B.
0	26/09/07	FINAL ISSUE	V.P.	J.B.	R.B.
A	26/09/07	FOR USE	V.P.	J.B.	

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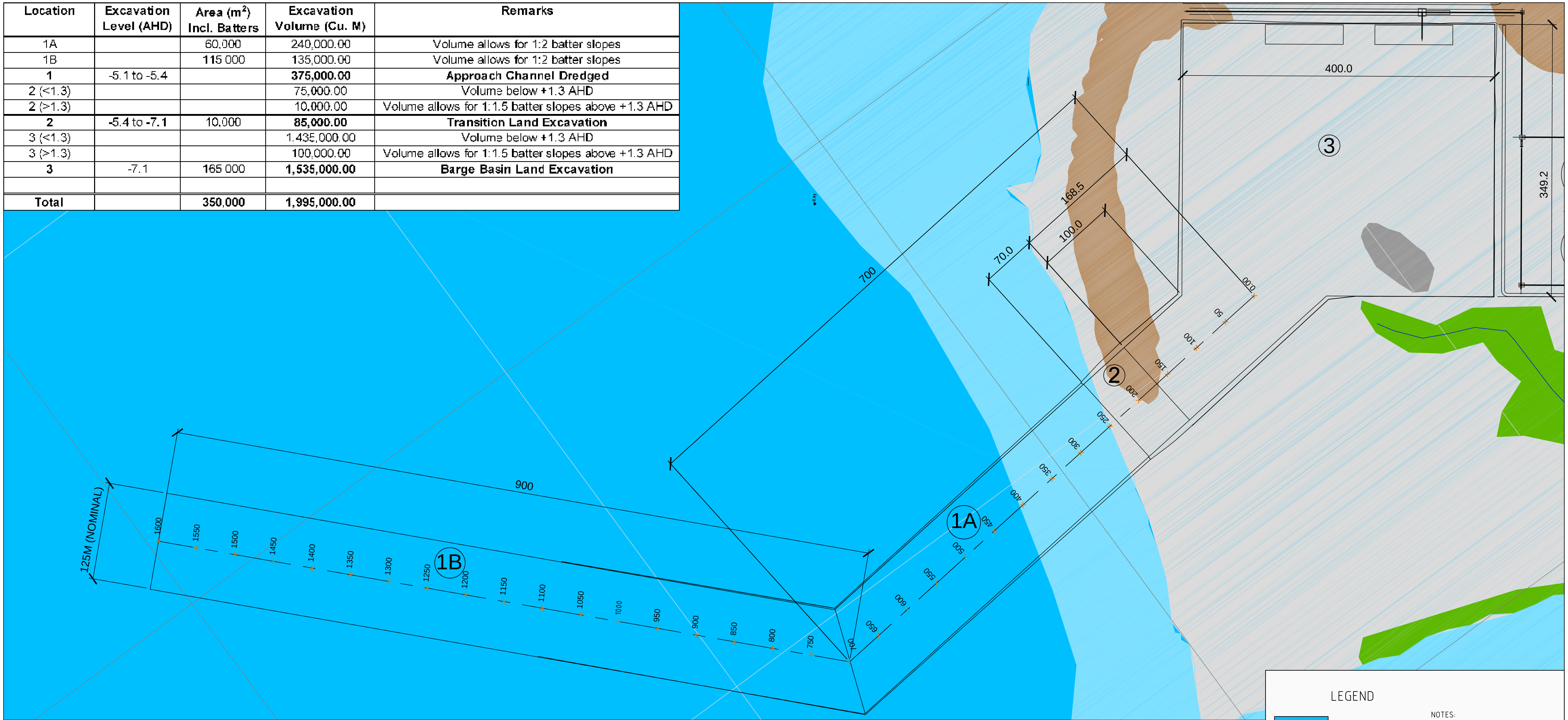
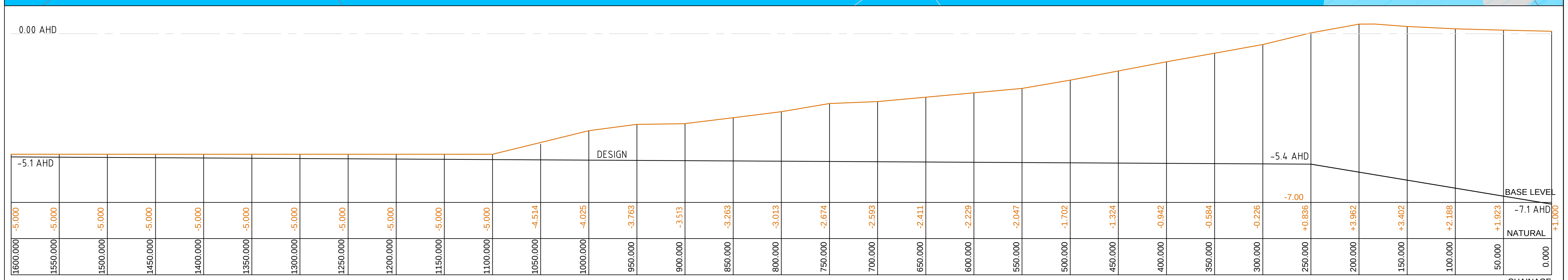
HOPE POINT GENERAL ARRANGEMENT

Project MGR.:	J.B.	Date:	11/01/08
Drawn:	V.P.	Revision:	3
Dwg No.:	YSPS-0000-SK-028	Design App.:	J.B.
Projection:	MGA 94 Zone 50 (GDA 94)	Scale:	1:10,000 @ A3

Appendix 4
Revised Hope Point barge channel and harbour layout

Location	Excavation Level (AHD)	Area (m^2) Incl. Batters	Excavation Volume (Cu. M)	Remarks
1A		60,000	240,000.00	Volume allows for 1:2 batter slopes
1B		115 000	135,000.00	Volume allows for 1:2 batter slopes
1	-5.1 to -5.4		**375,000.00**	**Approach Channel Dredged**
2 (<1.3)			75,000.00	Volume below +1.3 AHD
2 (>1.3)			10,000.00	Volume allows for 1:1.5 batter slopes above +1.3 AHD
2	**-5.4 to -7.1**	10,000	**85,000.00**	**Transition Land Excavation**
3 (<1.3)			1,435,000.00	Volume below +1.3 AHD
3 (>1.3)			100,000.00	Volume allows for 1:1.5 batter slopes above +1.3 AHD
3	-7.1	165 000	**1,535,000.00**	**Barge Basin Land Excavation**
Total		**350,000**	**1,995,000.00**	





LONGITUDINAL SECTION: BARGE BASIN CL
SCALES : HORIZ 1:2500
VERT 1:100

LEGEND

- SEA
- TIDAL BANK
- MANGROVES
- ALGAL MATS
- MUDFLATS
- HIGH GROUND (+4.0m AHD)
- CLAYPANS

GRID NORTH

Scale @ A3 - 1:5,000

NOTES:

1. CHANNEL & BASIN DIMENSIONS SET BY YANNARIE SOLAR (2006).
2. CD is 1.60m below AHD.

Important Note:
Elevation information contained within this drawing is adjusted from Fugro aerial surveys (Sep 2004, Accuracy 2.14m @ 95% Confidence Interval). A best fit adjustment was done by Whelans from limited ground surveys (2005 & 2006). The corrected vertical component is assessed at an accuracy of ± 0.5m. Whelans take no responsibility for the accuracy of this assessment and thus accepts no liability for any loss or damage howsoever arising from the use of this data.

Bathymetric data has been provided by Geoscience Australia and supplemented with surveys by AAM Hatch, Oceanica and Whelans. Whelans take no responsibility for the accuracy of third party datasets and thus accepts no liability for any loss or damage howsoever arising from the use of this data.

DRAFT PLAN

No.	DATE	DESCRIPTION	BY	CHKD.	ENGR.
2	16/01/08	DIMENSIONS CHANGED	VP	JB	
1	14/01/08	BARGE CHANNEL RELOCATED	VP	JB	
0	3/7/07	NEW DRAWING: INFORMATION TAKEN FROM DRAWING YSPS-0000-GA-034 Rev E	MWJ	JB	

REVISIONS

No.	DRAWING NUMBER	TITLE

REFERENCE DRAWINGS

CHKD. NAME: J. BARRIE (YS) SIGN: DATE:
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PROJECT MGR. NAME: J. BARRIE (YS) SIGN: DATE:

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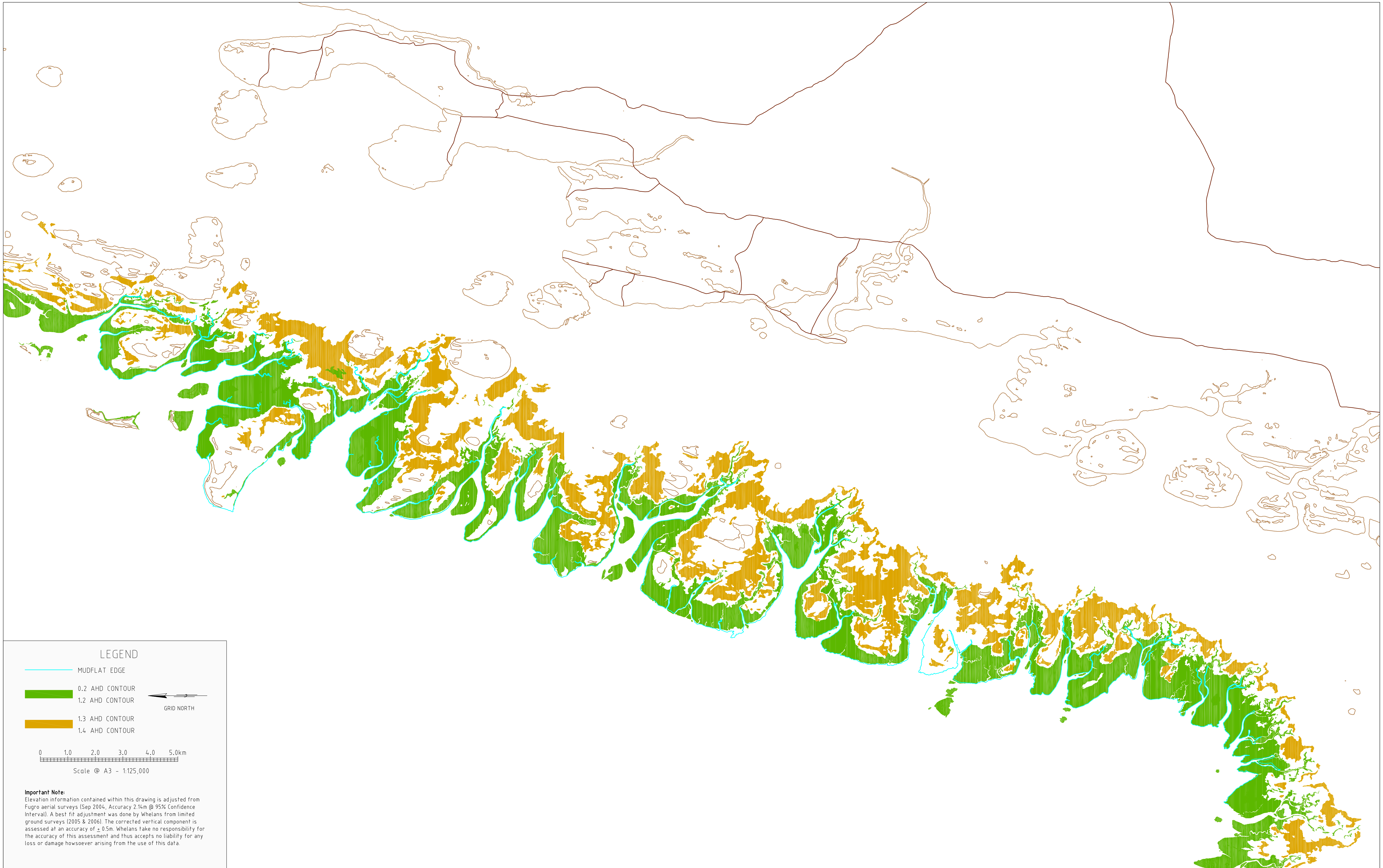
CONSULTANTS

HOPE POINT
BARGE CHANNEL & BASIN EXCAVATION VOLUMES (AHD)

DRAWING NUMBER YSPS-0000-SK-024

SCALE: 1:5,000 (A3) REVISION 2
DRN: VP DATE: 16/01/08

Appendix 5
Sea level rise mapping exercise



LEGEND

MUDFLAT EDGE

0.2 AHD CONTOUR
1.2 AHD CONTOUR

GRID NORTH

1.3 AHD CONTOUR
1.4 AHD CONTOUR

0 1.0 2.0 3.0 4.0 5.0km

Scale @ A3 - 1:125,000

Important Note:
Elevation information contained within this drawing is adjusted from Fugro aerial surveys (Sep 2004, Accuracy 2.14m @ 95% Confidence Interval). A best fit adjustment was done by Whelans from limited ground surveys (2005 & 2006). The corrected vertical component is assessed at an accuracy of ± 0.5m. Whelans take no responsibility for the accuracy of this assessment and thus accepts no liability for any loss or damage howsoever arising from the use of this data.

No.	DRAWING NUMBER	TITLE

REFERENCE DRAWINGS

No.	DATE	DESCRIPTION	BY	CHKD.	ENGR.
A	18/12/07	NEW DRAWING	MWJ	DGP	

REVISIONS

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DESIGN	NAME: M. WARDELL-JOHNSON (WH)	SIGN:	DATE: 18/12/07
DESIGN CHECK	NAME: D. PURNELL (WH)	SIGN:	DATE: 18/12/07
DESIGN APP.	NAME:	SIGN:	DATE:
PROJECT MGR.	NAME:	SIGN:	DATE:

ORIGINAL DRAWING APPROVAL

Yannarie Solar
a Straits initiative

STRAITS RESOURCES LTD
LEVEL 1 35 VENTNOR AVENUE
WEST PERTH
AUSTRALIA 6005
TELEPHONE: (618) 9480 0500

CONSULTANTS
whelans

POTENTIAL SEA LEVEL RISE
BASE SCENARIO
+0.0m SEA LEVEL RISE

DRAWING NUMBER
YSPS-0000-SK-035

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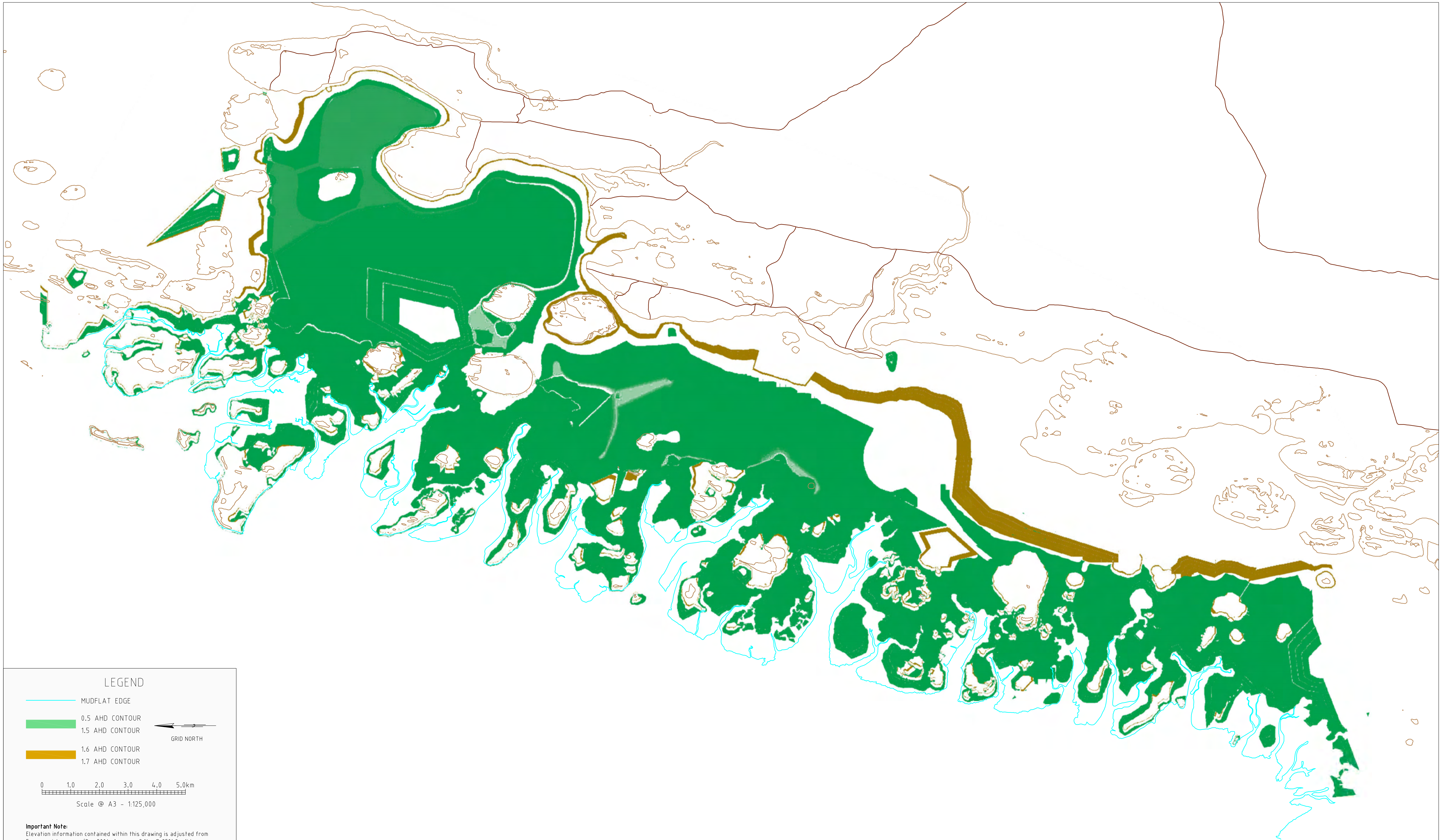

LEGEND

- MUDFLAT EDGE
- 0.5 AHD CONTOUR – 1.5 AHD CONTOUR
- 1.6 AHD CONTOUR – 1.7 AHD CONTOUR

GRID NORTH

0 1.0 2.0 3.0 4.0 5.0km

Scale @ A3 - 1:125,000

Important Note:
Elevation information contained within this drawing is adjusted from Fugro aerial surveys (Sep 2004, Accuracy 2.14m @ 95% Confidence Interval). A best fit adjustment was done by Whelans from limited ground surveys (2005 & 2006). The corrected vertical component is assessed at an accuracy of ± 0.5m. Whelans take no responsibility for the accuracy of this assessment and thus accepts no liability for any loss or damage howsoever arising from the use of this data.

REFERENCE DRAWINGS

No.	DRAWING NUMBER	TITLE

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A	22/11/07	NEW DRAWING	MWJ	DGP	

ORIGINAL DRAWING APPROVAL

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DESIGN	M. WARDELL-JOHNSON (WH)		17/12/07
DESIGN CHECK	D. PURNELL (WH)		17/12/07
DESIGN APP.			
PROJECT MGR.			

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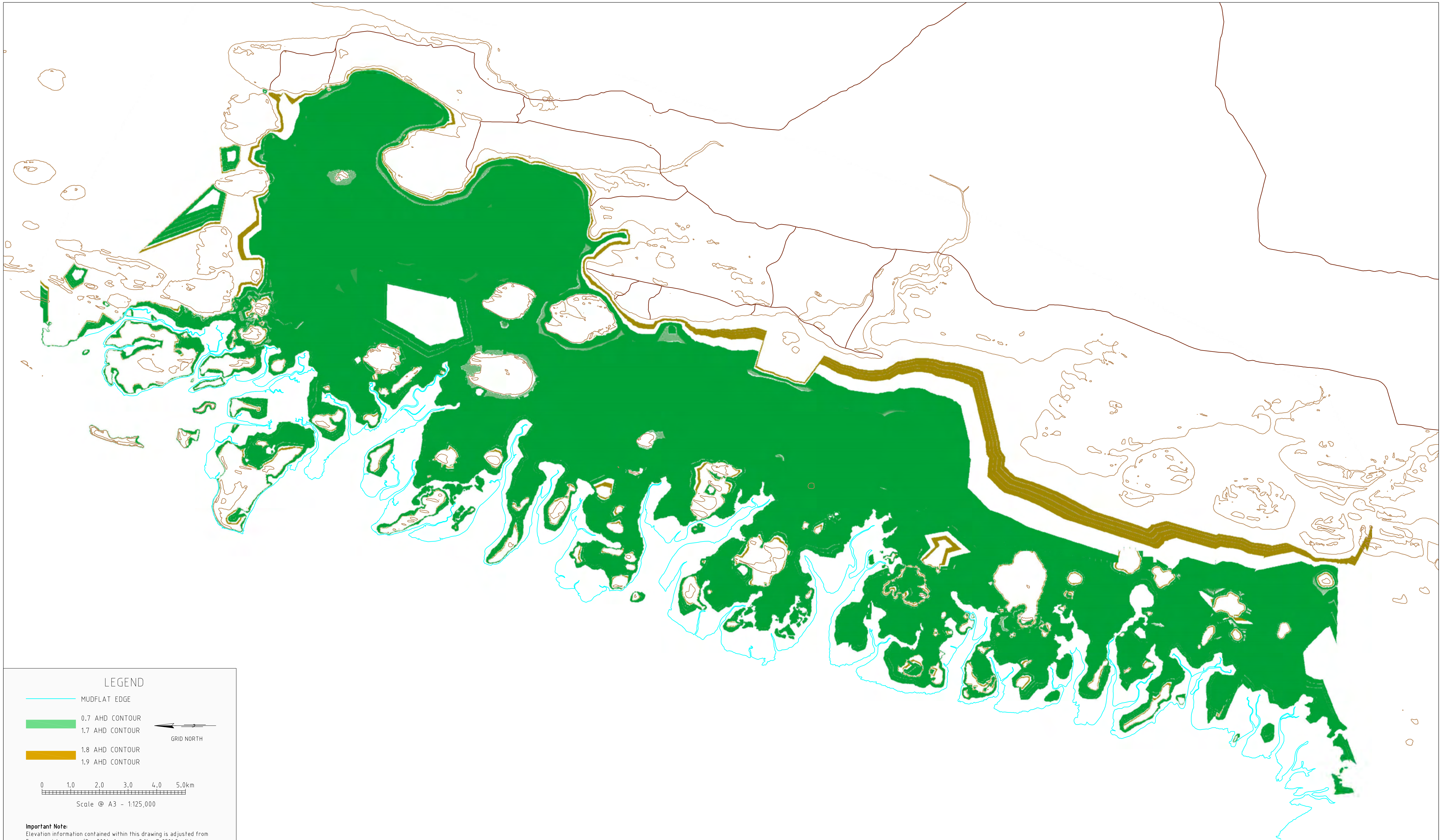
POTENTIAL SEA LEVEL RISE
SCENARIO 1
+0.3m SEA LEVEL RISE

DRAWING NUMBER: YSPS-0000-SK-032

SCALE: 1:125,000(A3) | REVISION: B
DRN: MWJ (WH) | DATE: 17/12/07



LEGEND

- MUDFLAT EDGE
- 0.7 AHD CONTOUR
- 1.7 AHD CONTOUR
- 1.8 AHD CONTOUR
- 1.9 AHD CONTOUR

GRID NORTH

0 1.0 2.0 3.0 4.0 5.0km

Scale @ A3 - 1:125,000

Important Note:
Elevation information contained within this drawing is adjusted from Fugro aerial surveys (Sep 2004, Accuracy 2.14m @ 95% Confidence Interval). A best fit adjustment was done by Whelans from limited ground surveys (2005 & 2006). The corrected vertical component is assessed at an accuracy of ± 0.5m. Whelans take no responsibility for the accuracy of this assessment and thus accepts no liability for any loss or damage howsoever arising from the use of this data.

REFERENCE DRAWINGS

No.	DRAWING NUMBER	TITLE

REVISIONS

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A	22/11/07	NEW DRAWING	MWJ	DGP	

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DESIGN CHECK	NAME: D. PURNELL (WH)	SIGN:	DATE: 17/12/07
DESIGN APP.	NAME:	SIGN:	DATE:
PROJECT MGR.	NAME:	SIGN:	DATE:

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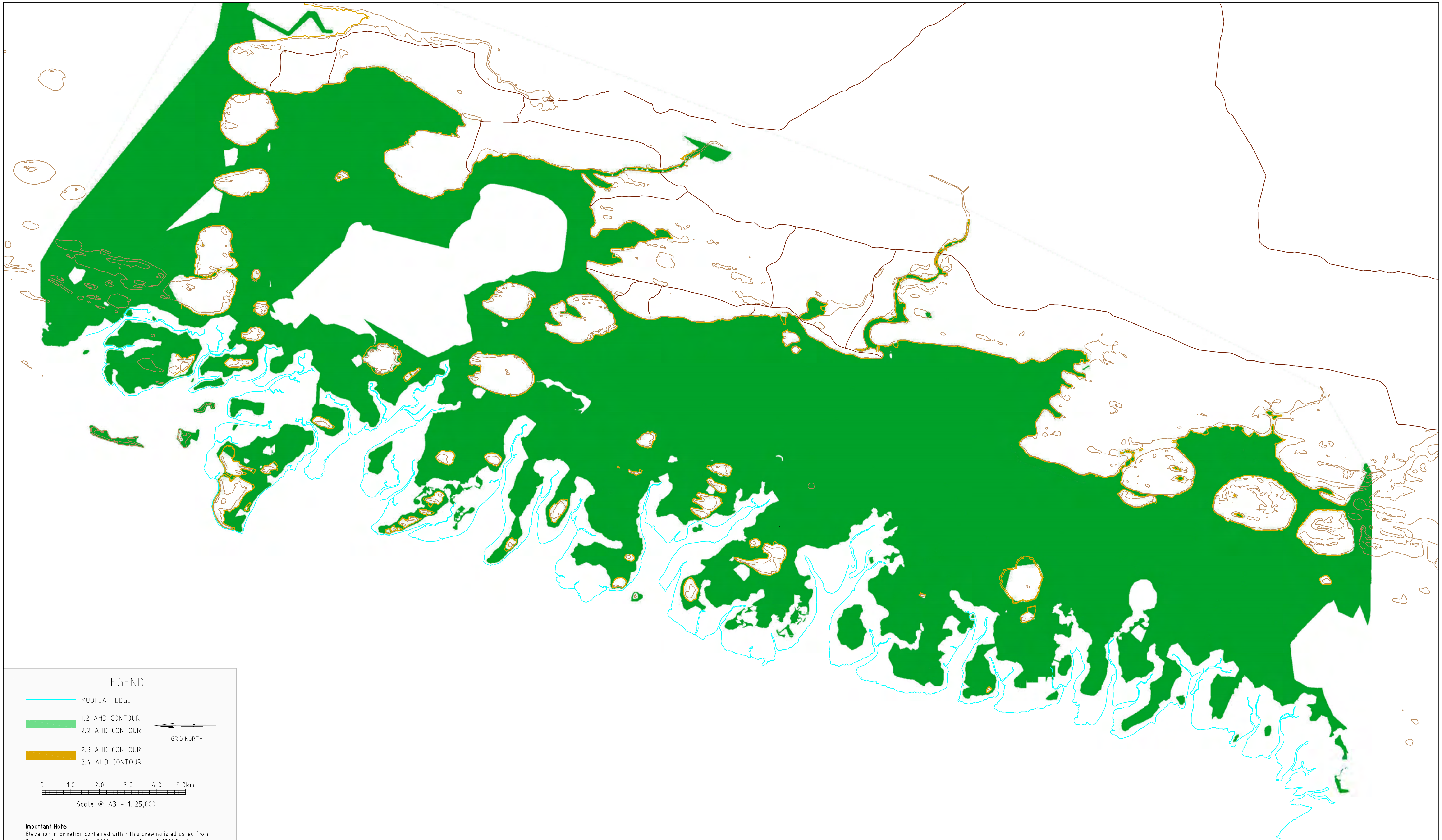
POTENTIAL SEA LEVEL RISE
SCENARIO 2
+0.5m SEA LEVEL RISE

DRAWING NUMBER
YSPS-0000-SK-033

SCALE: 1:125,000(A3) REVISION B
DRN: MWJ (WH) DATE: 17/12/07



LEGEND

- MUDFLAT EDGE
- 1.2 AHD CONTOUR / 2.2 AHD CONTOUR
- 2.3 AHD CONTOUR / 2.4 AHD CONTOUR

GRID NORTH

0 1.0 2.0 3.0 4.0 5.0km

Scale @ A3 - 1:125,000

Important Note:
Elevation information contained within this drawing is adjusted from Fugro aerial surveys (Sep 2004, Accuracy 2.14m @ 95% Confidence Interval). A best fit adjustment was done by Whelans from limited ground surveys (2005 & 2006). The corrected vertical component is assessed at an accuracy of ± 0.5m. Whelans take no responsibility for the accuracy of this assessment and thus accepts no liability for any loss or damage howsoever arising from the use of this data.

REFERENCE DRAWINGS

No.	DRAWING NUMBER	TITLE

REVISIONS

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ORIGINAL DRAWING APPROVAL

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DESIGN	NAME: M. WARDELL-JOHNSON (WH)	SIGN:	DATE: 17/12/07
DESIGN CHECK	NAME: D. PURNELL (WH)	SIGN:	DATE: 17/12/07
DESIGN APP.	NAME:	SIGN:	DATE:
PROJECT MGR.	NAME:	SIGN:	DATE:

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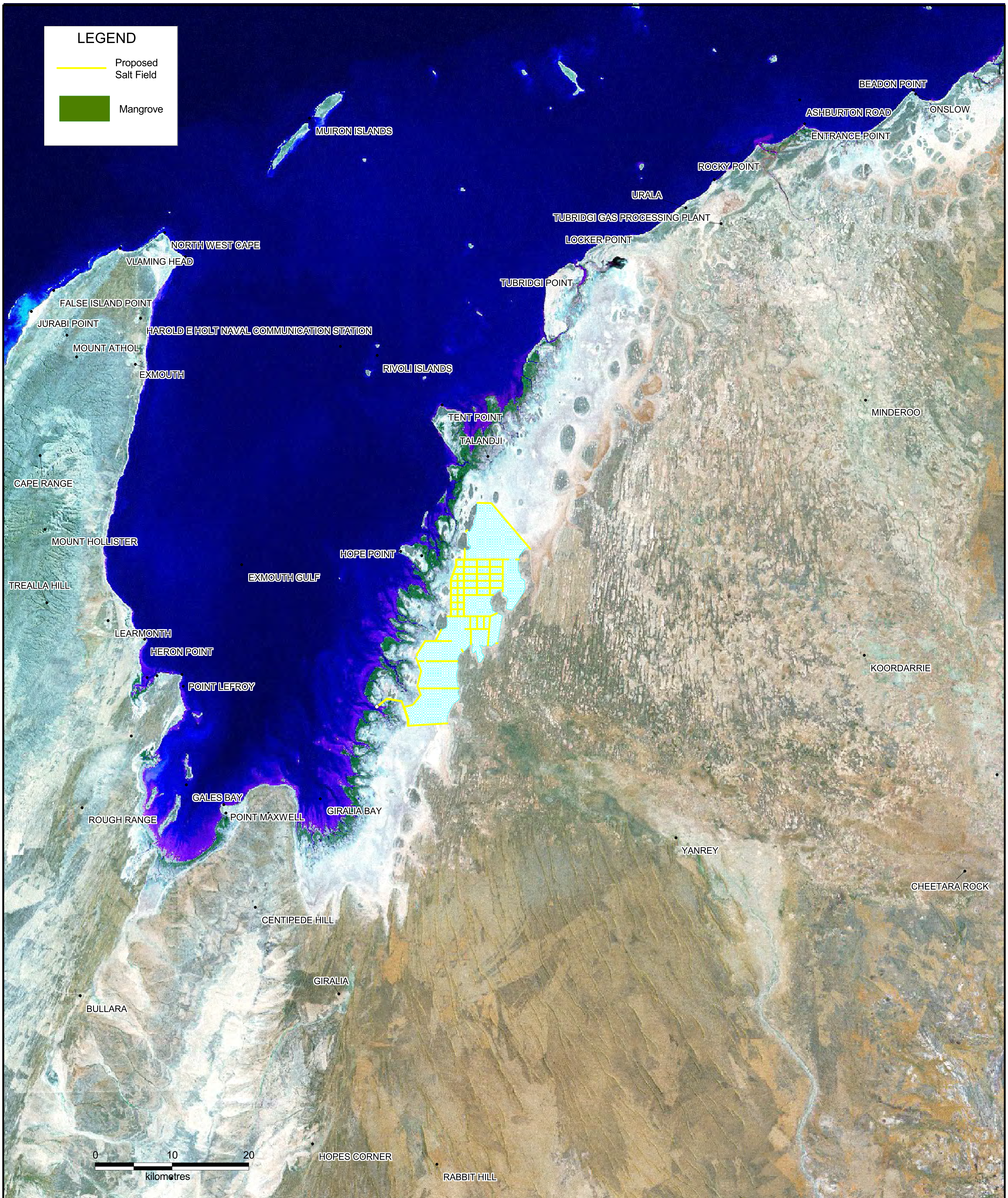
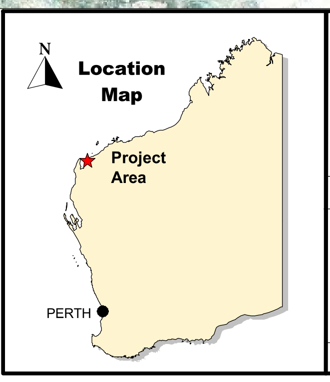
CONSULTANTS
whelans

