Yannarie Solar Salt
East Coast of Exmouth Gulf

Straits Salt Pty Ltd

Report and recommendations
of the Environmental Protection Authority

Environmental Protection Authority
Perth, Western Australia
Report 1295
July 2008

Environmental Impact Assessment Process Timelines

Date	Progress stages	Time (weeks)
28/5/04	**Level of Assessment set (following any appeals upheld)**	**-**
4/12/06	**Proponent Document Released for Public Comment**	**131**
12/3/07	**Public Comment Period Closed**	**14**
23/1/08	**Proponent response to the issues raised**	**45**
25/2/08	**Proponent release of modified proposal and supplementary reports.**	**5**
24/3/08	**Public Comment Period Closed**	**4**
7/5/08	**Final Proponent response to the issues raised**	**6**
23/7/08	**EPA report to the Minister for the Environment**	**11**

Report Released: 23/07/08

Appeals Close: 6/08/08

ISSN 1836-0483 (Print)
ISSN 1836-0491 (Online)

Assessment No. 1521

Summary and recommendations

Straits Salt proposes to construct and operate a 4.2 million tonne per annum solar salt farm on the east coast of Exmouth Gulf. This report provides the Environmental Protection Authority's (EPA's) advice and recommendations to the Minister for the Environment on the environmental factors relevant to the proposal.

Section 44 of the *Environmental Protection Act 1986* requires the EPA to report to the Minister for the Environment on the environmental factors relevant to the proposal and on the conditions and procedures to which the proposal should be subject, if implemented. In addition, the EPA may make recommendations as it sees fit.

The EPA is also required to have regard for the principles set out in section 4A of the *Environmental Protection Act 1986.*

Relevant environmental factors and principles

The EPA decided that the following environmental factors relevant to the proposal required detailed evaluation in the report:

(a) Conservation status and policy framework;

(b) Mangrove and algal mat communities – changes to relative sea level;

(c) Marine productivity - nutrient input;

(d) Biota and water quality - salinity and bitterns management;

(e) Water quality – acid and heavy metal release;

(f) Marine fauna - vessel operations; and

(g) Habitat loss.

There were a number of other factors which were relevant to the proposal, but the EPA is of the view that the information set out in Appendix 3 provides sufficient evaluation.

The following principles were considered by the EPA in relation to the proposal:

(a) The principle of conservation of biological diversity and ecological integrity;

(b) The precautionary principle;

(c) The principle of intergenerational equity; and

(d) The principle of minimisation of waste.

Conclusion

Having considered the proponent's Environmental Review and Management Programme report and supplementary information, public and government agency submissions, separate expert advice and the proponent's response to submissions, the EPA has concluded that the proposed solar salt farm is located in an area that presents unacceptably high risks of environmental harm to wetland values and unacceptable levels of uncertainty in relation to long term management of bitterns.

The whole of the east coast of Exmouth Gulf, including all of the salt flats and in-shore waters, are listed as a wetland of national importance in *A Directory of Important Wetlands in Australia* (ANCA, 1993). The EPA considers that it is environmentally unacceptable to locate a 17,765 hectare salt field within a wetland of national importance. While the salt farm is proposed to be largely located on an area of apparently bare salt flats, these flats form an integral part of the wetland ecosystem and land unit supporting the algal mats and mangroves which underpin the productivity of the wetland and Exmouth Gulf. Disturbance on the salt flats could have serious and irreversible adverse impacts on the algal mats and mangroves.

The EPA recognises wetlands that are listed in *A Directory of Important Wetlands in Australia* as 'critical assets' (EPA, 2006) representing the most important environmental assets in the State and requiring the highest level of protection. The status of the site as a critical environmental asset, together with the extent of predicted impacts, the high degree of residual uncertainty and the unacceptably high risks posed by the proposal have lead the EPA to conclude that the proposal is environmentally unacceptable.

The key areas where significant impacts or risks of impacts have been identified are:

- Loss of biodiversity and wetland values in a listed wetland of national importance;
- Significant loss and fragmentation of benthic primary producer habitat and associated ecosystem services as a result of salt pond levee walls blocking the distributional adjustments of algal mat and mangrove communities in response to sea level rise.
- Potential loss of regionally significant mangroves and algal mats caused by the mobilisation of hypersaline groundwater;
- A high level of uncertainty in relation to the proponent's ability to manage the ongoing production of over 1 million cubic metres per annum of bitterns C, which is toxic to marine biota and therefore likely to degrade wetland and biodiversity values should bitterns discharge occur either accidentally or be required to maintain salt farm production in the long term;
- Potentially significant and damaging changes to nutrient availability and delivery to coastal waters, affecting productivity in Exmouth Gulf; and
- Potential release of acid and heavy metals to coastal wetland environments during dredging operations and from stored acid sulphate sediments following excavation.

The proponent has not been able to demonstrate to the EPA that the environmental values of the area could be maintained with a high degree of certainty, nor that the risks to those values would be acceptably low in the long term.

Based on this assessment, the EPA does not believe that the proposal could be made environmentally acceptable and recommends that the proposal should not be permitted to proceed. Accordingly, the EPA has not recommended any conditions as it does not consider that the current proposal could be implemented in an environmentally acceptable manner.

Other advice

The EPA makes the following recommendation in relation to the potential for future expansion of the proposed salt field.

Should the Minister for the Environment consider the current proposal acceptable and issue a Statement permitting its construction, there is a likelihood that the proponent may wish to expand the proposed 4.2 million tonne per annum (Mtpa) of salts proposal to produce up to ten Mtpa of salts in the future.

The EPA considers the known impacts and residual uncertainties associated with the assessed 4.2 Mtpa proposal to be unacceptably high. Many of these impacts and risks are directly related to the size of the development footprint, the proportional length of coastline affected and the quantities of materials and natural resources consumed. An expanded salt field beyond four Mtpa would therefore be expected to have further unacceptable cumulative impacts.

Recommendations

The EPA submits the following recommendations to the Minister for the Environment:

1. That the Minister considers the report on the relevant environmental factors and principles that the EPA considered relevant to the proposal, as set out in Section 3;
2. That the Minister notes that the EPA considers that a 17,765 hectare salt field should not be located within a wetland of national significance that is a critical environmental asset;
3. That the Minister notes that the EPA has concluded that the proposal cannot meet the EPA's environmental objectives and is considered environmentally unacceptable, particularly with regard to the risk of impacts to biodiversity values and ecosystem functionality within a listed wetland of national significance, regionally significant mangrove communities, and water quality within an area recommended for 'maximum' water quality protection;
4. That the Minister notes that the EPA has not included in this Report conditions and procedures to which the proposal should be subject, if implemented, because the EPA holds the view that the proposal should not be implemented;
5. That the Minister not issue a statement that the proposal may be implemented; and
6. That the Minister notes the EPA's other advice presented in Section 4 in relation to the potential for future expansion, if consideration is given to approving the construction of the solar salt farm which is the subject of this assessment report.

Contents

Page

Tables

Figures

Appendices

1. Introduction and background

This report provides the advice and recommendations of the Environmental Protection Authority (EPA) to the Minister for the Environment on the environmental factors and principles relevant to the proposal by Straits Salt Pty Ltd to develop a solar salt field on the eastern shore of Exmouth Gulf (Figure 1). The proposal includes evaporation and crystalliser ponds covering 17,765 hectares of the coastal salt flats, plus the associated infrastructure for the production and export of 4.2 million tonnes per annum (Mtpa) of salts. The proposal involves the dredging of a 1.3 kilometre channel on the eastern side of Exmouth Gulf, the excavation of a harbour at Hope Point, and the extraction of 3 million cubic metres of clay from the adjacent hinterland for the construction of levee walls.

The proposed solar salt farm is described as having at least a 60 year life span. During the first ten years the proposal involves the use and potential storage of up to 11 million cubic metres of bitterns C (salt farm effluent) over an area of 3093 hectares. The proponent is thus proposing the establishment of a salt farm with a life in excess of 60 years but with plans for only 10 years of bitterns storage, in the expectation that all bitterns produced from that point onwards could be processed and sold. In the event that was not the case, the proponent states that management of bitterns beyond ten years would be the subject of a separate referral to the EPA for further assessment and consideration for approval by the Minister for the Environment.

The relatively sheltered and turbid waters of Exmouth Gulf support primarily soft sediment communities with dispersed limestone reefs and coral bommies. It provides important habitat for humpback whales, dugong and marine turtles. The Gulf also provides ecosystem services that form the basis of the Exmouth Gulf Prawn Managed Fishery and pearling and aquaculture industries.

Well developed arid zone mangroves and algal mats occur along the southern and eastern shores of Exmouth Gulf and behind these communities is an extensive salt flat up to 15 kilometres wide on which the salt ponds are proposed to be developed. The rivers and creeks that drain through the hinterland sand dunes and clay pans towards the Gulf flow intermittently after major rain events and cyclones.

The proposed development is located within the Exmouth Gulf East wetland (WA007) which is listed as being of national importance in the *Directory of Important Wetlands in Australia* (ANCA,1993). The area's high conservation values, reserve potential, and importance for recreation and fisheries protection have also been recognised in other Government policies.

The Straits Salt proposal was referred to the EPA for formal environmental assessment on 13 April 2004. The proposal is also a controlled action under the Commonwealth *Environmental Protection and Biodiversity Conservation Act* 1999. As such it is also being assessed by the Commonwealth, in parallel with the EPA's assessment.

Further details of the proposal are presented in Section 2 of this report. Section 3 discusses the environmental factors and principles relevant to the proposal. Section 4 provides Other Advice from the EPA, Section 5 presents the EPA's Conclusions and Section 6, the EPA's Recommendations.

A summary of submissions and the proponent's response to submissions is included on a compact disc inside the back cover of this report. It is included as a matter of information only and does not form part of the EPA's report and recommendations. Issues arising from this process, and which have been taken into account by the EPA, appear in the report itself.

2. The proposal

The main characteristics of the Straits Salt proposal are summarised in Table 1 below. A detailed description of the proposal is provided in chapter two of the Environmental Review and Management Programme ERMP (Straits Salt, 2006). Since the ERMP was released, the proponent has reduced the scale of the proposal from a salt production rate of 10 Million tonnes per annum to a production rate of 4.2 Million tonnes per annum. These changes are outlined in the Modified Proposal document and revised draft management plans that were published as supplementary documents in February 2008 (Biota, 2008, 2008a, Oceanica, 2008, Straits Salt, 2008a, 2008b). The ERMP and supplementary documents serve as the ERMP for the Western Australian assessment process as well as the draft Environmental Impact Statement for the purposes of the Commonwealth assessment process. Minor amendments made to the project after February 2008 have been included in Table 1. Figures 1, 2 and 3 provide a regional perspective, and outline the proposed arrangement of infrastructure.

Table 1: Summary of key proposal characteristics

Element	Description	
Project timeline	Life of development	>60 years
	Refer proposal for long term bitterns management to EPA	< 10 years
Size of recoverable resource	Salt production - approximate depending on rain and evaporation rates; NaCl $MgSO_4$ K_2SO_4 Total salt production	 4 million tonnes per annum 100,000 tonnes per annum 90,000 tonnes per annum 4.19 million tonnes per annum
Leases/tenements	Ministerial Temporary Reserve for potential future solar salt and gypsum production	Temporary Reserve 70/535 , 1970
Direct disturbance	Salt flats disturbance for salt and crystalliser ponds	17,765 ha
	Clearing of terrestrial vegetation on the hinterland plus Main Island and Hope Point	157 ha
	Clay pan excavation	75 ha
	Direct clearing of mangroves	2 ha
	Direct clearing of algal mats	17 ha

Element	Description	
	Direct disturbance of sea bed for dredged channel	Approx. 17 ha
Excavation volumes	Clay from hinterland clay pans	3,000,000 m^3
	Rock and sediments from harbour	1,535,000 m^3
	Rock and sediments from transition between harbour and dredge channel	85,000 m^3
	Dredge channel	375,000 m^3
	Dean's Creek (for pump station construction)	4,000 m^3
Construction material requirements	Rock armour from harbour and transition excavations	575,000 m^3
	Basecourse material from excavation and dredging of harbour, transition and harbour approach channel	1,390,000 m^3
	Clay	3,000,000 m^3
Levee walls	Dimensions:- Height Total length	Variable, approx. 5 m AHD Approx. 120 km
	Construction design:- Foundation Construction materials Design standard	Not keyed in at base Clay with 0.7 m rock armour on seaward levees and outer flume walls No overtopping in less than 1 in 50 year annual return interval (ARI) event Structural integrity maintained for >1 in 100 year ARI events
	Setback from algal mats	Minimum 100 m
Evaporation ponds	Total area of ponds on salt flats	17,765 ha
	Number of concentrator ponds	7
	Total area of concentrator ponds	8,434 ha
	Pond depths	Average of 0.5 m with a maximum of 0.8m
	Number of crystallizer ponds	Approx. 30
	Area of crystallizer ponds:- Primary crystallisers Reconstituted brine crystallisers (Bitterns A) Sulphate of potash crystallisers (Bitterns B)	 1,096 ha 748 ha 756 ha
	Bitterns processing area:-	

Element	Description	
	Bitterns A & B plus contingency concentration management area	5,142 ha
	Bitterns C	3,093 ha
	Total bitterns storage area	8,235 ha
	Maximum volume of bitterns C	11 Mm^3
Seawater intake infrastructure at Dean's Creek	Pump	
	Pumping rates:- max. hourly rate	56,000 m^3 per hour
	average hourly rate	29,000 m^3 per hour
	- average running times	14 hours per day
	- total annual intake volume	147,780,000 m^3 per year
	Power source;	Temporary diesel generator to be powered at a later date by electricity generated on Main Island.
	Temporary fuel storage; - storage design	Self bunded tank
	- storage capacity	14,000 L
Flume from Dean's Creek intake pump	Total length from pump to flume outlet in pond zero	Approx. 6.5 km
	Length of flume west of salt ponds	Approx. 4.3 km
	Width	Approx. 50 m
Main Island development	Power generation: - fuel source	diesel
	- size of each generator	1 MW
	- number of generators	6
	Diesel fuel farm: - Storage capacity	220,000 L
	- Height in relation to sea level	Above 8 m AHD
	Potable water plant: - source	Reverse osmosis
	- capacity	30 kL / day
	Waste water treatment; - design	package activated sludge unit
	- system capacity	75 person equivalent
	- disposal of dehydrated waste	Exmouth tip
	Other infrastructure:- - Salt product wash plant; - Administration building; - Laboratory; - Workshop; - Truck parking, refueling and wash-down facilities; - Helipad	
Infrastructure corridor between Main Island and Hope Point	Length	Approx. 6.5 km
	Conveyor; - design	Uncovered
	- power source	Electrically powered drives

Element	Description	
Hope Point infrastructure	Diesel fuel farm: - Storage capacity - Height in relation to sea level	140,000 L Above 8 m AHD
	Airport: - runway length	1.4 km
	Waste disposal; - unit design - Capacity	Composting toilets 10 person
	Sea water intake pump for salt processing and reverse osmosis plant; - capacity - power source	100 kL/day Electricity from Main Island generators
	Stockpile recovery ponds: - number	2
	Salt stockpile and infrastructure contingency: - Area - Foundation / construction - Stockpile volume -Stockpile maximum height - Number of stackers - Number of reclaimers	30 ha Up to 4 m depth of clay and dredged sediment with rock armour on seaward side. 1 million tonnes 25 m 2 1
	Conveyors; - design - power source	Uncovered Electrically powered drives
	Number of barge loaders.	1
	Excavated harbour: - depth - area	-5.5 m chart datum, (-7.1 m AHD) 16.5 ha
Channel for harbour access	Dimensions:- length Width Depth	1.65 km (*includes transition area*) 125 m - 143m -3.5 m Chart Datum
	Location	South-west and then west from Hope Point
Shipping	Bulk carriers: - size - frequency	Up to 65,000 tonnes Approx. 1 or 2 per week
	Barges: - size - frequency - propulsion	10,000 tonnes Approx. 8 trips per week Propelled by tug boat
	Diesel delivery: - amount - frequency	Up to 50 tonnes /week One delivery per week
Construction camp	Amount of accommodation	100 beds
	Area	17 ha
	Water	Transported by tanker from Main Island reverse osmosis plant
	Waste water treatment; - design	package activated sludge unit

Element	Description	
	- system capacity - disposal of dehydrated waste	100 person equivalent Exmouth tip
roads	Unsealed roads on top of all levee walls and between infrastructure components of the proposal.	
Greenhouse gas emissions		Approx. 43,500 tonnes CO_2 equivalent/yr

The following abbreviations are used in Table 1 above; AHD – Australian Height Datum, ARI – average recurrence interval, ha – hectares, km – kilometres, m – metres, m^3 – cubic metres, Mm^3 – million cubic metres, L – litres, kL – kilolitres.

3. Relevant environmental factors and principles

Section 44 of the *Environmental Protection Act 1986* requires the EPA to report to the Minister for the Environment on what the Authority considers to be the key environmental factors identified in the course of the assessment and the Authority's recommendations as to whether or not the proposal may be implemented. In addition, the EPA may include other information, advice and recommendations as it thinks fit.

The identification process for the key factors selected for detailed evaluation in this report is summarised in Appendix 3. The reader is referred to Appendix 3 for the evaluation of factors not discussed below. A number of these factors are relevant to the proposal, but the EPA is of the view that the information set out in Appendix 3 provides sufficient evaluation.

It is the EPA's opinion that the following environmental factors and issues relevant to the proposal require detailed evaluation in this report:

(a) Conservation status and policy framework;

(b) Mangrove and algal mat communities – changes to relative sea level;

(c) Marine productivity - nutrient input;

(d) Biota and water quality - salinity and bitterns management;

(e) Water quality – acid and heavy metal release.

(f) Marine fauna - vessel operations; and

(g) Habitat loss.

The above key factors were identified from the EPA's consideration and review of all environmental factors generated from the ERMP document (Straits Salt, 2006), the supplementary reports and draft management plans (Biota, 2008, 2008a, Oceanica, 2008, Straits Salt, 2008a, 2008b), and the submissions received, in conjunction with the proposal characteristics.

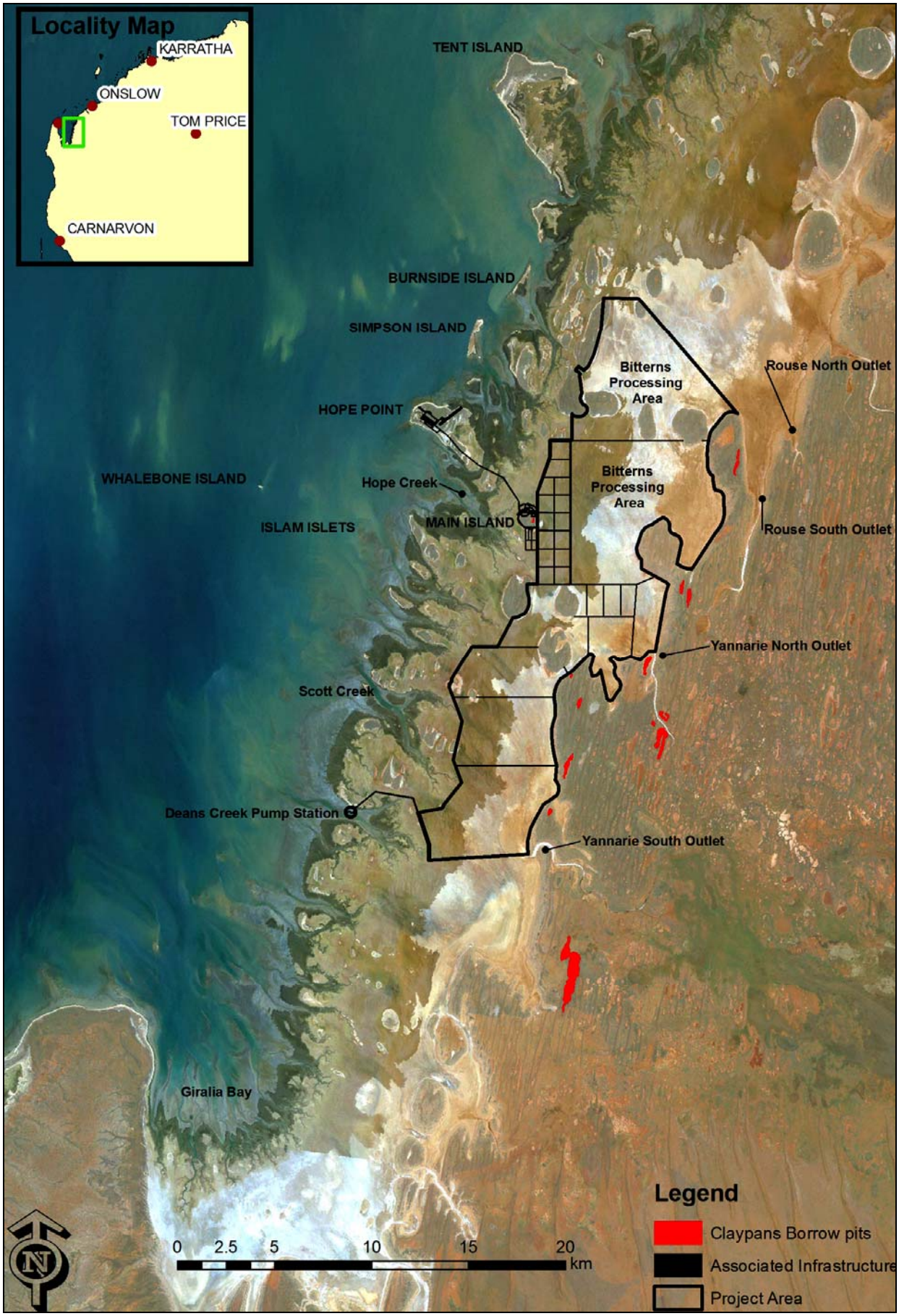

Figure 1: Location of Exmouth Gulf and Yannarie Solar proposed footprint.

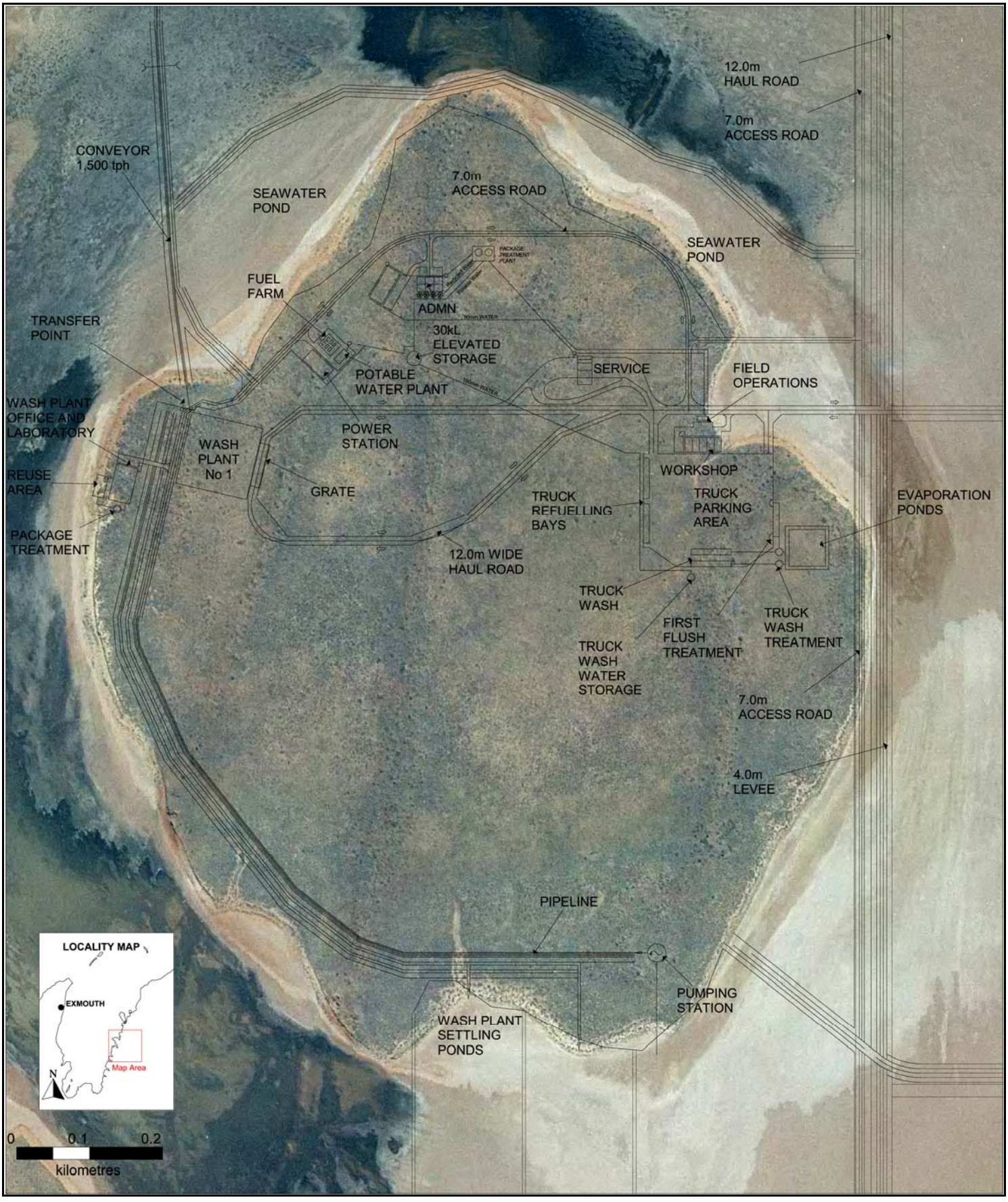

Figure 2: Proposed arrangement of infrastructure on Main Island.

Figure 3: Proposed arrangement of infrastructure at Hope Point.

Details on the key environmental factors and their assessment are contained in Sections 3.1 to 3.7. The description of each factor shows why it is relevant to the proposal and how it would be affected by the proposal. The assessment of each factoris where the EPA decides whether or not a proposal meets the environmental objective set for that factor.

The following principles were considered by the EPA in relation to the proposal:

(a) The principle of conservation of biological diversity and ecological integrity ;

(b) The precautionary principle ;

(c) The principle of intergenerational equity ; and

(d) The principle of minimisation of waste.

3.1 Conservation status and policy framework

Description

The Yannarie Solar salt field would be located primarily on the extensive salt flats that lie between the hinterland and the arid zone mangrove and algal mat communities that fringe the east coast of Exmouth Gulf. The salt pond footprint is about 30 kilometres long and would therefore lie adjacent to about 38 per cent of the 80 kilometre length of the mangrove and algal mat fringed coastline on the east side of the Gulf. The area of proposed salt ponds is 17,765 hectares which is equivalent to about 19 per cent of the area of the salt flats.

In 1970 an area on the salt flats was designated a Ministerial Temporary Reserve (70/535) for potential future solar salt and gypsum production. A small salt field was

previously located in part of the area but it was unsuccessful and has since been abandoned. The Temporary Reserve, however, has remained in place.

The conservation significance of the east coast of Exmouth Gulf was recognised in 1993 by its listing as a wetland of national importance in *A Directory of Important Wetlands in Australia* (ANCA, 1993*).* The listed wetland encompasses 120,000 hectares of the east coast of Exmouth Gulf from Giralia Bay to Urala Creek near Locker Point and is described as including marine water less than six metres deep at low tide, tidal mudflats and saline coastal flats that are five to fifteen kilometres wide. The area is described in the Directory as, "*an outstanding example of tidal wetland systems of low coast of north-west Australia, with well developed tidal creeks, extensive mangrove swamps and broad coastal flats*".

The conservation values of the east coast of Exmouth Gulf are also recognised in other Government publications, policies and guidelines:

- In 1975, the Conservation Through Reserves Committee recognised its conservation significance and recommended that a series of studies on biophysical characteristics of the tidal and supra-tidal flats of Exmouth Gulf be conducted (EPA, 1975).
- The fringe of arid zone mangroves along the east coast of Exmouth Gulf is recognised as being of 'regional significance' in EPA Guidance Statement No. 1. The EPA's objective for areas of regionally significant mangroves is that *"no development should take place that would adversely affect the mangrove habitat, the ecological function of these areas and the maintenance of ecological processes which sustain the mangrove habitats"* (EPA, 2001).
- The Western Australian Government *Wetlands Conservation Policy for Western Australia,* includes the following objectives:
  - *"To prevent further loss or degradation of valuable wetlands and wetland types, and promote wetland conservation, creation and restoration;* and
  - *To include viable representatives of all major wetland types and key wildlife habitats and associated flora and fauna within a Statewide network of appropriately located and managed conservation reserves which ensure the continued survival of species, ecosystems and ecological functions"* (WA. Government, 1997).
- The salt flats, mangrove creeks and inshore waters are within an indicative area recommended for reservation in the report entitled *A Representative Marine Reserve System for Western Australia* by the Marine Parks and Reserves Selection Working Group referred to as the Wilson Report (CALM, 1994).
- The coastal waters along the east coast of Exmouth Gulf have been recommended for the 'maximum' level of ecological protection in the Department of Environment document *Pilbara Coastal Water Quality Consultation Outcomes*, (DoE, 2006). The objectives for 'maximum' water quality protection are that there be no contamination and no detectable change from natural variation in water quality.
- The east coast of Exmouth Gulf has been listed for assessment as a National Heritage site under the *Environmental Protection and Biodiversity Conservation Act, 1999* and the area was initially recommended by the State

Government for World Heritage listing. Although the east coast of Exmouth Gulf is currently outside the proposed World Heritage area, it is adjacent to it.

- Humpback whales, dugong and both green and hawksbill turtles are all listed as specially protected under the *Wildlife Conservation Act 1950*, and occur in Exmouth Gulf or along its eastern shores. Other specially protected and migratory species regularly use the area.

To protect the ecosystem services and recreational enjoyment that are provided along the east coast of Exmouth Gulf, the coastal waters have been a permanent nursery closure area for trawling since 1983, and were recommended as a 'Fish Habitat Protection Area' in the draft *Fisheries Environmental Management Plan for the Gascoyne Region* (Shaw, 2002).

Consolidating this body of complementary policy instruments and guidelines, the *Ningaloo Coast Regional Strategy Carnarvon to Exmouth*, was endorsed by the WA Government and released by the WA Planning Commission in 2004 (WAPC, 2004). The strategy recommends that the southern and south-eastern mangrove areas of Exmouth Gulf and adjacent coastal waters become marine protected areas, consistent with the findings of the Wilson Report (CALM, 1994).

In 2006, the EPA published Position Statement No. 9, *Environmental Offsets* (EPA, 2006). This document identifies wetlands listed in *A Directory of Important Wetlands in Australia* (ANCA, 1993) as 'critical assets' which represent the most important environmental assets in the State that must be fully protected and conserved. Position Statement No. 9 states that there is a presumption against recommending approval for proposals that are likely to have significant adverse impacts on 'critical assets'.

The *Interim Biogeographic Regionalisation for Australia* (IBRA) (Thackway and Cresswell, 1995) provides a broadly endorsed framework for determining regional significance and the adequacy of ecosystem representation within reserves. The east coast of Exmouth Gulf is located within the Cape Range sub-region of the Carnarvon IBRA region. Only 2.2 per cent of the Cape Range sub-region is protected within reserves.

An audit of the status of biodiversity within the IBRA Cape Range sub-region was conducted in 2002 (May and McKenzie, 2003). Both 'Bare areas; mudflats' and 'Bare areas; claypans' were identified as being of high priority for reservation, with no representation of these ecosystems currently protected within reserves in the Cape Range sub-region.

Submissions

Submissions on this factor included the following:

- The east coast of Exmouth Gulf is considered an area of substantial importance for nature conservation and for sustaining fisheries.
- The proposal would adversely effect the environmental functioning of the wetlands.
- The area of the proposed Yannarie Solar development has been identified for the Comprehensive, Adequate and Representative reserve system.

- Six animal species that are listed as of special conservation significance use the general area.
- The proposed development would severely compromise the conservation values of one of the largest and last intact examples of sabkha (salt flat ecosystem) in Western Australia.
- The Yannarie wetland system mangle is internationally one of the largest contiguous stands of mangroves outside the wet tropics.
- The globally unique Yannarie delta is of geoheritage value and the salt farm development would both destroy the seaward part of the Yannarie delta and divide the seaward from the prodelta components of the delta system.
- The lack of representation of salt flats in the existing conservation reserves should be noted.
- The proposed salt operation would be inconsistent with the *Ningaloo Coast Regional Strategy* recommendation that the eastern side of Exmouth Gulf be included in the marine conservation reserve system.
- Salt extraction could conflict with conservation and recreation land uses proposed for the region.

Assessment

The EPA's environmental objective for this factor is

> *To ensure that management of the eastern fringe of Exmouth Gulf is consistent with the conservation needs and policy framework covering the area and its surroundings.*

The east coast of Exmouth Gulf is characterised by over 80 kilometres of interconnected coastal and arid land components that are largely intact, interconnected through natural processes and of a scale that encompasses both geological and ecological functionality. The area also provides both important habitat for listed species, ecosystem services, for example fisheries and pearl production plus some recreation and tourism.

Although a Temporary Ministerial Reserve was gazetted a generation ago in 1970 for the purpose of solar salt and gypsum production and has never been removed, other Western Australian and national policies and guidelines since that date have consistently supported environmental protection and reservation for conservation on the east coast of Exmouth Gulf. The EPA takes particular note of the existing designation of the area as a wetland of national importance over the coastal shallows, fringing mangrove and algal mat communities plus the whole of the salt flats along the east coast of Exmouth Gulf. The EPA also emphasises its established position on the regional significance of the Exmouth Gulf mangroves and their status as a 'critical asset' of the environment (EPA, 2006).

The proposed construction of salt ponds would effectively remove 17,765 hectares or 19 per cent of the area of the salt flat component of the wetland. Development along 30 kilometres or 38 per cent of the coastline would substantially disconnect the mainland and coastal components of the wetland along this stretch of coast. The proposed location in the centre of the salt flats would fragment the northern and southern components of the remaining wetland. The EPA considers the loss of 19 per cent of the salt flat area stretching along 38 percent of the fringing mangrove coastline to represent a significant reduction in, and fragmentation of, the conservation values

of this nationally listed wetland that has been repeatedly recommended for reservation for conservation.

The east coast of Exmouth Gulf was identified as a candidate area for reservation in the 1994 Wilson Report. While the Wilson Report does not delineate marine conservation reserve boundaries, it does provide indicative boundaries for further study and stakeholder consultation with a view to the establishment of marine conservation reserves. One of the categories of marine conservation reserves; marine management areas, can be gazetted for the purpose of mining as defined under the *Mining Act 1978*. The construction and operation of a solar salt farm within a Wilson Report area is therefore not necessarily at odds with the Western Australian concept of multiple use marine conservation reserves. However, the EPA considers that the construction of an industrial salt facility within the salt flats, prior to the commencement of reserve planning studies and stakeholder consultation, would severely constrain management options and pre-empt the outcome of the conservation planning process.

Government's intent with regard to reservation of the south and south-east coast of Exmouth Gulf was reinforced in 2004 in the Cabinet endorsed *Ningaloo Coast Regional Strategy Carnarvon to Exmouth* (WAPC, 2004). This document recommends that development within this portion of Exmouth Gulf be in accordance with the recommendations of the Wilson Report. As authors of the *Ningaloo Coast Regional Strategy Carnarvon to Exmouth*, the Department of Planning and Infrastructure (DPI) has advised the EPA of its concerns regarding potential land use conflicts between conservation and the operations of a solar salt field.

If constructed, future rehabilitation of the salt field, in particular the crystalliser ponds, to pre-construction condition would be costly and very difficult. The proponent has put forward a range of decommissioning options, including the use of some ponds for aquaculture, allowing evaporation to continue and leaving salt crusts in place, breaching levee walls to allow water flow or removal of levee wall material. It is likely however, that the construction of Yannarie Solar would prevent any future opportunity for reservation of a large intact salt flat that has continuous ecological connectivity with marine ecosystems of high conservation value. Advice from the Department of Environment and Conservation (DEC) states:

> *"Regardless of the reduced scale of the project, the opportunity for the reservation of this system as a representative example of intact, extensive arid zone supratidal flat adjoining an area of significant marine conservation value will be foregone in Western Australia".*

The EPA is of the view that locating a 17,765 hectare salt field within the salt flats would significantly reduce the potential size of, and fragment, any reserve system over the east coast of Exmouth Gulf and that this would represent a lost opportunity and greatly diminish its value. The EPA takes the firm view that because the whole salt flat area is already listed as a wetland of national significance and is therefore recognised as a critical environmental asset, the loss of wetland values associated with the construction of a 17,765 hectare solar salt farm stretching along 38 per cent of the mangrove fringed coastline would be contrary to the EPA's position that "'*critical assets' represent the most important environmental assets in the State the must be fully protected and conserved*" (EPA, 2006).

The EPA considers that the proposal is fundamentally in the wrong place. While its construction might be appropriate elsewhere, it considers that industrial development for solar salt production is not appropriate on the salt flats adjacent to the extensive mangrove and algal mat communities that comprise a wetland of national importance and form a critical asset for the maintenance of the Gulf environment and the natural resource and recreation activities that depend on it.

Summary

The EPA notes that;

- The proposal is located within a listed wetland of national importance;
- Wetlands of national importance are identified as 'critical assets' that should be fully protected and conserved (EPA, 2006);
- The salt pond footprint is 17,765 hectare and stretches along 38 per cent of the mangrove fringed coastline;
- The existing framework of policies and guidelines consistently advocate the protection and reservation of the east coast of Exmouth Gulf;
- The construction and operation of a salt farm would significantly compromise the planning outcomes for a multiple-use marine conservation reserve on the east coast of Exmouth Gulf; and
- the east coast of Exmouth Gulf provides the only opportunity to reserve the largest salt flats in WA with over 80 kilometres of interconnected coastal and arid land components that are largely intact, interconnected through natural processes and of a scale that encompasses both geological and ecological functionality.

Accordingly, the EPA concludes that the Yannarie Solar proposal does not meet the EPA's objective to ensure that management of the eastern fringe of Exmouth Gulf is consistent with protection of the conservation values and policy framework covering the area and its surroundings.

3.2 Mangrove and algal mat communities – changes to relative sea level

Description

Mangrove and algal mat distributions are defined by their tolerances to salinity and desiccation. Unless prevented by other influencing factors, the distributions of mangrove and algal mat communities will adjust to changes in relative sea levels to maintain these preferred inundation and salinity conditions.

Relative sea level and patterns of inundation are influenced by:

- coastal geomorphology;
- geological processes;
- tides, and other waves; and
- climate.

Spot heights along six east-west transects across the salt flats confirm that although there are very slight depressions, channels and ridges, the surface slopes are 1:5000 to 1:10,000 and elevations are only about 0.2 to 0.3 metres higher at the inland boundary of the flats compared with the edge of the algal mats. The tidal range is about 1.8

metres for spring tides and 0.6 metres for neap tides, with higher high tides and lower low tides at the southern, more constrained end of Exmouth Gulf. The salt flat is generally a few centimetres higher than high tides, but some areas are lower than the highest astronomical, and mean high water spring tides. While vulnerable to inundation, these very low lying areas rarely inundate on high tides because they are too far from the shoreline and generally the time required for water to flow this far is greater that the time during which the tide is high enough to provide the necessary head of water.

Weather has a strong influence on sea levels. Low atmospheric pressures result in higher high tides and strong onshore winds drive water further east across the salt flats. Extreme sea level events are associated with storms. One cyclone passes within 100 kilometres of North West Cape every one or two years and the area has been impacted by a severe cyclone approximately once every 25 years.

In 1999, Cyclone Vance passed within a few kilometres of the proposed development site. This was an extreme category five cyclone with recorded winds of 267 kilometres per hour. Turbridgi Point, approximately 30 kilometres north of the proposed Yannarie Solar development, was within the zone of maximum winds and the storm surge at this point came ashore as a six to seven metre high wall of water (Nott, 2006). Offshore islands, mainland outliers and fringing mangroves dispersed some of the storm surge energy before it struck the proposed development site further south. Proposed salt and bitterns ponds, water intake pumps, harbour infrastructure and salt stockpiles are within the area that was inundated by the Cyclone Vance storm surge. A constructed platform is proposed to elevate the salt stockpiles. The fuel storage facilities at Hope Point and Main Island are proposed to be three metres above the Cyclone Vance strand line.

Cyclone Vance is estimated to have struck the coast less than one and a half hours after low tide. The storm surge from this event is therefore unlikely to represent the worst case scenario that could have occurred if the surge had coincided with a high tide.

The patterns of present day tidal and storm related inundations are unlikely to remain static during the next century, due to climate change. The Intergovernmental Panel on Climate Change report (Nicholls *et al*., 2007), rates the possibilities of increased storm frequency and increased storm severity as 'likely'. Of the six scenarios analysed in the IPCC, 2007 report, predictions of sea level rise range from 0.18 to 0.59 metres during the 21st century.

The proponent has given consideration to a sea level rise of 0.38 metres based on the earlier 2001 IPCC report, and on their interpretation of *Statement of Planning Policy number* 2.6, *State Coastal Planning Policy, 2003* (WAPC, 2003). *Statement of Planning Policy number* 2.6 makes reference to the Bruun Rule which the proponent has used in support of their proposed minimum 100 metre setback between the landward margin of the algal mats and the outer levee walls.

The proponent has also prepared contour maps of the salt flats showing potential distributions of algal mat and mangrove communities for 0.3 metre, 0.5 metre and 1 metre sea level rise scenarios. These maps demonstrate that the proposed location of

salt pond levee walls coincides with tidal inundation regimes that, following sea level rise, are likely to be suitable for algal mat and mangrove community colonisation .

Relative sea level can also be influenced by tectonic activity and the accumulation, erosion and subsidence of sediments. The land mass along the east coast of Exmouth Gulf is rising at an approximate rate of 0.2 millimetres per year (Van de Graaff et al., 1975). This slow rate of tectonic rise is expected to continue.

Sediment accretion and subsidence commonly occurs in mangroves and on deltas. A detailed study of sediment dynamics within the Exmouth Gulf east coastal system has not been carried out. However, the available evidence indicates that sediment accumulation in Exmouth Gulf is very low and the coast is mildly erosive:

- Less than a metre of Holocene sediment has accumulated in most regions of the Gulf over the last 6,000 – 8,000 years and it seems likely that some of these Holocene sediments are being eroded and transported out of the Gulf, with the mangrove zone diminishing in area (Oceanica, 2005);
- There is little evidence of coastal trapping of sediment and oceanic elements in Exmouth Gulf, and some regions of the intertidal mangrove and saltflat zones are being eroded into the Gulf and adjacent shelf (Brunskill, *et al.* 2001); and
- The maturity of the mangal front suggests a stable state at present, but mildly erosive processes are indicated in the barren-burrowed terrain landward of the mangal (Brown, 1988).

An assessment of satellite images spanning the last thirty-six years shows no obvious consistent trends in accretion or erosion along the east coast of Exmouth Gulf coastline within this time frame.

The proponent has put forward the view that tidal activity is the predominant particulate transport mechanism and there is no large-scale long-shore sediment transport in the near shore area. A commitment has been made to monitor sedimentation including shoreline profiles at Hope Point and tidal creeks.

The proponent has indicted that the sandy silts and clays beneath the evaporation ponds have a pre-consolidation pressure of about 30 kilo-Pascals (kPa). This is much higher than the 8 kPa that would be exerted by the 0.8 metre depth of brine in the salt ponds. The weight of the salt ponds is therefore not expected to cause subsidence.

Submissions

Submissions relating to this factor raise the following points:

- Sea walls have the potential to restrict the capacity of algal mat and regionally significant arid zone mangroves retreating or adjusting to sea level rise.
- While it is possible that mangroves will vegetate the whole salt flat as a result of sea level rise, the salt flats may remain unsuitable for mangrove colonisation (e.g. due to soil salinity/structure). In this case, just a fringe of mangroves might migrate landward as sea level rises.
- The ponds will fragment mangroves that have moved across the salt flats to adjust to sea level rise.
- Salt ponds will reduce by approximately one quarter to one third the available potential mangrove habitat that may occur due to sea level rise.