POTENTIAL SEA LEVEL RISE
SCENARIO 3
+1.0m SEA LEVEL RISE

DRAWING NUMBER
YSPS-0000-SK-034

SCALE: 1:125,000(A3) | REVISION B
DRN: MWJ (WH) | DATE: 17/12/07





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1	EXMOUTH_LANDSAT.TAB	

No.	Data:	Revisions	BY	ENGR	CHKD
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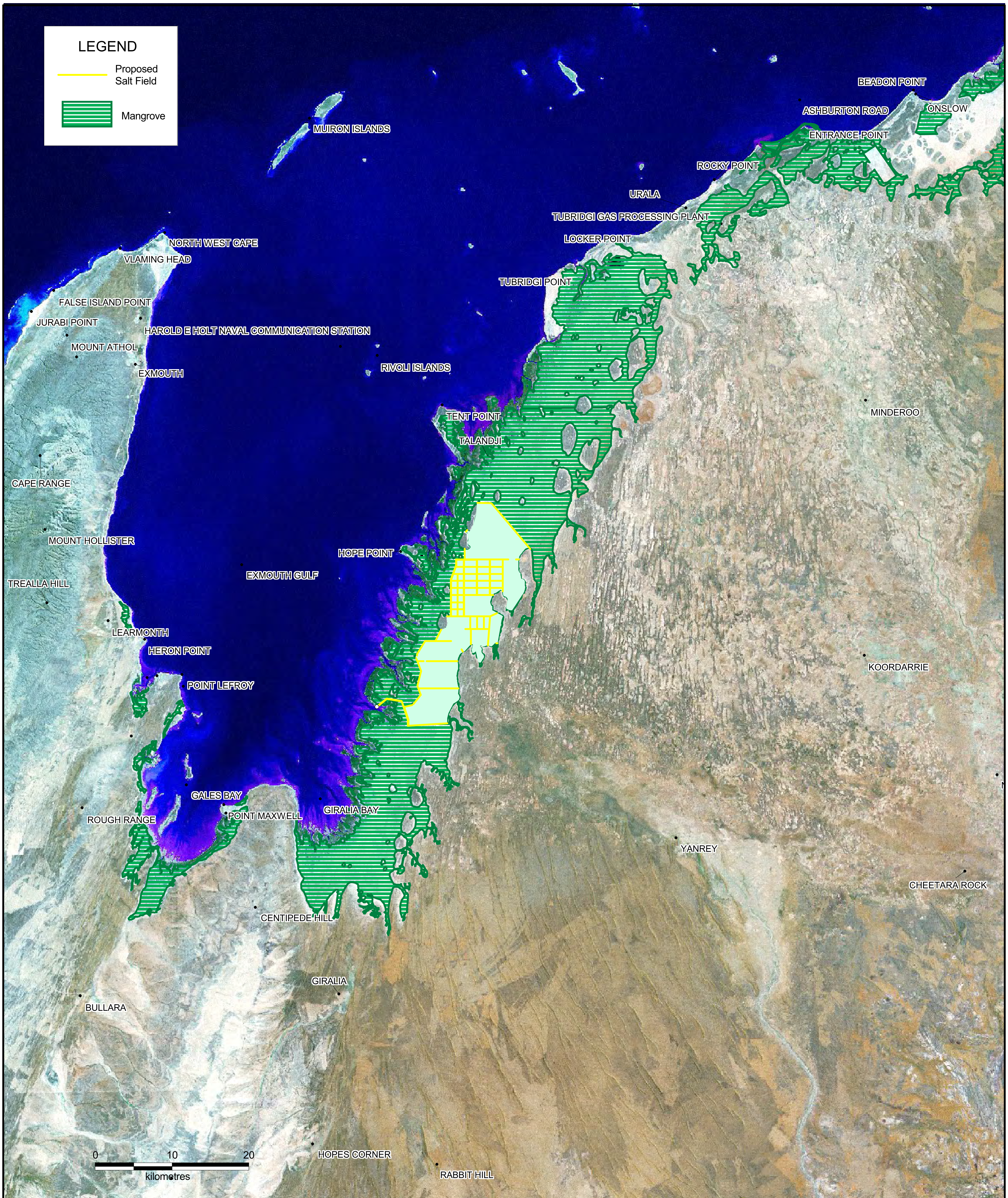
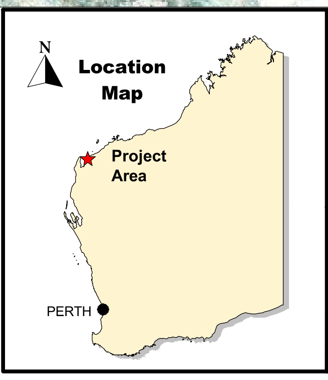
WEST PERTH
AUSTRALIA , 6005
TELEPHONE: (618) 9480 0500

CURRENT MANGROVE AREAS

Project MGR.: J.B.		Date: 19/12/07	
Drawn: V.P.		Revision: A	
Dwg No.: YSPS-0000-SK-037		Design App.:	
Projection: GDA94 Zone 50 (MGA)		Scale: 1:475,000 @ A3	





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2	EXM_NAMED_FEATURE.TAB
1	EXMOUTH_LANDSAT.TAB

TITLE

No.	Data:	Revisions	BY	ENGR	CHKD
A	19/12/07	ISSUED FOR USE	VP		JB

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WEST PERTH
AUSTRALIA , 6005
TELEPHONE: (618) 9480 0500

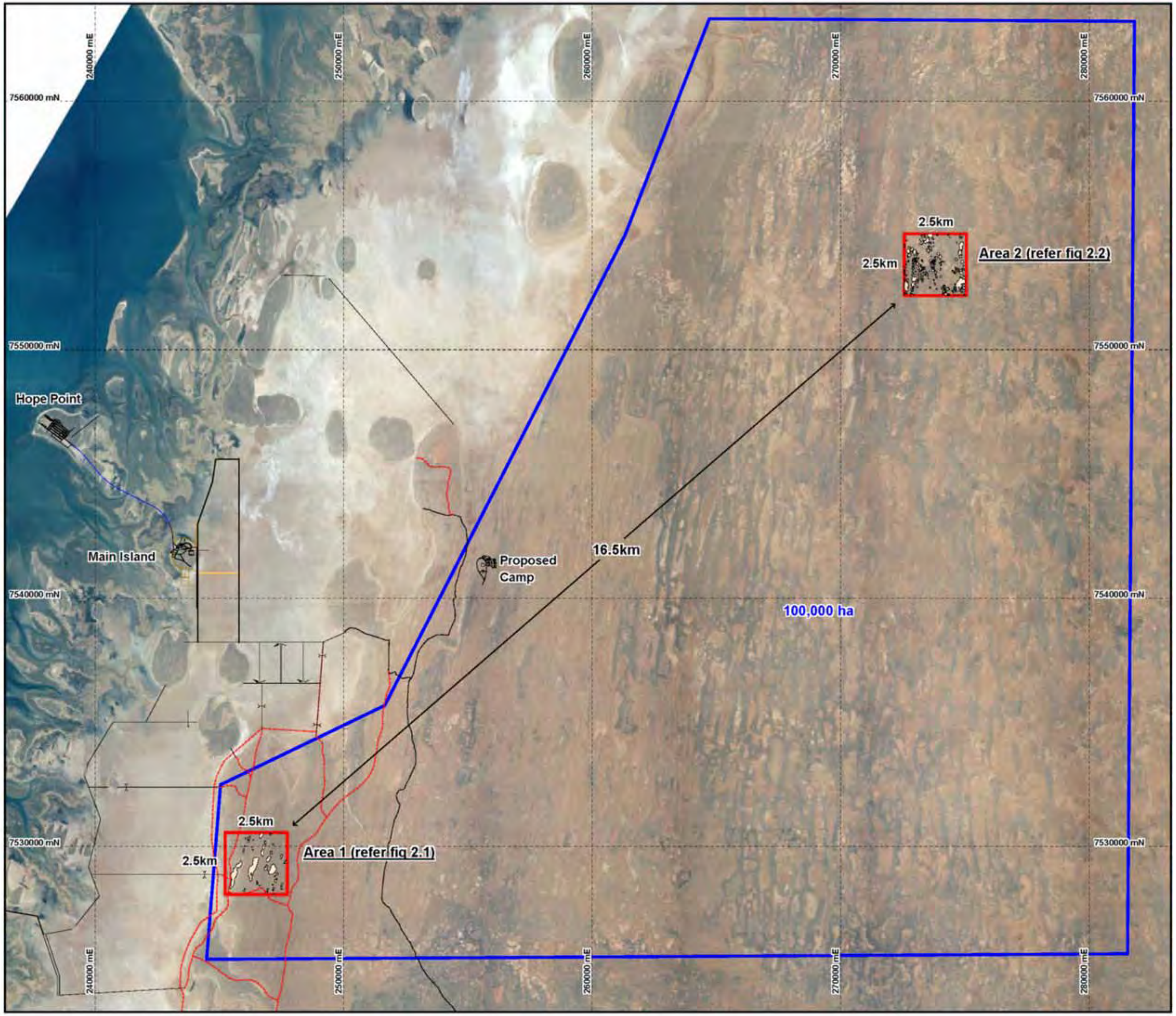
+1m SEA LEVEL RISE POTENTIAL MANGROVE AREAS

Project MGR.: J.B.		Date: 19/12/07	
Drawn: V.P.		Revision: A	
Dwg No.: YSPS-0000-SK-036		Design App.:	
Projection: GDA94 Zone 50 (MGA)		Scale: 1:475,000 @ A3	

Appendix 6 Hydrological investigation (Parsons Brinckerhoff 2008)

Parsons Brinckerhoff 2008, *Hydrogeological assessment: Yannarie Solar Project*, report prepared for Straits Salt Pty Ltd (final report to be provided at a later date).

Appendix 7
GIS analysis of claypans



Claypans Digitised from Photography (625ha)

Regional Reference (100,000ha)

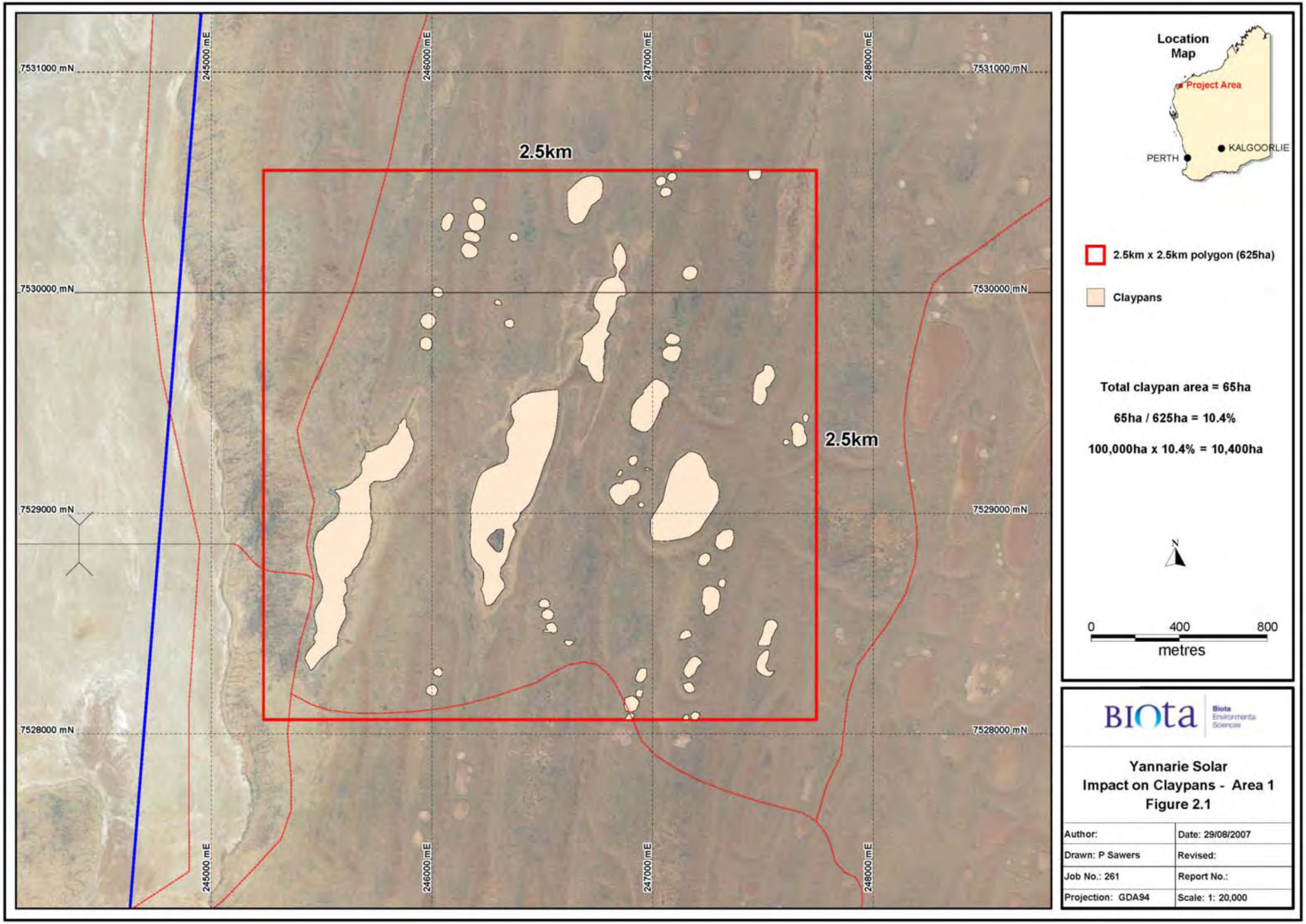
N

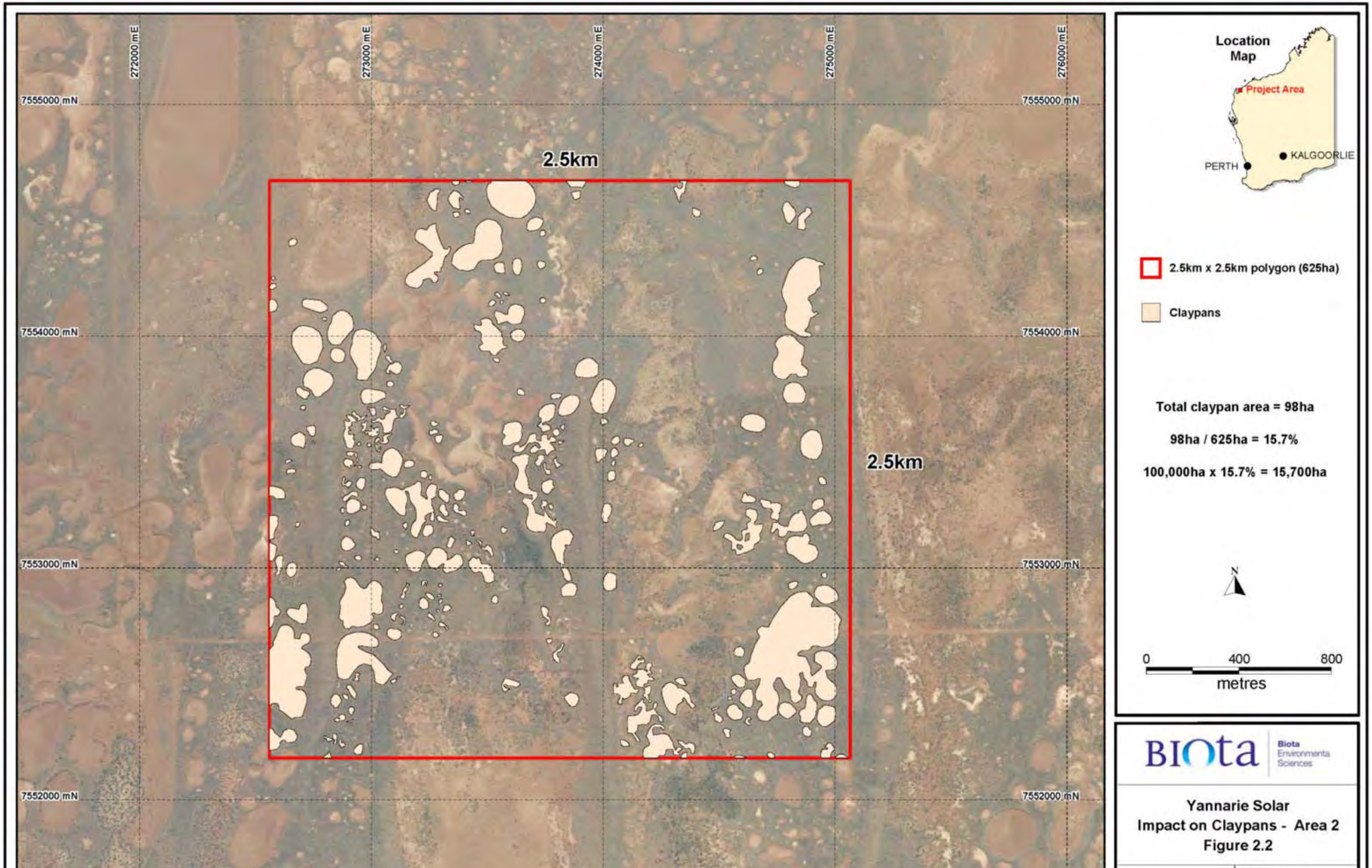
0 2.5 5
kilometres

Biota Environmental Sciences

Yannarie Solar
Impact on Claypans
Figure 1

Author:	Date: 29/08/2007
Drawn: P Sawers	Revised:
Job No.: 261	Report No.:
Projection: GDA94	Scale: 1: 200,000


7531000 mN
7530000 mN
7529000 mN
7528000 mN
245000 mE
246000 mE
247000 mE
248000 mE
2.5km
2.5km
Location Map
Project Area
PERTH
KALGOORLIE
2.5km x 2.5km polygon (625ha)
Claypans
Total claypan area = 65ha
65ha / 625ha = 10.4%
100,000ha x 10.4% = 10,400ha
N
0
400
800
metres
BIOta
Biota Environmental Sciences
Yannarie Solar
Impact on Claypans - Area 1
Figure 2.1
Author:
Date: 29/08/2007
Drawn: P Sawers
Revised:
Job No.: 261
Report No.:
Projection: GDA94
Scale: 1: 20,000



Yannarie Solar
Impact on Claypans - Area 2
Figure 2.2

Author:	Date: 29/08/2007
Drawn: P Sawers	Revised:
Job No.: 261	Report No.:
Projection: GDA94	Scale: 1: 20,000

Appendix 8
Subterranean fauna investigation (Biota 2008a)

Biota Environmental Sciences (Biota) 2008a, *Yannarie Salt Project: Subterranean Fauna Investigation*, prepared by Biota for Straits Salt (final report to be provided at a later date).

Appendix 9
Exmouth Gulf Fisheries and Aquaculture: Potential impacts and management (Oceanica 2005b)

Yannarie Salt Project

Exmouth Gulf Fisheries and Aquaculture: Potential Impacts and Management

Prepared for:

Straits Salt Pty Ltd

Prepared by:

Oceanica Consulting Pty Ltd

July 2005

Report No. 391/1

Client: Straits Salt Pty Ltd

Revisions history

Version	Author	DISTRIBUTION			REVIEW	
		Recipients	No. Copies & Format	Date	Reviewer	Date
1	E. HOLLINGSWORTH	Oceanica	digital	Jan 05	M. BAILEY	Jan 05
2	E. HOLLINGSWORTH	Fisheries	digital	Feb 05	M. KANGAS	2/3/05
3	M. Bailey	Oceanica Straits	digital	24/3/05	S Turner T Naughton	19/4/05
4	M. Bailey/ S. Turner	Rick Scoones & Associates	Digital	23/5/05	R Scoones	20/6/05
5	M. Bailey/ S. Turner	Straits	Hard copy	113/7/05	T Naughton	13/6/05
6	M. Bailey	Straits/Parsons Brinckehoff	Pdf and digital issued as final	26/7/05		

Status

This report is “Draft” until the author and director have signed it off for final release. A “Draft” report should not be used for any purpose other than to be reviewed with the intention of generating a “Final” version.

Approved for final release: Author Director 26/5/05 Date:

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Contents

List of Figures

1 Introduction

This review is primarily based on information published or provided by the Department of Fisheries Western Australia (Department of Fisheries). It is important to acknowledge that the report has been extensively based on the following Department of Fisheries reports:

- Department of Fisheries, 2004. *Draft Aquaculture Plan For Exmouth Gulf.* Fisheries Management Paper No. 172, Department of Fisheries, Western Australia.
- Department of Fisheries, 2003. *State of the Fisheries Report 2002/2003.* Department of Fisheries, Western Australia.
- Department of Fisheries, 2002. *Fisheries Environmental Management Plan For the Gascoyne Region-Draft Report.* Fisheries Management Paper No. 142, Department of Fisheries, Western Australia.
- Department of Fisheries, 2002. *Application to Environment Australia on the Exmouth Gulf Prawn Fishery*. Department of Fisheries, April 2002.
- Department of Fisheries, 2002. *Application to Environment Australia on the Pearl Oyster Fishery.* Department of Fisheries, Western Australia. October 2002.

The aim of the review is to provide background on the various fishing, pearling and aquaculture activities in the Exmouth Gulf to assist in the preparation of the Environmental Review and Management Programme (ERMP) for Straits Salt Pty Ltd's (Straits) proposed Yannarie Salt Project on the east coast of Exmouth Gulf (Straits 2004). The document will form an Appendix to the ERMP in which the assessment of impacts and their management will be discussed.

Commercial fishing, pearling and aquaculture are significant industries in the Gascoyne region. It is estimated that the commercial fishing industry employs over 1000 people out of a population of around 10,000 (Table 1.1). It is estimated that the main Gascoyne fisheries account for about 30 per cent of the total output of Western Australia's fisheries. The Department of Fisheries broadly estimated that the value of the commercial fishery in the Gascoyne, is somewhere between $78 million and $254 million (Department of Fisheries, 2002a).

Table 1.1 Population in the Gascoyne region (source: ABS 2005)

Region	2004 population
Carnarvon	6,340
Exmouth	2,271
Shark Bay	968
Upper Gascoyne	370
Total	**9,949**

This review addresses the points in the Environmental Scoping Document approved by the Environmental Protection Authority (EPA) (Straits 2004):

- Maps showing designated trawling grounds and aquaculture leases;
- Recent catch statistics and pearling and aquaculture species farmed;
- Information on factors known to influence catches (e.g. rainfall, cyclones);
- Information on seasonal closure times;

- Information on known life histories of key species with emphasis on the significance of intertidal areas;
- Water quality requirements for pearling and aquaculture;
- Current information on the environmental, economic and social influences of trawling, aquaculture and, where possible, recreational fishing;
- The most likely number of vessel movements and their locations within the Gulf; and
- The current status of environmental accreditation of the industry.

On the basis of the information in this review, the ERMP will outline the potential impacts on existing commercial and recreational fishing and aquaculture operations and the measures that will be taken to avoid, minimise, mitigate and manage identified impacts.

The following industries have been identified as occurring in Exmouth Gulf and are described in this review:

1. Exmouth Gulf Prawn Managed Fishery (Section 2);
2. Exmouth Gulf Beach Seine Fishery (Section 3);
3. Recreational Fishery (Section 4);
4. Aquaculture (Section 5);
5. Pearling (Section 6);
6. Blue Swimmer Crab Fishery (Section 7);
7. Tropical Rock Lobster (Section 8);
8. Marine Aquarium Fishery (Section 9); and
9. Specimen Shell Managed Fishery (Section 10).

Bêche de Mer (sea cucumber) and Edible Oyster fisheries were also identified for the Gascoyne region, however, the fisheries are very small and do not have a significant presence in Exmouth Gulf.

2 Exmouth Gulf Prawn Managed Fishery

2.1 Background

The Exmouth Gulf Prawn Managed Fishery is one of Western Australia's three most valuable managed fisheries (Shaw, 2000). It is the second largest prawn fishery in Western Australia, with an estimated annual value (to fishers) for 2002 of $11.7 million.

This fishery began with banana prawns as the target in 1963 and by 1966 night trawling, which targeted tiger prawns, had become the major fishing activity in Exmouth Gulf. In 1981 and 1982, there was a decline in recruitment and subsequent catch of tiger prawns due to overfishing of the tiger prawn stock. Tighter management restrictions were introduced at this time in order to rebuild stocks (Figure 2.1). Since the introduction of the additional management measures, tiger prawn stocks have continued to show improvement as their breeding stocks have increased. This improvement is reflected in the tiger prawn catches, which have returned to levels achieved in the 1970s (Department of Fisheries, 2002b; refer Section 2.3).

The industry currently targets western king prawns (*Penaeus latisulcatus*), brown tiger prawns (*Penaeus esculentus*), endeavour prawns (*Metapenaeus endeavouri*) and banana prawns (*Penaeus merguiensis*). There were 13 boats licensed to operate in the Exmouth Gulf Prawn Managed Fishery during the 2004/05 season, with the number of trawlers constant at this level since 2000.

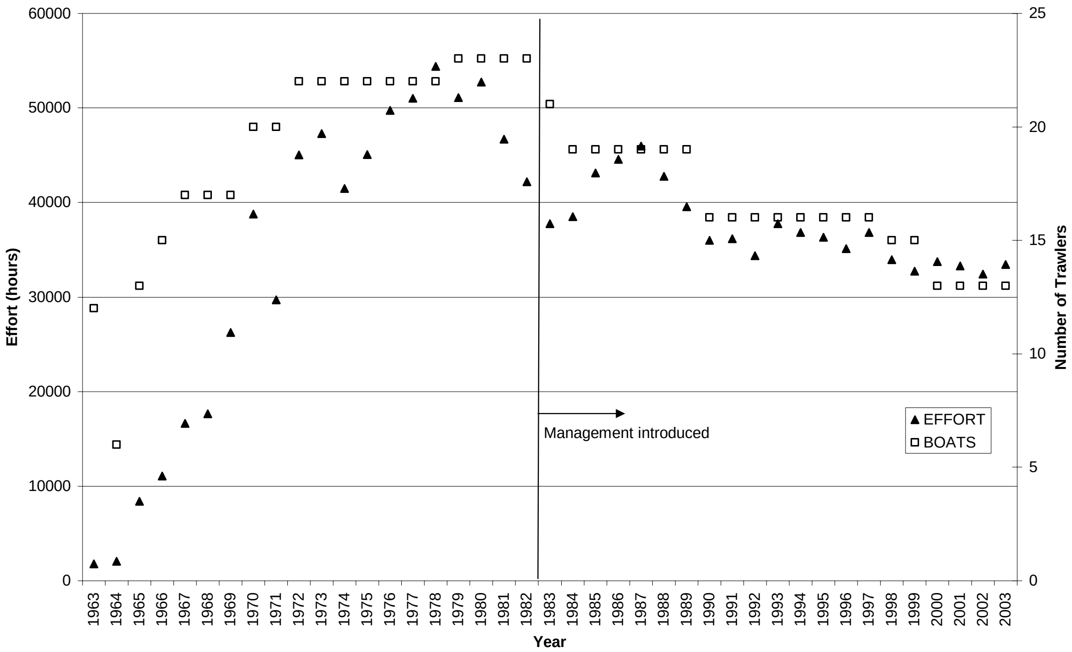

Figure 2.1 Fishing effort is directly related to the number of trawlers, with management introduced in 1982/83 (Source: Department of Fisheries)

2.2 Fishing Grounds

As defined in the *Exmouth Gulf Prawn Management Plan* 1989 (the EGP Management Plan), which is subsidiary legislation to the *Fish Resources Management Act* 1994, the EGP fishery exists within:

“The waters of the Indian Ocean and Exmouth Gulf below high water mark lying south of a line starting at Point Murat and extending northeasterly to the southern extremity of South Muiron island; thence generally northeasterly along the southeastern shore of that Island to its easternmost extremity; thence northeasterly to the southern extremity of North Muiron island; thence northeasterly and northerly along the south eastern and eastern shores of that Island to its northern extremity; thence easterly to the northern extremity of Serrurier Island (also known as Long Island); thence generally southerly along the western shores of that Island to its southern extremity; thence southeasterly to the southern extremity of Locker Island and then due south to the mainland” .

The Fishery is further divided up into four distinct fishing areas, Areas A, B, C and D and a permanently closed nursery area, which are described in Figure 2.2.

During 2002, 38% of the licensed fishery area, and approximately 35% of the target species habitat was fished (Department of Fisheries, 2003). An extensive permanent trawl closure in the shallow eastern and southern sectors (‘permanent nursery’) accounts for 28% of the licensed fishery area.

The permanent nursery area is designated as a Fish Habitat Protection Area in the EGP Management Plan, while the Ningaloo Marine Park creates another area where fishing access in Area A is restricted (Figure 2.2 and Figure 2.3).

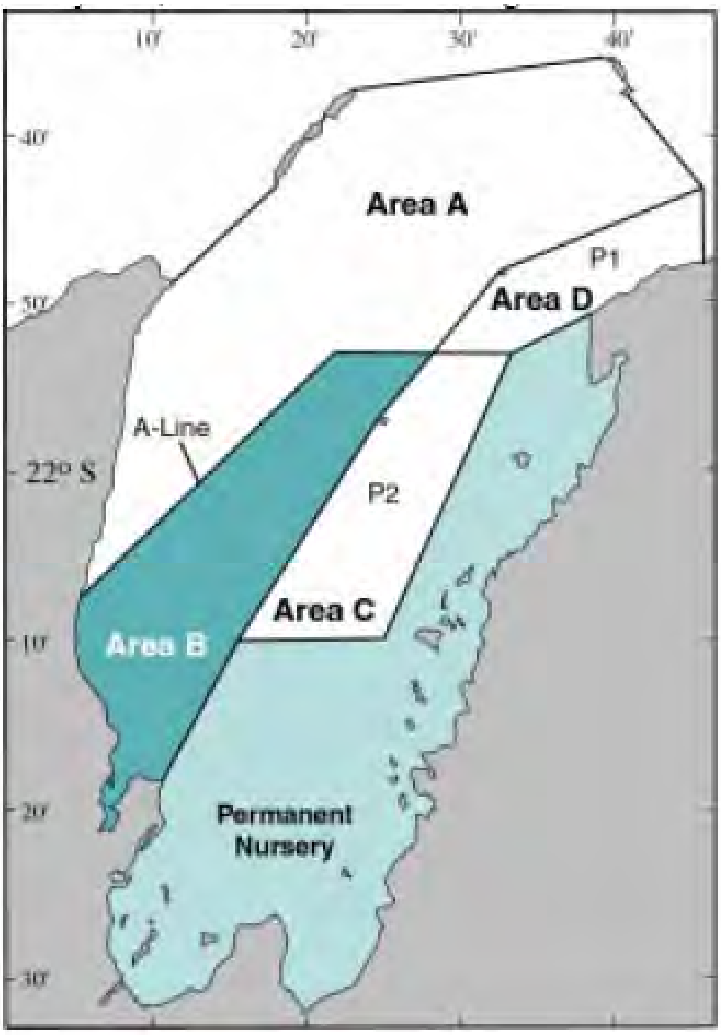

Figure 2.2 Boundaries of the Exmouth Gulf Prawn fishery

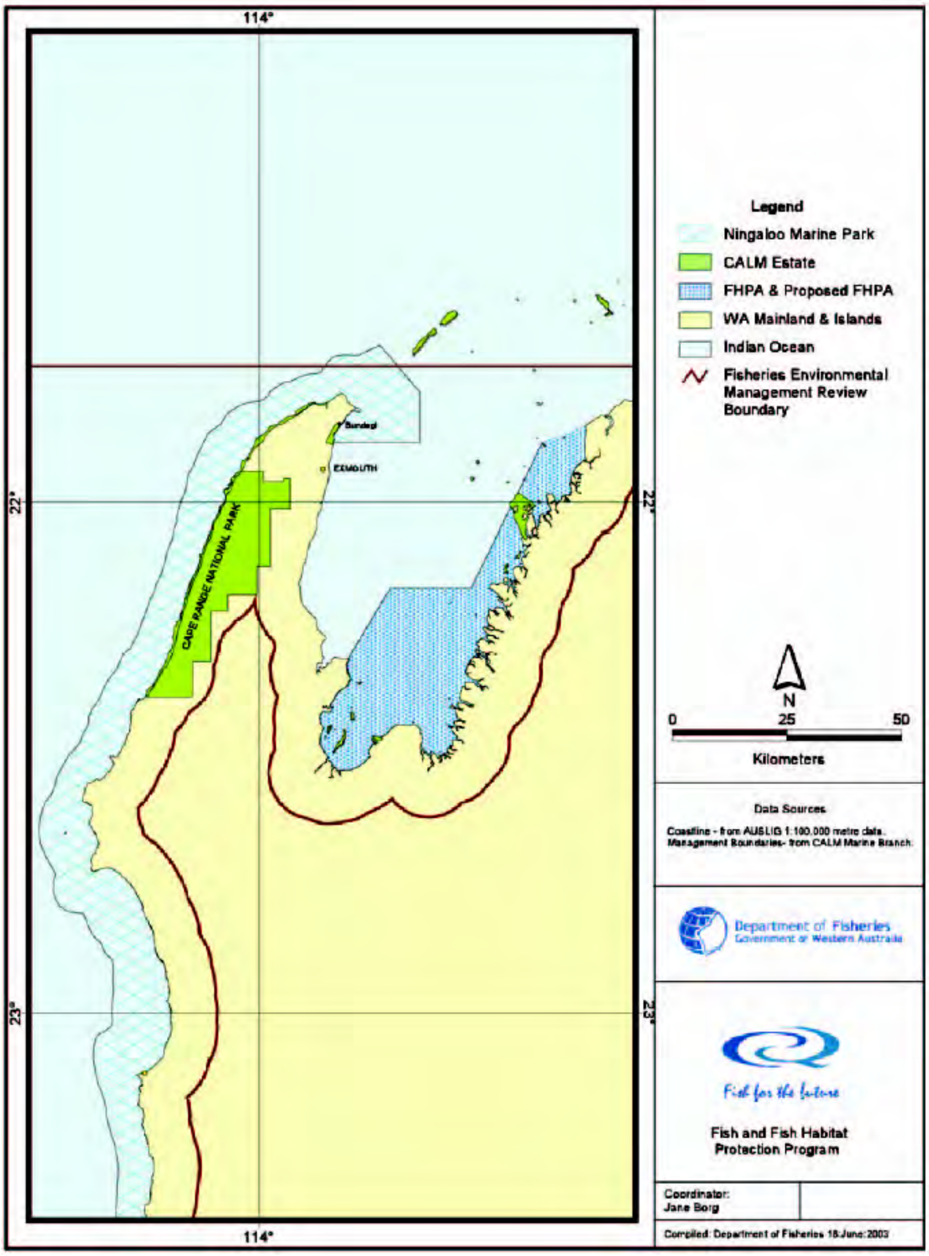

Figure 2.3 Marine and Terrestrial Conservation Estate, Exmouth Gulf

2.3 Fishing Methods

The main method of fishing used in the EGP fishery is demersal otter trawling (refer Figure 2.4). Until recently, vessels towed two standard otter trawl nets and one otter trawl try-net. However, it is understood that most, if not all, vessels are now using quad gear (four smaller nets; refer Figure 2.5).

Each tow is between 60 and 200 minutes in duration. Forces produced by water flowing over the otter boards open the trawl nets laterally and directs the boards, with the attached net, downwards onto the seabed. The ground chain scrapes the sea floor and disturbs prawns so they rise from the seafloor and into the path of the oncoming net. All nets used in the Gulf are now fitted with turtle exclusion devices (TEDs), while about half the trawlers also use nets fitted with fish escapement devices (FEDs) ([Prowest 2004]; refer also to section 2.8.1).

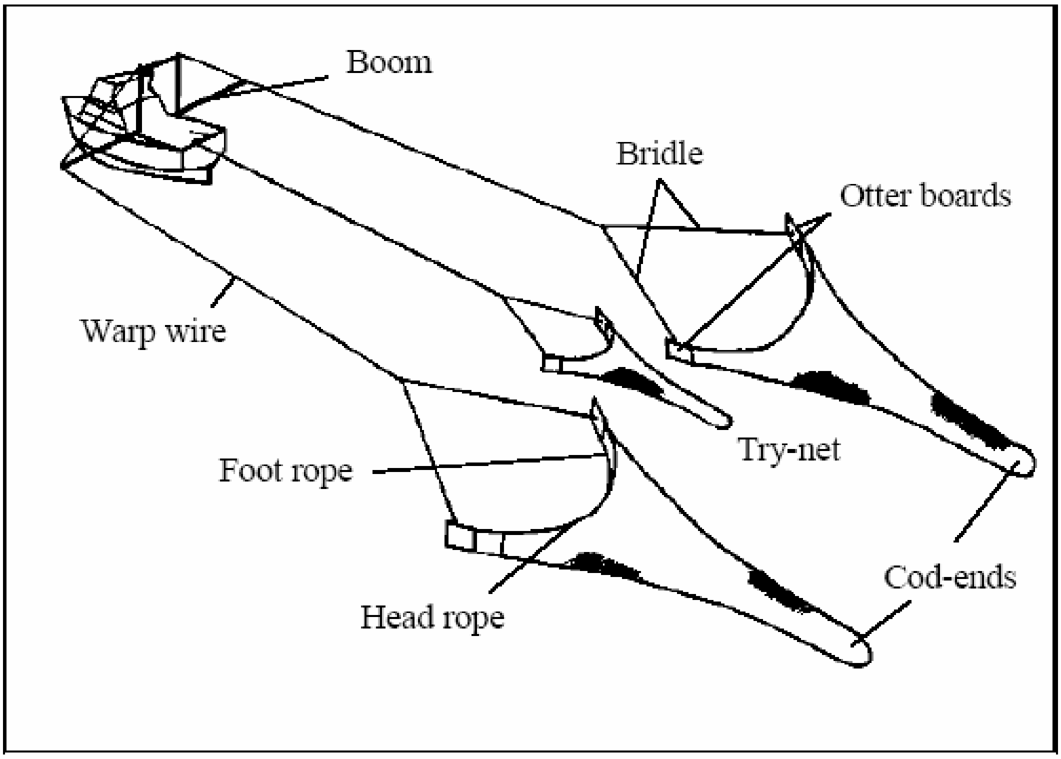

Figure 2.4 **The standard twin otter rig and try gear used by prawn trawlers in Exmouth Gulf**

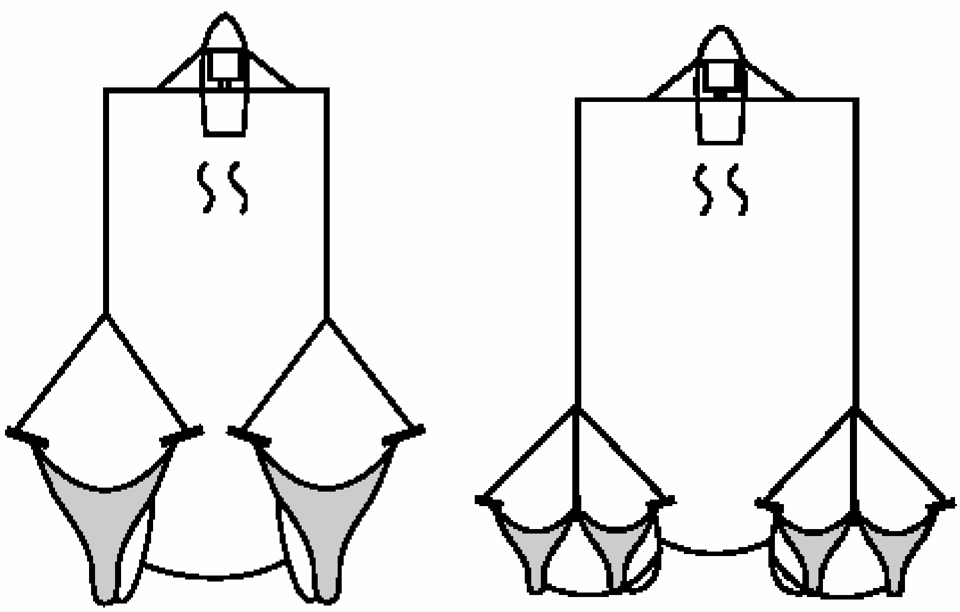

Figure 2.5 **Twin Gear and Quad Gear: schematic**

2.4 Recent catch statistics

Figure 2.6 depicts the Exmouth Gulf Prawn Managed Fishery annual landings and effort, 1963-2003 (unpublished data supplied by the Department of Fisheries in February 2005). The total prawn landings from Exmouth Gulf for the 2003 season were 1,089 tonnes, up from 809 tonnes in the 2002 season and within the Department of Fisheries nominated acceptable catch range of 771-1,276 tonnes. The 2003 catch comprised 231 tonnes of western king prawns, 635 tonnes of tiger prawns and 225 tonnes of endeavour prawns; the increase was primarily due to an increased tiger prawn catch. No commercial quantities of banana prawns were caught in either 2002 or 2003.

The western king prawn catch in 2003 was below the Department of Fisheries nominated acceptable catch range (350-550 tonnes) for the fourth year running, having fallen back to levels seen in the 1970s and 1980s. Surveys and monitoring of the western king prawn stocks have been instigated to review whether the low catches are a result of changes in the fishing strategy over the past two years (targeting tiger prawns at the start of the season), or if a longer-term effect of Tropical Cyclone Vance is impacting catches (Department of Fisheries, 2003).

The tiger prawn catch during 2003 was in the range projected for 2003 based on pre-season surveys (540-810 tonnes), which is the second highest catch of tiger prawns since the collapse of the stocks in the 1970s (Department of Fisheries, 2003). It is apparent that the stocks have recovered from the low of 2000 which followed the habitat destruction caused by Tropical Cyclone Vance that struck on 22nd March 1999 (Figure 2.7).

The endeavour prawn stock was moderately fished in 2003 (225 tonnes, the Department of Fisheries nominated acceptable catch range was 120-300 tonnes) (Department of Fisheries, 2003).

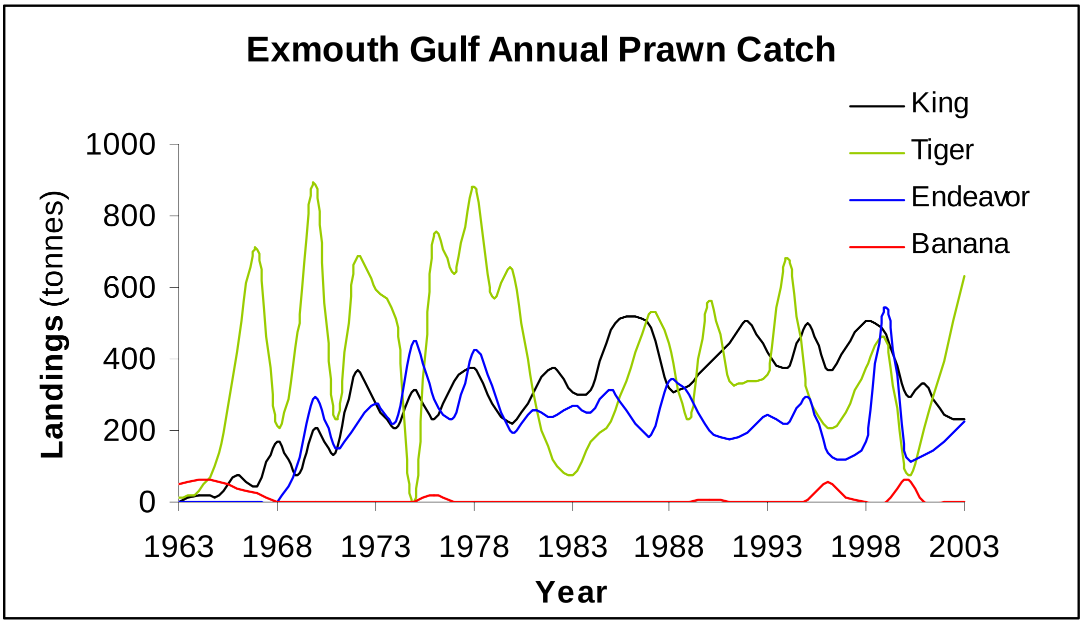

Figure 2.6 **Exmouth Gulf Prawn Managed Fishery annual landings, 1963-2002 (Source: Department of Fisheries)**

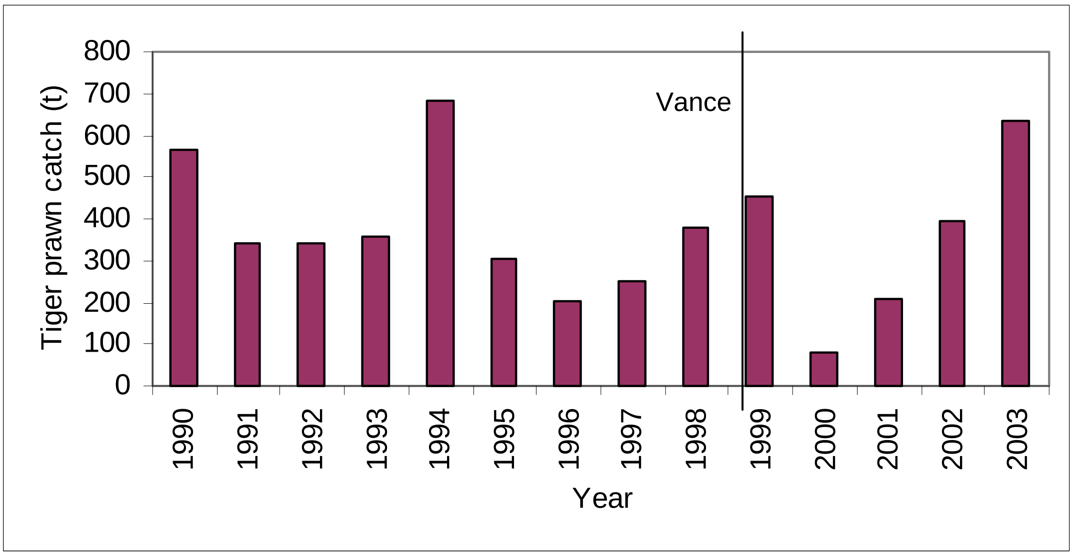

Figure 2.7 Influence of Tropical Cyclone Vance (March 1999) on tiger prawn catches (Source: Department of Fisheries)

2.5 Life Histories

2.5.1 Western King Prawn (*Penaeus latisulcatus*)

Spawning

Western king prawns have the ability to spawn numerous times throughout the year, producing between 100,000 and 700,000 eggs per spawning per prawn. During spawning, the females swim near the bottom releasing the eggs, which float and usually hatch within 24 hours. After hatching from the egg the larvae (nauplii) swim freely in the water column but do not feed.

The larval development continues through several stages: protozoa, mysis and postlarvae. This process generally takes from one to three weeks before the larvae are at the stage where they can settle onto the sea floor. During this period, many of the larvae are lost to predators. If by this time the larvae have drifted to a suitable nursery area (i.e. shallow sand/mud flats) they will settle (at around 10 mm total length) and continue to grow into juveniles. If settlement occurs into unsuitable habitats, they are likely to perish (Penn and Stalker, 1979).

Juveniles

Juvenile western king prawns bury into the substrate (generally shallow sandy banks) during the day. While in the nursery grounds, western king prawns are nocturnal and forage at night feeding on small animals and detritus. Juveniles spend around three to six months in nursery grounds, during which time they grow to between 107 and 127 mm total length (Penn and Stalker, 1979). At this point they begin to migrate offshore to oceanic waters and enter the trawl fishing grounds. This migration takes place in the summer and autumn of each year and is termed 'recruitment to the fishery' (Department of Fisheries, 2002b).

Mature Prawns

Western king prawns tend to occur in concentrated pockets often associated with hypersaline areas of water such as those found in Exmouth Gulf, and are found over silt or sandy substrates (Shaw, 2000). The western king prawn feeds primarily on microscopic fauna and decayed organic matter (detritus) and are prey to a large variety of fishes, and also molluscs, e.g. squid and cuttlefish (Department of Fisheries, 2002b).

2.5.2 Brown Tiger Prawn (*Penaeus esculentus*)

Spawning

The spawning cycles of the tiger prawn stock in Exmouth Gulf have been reported in White (1975a), Penn and Caputi (1985, 1986) and Penn *et al.* (1995). In Exmouth Gulf, spawning takes place from August through to March. In July-August, recruiting female tiger prawns from the previous spring (now 10 months old) are sexually mature and aggregate in the 13 to 20 m depth zone in the centre of the Gulf. Spawning commences around this time for the majority of this cohort, peaking in the late winter-spring period (August-October).

At spawning, the females swim near the bottom releasing the eggs (50,000 to 400,000 eggs per spawning), which float and hatch within about 24 hours. After hatching from the egg, the larvae (nauplii) swim freely in the water column but do not feed. The larval development continues through several stages: protozoa, mysis and postlarvae. This process generally takes from one to three weeks before the larvae are at the stage where they can settle onto the sea floor. During this period, predators are responsible for high mortality of the larvae. If by this time the larvae have drifted to a suitable nursery area, they will settle (at around 10 mm total length) and continue to grow into juveniles. In general, juvenile tiger prawns prefer to inhabit structured habitats such as algae or seagrasses.

Mature females continue to spawn throughout the summer months, with each moult (Penn and Caputi, 1985). Although unconfirmed, a second smaller peak in spawning is believed to occur around autumn (March-April), coinciding with the peak recruitment period from the previous spawning in spring. The number of eggs released reaches a peak during autumn and again in spring with lower levels of spawning activity (compared to western king prawns) occurring throughout the year (Penn and Stalker, 1979).

Juveniles

The juvenile phase occurs in the vegetated shallow waters along the eastern shoreline of Exmouth Gulf (nursery grounds). Tiger prawns become mature at 6 to 7 months of age and 101 and 121 mm total length (Penn and Stalker, 1979). The juveniles are vulnerable to predation by fish species including barramundi, threadfin salmon, cod and small sharks (Department of Fisheries, 2002b).

On maturity, they migrate offshore entering the trawl fishing grounds. This usually takes place in the summer and autumn of each year (Penn and Stalker, 1979). In Exmouth Gulf, primary recruitment occurs along the south-eastern and eastern sections of the Gulf (Department of Fisheries, 2002b).

Mature Prawns

Mature tiger prawns feed at night, primarily on microscopic fauna including molluscs, crustaceans and polychaete worms (Wassenberg and Hill, 1987). They are prey to squid, cuttlefish and a variety of demersal fishes.

2.5.3 Endeavour Prawn (*Metapenaeus endeavouri*)

The endeavour prawn is generally found in coastal waters down to approximately 50 m and is commonly caught in muddy or sand/mud sediment substrates. They are generally found inshore of the main fishing grounds for the tiger and king prawns. Endeavour prawns are carnivorous benthic feeders. Squid, cuttlefish and a large number of demersal finfish species commonly prey upon endeavour prawns (Department of Fisheries, 2002b).

There is limited information on the lifecycle of endeavour prawns in the Gulf. They spawn year round and in Queensland spawning peaks in March and September (Courtney *et al.,* 1989). Juvenile endeavour prawns are most commonly associated with seagrass beds in shallow estuaries although they are occasionally found in other areas (Staples *et al.*, 1985). They spend a short period of time in nursery areas and migration to adult habitats occurs at a small size (Buckworth, 1992). In the Torres Strait, recruitment is mainly in the summer months (Somers *et al.*, 1987). It is assumed that endeavour prawns in the Gulf also recruit in summer.

2.5.4 Banana Prawn (*Penaeus merguiensis*)

Banana prawns prefer shallow estuarine and intertidal areas. They live in turbid waters most of their lives, inhabiting sheltered mangrove creeks as juveniles and medium and low energy coastlines as adults (Shaw, 2000).

Banana prawns typically aggregate and in some instances may be so dense as to produce surface ‘boils’. This aggregating behaviour makes them highly vulnerable to exploitation. Banana prawns are bottom feeders, feeding on polychaete worms and bivalves. Predation by sharks and finfish accounts for a large part of their natural mortality (Staples *et al.,* 1985) (Department of Fisheries, 2002b).

Banana prawns become sexually mature at around 7 to 8 months of age and will spawn continually until they die. However, there are generally spawning ‘peaks’ during both spring and autumn. The larval stage is about 2 to 3 weeks long (temperature dependent) and then the post-larvae will move into and settle in shallow nursery areas. The post-larvae will spend around 2 to 4 months in the nursery areas before they start to move offshore; this movement can take up to 2 months to complete, so banana prawns are around 5 to 8 months old when they move into the fishing grounds (Department of Fisheries, 2002b). The maximum life span for banana prawns is around 12 to 18 months.

2.6 Factors Which Influence Prawn Catches

2.6.1 Climate

Inter-annual variation in the catches of all species is evident and is most likely due to weather and especially cyclone events, which have either a positive or negative effect, depending upon the species. On 22 March 1999, Cyclone Vance crossed Exmouth Gulf, resulting in gale force winds and heavy rainfall. This increased the migration of tiger and endeavour prawns into the trawl grounds and increased the level of suspended sediments in the Gulf creating high turbidity for several months after the cyclone. The short-term effects of the cyclone were higher catch rates for all species, particularly endeavour prawns with higher total landings observed for the 1999 season followed by a subsequent decline (Figure 2.7). Fig 2.7 relates only to tiger prawns.

In other regions of Australia where the banana prawn is a key target species, it has been found that there is a significant positive correlation between rainfall events and catches. However, an examination of the Exmouth Gulf data does not suggest any correlation between banana prawn catches and rainfall (Figure 2.8). It is suggested that the very low catches overall may be a result of the very low rainfall runoff to the

Gulf with rainfall events not being significant enough to have a bearing on local catches (M. Kangas, Department of Fisheries, pers. comm. 2005).

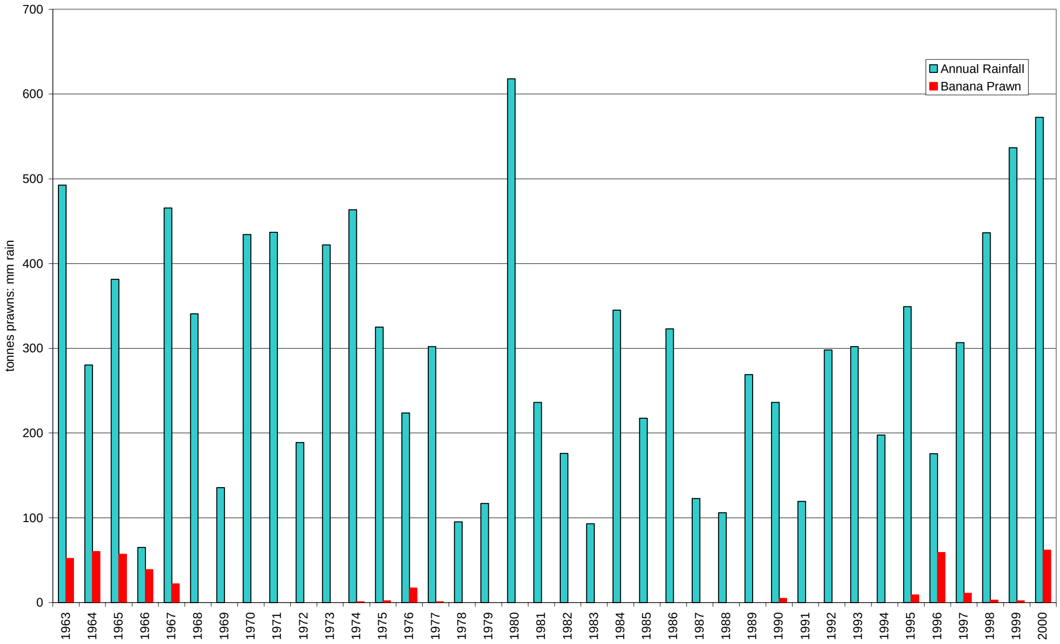

Figure 2.8 Red: Banana prawn catches (t). Blue: Rainfall (mm, at Learmonth) for Exmouth Gulf (source: Department of Fisheries & Bureau of Meteorology)

2.6.2 Habitat

Research in tropical and sub-tropical Australia has shown that inshore seagrass and macro-algal communities form critical nursery habitat for juvenile tiger prawns (Loneragan *et al.*, 2003).

Permanent structured habitat loss, particularly within the nursery area on the eastern side of the Gulf, would pose a major threat to the tiger prawn fishery as shown by the drop in catches following the loss caused by Vance (Figure 2.7). Cyclone Vance caused widespread loss of seagrass and macroalgae in the inshore areas (nursery habitats) of Exmouth Gulf (Department of Fisheries, 2002b). Surveys of the juvenile tiger prawn habitat were undertaken in the spring of 1999, 2000 and 2001 by CSIRO and in early 2003 by Department of Fisheries, all in conjunction with the prawn industry. The results indicated an increasing trend in seagrass cover after the destruction caused by Vance, from 1% in 1999, to 10% in 2000 and 40% in 2001. Over 60% cover was observed in many areas in 2003 (Department of Fisheries, 2003). The recovery of the tiger prawn catch is directly correlated with the recovery of the structured habitat measured as percent cover in the preceding season.

2.7 Seasonal and Monthly Closures

The fishing season commences in early April and closes in late November (Department of Fisheries, 2003). Within the fishing season, “moon closures” involve closing the fishery for three to five nights around the full moon. The closures reduce the proportion of soft, newly-moulted prawns in the catch and improve the efficiency of the fleet (BBG, 2004). During the 2002 season, there was a minimum of 28 non-fishing nights for moon closures (minimum of four nights each moon closure period, closures are generally for 5 to 6 nights: Pers. Comm. Errol Sporer Department of Fisheries, 2005). For example, the 2002 season allowed for a maximum of 200 fishing nights; however the entire fleet utilized only 183 nights (Department of Fisheries, 2003).

2.8 Environmental Impacts

2.8.1 Bycatch

Prawn trawling results in high levels of by-catch of finfish and other marine life (Bunting, 2002). Trawling contributes to the mortality of non-targeted species (small fish, invertebrates and sponges) that die due to the damage and disturbance they experience in the trawl net or from being out of water during the sorting process. These species are discarded overboard. The mass of non-target species returned overboard is between 2 and 5 times the total annual mass of the prawn catch for the EGP fishery (Department of Fisheries, 2002b).

There is limited published information on the current level and nature of by-catch in the EGP fishery or the levels and composition of by-catch throughout the history of the fishery. The Department of Environment and Heritage (2002) estimated that 70-80% of the by-catch consists of small finfish, while Murdoch University (2003) reported that less than 1% of the discarded by-catch of the EGP fishery represented commercial or recreational fish species.

An FRDC/industry funded research project comparing trawl by-catch in trawled and untrawled areas of Exmouth Gulf is expected to be completed by early 2006 (M. Kangas Department of Fisheries pers. comm. 2004).

Retained by-catch species include coral prawns, squid, cuttlefish, octopus, bugs, cobia, cod, blue swimmer crabs, mackerel, NW snapper and shark (Department of Fisheries, 2002b). Recorded landings of by-product for the 2002 season included 48 t of coral prawns, 12 t of blue swimmer crab, 8 t of squid, 5 t of cuttlefish, 4 t of bugs, 1 t each of shark and octopus and an “insignificant amount” of mixed finfish species (Department of Fisheries, 2003). In the past, non-retained by-catch species included protected species such as sea snakes and syngnathids (e.g. sea horses and pipe fish), threatened species including green, loggerhead, flatback, hawksbill and leatherback turtles, and other species including invertebrates and fish (Department of Fisheries, 2002b).

An observer program conducted in Exmouth Gulf during 2000 to 2003 indicated no captures of dugongs or dolphins in this fishery and that the population of dolphins could be increased as a result of feeding on discarded by-catch (Shaw, 2000). There is no information on the effects of trawling on the behaviour of whales in the Gulf, however, the fact that numbers of whales in the Gulf have been increasing over the decades while trawling has been occurring suggests that trawling is not having a negative impact.

By-catch Reduction Devices (BRDs) are a modification to the fishing gear to reduce the catch or mortality of non-target species during fishing operations. Two types of BRDs are used in the Gulf: Turtle Exclusion Devices (TEDs) and Fish Escapement Devices (FEDs).

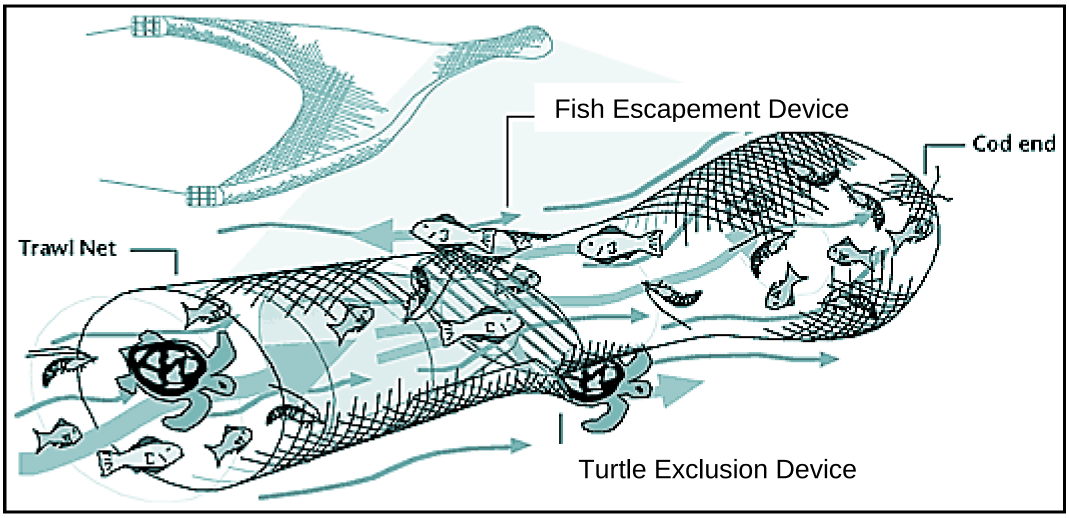

Figure 2.9 Conceptual diagram showing how by-catch reduction devices operate (source: Great Barrier Reef Marine Park Authority)

Figure 2.9 shows how the two forms of BRD work. TEDs are steel grids that prevent turtles (and other large fauna such as sharks, rays and large fish) from entering the cod end combined with an 'eye' in the net immediately upstream of the TED through which turtles can escape. FEDs are larger openings in the net (usually special panels of large size mesh) downstream of the TED grid, as fish have a tendency to swim against a current the FED relies on this principle to allow fish which have passed through the TED grid to escape.

TEDs are now compulsory for all prawn fisheries in WA while FEDs are being used on at least half of the trawlers in Exmouth Gulf. By 2005, FEDs will be required in all nets (Department of Environment and Heritage, 2002).

The successful implementation of TEDs into the Exmouth Gulf Prawn fleet has recently gained access for the fishery to the valuable United States market (Young, 2004).

The EGP industry has also installed additional 'well' sorting systems often called 'hoppers' on vessels (Department of Fisheries, 2003). This system allows for the catch to remain in water for an extended period thereby maximising the survival of discarded species (Department of Fisheries, 2002b). Nine of the twelve vessels currently operating in the Exmouth Gulf Prawn Managed Fishery have these hopper systems installed (M. Kangas, Department of Fisheries pers. comm. 2005).

As the by-catch volume remains high in trawl fisheries, it could be argued that management measures put in place to protect the resource (prawns) and habitat have also been successful in sustaining the by-catch (Department of Fisheries, 2002c). Anecdotal evidence suggests that the by-catch of the Exmouth Gulf Prawn Managed Fishery has probably changed over time, with the more vulnerable fish species (e.g. cods) decreasing in abundance and the more robust species (e.g. grinners and goat fish) remaining. However, there are no data to support this or to infer that any changes are entirely a result of the trawl fishery (Shaw, 2000). By-catch levels for Exmouth Gulf are relatively low by tropical trawl fisheries standards with by-catch to target species catch ratios between two and five to one (e.g. two to five times more by-catch than prawns) (Kangas and Thomson 2004), with few species of commercial significance to other fishing sectors being taken (Department of Fisheries, 2003). In contrast, mean catch to by-catch ratios in Queensland where BRD were not used were 1:7.76 ±0.69 for standard trawl gear used in the fishery, and 1:3.51±0.60 with BRDs fitted to the nets (Southern Fisheries Centre 1999).

2.8.2 Impact on Benthic Flora and Fauna

2.8.2.1 Review of literature

As well as the effects associated with the direct removal of the target species (including through overfishing), the removal of species associated with or dependent on the target species (such as predators or prey of the target species resulting in fishing-induced changes to trophic relationships; e.g. Pauly et al. 1998) and incidental take (by-catch; Section 2.8.1) demersal trawling can have many, varying direct impacts on the benthic (seafloor) environment. Given that trawls are designed to be dragged across the seafloor to capture benthic or near-benthic species in the water column or in/on the seafloor, there is the potential for significant impacts on seafloor habitats and benthic communities. There is a wealth of information (see Rester 2000 and subsequent updates) and a number of recent scientific reviews (e.g. Dayton et al. 1995, 2002; Auster & Langton 1999; Mueter 2001; Kaiser et al. 2002; Thrush & Dayton 2002; Morgan & Chuenpagdee, 2003; Beaumont & Hadley, 2004) that have reported on the effects of demersal trawling on benthic environments. While there is broad consensus regarding the impacts of trawling on the benthic environment, there are still some uncertainties associated with the magnitude of the impacts of trawling, as not all studies have been undertaken on realistic temporal and/or spatial scales to enable the effects of trawling to be distinguished from often large natural temporal and spatial variation (e.g. Kaiser 1998; Collie et al. 2000; Mueter 2001).

Trawling can have both short and long-term environmental impacts, resulting in changes in seafloor structure, habitats and benthic fauna and flora. Trawling results in alterations to topographic bedform features (e.g. boulders, cobbles, gravel, sand, mud, as well as the mounds and depressions caused by burrowing infauna) and modification or destruction of epibenthic fauna and flora (e.g. sponges, hydroids, corals, bryozoans, biogenic reefs, seagrass). These geological and biological structures provide heterogeneity and structural complexity, and represent important habitat (including nursery areas and refugia) for fish (including commercially and recreationally valuable fisheries species) and other organisms living in, on or near the seafloor. These structures support a diverse community of associated species and play a significant role in the maintenance of biodiversity and the biocomplexity of seafloor processes (Turner et al. 1999; Thrush et al. 2001; Dayton et al. 2002). A reduction in benthic habitat complexity may in turn lead to impacts on species composition and diversity, size distributions and abundance, biomass and total productivity, and overall ecosystem functioning (e.g. Rumohr & Krost 1991; Sainsbury 1991; Sainsbury et al. 1997; Thrush et al. 1998; Tuck et al. 1998; Prena et al. 1999; Jennings et al. 2002; Kaiser et al. 2000; Widdicombe et al. 2004). Trawling may result in changes in food webs, such as increased populations of opportunistic species and mobile predatory and scavenging species which are attracted by disturbed sediments, damaged and exposed organisms (e.g. Rumohr 1989; Engel & Kvitek 1998; Demestre et al. 2000). Trawling disturbances can also disrupt the biogeochemical pathways that support ecosystem function, alter sediment particle size, suspend bottom contaminants and alter the nutrient flux between the sediment and the water column (Black & Parry 1994; Dayton et al. 1995, 2002; Pilskaln et al. 1998; Schwinghammer et al. 1998; Kaiser et al. 2002; Beaumont & Hadley 2004; Widdicombe et al. 2004). The re-suspension of seafloor sediments associated with trawling activity can result in increased water turbidity, with the potential for effects on suspension-feeding organisms and submerged aquatic vegetation.

The physical impact of the trawling gear dragged across the seafloor is influenced by gear mass, the point or points of contact with the seafloor (gear footprint), the duration of contact, and the speed with which the gear is dragged (e.g. Jones 1992). The magnitude of the environmental effects associated with trawling will depend on a number of factors, including the frequency and intensity with which a particular area is trawled, as well as the spatial distribution and extent of trawling (e.g. Watling & Norse 1998; Beaumont & Hadley 2004). In addition, benthic environments differ in their vulnerabilities to trawling, recovery rates and resilience to trawling impacts (e.g. Watling & Norse 1998; Collie et al. 2000; Kaiser et al. 2002). For example, deeper environments which experience less frequent natural disturbance (e.g. from storm-wave activity) are likely to be less resilient to trawling activities than shallower environments which experience regular natural disturbance.

2.8.2.2 Information on Exmouth Gulf

The Department of Fisheries (2003) reported that:
"*Historically the fishery impacted on shallow water areas (<12 m) containing sponge habitats, but the refocussing of the fishery into deeper waters to take larger prawns since the early 1980s has reduced this interaction. The trawling effort is now focused on the deeper central and north-western sectors of Exmouth Gulf.*"

In a review of the marine and intertidal environments of the Exmouth Gulf, with specific reference to human usage, BBG (2004) reported that:
"*In the early days of trawling in Exmouth Gulf the grounds were unknown and echo-sounding and navigation devices were very primitive. Suitable areas for trawling were discovered by trawling the seabed. In some areas, a technique called "breaking the ground" was employed where chains would be strung between trawlers and dragged, to remove obstacles for the nets. The overall effects of such practices are unknown, but are likely to have caused significant habitat modification towards soft substrates. After forty years of trawling in Exmouth Gulf the areas that are the subject of ongoing trawling are likely to have become stable habitats. Visual observations of these areas has encountered mainly bare sands with virtually no epibenthic, and very limited mobile organisms present.*"

The extensively trawled areas of the Exmouth Gulf were estimated by Department of Fisheries to be about 35% of the total waters in Exmouth Gulf (1,475 km^2). In their application to Environment Australia to support the continued listing on Section 303DB of the *EPBC Act 1991* of the Exmouth Gulf Managed Prawn Fishery, the Department of Fisheries (2002) reviewed studies on the impacts of trawling and concluded that that trawling in the Exmouth Gulf was likely to only cause minor and short-lived impacts to mud/sand habitats. The Department of Fisheries argued that 35% is a relatively small percentage of the total area of the Gulf and considered that there would still be a substantial amount of refuge from the effects of trawling even if the area trawled was extensively impacted.

The fact is, there is no quantitative information on the impacts of trawling on the benthic structure and ecology of Exmouth Gulf, nor are studies underway to directly characterise the extent of any impact or recovery. The Department of Fisheries is currently (June 2005) analysing fish data from trawl surveys of trawled and untrawled areas in the Gulf as an analogue to establish the effects of trawling. It is expected that a report on these surveys will be released in early 2006 (M. Kangas, Department of Fisheries pers. comm.). There are no habitat or ecosystem impact related studies planned.

2.8.3 General

2.8.3.1 Creation of turbidity

The interaction between trawl gear and the sea floor results in increased turbidity. If turbidity resulting from trawling activities is above the natural turbidity range (in terms of either intensity or duration), then there could be adverse impacts on benthic communities caused by a reduction of the light required to maintain productivity, through either increased water turbidity or direct smothering.