- Development planning ignores local variations in sediment cell behaviour and inter-annual and longer variations in ocean climate.
- The proponent has not adequately addressed climate change risks or the need for climate change adaptation in the design and management of the project.
- Existing mangrove creeks could vanish with sea level rise and this could impact nursery areas for prawns and other organisms.
- Sea level rise could damage a section of the mangroves allowing increased storm wave energy to have greater influence on the salt flats.
- The Yannarie development should be designed based on the worst case scenario combinations of storm surge, wind, high tides and climate change sea level rise estimates.
- Sea level rise is inevitable and estimates used in the Statement of Planning Policy 2.6 are out of date and not precautionary with respect to more recent predictions.
- Flood and storm surges could inundate the project area. Inundation potential should be modelled and the DPI should assess this work.
- The response of the shoreline to a 0.38 metre sea level rise is likely to be complex and should be considered in significantly more detail by the proponent.
- Sea level is rising at a much faster rate than was previously anticipated.
- In the past, storm surges have taken trawlers over/through the mangroves and left them stranded well inland.
- Before Cyclone Vance, there was a debris line of tree trunks from previous cyclones. The measured vertical height of this debris line was 10 metres above high water mark.
- The Bruun Rule is relevant to sandy shores. It is invalid for muddy shoreline predictions.
- Salt pond loads and their potential to depress sediments should be considered in relation to sea level.
- The diversion of surface waters (associated with hinterland river diversions) may cause erosion of mangrove communities due to the reduction in terrestrial sediment supply.
- Sea walls risk altering coastal water flows and associated sedimentation patterns because of deflection of waves from levee walls causing erosion and prolonged inundation.
- Scientific papers provide little evidence of coastal trapping, therefore mangroves might be diminishing already.
- Modelling should be carried out to examine both changes in runoff patterns/erosion of the channels and banks and sediment movements which generate turbidity in the Gulf.

Assessment

The EPA's objective for this factor is;

> *To ensure that the ecological functioning of, and ecosystem services provided by mangrove and algal mat communities are not significantly disrupted as they adjust to altered patterns of inundation caused by predicted sea level change.*

Storm surges and climate change have the greatest potential to alter relative sea levels on the east coast of Exmouth Gulf. Tectonic rise is predicted to continue at a rate (0.2 millimetres per year) which is an order of magnitude slower than climate change induced sea level rise. Information relating to sediment accretion and erosion, although limited, indicates that neither of these processes have contributed significantly to changes in relative sea level for hundreds of years.

The Yannarie Solar proposal could cause a reduction in the availability of sediment, increased erosion and a redistribution of sediments through:

- Sediment trapping upstream of the inland weir;
- Partial blocking of river outflows across the salt flats;
- The excavation of a dredged channel; and
- Seaward reflection and refraction of extreme waves from levee walls.

Predictions as to the scale and extent of such changes have not been investigated in detail and therefore remain a source of uncertainty. However, other than in localised patches of the coast, it is considered very unlikely that accretion will increase to a rate that would keep pace with projected levels of sea level rise associated with climate change. Any localised increases in erosion along the coastal fringe would further exacerbate impacts associated with climate change.

The height of the salt ponds themselves relative to changing sea levels would not be influenced by altered patterns of accretion and erosion. Subsidence could occur, but information provided indicates that subsidence as a result of sediment compaction beneath the salt ponds is unlikely.

The DPI advised that a detailed assessment of shoreline response to sea level rise should be conducted at the site in both the pre-development and post-development scenario and that the results of this study, along with consideration of severe cyclonic impacts and historic shoreline change should be used to inform an analysis of development setback.

The proponent has approached the subject of setback and sea level rise in two ways;

- reference has been made to *Statement of Planning Policy number 2.6* and the Bruun Rule to justify the proposed setback of 100 metres from algal mats; and,
- three contour maps have been prepared showing the likely distributions of tidal inundation regimes suitable for mangrove and algal mat communities on the salt flats if sea level rose 0.3 metres, 0.5 metres or 1 metre.

Reference within the *Statement of Planning Policy number 2.6* to a sea level rise of 0.38 metres is based on the mean of the median predicted sea level rises across all IPCC scenarios investigated in 2001 (Church *et a*l., 2001). By definition, the mean of the medians does not provide a precautionary approach. It should also be noted that the IPCC predictions are modelled outputs based on thermal expansion and ice melt. They do not include any contribution to sea level rise that would be made by rapid melting of the major ice caps. This additional factor would increase the rate of rise and sea levels themselves well above IPCC predictions.

The Bruun Rule refers to a one hundred to one relationship between horizontal coastline adjustment and changes to sea level. For example, using the Bruun rule, the shoreline would be predicted to move 100 metres inland in response to a 1 metre rise

in sea level. The Bruun Rule however, requires uninterrupted on-shore, off-shore sediment exchange (Bruun, 1988). Such exchange would be obstructed by the proposed salt ponds. As stated in *Statement of Planning Policy number* 2.6, the applicability of the Bruun Rule is restricted to some sandy shores. Its use by the proponent to justify a 100 metre setback from algal mat communities is therefore of questionable validity. The EPA is not convinced that either a predicted 0.38 metre rise in sea level or the use of a one hundred to one relationship between horizontal shoreline movement and sea level rise necessarily provide a conservative estimate of setback requirements to avoid levee wall impacts on algal mat and mangrove communities.

The contour maps showing the distribution of inundation patterns likely to be associated with 0.3 metre, 0.5 metre and 1 metre rises in sea level further demonstrate the inappropriateness of relying on the Bruun Rule to determine setbacks at this site. The DPI advised that:

> … *"we would expect the extent of inundation for a 0.38m sea level rise at this site to be extensive"*.

The maps demonstrate that this expectation is indeed the most likely scenario. Even for a 0.3 metre rise in sea level, the ideal inundation regimes for both algal mat and mangrove communities are likely to have migrated up to and beyond the proposed location of the seaward levee walls.

If algal mat communities adjust to changing inundation regimes by moving inshore, their continued progress would be interrupted along 30 kilometres, or approximately 38 per cent, of the mangrove fringed coastline by the salt field levee walls. Algal mats can tolerant only a narrow band of inundation regimes at the upper end of the tidal range. They might be able to colonise a narrow band on the levee walls themselves, but further retreat inland would be blocked by the levee walls.

The construction of salt field levee walls could therefore be expected to both reduce the available area for algal mat colonisation and fragment the algal mat communities to the north and south of the salt field as they adjust to sea level rise. Algal mats are one of the main sources of nutrients driving the Exmouth Gulf ecosystem (see Section 3.3 in this report). Disruption to algal mat communities along 38 per cent of the coastline, is therefore likely to impact productivity in Exmouth Gulf.

If mangrove communities adjust to changing inundation regimes by moving inshore, once again, their continued progress would be interrupted along 30 kilometres of the mangrove fringed coastline by the salt field levee walls. Mangroves tolerate a broader range of tidal inundation patterns than algal mats and might be able to colonise a narrow fringe along and adjacent to the pond walls. A high potential would remain however, for the fragmentation of what are recognised as regionally significant arid zone mangroves (EPA, 2001).

Although, the 0.3, 0.5 and 1 metre inundation maps produced by the proponent are based only on spot heights and do not take account of inundation regimes associated with tidal flows, they indicate that with higher sea levels, the total area of mangroves has the potential to be significantly larger than it is today because of the very flat terrain. The maps indicate that if the salt flat substrates support mangrove growth, they could completely surround the proposed salt farm.

EPA Guidance Statement number 29 provides a framework for determining the acceptability of habitat loss, including the loss of potential habitat, for benthic primary producers in areas of high protection. Both mangroves and algal mats are classed as benthic primary producers. An analysis of algal mat and mangrove habitat loss as a direct result of the salt field, using the three mapped sea level rise scenarios, confirms that the losses would be above the guideline of a maximum of one per cent loss within management units of approximately 50 square kilometres. It is the EPA's view that the construction of levee walls along 38 per cent of the mangrove fringed coastline poses an unacceptable threat of habitat loss and community fragmentation to algal mat and mangrove communities that adjust to rising sea level.

If the mangrove and algal mat communities are unable to successfully adjust their distributions to changing sea levels by moving inshore, their demise will occur whether Yannarie Solar is constructed or not. However, mangrove communities currently provide shelter from storm surges and loss of this protective buffer on the seaward side of the salt farm would increase the exposure and vulnerability of levee walls to severe storm surges. Climate change therefore is likely to increase the vulnerability of infrastructure, in particular the salt pond levee walls, not only because of higher sea levels, but also because of the likely increase in storm frequency, the likely increase in storm severity and potential increased exposure due to a reduced level of protection from fringing mangroves.

The proponent has indicated that levee walls would be designed to withstand a 1 in 100 year Average Recurrence Interval (ARI) storm event and to prevent overtopping in storms of 1 in 50 year ARI event magnitude. They have also indicated that the heights of levee walls would vary to take account of the different amounts of shelter from or exposure to storm surges along each stretch of coastline. However, the storm standards and storm surge estimates are based on current storms, current sea levels and current levels of protection. These parametres could change during the life of the proposal requiring the structural upgrading of levee walls.

Infrastructure is considered in more detail in Section 3.4.1 "Salinity and bitterns management".

Summary

The EPA has noted that;

- Exmouth Gulf and in particular the algal mat and mangrove communities are of high conservation value;
- The proposal would potentially result in habitat loss and fragmentation of regionally significant mangroves;
- The proposal would potentially result in habitat loss and fragmentation of algal mat communities that contribute significantly to the productivity of Exmouth Gulf; and
- Management options to prevent impacts to mangroves and algal mats from sea level rise in the face of extensive levee walls are limited.

The EPA concludes that the proposal does not meet the EPA's objective of ensuring that the ecological functioning of, and ecosystem services provided by mangrove and algal mat communities are not significantly disrupted as they adjust to altered patterns of inundation caused by sea level change.

3.3 Marine productivity - nutrient input

Description

Following cyclones and other major events that result in surface runoff and high levels of turbidity, the Exmouth Gulf ecosystem sometimes has a burst of productivity characterised by extensive seagrass growth and high prawn catches (Kenyon and Loneragan, 2004). Depending on the intensity and seasonality of the event, productivity drops off after a matter of months to a few years (Kangas *et al*., 2007).

Research by the Australian Institute of Marine Science (Ayukai and Miller, 1998, and McKinnon and Ayukai, 1996) has identified that even during periods that are not associated with disturbance events, productivity in Exmouth Gulf is higher than can be accounted for solely by the recycling of nutrients within the Gulf system. This means that nutrient inputs from mangroves, algal mats or other sources are likely to be important for productivity in the Gulf.

Nitrogen and phosphorus are both important nutrients for the growth of photosynthetic organisms such as algae, seagrasses, mangroves and phytoplanktonic organisms. Growth is limited when one or other nutrient is in short supply. Marine phytoplankton production is generally considered to be limited by nitrogen rather than phosphorus (Ayukai and Miller, 1998) and most of the marine biological studies relating to nutrient pathways focus on nitrogen limitation. There are, however, two schools of thought regarding nutrient limitation in marine environments. Some consider nitrogen to be limiting, while others are of the view, particularly in relation to estuaries and slowly flushed embayments, that phosphorus availability limits net organic production (Smith, 1984). Seasonal shifting between phosphorus and nitrogen limitation has been recorded in at least one ecosystem (McComb *et al*.,1981).

The proponent has focused investigations relating to nutrient pathways and availability on nitrogen. The potential for phosphorus limitation in Exmouth Gulf has not been considered.

There are several potential supplementary sources of nutrients for Exmouth Gulf. Some have the potential to contribute nutrients on an ongoing basis. Others have the potential to provide an intermittent source of nutrients.

Table 2: Potential ongoing and intermittent sources of nutrients.

Ongoing nutrient input	Intermittent nutrient input
• Algal mat communities (atmospheric nitrogen fixation) • Wind driven dust from the hinterland, coastal dunes and salt flats	• Ocean up-welling • Storm disturbance of Exmouth Gulf sediments • Periodic river surface flows; • Flushing from salt flat microbial crusts (atmospheric nitrogen fixation); • Flushing of nutrients accumulated by evaporation; • Flushing of nutrients from sediments oxidised during slow tectonic rise.

Algal mats occur inshore of the mangrove communities, occupying the highest intertidal zone which is inundated for between just one and three per cent of the time during normal tidal cycles. They consist of species that fix atmospheric nitrogen which is then lost principally as organic nitrogen during high spring tides and surface flushing by rain. The algal mats along the east coast of Exmouth Gulf cover 8054 hectares or about nine per cent of the salt flats and it is estimated that they contribute 68 kilograms of nitrogen per hectare per year, or a total of 547 tonnes of nitrogen per year to the Gulf marine ecosystem (Paling and McComb, 1994 and Biota, 2005).

There is no information about nutrient contributions from wind driven dust off the hinterland and salt flats. Input from this source would not be expected to coincide with observed productivity pulses following major storm and rainfall events.

Periodic deep ocean up-wellings occur along the edge of the continental shelf, west of North West Cape (*Hanson et al., 2005*). It has been suggested that some of this nutrient rich water could enter Exmouth Gulf. The tidal input of Indian Ocean water to Exmouth Gulf is estimated to be 3.8×10^{11} cubic metres per year, but the frequency of up-wellings and the amount of nutrients entering the Gulf system from this source is not known. Nutrient pulses from ocean up-wellings would not necessarily be expected to coincide with storm events and observed productivity pulses. The Yannarie Solar development is not predicted to have an impact on nutrient input to the Gulf from ocean up-wellings.

Freshwater input to Exmouth Gulf from all of the ephemeral rivers around its shores is estimated to be four orders of magnitude lower than tidal inputs of Indian Ocean water. The average annual amount of freshwater input has been estimated at 5.8×10^{7} cubic metres per year. Despite this comparatively small freshwater input, pulses of productivity in the Gulf are sometimes reported to follow surface water flood events.

Yannarie Solar would require the construction of a weir across one of the ephemeral rivers that drains the hinterland, and the construction of salt ponds that extend along 30 kilometres of the mangrove fringed coastline. Concerns have been raised that the ponding and diversion of periodic surface water flows by the weir and salt pond levee walls could reduce nutrient input from the hinterland and other sources to the Gulf ecosystem, causing a reduction in productivity.

Two ephemeral watercourses, the Yannarie and Rouse Rivers, drain the hinterland and discharge onto the salt flats adjacent to the proposed development. Each river has two outlet channels known simply as North and South. The expected flows from each of the four channels have been modelled for a range of rainfall scenarios. Because the rivers flow through a sand dune system prior to discharge onto the salt flats, results of the surface water flow modelling by the proponent indicate that the river systems only discharge to Exmouth Gulf during at least 20 year (ARI) events. Nutrient levels in the ephemeral rivers draining the hinterland have not been measured.

The proposed salt pond footprint would block the direct flow of surface water discharge to 38 per cent of the mangrove shoreline along the east coast of Exmouth Gulf. Results of the proponent's flow models for Yannarie and Rouse Rivers indicate that Yannarie South is the dominant channel comprising approximately 37 per cent and 67 per cent of the total outflow for 100 year and 20 year ARI events respectively.

This channel discharges at the southern end of the proposed salt field. According to the surface flow modelling, Yannarie North discharges about 25 per cent of the total surface water outflow. This would be diverted north to the Rouse South discharge channel, more than doubling the outflow from this outlet. Rouse South and Rouse North would discharge to the north of the salt pond footprint.

Hinterland river drainage is not the only source of nutrients that could be mobilised by flood waters flowing across the salt flats. Elevated nitrogen levels (mean total nitrogen concentrations of 12.18 milligram per litre (mg/l) occur in the superficial groundwater beneath the salt flats. These elevated levels of nitrogen could be the result of concentration by evaporation, microbial crusts and other hyper-saline tolerant microbes and/or, continuing slow tectonic activity resulting in oxidation. Elevated levels of phosphorus (0.46 mg/l, which is over four times the usual level of 0.1 mg/l in regional soils) are also reported in the groundwater of the superficial aquifer below the salt flats.

A clay layer separates the superficial aquifer from a deeper aquifer beneath the salt flats. The upper surface of the clay layer is below mean sea level allowing connection between the waters of Exmouth Gulf and the hyper-saline superficial aquifer. Authors of a salt flat hydro-geological study concluded that the nitrogen rich superficial groundwater slowly moves west discharging directly into the Gulf (Parsons Brinckerhoff, 2008).

When inundated, the connection between the superficial aquifer and waters flowing over the surface has the potential to provide another pathway for the release of groundwater nutrients. The release of nutrients from groundwater would not require a major storm greater than a 20 year ARI event as was predicted to be required for the flow of surface water from the hinterland. Any heavy rain that resulted in surface flows over the salt flats has the potential to transport nutrients from the superficial aquifer and surface salt flat sediments to Exmouth Gulf.

In addition to the potential transport of groundwater nutrients via surface floods, salt flat inundation would tend to recharge the slow groundwater flows directly into the Gulf. The potential for mobilisation of nutrients in superficial groundwater either by transfer to surface flood flows or by enhanced groundwater flows during flood events has not been investigated. If these mechanisms do occur, the timing of nutrient release induced by flooding events would coincide with observed pulses in Gulf productivity following storm and rainfall events.

Submissions

Submissions relating to this factor raise the following points:

- A large number of submissions expressed the view that periodic surface water floods from the hinterland to Exmouth Gulf provide an important source of nutrients for the mangrove and Gulf ecosystems. Several of these submissions made reference to a photograph of the surface flood following Cyclone Bobby in 1995 which shows sediment laden sheet flow from the hinterland across the salt flats and out into the Gulf.
- Uncertainty remains regarding the relationship between surface flows and Gulf productivity, in particular the potential impact of diverting surface flood

waters to the north and south of the salt ponds and away from shoreline mangrove creeks adjacent to the salt pond footprint.

- Although cyclones do not occur every year, infrequent events can still be vital ecosystem drivers and should be understood as a constant force shaping the Gulf's communities.
- For much of the time, production in the Gulf appears to be based on recycling of nutrients, but these are probably recharged at some stage and the potential importance of infrequent, aperiodic terrigenous inputs cannot be discounted.
- Contained water in the constructed weir will cause nutrients and sediments to drop out of flood waters prior to reaching the Gulf.
- Surface water quality monitoring has not been carried out.
- Increased productivity follows cyclonic events and seagrass recovered rapidly following Cyclone Vance.
- The surface water flow model has not been verified.
- Although the surface water flow model predicts that flows from the hinterland will not reach the Gulf following ARI events less than 20 year ARI, local records indicate that flood events occur much more frequently than approximately once every 20 years.
- The relationship between surface and ground water is unclear, making the prediction of impacts difficult.
- Nutrient transport from ground water has not been investigated.
- Pulsed productivity may be supported by re-suspension of nutrients in Gulf sediments.
- The construction of salt ponds will eliminate large areas of salt flat microflora from the natural system.
- Small changes in nutrient cycling due to changed runoff may significantly affect the productivity of epiphytes growing on the seagrasses.
- Zooplankton biomass and grazing pressure appear to be far in excess of available phytoplankton production.

Assessment

The EPA's environmental objective is;

> *to maintain the quality and quantity of surface and ground water flows so that environmental values, including ecosystem maintenance, are protected.*

The proponent has presented information confirming the importance of algal mats in the ongoing provision of nitrogen to Exmouth Gulf. The EPA notes the proponent's plan to construct salt pond levee walls a minimum of 100 metres away from algal mat communities to protect them and the important role they play in providing nutrients to Exmouth Gulf. It is the EPA's view, however, that within the life of the project (>60 years), sea level will rise sufficiently to change the current distribution of algal mats and diminish or eliminate this 100 metre buffer. The presence of the salt ponds would prevent the re-establishment of algal mats in the area occupied by salt ponds. The ecosystem function provided by algal mats in an area designated as a critical asset because of its status as a wetland of national importance highlights the need to completely protect and conserve algal mats along this shoreline.

The proponent's focus on nitrogen as the limiting nutrient in Exmouth Gulf assumes that phosphorus is in sufficient supply. The EPA notes that debate exists about whether phosphorus is limiting in marine environments.

Little is known about the observed pulses of productivity in Exmouth Gulf which sometimes occur following storm events. It is not known for example whether these peak productivity events represent peaks on top of a sustainable minimum productivity level, or whether productivity in the Gulf is reliant on these periodic inputs. Without information to support the hypothesis that productivity in Exmouth Gulf is sustainable without, or is not reliant on, the observed periodic pulses, the EPA is bound to take a precautionary approach so that the source or sources of nutrients that drive periodic pulses of productivity are protected.

Many submissions expressed the view that the sediment laden surface flood waters that flow following infrequent storm events carry significant amounts of nutrients from the hinterland to Exmouth Gulf. The proponent holds the view that the ancient leached soils of the hinterland are too poor in nutrient content and, surface water discharge from the hinterland is too infrequent, for the nutrient content of river flood waters to contribute significantly to observed pulses of productivity. With reference to modelled surface water flows, the proponent refers to there being an 'hydrological disconnect' between the hinterland and Exmouth Gulf.

Verification of the surface water flow modelling is limited and the model may underestimate the frequency of east coast river discharge events to Exmouth Gulf. The model predicts that flood waters reach Exmouth Gulf only after 20 year ARI or more severe events, yet there have been four such floods recorded during the last 11 years:

- Cyclone Bobby in 1997;
- Cyclone Vance in 1999;
- A winter extreme rain event in 2002; and
- Cyclone Pancho in 2008.

While they may be statistical anomalies, these recent observations do not support the proponent's view that flood events only reach Exmouth Gulf less than once every 20 years.

The EPA has received advice from the DEC that although the river catchments are characterised by leached soils, these support abundant *Acacia* species which have adapted to poor soils by developing their own nitrogen fixing capability. Nitrogen fixed by vegetation is then characteristically made bio-available and mobilised through the action of termites and other processes that break down plant material.

The proponent has provided rough estimates of nitrogen from the hinterland (~30 tonnes per annum of nitrogen), algal mats (~550 tonnes per annum of nitrogen) and offshore waters (~7,400 tonnes per annum nitrogen) to support its view that nutrients transported from the hinterland do not make a significant contribution to Gulf productivity. However, these estimates are annual averages and it is not clear how they relate to the observed intermittent productivity pulses that are of interest in relation to periodic hinterland flows. It is also relevant to point out that the estimated annual average of nitrogen input from hinterland flows would all flow into the Gulf

during just a few days or weeks following a flood event which may occur only once every few years.

The nutrient content of ephemeral river flows has not been measured to determine the potential contribution made by river flood events to Gulf productivity. The proponent's view that flood waters carry only low concentrations of nutrients from the hinterland therefore remains unverified.