A further long-term effect of trawling is the removal of benthic flora and fauna from the region, including many organisms which play an important role in reducing the re-suspension of sediments. It is likely that trawling results in increased turbidity both directly, via the interaction of trawl gear (*i.e.* the ground chain and otter boards that scrape across the sea floor) and indirectly through the removal of benthic communities that previously suppressed re-suspension of sediment (Jones (1992) and Pilskaln *et al.* (1998).

2.8.3.2 Trophic Interaction

The variation in prawn numbers in Exmouth Gulf due to mortality caused by fishing is believed to be relatively low compared with the natural seasonal variability of prawn populations caused by environmental conditions such as water temperature, currents and natural events such as cyclones. Furthermore, there are no known prawn predators which are likely to be directly impacted upon by the removal of adult sized prawns. Most carnivorous predators are opportunistic and/or scavengers and therefore are not considered dependent on any one species. Consequently, Department of Fisheries (2002b) considered that the commercial take of prawns has not impacted on the trophic structure within the Exmouth Gulf ecosystem through the removal of a potential food source.

2.8.3.3 Translocation of non-indigenous marine species

Oceanica (2005) has reported on the issue of non-indigenous marine species (NIMS) in Exmouth Gulf.

The Department of Fisheries (2002b) assessed the risk of introducing NIMS associated with the movement of fishing trawlers between Exmouth and Fremantle as low on the basis of the difference in water temperature between the two locations

The tropical conditions at Exmouth would suggest there is greater risk from invasion from tropical species. There are tropical ports further north with established NIMS, such as Port Hedland and Darwin and transport occurs between these ports and Exmouth. Hull fouling of recreational craft is considered to be an even bigger issue in the tropical waters of Exmouth than it was in the temperate-tropical waters of Shark Bay (Wyatt *et al.* 2005).

The following facts with respect to Exmouth Gulf are known:

1. Exmouth Gulf has been visited by significant numbers of international vessels for over a century, with the nineteenth and twentieth centuries characterised by periods of whaling activity, pearling and oil exploration.
2. The Gulf has also been subject to approximately 30 years of continuous prawn trawling, with regular movements of trawlers between the Gulf and Fremantle and other ports south of Exmouth.

3. The Gulf is subject to continuous international yacht visits and charter boat movements.
4. The seas offshore of Ningaloo and the Muiron Islands are a busy international shipping route with approximately 1,200 ships passing per annum .
5. The northern end of the Gulf is popular for recreational boating and work by Wyatt *et al*. (2005) has shown that recreational boating appears to have been a significant vector in facilitating NIMS introductions to Shark Bay.

Oceanica (2005) concluded that:

1. It is likely that NIMS have already established in the Gulf given the past and current vessel movements.
2. The removal/modification of benthic habitat by trawling may have further enhanced opportunities for introduced species to establish with the removal of competing native organisms.
3. There is no information on the presence or absence of NIMS in the Gulf or in Ningaloo Marine Park.
4. There is no programme planned or in place to monitor or measure NIMS in the Gulf or in Ningaloo Marine Park
5. The tropical environment at Exmouth means that the risk of introduction is considered to be greatest from tropical ports (e.g. traffic from the north).

2.8.3.4 Discharge from processing facilities

MG Kailis' Learmonth seafood processing plant is licensed to discharge liquid waste resulting from the processing of up to 2000 tonnes of seafood per annum into Exmouth Gulf. The waste is discharged a short distance offshore from the processing facility and the results of an ongoing monitoring program are reported to the Department of Environmental Protection.

2.9 Economic Benefit to Exmouth

Within the Exmouth area, the prawn fishery is a major regional employer and contributes to the economic viability of the Exmouth town, which also relies on other fisheries, tourism and the communications facility for employment.

Department of Fisheries (2003) reported that the Exmouth Gulf Prawn Fishery employed approximately 120 people directly (fishing, processing and administration) with some 20 other jobs as an indirect activity (engineering, equipment supplies etc). The estimated employment by the fishing sector for 2002 was 52 skippers and crew (Department of Fisheries, 2003). On the basis that the number of vessels operating has not changed since 2002, employment is likely to be similar in 2005.

2.10 Management and Environmental Accreditation

The *Fish Resources Management Act*, 1994, provides the legislative framework for the management of the fishery. The EGP Management Plan is the current management plan for the fishery, and is a formal statutory document that dictates the management measures for the fishery.

The Exmouth Gulf Prawn Management Advisory Committee is the body that directs the management of the fishery through the provision of advice with the aim of achieving the maximum economic return from the prawn resource as well as maintaining sustainability of the fishery and ensuring cost effective management.

Management of the EGP fishery is based on "input controls" using a combination of management restrictions, including limited entry, boat size, engine power, and gear controls, and seasonally varied spatial and temporal closures (Department of Fisheries, 2002b).

Long-term quantitative catch data have been recorded by the commercial fishers operating in the Exmouth Gulf Prawn Managed Fishery (Department of Fisheries). As with all skippers of WA fishing boats, there is a statutory licence requirement to submit monthly returns indicating the level of catch and effort. In Exmouth Gulf, all trawler skippers also complete daily log sheets. Fishery-independent data is collected to gauge the level of recruitment during March and April each year and to determine the level of spawning stock during August, September and October each year. Two commercial boats assist the Department of Fisheries in each of these surveys (Department of Fisheries, 2002b). The Department of Fisheries has also introduced a satellite tracking system (Vessel Monitoring System (VMS)) which 'polls' the locations of the trawlers in the Gulf as they work. VMS data allow checks to be made that closures are being adhered to (refer to Section 2.11 for examples of VMS data).

An important recent development is that the Department of the Environment and Heritage has declared that the fishery is managed in an ecologically sustainable manner under the provisions of the *Environment Protection and Biodiversity Conservation Act 1999.* Some conclusions that the Department of the Environment and Heritage (Department of Environment and Heritage 2002) came to in its environmental assessment of the EGP Fishery were as follows:

- The potential to impact unacceptably and unsustainably on the environment is generally quite high in trawl fisheries. The Department of Fisheries has conducted a risk assessment of these issues in this fishery and has implemented actions to address areas of significant concern.
- Management arrangements in the WA EGP Fishery are reasonably precautionary. The Department of the Environment and Heritage is confident that the Department of Fisheries will continue to manage the fishery to reasonable levels of precaution in the next five years.
- The submission was silent on specific actions and requirements in the fishery related to the prevention of marine pollution from vessels; however the Department of Fisheries has informed the Department of the Environment and Heritage that they undertake annual inspections of all vessels for seaworthiness. It was concluded that air and water quality issues are of a low enough risk not to require a managerial response or a justification within the report.
- The management methods used to maintain significant levels of prawns and byproduct species assist with minimising the impact of the fishery on the broader ecosystem. The fishery currently trawls only 35% of the licensed habitat in Exmouth Gulf. The trawl grounds have been contracting over the past decade due to direct management and reductions in overall levels of effort. A performance measure is set that no more than 40% of the mud/shell habitat of Exmouth Gulf will be available for trawling.
- Funding has been secured for studies to be conducted on the different habitats within Exmouth Gulf and a Vessel Monitoring System (VMS) was introduced in 2002. This will provide further information allowing a more accurate assessment of the impacts. It is intended to then use this information to check the suitability of the closure boundaries and, if required, redraw some of the

closure boundaries to ensure the continuation of key habitats, such as sponge gardens.

- There is a general aim to reduce the impact of fishing operations on the benthic environment and on the broader ecosystem through the use of bycatch reduction devices, 10 mm ground chains, spatial closures and restrictions on fishing gear.
- The feasibility of tiger prawn stock enhancement in Exmouth Gulf has been assessed by MG Kailis Gulf Fisheries, the FRDC, CSIRO and the Department of Fisheries. The Department of the Environment and Heritage advises extreme caution be taken in the introduction of stock enhancement to any fishery as stock enhancement projects raise a number of concerns in relation to the ecological impact on the area. These issues include impacts on the genetic diversity of stocks, habitat disturbance and possible introduction of disease or pests.

2.11 Vessel Movements

The Department of Fisheries provided Oceanica with the VMS data for the fishery for 2003/04. The VMS output gives the location of trawlers ‘polled’ at certain points in time (rather than tracks). An example is provided in Figure 2.10; in this case it is apparent that the central region of the Gulf was the most intensively trawled, with trawl paths generally running parallel to the long axis of the Gulf, following the depth contours.

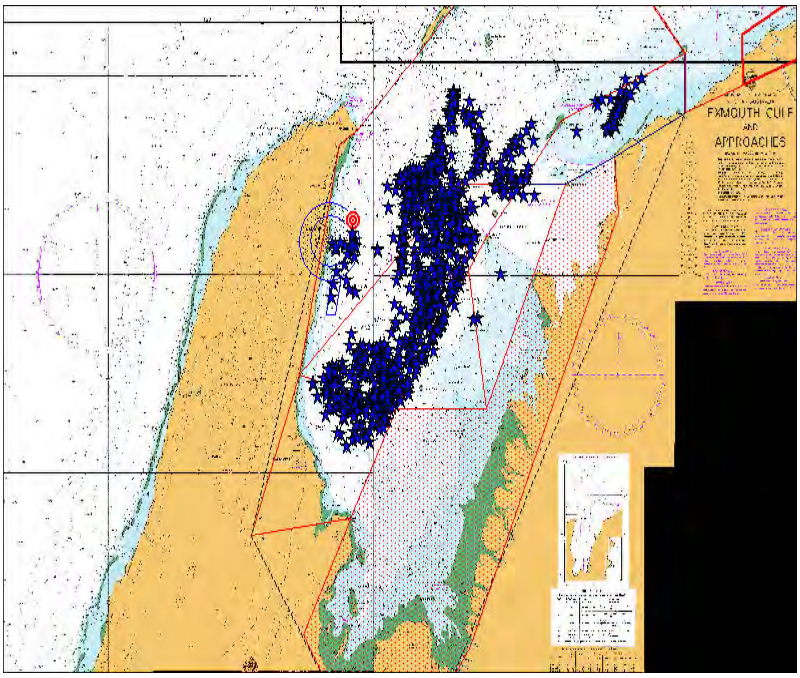

Figure 2.10 Example of VMS data for 4 trawlers (period: June 2004)

The Department of Fisheries manage the location and duration of trawling effort via a system of closures throughout the season. Examples of closures throughout the 2003 season are shown in Figures 2.10 to 2.16, in which VMS data can be seen along with the changing boundaries of the prawn fishery. The system is seen to be highly effective as the trawlers rarely stray across the boundaries communicated by the Department of Fisheries. Trawlers will occasionally cross boundaries if they are undertaking research trawls on behalf of the Department of Fisheries, and this shows in the plots of VMS data.

The research trawls and information from skippers is used to guide the program of closures, the timing for closures is communicated by the Department of Fisheries to vessel owners, skippers and managers at least 24 hours prior to a closure being implemented (Errol Sporer, Department of Fisheries, Pers. Comm. 2005).

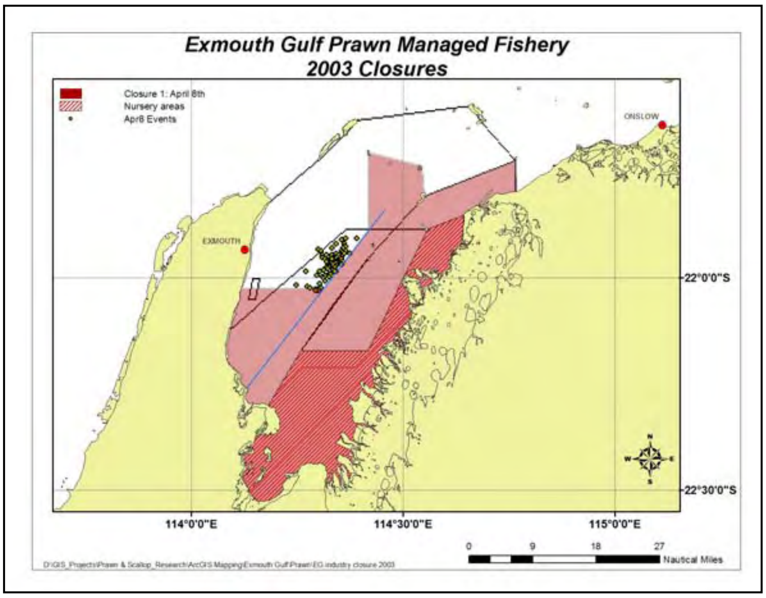

Figure 2.11 Exmouth Gulf Prawn Managed Fishery Closure: 8/4/03

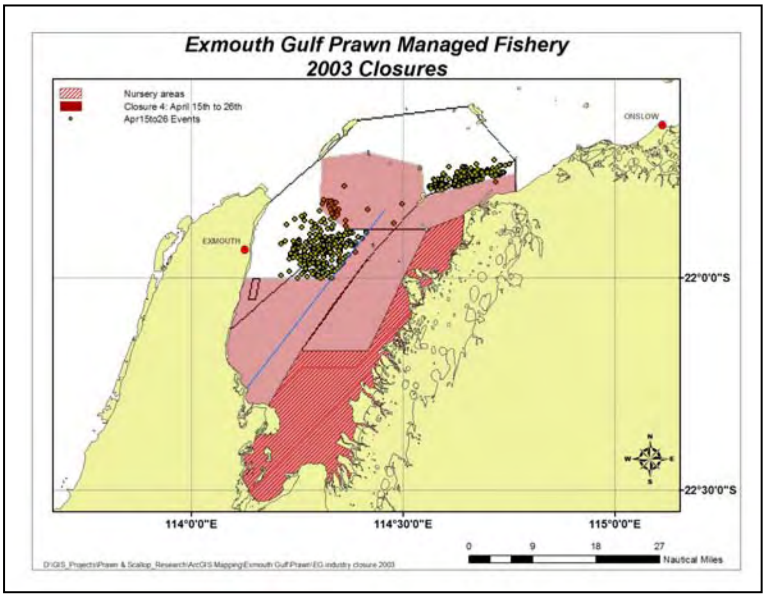

Figure 2.12 Exmouth Gulf Prawn Managed Fishery Closure: 15-26/4/03

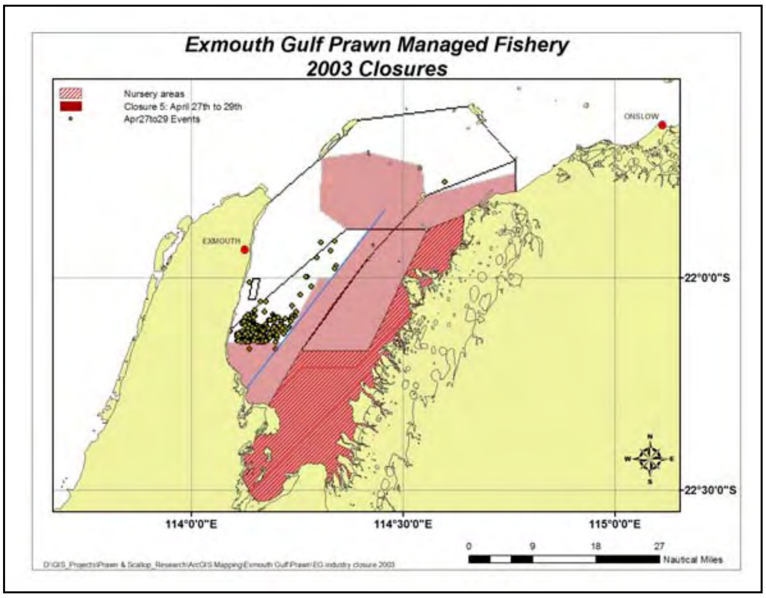

Figure 2.13 Exmouth Gulf Prawn Managed Fishery Closure: 27-29/4/03

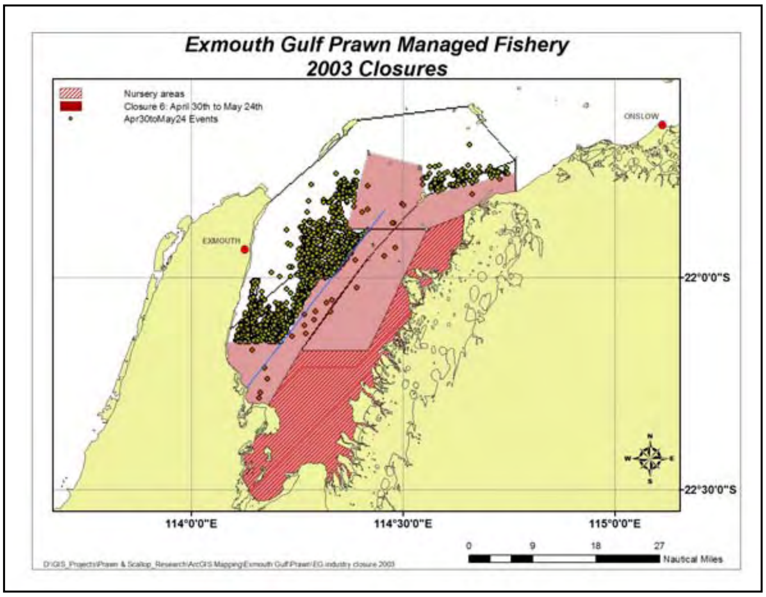

Figure 2.14 Exmouth Gulf Prawn Managed Fishery Closure: 30/4/03-6/5/03

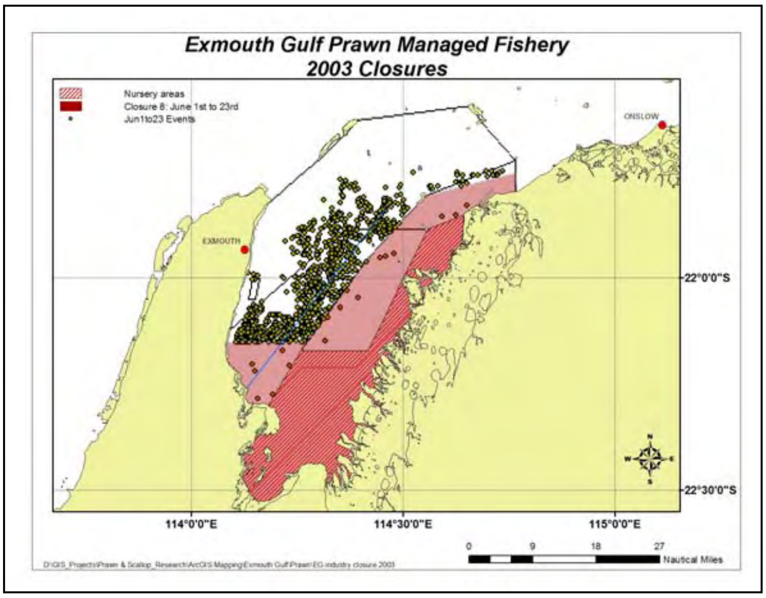

Figure 2.15 Exmouth Gulf Prawn Managed Fishery Closure: 1-23/6/03

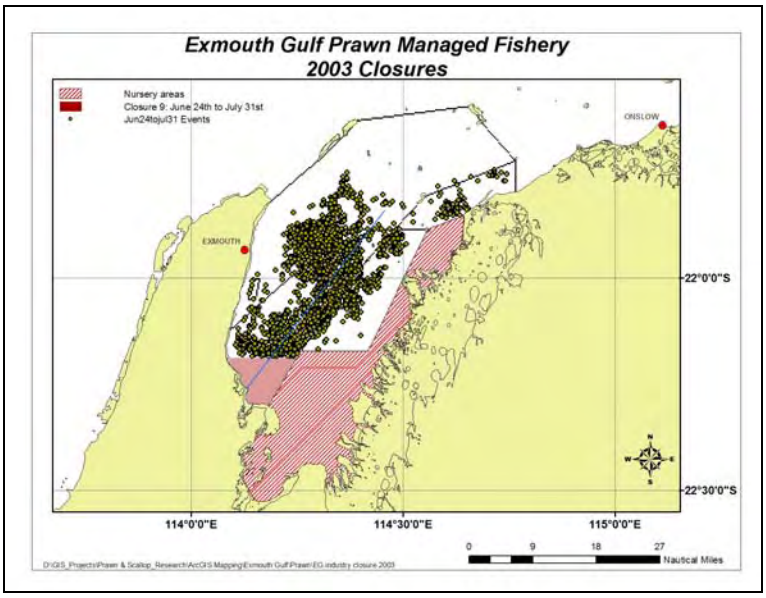

Figure 2.16 Exmouth Gulf Prawn Managed Fishery Closure: 24/6/03-31/7/03

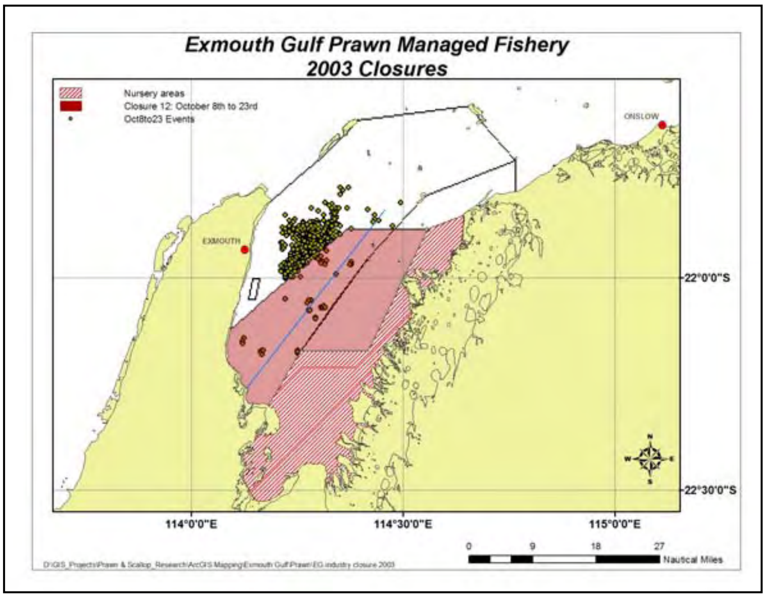

Figure 2.17 Exmouth Gulf Prawn Managed Fishery Closure: 8-23/10/03

2.12 Summary

The Exmouth Gulf Prawn Managed Fishery is one of Western Australia's three most valuable managed fisheries. It is the second largest prawn fishery in Western Australia after the Shark Bay Prawn Fishery, and has an annual value to fishers of approximately $12 million.

The fishery targets western king prawns and brown tiger prawns, with lesser, but still commercially significant, catches of endeavour prawns and occasionally banana prawns.

The following factors are known to influence prawn catches:

- Fishing pressure: the number of trawlers is limited to 13, and the number of nights in a year on which fishing can occur is capped at 200.
- Gear used: Trawlers use quad gear with 10 mm ground chains, with limits on the power of the vessels and the total length of the head ropes of nets.

- Locations fished: Trawl areas are opened and closed throughout the season to protect juvenile and spawning stocks. There is permanent closure of the eastern shore to protect the nursery habitat.
- Cyclones: Tropical Cyclone Vance caused widespread destruction of nursery habitat and disturbance of the seabed. The prawn catches were below average for the following two years.
- Rainfall: Although rainfall is positively correlated with Banana Prawn catches elsewhere, there is no correlation in the records for Exmouth Gulf.

Seasonal closure times

- The season opens in early April and closes in mid to late November.
- Within season 'moon closures' involve closing the season for three to five nights around the full moon to protect moulting prawns.

Life histories of key species and the significance of shallow and intertidal areas

- Brown Tiger Prawn:
    - Spawning takes place from August through to March with 50,000 to 400,000 eggs released per prawn per spawning. The number of eggs released reaches a peak during autumn and again in spring with lower levels of spawning activity occurring throughout the year.
    - When planktonic larvae have drifted to a suitable nursery area containing structured habitats such as algae or seagrasses they settle and grow into juveniles.
    - The juvenile phase occurs in the vegetated shallow waters along the eastern shoreline of Exmouth Gulf (nursery grounds). Tiger prawns become mature at 6 to 7 months of age. The juveniles are vulnerable to predation by fish species including barramundi, threadfin salmon, cod and small sharks.
    - The young adult prawns migrate offshore entering the trawl fishing grounds in the summer and autumn of each year
- Western King Prawn:
    - This species spawns numerous times throughout the year, producing approximately 100,000 to 700,000 eggs per spawning per female prawn.
    - When larvae have drifted to a suitable nursery area (i.e. shallow sand/mud flats) they settle and continue to grow into juveniles.
    - Juvenile western king prawns spend around three to six months in the nursery grounds.
    - Recruitment to the trawl fishing grounds occurs in the summer and autumn of each year.
    - Mature prawns are found over silt or sandy substrates.
- Endeavour Prawn:
    - These prawns are believed to spawn year-round in the Exmouth Gulf, with spawning peaks occurring in March and September.
    - Juvenile endeavour prawns are most commonly associated with seagrass beds. They spend a short period of time in nursery areas and migration to adult habitats occurs at a small size. Recruitment occurs mainly in the summer months.
    - Mature endeavour prawns are generally found in coastal waters down to approximately 50 m and are commonly caught in muddy or sand/mud

substrates. They are generally found inshore of the main fishing grounds for the tiger and king prawns.

- Banana Prawn:
  - o Becomes sexually mature at 7 to 8 months of age and spawns continually until it dies. Spawning is strongly related to rainfall events elsewhere in Australia but the population in Exmouth Gulf has not shown such a relationship.
  - o Post-larvae settle shallow nursery areas and spend 2 to 4 months there before starting to move offshore; this movement can take up to 2 months to complete. The maximum life span for banana prawns is 12 to 18 months.
  - o Banana prawns typically aggregate and in some instances may be so dense as to produce surface 'boils'. This aggregating behaviour makes them highly vulnerable to exploitation.

Current information on the environmental, economic and social influences

- By-catch associated with prawn trawling is significant, with 2-5 times the total annual weight of the prawn catch being non-target species which are thrown overboard, largely dead.
- All nets are fitted with Turtle Exclusion Devices and most are fitted with Fish Escapement Devices. These have been demonstrated to significantly reduce the amount of by-catch and the incidence of turtles and larger animals being caught is understood to have dropped to close to zero.
- The same grounds have been trawled for over four decades. Evidence from other studies strongly suggests that the ground chains will have essentially cleared any pre-existing structured habitat (e.g. sponges and corals) from the trawl grounds, which now largely comprise of muddy sediments.
- Number of workers: The fishery employs 120 people directly (fishing, processing and administration) with some 20 other jobs as a support activities (engineering, equipment supplies etc).
- The fishery is worth about $12 million per annum, measured as the value of the landed catch.

Vessel movements and their locations within the Gulf

- The Department of Fisheries have a sophisticated Vessel Monitoring System (VMS), which polls the locations of trawlers and ensures that they are operating within the areas designated. The trawlers generally target the deeper waters in the centre and north of the Gulf.

Status of environmental accreditation of the industry:

- Department of the Environment and Heritage has declared that the fishery is managed in an ecologically sustainable manner under the provisions of the *Environment Protection and Biodiversity Conservation Act 1999.*

2.13 Interaction with the Straits Salt project

The Salt project has the following potential interactions with the prawn fishery and associated activities in the Gulf:

1. <u>Navigation risks</u> posed by increased vessel movements across the Gulf, potentially between the trawlers and shipping entering and exiting the Gulf,

ship anchoring and barging operations. The level of interaction is reduced somewhat by the fact that ships will only enter and exit the Gulf during daylight hours, while trawling commences at night-fall and trawlers return to offload the catch in the morning. The ERMP will provide details of the issues related to coordination of navigation and mooring.

2. Ship mooring procedures within the Gulf will be designed to minimise interaction with trawling operations. These procedures will be developed in consultation with the Department of Fisheries and the trawler operators. The intention is avoid any restrictions on trawling due to mooring activity. The ERMP will provide details of the issues and the approach to coordinating mooring and navigation.

3. The effects of discharged bitterns on juvenile prawns. On occasions, bitterns will be discharged into the barge harbour and flow into the Gulf via the barge channel. The ERMP will provide a detailed assessment of the likely extent of impacts of the bitterns on seagrasses, mangroves and prawn survival, and will outline procedures to be put in place to manage those impacts. Notwithstanding the above, the bitterns will be stored on site for up to 10 years before any discharge is necessary, depending on a number of factors currently under consideration.

4. Potential for localised losses of prawns and fish larvae though seawater pumping. The seawater intake pumps will take large volumes of water out of one or two creeks and deliver it into the evaporation ponds. Experience with other salt-fields shows that these pumps will entrain larval and juvenile fish and prawns which will then develop in the intake channel and primary evaporation ponds. The ERMP will provide discussion on the effects of seawater pumping on the creek systems and will outline procedures to manage those impacts.

5. Increased risk of introduction of non-indigenous marine species. Mooring of international shipping in the Gulf will increase the risk of introduction of non-indigenous marine species. A separate report (Oceanica 2005) has been prepared on this issue and it will be included with the ERMP, as will a Draft Non-indigenous Marine Species Management Plan.

3 Exmouth Gulf Beach Seine Fishery

3.1 Background

The Exmouth Gulf Beach Seine Fishery is a small fishery that has operated in southern Exmouth Gulf since 1988 (Figure 3.1; BBG, 2004). There were only two licensed fishers as of 2000 (Shaw, 2000) using beach seines and gill nets. The fishery produces a mixed catch of mullet, Perth herring, shark, whiting and yellowfin bream. Of these, the main species caught are Perth herring, western sand whiting and shark. Catch and values for fisheries with fewer than five operators are not reported for reasons of confidentiality (Department of Fisheries, 2004). The estimated maximum catch handled in one netting operation is around 0.5 tonnes of fish, if the fish are for human consumption (Shaw, 2000).

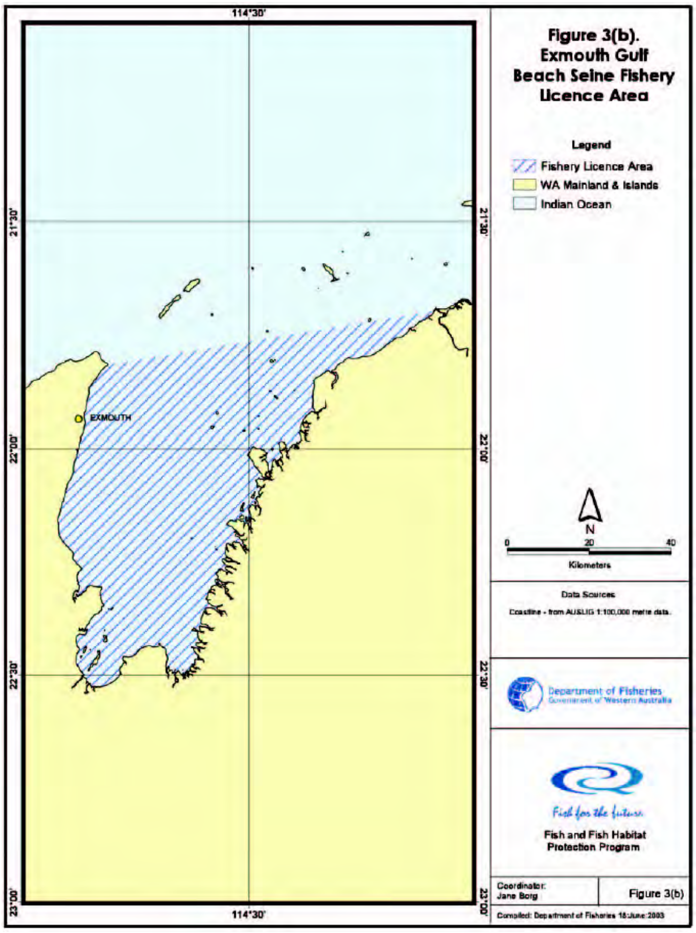

Figure 3.1 Exmouth Gulf Beach Seine Fishery Licence Area (source Department of Fisheries)

3.2 Factors Influencing Catch

3.2.1 Climate

High water temperatures in summer mean that fish can only be caught and handled without risk of rapid deteriorating in the cooler winter months of the year (April-November), while bad weather can further limit available fishing time (Shaw, 2000).

3.2.2 Habitat

The large mangrove community on the eastern side of the Gulf and extensive seagrass areas on the shallow banks of the Gulf are considered important nursery areas for many of the fish species caught in the fishery (Shaw, 2000).

3.3 Environmental Influence

3.3.1 By-catch

By-catch is significantly reduced in this fishery compared to others, as commercial fishers stay with their nets, clearing them of target and non-target species before unwanted species die and high temperatures spoil the quality of the target species. Mesh sizes of nets are restricted to allow juvenile fish to avoid capture and to select the target species within a narrow size range. Entanglement of protected species (turtles, dugongs) is not considered to be an issue as the fishers generally watch their nets (Shaw, 2000).

3.3.2 General

There are few environmental impacts related to this fishery. Tides, difficult access and unsuitable bottom type limit the times and areas available for fishing. Netting can only occur on incoming or high tides, which occurs in daylight hours for about 3-4 hrs on average for two weeks in every month. Rocky ground prevents beach seining, and shore-based operators are forced to wait for fish to swim into suitable areas for seining rather than actively searching for them (Shaw, 2000).

Overfishing is unlikely due to the small number of commercial fishers, the limited area available for fishing and the short time in which commercial fishers can effectively fish (Shaw, 2000).

Beach erosion from the use of four-wheel drive vehicles by commercial and recreational fishers is a potential problem (Shaw, 2000).

3.4 Management

There are a limited number of licenses, controls on boat sizes and a maximum net length to restrict fishing effort (Shaw, 2000).

As part of commercial license obligations, fishers record catch details and time spent searching or catching. These data are analysed by the Department of Fisheries, and provide a good indication of the status of fish stocks and general health of the ecosystem. Commercial fishing data of this type usually provide a better index of the status of stocks than recreational data because many of the problems of species catchability and gear selectivity inherent in recreational line fishing data are not present (Shaw, 2000).

The number of recreational fishers visiting the Exmouth Gulf region is increasing. This is likely to place greater pressure on fisheries managers to reallocate fish resources and to make a larger proportion of the stocks available for the recreational sector (Shaw, 2000).

3.5 Interaction with Straits Salt project

There are unlikely to be any significant interactions or impacts arising from the Straits Salt project on this fishery because:

- The coastal area from which Straits will operate is not easily accessed from the land and the creeks are not easily accessible by boat except on favourable tides.
- The fishery is very small with only two participants; and
- The project will have a relatively small effect on the stocks of fish in creeks that are available for net fishing in the Gulf.

The ERMP will provide discussion of the potential impact of the project on fish stocks and outline measures that will be taken to monitor any such impacts.

4 Recreational Fishery

4.1 Background

Recreational fishing activity in the Gascoyne has increased significantly since the early 1980s. The estimate of recreational fishing participation in the region is 5% of the State's fishers or 30,000 fishers a year (Baharthah and Sumner, 2003). Fishing activity tends to peak between April and August each year. Most fishers stay an average of less than two weeks and intend to fish every day (Sumner *et al.* 2002).

4.2 Fishing Grounds

A 12-month survey of recreational fishing in the Gascoyne was conducted during 1998-99 by Sumner *et al.* (2002). The spatial distribution of recreational fishing effort in the Gascoyne was recorded and the findings are shown in Figure 4.1. Recreational fishing data from the Exmouth region are presented in Figure 4.2 (Department of Fisheries, 2004).

4.3 Recent Catch Statistics

Sumner *et al.* (2002) estimated that the total annual recreational fishing effort for the Gascoyne was 243,000 fisher-days from April 1998 to March 1999. The total recreational catch of all finfish species was estimated at 350 tonnes. This was one third of the commercial catch of 1,082 t at the time. The most common species kept by recreational fishers in the Gascoyne bioregion were (in order of estimated weight kept):

- Spangled emperor (*Lethrinus nebulosus*) (79 tonnes, or 30,000 fish);
- Pink snapper (*Pagrus auratus*) (79 tonnes, or 28,000 fish);
- Mackerel (*Scomberomorus* spp.) (Spanish mackerel 47 tonnes, or 8,000 fish, other mackerel 8 tonnes);
- Black snapper/grass emperor/blue-lined emperor (*Lethrinus laticaudis*) (34 tonnes, or 33,000 fish);
- Golden trevally (*Gnathanodon speciosus*) (20 tonnes or 6,000 fish);
- Sweetlip emperor (*Lethrinus miniatus*) (16 tonnes or 13,000 fish);
- Chinaman cod (*Epinephelus rivulatus*) (10 tonnes or 23,000 fish);
- Western yellowfin bream (*Acanthopagrus latus*) (5 tonnes or 10,000 fish);
- Tailor (*Pomatomus saltatrix*) (5 tonnes or 7,000 fish); and
- Whiting species (Sillaginidae) (5 tonnes or 34,000 fish).

These figures do not include the catch from charter boats and therefore understate the total recreational catch for the bioregion (Sumner *et al.*, 2002). Charter activity is significant, with 72 fishing tour licences and 12 "ecotour" licences valid for the Gascoyne region in 2003 (Department of Fisheries, 2003).

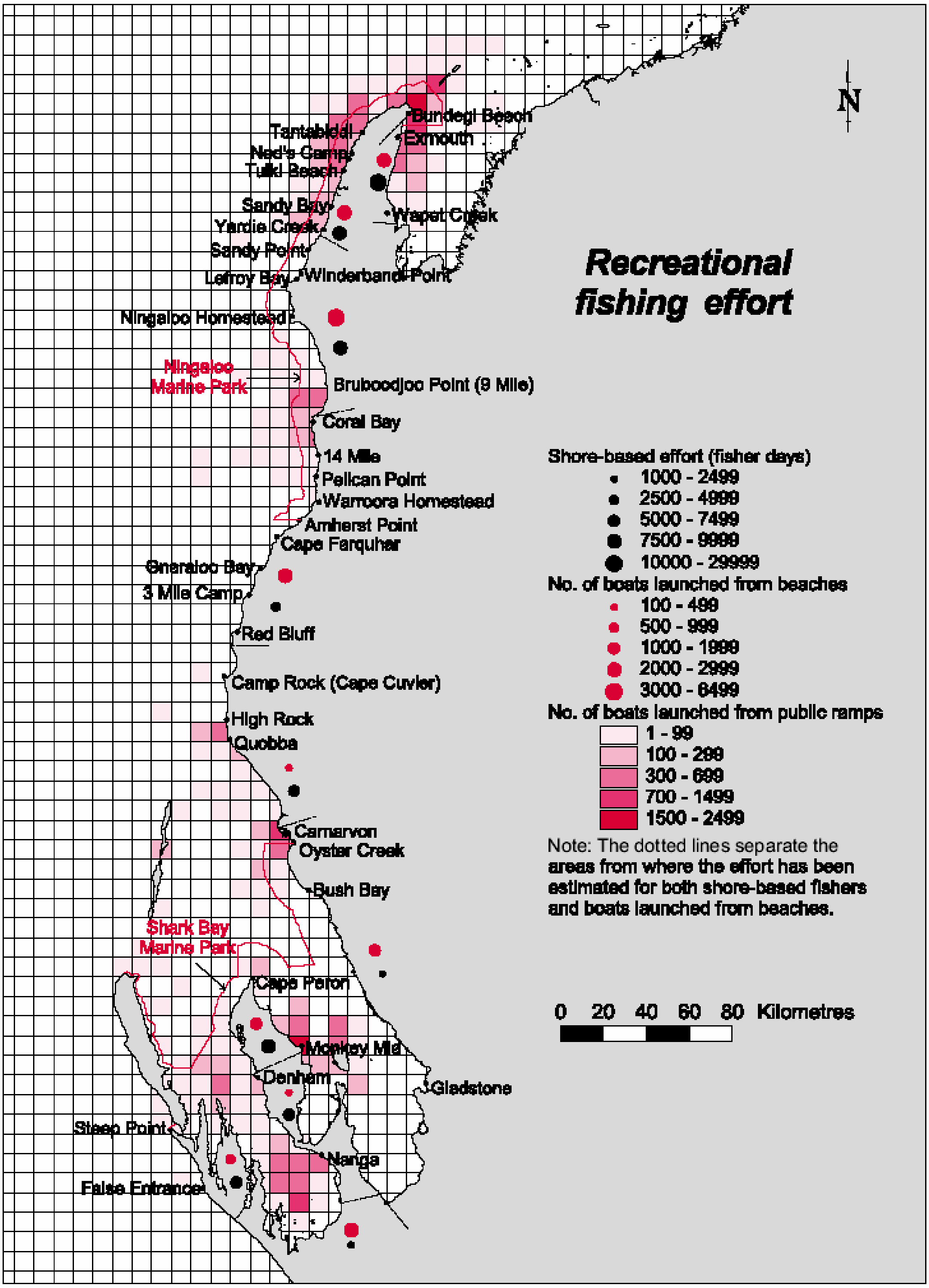

Figure 4.1 Spatial distribution of recreational fishing effort in the Gascoyne bioregion from April 1998 to March 1999 (Sumner et. al. 2002)

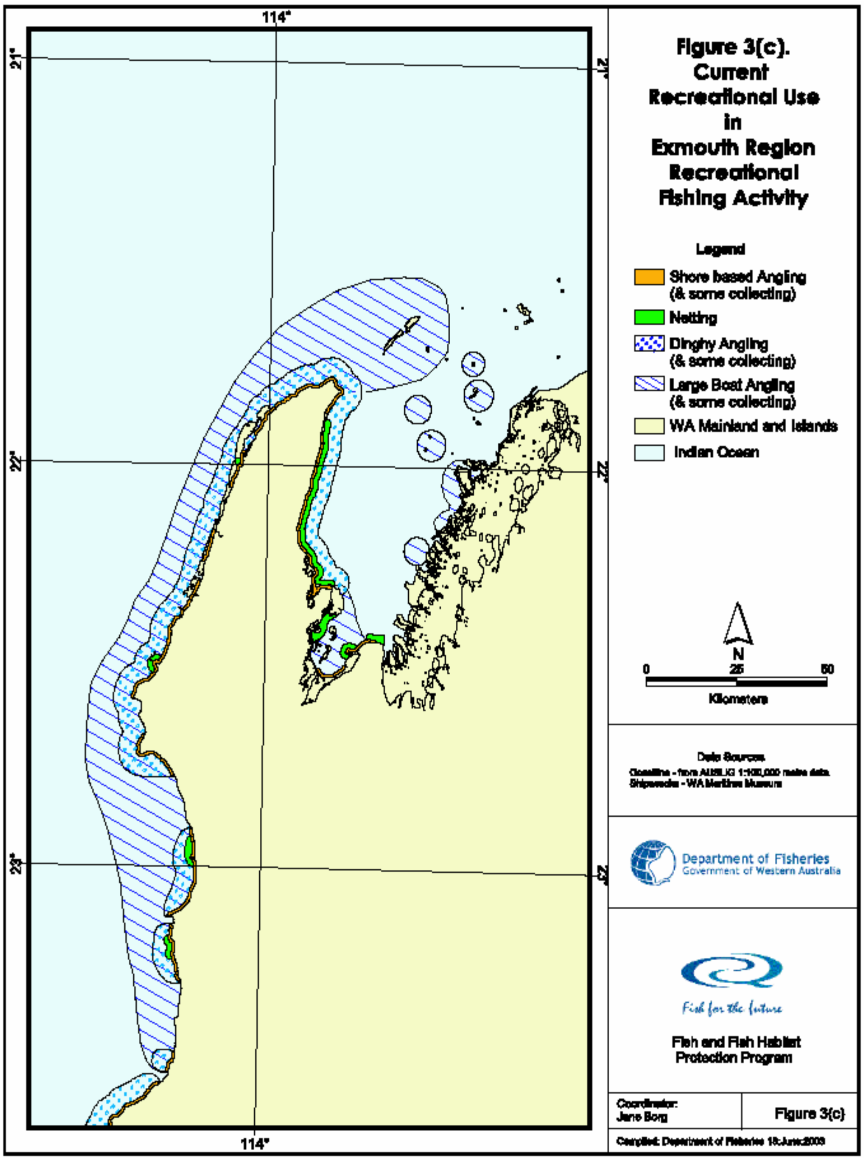

Figure 4.2 **Current recreational fishing activity in Exmouth Gulf region (Department of Fisheries, 2004)**

4.4 Recreational Rock Lobster

There is no significant recreational rock lobster fishing in Exmouth Gulf.

The recreational component of the western rock lobster (*Panulirus cygnus*) fishery is managed under a mix of fisheries regulations including a specific recreational licence. Night-time fishing is prohibited and fishers are restricted to two pots per licence holder. The pots must meet specific size requirements and must have gaps to allow under-sized lobsters to escape. Divers are also restricted to catching by hand, snare or blunt crook in order that the lobsters are not damaged. Minimum size limits apply, and the take of female lobsters carrying eggs is prohibited at all times. A daily bag limit of 8 lobsters per fisher, and a daily boat limit of 16 prevents recreational fishers accumulating quasi-commercial quantities of lobster (Department of Fisheries, 2003).

4.5 Environmental Influences

The main impact of recreational fishing is concentrated around popular resorts, ports and boat ramps. Inshore ecosystems can be affected when boat ramps and access points are provided or improved in an area. Pristine areas can be damaged and high-value fishing areas may be more heavily impacted. There may also be long-term effects on the ecosystem if older, large resident fish are quickly removed. The depletion of pink snapper in the eastern and western gulfs of Shark Bay has shown the high level of impact recreational fishers can have on fish stocks (Department of Fisheries, 2002d).

4.6 Management

The Gascoyne coast bioregion has eight Fisheries Officers working out of three District Offices located at Denham, Carnarvon and Exmouth. During 2003, these officers were supplemented by the seasonal deployment of a mobile recreational fisheries patrol of two additional Fisheries Officers. Collectively, the officers deal with a wide range of recreational fisheries within the region, encompassing boat and shore angling, rock lobster (including diving), netting, crabbing (mud crabs and blue swimmer crabs), and creek fishing (Department of Fisheries, 2003).

A review of recreational fisheries management arrangements for the Gascoyne bioregion has been completed and new management arrangements are due to be implemented (Department of Fisheries, 2003).

4.7 Interactions with Straits Salt project

The Salt project will have the following interactions with recreational fishing:

1. The development of facilities on the east coast of the Gulf may increase awareness of the region and consequently increase fishing pressure;
2. The existence of manned facilities will increase the resources available for emergency use (a positive impact);
3. There will be visual impact on parts of the east coast of the Gulf; and
4. Recreational fishers will seek access to the first stage salt ponds as they will hold fish that have grown up within the ponds.

5 Aquaculture

5.1 Background

A variety of aquaculture activities takes place in Exmouth Gulf. The Gascoyne region's potential for aquaculture is considerable as land availability is high and natural water resources that include hypersaline, marine, brackish, fresh and artesian water are available. In addition, the region supports many fish and shellfish species that are high value and considered good prospects for aquaculture development (Department of Fisheries, 2004).

There are currently 21 aquaculture licenses and 8 pearl farm lease sites in Exmouth Gulf (Figure 5.1). The main aquaculture species are silver lipped pearl oysters (*Pinctada maxima*), black lipped pearl oysters (*P. margaritifera*) and black tiger prawns (*Penaeus monodon*).

Ocean West Fisheries Pty Ltd has a licensed, land-based, multi-species hatchery and grow-out facility at Giralia Bay, in the south-east corner of Exmouth Gulf. Species include finfish, beche-de-mer (sea cucumber), black lipped pearl oysters and wing shells), shrimp and mud crab. Cape Sea Farms Pty Ltd holds an Aquaculture Licence for a 120 hectare prawn farm on the coast at Heron Point, 35 km south of Exmouth (Department of Fisheries, 2004).

A project part-funded by the Fisheries Research and Development Corporation has seen advancements in the development of raceway culture systems for the nursery culture of prawns. In 2002/2003, the M G Kailis Group was given approval to release a significant quantity of hatchery-raised juvenile brown tiger prawns into Exmouth Gulf to evaluate the viability of stock enhancement for prawn fisheries (Department of Fisheries, 2003).

A large-scale land-based aquaculture license has been issued for the first commercial finfish farm in the State, located at Exmouth (Department of Fisheries, 2003). That project is currently focussed on the production of mahi mahi or dolphin fish (*Coryphaena hippurus*).

5.2 Environmental Influence

Two of the biggest concerns related to aquaculture are disease and genetics, especially where the aquaculture results in a mixing of hatchery and wild stock, or wastewater and marine ecosystems. In Western Australia, there are stringent controls in place concerning the translocation of stocks and the release of hatchery stock into the marine environment. Disease testing requirements for hatchery stock are aimed at removing the risk of introducing disease from this source (Department of Fisheries, 2004).

Other potential environmental impacts that can occur from marine aquaculture projects include (Department of Fisheries, 2004):

- Impacts on sensitive benthic habitats such as seagrass, mangroves and corals. These impacts can be either direct through accidental (e.g. from boat anchors) or deliberate clearing; or indirectly as a result of contaminant/pollutant inputs. An example of indirect impacts from contaminant inputs would be changes in nutrient concentrations leading to growth of epiphytic algae on seagrass or corals;

- Disturbance to wildlife;
- Enhanced impacts from nutrients due to poor water circulation at offshore aquaculture sites;
- Visual impacts from poorly located or poorly managed facilities; and
- Discharge of wastewater from onshore facilities: Marine Farms Aquaculture (10km south of Exmouth) and Oceanwest Fisheries Aquaculture (located north of Giralia) both have licences from the Department of Environmental Protection to discharge liquid waste into the adjacent marine environment.

Environmental impacts from current aquaculture operations in Exmouth Gulf are believed to be relatively minor, compared to other environmental impacts that have occurred in Exmouth Gulf since European settlement, such as the introduction of alien fauna (Department of Fisheries 2004), and commercial fishing.

5.3 Interactions with Straits Salt project

The potential interactions between aquaculture and the salt project include:

1. Potential for onshore aquaculture-related activities to be incorporated in the evaporation ponds or close to water supply channels (a positive benefit).

The Exmouth Gulf Aquaculture Plan (Department of Fisheries 2004) recognises the benefits that the establishment of solar salt production facilities would have with regard to providing potential aquaculture facilities. For example, salt fields are highly suitable for the production of *Artemia* (or brine shrimp).

"*Artemia are produced in arid tropical and subtropical environments and used worldwide as a live food in marine and freshwater aquaculture hatcheries. Per unit weight, Artemia may be considered a high-value aquaculture product.*

The culture technology for Artemia is well known; however, as a rule, aquaculture operations producing the species do not have any operational inputs and hence costs, but depend instead on the natural productivity of salt lakes and harvest the desiccated cysts seasonally. Using this production method, the production efficiency is high. The commercial viability of Artemia aquaculture in Exmouth may be good if salt lakes that can provide the requisite production and harvesting areas can be established economically. Large areas on the eastern side of the Gulf have previously been contemplated for salt mining, so the area may suit the construction of evaporative ponds for Artemia production, possibly integrated with salt mining." (Department of Fisheries 2004).

2. Reduced water quality from release of bitterns. Bitterns will be discharged from the barge harbour at Hope Point. The ERMP will provide a detailed assessment of the likely extent of impacts of the bitterns with respect to impacts on water quality, and will outline procedures to be put in place to manage any impacts.

3. Increased risk of introduction of marine pests.

Mooring of international shipping in the Gulf will increase the risk of marine pests becoming established. A separate report (Oceanica 2005) has been prepared on this issue and it will be included with the ERMP, as will a draft Marine Pest Management Plan.

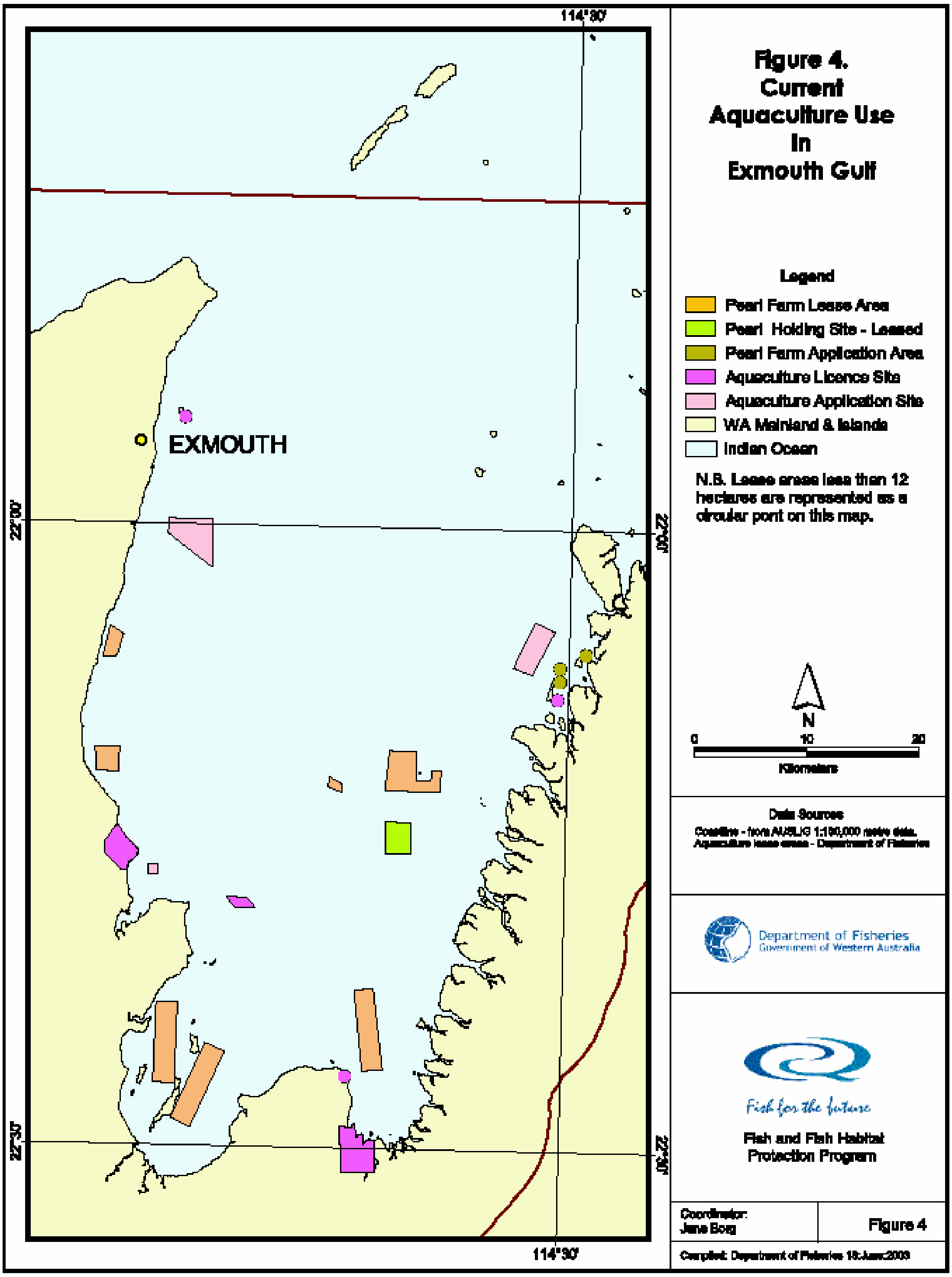

Figure 5.1 **Aquaculture and pearl farming sites of Exmouth Gulf (source: Department of Fisheries, 2004)**

6 Pearling

6.1 Background

In Exmouth Gulf, pearling involves both the capture of wild pearl oysters by diving and the cultivation of pearl oysters on pearl farms. South sea pearls are grown in the silver lipped pearl oyster (*Pinctada maxima)* which occurs naturally in Exmouth Gulf and in all tropical waters of Western Australia.

6.2 Pearl Oyster Fishery in WA

The Pearl Oyster Fishery of Western Australia operates in shallow coastal waters along WA's North coast. The WA pearl industry currently comprises 16 licenses that can collect pearl oysters from Exmouth Gulf to the Northern Territory border. In any given year, there can be between 12 and 16 vessels fishing for pearl oysters (Department of Fisheries, 2003). The pearl industry is the most valuable aquaculture industry in Western Australia and second only to the State's rock lobster fishery in the value of its export earnings (Department of Fisheries, 2003). The value of pearling in the Gulf is difficult to estimate due to the pearl companies preferring to guard their production information closely, but Exmouth Pearls has a quota of 15,000 wild pearl oysters and 20,000 spat. It is thought, but not confirmed, that Exmouth Pearls no longer culture pearls on their Exmouth Gulf sites, but that the sites are used to culture juvenile pearl oysters after they leave the hatchery which lies on the western side of Exmouth Gulf.

Pearl oysters (*P. maxima*) have been fished in Exmouth Gulf since 1961. Without controls or supervision, the oyster beds were degraded and the stocks depleted. The industry was revived a number of times, but stock levels remained in a poor condition (Shaw, 2000). In 1991, the Commonwealth and State Governments agreed to vest management of the fishery in the West Australian Fisheries Joint Authority. Since February 1995, all aspects of the industry have been managed solely by Western Australia in accordance with the *Pearling Act* 1990 which relates specifically to the *P. maxima* and hybrids. Non-*maxima* pearl farms are managed separately under the *Fish Resources Management Act 1994*.

6.2.1 Fishing Grounds

The fishery is separated into four zones (Figure 6.1) to manage wild shell stocks and translocation issues. The zones are:

- ***Pearl Oyster Zone 1***: 5 licensees - NW Cape (including Exmouth Gulf) to longitude 119º30' E.
- ***Pearl Oyster Zone 2***: 9 licensees - East of Cape Thouin (118º10' E) and south of latitude 18º14' S.
- ***Pearl Oyster Zone 3***: 2 licensees – West of longitude 125º20' E and north of latitude 18º14' S.
- ***Pearl Oyster Zone 4***: East of longitude 125º20' E to WA/NT border. Note that although all licensees have access to this zone, exploratory fishing has shown that stocks in this area are not commercially viable. However, pearl farming does occur.

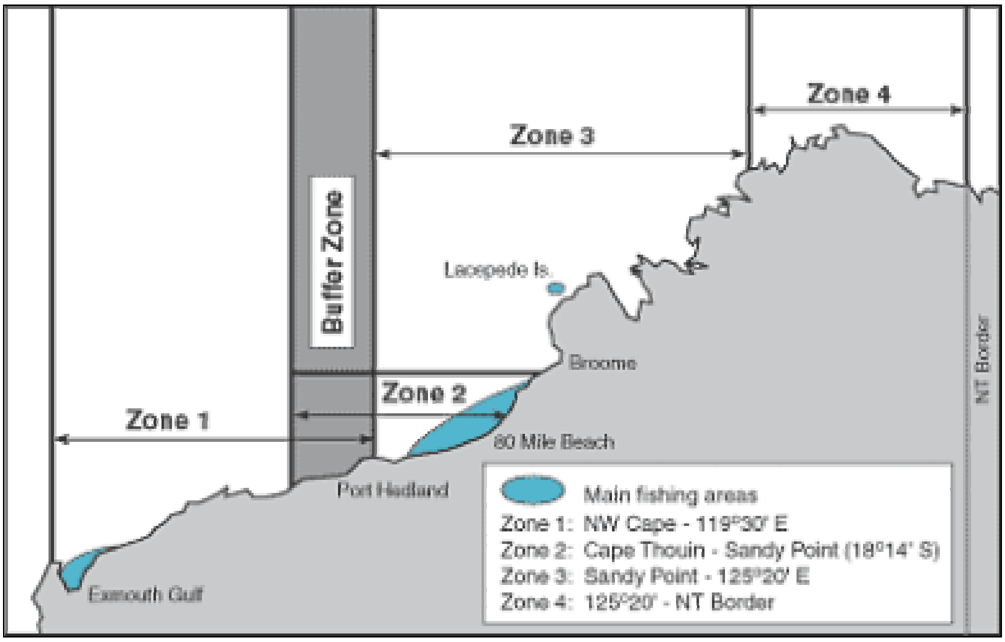

Figure 6.1 The Pearl Oyster Fishery Zones in WA (Department of Fisheries, 2002c)

The area where fishing operates comprises only a relatively small percentage of the total distribution of pearl oysters in this region (<10%) (Department of Fisheries, 2002c). The unfished areas have significant quantities of pearl shells that are either too deep to harvest safely or do not occur in commercially viable densities. Even with the targeted 'culture shell' size range, the efficiency of hand collection results in over 50% of these individuals being left behind (Department of Fisheries, 2002c).

6.2.2 Catches

In 2002, the number of wild-caught pearl oysters was 508,688, of a Total Allowable Catch (TAC) of 534,750 shell (Department of Fisheries, 2003).

In response to concerns regarding the increasing level of effort required to take wild stock quota in Zone 1 (NW Cape), licensees in this zone were allocated a reduced overall TAC of 55,000 shell in 2002. The reported catch of only 29,126 (which equates to 58% less catch than 2001), was well below this allocation, as some licensees chose to use hatchery-reared shells in preference to wild stock. This conversion to hatchery stock is due to a decrease in economic viability of harvesting wild stock culture shell resulting from lower availability of culture-sized oysters and the increased effort required to fill wild stock quotas (Department of Fisheries, 2003). The lower availability of wild culture-sized oysters was attributed to damage of the benthic habitats of traditionally "productive" areas, particularly in Exmouth Gulf, by Cyclone Vance (Department of Fisheries, 2002c).

6.2.3 Fishing Methods

The industry currently relies on the collection of wild caught pearl oysters for the majority of its pearl production stocks, although some hatchery produced pearl oysters are now used to supplement the wild oyster quota in Zone 1 (currently around 50% of the quota for this zone) (Department of Fisheries, 2002c).

The silver lipped pearl oyster is collected individually by divers towed behind specially designed vessels. Fishing generally involves the extension of a large boom from each side of the vessel with a number of weighted ropes hung vertically from each boom to a height of approximately one to two meters from the seabed. Since water clarity is important for divers to collect the pearl oysters efficiently, the height of the weight is carefully controlled to ensure that it does not strike the seabed (Department of Fisheries, 2002c).

At the end of the dives, the pearl oysters are recovered to the vessel and graded; oysters that are too big or too small are returned immediately to the vicinity from which they were taken from. Shells of the target-size are cleaned by cleaver to remove encrusting organisms or medium-pressure water jet; no chemicals are used in the process. The pearl oysters are placed in transport panels and taken to a pearl oyster “fishing holding site”, where they are returned to the sea floor attached to longlines and the site is marked with a surface buoy. The period of up to two months that the pearl oysters remain at the fishing holding sites allows the pearl oysters to recover from the disturbance experienced during fishing (Department of Fisheries, 2002c).

6.2.4 Factors Influencing Pearl Oyster Catches

6.2.4.1 Climate

Environmental factors such as climatic changes, ocean currents, cyclone events and sea temperatures are known to affect the productivity of pearl oyster stocks through survival of spawning stock or recruits, and effects on growth. Mechanisms include:

1. Cyclone induced smothering of breeding stock and recruits;
2. Mortality of larvae; and
3. Variation in growth (temperature and food related).

Similarly, weather conditions can affect visibility for divers and the level of access fishers have to stocks (Department of Fisheries, 2002c).

6.2.4.2 Habitat

Following the start of prawn trawling in Exmouth Gulf, early reports indicated some concern for the pearl oyster grounds. There has been no specific research in Exmouth Gulf on this, but research by Penn and Dybdahl (1988) off the coast of Broome indicated that trawling could be expected to cause some minor accidental damage to adjoining pearl oyster habitat, although the stocks of pearl oysters and king prawns did not overlap markedly (Shaw, 2000).

6.2.4.3 Water Quality

Aquaculture industries require detailed information on the background levels of the productivity of those waters. A simple method of comparing the productivity of different regions is provided by measuring the concentrations of chlorophyll-a in the water column, giving an indication of the biomass of phytoplankton, the drifting (and typically microscopic) plants that form the base of the marine food chain. Chlorophyll information for Exmouth Gulf collected by McKinnon and Ayukai (1996) in September/October 1994 found that the chlorophyll-a concentrations were low (0.15-0.35 μg/L), with the two highest values being from stations near the eastern shore of the Gulf. Pearce *et al.* (2000) suggested that Exmouth Gulf, and most sections of the Western Australian coast, may not be sufficiently productive for successful bivalve aquaculture.

In a detailed review of factors influencing bivalve growth, Saxby (2002) found that successful aquaculture of bivalves generally requires:

- Mean chlorophyll-a concentrations consistently in excess of 1 μg/L;

- Mean annual chlorophyll-a concentrations between 2 and 3 µg/L;
- Water temperatures ranging between 7 and 25^{o}C;
- Adequate water exchange and current flow;
- Sheltered conditions;
- A regular marine or terrestrial source of dissolved nutrient or particulate food; and
- A range of salinity, and a temporal salinity regime, that does not put the animals under prolonged periods of physiological stress.

6.2.5 Seasonal Closures

Fishing begins in early January and continues for up to seven months or until pearl oyster quotas are filled.

6.2.6 Life History

Five species of the genus *Pinctada* (which belong to the Family Pteriidae) occur in Western Australia, including *P. albina* (Shark Bay or bastard pearl oyster), *P. fucata* (Akoya shell), *P. maculata* (pipi), *P. maxima* (silver lipped pearl oyster) and *P. margaritifera* (black lipped pearl oyster). Of these, only *P. albina*, *P. maxima* and *P. margaritifera* are currently being used for pearl production in WA (Department of Fisheries, 2002c).

P. maxima are found from Shark Bay north to Thailand. They are commonly found in areas where the seabed has crevices that allow the young animals to settle into a protected environment, and a hard substratum for them to attach (Department of Fisheries, 2002c).

The breeding season of *P. maxima* begins in September or October and runs though to April or May. Spawning generally occurs from the middle of October to December, and a smaller secondary spawning occurs in February and March (Rose *et al.*, 1990; Rose and Baker, 1994). During the spawning season, gametes are released into the water column where fertilisation occurs. The animals develop into a tiny veliger stage, a planktonic distributional phase which allows the young pearl oysters to reach and colonise new areas if suitable habitat can be found. Settlement usually occurs between 28 and 35 days after spawning. The larvae begin to develop a shell and sink to the bottom. If an appropriate area is found, they settle on it and metamorphose into the juvenile phase. If no suitable settlement site is found within a short period, the larvae die. During the juvenile and adult phases of the life cycle for *P. maxima*, it attaches to the seabed by their byssus threads. Once attached, the connection is permanent and, owing also to their increased mass, the animals have no further ability to colonise new habitats or move to a more favourable position (Department of Fisheries, 2002c).

6.2.7 Environmental Influence

6.2.7.1 Trophic Interaction

In the wild, pearl oysters make up only a small proportion of filter feeders present, and removal of only a small part of this stock would not cause a measurable change to the level of primary productivity and other particulates in the water column (Department of Fisheries, 2002c).

The removal of pearl oysters is also not expected to affect predators, as there is no obligate predator for pearl oysters. Divers target only a small size range of pearl oysters for pearl production (generally less than 170 mm), and less than 10% of a region is fished (Department of Fisheries, 2002c).

6.2.7.2 Benthic Habitat

Pearl divers are towed behind the pearling vessel on work lines hanging from the booms of the vessel. The divers try to keep just above the seabed to avoid increasing turbidity which would limit visibility and reduce their ability to locate pearl oysters. Divers' fishing equipment is maintained at a level just above the seabed by deck tenders to ensure that is not damaged and that it does not hinder diving operations. This, in turn, ensures that the substrate is not negatively impacted (Department of Fisheries, 2002c).

6.2.7.3 General

Live oysters that are found to be unsuitable for pearl production when inspected on the deck are returned to the seabed in the vicinity from where they were taken. There is no evidence that returned oysters suffer from their short period of exposure (Department of Fisheries, 2002c).

6.2.8 Economic Influence

The value of cultured pearls and by-products in Western Australia was estimated to be approximately $130 million for the financial year 2001/2002 (Department of Fisheries, 2003).

There are no published data on the economic effect of pearling on the town of Exmouth. Details of individual cultured pearl operations are also difficult to obtain, for understandable reasons of security and commercial confidentiality.

6.2.9 Management and Environmental Accreditation

The *Pearling Act* 1990 provides the legislative mechanism to control the harvest from the *P. maxima* fishery. The WA Department of Fisheries ensures the legislative basis and employs operational staff to ensure compliance with the critical aspects of the management arrangements for the Pearl Oyster Fishery. This includes assessing and analysing the distribution of fishing effort, catch rates, pearl oyster sizes and the conduct of surveys against agreed indicators. There is an annual review of the performance of the major aspects of the Pearl Oyster Fishery through the completion of the "State of the Fisheries" report. This is updated and published each year following review by the Office of the Auditor General (OAG) (Department of Fisheries, 2002c).

A Pearling Industry Advisory Committee (PIAC) has been established under the Pearling Act to provide the Minister with independent advice on the management of the industry (Department of Fisheries, 2003).

Environment Australia has recently declared that the pearl oyster fishery is being managed in an ecologically sustainable manner under the provisions of the *Environment Protection and Biodiversity Conservation Act 1999* (Department of the Environment and Heritage, 2003).

6.3 Pearl Oyster Cultivation

Once collected, the wild pearl oyster is stored in holding sites (refer 6.2.3). In the past, wild pearl oysters were transported from these sites to farms where seeding was performed (Brown, 2004). However, most West Australian pearl companies now significantly reduce mortality rates that used to occur as a consequence of this transfer by seeding wild pearl oysters (from June to September) at the fishing grounds using vessels that are equipped with clean operating facilities (Brown, 2004).

Following seeding, the implanted pearl oysters are returned to net panels on bottom longlines at holding sites adjacent to the operating sites. Here they remain for up to three months, during which time they are inspected and turned regularly by divers to ensure that an even envelope of nacre secreting cells (the pearl sac) forms around the nucleus. After this stage has been completed, the net panels are retrieved (during October and November) and the implanted pearl oysters are transported by boat to pearl farms in protected coastal bays and inlets (Brown, 2004). The pearls are harvested in the cooler winter months, after about two years of cultivation (Brown, 2004).