The EPA notes the absence of information verifying the proponent's view that the nutrient content of surface flood waters from the hinterland is too low to drive productivity pulses in the Gulf and, the significantly higher frequency of major floods recorded than predicted by flood modelling, and concludes that the proponent has not demonstrated that there is an 'hydrological disconnect' between the hinterland and the Exmouth Gulf ecosystem. The EPA advises that the functional importance of periodic hinterland drainage in relation to post flood productivity peaks in the Gulf remains uncertain and a precautionary approach should be taken to ensure that any modification of hinterland flows does not prevent their discharging to the Gulf and does not result in significant disruption to the pattern of delivery of nutrients from this source.

The accumulation of available nutrients in surface sediments and the superficial groundwater beneath the salt flats has been identified as another potential source of nutrients that could contribute to the observed productivity pulses. Although the transfer of nutrients from ground water to surface flood waters and from surface sediment to surface flood waters have not been verified, there remains the possibility that these sources enrich the nutrient levels of flood waters crossing the salt flats. If these sources did contribute significant amounts of nutrients to the Gulf, possible impacts of the salt farm would include:

- displacement of microbial crusts from the area of constructed salt ponds (19 per cent of the salt flats);
- prevention of flood water access over an area of surface sediments and superficial aquifer equivalent to the area of constructed salt ponds;
- prevention of evaporative accumulation of nutrients in surface layers beneath the salt ponds ;
- altered groundwater hydrology potentially disrupting slow groundwater flows from further east and mobilising the nutrient rich groundwater currently beneath the salt flats as a plume along 30 kilometres of the coastline.

There is insufficient information to undertake a detailed assessment of these potential nutrient sources and associated impacts. However, their identification adds to the complexity of the issue under consideration, and while information to discount them as sources of nutrients remains absent, it raises the level of uncertainty regarding the understanding of the relationship between nutrients and productivity in Exmouth Gulf.

The construction of a diversion weir on the Yannarie North discharge channel is likely to result in some sedimentation and associated nutrient loss upstream. However, the proponent has predicted that flows would continue beyond the diversion low point and into the Rouse South channel following five year ARI and larger events and that relatively small rainfall events would not reach Exmouth Gulf anyway.

Salt pond levee walls would block 30 kilometres of the shoreline from hinterland surface flows off the hinterland. The surface flows would be diverted to the north and south of the salt pond footprint but would not be entirely prevented from delivering nutrients to the Gulf ecosystem. The EPA is of the view, however, that if hinterland flows carry nutrient loads which are important to overall productivity in the Gulf, localised changes to pulsed nutrient availability may occur in the near-shore areas and mangrove creeks affected by the diversion of waters around the salt ponds.

Because of the prevailing anticlockwise current within Exmouth Gulf, it would be expected that nutrients in surface flood waters discharged at the southern end of the salt ponds would continue to have some influence in inshore areas adjacent to the salt ponds immediately to the north of the discharge point. Nutrients in surface waters discharged at the northern end of the salt ponds would, however, be expected to have a significantly reduced influence in inshore areas adjacent to the salt ponds south of the discharge point. This expectation is illustrated in the photograph of discharge patterns taken from space in 1995 following Cyclone Bobby (Figure 4). The path of discoloured, sediment laden water flowing into the Gulf can be seen to move offshore and generally to the north. The proposed diversion of the Yannarie North channel into the Rouse River outlets would potentially divert an important source of inflow (25 per cent of hinterland flows according to surface water modelling) away from the section of coast that now receives inflows from this channel.

If, after construction of the salt field, the diversion and obstruction of surface flood waters around the salt field was found to significantly impact on mangrove creeks and inshore environments, the only management option available to remediate such impacts would be the reinstatement of pre-construction flows. The implementation of this option is likely to be severely compromised by the presence of the salt field.

The EPA advises that in view of the high conservation status and biodiversity values of Exmouth Gulf and its eastern shoreline, together with the lack of options to address potential impacts associated with floodwater diversions, that the proposed diversion of surface flood waters from the hinterland presents an unacceptable level of uncertainty regarding the potential to significantly disrupt the delivery of nutrients to inshore areas and mangrove creeks adjacent to the proposed salt field.

The proponent has expressed the view that productivity pulses are driven by the disturbance of sediments within the Gulf and nutrient input from algal mats. Sediment disturbance nearly always occurs in association with river flood events during storms. The EPA agrees that sediment disturbance is likely to release nutrients during storm events. While it is known that algal mats can continue to fix nitrogen while inundated by flood waters, no evidence has been presented to support the view that algal mats release more nitrogen during storm events that could drive the observed pulses of productivity. If they did, the threats to algal mats posed by the proposal add weight to a recommendation that the proposal poses an unacceptable risk to nutrient flows into Exmouth Gulf.

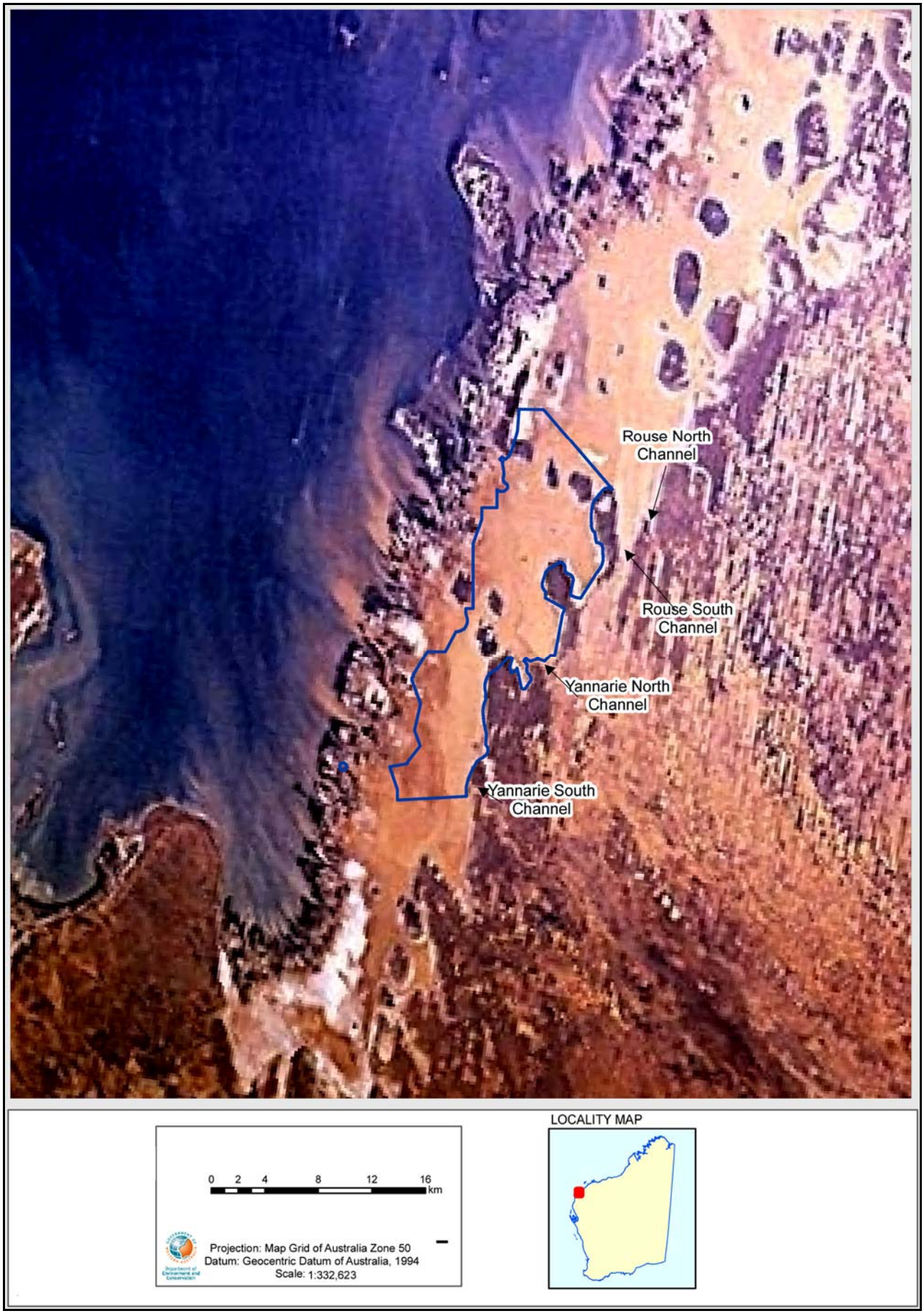

Figure 4: ***Photograph taken from space station of Exmouth Gulf flood event following Cyclone Bobby in 1997***

Whether or not nutrients carried by surface flows from the hinterland are important to the overall nutrient budget of Exmouth Gulf, algal mats and mangrove zones are acknowledged as critical sources of nutrients. The threats posed to algal mats, in particular by the proposed establishment of a salt field where it would disrupt algal mat redistribution in response to sea level rise, persuades the EPA that the proposal may have unacceptable impacts on nutrient inputs to the Gulf.

The EPA notes that productivity in Exmouth Gulf is complex and not well understood. The EPA recognises the importance of algal mats in the ongoing supply of nitrogen to the Gulf, and that there are a number of potential sources of nitrogen and phosphorus that could drive the observed productivity pulses associated with storm events. The EPA is of the view that levels of uncertainty associated with potential impacts of the proposed salt field on nutrient availability, delivery and distribution pose an unacceptable risk to near-shore and mangrove creek productivity.

Summary
The EPA notes that:

- Exmouth Gulf and its eastern coastal fringe have high environmental and biodiversity values;
- Algal mats play an important role in the provision of nutrients to Exmouth Gulf;
- The construction of salt pond levee walls within areas likely to have inundation regimes suitable for algal mat growth under rising sea levels could significantly reduce nutrient inputs to the Gulf ecosystem;
- There are high levels of uncertainty associated with the identification of nutrient sources that drive observed productivity pulses;
- There are high levels of uncertainty associated with potential impacts of alterations to nutrient inputs on the Gulf ecosystem and coastal wetland values; and
- There is limited capacity for management remediation of impacts associated with altered nutrient inputs.

Given the lack of direct evidence from Exmouth Gulf, the EPA takes a precautionary view about the potential role of nitrogen and other nutrients and the possibility that terrestrial inputs from flood events may have a role to play in driving pulses of productivity in the Gulf. The EPA therefore considers that the proposal does not meet the EPA's objective to maintain the quality and quantity of surface and ground water flows so that environmental values, including ecosystem maintenance, are protected.

3.4 Biota and water quality - salinity and bitterns management

Description
Three components of salinity and bitterns management are discussed below, discharge of contained brines and bitterns, long term bitterns management and salt production and transport. The EPA objective for salinity and bitterns management is;

> *to maintain the quality of surface and ground water so that environmental values, including ecosystem maintenance, are protected.*

The salt production process would involve seawater passing through a series of seven large concentrator ponds covering a total area of 8,434 hectares. The concentrated brine would then enter small crystallizer ponds in which the salt crystals would be grown. The waste product from this process is called bitterns. Three types of bitterns would be produced:

- Bitterns A – residue from the first evaporative process to extract primarily NaCl;
- Bitterns B – residue from the second evaporative process to extract primarily NaCl;
- Bitterns C – residue from the third evaporative process to extract primarily K_2SO_4, $MgSO_4$ and KCl.

Bitterns contains high concentrations of magnesium salts and other constituents. It becomes increasingly dense and does not mix easily with water.

The total area set aside for ponds to process and store bitterns A, B and C would be 8,235 hectares. The processing of bitterns A would require small ponds like the crystallizer ponds. Although the final layout of ponds is yet to be determined, the likely location for A ponds would be adjacent to the small crystallizer ponds shown on Figure 1. A mixture of large and small ponds would be required for bitterns B processing and these would most likely be located in the most northerly section of the salt pond footprint. The proponent has indicated that a mixture of large and small ponds covering a total area of 3,093 hectares would be used to store bitterns C. These would be located in the south eastern section of the northern area labelled bitterns storage and processing in Figure 1. The proponent estimates the maximum volume of stored bitterns C to be about 11 million cubic metres.

3.4.1 Discharge of contained brines and bitterns

Seepage of ponded brine and bitterns through constructed levee walls and floor sediments occurs at other salt farms. The proponent has indicated that seepage might encourage algal growth in areas near levee walls. Filled ponds can also result in the mobilisation of hypersaline groundwater as a result of hydrostatic pressure exerted by ponded brine and bitterns. The slow mobilisation of hypersaline groundwater caused by the hydrostatic pressure of ponded brine has occurred at another solar salt farm in the Pilbara, resulting in mangrove deaths some distance from the levee walls.

Salt field levees have failed at other salt fields in the Pilbara. The cause of failure has been the overtopping and subsequent erosion of levee walls from waves generated within salt ponds. The potential impact of catastrophic failure resulting in the release of large volumes of bitterns or brine into Exmouth Gulf has not been investigated.

A commitment has been made not to construct levee walls any closer than 100 metres from the algal mat communities and the proponent considers that they are sheltered from the full brunt of tidal surges by fringing mangroves. Some sections of the salt field would also be protected by hinterland remnants up to 13 metres above AHD. Levee walls would be constructed with a core of low permeability clay material protected by a blanket of rock armour designed to prevent displacement and erosion during storms. The seaward outer walls would be designed in accordance with the Coastal Engineering Manual (US Army Corps of Engineers, 2002) to prevent wave run-up and overtopping for a 1 in 50 year ARI storm event and to withstand a 1 in 100 year ARI event. External levee walls would be about five metres AHD, but the height

would vary based on salt flat elevation and calculations to determine the likely differences in storm surge intensities along different exposed or more sheltered sections of coastline. A double outer wall would be constructed on the seaward side of the crystalliser ponds. Levee walls would be between 1.5 to 2 metres higher than the level of contained fluid after allowing for 200 millimetre rainfall events. This is to contain projected wave run-up that could occur with extensive fetch and rough water conditions in the ponds. Both external and internal levee walls would be topped with a four metre wide road. The proponent has stated that the levees would be designed to withstand any structural challenge from water on both sides of the wall as would be experienced in the case of sea level rise inundating the salt flats.

The salt farm ponds have been designed to sit on top of natural salt-flat sediments. These sediments contain a two to five metre thick superficial hypersaline aquifer which is close to the surface. Below this aquifer is a layer of clay which separates the superficial aquifer from the deeper aquifer beneath. The proponent has indicated that current hyper-saline groundwater discharge from the salt flat is by through-flow into the mangroves and intertidal flats, evaporation, and localised base-flow into drainage channels of the Yannarie and Rouse River systems. The levee walls proposed for Yannarie Solar would not be keyed into the low permeability clay layer beneath the superficial aquifer. The proponent has indicated that measured permeabilities of clay materials and sediments are low to very low and that permeabilities would be further reduced by compaction from construction vehicles and the build up of salt crusts on the inside of salt ponds. The maximum seepage rate is estimated to be 3.09×10^{-7} cubic metres per second per square metre of wall with horizontal seepage in the vicinity of the crystallisers expected to be generally less than 4.4 metres per year.

Wildlife, in particular shore birds, are attracted to salt ponds at other Pilbara salt fields and the proponent has expressed the view that Yannarie Solar provides a positive environmental contribution by creating additional habitat. Although bitterns is not expected to support plant and animal life that would attract birds and other wildlife, concerns have been raised regarding the potential for both feather damage from crystallised salts and poisoning from subsequent preening.

Submissions

Submissions relating to discharge of contained brines and bitterns raised the following points:

- Uncertainty over hydrological linkage between salt ponds and Exmouth Gulf should be investigated thoroughly and independently reviewed by hydrological experts.
- Bitterns has acute toxic effects on most aquatic species due to hypersalinity and alterations in the ionic composition of the brine. The discharge of undiluted bitterns into a marine environment either though deliberate discharge or by accidental seepage can cause widespread environmental harm through magnesium toxicosis, anoxia and hydrogen suphide poisoning.
- The chemical composition of bitterns is particularly toxic to invertebrate species such as prawns and pearl oysters that are the mainstay of commercial fisheries in the region.
- The storage of large quantities of toxic bitterns in a sensitive environment is unacceptable because its release could be catastrophic, killing vast numbers of marine species.

- The bitterns ponds could become a death trap for birds with salts caking onto feathers and subsequent preening causing poisoning.
- The proponent should model pond wall failure and the release of hypersaline and toxic waste to provide information on potential ecological and biodiversity consequences of catastrophic failure of bitterns pond levees.
- The proponent should do a risk assessment of storage seepage, accidental bitterns discharge and tide surge and flooding release on groundwater systems, tidal creeks mangroves and algal mats.
- Mangroves at a solar salt production facility at Port Hedland suffered defoliation and death in the vicinity of levees (Gordon et al., 1995). Following the construction of ponds, the water table rose to the surface, water-logging the mangroves and the salinity of already hypersaline soil water increased by 50 per cent.
- Large scale mangrove mortalities have been shown to be associated with the formation of concentrator ponds in Port Hedland. The ponds were constructed in the mid 1990s and significant mangrove mortalities (many hectares) were still found to be occurring in 2005, some more than one kilometre from the bund wall.
- Evaporation ponds with a relatively high hydraulic head will result in seepage plumes of dense saline water into the underlying sediments, which will discharge seawards, emerging from under the tidal flats. This discharge will fundamentally alter the ecosystem of the tidal flats from a microbial perspective and for macrobiota such as invertebrate fauna and mangroves.
- Sea level rise could damage a section of the mangroves allowing increased storm wave energy to have greater influence on the salt flats.
- Sea level rise projections result in a high level of uncertainty with regard to increased risks of leachate and levee failure.
- An increase in seepage of up to 25 per cent and a decrease in structural integrity might occur if hypersaline clays are used for construction.
- The proponent does not provide an adequate assessment of the impact of a severe cyclone upon the structural integrity of external seawalls nor a design report that includes the structural design of the external seawall, design conditions and performance of the seawall under events that exceed design conditions.
- The proponent should investigate the potential release and associated risks of heavy metals from within the sabka (salt flat habitat). Sediment sampling should be undertaken.
- Microbial mats accumulate large amounts of heavy metals which risk being released and discharged to nearshore environments.
- The potential for bioaccumulation should be investigated.
- Seeped waters would not only contain extremely concentrated salts, they would also contain toxic concentrations of fluoride and heavy metals that could bioaccumulate such as selenium.

Assessment

An area of 8,235 hectares of open ponds for the storage and processing of bitterns would be unprecedented in Australia. Bitterns A, B and C are all toxic to wildlife causing ionic imbalance and oxygen deprivation. Concentrations of magnesium in bitterns C (82,000 milligrams per litre) would be approximately 58 times higher than

in the waters of Exmouth Gulf. This is after the removal of about half of the magnesium to produce 100,000 tonnes of magnesium sulphate ($MgSO_4$) each year. The concentration of other constituents in bitterns, for example any heavy metals that do not precipitate during salt production, might therefore be expected to be about 100 times that in seawater. Data provided by the proponent indicate that some heavy metal concentrations in seawater from Hope Point might naturally be in excess of ANZECC trigger values for marine ecosystem protection (ANZECC, 2000). A further 100 times concentration would be of considerable concern especially as some heavy metals are known to bio-accumulate.

Advice from the DEC has indicated that bird dependence on salt ponds in the Pilbara has already disrupted migrations and resulted in their dependence on insecure constructed habitats.

In the case of Yannarie, in addition to further disruptions to migration patterns, the attraction of birds to remain in an area that includes thousands of hectares of bitterns, would increase the risk of their exposure to toxicity and bioaccumulation of heavy metals. The proponent has indicated that the bitterns ponds are unlikely to support life that would attract birds to feed in them. The proponent has also stated their understanding that no incidents of birds dying in bitterns ponds have been recorded at other Pilbara salt fields. However, the other Pilbara salt farms have only very limited capacity to store bitterns. A detailed response has not been provided to address concerns raised about potential damage to feathers and subsequent ingestion of bitterns during preening. Published literature on this issue indicates that some ducks succumb to rapid and lethal poisoning from high salt concentrations but that shore birds do not share the same degree of vulnerability.

Although the outer levee walls on the western side of the salt field would be designed to withstand 1 in 100 year storm events, they would not be designed to prevent overtopping of storm surges or internal waves associated with a storm of greater intensity than a 1 in 50 year ARI event. The life of the proposal is described as greater than 60 years. During that time, sea levels are expected to rise, and both the frequency and severity of storms are likely to increase. Considering all of these factors, it is almost certain that the walls would be overtopped at least once during the projected life of the proposal.

Discharge from overtopping by internal waves would be more likely to occur in large ponds that have a long fetch and which are located adjacent to an external levee wall. Although the layout of salt ponds has not been finalised, an indicative layout provided by the proponent shows large bitterns C and bitterns B ponds adjacent to external levee walls. One of the proposed bitterns B ponds which lies adjacent to the whole of the northern levee wall, measures seven by four kilometres.

Overtopping by storm surges is most likely to affect ponds on the western side of the salt field. The proponent has indicated that crystalliser ponds on the western side of the salt field would be protected by a double levee wall. The bitterns storage and processing ponds would be located across the whole of the northern end of the salt field where they would be afforded some protection from storm surges by mainland outliers to the west. The proposed location of bitterns C ponds on the eastern side of

the bitterns storage and processing area would reduce the chance of direct storm surge overtopping of these ponds.

If a bitterns pond was overtopped by a storm surge, some mixing with the bitterns is likely to occur and some of the bitterns mixture might drain back over the levee wall. It is possible that as a storm surge moved east across the salt field, it would cause the overtopping of ponds on their eastern sides. Although there is likely to be a relationship between the amount of bitterns discharged as a result of overtopping waves, and the capacity of turbulent coastal waters to mix with and disperse a bitterns spill, a severe storm surge associated with a 1 in 100 year ARI event, could run right over the salt field causing discharge of brines and bitterns over levee walls in any direction.

The proponent is of the view that salt pond levee walls that have failed at other solar salt farms in the Pilbara were not built to the same standards proposed for Yannarie Solar. A detailed comparison of standards has however, not been provided.

Depending on the degree of dilution with sea water, catastrophic failure with the release of large quantities of bitterns, could be expected to cause major impacts on marine and coastal habitats. Without thorough mixing, dense bitterns would generally flow along the seabed to deep areas of the Gulf. It would be toxic to plant and animal life and is likely to cause anoxic conditions. The risk of large volumes being discharged as a result of catastrophic failure could in part be managed by the sizes of ponds adjoining outer levee walls. Smaller ponds do not have the potential to discharge as much bitterns as large ponds. However, an indicative plan of bitterns pond layout, includes large bitterns B and bitterns C ponds next to the outer wall.