6.4 Hatchery Production

Hatchery production of *P. maxima* is of critical importance to the pearl industry in the Gascoyne Coast bioregion, where recruitment of oysters in the wild is irregular and unable to be relied on for commercial operations. There are two hatcheries, one in Carnarvon and one in Exmouth, producing significant quantities of spat to supply pearl farms in the Exmouth Gulf and the Montebello Islands (Department of Fisheries 2002d).

For example, MG Kailis have concentrated all of their pearl oyster spat culturing operations in Exmouth Gulf, however, they culture only very few actual pearls. Almost all of their pearls are cultured in the warmer waters north of Broome where growth rates are much better than the relatively cool waters of Exmouth Gulf.

The emphasis on spat culture in Exmouth has come about through the reduction in fishing wild pearl oysters and increasing their use of hatchery-produced animals. There are greater efficiencies in this method as fishing wild pearl oysters is relatively expensive and there is no control over any genetic issues, while hatchery production allows them to benefit from in-house genetics research programs (such progams are believed to be common in the industry).

It is believed that the future use of hatchery-bred pearl oysters will increase in the Australian industry from its current relatively low levels. However, there is a view that wild pearl oysters yield better quality and superior colours than those produced by hatchery-grown shell (Brown, 2004).

6.5 Interaction with Straits Salt

The potential interactions between pearling and the salt project include:

1. Reduced water quality from the release of bitterns.

Bitterns will be discharged to a barge harbour located at Hope Point. The ERMP will provide a detailed assessment of the likely extent of impacts of the bitterns with respect to impacts on water quality and outline procedures to be put in place to manage impacts (draft Bitterns Release Management Plan).

2. Increased risk of introduction of non-indigenous marine species.

Mooring of international shipping in the Gulf will increase the risk of introduction of non-indigenous marine species. A separate report (Oceanica 2005) has been prepared on this issue and it will be included with the ERMP, as will a draft Non-Indigenous Marine Species Environmental Management Plan.

7 Blue Swimmer Crab Fishery

Experimental fishing for the blue swimmer crab (*Portunus pelagicus*) occurred in the region during 2002/03, with dedicated crab trap fishers operating intermittently throughout the year. Total blue swimmer crab landings were 30.5 tonnes, a 43% increase over the 21.3 tonnes taken in 2001/02 (Department of Fisheries 2003). Conversely, the retained catch from trawlers operating in the area fell considerably. During 2002/03, trawlers retained 3.1 tonnes of blue swimmer crabs, compared to 17.5 tonnes in 2001/02 (Department of Fisheries 2003). In the Gascoyne region, the Carnarvon Crab Trap Developmental fishery is anticipated to become a managed fishery by the end of 2005 and the Exmouth Gulf Crab Trap Developmental fishery currently has one active participant (M. Kangas Pers. Comm.).

7.1 Management

The principle management tool to ensure sustainability in the commercial crab fisheries is maintaining minimum size limits well above the size of sexual maturity of crabs. Blue swimmer crabs become sexually mature below 100mm (carapace width) while legal minimum sizes range from 127 mm to 135 mm in the different commercial crab industries (Department of Fisheries, 2003).

Acceptable catch rates for Exmouth Gulf are yet to be derived due to the lack of a sufficient time series of commercial fishery data. Currently there is no monitoring or research program in the region. License holders in the Exmouth Gulf Beach Seine Fishery are permitted to take blue swimmer crabs by drop net or set net (Department of Fisheries, 2003).

7.2 Interaction with Straits Salt

There is not expected to be any interaction between the blue swimmer crab fishery and the Straits Salt project due to the small scale of the fishery and the very limited scale of the salt field interaction with the marine environment.

8 Tropical Rock Lobster

8.1 Overview

Commercial fishing for tropical rock lobsters is relatively new, with an increased interest in the early 1990's. There are two licensees in the fishery, and both are currently active within the Gascoyne bioregion (Shaw, 2000). The main fishing method is diving because tropical rock lobsters will not normally enter baited pots.

There are two main species of tropical rock lobster taken in the Gascoyne Region: the green rock lobster (*Panulirus versicolor*) and the ornate or painted rock lobster (*P. ornatus*) (Department of Fisheries, 2003). Both have distinctive colourings and are common in waters north of Ningaloo Reef. They are found in shallow waters and are often associated with coral reefs. The species have a wide Indo-Pacific distribution and consequently a widespread larval distribution (Shaw, 2000).

Current catch and estimated value to fishers is not available while breeding levels are unknown and a stock assessment has not been completed. The fishery is considered under-exploited, but periodically areas of local depletion occur (Shaw, 2000).

Commercial fishers are required by law to return monthly catch and fishing effort data on all species retained. Tropical rock lobsters are caught incidentally south of Point Quobba, but are significant in the Exmouth Gulf and northern Ningaloo Reef area (Shaw, 2000).

It is understood that the commercial fishery is currently being closed through a Voluntary Fisheries Adjustment Scheme in response to pressure from recreational lobby groups (Shaw, 2000).

8.2 Interaction with Straits Salt

There are not expected to be any interaction between the tropical rock lobster fishery and the Straits Salt project due to the small scale of the fishery.

9 Marine Aquarium Managed Fishery

The Marine Aquarium Managed Fishery comprises 13 licensees who operate throughout Western Australian waters under the Marine Aquarium Fishery Management Plan 1995. The fishery targets in excess of 250 different species of fish for the marine aquarium industry, but catches are fairly low in volume because of the special handling requirements of live fish (Department of Fisheries, 2003).

Commercial fishers do not have designated areas, but many tend to fish in their 'home areas' (Shaw, 2000).

Fish are collected throughout WA for the local and overseas (USA and Asian) market. To date, most collecting and marketing has been for the local market and is considered to be at a relatively low level by national and international standards.

Principle fishing areas, value of the fishery, exploitation status, current catch and effort data are unknown. Stock assessment has not been completed and breeding stock levels are unknown (Shaw, 2000).

9.1 Environmental Influence

Overfishing or localised depletion of some species could be an issue. However, there is no evidence of this and it is unlikely in the Gascoyne region because of the small and restricted number of commercial fishers. The high natural mortality rate of many small fish also makes them resistant to low levels of exploitation (Shaw, 2000).

9.2 Management and Environmental Accreditation

The Fishery was reviewed in 1991 and the number of licensees increased to 25 in 1994. Because annual performance criteria had to be met to retain the license, the number of licenses in the fishery has declined to the current 13 (Shaw, 2000).

Fish caught in the fishery cannot be used for food purposes. Operators cannot take juvenile specimens of the commercially exploited species where there are specific size limits, and are not permitted to take species for which there are specific management arrangements or management plans. The fishery's management plan establishes the legislative controls on the number of licenses and operators, vessel size and permitted means of capture (Department of Fisheries, 2003). There are also controls on the level of effort that can be expended, regulated by limits on the number of boats and the number of crew able to fish (Shaw, 2000). Other legislation imposes constraints on the areas in which commercial collecting of marine aquarium species can be undertaken (Department of Fisheries, 2003).

It is a legal requirement for all fishing license holders to fill in monthly log books indicating the area fished (in 1° blocks), type and number of fish caught. The Department of Fisheries enter these returns in a database, but there is presently no workable system in place to validate the returns or analyse the data (Shaw, 2000).

The size and extent of the recreational marine aquarium fishery is unknown. There are no specific management arrangements for recreational fishers taking aquarium fish, other than the recreational bag limits of 40 fish per species per person per day. Although there is no information on the quantities taken, it is not considered to impact significantly on local fish populations (Shaw, 2000).

The fishery currently meets the reporting requirements of DEH specifically in relation to the commercial harvest of syngnathids (sea horses, sea dragons and pipefish), and a proposal to provide for all licensees in the fishery to take limited quantities of live rock, live sand, coral and selected invertebrates is under development (Department of Fisheries, 2003)

9.3 Interaction with Straits Salt

There is not expected to be any interaction between the Marine Aquarium Managed fishery and the Straits Salt project due to the small scale of the fishery in the Gulf.

10 Specimen Shell Managed Fishery

10.1 Background

The Specimen Shell Managed Fishery targets a range of specimen shell species along the entire Western Australian coastline, except where there are specific closures, for example within some marine parks and aquatic reserves. The fishery has 34 licensees who operate under the Specimen Shell Management Plan 1995 (Department of Fisheries, 2003). Licensees do not have designated fishing areas and often fish their 'own territory' (Shaw, 2000).

10.2 Environmental Influence

The fishery is selective, taking only perfect shells and keeping numbers low to prevent 'market flooding'. Collection in the Gascoyne is only possible for a short time of the year because of adverse weather conditions and turbidity (Shaw, 2000).

10.3 Management

The number of licenses in the fishery (34) is fixed and there are limitations on boats and crew numbers. There are restrictions on where fishing can occur, but each license holder can fish anywhere around the coast. Participants in this fishery are not permitted to take any species of the genus: *Haliotis* spp. (abalone), *Pinctada* spp. and *Pteria penquin* (pearl oysters), *Pecten* spp. (scallops), *Mytilus* spp. (mussels), *Amusium balloti* (saucer scallops), *Tectus niloticus* (turban shell) and *Tridacna spp* (giant clams). The take of molluscs of the Order Sepioidea (cuttlefish), Teuthoidea (squid) and Octopoda (octopus) is also prohibited (Shaw, 2000).

There is limited catch data and no effort data available for this fishery. It is a legal requirement for all fishing license holders to fill in monthly logbooks, indicating the area fished and the type and number of fish caught. The Department of Fisheries enter these returns onto a database, but there is presently no workable system in place to validate the returns or analyse the data. The value of the fishery is unknown, a stock assessment has not been completed and breeding stock levels and exploitation status are unknown. However, licensees have a good working knowledge of the abundance of stocks and collection limitations. Licensees are particularly concerned about the illegal take of molluscs and localised depletion (Shaw, 2000).

A Specimen Shell Management Plan was completed in 1995 to allow for the export of specimen shells from WA waters under the Commonwealth *Wildlife Protection (Regulation of Export and Imports) Act 1982*. The plan was amended in 1997 to clarify that specimen shells were to be taken for their shell only - the meat cannot be taken for any purpose (Shaw, 2000). An ecological sustainability report addressing the fishery is to be prepared and submitted to the DEH, applying to have the fishery's products approved for export in future under the Environment Protection and Biodiversity Conservation Act 1999 (Department of Fisheries, 2003).

10.4 Interaction with Straits Salt

There is not expected to be any interaction between the Specimen Shell Managed Fishery and the Straits Salt project due to the small scale of the fishery in the Gulf.

11 Other Vessel movements

The primary vessel movements within the Gulf are associated with the prawn trawlers as discussed in Section 2.10. In addition to the prawn trawlers, the following vessel movements occur.

11.1 Shipping

Exmouth is occasionally visited by passenger cruise liners and large naval and research vessels. These ships moor at Exmouth and rarely enter further south into the Gulf.

11.2 Oil & Gas Exploration

Exmouth Gulf is covered by prospective oil and gas leases. It is occasionally surveyed, but oil and gas exploration is not a significant source of vessel movements in the Gulf.

11.3 Pearling and Aquaculture

There are regular passages between Exmouth Marina, the MG Kailis factory near Learmonth and the pearl and aquaculture leases around the Gulf (refer Figure 5.1 for locations). For example, divers are transported daily to and from pearl holding areas to clean pearl oysters. The vessels used are generally fast aluminium craft of 10-14 m length.

11.4 Charters

A number of charter boats operate out of Exmouth, the number varying with season. There would currently be fewer than 20 operators and licenses are tightly controlled by the Department of Planning and Infrastructure.

The charters are generally focussed on the Ningaloo Marine Park or the Muiron Islands. However, during the months of peak humpback whale aggregation, operators run whale-watching tours in the deep area of the Gulf. Self-charter boats are also available for hire and these are occasionally used by fishers to access the east coast of the Gulf.

11.5 Recreational

Locals at Exmouth enjoy fishing and visiting the east coast of the Gulf when conditions are suitable for small boats. However, the frequent strong winds, the distance across the Gulf (approximately 40 km) and the proximity to other attractions such as Ningaloo Reef and the Muiron Islands means that recreational boating is not a significant source of vessel movement across the Gulf.

11.6 Exmouth Marina

The Department of Planning and Infrastructure (DPI) is responsible for the operation of the marina at Exmouth. DPI supplied recent (21/2/05) data on vessels in the marina which are summarised in Table 11.1. The numbers are likely to be low in the annual cycle because February is in the off season for tourism and prawning, and commercial vessels are normally undergoing maintenance or are elsewhere in WA at that time. There were 34 vessels in pens in the marina on the 21st of February; the marina has a capacity of 50 pens (eight trawler pens; three 25 metre pens; twelve 20 metre pens; fourteen 15 metre pens; and, thirteen 10 metre pens).

Table 11.1 Vessels in Exmouth Marina as at 21/2/2005

Vessel size	Number in Marina	Comments
5 to <10 m	4	
10 to <15 m	16	
15 to <20 m	10	
Trawlers	4	Trawlers off season and being moved between pens and the service wharf for maintenance

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Appendix 10
Revised Table 5-6 from ERMP

Revised Table 5-6 from ERMP: Reservation priority ecosystems within the Cape Range subregion as they relate to the project area, and maximum % of disturbance within each vegetation type

Ecosystem (CALM 2002)	Reservation priority	Equivalent vegetation type within the project area	Location and likely impacts	Maximum % of disturbance within equivalent vegetation type within project area
Medium Woodland; Coolibah (*E. microtheca**)	High	Ambiguous community description. Possible equivalent to 3b: Coolibah *Eucalyptus victrix* Low Woodland over Grassland on vegetated claypans. There were some patches of *E. victrix* also within dune swales (Vegetation Type 2c).	Mainly inland. May be minimally affected by access road construction. Borrow pits have not been selected but are likely to be along the access track and these areas will be avoided.	Vegetation Type 2c: 1.6
Bare Areas: mudflats	High	Ambiguous community description. Possible equivalent to 4: Saline mudflats (devoid of vegetation). Could also refer to tidal mudflats.	Salt located in this area. Soil will be disturbed and salt flats inundated. The study area covers a large proportion of the largest expanse of supratidal salt flats in the Cape Range sub-Bioregion.	N/A (devoid of vegetation)
Succulent Steppe: samphire	High	1a: Island and coast margins and inland saline flats: Samphire.	Island margins and saline flats on islands will be inundated. Inland samphire flats should only be minimally affected by access road.	4.4
Open Dwarf Scrub, waterwood (*Acacia coriacea*) on recent dunes	High	Ambiguous community description. Probably equivalent to 2d: Semi-consolidated Linear and Parallel Dunes.	Mainly in the centre of islands and inland. Minimal impact expected, although these areas are vulnerable to slow decline through Buffel grass invasion. Increased fires or soil disturbance may aid Buffel spread.	0.8
Bare Areas: claypans	High	3a: Bare Claypans.	Some island claypans may be inundated. Inland claypans may be affected by quarries and construction of access track or borrow pits, which are likely to be located at intervals along the access track.	0.02
Shrublands*: Acacia sclerosperma* and *A. victoriae*** scrub	Medium	2c: Sparse Mixed shrub and *Acacia* species over *Triodia epactia*.	This vegetation type is widespread in the study area, occurring on islands and the mainland. Low lying areas may be inundated on islands. Level of disturbance on mainland will depend on where quarries and borrow pits are to be located. This area will be vulnerable to Buffel grass infestation if disturbed.	1.5

Source: adapted from Biota 2005a

* *Eucalyptus microtheca* in this area is now *E. vitrix* ** *Acacia victoriae* in this area is now *A. synchronicia*

Appendix 11
Hope Point Habitat Mapping 2007 (Oceanica 2008)

Oceanica Consulting Pty Ltd (Oceanica) 2008, *Yannarie Solar Hope Point Mapping: 2007*, report prepared by Oceanica Consulting Pty Ltd for Straits Salt, January 2008 (final report to be provided at a later date).

Appendix 12
Fate of sediments suspended by dredging (APASA 2005c)

Yannarie Salt Farm Project for Straits Resources

Phase 2 Draft Report

Fate of sediments suspended by dredging

Asia - Pacific Applied Science Associates

Marine and Freshwater Environmental Modelling

4. Quantification of suspended sediment and sedimentation loads associated with dredging

4.1 Background

Straits Resources propose to dredge a 125m wide, 800m long and 3m deep channel to provide access by barges to a boat harbour that would be constructed at Hope Point. Dredging of the channel would be expected to suspend sediments into the water column and therefore generate locally-elevated levels of suspended sediments and sedimentation during the period of the dredging. Modelling was undertaken to estimate the above-background concentrations and distribution of suspended sediments and sedimentation that would be generated by the operation. Geochemical studies of the sediments and bedrock along the dredge path indicate that the seabed consists of natural marine sediments overlying limestone pavement so that release of chemical contaminants is not an issue of concern from this operation. Thus, the study focussed upon the potential for harmful levels of turbidity and the potential for smothering of benthos.

4.2 Model selection

Modelling of the fate of sediments suspended by the dredging operation was carried out using the SSFATE model jointly developed by Applied Science Associates (ASA) and U.S. Army Corps of Engineers (USACE) Environmental Research and Development Center (ERDC). It is a windows-based version of the SSFATE model initially developed by USACE, based on extensive empirical measurement during dredging operations. SSFATE has an embedded geographic information system (GIS) for defining the location and nature of natural resources, and a suite of models that predict the transport, dispersion, and settling of suspended material released to the water column as a result of dredging operations. The focus of the model is on the far-field (i.e. outside of the initial release zone) processes affecting the fate of suspended sediment. The model simulates suspended sediment source strengths (i.e. rates of discharge) and vertical distributions of sediments generated by different types of mechanical or hydraulic dredges, sediment dumping practices or other sediment-disturbing activities such as jetting or plowing for pipeline burial. The model then simulates the transport, sinking and settlement of sediment particles as multiple sediment types or fractions. The model uses the proportional representation by five sediment size classes, corresponding to the diameters of coarse and fine sands, coarse and fine silts and clays. Settlement is calculated based on sinking rates of the particles, shear stress in the water column and critical settling velocities for each particle class. The model also incorporates enhanced settlement rates for clay- and fine-silt sized particles due to flocculation, based on measurement during multiple dredging operations (Teeter 1998, Swanson *et. al.* 2004).

Horizontal transport, sinking and turbulence-induced rise of each particle is modelled independently at each time step and the position recorded as a vertical and horizontal location within a borderless space to avoid errors associated with boundary effects. Following particle-transport calculations, concentration fields at each time step using a dynamically-evolving grid. The volume of all cells (length, width, depth) is fixed within this grid but the number of cells increases over time with the horizontal extent of the plume, thus ensuring that concentration estimates are comparable over the period of the simulation. These cell volumes are user-defined and independent of the resolution of the circulation data, and therefore, concentration fields can be estimated at higher spatial resolution than the available hydrodynamic data, thus supporting the spatial differentiation of high concentration patches.

Model outputs consist of suspended sediments concentrations, as contours in both horizontal and vertical planes, time-series plots of suspended sediment concentrations, and thickness contours of sediment deposited on the sea floor. Sediment particle movement and the evolution of concentration fields may also be animated over GIS-layers depicting sensitive resources.

4.3 Application of the Model to this Study

Surveys of the proposed channel route indicate that the operation would involve dredging of two major sections (Figure 1). The offshore section, measuring 125 m wide and 400 m long, would involve removal of overlying loose sediment with an average thickness of 300mm. The estimated volume of material in this section is 20,625 m^3, with an anticipated time for removal of 1 week (7 days). The inshore section, measuring 125 m wide by 480 m long would involve removal of limestone bedrock with a thin layer of overlying sediments. This latter section of the channel contains the bulk of the material to be removed with 284,625 m^3, inclusive of batter, and has an anticipated removal time of 3 months (120 days). Straits Resources reported that material recovered from the seabed would be discharged onto evaporation basins onshore for use in earthworks so that it is assumed that the only sources of suspended sediments generated by the operations would be material disturbed by the dredging equipment. An average loss rate of 3% of the removed material (totalling 305,250 m^3) was assumed, totalling 9,157.5 m^3 of sediment discharge for the two sections.

The average removal rate of sediments was calculated on the basis that the dredger would be active for half the number of hours within the defined dredging durations, assuming that the operation would proceed during daylight hours only, giving a total dredging time of 1,524 hours. This yielded an average removal rate of 245 m^3/hr and thus an average discharge rate of 7.35 m^3/hr. SSFATE was set to suspend sediments as a moving source, representing the progression of the dredging operation from the offshore end of the dredging pocket. The speed of movement was controlled by the removal rate and the cross-sectional area of the dredge channel, calculated as the product of the channel width and depth. To account for changing depths of the limestone (increasing on approach to shore), discharge through the limestone section was treated as discharge from 8 contiguous sections, with a decreasing rate of movement through each section. Thus, discharge close to the shore (where the limestone has greatest depth) was for longer than further offshore.

Size-distributions of material discharged from the offshore section, where no bedrock has to be removed, were assumed to be the same as that of the overlying sediments. Average size-distributions of two sediment samples (Designated as T2_S2 and T2_S1) collected at adjacent sites off Hope Point by Oceanica, and measured by the CSIRO Division of Minerals, were available as input into the model. Sediments in this section consist primarily of coarse sands, with < 3.5% by mass as silt and clay-sized particles (Table 1). Material within the second section, consisting of solid rock, must be cut or broken to clear and a range of particle sizes could be created in the process. The dredging method and equipment that will be used for this section is yet to be determined, however, as a conservative measure, it was assumed that rock grinding would be required for the limestone section and, therefore, a large proportion of the released sediments would be fine “rock-flour” (Table 2) and, hence, will remain suspended for longer than coarser particles. Size-fractions of sediments suspended by limestone rock-grinding at Geraldton (GEMS 2003) were used to represent the size-distribution of sediments from this section. Silt and clay-size particles were assumed to represent 100% of this material, with clay-size particles contributing 60%.

Initial vertical distributions of suspended sediments were based on typical distributions measured for cutting-head dredgers (Swanson *et. al*. 2004), with consideration for the available water depth over each section. The offshore section has an average water depth of about 2.7m CD while the inshore section has an average depth of about 1.5 m CD. Sediments were assumed to suspend throughout the water column in each section, but to be concentrated in the lower part of the water column. For the offshore section, where a cutter-suction dredger is most likely to be used, it was assumed that 85% of sediment particles, by mass, would be concentrated in the lower 1.5 m (following Swanson *et al*. 2004). For the inshore section, highest concentrations were still assumed to be closest to the seabed but with a more even spread throughout the lower to mid water-column, representative of a leaking source moving up through the water column such as an excavator or open bucket–type dredger.

Settling rates for the suspended particles were calculated using Stokes equations for the particle-size classes and assumed that the sinking rates of the smaller size-classes (clays and fine silts) would increase due to flocculation using a concentration-dependent algorithm. Suspended material was assumed to have a density of 2,700 kg/m^3, appropriate to limestone and local sediments. The model applied a bathymetric grid for the study area to define the fall distances below particles, given their vertical and horizontal position in the water column. SSFATE also calculates settling probability for particles of a given size based on critical settling velocities to account for the resistance to settling caused by excessive current speeds and associated turbulence at the seabed. However, APASA received instructions to specify settling for all particles uniformly as the point at which particles reached the seabed. Therefore, resistance to settling was limited to shear-induced turbulence within the water column. This is calculated by the model using a depth-dependent formulation. Resuspension of previously settled particles by currents or wave action was not represented.

SSFATE uses time-varying two or three-dimensional current fields to represent hydrodynamic transport of particles. As the spread of particles could be potentially large, we applied three-dimensional current data generated by the HYDROMAP model over the regional-scale (see section 2.) The HYDROMAP current data provided current fields at 5 vertical levels, at hourly time steps for a 3 month period and was produced using forcing from tides and the HIRES spatial wind field for November-December 1994. As this wind data was from a summer period, the predominant wind direction was south-westerly and, therefore, at an oblique onshore-angle to the eastern coast, which resulted in a net-northward longshore drift in the sample current data. These conditions were likely to maximise the northward transport of sediment plumes as well as the interaction of the plume with the creeks and shallow-water habitats along the coastal margin. While the discharge is estimated to persist for ~127 days, the available current data had shorter duration. Thus, durations of the simulations were shortened to 60 days, and two separate simulations were run. One simulation used the calculated rate of discharge (and thus half the total discharge mass) to predict the resulting suspended sediment concentrations. The other used a scaled up rate of discharge that resulted in complete discharge of the full discharge mass in 60 days, and was used to define sedimentation levels.

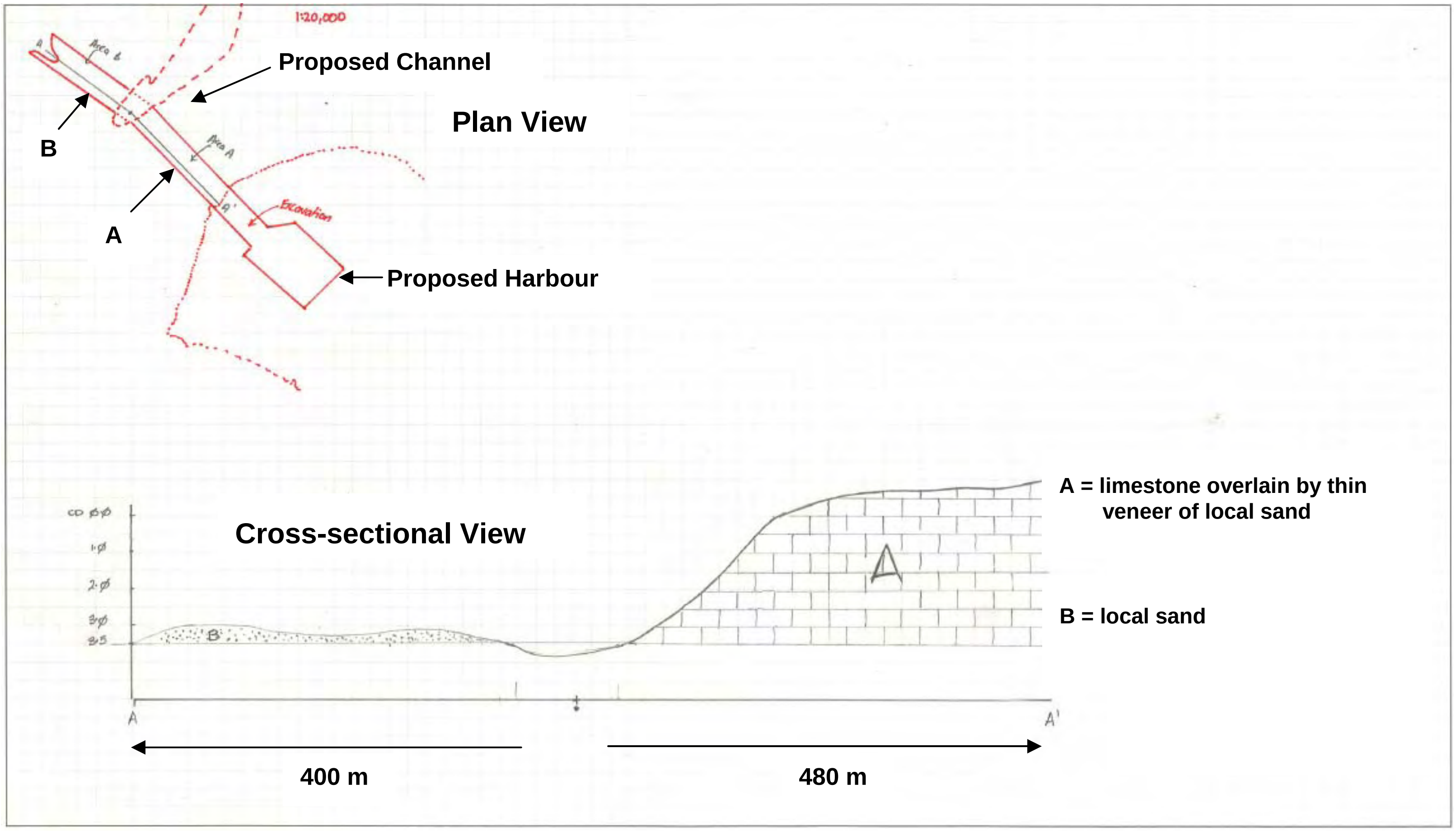

Figure 1: **Plan and cross-sectional view of existing bathymetry along the proposed access channel.**

Table 1: Assumed size and vertical distribution of sediments suspended by dredging operations: offshore section.

Size class distribution	
Particle class	% of release mass
Clay	1.46
Fine silt	0.96
Coarse silt	1.06
Fine sand	0.7
Coarse sand	95.82

Vertical distribution of sediment (all classes) in the water column	
Distance from seabed (m)	% of mass
4.23	5
3	10
1.5	15
0.5	20
0.1	50

Table 2: Assumed size and vertical distribution of sediments suspended by dredging operations: inshore section.

Size class distribution	
Particle class	% of release mass
Clay	60
Fine silt	30
Coarse silt	10
Fine sand	0
Coarse sand	0

Vertical distribution of sediment (all classes) in the water column	
Distance from seabed (m)	% of mass
2	5
1.8	10
1	15
0.5	30
0.1	40

4.4 Modelling Results

Modelling indicated that sediments suspended by dredging operations would tend to migrate with a combination of wind and tidal driven circulation. The plume is predicted to oscillate inshore and offshore with the tide and to drift slowly northeast with the net northward longshore current set up by onshore winds. This is expected to result in the migration of plumes across the creek deltas adjacent to Hope Point (Figure 2). Simulations indicated generally low concentrations of suspende sediment would be generated during dredging of the offshore section, with maximum concentrations in the range 3-5 mg/l above background occurring locally around the dredging site due to rapid setting of the predominantly coarse sands that would be suspended in this section. Dredging of the inshore section, where it was assumed that rock grinding would produce a high proportion of very fine sediments (< 10 μm), was predicted to produce higher concentrations of suspended sediments over a wider area (Figure 2 bottom).

Plumes of suspended sediment generated from the inshore section were predicted to persist within the water column for some time (hours) due to the low settling velocity and susceptibility to turbulent mixing of this fine material. The predominant drift direction was predicted to be northward under the sample conditions, and therefore over the shallow waters between Hope point and Tent Island and extending on occasion beyond Tent Island. Plumes were also predicted to migrate on occasions into the delta of Scotts Creek to the south of Hope Point.

Integration of the instantaneous maximum concentrations predicted for each location surrounding the source throughout the simulation indicated that suspended sediment concentrations within 400 m of the dredger could be expected to exceed 100 mg/l at some point in time while peak concentrations exceeding 55 mg/l could be expected up to 4000 m from the source. It should be understood that the peak instantaneous concentrations shown in Figure 3 & 4 are not contemporaneous for each location. Concentrations were predicted to be highly variable over time and space, with patches of higher and lower concentrations being generated at the source and these patches dispersing with distance. Examination of the time-varying concentrations expected at sites along the drift path (Figure 5) indicated that long-term average concentrations would be up to 50 mg/l within 200 m of the dredger, decreasing exponentially to about 10 mg/l at 5 km and < 2 mg/l at 12 km. Thus, the peak instantaneous concentrations shown in Figures 3 & 4 should be expected to occur only as infrequent and short-lived (< 1 hour) episodes. In terms of the potential for repeated exposure to above-background suspended sediment concentrations, locations as far as 3000 m from the dredger could be expected to experience concentrations exceeding 50 mg/l at least once per day over several days in a row and locations up to 6,000 m from the source could experience daily exposure to concentrations exceeding 25 mg/l during the operation. Tidal flooding and ebbing is expected to play a major role in the concentrations occurring over a given location, as the plume tends to migrate inshore and offshore with the tide.

Examination of the settling patterns of individual sediment size-classes indicates that material will settle out at rates determined by their size, with coarse sands expected to settle within 1,200 m of the source and fine sands and coarse silts settling within 6,000 m (Figure 6, top). Only the fine-silts and clay-sized particles are expected to remain suspended within waters extending to Hope Point and only clay-sized particles are expected to drift beyond Tent Island. The extended drift of these particles can be attributed both to their slow sinking rates and susceptibility to turbulent mixing within the shallow waters extending along the inshore zone. Cumulative deposition patterns predicted from the operation, assuming that particles remain settled where they first settle and are not subsequently resuspended and moved by waves and currents, indicate that the bulk of material would settle within 5,000 m of the dredge channel, with settlement rates decreasing exponentially with distance from the source (Figure 6, bottom). Highest cumulative sedimentation loads (13 kg m^{-2}) were predicted for locations immediately neighbouring the dredge channel, with material primarily consisting of coarse sand. Average daily sedimentation rates were predicted to decrease from 216 g d^{-1} adjacent to the channel to ~ 60 g d^{-1} within 1,500 m and 12 g d within 2000 m (Figures 7 & 8). Locations greater than 7000 m from the dredger are not expected to receive > 1 g d^{-1}. Peak concentrations adjacent to the dredging equate to a thickness of approximately 7 mm, but the cumulative thicknesses were expected to decrease rapidly to < 1 mm within 2000 m and to be < 0.01 mm over the larger part of the total area of sedimentation (Figure 9).