Recovery of natural biological communities in deeper areas of Exmouth Gulf could occur if the dense bitterns thoroughly mixed with, and then dispersed in, the much less dense layers above. Exmouth Gulf does not have a well-defined sill and is not generally stratified, indicating that it is normally fairly well mixed. However, bitterns does not mix readily with sea water because it is so dense and without dispersion modelling it is not known how long mixing and dispersal might take.

The EPA is of the view that levee walls constructed to a design standard which is almost certain to allow overtopping to occur during the life of the project are not adequate to ensure that concentrated brines and toxic bitterns would be fully contained within the salt field. The EPA notes that over 8000 hectares of bitterns storage and processing ponds would be constructed, that there has been no detailed assessment of the likely impacts of overtopping or catastrophic wall failure, that several of the ponds proposed for storage and processing of bitterns are large and adjacent to external levee walls, and that Exmouth Gulf is an area subject to severe storms which are sometimes associated with storm surges several metres in height. The EPA is therefore of the view that the risks and uncertainties associated with these points pose an unacceptably high risk to the high environmental values of Exmouth Gulf.

Some seepage is likely to occur through and beneath the proposed levee walls. Permeability tests indicate that both the clays to be used for levee wall construction and the sediments on the salt flats have low or very low permeabilities. However,

these laboratory tests are limited to small samples of sediment and do not take account of larger scale processes and features such as small cracks and variations in texture caused by, for example, expansion and contraction due to wetting and drying or chemical reactions.

Water that seeped through or under levee walls surrounding the first concentrator pond might be expected to provide new habitat for mangroves and algal mats. However, brine that seeped through and under levee walls surrounding other sections of the salt field containing more concentrated solutions would more likely be toxic to algal mat and mangrove communities.

The proponent has not provided additional advice relating to concerns raised about potential alterations to structural integrity and increased seepage through clays that are hyper-saline. While establishing that the clays sourced in the hinterland would not be hyper-saline, consideration did not extend to the likely salt impregnation of clays in levee walls through the process of seepage. Without information to discount this concern, it remains a source of uncertainty in the EPA's assessment of overall risk.

Significant environmental impacts due to brine seepage have not been reported at other Pilbara salt fields with seeped brine evaporating well within 100 metres of the walls. However, as sea level rises, the proposed 100 metre buffer between levee walls and both algal mat and mangrove communities would diminish and likely disappear altogether allowing the potential effects of seepage to directly impact these communities within their adjusted ranges. While recognising that seepage through and under levee walls adjacent to the first, lower salinity concentration pond is less likely to adversely impact algal mats and mangroves, the EPA holds the view that seepage of more concentrated brines and bitterns into areas projected, within the life of the project, to have suitable inundation regimes to support algal mat and mangrove communities, poses an unacceptable risk to these communities.

The potential impacts of bitterns seepage into the natural environment outside the levee walls remains unknown. The levels of magnesium salts and heavy metals in bitterns are elevated over those in brine and these components can be toxic to marine organisms and bioaccumulate in marine and coastal ecosystems.

The mobilisation of hypersaline groundwater and its impact on mangrove communities at Port Hedland was first reported in a scientific paper in 1995 (Gordon *et al*. 1995). Groundwater and measurements of leaf area were tracked for three years adjacent to recently filled salt ponds. The groundwater salinity rose beyond the upper value typically experienced by mangrove vegetation in this region and rising groundwater levels resulted in chronic water-logging and saturation of the mangrove root zone for several tens of metres away from the pond wall. Changes in vegetation included defoliation of the leaf canopy and reduced photosynthetic rates, leading to complete defoliation and loss of productivity in affected stands. As the impact spread, about one year after the onset of disturbance at each site, groundwater salinity reverted to concentrations lower than those that existed before the onset of disturbance, but water levels had not recovered when the paper was published in 1995.

Gordon *et al.* considered that this phenomenon was possibly related to a change in the hydrostatic head created by elevated water levels in ponds on the tidal flats. The flats, although modified by pond levees, still had a hydrological connection with the adjacent mangroves. Since 1995, the EPA has observed mangrove impacts at this site first hand and reports indicate that the phenomenon has spread to distances (about 1000 metres) well beyond both the 100 metre buffer proposed between levee walls and algal mats and the 500 metres that the proponent indicates is the minimum distance currently between levee walls and mangrove communities. No management techniques have been identified to remediate the impacts caused by hyper-saline groundwater mobilisation.

The proponent has responded to submissions relating to this issue by stating that the displacement of hyper-saline water in the supra-tidal flat toward the mangrove zone in Exmouth Gulf is unlikely to be environmentally significant on the basis of the following:

- The natural discharge of hyper-saline groundwater at the intertidal fringe (mangrove fringe and tidal creeks) occurs in any case;
- Sediment permeabilities at Exmouth Gulf are well below those at Port Hedland which would result in a very slow movement of groundwater towards the coast;
- The flat topography and relatively small tidal range in Exmouth Gulf provide a much smaller hydraulic gradient than at Port Hedland, again resulting in very slow movement of groundwater towards the coast; and
- Regular recharge of the supratidal salt aquifer by tides is much greater than seepage flows.

The proponent also points out that this phenomenon has been reported at only one of the salt fields in the Pilbara and may therefore be a special case.

The EPA is concerned that the proponent has failed to thoroughly investigate the potential for hyper-saline groundwater mobilisation and conclusively determine, through rigorous comparison, that Yannarie Solar would not cause similar extensive mangrove degradation. The EPA is therefore of the view that the level of uncertainty regarding potential impacts from hyper-saline groundwater mobilisation, together with the lack of known management techniques to remediate impacts, pose an unacceptable risk to the regionally significant arid zone mangroves communities on the east coast of Exmouth Gulf.

Summary

The EPA notes:

- The high conservation and wetland values of Exmouth Gulf;
- The requirement for maximum water quality protection in Exmouth Gulf, with no contamination or detectable change from natural variation in water quality;
- The potentially toxic nature of bitterns to marine biota and bird life;
- The environmental risks associated with the establishment of over 8000 hectares of bitterns ponds in an area prone to storm surges with levee walls that are highly likely to be overtopped during the life of the project;
- Uncertainty remains regarding the extent of impact and likelihood of recovery from catastrophic failure;

- The critical importance of algal mat and mangrove communities in underpinning ecological functions in Exmouth Gulf;
- The likelihood that impacts from brine and bitterns seepage would occur within areas of suitable tidal inundation for algal mat and mangrove communities that adjust to sea level rise;
- That hyper-saline groundwater discharge linked to salt pond construction has been implicated in the death of mangroves over 1000m from salt ponds at Port Hedland;
- The high level of uncertainty regarding potential impacts from hypersaline groundwater mobilisation and the lack of known management techniques to remediate impacts associated with this phenomenon.

The EPA concludes that the proposal does not meet the EPA's objective to maintain the quality of surface and ground water so that environmental values, including ecosystem maintenance, are protected.

3.4.2 Long term bitterns management

Yannarie Solar has a proposed life span of at least 60 years. During the first ten years, bitterns would be used to line the floors of crystalliser ponds. Bitterns would then be accumulated until there was sufficient to extract potassium and magnesium sulphate. The remainder would be stored. The proponent states that management of bitterns beyond ten years would be the subject of a separate EPA referral. The current proposal does not include the discharge of bitterns to Exmouth Gulf.

The proponent has indicated that they are researching options to sell bitterns and extract additional salts so that they are not required to discharge bitterns beyond the first ten years of operation. The EPA requested that the proponent provide additional information about long term bitterns management to assist the EPA with its assessment of environmental risk should their research not provide sufficient markets to dispose of bitterns products beyond the first ten years of operation.

To address the EPA's request, the proponent provided bitterns plume modelling for a theoretical annual discharge of 1.1 million cubic metres of bitterns C through the constructed harbour to Exmouth Gulf. While this scenario results in most of the annual bitterns C production being discharged through the harbour, the proponents also indicated that they would accumulate about 21,000 tonnes of magnesium salts per year (which is equivalent to a thickness of 0.6 millimetres of salts per year) over pond floors in the proposed bitterns storage and processing area.

Submissions

Submissions relating to long term bitterns management raised the following points:

- The proposal to address bitterns management after the project has been assessed by the EPA is unacceptable. Until satisfactory proposals for responsible management of the toxic waste or bitterns is established and discharge options are carefully evaluated, the entire proposal to generate salt production should be rejected.
- Feasibility of 100 per cent resource recovery of the bitterns produced is very unlikely.
- It is unlikely that bitterns storage or release into Exmouth Gulf could be managed to achieve acceptable environmental outcomes.

- The ERMP doesn't have enough information on economic and technical viability plus environmental acceptability of discharge.
- Bitterns dilution is often difficult because of the density difference between bitterns and water, but without adequate mixing, a slug of brine may end up sitting on the sea floor and killing the local benthic environment through high salinity, hydrogen sulphide toxicity and anoxia.
- The bitterns plume modelling report contained limited discussion on how Straits would manage the possibility of a plume not continuing to mix sufficiently, resulting in its intensification on the coast. This also has the potential to result in water stratification due to a halocline forming layers that act as barriers to water mixing.
- Incorrect background data were used to determine whether bitterns discharge and mixing would result in salinity and magnesium concentrations significantly above background levels.
- Predicted magnesium and salinity concentrations were above background levels despite the proponent's use of inappropriate sampling sites when attempting to determine background levels. This indicates that the exceedance of background is likely to be much higher and more frequent than predicted in the plume modelling.
- The proponent should undertake ecotoxicity testing in conjunction with ecological risk assessment .
- Bitterns plume modelling indicated the potential for flooding tides and prevailing winds to force the emergent plume back onto the coast of Hope Point. Therefore the plume had the potential to drift north and remain inshore.

Assessment

The proponent remains confident of achieving full resource recovery of bitterns, although no comprehensive details of how this would be achieved for the total amount of bitterns produced have been provided to the EPA. In response to issues raised in submissions about the likelihood of being able to market bitterns and additional products from bitterns, the proponent has indicated that synthetic magnesium hydroxide production has been practised worldwide for decades. The proponent has advised that bitterns resource recovery is an economically viable process in Israel, the Great Salt Lakes in America, the Ukraine and Germany. In Australia, SunSalt in Victoria commercially extracts magnesium sulphate (Epsom salts) from bitterns B. However, the proponent has not investigated whether overseas operations achieve zero discharge and has advised that, to the best of their knowledge, no seawater solar salt operation has a zero bitterns discharge process in Australia.

The proponent is of the view that other salt farms of similar size in Western Australia do not market bitterns products because they do not have the operational space to produce them. Yannarie Solar proposes a much larger area that would provide the opportunity for further extraction and resource recovery.

The waters of Exmouth Gulf are afforded 'maximum' protection in accordance with the *Pilbara Coastal Waters Quality Consultation Outcomes* report (DoE, 2006). The objectives for 'maximum' water quality protection are that there be no contamination and no detectable change from natural variation in water quality. The proponent was advised by the EPA that bitterns discharge would need to achieve background concentrations at the point of exiting the constructed harbour. Background levels

would be reached when the median magnesium concentration in the plume met the 95th percentile of magnesium concentrations in water at the discharge point.

There are several concerns relating to the bitterns plume modelling that was provided to assist the EPA with its assessment of risk:

- The determination of background and dilution intake levels of salinity and magnesium were based on nine data points over seven and a half months compared with the *ANZECC Marine Water Quality Guidelines* (ANZECC, 2000) recommendation of a minimum of 24 data points over 24 months. As a consequence, background magnesium concentrations used for modelling were significantly skewed by a single very high reading.
- Data from Hope Point were not used to determine background levels of salinity and magnesium at Hope Point. Salinity levels used for modelling background levels at the discharge point (median of 42.9 parts per thousand) were significantly higher than data published in;
    - the ERMP "*median near-shore salinity 37.9 parts per thousand"* (Straits Salt, 2006), and,
    - a CSIRO report "*ranges from, about 35 ppt to 39ppt depending on location and time of year*" (CSIRO Marine Research, unpublished data, referred to in Kenyon, and Loneragan, 2004),

  which further calls into question the validity of background magnesium levels used in the modelling.
- The model was run using a 1 part bitterns to 89 parts seawater dilution factor which did not attain background levels at the mouth of the harbour.
- The model does not demonstrate what ratio of dilution would be required to dispose of magnesium, to meet the (potentially inflated) background levels. The proponent's conclusion that *…125 Mm^3 per annum of dilution water ..… should be sufficient to achieve acceptable dilution to meet the target threshold at the harbour …..* does not address the difficulties associated with the non linear relationship characteristic of dilution curves. Concentration falls rapidly with the first few dilutions, but it takes a great number of additional dilutions to cause further falls in concentrations, particularly when the dilution medium (seawater), also contains significant amounts of the substance to be diluted, in this case, magnesium.

In addition, the mass balance analysis was based on intake magnesium concentrations of 1500 milligrams per litre. However, the measured median concentration at the site closest to the proposed intake pump, according to a map provided in the plume modelling report, appears to be 1700 milligrams per litre. Calculations using 1700 milligrams per litre of magnesium as the input concentration adds an additional 28,900 tonnes of magnesium to the system each year. Eco-toxicological studies were not conducted to investigate the toxicity of different magnesium concentrations.

The more dilution required, the more expensive it would become to run the dilution water intake pumps. Because of the planned production of magnesium salts, the bitterns plume modelling was run on less than half of the magnesium pumped into the salt field system, but modelling demonstrated that it would still require a dilution pumping rate of at least 125 million cubic metres per year. This estimate, which has been questioned above, is about 85 per cent of the pumping capacity of the main salt field intake pump proposed at Dean's Creek. Although it is theoretically possible to continue increasing the pre-discharge dilution of bitterns to achieve the 95th percentile

of background concentrations, the operation would become more expensive and less practical.

The EPA has received advice from:

- The Department of Fisheries (DoF);
  Bitterns discharge can result in acute short-term localised damage and the Department of Fisheries would not support the release of any bitterns to the Gulf. This is a point that cannot be compromised upon and consideration and management of risk of seepage into the groundwater system or the effect of cyclonic tide surge and associated flooding rainfall needs to be directly addressed.
- The Department of Environment and Conservation;
  DEC is not confident that the proponent has a substantial irrevocable commitment to avoid discharge,
- The Marine Parks and Reserves Authority;
  The ERMP does not adequately address the storage and disposal of the toxic bitterns as a by product of salt production. There is a very high probability these will be released through natural storm processes and in any case they pose a major future disposal problem. The release of bitterns either intentionally or as a result of natural processes, is likely to have a significant negative impact on the ecology of the Gulf and it is unacceptable that this matter has been simply left as a future problem; and,
- The Department of Industry and Resources (DoIR);
  options for the final discharge of the end product need to be considered prior to the start of the project.

All these agencies express serious concerns regarding the staged approach to long term bitterns management and the potential consequences of bitterns discharge should this be necessary.

The EPA therefore draws the conclusion that, although bitterns discharge is not part of the proponent's current proposal, bitterns reuse and sale is not yet certain and the proponent has failed to demonstrate conclusively that the ongoing annual production and storage of over 1 million cubic metres of bitterns C can be managed sustainably to meet maximum levels of water quality protection in Exmouth Gulf over the long term.

Summary

The EPA notes;

- The high conservation and wetland values of Exmouth Gulf;
- The potentially toxic nature of bitterns to marine biota;
- The requirement for maximum water quality protection in Exmouth Gulf, with no contamination or detectable change from natural variation in water quality;
- The proponent's failure to demonstrate conclusively that the ongoing production and storage of large quantities (over 1 million cubic metres per annum) of bitterns C can be managed sustainably to meet maximum levels of water quality protection in Exmouth Gulf over the long term.

The EPA therefore considers that the proposal does not meet the EPA's objective to maintain the quality of surface and ground water so that environmental values, including ecosystem maintenance, are protected.

3.4.3 Salt production and transport

Water for desalination and salt processing would be pumped from a location just south of Hope Point. Seawater for salt field operations would be pumped from Dean's Creek at the southern end of the salt field. Dean's Creek is one of the largest mangrove creek systems adjacent to the proposed development. The water in Dean's Creek has a higher salinity than water offshore in Exmouth Gulf and the species that live in the creek are therefore adapted to, and potentially rely on, higher salinities.

Pumping rates would vary seasonally according to the amount of evaporation taking place. Higher volumes of water would be pumped from Dean's Creek during summer months. The highest rate of pumping proposed is 56,000 cubic metres per hour for 3.5 hours either side of each high tide; i.e. 14 hours per day. The average pumping rate would be 29,000 cubic metres per hour over 14 hours per day which is equivalent to about 148 million cubic metres per year.

The DEC, and the DoF, expressed concern regarding the potential for reduced juvenile fish and prawn survival should the removal of very large volumes of the more saline water result in the general lowering of salinity levels in Dean's Creek. Concern was also raised in relation to the attraction of some species to high salinities, potentially enhancing their entrapment in intake pump waters.

A sophisticated model was used to assess the impact of Dean's Creek pumping station on tidal velocities and current direction. The results indicated that pumping would draw an average 4.3 per cent of the monthly tidal prism of the creek, and maximum current velocities induced by the intake pump (approx. 0.63 m/s), were an order of magnitude lower than the maximum currents resulting from the twice daily tidal flows.

The proponent has indicated that it may use targeted removal or construct a system of bund walls just within the first concentrator pond to facilitate the return of entrapped organisms back out to Dean's Creek. A commitment has been made to monitor any changes to creek morphology caused by altered water flows and the effectiveness of management methods would be assessed by comparing the results of baseline pre-development surveys with repeat surveys conducted after commencement of pump operations.

After removal from crystalliser ponds, salt would be transported by truck to a wash plant located on Main Island. From here it is proposed to transport salt by conveyor to the main stockpile at Hope Point. Salt would then be transferred from land onto barges in the constructed harbour and transferred to bulk carriers in Exmouth Gulf. Water that was used to wash salt would be channelled back into the salt production process. Surface water runoff from the salt stockpiles would be channelled to an evaporation pond and would not be discharged to the marine environment.

The potential for salt spills has raised some concern in submissions. Salt spills could occur during transportation by truck, conveyor or barge and during salt transfer both onto barges and onto bulk carriers from barges. The roads used to truck salt from crystalliser ponds to the wash plant run along the tops of levee walls. The use of roads along external levee walls would be minimised for the transportation of salt.

The six and a half kilometre conveyer between Main Island and Hope Point would remain uncovered because salt crystals tend to stick together preventing the formation of dust and the salt would be wet, having just been washed. The conveyor would be located within the infrastructure corridor and over constructed levees which would have a minimum width of 1.5 metres on one side of the conveyer with a 12 metre wide road on the other side.

The proponent has indicated that barges would be custom designed with high side boards to prevent spillage when underway. The barges would have a conveyor system installed to unload directly to bulk carrier ships. The proponent has also stated that transport of salt between the barge harbour and receiving ships would be scheduled to avoid fishing trawlers and that salt transportation/loading operations would not occur in adverse weather conditions.

Submissions

Submissions relating to salt production and transport raised the following points:

- Prawn larvae are able to survive in hyper-saline water of 50-60 parts per thousand where some predators cannot. A reduced salinity caused by the pumping of high salinity sea water could allow larval predators to enter previously uninhabitable areas, essentially eradicating the nursery grounds.
- The potential for impact on near shore salinity due to pumping has not been adequately assessed. The proponent should investigate this issue further and consider the importance of near-shore salinity for marine flora and flora.
- Initial start-up pumping should avoid prawn spawning periods.
- The growth rates of prawns are dependent on optimal salinities.
- Post larval prawns are designed to maximise their movement into nursery areas. Pump generated flows can therefore be expected to significantly magnify the numbers of post larvae trapped by the proposed pumping system and decrease prawn survival and production.
- High fisheries productivity is related to the hyper-saline nature of the eastern shoreline.
- The proponent needs to present management arrangements for salt spillage including an assessment of impacts on marine fauna and flora, especially as spills could take place in trawling and tiger prawn spawning areas.

Assessment

The percentage of creek water pumped out of the creek and likely changes to current velocities and directions were minimised through the selection of Dean's Creek as one of the largest creek systems along the east coast of the Gulf. Modelled estimates of the effects of pumping were based on the assumption that pumping rates would be those required to drive a larger salt farm than is now proposed. Modifications to the proposal have reduced pumping requirements to 70 per cent of the volumes modelled. This reduces the modelled pump draw from an average 4.3 per cent to about 3 per cent of the monthly prism of the creek. At a regional scale, the proponent estimated that the pumping of seawater from Dean's Creek would result in the entrainment of about 0.35 per cent of all small biota in the tidal prism in creeks between Giralia Bay and Hope Point.

The EPA notes the size of Dean's Creek, the number of creek systems along the east coast of Exmouth Gulf, the tidal flux model outputs and options to construct systems

that return some of the entrained wildlife to Dean's Creek after each period of pumping. The EPA draws the conclusion that the proposed pumping of 148 million cubic metres of sea water per year from Dean's Creek would be unlikely to cause sufficient changes to inshore salinity to alter either 1) the distributions of larval prawns resulting in a significant increase in larval prawn entrainment, or 2) predator distributions, resulting in increased predation on larval prawns.

In comparison to Dean's Creek, only small volumes of seawater would be pumped for desalination and salt processing. This second pump would be located south of Hope Point on a comparatively open stretch of coastline with little potential to cause changes in salinity. Should dilution water for bitterns discharge be required at a later date, pumping from this site would, however, increase about tenfold.

Spills associated with ordinary salt would discharge sodium chloride. This is the main constituent of sea water and is of low toxicity to marine life. The EPA considers that small spills of sodium chloride during loading and unloading of barges would cause only minor and temporary changes to local salinity. The loss of a 10,000 tonne barge load of salt during transportation is considered very unlikely. Although the impacts of such a loss have not been investigated in detail, the EPA holds the view that the death and degradation of benthic communities caused by 10,000 tonnes of sodium chloride is likely to be temporary with recovery occurring following its dissolution and dispersion.

The Yannarie Solar proposal includes the production of 100,000 tonnes of magnesium sulphate and 90,000 tonnes of potassium sulphate each year. These salts, in particular magnesium sulphate, are more toxic to marine life than sodium chloride. Specific toxicity assessments of these products have not, however, been conducted. Magnesium and potassium sulphate would be stockpiled either on Main Island, or in the bitterns processing area in the northern section of the project footprint.