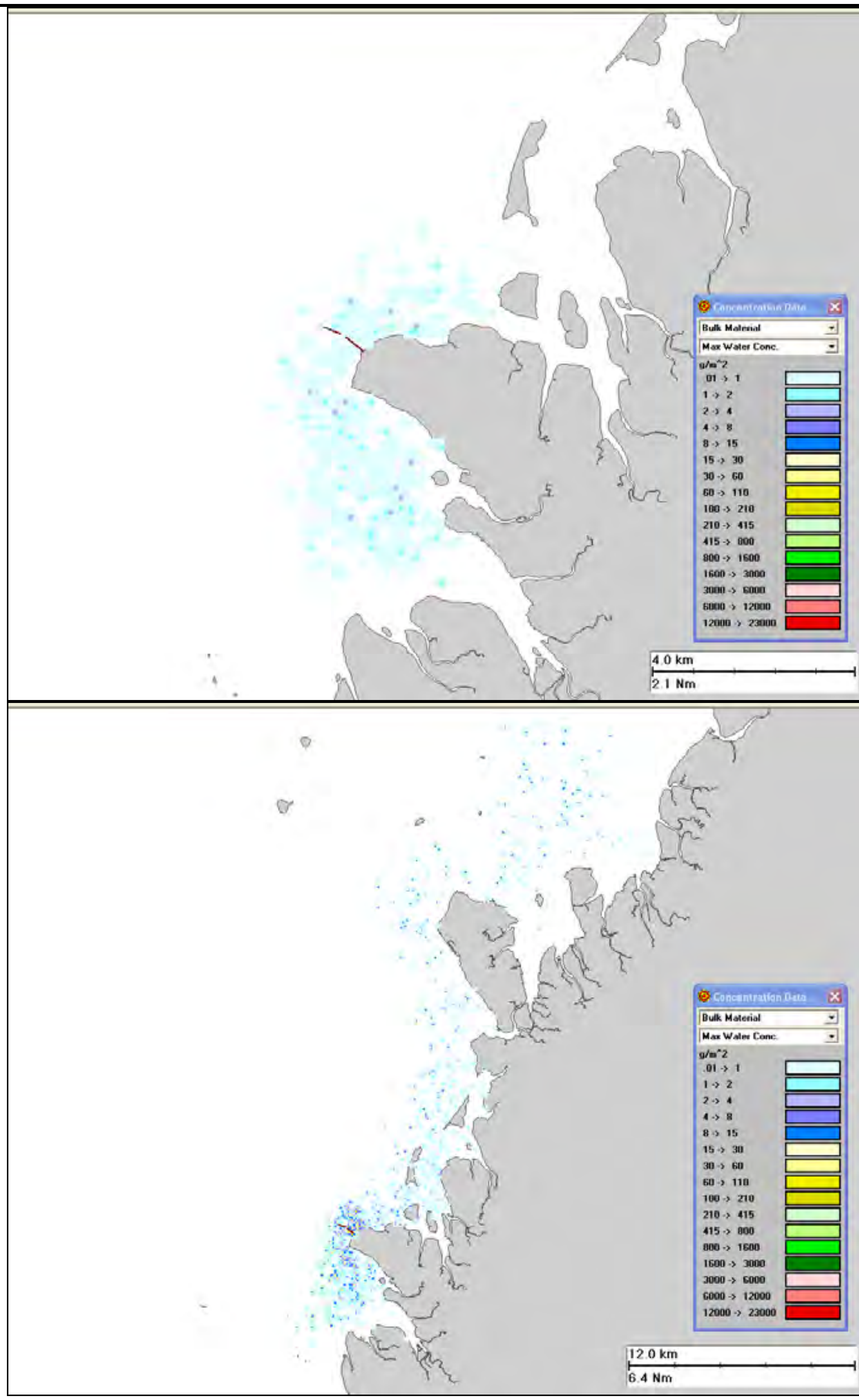

Figure 2: **Examples of the instantaneous suspended sediment concentrations (mg/l or g/m^3) expected during dredging. Upper image is for the offshore section. Lower image is for the inshore section. Brown lines indicate the axis of the dredging sections. Note the different scales of each image.**

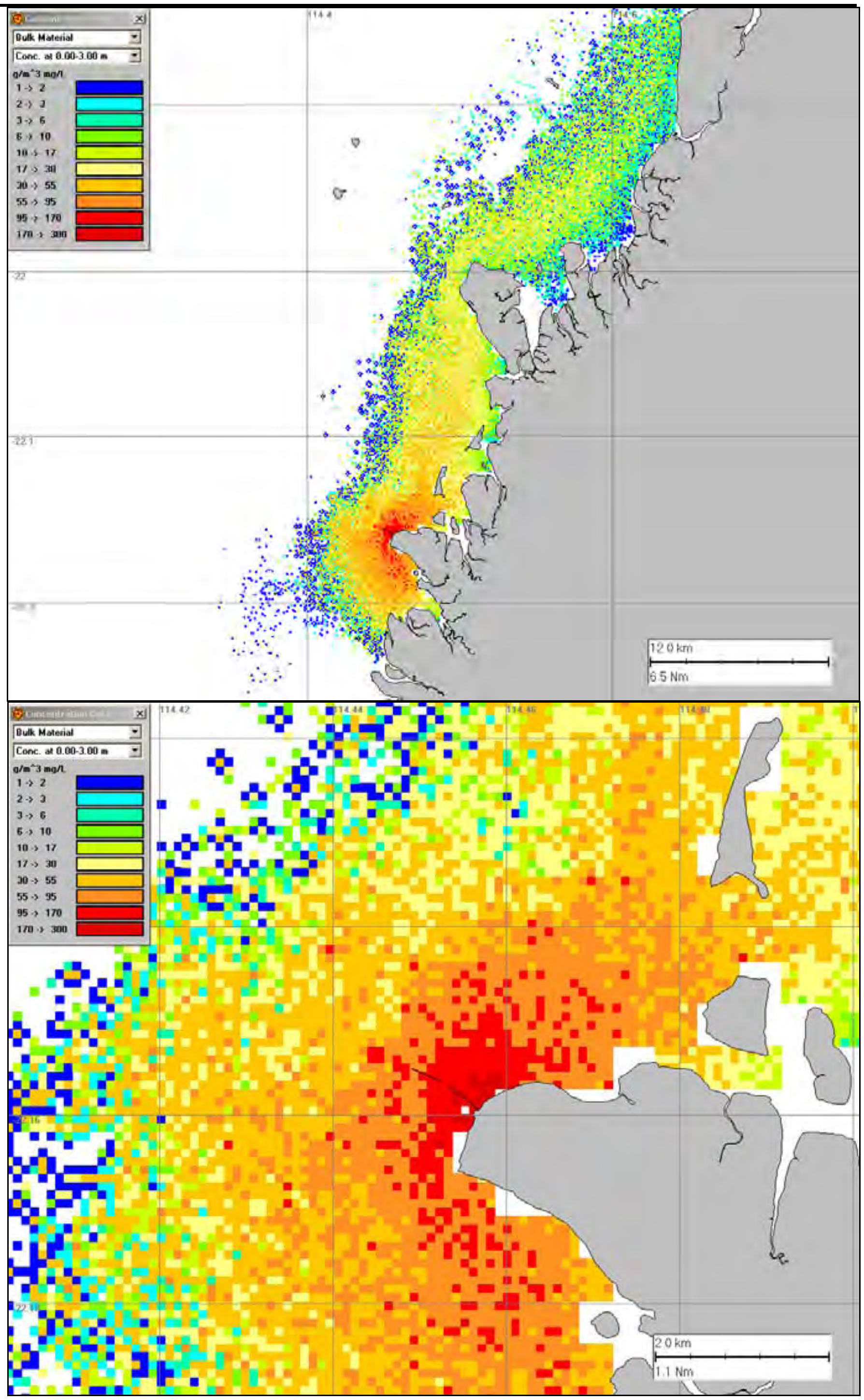

Figure 3: **Highest instantaneous suspended sediment concentration predicted for each location during the simulation. Results are shown for a wider view (top) and for the immediate area around the dredging (bottom). Results for each location are independent over time. See Figure 5 for details of variation over time..**

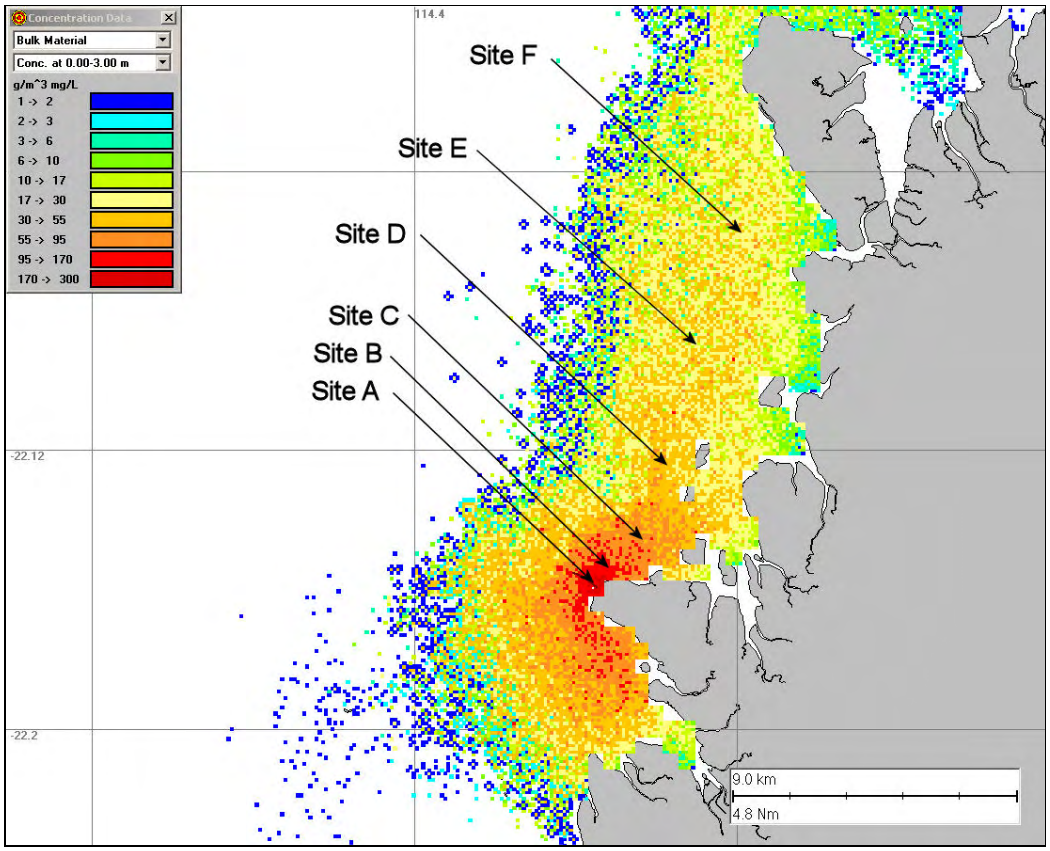

Figure 4: **Highest instantaneous suspended sediment concentrations with locations where time varying concentrations have been extracted and displayed at Figure 5.**

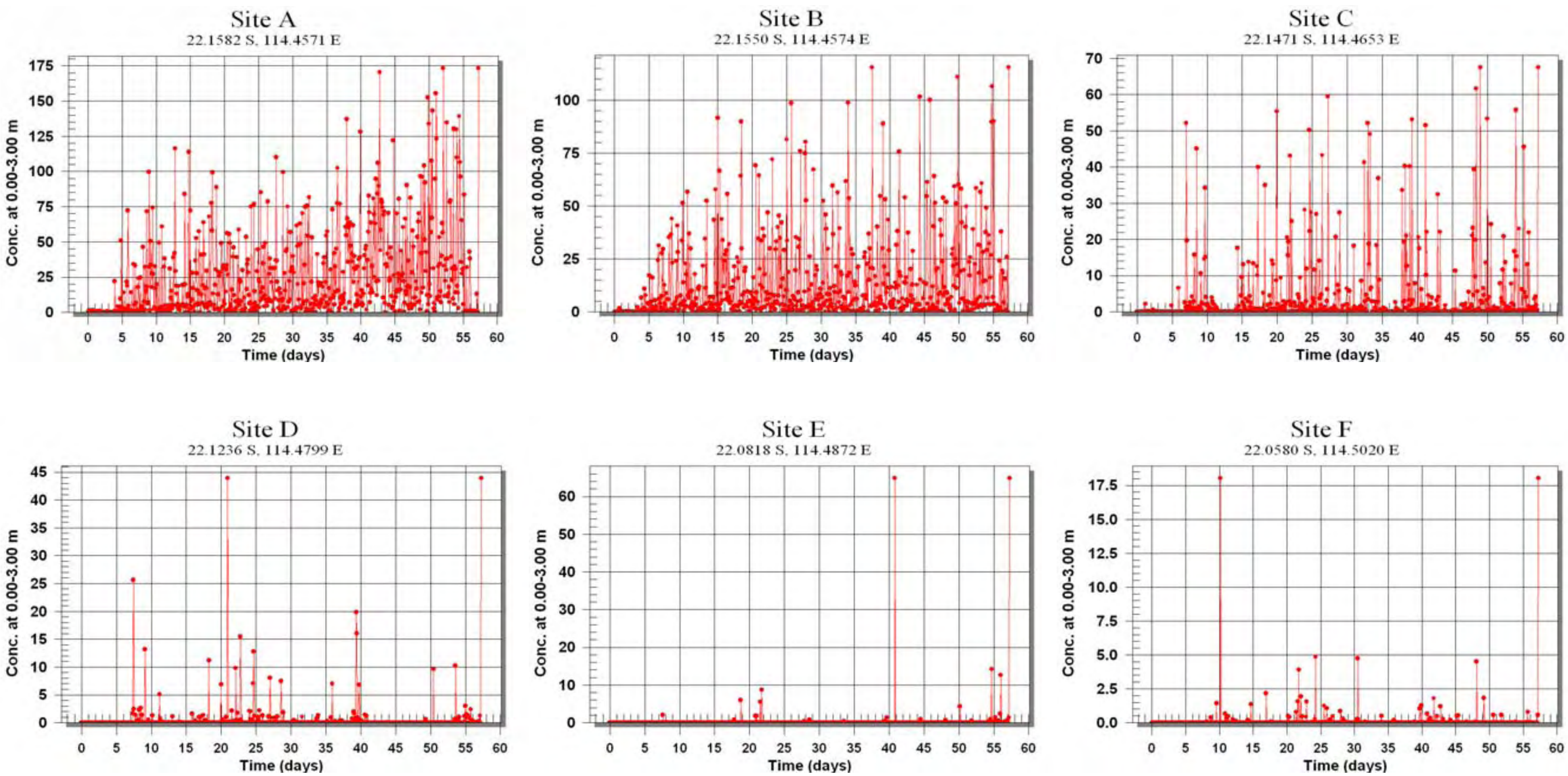

Figure 5: **Time-varying concentrations of suspended sediments predicted for locations indicated in Figure 4. Note that the vertical axis scale has been varied to provide temporal detail at each site. The last point on each graph indicates the maximum instantaneous concentration predicted for that site.**

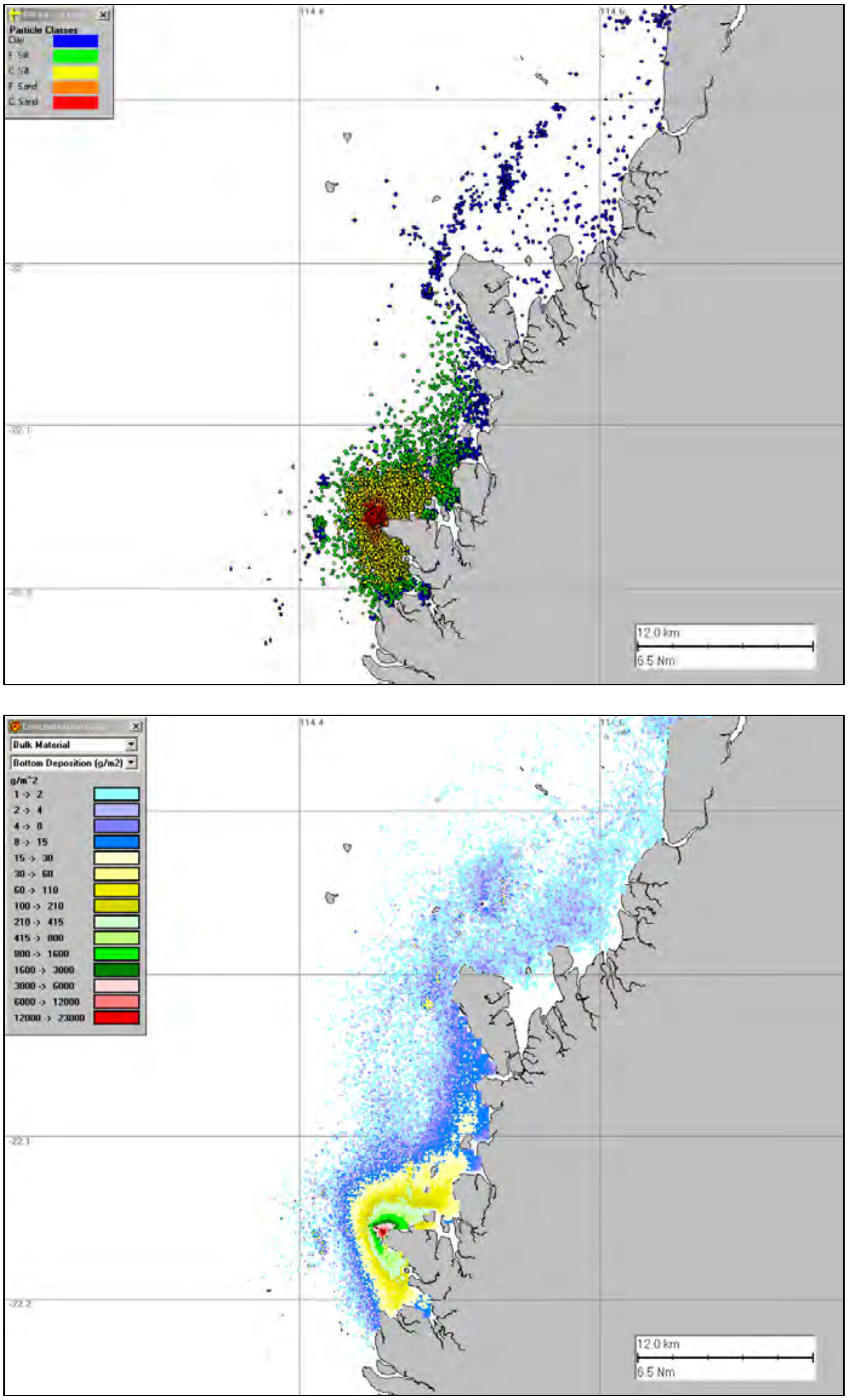

Figure 6: **Predicted bottom sedimentation in the study area. Results are shown by particle class (top) and as concentration for all particle classes (bottom).**

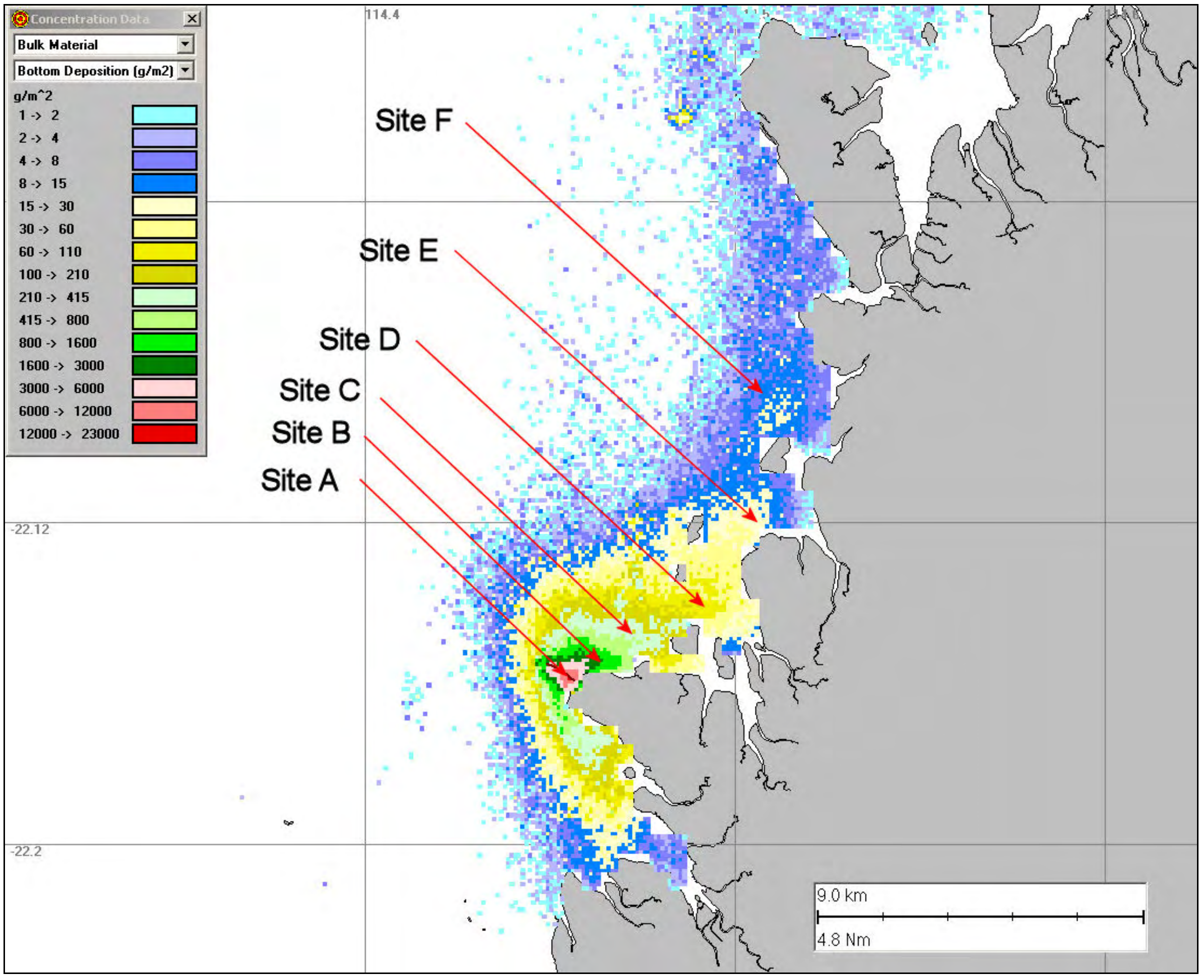

Figure 7: **Predicted bottom sedimentation in the study area. Results are shown as estimated concentration, assuming no subsequent resuspension.**

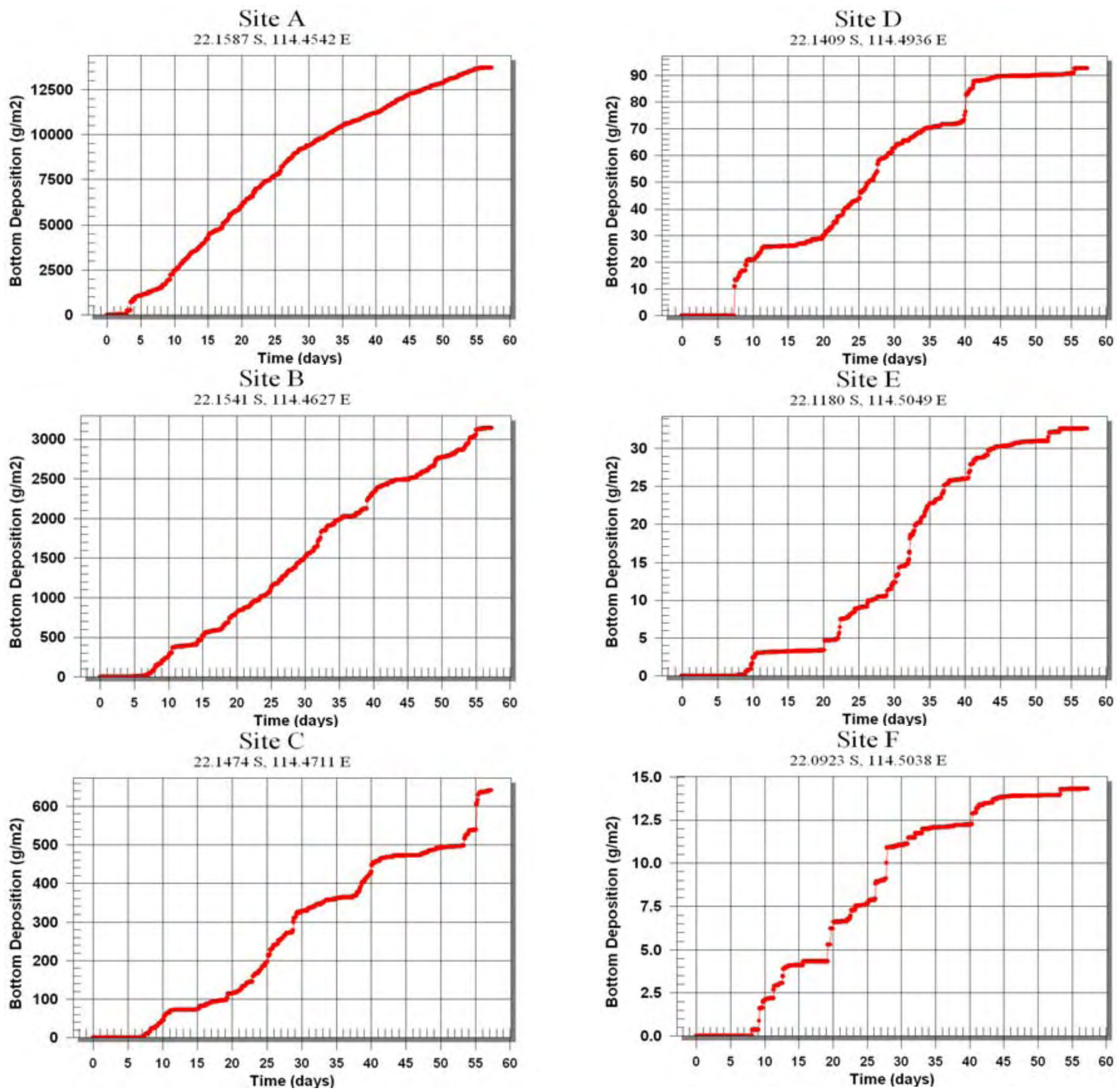

Figure 8: **Cumulative concentrations of bottom sedimentation for locations indicated in figure 7.**

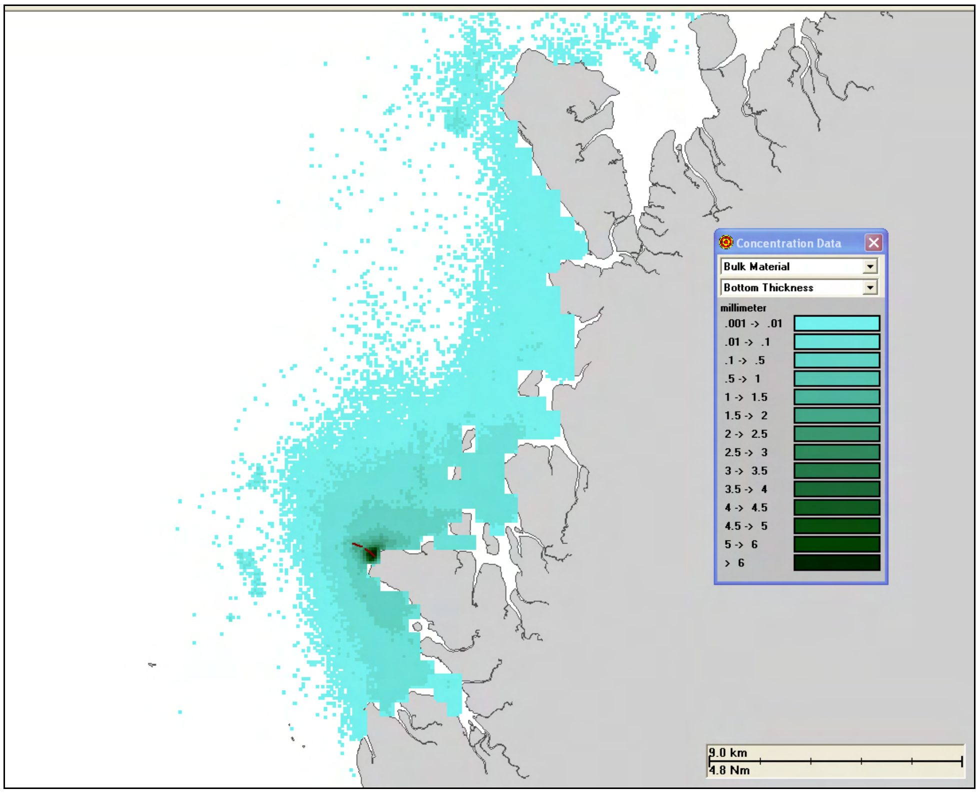

Figure 9: Predicted bottom sedimentation in the study area. Results are shown as estimated thickness, assuming no subsequent resuspension.

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Appendix 13
Mixing and dilution of Bitterns C discharge (APASP 2007)

Yannarie Salt field environmental investigations: Mixing and dilution of Bitterns C discharge

To: Straits Resources

5th December 2007

Asia - Pacific Applied Science Associates

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Version 4 after client review		*Marc Zapata* *Scott Langtry*	*Scott Langtry*	*5/12/2007*
Final report to client			*Scott Langtry*	*14/12/2007*

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Document Title: Mixing and dilution of Bitterns C Final.doc

Contents

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1 Introduction

Straits Salt (Straits) proposes to develop the Yannarie solar-salt production field along the east coast of Exmouth Gulf. This development will extract various salts from seawater via solar evaporation. The remaining salt mixture, termed bitterns, will become progressively more concentrated as it passes through the field, and will have an increasingly altered mixture of salts compared to seawater during each stage. The end-point of production during the early life of the salt-field has been termed Bitterns Mixture C. Bitterns C is expected to have high density (1.35 kg/l) compared to the density of ambient seawater (Average ~1.029-1.037 kg/l along Deans Creek on the east coast of Exmouth Gulf, based on analysis by ALS Environmental), as well as a disproportionately high concentration of magnesium (82,100 mg/l of Mg compared to ~1,489-1,927 mg/l in ambient seawater (ALS Environmenal).

Table 1: Characteristics of discharge and receiving waters.

	Density (kg/l)	Mg Concentration (mg/l)	Source
Bitterns C	1.350	82,100	Straits Salt
Ambient Seawater	1.029-1.037	1,489-1927	Deans Creek field sampling, analysis by ALS Environmental

Straits does not propose to discharge this product but will store it on-site for later use and sale. However, Straits has been requested to demonstrate that the product could be safely discharged to Exmouth Gulf if the storage capacity within the field became exhausted and there were no alternative options for removal from the field.

Straits commissioned discharge modelling to estimate the mixing and dilution of the bitterns that were pre-diluted with seawater before discharge into an artificial boat harbour planned for construction at the end of Hope Point. The EPA has set criteria for the acceptable dilution of the product. They state that the median concentration of magnesium in the discharge plume, measured at the entrance to the harbour, should not exceed the 95th percentile concentration of Mg determined for local waters. The EPA also required that modelling should account for:

- density effects in the circulation and mixing dynamics
- the natural salinity gradient that extends offshore from the creeks and inshore waters along the east coast of Exmouth Gulf
- a wide range of environmental conditions that could occur at the location, including seasonal and interannual variations.

The following report describes the methods and findings of modelling that accounted for the EPA requirements, with the exception of seasonal and interannual variations. The study focuses on testing the required pre-mixing rate under a set of sample conditions and used:

- a previously developed and verified hydrodynamic model of the boat harbour and surrounding waters
- recently revised estimates for the salinity and Mg composition for unmixed Bitterns C (Table 1)
- specification of the rates of discharge of Bitterns C and of mixing water
- field data to define gradients in the salinity and Mg concentration of the receiving waters, which were used to define the composition of the dilution water and determine the 95th percentile target concentrations at the harbour entrance.

2 Methods

Modelling was undertaken using components of a water quality modelling system, termed WQMAP, which was previously developed to define the fate of discharges from the proposed Yannarie Salt Field. BF-HYDRO is a three-dimensional hydrodynamic model suitable for open ocean, coastal, and riverine settings. This model was selected for the following capabilities:

- The model is three-dimensional.
- The model operates over a boundary-conforming grid (using quadrilaterals of variable size and shape) to best represent the true shape of the complex coastline around Hope Point.
- Boundary conditions could be represented by nesting within the existing HYDROMAP model for Exmouth Gulf, which was previously validated for the propagation of the tidal signature.

- The model was able to represent the influence of tidal inundation on the mass of water flowing along the adjacent creeks through specification of upstream water-sheds, using tidal flow data available for these creeks from a previously developed tidal-inundation model (Worley 2005).
- It can account for both barotropic (tides, winds, river flux and net sea-level variations) and baroclinic forcing (density variations). This was important to represent the influence of bitterns density on the circulation dynamics and to account for natural salt gradients in the offshore-onshore direction.
- It has a long history of development and publication in the scientific literature.
- The model has been applied to simulation of bitterns discharge from other facilities.

This model and the configuration for this study area is more fully described in APASA (2005). A number of modifications were made to the model for this study. An onshore-offshore salinity gradient was defined as a starting condition for the model from the field surveys of total salinity and density obtained by Straits. Salinities were assumed to be vertically constant at the commencement of the simulation and a run-up simulation was preformed to establish a vertical gradient prior to generating current data for use in discharge simulations. .Salinity data were available for locations along a transect running down the centre of Deans Creek and extending offshore to approximately parallel with Hope Point (Figure 1, Tables 2 and 3). Data were available for 9 time-points, allowing calculation of time-based statistical summaries for each location along Deans Creek. Median salinity values at each location along this transect were used to define an initial salinity gradient within the wider model grid, on the assumption that the salinity gradient was fairly uniform in the long-shore direction. The data for Deans Creek indicate a gradient with increasing salinity and density towards the landward boundary.

The same salinity gradient was applied to the boundary conditions so that the general gradient would be maintained during the model simulation. Figure 2 shows the initial gradient and the extent of the model grid.

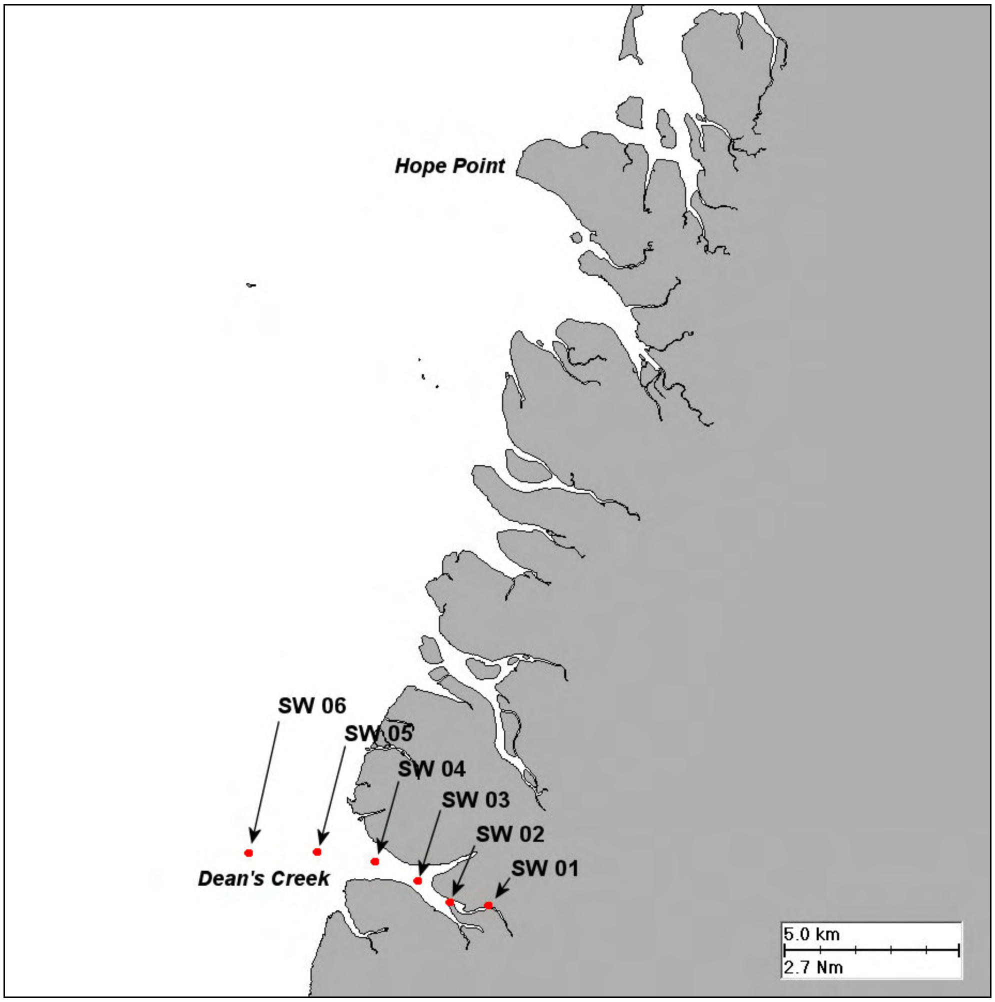

Figure 1: Seawater sampling sites for locations running along the centre of Dean's creek and extending offshore.

Table 2: Total salinity (mg/) and density (g/l) of seawater measured along a transect extending from Deans Creek.

Salinity (mg/l)						
Date	**SW06**	**SW05**	**SW04**	**SW03**	**SW02**	**SW01**
12/10/2006	50100	49700	57600	63000	55500	58600
26/10/2006	47200	48100	45900	47700	50200	56700
7/11/2006	41100	40300	49200	49900	51800	58800
4/12/2006	45000	51800	52800	54600	56900	60200
21/12/2006	44300	47000	52800	54200	77900	69500
19/01/2007	38400	39800	43500	44000	46000	54000
3/03/2007	41500	44600	49800	45600	52800	49300
22/04/2007	38800	41500	43700	47300	51700	51400
20/05/2007	42900	46100	43500	43400	45800	54200
Median	42900	46100	49200	47700	51800	56700
Average	43256	45433	48756	49967	54289	56967
50th percentile	42900	46100	49200	47700	51800	56700
80th percentile	45880	48740	52800	54360	56060	59360
90th percentile	47780	50120	53760	56280	61100	62060
95th percentile	48940	50960	55680	59640	69500	65780
Count	9	9	9	9	9	9
Std Dev	3837.7	4227.8	5014.8	6317.6	9607.1	5914.6

Density (g/l)						
Date	**SW06**	**SW05**	**SW04**	**SW03**	**SW02**	**SW01**
12/10/2006	1035	1036	1036	1036	1036	1036
26/10/2006	1028	1030	1033	1032	1036	1039
7/11/2006	1028	1030	1033	1033	1036	1038
4/12/2006	1029	1032	1034	1035	1036	1040
21/12/2006	1029	1031	1034	1036	1040	1042
19/01/2007	1028	1029	1031	1032	1034	1037
3/03/2007	1028	1029	1031	1032	1033	1036
23/03/2007	1029	1030	1031	1033	1033	1035
22/04/2007	1029	1030	1032	1034	1036	1038
20/05/2007	1029	1030	1030	1031	1031	1033
Median	1029	1030	1032	1033	1036	1037
Average	1029	1031	1032	1033	1035	1037
50th percentile	1029	1030	1033	1033	1036	1037
80th percentile	1029	1031	1034	1035	1036	1039
90th percentile	1030	1032	1034	1036	1036	1040
95th percentile	1032	1034	1035	1036	1038	1041
Count	10	10	10	10	10	10
Std Dev	2	2	1.7	1.8	2.3	2.6

Table 3: Magnesium concentration of seawater measured along a transect extending from Deans Creek.

Magnesium (mg/l)						
Date	**SW06**	**SW05**	**SW04**	**SW03**	**SW02**	**SW01**
12/10/2006	1910	1840	1980	1900	2040	2160
26/10/2006	1500	1580	1780	1780	1970	2030
7/11/2006	1440	1550	1700	1750	1830	1960
4/12/2006	1600	1670	1850	1870	1860	2040
21/12/2006	1580	1700	1880	1850	2000	2220
19/01/2007	1300	1410	1540	1570	1650	1810
3/03/2007	1300	1400	1460	1450	1580	1670
22/04/2007	1370	1530	1680	1720	1740	1820
20/05/2007	1400	1440	1490	1520	1530	1630
Median	1440	1550	1700	1750	1830	1960
Average	1489	1569	1707	1712	1800	1927
50th percentile	1440	1550	1700	1750	1830	1960
80th percentile	1588	1682	1862	1858	1982	2088
90th percentile	1662	1728	1900	1876	2008	2172
95th percentile	1786	1784	1940	1888	2024	2196
Count	9	9	9	9	9	9
Std Dev	191.7	147.2	182.7	162.5	186.5	207.4

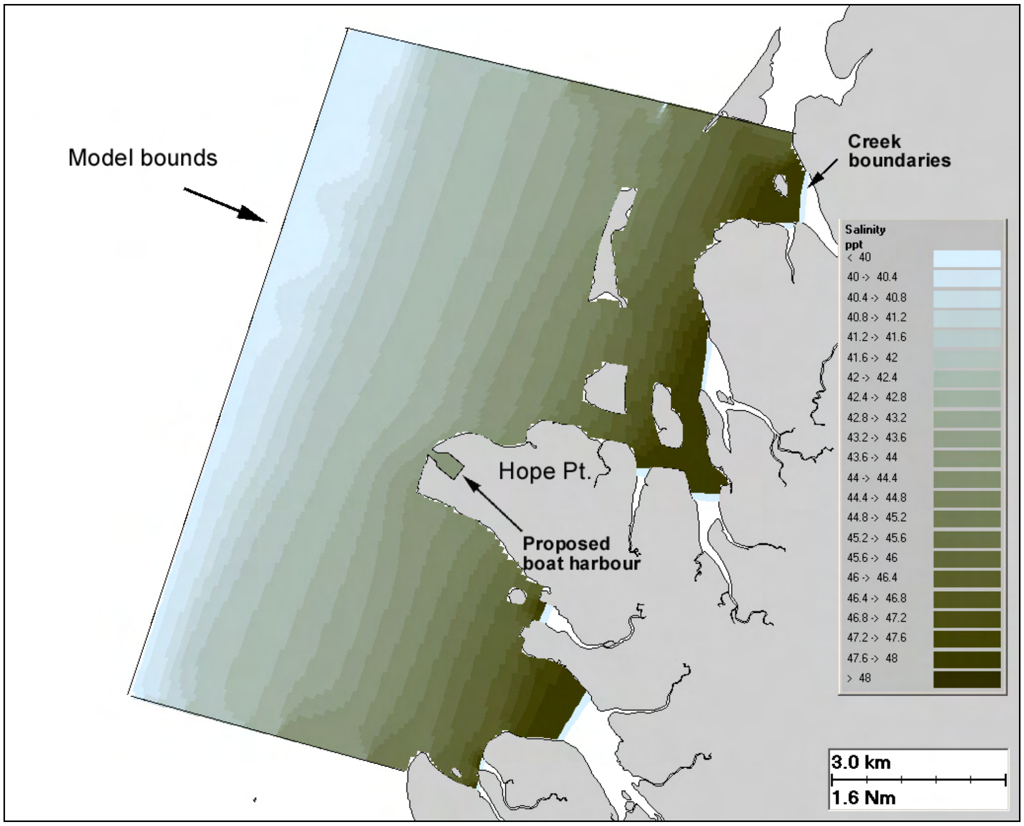

Figure 2: Initial salinity gradient imposed into the model grid and boundaries, based on field measurements along Deans Creek.

The salinity-to-density ratio will differ between that in Bitterns C and the mixing and receiving waters, due to differences in the component salt ratios and densities. Consequently, the hydrodynamic model configuration was specified in terms of densities as the physical parameter of concern.

The average density of seawater measured at site SWO5, which was positioned approximately the same distance offshore as the proposed mixing-water intake, was used to estimate the average density of the discharge after pre-mixing with concentrated Bitterns C.

Average density of seawater at SWO5 (n = 10) 1031 g/l ……………….(A; Table 2)

Average density of Bitterns C = 1350 g/l ………………………… (B; Straits Salt)

Proposed pumping rate of seawater = 100.13 M m^3 per annum …….(C; Straits Salt)

Proposed discharge rate of Bitterns C = 1.125 Mm^3 per annum ……(D; Straits Salt)

Annual discharged rate for combined stream = 101.255 M m^3/year …….(C +D)

= 3210.77 l/s ………………(E)

Average density of combined stream = $\frac{(100.13 \times 1031)+(1.125 \times 1350)}{(101.255)}$ … $\frac{(CxA)+(DxB)}{(C+D)}$

= 1035 g/l …………………………….(G)

Mixing ratio: 1 part bitterns to 89 parts mixing water

It was assumed that the discharge would have the same temperature as the receiving waters due to the rapid rate of throughput and the high mixing ratio of ambient water to Bitterns C. Hence, a uniform temperature was applied (29° C).

These calculations indicate that the discharge would have only slightly higher average density (4 g/l or 0.4% greater) relative to the average density of receiving waters at the entrance to the harbour. This density would equate to the 95^{th} percentile density of seawater at SW05 and exceed the 95^{th} percentile density calculated for the harbour entrance by only 2 g/l. It should also be noted that, due to the natural salinity/density gradient around Hope Point, the median density of the mixing water alone (represented by data from SW05) would lie between the 80^{th} and 90^{th} percentile water density at the harbour entrance (represented by data from SW06).

The baroclinic hydrodynamic model was run in three-dimensional (layered) mode for a 30-day period using a sample wind and tidal field. The 30-day period covered 2 neap and spring tide cycles and the wind sample was from April (predominantly south-westerly). Time-varying flows from tidal draining of the creek and tidally submerged areas were derived from the previous modelling of the tidal creeks and intertidal flats that was undertaken by WorleyParsons (2005). Estimates for the flow rate of water draining from the creeks and tidal flats were specified as a function of the tidal height using the WorleyParsons model that was calculating wetting and drying of the tidal flats. This was done to represent the flushing effects of water draining from and encroaching onto the tidally submerged areas.

The salt content of the discharge would differ from that of the receiving water. Hence, to estimate Mg concentrations generated by the discharge, concentrations of an inert tracer were released with the baroclinic plume. Initial concentrations of the tracer were calculated from the estimated concentration of Mg in Bitterns C and in background seawater, treating SW05 sample data as representative of the water to be drawn on for mixing, as follows:

Mg composition of Bitterns C = 82,100 mg/l ………………………..(F; Straits Salt)

Average Mg concentration in SW05 water = 1,569 mg/l…………….. (G; Table 3)

Average Mg concentration of combined stream after mixing

$$= \frac{(100.13 \times 1{,}569)+(1.125 \times 82{,}100)}{(101.255)} \ldots\ldots\ldots \frac{(CxG)+(DxF)}{(C+D)} \ldots\ldots \textbf{formula 1}$$

= 2,463 mg/l ………………………………………………………….(H)

Average Mg Discharge rate = 2,463 mg/l x 3210.77 l/s ……………….(H x E)

= 7,908,127 mg of Mg/second

= 7.908 kg/second……………………………………….(I)

For comparison, the average Mg discharge rate calculated for SW05 water alone, without the addition of Bitterns C, would be:

Proposed pumping rate of seawater = 100.13 M m^3 per annum …….(C; Straits Salt)

= 3175.10 l/s

Average Mg concentration in SW05 water = 1,569 mg/l…………….. (G; Table 3)

Average Mg concentration of mixing water stream

= 1,569 mg/l x 3175.10 l/s

= 4.98 kg/second

3 Results

3.1 Salinity

The predicted increases in salinity over time at the harbour entrance were relatively subtle, with variations in the tidal state and weather generating temporal variation. Figure 3 shows a comparison of the model-predicted tidal elevations and salinity at the entrance to the harbour. The salinity of the plume within the harbour was predicted to increase over an extended period to approximate the salinity specified for the discharge (45 ppt). Partial flushing of the harbour by tidal exchange was predicted to result in the salinity climbing over an extended period (> 12 days), and this increase did not appear to have any relationship to the spring/neap tidal cycle. The salinity was predicted to remain around 45 ppt over the remaining duration of the simulation, based on the prevailing conditions in this model run. This result suggests that the 95th percentile concentration for background salinity (48.94 ppt from Table 1), in terms of total salts, would not be exceeded.

The salinity gradients in both the wider model and the harbour (with discharge) were observed to migrate onshore and offshore with the flooding and ebbing tides to mix around the harbour entrance (Figure 4). Variations in the longshore drift due to prevailing winds also resulted in the background salinity gradient being displaced from Hope Creek and forced around Hope Point on occasions during the simulation, and this water was predicted to have higher salinity than the specifications for the harbour (Figure 5). As a result, the predictions for the salinity at the harbour entrance in Figure 3 also include results of variations in the background salt gradient that are not related to the bitterns discharge. This indicates that water salinity, as total salts, will vary markedly around the entrance to Hope Point as a consequence of the sharp salinity gradient that occurs naturally, irrespective of discharge.

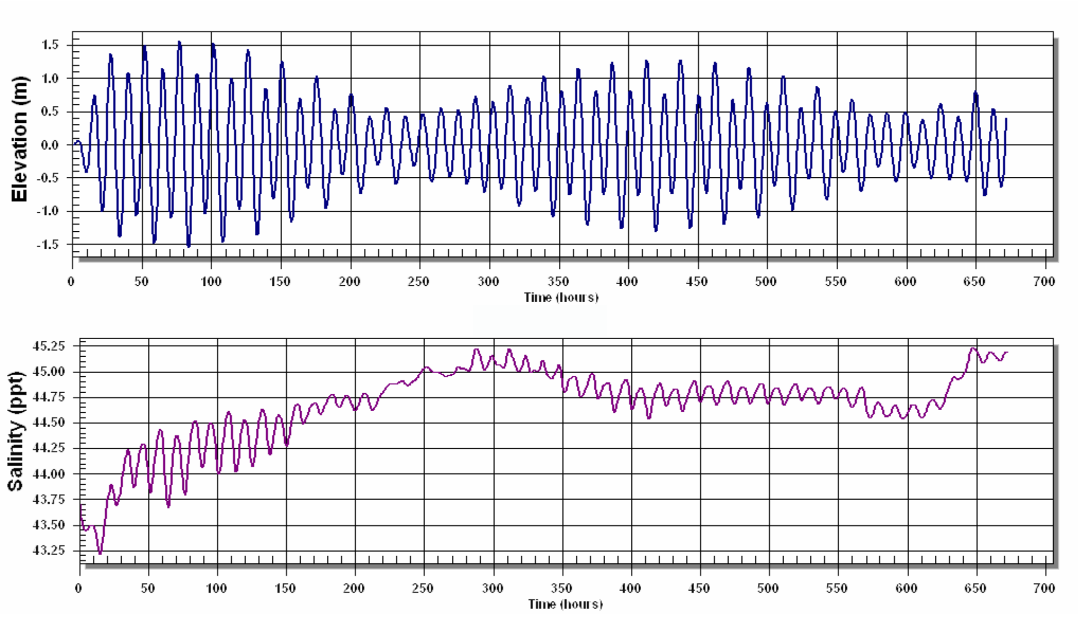

Figure 3: Model-predicted tidal elevation (m) and salinity (ppt) over time (hours) at the entrance to the boat harbour in the simulation.

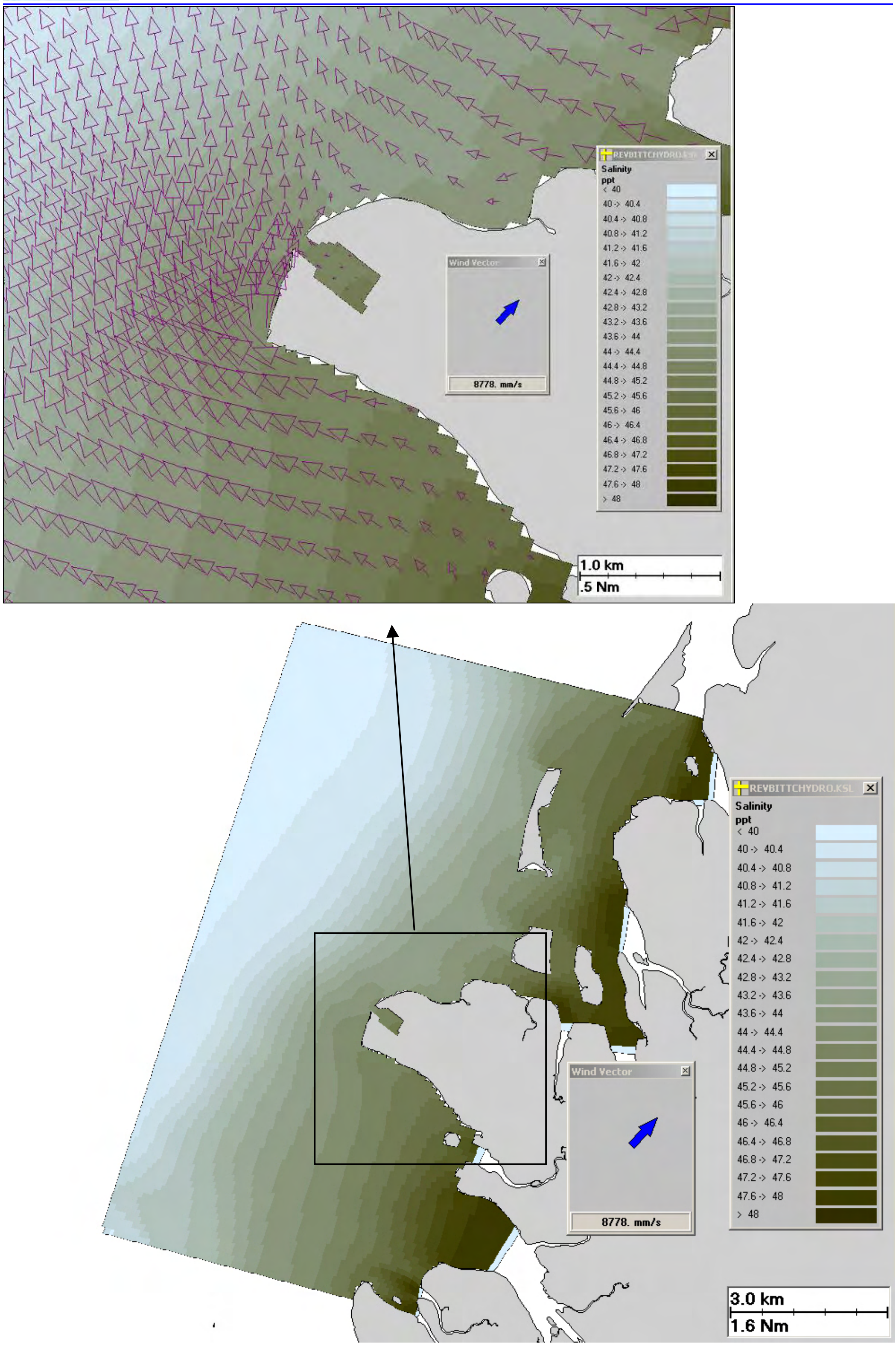

Figure 4: Example of the salinity plume emerging from the harbour and mixing with the local salinity gradient during an ebbing tide. Upper image shows a zoom around the harbour entrance with current vectors (every 3rd vector shown for clarity). Note that the plume is distinguishable for only a short distance.

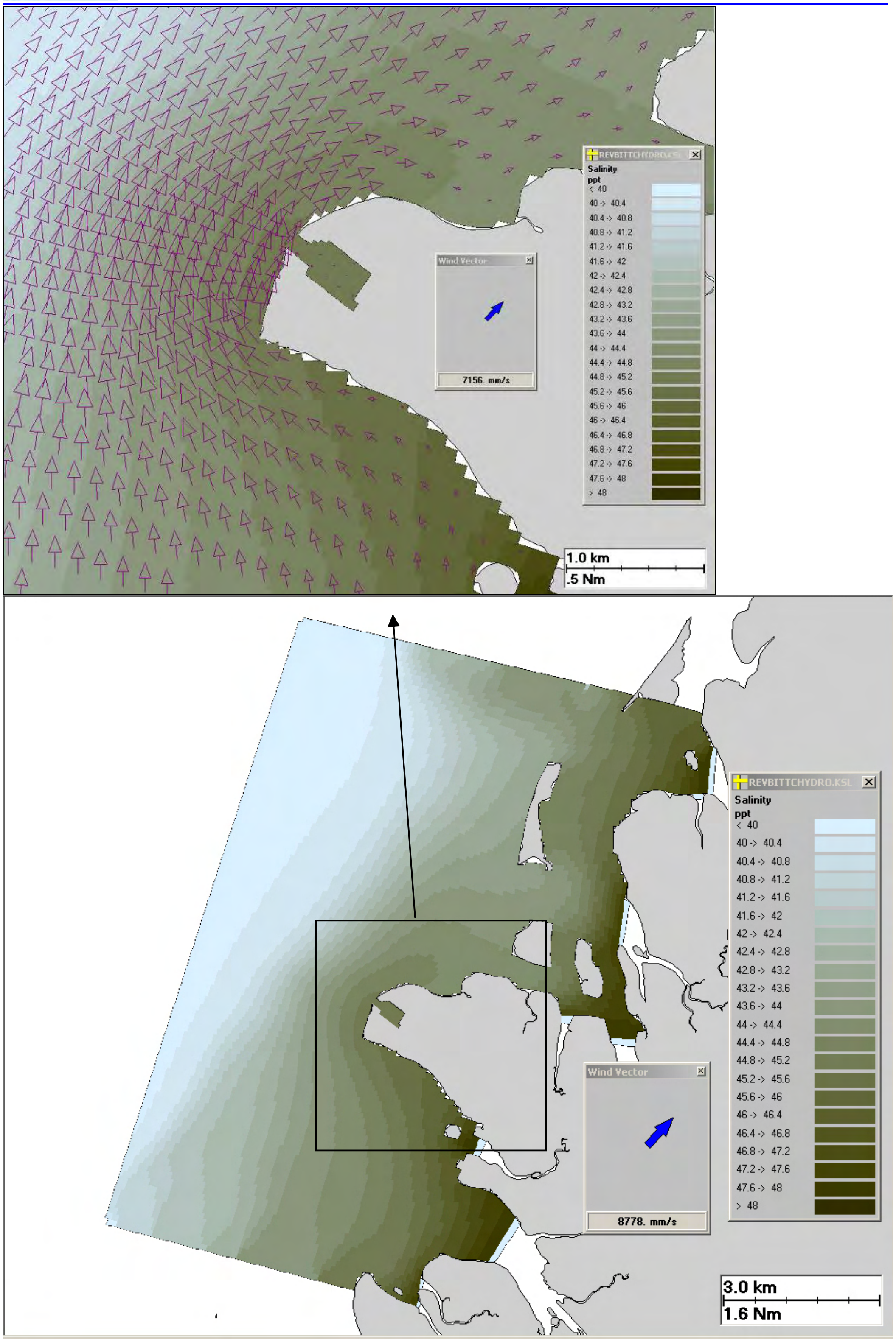

Figure 5: Example of the salinity plume being displaced northward and mixing with higher salinity water displaced from Hope Creek. Upper image shows a zoom around the harbour entrance with current vectors (every 3rd vector shown for clarity).

3.2 Mg Concentrations

As for the concentrations of total salts, concentrations of Mg in the back of the harbour around the discharge point were predicted by the model to rise over the first 12 days of discharge before stabilising around an average of 2256 (St. deviation = ± 86) mg/l. Concentrations at the harbour entrance were predicted by the model to stabilise at an average of 1914 ± 154 mg/l above background (Figure 6). After concentrations had plateaued (calculated from hour 200 onward), the median Mg concentration at the harbour entrance was calculated by the model as 1884 mg/l. This median concentration would exceed the 95th percentile Mg concentration estimated from sampling at SW06 by 98 mg/l.

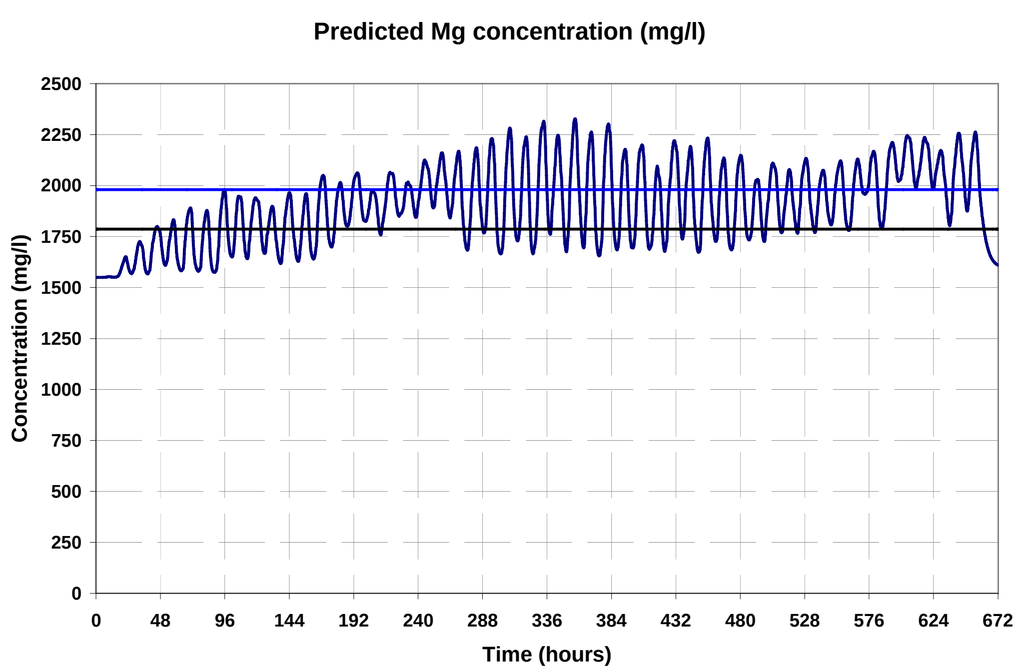

Figure 6: Model predictions for the Mg concentration predicted by the model at the entrance of the proposed harbour, given discharge at the defined rate. The horizontal blue line indicates the median predicted concentration from hour 200. The horizontal black line indicates the 95th percentile concentration derived from field measurements at SW06.

For the limited set of conditions modelled the field of effect of plume concentrations exceeding the threshold (1786 mg/l of Mg) had only a limited extent beyond the harbour. The median plume concentration was predicted to reach the 95th percentile concentration at SW06 within about 200 m offshore (Figure 7), a location that would be about 15% of the length of the proposed navigation channel.

Flooding tides commonly forced the emergent plume back onto the coast of Hope Point around the harbour entrance at concentrations exceeding this threshold and under the conditions modelled (SW winds dominating), the diluting plume tended to drift north and remain inshore (Figure 8). The field of effect in the long-shore direction (using the above criteria) was predicted in the model to approximate 250 m.

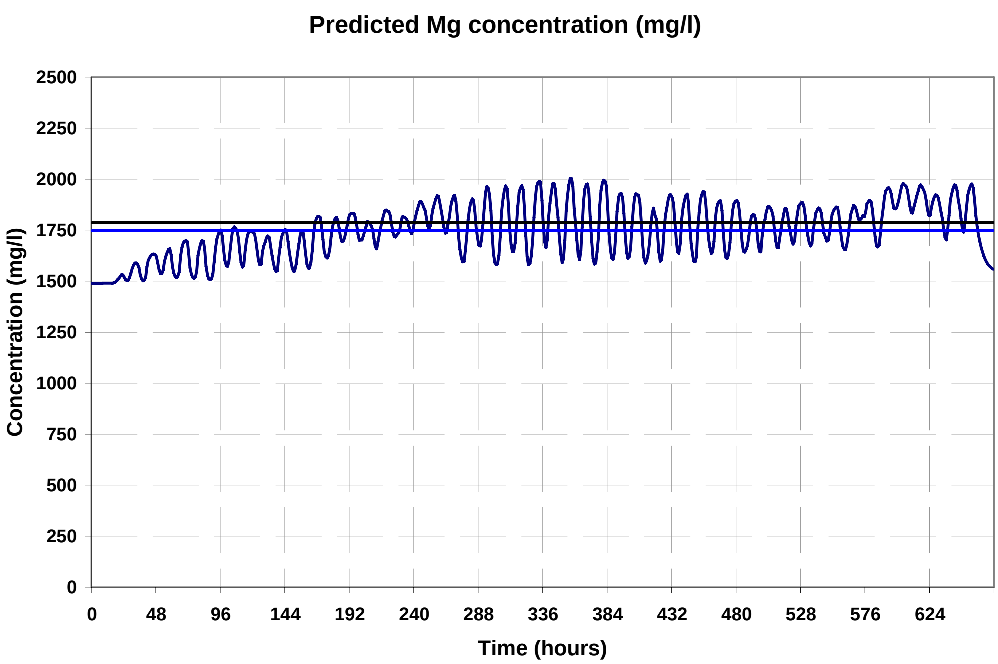

Figure 7: Model predictions for the above-background (median) Mg concentration predicted by the model 200m along the proposed navigation channel from the harbour entrance, given discharge at the defined rate. The horizontal blue line indicates the median predicted concentration from hour 200. The horizontal black line indicates the 95th percentile concentration derived from field measurements at SW06.

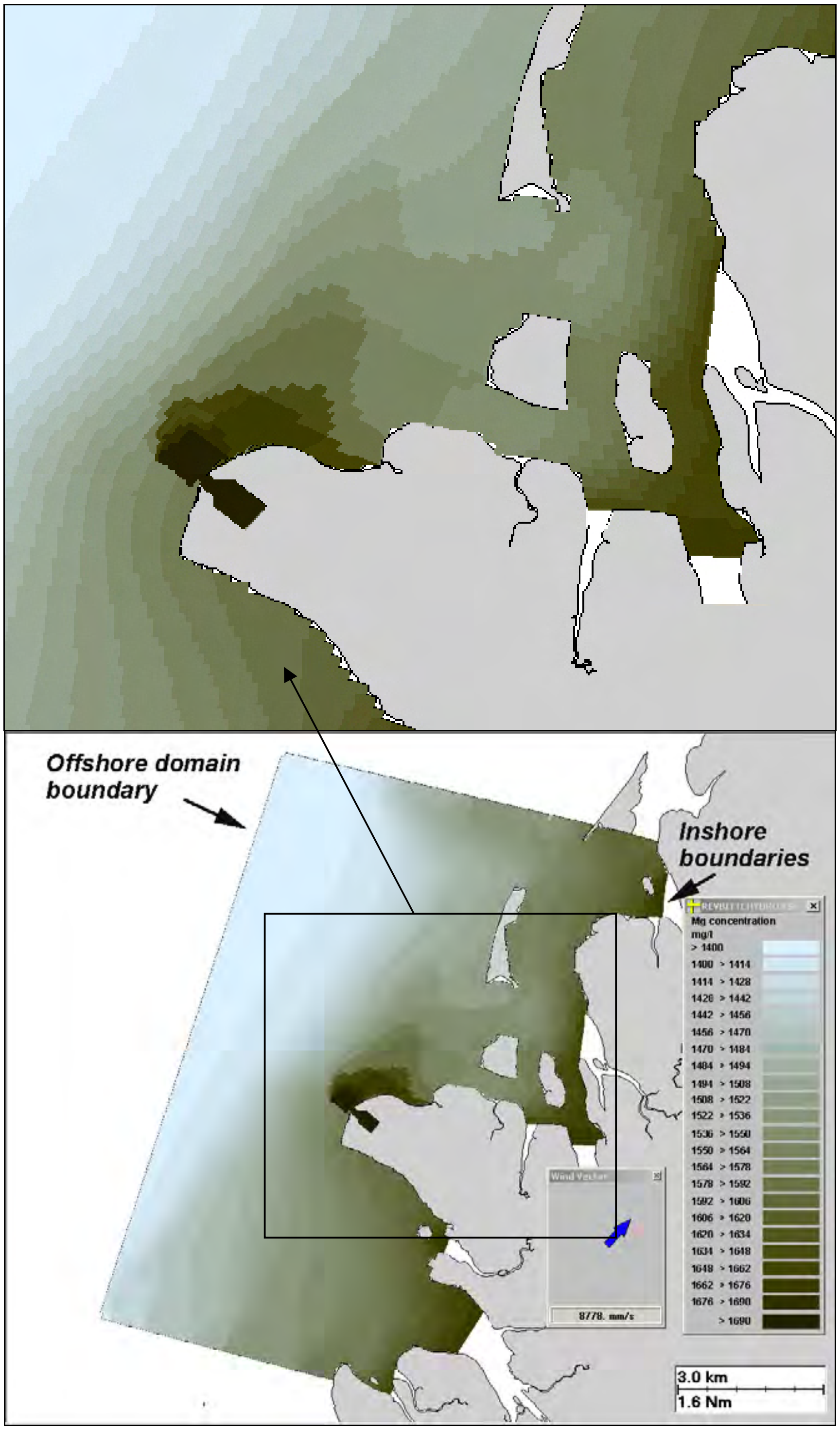

Figure 8: Model predictions for total Mg concentration at the benthic layer at a point in time when the plume is flowing out of the harbour (ebbing tide). Concentrations are inclusive of background and are in mg/l. The panel above shows an enlargement around Hope Point.

Advice on required dilution rate

After the first 2 weeks of discharge, the model predicted an average dilution at the harbour entrance that was approximately 78% of the average concentration calculated for the discharge after pre-mixing, indicating that the harbour would function to reduce the discharge concentration. With the assumed premixing ratio (101.13 Mm^3 added to 1.125 Mm^3 of Bitterns C) the median concentration predicted at the harbour entrance is approximately 7% higher than the acceptable level (based on the 95%ile concentrations measured at SW06.)

Assuming a linear relationship between the concentration of the discharge and the concentration at the harbour entrance, the mixing ratio achieved within the harbour provides a guide to the average discharge concentration that would be required to reduce the concentration at the harbour to an acceptable level.

Average estimated concentration with discharge at 101.13 Mm^3

= 2,463 mg/l ………………………………………….(H)

Concentration with 7% reduction

= 2,290 mg/l…………………………..H' =(H x 0.93)

The target discharge rate (C) can be estimated for a target discharge concentration (L) as follows:

$$C = \frac{D \times (H'-F)}{G-H'}$$ ……………………….................. (by rearrangement of formula 1)

Hence, the target discharge rate

$$= \frac{1.125 \times (2{,}290-82{,}100)}{(1{,}569-2{,}290)}$$

= 124.5 M m^3 per annum

These results indicate that for a discharge rate for Bitterns C of 1.125 Mm^3 per annum, a throughput of approximately 125 Mm^3 per annum of diluting water of the average concentration at SW05 should be sufficient to achieve acceptable dilution to meet the target threshold at the harbour entrance.

I

References

ALS Environmental (Undated data sheets) Analytical results of water samples collected by Sagramore Pty Ltd.

APASA (2005) Yannarie Salt Project: Quantification of mixing zones for proposed discharge of salt bitterns. Final Report to Straits Resources Limited. 31 August 2005. 25 October 2005.

Worley (2005) Yannarie Salt Project Hydrodynamic Modelling. Mangrove Inundation Analysis. Southern Region. Report 302/08360a01. Report to Straits Resources Limited. 31 August 2005.

Appendix 14
Biota 2008b Additional flora investigations

Biota Environmental Sciences (Biota) 2008b, *Yannarie Salt Project: Additional Flora and Vegetation Assessment 2007*, prepared by Biota for Straits Salt (final report to be provided at a later date).