Magnesium and potassium sulphate would be exported from the site either by ship or by road. The export of 190,000 tonnes of these salts by ship would be equivalent to 19 barge loads per annum. Small spills of magnesium and potassium sulphate during barge loading could temporarily reduce water quality within the confined harbour. Small spills during loading of bulk carriers in the open water of the Gulf would be better flushed and less likely to cause a significant reduction in water quality. The loss of a whole barge load of sulphate salts is considered unlikely. However, should a spill of this magnitude occur, it could behave like bitterns, forming a very dense toxic layer on the seabed with limited mixing and dispersion in the waters above. The consequence of this event could be high over the affected area. The overall risk to the environment is therefore considered moderate.

Summary

The EPA's notes;

- The high conservation and wetland values of Exmouth Gulf;
- The potentially toxic nature of sulphate salts, particularly magnesium sulphate, to marine biota;
- The requirement for maximum water quality protection in Exmouth Gulf, with no contamination or detectable change from natural variation in water quality; and

- The risk to the environment of a sulphate salt spill is considered moderate.

The EPA holds the view that, the proponent has not demonstrated that sulphate salt transfer and transportation from Hope Point can be managed to ensure the maintenance of water quality. The EPA concludes therefore, that as presented, the proposal does not meet the EPA's objective to maintain the quality of surface and ground water so that environmental values, including ecosystem maintenance, are protected with an adequate level of certainty.

3.5 Water quality - acid and heavy metal release

Description

The term acid sulphate soil (ASS) is used to describe sediments that when oxidised release acid which in turn leaches metals from the sediments. When anoxic sediments containing iron sulphides are exposed to air or aerated water during or following disturbance, the iron sulphides (pyrite) oxidise to produce sulphuric acid and iron precipitates. Due to the increased acidity (low pH) that is generated during this reaction, naturally occurring elements such as aluminium, iron, arsenic and other potentially toxic heavy metals can be mobilised and released to the environment.

Potential ASS are likely to occur in environments where sulphate concentrations are high. Seawater contains high concentrations of sulphate which becomes reduced in anoxic conditions such as mangrove mud to form sulphide minerals. In salt flats, remnant organic matter, together with both sulphate minerals of marine origin and iron minerals of terrestrial origin, have the potential to generate acidity.

Sediment disturbance during dredging and excavation can result in the oxidation of ASS. Acid and heavy metal contaminants can be discharged to the environment at the site of dredging or excavation, at sites where ASS sediments are being stored or treated and in return water that has drained from dredged ASS sediment after being pumped ashore.

Concern has been expressed about excavation for the Hope Point harbour and entrance channel, Dean's Creek pumping station and construction clay from claypan borrow pits on the hinterland. The proponent has indicated that salt flat sediments would not be disturbed during construction of either the salt pond levee walls or the infrastructure corridor between Main Island and Hope Point. These structures are designed to rest on top of the natural sediment surfaces without below ground foundations or being keyed into deeper sediment layers beneath.

Western Australia's ASS management guidance documents (DEC, 2004 and 2006) are based on the recommendations of the National Committee for Acid Sulphate Soils and are currently being reviewed to provide more detailed information. Where these documents lack detail, reference is generally made to the *Queensland Acid Sulfate Soil Technical Manual* (Dear *et al*., 2002 and Ahearn, *et al.,* 2004) which is also based on the recommendations of the National Committee for Acid Sulfate Soils and functions as a *de facto* national standard.

Water and shallow sediment samples from Hope Point and at Dean's Creek have been analysed for reducible sulphur and tested for acidity, acid forming capacity and acid neutralising capacity. The Western Australian and Queensland ASS management

guidelines (DEC, 2006 and Dear *et al*., 2002), provide a decision framework for determining management actions. The action criterion of 0.03 per cent reducible sulphate is the concentration above which site management is required. All sediment samples from Hope Point and Dean's Creek significantly exceeded this action criterion. Levels between 0.05 and 0.1 per cent were recorded at Hope Point and between 0.31 and 1.2 per cent from Dean's Creek. This confirms that all samples from these sites are potentially acid forming soils.

A sediment core was taken to a depth of 1.1 metres from one of the hinterland claypans. The sediments comprised alkaline medium clay with a pH of 8.1. Percentages of reducible sulphur were not determined in these sediments.

Heavy metal concentrations in sediment samples from Hope Point and Dean's Creek showed naturally high levels of arsenic above the ANZECC guideline trigger values for further investigation (ANZECC, 2000). However, tests to determine the bio-availability of arsenic as well as other metals as a result of disturbance induced oxidation, have not been carried out.

A map of the likelihood of ASS occurrence in the top three metres of sediment has been prepared by the DEC. The salt flat and mangrove shoreline on the east coast of Exmouth Gulf have been identified as areas where there is a high to moderate risk of ASS occurrence. The risk of ASS occurrence in the surface three metres of sediments on hinterland outliers is mapped as moderate to low.

The proponent has undertaken a risk assessment to determine the relative risk of ASS at some of the proposed disturbance sites. Based both on the depositional environment and the current location of sediments within the landscape, the proponent determined that the risk of acid release from disturbed sediments at Dean's Creek was high, the risk at the barge harbour and dredged access channel was medium and the risk associated with hinterland claypans was low. The proponent assessed the risk of ASS in Carnarvon Dune system sediments as low.

The proponent has estimated what they consider to be worst case scenario ASS volumes that could be generated by proposed excavation and dredging. At Dean's Creek, the worst case scenario estimate includes all of the 4,000 cubic metres of excavated material. The worst case scenario estimate of acid forming material from Hope Point barge channel is 31,000 cubic metres. This is about eight per cent of the 375,000 cubic metres of material that would be excavated from the channel. The worst case scenario estimate of acid forming material from Hope Point harbour is 50,000 cubic metres. This is equivalent to about three per cent of the material proposed to be excavated from the harbour.

Construction clay from hinterland claypans would not be excavated below the water table because wet clay is of little use for construction purposes. The proponent does not expect to encounter ASS material in claypans. A summary of sediment volumes and ASS investigations is provided in the table below.

Table 3: Acid sulphate soil volume estimates and previous investigations.

Location	Volume of disturbance (m^3)	Estimated worst case ASS volume (m^3)	Maximum depth of disturbance (m)	Previous ASS investigations
Hope Point Channel	375,000	31,000	5.5	Yes
Hope Point harbour & transition between channel and harbour	1,535,000 + 85,000	50,000	8	No
Dean's Creek pump station	4,000	4,000	4	Yes
Claypan borrow pits.	3,000,000	0	2 – 4.7	No

The proponent's preferred option for management of ASS material from the harbour and dredge channel at Hope Point is encapsulation. It is proposed that the combined 750 metre by approximately 300 metre area shown in Figure 3 as stockpile plus infrastructure contingency would be built up to a height of approximately 5.5 metres AHD using encapsulated excavated and dredged material. This would elevate salt stockpiles above the storm surge zone.

The encapsulation structure would be designed with a floor of 0.5 metre thick compacted clay covered with about 0.2 metres of calcarenite rubble. ASS material from the barge harbour would be placed on this floor to form a wedge shaped layer capped with at least 0.3 metres of compacted clay.

The clay capping over material excavated from the barge harbour would then form the base for the holding pond that would receive the dredge slurry from the barge channel dredging operation. The proponent has indicated that all dredged material from the Hope Point channel would be pumped ashore as a slurry. Water draining from the slurry would flow around a series of internal baffles within the holding pond to allow for sediments to drop out and the water would be monitored prior to release to the environment through the newly constructed harbour. The proponent has committed to release return water at background concentration levels.

Once the water has drained from the dredge slurry pond and non-ASS material removed for construction, a compacted 0.3 metre layer of clay would be used to cap the dredge fill material. The proponent has indicated that lime would be added in alternating layers to encapsulated ASS material and non-ASS fill would be used immediately beneath the surface cap. The seaward face of the encapsulation structure would be capped with clay fill four metres deep at ground level and lined with calcarenite armour. The ends of the elevated encapsulation structure would also be capped with clay and lined with calcarenite armour to provide a sealed and armoured encapsulation cell and an elevated platform for salt stockpile operations. A leachate collection system would be constructed around the perimetre of the base clay layer draining to a sealed pond for monitoring and management prior to discharge.

The proponent has presented two options for managing ASS sediments from Dean's Creek. One option is to bury the material in an excavated claypan on the hinterland. Following additional monitoring to characterise groundwater depths and flows in the claypan, the clay material would be disposed to the pit in alternating layers with

crushed lime or calcarenite in between. The ASS material would be compacted and covered with non-ASS material such as crushed lime or calcarenite. A compacted clay layer of at least 0.5 metres thickness would then be reinstated on top. It is unclear whether this burial would be above the water table, or whether deeper excavation would be undertaken to bury ASS sediments from Dean's Creek below the water table in the proposed claypan pit.

A second option presented by the proponent for management of ASS material from Dean's Creek would be encapsulation in a clay cell within pump station infrastructure at Dean's Creek. The ASS material would be placed on a minimum of 0.5 metres of compacted clay and 0.3 metres of crushed calcarenite or limestone and be surrounded on all sides by at least 0.5 metres of clay and rock armour. A leachate collection system would be installed, and leachate monitored prior to discharge. The bund walls at this location would be 5 metres high.

The proponent has committed to:

- Not disturb sediments during the construction of levee walls and the infrastructure corridor between Main Island and Hope Point;
- Not dewater at any of the proposed excavation sites;
- Discharge return water at background water concentrations; and
- Undertake a sediment sampling and analysis program at all proposed excavation sites to better determine the volumes and concentrations of ASS material prior to ground disturbing activity.

High evaporation rates over the salt flats have the potential to concentrate not only salts but also other constituents in the evaporated water. Water samples from the superficial aquifer under the salt flats confirm that some heavy metals are at high concentrations. Concern has been expressed that the superficial aquifer could be mobilised by the increased hydrostatic head of brines in constructed salt ponds and that a hypersaline plume which also contains other concentrated toxicants such as heavy metals could migrate to and impact mangrove and other coastal communities. The issue of hypersaline groundwater mobilisation as well as the potential impacts of heavy metals in bitterns are considered in section 3.4.1 of this report.

Submissions

Submissions relating to ASS raise the following points:

- Appropriate and thorough testing has not been conducted in relation to acid sulphate soils.
- The proponent's assessment and management of acid sulphate soils is inadequate in relation to dredge material disposal infrastructure.
- Quantitative and adequately justified estimates of the volumes of acid forming material should be provided.
- A map should be provided showing ASS overlaid with proposed areas of disturbance.
- Baseline surveys for ASS need to be conducted prior to the lodgement of the Mining Proposal to the Department of Industry and Resources rather than just prior to construction.
- Acid generating capacity needs to be determined though lab testing not just field testing.

- A conservative approach should be adopted regarding the re-use of treated soils for fill in borrow pits or fill for haul roads.
- Monitoring should be conducted during the construction phase of the seawater pumps and the barge harbour.
- Clay borrow pits at the Onslow salt field looked yellow which is likely to be caused by acidity and high concentrations of sulphur with bioavailable metals.
- A thorough analysis should be undertaken of risks and consequences of disturbing acid forming materials on benthic habitats, water quality and marine and coastal fauna.
- It is not clear how a wet cover will be maintained over ASS in an area of very high evaporation.
- Compacted clay and crushed lime should be used as a base for storing ASS.
- Soil bores need to be installed to provide data on ASS before assessment is complete.
- The limestone at Hope Point is porous so dewatering will spread into the surrounding area. Pumped water will need to be managed to remove acidity and treat iron and aluminium precipitates.
- ASS management commitments should be consistent with national standards.
- The volume of lime required for management of acid generating material and the source of lime should be provided.

Assessment

The EPA objective for chemical release is;

> *to maintain the quality of surface and ground water so that environmental values, including ecosystem maintenance, are protected.*

The proponent has committed to undertaking further survey work to better gauge the volumes and concentrations of ASS materials to be disturbed. This commitment highlights the limited information currently available on which to base both management planning and a thorough environmental impact assessment.

The proponent has estimated the total volume of rock and sediment to be excavated from the harbour and channel to be 1,995,000 cubic metres, of which 1,965,000 cubic metres is required for salt field construction. With just a 30,000 cubic metres difference between these two estimates, it is apparent that the 81,000 cubic metre worst case ASS scenario for volumes from the harbour and channel would result in a shortfall in the required construction materials from local sources.

It is considered unlikely that clay extracted from above the water table in hinterland claypans would contain ASS. However, the proposal would require three million cubic metres of clay from this source and its testing for ASS prior to ground disturbance would be considered essential.

The estimates presented as worst cast scenario ASS volumes from the barge harbour and access channel are based on shallow core samples. The core sampling technique used precluded sampling from below the surface of hard rock material. While limestone rock will not itself contain ASS, it remains uncertain whether the limestone is continuous to the base of proposed excavation and dredging sites, some of which are several metres deep.

Having determined that all sediment samples from both Hope Point and Dean's Creek showed values of reducible sulphur significantly in excess of the ASS guideline (DEC, 2006 and Dear *et al*., 2002) action criterion of 0.03 per cent, the proponent undertook additional sediment analyses. Standard sediment pH tests indicated that samples were alkaline with pH readings of around nine. The total acid forming capacity was measured in the field by adding peroxides to sediment slurries forcing their rapid and complete oxidation. The results appear to further demonstrate that some of the sediments have the capacity to generate acidic conditions when exposed to oxygen.

Acid neutralising capacity is a measure of the amount of acid neutralising material in the sample expressed as a percentage of calcium carbonate. The acid neutralising capacities of sediment samples from Hope Point and Dean's Creek were tested and found to be approximately 30 to 40 per cent. The proponent is of the view that the high carbonate content in sediments would ensure that the potential for acid generation by sediments exposed to oxygen would be very low and that this natural neutralising capacity would also provide a buffering environment for reburial of ASS material. There can, however, be problems with reliance on percentages of calcium carbonate as a measure of neutralising capacity. Natural oxidation often takes place faster than neutralisation. Under these circumstances metals are released before neutralisation takes effect. In addition, the reactive surface area of the neutralising material is often too small, either because the particles are large, for example whole shells, or the material is armoured or coated with iron or gypsum, rendering it chemically unavailable.

The *Queensland Acid Sulfate Soils Manual, Soil Management Guidelines* (Dear, *et al*., 2002), state that if measured appropriately, the natural buffering capacity of a soil can be used to reduce the level of treatment, provided particle size distribution and reactivity is also assessed in accordance with the associated *Queensland Acid Sulfate Soils Manual, Laboratory Methods Guidelines* (Ahern, *et al*., 2004). These laboratory guidelines include a requirement for kinetic testing which assesses the relative rates of oxidation and neutralisation reactions. The DEC guideline (DEC, 2006) states;

> …" *utilization of ANC* (acid neutralising capacity) *values without confirmatory field kinetic testing or modified laboratory methods cannot be used as an argument to reduce the level of management required*"

The EPA is of the view that without the results of kinetic tests on sediment samples from Hope Point, Dean's Creek and other proposed excavation sites, there is insufficient information to demonstrate the adequacy of buffering from natural sediment neutralisation, and sediment treatment levels should therefore be in accordance with those outlined in the Queensland ASS management guidelines.

Sediment analysis revealed naturally high levels of arsenic in Hope Point sediments. The levels recorded trigger the requirement for elutriate testing under the ANZECC guidelines (ANZECC, 2000). Although other metal concentrations in sediments were below ANZECC trigger levels, and would not normally require elutriate testing, the high levels of sulphur and therefore potential for acid generation, means that there is a risk of other metals being released. Full elutriate testing would therefore have been appropriate. The proponent did not conduct elutriate testing and the levels of bio-

available metals which could be released during sediment disturbance remains uncertain.

Under certain conditions, metals released during oxidation of ASS form anoxic colloidal complexes which accumulate on the seabed. These colloidal complexes, e.g. monosulphidic black oozes (MBOs), can smother and rapidly deoxygenate benthic communities. They are easily mobilised or resuspended during natural disturbance events or repeat dredging and excavation and often cause severe acidification, deoxygenation and the release of heavy metals. The colloidal form of MBOs means that they are like gels and sit lightly on the sediment so their accumulation occurs only in areas with little water movement. Dean's Creek is subject to strong tidal flows and Hope Point is influenced by wave action making the accumulation of MBOs unlikely at these locations. The proponent has responded to concerns regarding MBOs by stating that sea water in the near-shore waters on the east coast of Exmouth Gulf is characterised by high levels of dissolved oxygen and pH values between 8.1 and 8.2. The EPA is of the view that MBOs are unlikely to form or accumulate under these conditions. The risk of MBO formation could be further reduced by designing proposed excavations so that they remain well flushed.

Acid and metal release at the site of dredging and excavation could occur on dispersed sediment particles and/or in seawater solution. The proponent has indicated that a cutter suction dredge would be used in the harbour channel. This equipment grinds and suspends hard substrates, some of which are then sucked from the dredging interface. The relative sizes of the cutter and suction devices can make a significant difference to the proportion of suspended material that is removed from the water column. Small cutters with large suction devices tend to remove the highest proportion of suspended sediment and therefore generate the smallest sediment plumes. Dredges with small cutters and large suction devices would also be most effective in removing seawater contaminated with heavy metals that have been in contact with disturbed ASS sediment. The cutter and suction capacities of the dredge to be used is not known.

Dean's Creek would be excavated using a bucket scoop excavation technique that does not rely on completely breaking up and suspending the sediment. The potential for oxidation is therefore likely to be lower at Dean's Creek. However, a suction device would not be used at this site to remove suspended material or contaminated water.

The proponent has indicated that a silt curtain would be used around the site of sediment disturbance. The effective deployment of a silt curtain would significantly reduce the dispersal of suspended sediment, however, stronger tidal currents in Dean's Creek may prevent the effective deployment of a silt curtain at this site.

Plumes associated with excavation in Dean's Creek have not been investigated. However, the proponent has undertaken dredge plume modelling to estimate plume characteristics and sediment settling associated with benthic primary producer habitat in the vicinity of the proposed channel at Hope Point. The model predicts that an area of 17 hectares would be subject to direct permanent loss of benthic primary producer habitat with an additional 14.5 hectares subject to reversible losses. However, as

discussed further in section 3.7.4 of this report, the combination of assumptions made when running the dredge plume model limited its capacity to predict impacts.

The proponent's analysis of dredge plume modelling is limited to the physical impacts of turbidity and smothering sediment plumes. It is recognised that the dredging proposed in Exmouth Gulf is small in comparison with major ports on the Pilbara coast and that there is limited scope for severe environmental impacts as a result of turbidity and smothering from a program of this scale. However, impacts from chemical release relate more to the nature of the sediments themselves and in this regard, direct comparisons with other dredging programs based on sediment volumes alone may be misleading. The analysis of a likely dredge plume at Hope Point has not considered potential impacts from chemical release or potential depletion of oxygen from the water column.

The coastal waters of Exmouth Gulf lie within the boundaries of the listed wetland of national importance and therefore form part of a critical environmental asset as outlined in EPA Position Statement No. 9 (EPA, 2006). The inshore waters also provide critical habitat for listed species and juvenile marine organisms, some of which support commercial fisheries. The protection of water quality at this location is therefore of paramount importance and the EPA is of the view that it is appropriate to apply a more rigorous level of assessment and management standards to an area with such high biodiversity and wetland values than would be appropriate in areas that already represent industrial hubs.

The waters of Exmouth Gulf are afforded 'maximum' protection in accordance with the *Pilbara Coastal Waters Quality Consultation Outcomes: report*, (DoE, 2006). With the objectives for 'maximum' water quality protection of no contamination and no detectable change from natural variation in water quality, the discharge of return water from dredge slurry would need to achieve background concentrations at the point of discharge or the point of exiting the constructed harbour. Background levels would be reached when the median concentration at the test site is less than the 95th percentile of concentrations in water measured at the pre-disturbance discharge point.

Excavation of the harbour would be undertaken underwater. The proponent's commitment not to dewater during excavation significantly reduces the risk of acid release. Excavated sediments from the harbour would be placed on a shallow clay and lime or calcarenite lined storage basin. Only small volumes of water would be expected to drain from material extracted using an excavator and this would flow back to the harbour. Water within the harbour would not be able to flow directly to the marine environment until the harbour entrance was breached. This would provide the opportunity to monitor and treat the contained water until water quality reached background levels of turbidity, salinity, acidity and metal concentrations.

The proponent has indicated that all dredged material would be brought ashore as a slurry. This would provide further opportunities for monitoring and treatment prior to sediment storage or use and the discharge of return water back to Exmouth Gulf.

Dredged slurry from the channel would be pumped to a clay and lime or calcarenite lined containment pond on top of buried ASS material from the harbour. The proponent has indicated that water draining from this material would pass through a

series of baffles to facilitate the settlement of suspended sediments and would be monitored prior to draining into the constructed harbour. The water draining from the dredged slurry could be acidic, with high metal concentrations and therefore require treatment prior to discharge.

An estimate of the volume of return water has not been provided. However, the amount of material to be dredged is 1,535,000 cubic metres and the proponent has indicated that the clay lined pond system would have an area of about 225,000 square metres. It would appear therefore that unless additional containment ponds were anticipated, water would need to be drained during the dredging program to maintain space for freshly dredged slurry.

The proponent's *Acid Sulphate Soils Draft Environmental Management Plan* (Straits Salt, 2008b) stipulates acceptable threshold and exceedance triggers for pH and total acidity values in surface water run-off. The proponent has not presented an analysis of how these trigger values relate to measured background levels and the *Pilbara Coastal Waters Quality Consultation Outcomes: report*, (DoE, 2006) requirements for areas of 'maximum' water quality protection. While the performance criteria identified in the *Acid Sulphate Soils Draft Environmental Management Plan* are 'preliminary', it is of some concern that there are currently no performance criteria or explanations as to how heavy metal concentrations or turbidity and salinity levels in surface return water would be monitored and managed to achieve background levels at the point of discharge within the time constraints imposed by the size of the treatment pond area.

Based on a summary of heavy metal and other trace element concentrations in sea water sampled at Hope Point, the proponent is of the view that heavy metals are naturally elevated at this location and return water is therefore unlikely to impact natural communities. Although the ANZECC guidelines (ANZECC, 2000) do not define trigger levels for many heavy metals in sea water, the measured concentrations in sea water sampled at Hope Point of chromium, cobalt, copper and zinc concentrations are all higher than might be expected for the protection of 100 per cent of species. A comparison between these sample concentrations and concentrations in standard sea water shows that the concentration measurements of sea water at Hope Point may be many times higher than in standard sea water. The DEC however, has advised there is some doubt on the validity of measured heavy metal concentrations in sea water from Hope Point and would consider it essential to verify background levels prior to setting discharge exceedence and trigger levels. Regardless of whether or not the natural levels of heavy metals are elevated in sea water at Hope Point, the EPA holds the view that metal concentrations in return water would need to be rigorously monitored and managed to ensure they reached background levels prior to discharge.

Although the *Acid Sulphate Soil Draft Environmental Management Plan* for the Yannarie proposal includes discussion relating to ASS treatment, the proponent also states that:

> *…" based on the worse case scenario for ASS it is not considered feasible to comprehensively neutralise the excavated material".*

There is expected to be a direct relationship between the amount of ASS material extracted and the amount of treatment required to neutralise and remove metals from return water. The neutralisation process of return water would be similar to that

required for the treatment of solid ASS material. It remains unclear as to how the commitment to not discharge return water unless constituents are at background levels can be reconciled with the statement that comprehensive neutralisation of excavated material is not feasible.

Extraction of material from Dean's Creek would be undertaken using an excavator. The small amount of return water from this operation, with careful monitoring and treatment, is considered manageable to achieve background levels at the point of discharge.

It is unclear from the proponent's *Acid Sulphate Soil Draft Environmental Management Plan* how, and within what time frames, ASS material would be separated from non-ASS material, drained and treated. The Queensland ASS management guidelines make reference to 'Higher Risk Management Strategies' and ASS material stockpiling is included in this category. The recommended maximum time period for which ASS material should be temporarily stockpiled without treatment depends on the sediment type. For clay materials it is five days and for course material where rapid oxygen penetration is likely, the recommended maximum time without treatment is overnight. Dredged sediments coming ashore as a slurry would be broken apart and well mixed with water providing enhanced opportunities for oxidation. Rapid treatment of ASS material would therefore be appropriate. With the complexity and scale of the proposed operation, it remains unclear to the EPA how the proponent would manage ASS material in accordance with the time constraints and management standards outlined in the Queensland ASS management guidelines.

The proponent has indicated their intention to encapsulate ASS material from the harbour and channel at Hope Point. The resultant structure would form an elevated base for the salt stock pile and so protect it from storm surge. The proponent has however stated that should the worst case scenario volume of 81,000 cubic metres of ASS material be found at this site, it would not be feasible to comprehensively neutralise it prior to encapsulation. Without comprehensive neutralisation, ASS material treatment would be reliant on the surface capping to both reduce exposure to oxygen and remain non-porous to water to prevent leaching.

The Queensland ASS management guidelines categorise above ground encapsulation under 'Generally Unacceptable Management Strategies'. The guidelines state:

> *"Capping ASS above the ground is a potentially high-risk activity and is not recommended due to the associated level of environmental risk"*.

The guidelines put forward two general design options for capping above ground structures: oxygen barrier covers which rely on a compacted clay layer with suitably low hydraulic conductivity that must be maintained at 80 per cent saturation at all times; and, supersponge covers which depend on a suitable combination of soil types and thickness together with a vegetation cover to absorb any rain events without allowing for transmission of water to the underlying sulphidic soils.

The clay cover proposed over encapsulated ASS material at Hope Point would not be maintained wet and would not be vegetated. The structure would instead be used as the base for salt storage. Concerns have been raised regarding the structural integrity of hypersaline clays, and acidity is also known to break down clay structure because

of aluminium exchange. Stockpile operations including the use of machinery on top of the structure would necessitate specific design criteria to prevent any mechanical weakening of the capping. While the construction of an elevated base beneath the salt stockpile would serve to raise the stockpile above the storm surge zone, the encapsulated ASS material would itself be located within the storm surge zone further adding to the risk of failure and the release of acidic material with high metal content to the coastal environment.

With only 4000 cubic metres of sediment to be extracted from Dean's Creek, effective treatment and complete neutralisation is considered possible. The proponent has indicated that ASS material would be placed either in a lined claypan pit or an encapsulation structure with alternating layers of neutralising material. However although the draft management plan provides examples of how the amount of neutralising material would be calculated, a clear commitment to undertake the necessary calculations and apply the neutralising material in accordance with best practices outlined in the Queensland ASS management guidelines prior to burial or encapsulation is not evident in the draft environmental management plan.

If ASS material was to be encapsulated prior to its comprehensive neutralisation, it would require ongoing monitoring and management beyond the projected life of the proposal. The question therefore arises as to who would become responsible for management after salt field closure. The proponent's draft *Preliminary Closure Plan* (Straits Salt, 2008b) assesses the risk of leakage of acidic discharge from encapsulated ASS as 'low' and identifies the following mitigation actions; careful construction including acid buffering and neutralisation of the encapsulation structure 60 years or more earlier, together with a program to monitor surrounding groundwater bores. The issue of who would be responsible for the legacy of ongoing monitoring and managing the site is not addressed.

The EPA is of the view that the encapsulation or burial of ASS material above the water table, especially within the storm surge zone, without thorough mixing and comprehensive treatment as outlined in the Queensland ASS management guidelines prior to encapsulation poses an unacceptable risk to the biodiversity and wetland values of Exmouth Gulf. The EPA is also of the view that encapsulation of ASS material prior to comprehensive neutralisation does not provide a legacy-free solution, but instead generates an ongoing liability for future generations.

Summary

The EPA notes:

- The high conservation and wetland values of Exmouth Gulf;
- The requirement for 'maximum' water quality protection in Exmouth Gulf, with no contamination or detectable change from natural variation in water quality;
- Uncertainties regarding ASS volumes and acid generating capacity;
- Uncertainties regarding potential bioavailability of heavy metals in water from oxidised ASS;
- Uncertainties regarding treatment mechanisms and trigger values for heavy metals in return water prior to discharge;

- Uncertainties regarding the proponent's commitment to comprehensively neutralise ASS material prior to its encapsulation or burial above ground water; and
- The proponent's preferred option to use a high risk management encapsulation strategy to dispose of ASS material within the storm surge zone.

The EPA recognises that the proponent plans to undertake additional ASS surveys which could significantly reduce the level of uncertainty. The EPA concludes however, that as presented, the proposal does not meet the EPA's objective to maintain the quality of surface and ground water so that environmental values, including ecosystem maintenance, are protected.

3.6 Marine fauna - vessel operations

Salt for export would be transported in 10,000 tonne barges from Hope Point to bulk carriers of up to 65,000 tonnes at anchor in Exmouth Gulf. There would be between one and two bulk carriers and approximately eight barge trips per week. Barges would be powered and manoeuvred by a tug. Bulk carriers would be piloted through the channel between North West Cape and the Muiron Islands. Bulk carriers required to wait before entering Exmouth Gulf, would anchor about three kilometres west of South Muiron Island. The proponent advises that 50 tonnes of fuel would be delivered by boat from Exmouth or Barrow Island each week. Dredging would take place for up to four months during construction.

An overview of the conservation and wetland values of Exmouth Gulf and its eastern coastline were described in section 3.1. The western and central sections of Exmouth Gulf are important resting and nursing areas for southward migrating humpback whales. Humpback whales use Exmouth Gulf between early August and late November with peak numbers occurring during the end of September and the first two weeks of October. Mothers nurse their calves and rest before continuing their southward migration. Males sing and fight and mating also occurs in this area. In addition, dugong and turtles use the eastern and south-eastern portions of Exmouth Gulf adjacent to the proposal.

Three factors relating to vessels and shipping are discussed below; acoustic emissions, vessel strike, and the introduction of non-indigenous marine species. The EPA objectives for vessels and shipping are;

- *To protect specially protected fauna and their habitats consistent with the provisions of the Wildlife Conservation Act 1950.*
- *To minimise the risk of introduction of non-indigenous marine organisms.*

3.6.1 Acoustic emissions

Description

Marine wildlife use sound and hearing to detect predators and prey and to communicate with each other. Species with gas filled chambers, for example lungs, swim bladders and ear cavities, are vulnerable to damage caused by pressure waves from intense sound.

The major sources of marine based acoustic emissions associated with the Yannarie proposal would be tugs underway with barges, tugs manoeuvring barges alongside bulk carriers, bulk carriers under way and bulk carriers at anchor. It is likely that

several of these noise sources would be emitting sound concurrently, together with the pilot boat, fuel vessel and vessels external to the proposed Yannarie Solar operation such as trawlers, charter boats and recreational vessels.

Bulk carriers would generally be loaded within the area of Exmouth Gulf that is favoured by southward migrating humpback whales. Distribution maps of whales, dugong and other marine megafauna have been compiled from aerial and boat based surveys of Exmouth Gulf (Jenner, 2005 and 2006). All vessels using the constructed harbour at Hope Point would pass through preferred dugong and turtle habitat on the east coast of Exmouth Gulf. They would generally be moving slowly and would not undertake complex manoeuvring, with associated engine or propeller cavitation noise, in this area.

Noise emissions vary greatly according to the type of vessel and the way it is operated; e.g. slow speed, slow changes of speed, a clean hull, an undamaged propeller and a well maintained engine all reduce vessel noise emissions. The distances over which sound can be detected is also dependent on a range of factors for example background noise (rough seas are much louder than calm conditions), sound frequencies (low frequencies travel further), water depth (sound attenuates rapidly in shallow water) and substrate type.

Noise modelling was commissioned by the proponent to assess noise emissions and their likely impacts on humpback whales and other marine wildlife (McCauley and Maggi, 2005). While the model does not take account of dredging during construction, or the fuel delivery and pilot vessels, it does include the main operational components of tug, barge and bulk carrier operations.

Based on model outputs, none of the noise sources are predicted to cause physical damage to marine organisms. Noise model results indicate that the most intense noise emissions would be associated with tugs manoeuvring barges alongside bulk carriers. These intensive manoeuvring activities would be heard over ten kilometres away with high noise levels over a radius of 2.8 kilometres. Whale avoidance behaviour is considered likely within one kilometre of such a noise source. Intensive tug manoeuvring would be expected to last for about 30 minutes each time a barge comes along side a bulk carrier. This is equivalent to less then five per cent of the time.

A transiting bulk carrier would emit sound that is audible over a seven kilometre radius. However, high levels of noise would occur within about one kilometre of the ship. A tug working a barge along the dredged channel would emit audible sound over a radius of about four kilometres with high noise levels experienced within 0.6 kilometres of the vessels.

Whale songs contain different components, some of which travel further than others. For a humpback singing at one kilometre away from an anchored bulk carrier, it was predicted that the complete song would be masked within one hundred metres of the vessel, half of the song would be discernable at 250 metres from the vessel and the whole song would be heard at 700 metres from the vessel.

To minimise impacts from vessel noise emissions, the proponent has committed to:

- Impose speed limits of;

  - Less than ten knots on all vessels associated with salt loading (bulk carriers, tugs and barges), within Exmouth Gulf. Laden barges are proposed to travel at three knots and empty barges at six knots,
  - Ten knots for all vessels in the proposed fish habitat protection area, which contains the highest concentration of dugong,
  - Ten knots for all vessels anywhere in the Gulf during the four week peak period for whales,
  - Six knots while transiting the median density (75 per cent probability) area of mapped whale distributions, if this area cannot be avoided altogether during the peak four week whale season;
- Implementing a one and a half kilometre buffer between ship loading activities and the median density (75 per cent probability) contour of mapped whale distributions, during the peak four week whale season (notionally 20 September to 17 October);
- Maintain a minimum 100 metre approach limit to whales;
- Maintain a communication network to pre-warn where possible, ship's captains of the locations of whale pods; and
- Continue to support research and monitoring to assess the relationship between ship disturbance and the risk of whale displacement from Exmouth Gulf.

Submissions

Submissions relating to acoustic emissions raised the following points:

- More research is required on the impacts and management of noise on cow/calf whale pods.
- Underwater noise would cause at least some displacement of whale cows and calves.
- Cow/calf pods are more sensitive to noise than adult whales.
- Increased noise could lead to a reduction in birthing rates of species such as dolphins as shown in a Shark Bay study.

Assessment

Advice from the Centre for Whale Research (CWR) indicates that in the past, humpback whales made extensive use of other inshore areas such as the Dampier Archipelago, and their near abandonment of these areas today is likely to be linked to increased shipping and associated noise. Because of their altered patterns of behaviour and apparent alienation from other inshore areas, the protection of remaining humpback habitat in Exmouth Gulf is particularly important. However, the threshold of shipping numbers and noise levels that might cause whales to stop using an area remains unknown.

In addition to conducting the noise modelling for Yannarie Solar operations, McCauley and Maggi (2005) provided advice regarding likely whale responses. Based on their professional knowledge and understanding of other research in this field, they advised that whale pods of cow/calf pairs are more sensitive to high level acoustic emissions than other adult pods and that the most vigorous behavioural responses to noise are generally associated with loud sounds that change suddenly. Different species and different individuals within species are likely to show a range of behaviours, though male and juvenile whales are more likely to be curious while

others would exhibit avoidance behaviours. McCauley and Maggi reported that a level of habituation could occur.

The CWR recommended that during the peak four week period of cow/calf usage of Exmouth Gulf, bulk carriers and loading from barges should remain outside the median density area (75 per cent probability) of mapped whale distributions. The proponent's commitment to load ships no closer than 1.5 kilometres outside this area means that the estimated area of one kilometre radius in which whales are likely to exhibit avoidance behaviour would also remain outside the area of preferred whale distribution.

It may not be possible for bulk carriers to avoid the preferred whale area altogether because of depth constraints. However, the proponent has stated that it would minimise bulk carrier incursions into this area and reduce the maximum speed limit to six knots during the four week peak whale season. The proponent has indicated that they would maintain a minimum 100 metre distance between whales and all vessels including bulk carriers. This distance is consistent with the 100 metre requirement outlined in the whale watching code of conduct (DEC, 2007).

The passage of ships between the Murion Islands and North West Cape would be audible across the whole channel. However, noise levels across most of the width of the channel would remain below high levels.

Turtle and dugong distributions coincide with the barge and tug route between Hope Point and anchored bulk carriers in the Gulf. There would be eight barge trips per week and emissions associated with the slow and consistent movement of these vessels are expected to provide sufficient warning for animals to move away without being startled or significantly disturbed. The higher intensity and inconsistent acoustic emissions associated with manoeuvring barges along side bulk carriers would be more than eight kilometres from the median density area (75 per cent probability) of mapped dugong and just to the north of the median density area (75 per cent probability) of mapped turtle distributions.

Concerns raised regarding potential impacts on dolphin birthing rates were addressed by the proponent with reference to a study in Shark Bay into the impacts of tourist vessels. It was concluded by the proponent that the higher frequency and longer duration of contact, together with the pursuit-type approach pattern characteristic of tourist vessels, are more likely to have caused the observed impacts on dolphins than vessel noise in Shark Bay. The study therefore bore little resemblance to the Yannarie Solar scenario where vessels would be travelling slowly, on a steady course.

Summary

The EPA notes:

- The results of noise modelling;
- The limited number of vessel movements proposed;
- Management commitments to;
  - limit vessel speeds, and
  - impose a 1.5 kilometre buffer between salt loading and the preferred habitat of humpback whales during the four week peak whale season.

The EPA is of the view that underwater acoustic emissions, if managed carefully, would not cause significant impacts to specially protected fauna and their habitats in Exmouth Gulf.

3.6.2 Vessel strike

Description

Vessel strike can injure or kill megafauna and is a significant cause of dugong death in Queensland. Dugong populations are declining worldwide and the dugong that occur in northwest Australia are part of the largest remaining population in the world. Dugong abundance in Exmouth Gulf is second only to that in Shark Bay. Dugong can undergo large scale movements when habitat is degraded by cyclones. Exmouth Gulf provides vital habitat linking the Shark Bay and Pilbara components of the north-west population.

The Great Barrier Reef Marine Park Authority has instigated dugong management areas with controls on vessel size and speed limits of 20, 10 or 6 knots (Preen, 2001). Vessel strike is also a significant cause of death for dugong in Hervey Bay in Queensland. The shallow depth of water, dual hulls and speed of fast ferries, are thought to contribute to vessel strike by ship propellors.

The inshore eastern and southern sections of Exmouth Gulf are the focus for developmental and foraging habitat for marine turtles. Whale distributions focus on the western and central sections of the Gulf and include an area between the Muiron Islands and North West Cape. Based on distribution maps of turtles, dugong and humpback whales in Exmouth Gulf, DEC analysis predicts the following vessel interactions;

Table 4: Vessel route lengths through preferred megafauna habitat.

animal	Approx. length of vessel route within preferred distribution (75% probability contour)	Vessel types
Humpback whale	5 to 20 km depending on exact route past Muiron Islands and northern end of Gulf	Pilot vessel Bulk carriers Fuel carrier Barges & tugs (during shoulder seasons outside the four week peak whale season)
Dugong	1 km	Barges Tugs Fuel carrier
Turtles	12 km	Barges Tugs Fuel carrier

During the four week peak humpback whale season, barges would not be entering the preferred area for humpback whales (based on the median density area, 75 per cent probability of mapped animals) because of a proponent commitment to implement an exclusion zone for salt loading during this period. However, fuel delivery vessels would be passing through the preferred whale area and bulk carriers would pass through at times other than the four week peak whale season and within sections

where these vessels are constrained by water depths outside. The proponent has also committed to:

- Using an aircraft to transport staff to and from Exmouth rather than use a fast commuter vessel;
- Implementing vessel speed limits of ten knots at all times, with limits of six knots for bulk carriers in the preferred whale area during the four week peak whale season and barge speeds of three knots while laden and six knots when empty; and
- Maintaining a watch for whales and warning the skippers of vessels associated with Yannarie operations about whales in the area.

Submissions

Submissions relating to vessel strike raised the following points:

- The population of dugong in the north-west of WA is part of the largest in the world.
- The EPA should note that Exmouth Gulf is the second largest dugong habitat in WA and is vitally important for the conservation of Pilbara coastal and main Shark Bay populations.
- The proposal must include information, research and a thorough analysis of the significance of Exmouth Gulf for dugong and turtles and the potential for their death and displacement due to vessel collisions.
- Detailed mapping of dugong activities should be undertaken to find out which areas are important for feeding, lekking, travelling, shelter, calving and thermal refuges and boating traffic should be managed to avoid impacts on these areas when the animals are most vulnerable.
- Dugong are vulnerable to boat strike while in the dredge channel and barge route, which cross an important feeding ground.
- The ten knot speed limit near to Hinchinbrook Island in Queensland is for recreational boats and may not be appropriate for large commercial vessels.

Assessment

There is currently very little boat traffic on the eastern and southern waters of Exmouth Gulf. However, prawn trawlers use the central portion of the Gulf and there are increasing numbers of charter and recreational vessels which use the west coast and the passage between North West Cape and the Muiron Islands.

Most vessel strike studies in Queensland relate to recreational vessels and fast ferries, so dugong vulnerability to vessel strike by large slow commercial vessels is not directly comparable. While barges are not expected to be very manoeuvrable, the proponent has stated that barges would travel at three knots when laden and six knots when empty.

The salt barges would be flat bottomed and there would be little space remaining between the hull and sea bed. However, unlike the Queensland ferries, they would travel very slowly and they do not have propellers. The salt barges would be moved by tugs with single hulls that are considered less likely to direct a dugong into the path of their propellers.

The vessel path crosses only about one kilometre of the preferred dugong distribution (based on the 75 per cent probability distribution contours) and this short length

provides options for additional management e.g. reducing speeds of empty barges to three knots and even the use of small runabout vessels to shepherd surface dugong out of the way if necessary.

It is considered likely that dugong would neither congregate nor linger in the dredged channel unless seagrass re-establishes to provide an attractive food source. Noise from the barges and tugs is expected to provide enough warning for dugong to avoid vessels. The EPA is therefore of the view, noting the low number of barge trips, their slow speed and lack of propellers that Yannarie Solar vessel operations do not pose a significant risk of vessel strike to dugong on the east coast of Exmouth Gulf.

There would be one or two bulk carriers entering Exmouth Gulf each week and the proponent has committed to six knot speed limits for bulk carriers within the preferred whale area during the peak four week whale season. Most of the boating activity associated with salt loading would take place more than 1.5 kilometres away from the preferred whale habitat during this peak season. The Yannarie Solar vessels would be travelling slowly with no sudden manoeuvres and it is considered likely that the noise of these vessels would provide sufficient warning for whales to avoid collision.

Turtles are agile and relatively fast in the water and although Yannarie operational vessels would traverse approximately twelve kilometres of preferred turtle habitat, they are not considered to be at significant risk from slow moving vessels which maintain a steady course.

Summary
The EPA notes:

- The limited number of vessel movements proposed;
- Management commitments to;
  - transport staff by air,
  - limit vessel speeds, and
  - impose a 1.5 kilometre buffer between salt loading and the preferred habitat of humpback whales during the four week peak whale season.

The EPA is of the view that vessel strike, if managed carefully, should not cause significant impacts to specially protected fauna and their habitats in Exmouth Gulf.

3.6.3 Non-indigenous introduced marine pests

Description
There are over 250 species of non-indigenous marine species (NIMS) in Australia. They include viruses, bacteria, marine plants and animals. The National Oceans Office database identifies over fifty NIMS in the Pilbara Nearshore Bioregion.

NIMS can cause significant impacts to natural communities and have been blamed for the collapse of fisheries. Their effects can be very rapid, for example the North Pacific sea star population reached over 100 million within two years of arriving in Port Phillip Bay and the Black Stripped mussel was discovered with densities up to 23,600 per square metre just six months after a previous inspection found nothing. The control of NIMS can be very expensive; Black Stripped mussel control in Darwin cost $2.2 million and the control of a close mussel relative costs American authorities about $18 million each year. Eradication of aggressive NIMS is usually not possible.

Shipping can introduce NIMS in two ways;

- in water and sediments transported as ballast; and
- through the settlement of fouling organisms on ships' hulls and equipment.

Approximately 85 per cent of NIMS in tropical areas have been introduced through bio-fouling.

Exmouth Gulf has been visited by pearling, whaling, military, fishing and recreational boats for over a century and it is likely therefore that NIMS are already established in the area. However, no survey data are available on the status of NIMS in Exmouth Gulf. Shipping usage of the eastern Gulf is likely to have been much less than shipping usage of the western side of the Gulf.

The Australian Quarantine and Inspection Service (AQIS) administers the *Quarantine Act 1908* requiring all vessels from overseas to exchange ballast water outside Australia's territorial limit (12 nautical miles). AQIS officers board all vessels coming from overseas and inspect ships' records relating to ballast exchange. There is currently no State legislation requiring the treatment of ballast from other ports within Australia, though this is being developed.

Fouling organisms make a hull rough and slow so operators use anti-fouling paints to prevent settlement and growth. There is a National protocol for managing fouling risks (ANZECC, 2000a) but it is voluntary and there is no National or State legislation. Hull cleaning by physically scrubbing can result in fouling organisms being knocked off and introduced to the location where cleaning is taking place. Minimal risk hull cleaning is done many kilometres off shore in very deep water.

Anti-fouling paints are used to control the settlement and growth of fouling organisms. However, anti-fouling paints are toxic and can cause contamination of sediments though the action of gradual sloughing or by operators actively scrubbing vessels. Tribulyl tin (TBT) is of particular concern because it sloughs off hulls and is known to interrupt molluscan reproduction. Other anti-fouling paints include copper oxide which is also toxic. Surveys showed no TBT contamination in sediments on the east coast of Exmouth Gulf.

The International Maritime Organisation's, *International Convention on the Control of Harmful Anti-fouling Systems on Ships* (ANZECC, 2000a) will come into force in September 2008. After that date, parties to the convention will be required to prohibit and/or restrict the use of harmful anti-fouling systems on ships flying their flag, as well as ships which operate under their authority and all ships that enter a port, shipyard or offshore terminal.

The DoF is the lead agency for managing risks associated with NIMS in Western Australia. Hull cleaning and accredited inspections are required by this agency when the risks of introductions are high. The DoF has developed an emergency/incident response plan should any NIMS be introduced in Western Australia and the department is currently drafting instructions for NIMS regulations under a new Bio-security and Agriculture Management Bill.

The risk of foreign organisms becoming established in new ports following their discharge in ballast water or from hull fouling is greatly increased if the ports are at

similar latitudes with similar environmental conditions. Bulk carriers would be entering Exmouth Gulf from South-East Asia, China or India. Some of these destinations can be expected to have similar climatic and environmental conditions to Exmouth Gulf. A dredge is required during construction and this might come either from overseas or from a dredging program elsewhere in Australia. Extensive dredging programs are planned further east on the Pilbara coast. Ports on the Pilbara coast are likely to harbour NIMS because of the large numbers of vessels that use the area. Fuel would be delivered from Exmouth or Barrow Island.

The proponent has made the following commitments beyond legal requirements in relation to vessel management:

- To undertake regular inspections of tugs and barges;
- To clean vessels in accordance with ANZECC 2000 guidelines (i.e. offshore);
- To use current best practice anti-fouling systems on Yannarie vessels including tugs and barges and also require contractors to use current best practice anti-fouling systems;
- To establish baseline information on NIMS in Exmouth Gulf;
- To monitor Hope Point and anchoring areas for NIMS and contact relevant authorities if suspicious organisms are found; and
- To undertake necessary cleaning and inspections of the dredge prior to operations in Exmouth Gulf.

Submissions

Submissions relating to non-indigenous introduced marine pests raised the following points:

- Ballast water management relies on an honour system which is too risky for Exmouth Gulf.
- There is a need to establish a baseline on native and introduced species in the Gulf prior to assessment.
- There is no formal management strategy for bio-fouling. A State management strategy for bio-fouling is required prior to the proposal being considered.
- AQIS deals primarily with ballast water and does not protect against introduction through bio-fouling.
- Dredges and barges present a high risk because they are slow moving and operate in shallow water.
- Better assessment is needed of which pest species have the greatest potential to become established and disrupt fisheries. These should then require detailed management and emergency response plans.
- The proponent should present a risk assessment matrix of vessels and activities.
- Vessels from high risk areas or with a history of high risk activities like dredging should be inspected in dry dock by a suitably qualified person.
- The financial consequences of NIMS is potentially devastating for the prawn and pearling industries.
- The freedom to transfer juvenile pearl oysters depends on maintaining their disease and NIMS free status. The presence of NIMS would trigger the pearl oyster translocation protocol with significant operational and financial implications for the pearling industry.

- The prawn industry could be impacted by disease, toxicity or direct competition.

Assessment

The DoF has advised that of the vessels required for constructing and operating Yannarie Solar, dredges pose the highest risk of introducing NIMS to Exmouth Gulf. This is largely because they have been in direct contact with the seabed and they move slowly, at speeds that would allow the settlement of larvae on vessel surfaces.

The dredge used for Yannarie Solar construction would most likely travel from one of the large dredging programs on the Pilbara coast further north. Most dredges which are brought into the Pilbara region have been dry dock cleaned overseas just prior to engagement. The requirement for further in-water inspection or dry dock cleaning before entering Exmouth Gulf would depend on the recent operational history of the vessel.

The DoF has advised that there is currently a shortage of qualified taxonomists to process in-water inspection samples. In the absence of expert identification, it is the EPA's view that a precautionary approach would need to be taken to vessel inspections, requiring dry dock cleaning should any bio-fouling organism be found unless it can be verified as one which occurs naturally within Exmouth Gulf.

Based on the infrequent use of dredges, the management commitments made by the proponent and the DoF expertise and active management role, the EPA is of the view that with care, an appropriate management plan and a precautionary approach, the risks associated with the use of a dredge within Exmouth Gulf are acceptable and in line with the risks associated with dredging programs in other sensitive marine environments in the north-west of the State.

Bulk carriers would be travelling regularly from ports which are likely to harbour species with the potential to significantly impact Exmouth Gulf if successfully translocated and established. All foreign vessels are boarded by AQIS officers on entering the country and it is unlikely that water from foreign ports would be discharged to Exmouth Gulf. Bulk carriers, like other commercial vessels, generally pose a low relative hazard of accumulating and translocating biofouling organisms. This is because of the economic and operational incentives associated with maintaining vessel hulls free of biofouling organisms to reduce hydrodynamic drag and fuel consumption. Bulk carriers therefore generally have superior antifouling management (pers. comm. DoF officers). In addition, it is normal for bulk carriers to have fast turn around times at each destination providing little time for bio-fouling, and to travel at high speed which provides little opportunity for bio-fouling organisms to successfully attach.

As long as bulk carriers compl with AQIS requirements and were not cleaned in Exmouth Gulf, the EPA is of the view that the risks associated with introducing marine pest are no greater than risks associated with other similar activities in Exmouth Gulf, e.g. access by naval ships. While the proposal would increase the total number of ships entering Exmouth Gulf, NIMS introduction is considered manageable with proper control measures.

It is uncertain at this stage whether fuel would be delivered from Barrow Island or from Exmouth. Until a baseline survey of introduced marine pests in Exmouth Gulf has been conducted, the relative risk of introducing pest species to the east coast of Exmouth Gulf from Exmouth or Barrow Island cannot be determined. Other vessels used during the operational phase of the Yannarie proposal would remain in Exmouth Gulf except for maintenance or hull cleaning.

The Department of Fisheries made the following recommendations:

> … *that the proponent should develop a more thorough NIMS and disease management strategy, including a risk assessment of all vessels to be used in the proposed operations and appropriate mitigation and management commitments.*

It is the EPA's view that the risks of vessels associated with the Yannarie proposal introducing NIMS to the east coast of Exmouth Gulf can be managed in line with existing levels of risk posed by other activities currently operating or approved within Exmouth Gulf as long as:

- A more thorough NIMS and disease management strategy is prepared, including a risk assessment of all vessels to be used in the proposed operations together with appropriate mitigation and management commitments.
- Baseline NIMS data are obtained from Exmouth, the salt loading area and Hope Point and the results of these surveys are used to inform the risk assessment and associated management framework prior to commencement of operations;
- The proponent's commitments relating to ongoing NIMS monitoring, plus vessel inspections and management are adhered to;
- The DoF oversees the approval and implementation of vessel management prior to operating in the Gulf; and
- All operational vessels that depart from the Gulf, lodge a request for approval with the DoF and undertake any necessary management prior to re-entering the Gulf.

Summary

The EPA notes:

- The limited number of vessel movements proposed;
- The proponent's management commitments to;
  - use best practice hull cleaning and maintenance, and
  - monitor and report NIMS; and
- The DoF expertise and active role in NIMS management.

The EPA therefore considers that, with a careful and precautionary approach, the proposal can be managed to meet the EPA's objectives to protect specially protected fauna and their habitats consistent with the provisions of the *Wildlife Conservation Act 1950* and to minimise the risk of introduction of non-indigenous marine organisms.

3.7 Habitat loss

Yannarie Solar is situated in the Cape Range subregion of the Carnarvon Biogegion and at the western end of the Northwest marine and coastal province. The proposal

requires direct habitat disturbance of terrestrial flora and vegetation, potential subterranean fauna habitat, and both intertidal and subtidal benthic habitats.

This section considers four aspects of habitat loss; terrestrial vegetation, subterranean fauna, algal mat and mangrove communities, and subtidal benthic communities. The EPA objectives for habitat loss are;

- *To maintain the abundance, diversity, geographic distribution and productivity of flora at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.*
- *To maintain the abundance, diversity and geographical distribution of subterranean fauna.*

3.7.1 Terrestrial vegetation

Description

The proposal requires the direct clearing of 157 hectares of terrestrial vegetation. A database search identified 26 priority species in the Cape Range subregion of which nine might occur within the project area. Two flora and vegetation surveys were commissioned by the proponent and the data were used to map a project area of 13,000 hectares.

No species of Declared Rare Flora, priority species, or species of significance under the *Environmental Protection and Biodiversity Conservation Act 1999* were recorded in the project area. However, 41 species in the project area are range extensions and 21 species are at their northern limits. The majority of vegetation is in good or excellent condition. Two species of introduced plants were recorded.

There have either been insufficient surveys, or the administrative process has not proceeded sufficiently to classify Threatened Ecological Communities in this region of Western Australia. None of the vegetation types recorded are Priority Ecological communities.

One plant assemblage, characterised by *Melaleuca cardiophylla* shrubland, occurs only at Hope Point within the study area. However, it would not be cleared as part of the Yannarie Solar proposal. *Melaleuca cardiophylla* shrubland is a vegetation type that is well represented elsewhere in the region.

Detailed vegetation mapping of the Cape Range subregion and Pilbara region is patchy. At a regional scale, proposed clearing for the Yannarie proposal represents less than one per cent of each of the three broad scale vegetation units defined by Beard in 1975, and less than ten per cent of each of the four land systems defined by Payne in 1988.

Eleven vegetation types were identified in the detailed vegetation surveys commissioned by the proponent. No more than five percent of any vegetation type within the 13,000 hectare mapped area is proposed to be cleared for the Yannarie development.

A regional analysis was undertaken using data from the Yannarie surveys plus data from 142 sites recorded during other equivalent surveys in Pilbara coastal areas. This

analysis did not identify any floristic assemblages that occur only in the impact areas, even when analysed to the detailed level of 20 groupings.

Claypans have been identified as priority ecosystems for reservation within the Cape Range Subregion (May and McKenzie, 2003) and the proposed extraction of three million cubic metres of clay from twelve clay-pans covering a total area of 75 hectares is of some concern to the DEC.

The proponent has made the following commitment to manage terrestrial vegetation;

- Installation of a wash-down facility at the entry point and a requirement for all vehicles and equipment to be cleaned and pass inspection before entering the site;
- Weed mapping and implementation of weed control in areas of weed infestation;
- Separate storage and management of weed infested soils;
- Prompt rehabilitation of temporally disturbed areas;
- Use of seed from cleared vegetation and local provenance areas for revegetation; and
- Ongoing vegetation monitoring.

Submissions

Submissions relating to terrestrial vegetation raised the following points:

- Diversion, flood-out areas and impacted terrestrial vegetation is not identified in the amounts of vegetation clearing.
- Water pooling behind the weir could affect an additional 151 hectares of vegetation.
- The proponent should assess potential clearing for land-based access through Giralia Station.
- Flora and vegetation surveys were not carried out after rain and therefore don't sample ephemeral species. Additional information is required regarding seasonality of vegetation.
- A lack of regional data should result in suspension of the project until this information is available.
- The proponent needs to provide information about the frequency of maintenance dredging, (in relation to ongoing requirements for clay).

Assessment

The estimated extent of terrestrial vegetation to be cleared does not include potential indirect impacts from flooding upstream of the weir, road construction to access the project site or, potentially rising hypersaline ground water.

Ponding upstream of the weir has the potential to inundate an area of 151 hectares following a five year ARI event. Rain events of greater magnitude would flow over the choke point into diversion channels. Vegetation within the area of ponded water upstream of the diversion weir would be inundated for longer periods while the water infiltrates or evaporates.

Vegetation affected by the weir is within the Yanrey Land System which consists of gilgai floodplains, coolibah woodland with weeping grass and other tussock grasses.

These vegetation types are subject to inundation under natural conditions and some units, including drainage lines and claypans, are unlikely to be affected by additional inundation. The tussock grasslands however, may be affected. The proponent has indicated that the water contained by the weir would be likely to remain on the surface for several days longer than prior to its construction, however, if the grasses remained under water for two to four weeks, they could die-off.

Vegetation along the Yannarie North channel downstream of the proposed weir would likely be impacted by the loss of surface water flows diverted to the north. An analysis of likely impacts on downstream vegetation has not been provided by the proponent.

Although the proposed weir is predicted to impact vegetation, no loss of vulnerable communities is expected. Instead, communities would be likely to adjust their distributions to coincide with altered inundation regimes, with some areas becoming more suitable for plants which tolerate inundation while others would suit plants requiring drier conditions. All of the vegetation communities likely to be impacted by altered inundations are well represented elsewhere in the region.

Road access to the project site would be on the B-Mack Road through Yanrey Station. This road joins the public road system 55 kilometres from the Yannarie project site. The proponent has indicated that B-Mack Road would provide the initial access for construction purposes until the barge harbour and airstrip were operational. The B-Mack road is not a public road but required maintenance would be limited to occasional regrading and the proponent does not envisage the need for additional vegetation clearing

The proponent gave consideration to the potential for degradation of vegetation on mainland outliers on the salt flats as a result of hypersaline groundwater rising in response to adjacent salt ponds. The salt ponds have since been redesigned to accommodate shallower depths, reducing the hydrostatic pressure that would be exerted by them on groundwater beneath the outliers. The estimated areas of vegetation likely to be impacted by elevated hypersaline ground water were small and the reduction in pond depth would further reduce the likelihood of significant impacts from hypersaline ground water on low lying vegetation on mainland outliers.

Both of the flora and vegetation surveys were conducted during dry periods and were therefore unlikely to detect either winter growth or summer growth ephemeral species. However, vegetation types and landscapes within proposed impact areas are repeated within the project area and more broadly across the region. The habitats of ephemeral species are therefore well represented elsewhere and the likelihood of there being an ephemeral species that is restricted to the impact area is considered very low.

Because flora and vegetation surveys were conducted during dry periods, the results cannot be used to distinguish claypans that have ephemeral vegetation from those that are un-vegetated. It has also recently come to light from the DEC Pilbara biological surveys that claypans between Onslow and Port Hedland harbour freshwater invertebrate species that display short-range to regional range endemism. Fairy shrimp, ostracods and clam shrimp have been reported, some of which are new to

science. The DEC advises that claypans adjacent to the Yannarie proposal are also likely to contain undescribed species which may have restricted distributions.

The proponent has not included estimates of clay required for ongoing maintenance of levee walls and other infrastructure but the estimate of clay required for initial construction amounts to 75 hectares of claypan habitat. The proponent has estimated that 75 hectares is equivalent to less than one per cent of claypans in the region. The 12 claypans that have been identified for extraction are spread along about 24 kilometres of the hinterland and there are many other claypans in-between. It is considered unlikely that invertebrate species are confined to single claypans and the risk of the proposed clay extraction changing the conservation status of any claypan invertebrates is therefore considered very low.

While the condition of most survey sites was recorded as good or excellent, two weed species were found, one of which, buffel grass (*Cenchrus ciliaris)* is wide spread. Buffel grass has the capacity to spread rapidly and degrade large areas of native vegetation if not managed effectively. It characteristically establishes on, and then spreads from disturbed ground. Effective weed control would therefore be essential to ensure vegetation protection.

EPA Position Statement number two, *Environmental Protection of Native Vegetation in Western Australia* (EPA, 2000) provides a framework for the assessment of vegetation clearing. Percentage areas of clearing for all eleven vegetation types are less than five per cent. This is well below maximum clearing levels outlined in Guidance Statement No. 2. In addition, vegetation types extend well beyond the boundary of the mapped area. The percentage values would therefore be even lower in a regional context.

Summary

The EPA notes;

- Proposed clearing would be in accordance with EPA Position Statement No. 2, *Environmental Protection of Native Vegetation in Western Australia* and would not impact Declared Rare Flora, Priority Flora or Priority Ecological communities;
- Indirect impacts on vegetation caused by the proposed weir across Yanrey North channel, would be unlikely to result in unacceptable loss or degradation of vegetation; and
- The extraction of three million cubic metres of clay from 75 hectares of claypans for salt farm construction would be unlikely to change the conservation status of clay pan invertebrates.

The EPA therefore considers that, with care and diligent attention to weed management, the proposal can be managed to meet the EPA's objective to maintain the abundance, diversity, geographic distribution and productivity of flora at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.

4.2.2 Subterranean fauna

Description

Limestone occurs within the project area and the potential for short range endemic subterranean fauna raised concerns in relation to proposed ground disturbance and

altered ground water hydrology associated with the Yannarie proposal. Stygofauna have previously been recorded from the general locality with records from Giralia, Yanrey and Minderoo stations.

Nineteen bores were drilled in locations targeting potential impact areas, and geologically similar sites outside the project footprint. An analysis of sediment cores and groundwater quality was carried out, but fauna sampling was not conducted.

Based on high levels of salinity in the groundwater, and the lack of suitable cracks and tunnels in the rocks sampled, the proponent concluded that the substrates do not provide suitable habitat for subterranean fauna species.

Submissions
Submissions relating to subterranean fauna raise the following points:

- Impacts on subterranean fauna cannot be ascertained in the absence of an adequate understanding of the hydrogeology.
- Fauna sampling should have been carried out. Without it, the confidence levels for this risk-based assessment cannot be considered high.

Assessment
Hydrogeological studies of the project area have not identified any superficial drainage systems with associated alluvial aquifers in the project area and measured groundwater salinities are considered too high for stygofauna in most areas. The consultant company, Biota reported that the only area that has any prospect of supporting stygofauna and troglofauna is Hope Point. However, even this area has groundwater salinities equivalent to seawater, the average rock thickness above groundwater is no greater than eight metres and the substrate material generally lacks naturally air-filled channels and chambers.

Noting the high groundwater salinities and lack of naturally air-filled channels and chambers in the substrates, the EPA considers that there is, on balance, likely to be a low risk to subterranean fauna associated with the construction of Yannarie Solar infrastructure.

Summary
The EPA advises that the risk of significant disturbance to subterranean fauna communities is acceptably low and therefore concludes that the proposal meets the EPA's objective to maintain the abundance, diversity and geographical distribution of subterranean fauna.

4.2.3 Mangrove and algal mat communities

Description
The Yannarie Solar proposal has been designed to avoid mangrove and algal mat communities where possible. There are two components of the proposal however, where disturbance is unavoidable; to allow for the intake of seawater, and the export of salt by sea. Direct clearing of a total of two hectares of mangroves is required for both the construction of a pump station with associated flume at Dean's Creek, and an infrastructure corridor between Main Island and Hope Point.

Field survey results were used to map 11,154 hectares of mangroves along the east coast of Exmouth Gulf. Five living mangrove associations were identified as well as one dead mangrove association. Direct clearing would not impact three of the five living mangrove associations. Of the two associations affected, no more than 0.1 per cent of either association would be directly impacted.

Algal mats occur in a zone landward of the mangrove communities in approximately the upper ten centimetres of tidal range. 8054 hectares of algal mats have been mapped of which 17 hectares, or 0.2 per cent are proposed to be cleared.

The proponent has committed to rehabilitate two hectares of mangroves after construction of the salt field.

Submissions

Submissions relating to algal mat and mangrove communities raise the following points:

- The proponent's documentation does not emphasise the ecological importance of the mangroves in the eastern Gulf.
- There is not enough information about direct and indirect impacts on mangroves.

Most submissions that raised issues relating to mangrove and algal mat communities focused on potential indirect clearing associated with sea level rise, potential disruptions to hydrology and potential alterations to nutrient availability. These issues are addressed in Sections 3-2, 3-3 and 3-4 of this report.

Assessment

An assessment of cumulative losses has been carried out in accordance with EPA Guidance Statement number 29, *Benthic Primary Producer Habitat Protection for Western Australia's Marine Environment* (EPA, 2004). Of the four management units defined by the proponent, clearing would be required in two of them. The areas and percentages of mangroves and algal mats to be cleared in each of the two management units are presented in the table below.

Table 5: Estimates of direct loss of algal mat and mangrove communities.

Management unit	Area (km2)	Current area (ha)		Losses within units (ha) & (%)		Cumulative loss (ha) & (%)
		Mangroves	Algal mats	Mangroves	Algal mats	
Hope Point to Tent Island	81	1697	1147	1.0 (0.06)	3.6 (0.31)	4.6 (0.16)
Giralia Bay to Hope Point	160	3987	3377	0.8 (0.02)	12.7 (0.38)	13.5 (0.18)
				1.8 ha	16.3 ha	18.1 ha

The percentage areas of both algal mat and mangroves proposed to be cleared are less than one percent of the areas of these communities in each management unit. EPA Guidance Statement number 29 recommends that management units should be about 50 square kilometres in area, but the proponent has delineated significantly larger management units of 81 and 160 square kilometres for the assessment of impacts in this case. Smaller management units would have increased the percentage value. The use of 50 square kilometre management areas could have increased the percentage

area estimate of cleared algal mats to values approaching one per cent in the Giralia Bay to Hope Point Management Unit.

EPA Guidance Statement number one, *Guidance Statement for Protection of Tropical Arid Zone Mangroves along the Pilbara Coastline* (EPA, 2001), recognises the mangrove communities along the east coast of Exmouth Gulf as having "very high conservation significance" and being of regional significance. The EPA operational objective for mangroves of regional significance is that *no development should take place that would adversely affect the mangrove habitat, the ecological function of these areas and the maintenance of ecological processes which sustain the mangrove habitats.*

The maximum cumulative loss recommended for category A or 'Extremely Special Areas' areas in Guidance Statement No. 29 is zero disturbance, while the recommended maximum for category B or 'High Protection Areas' is one per cent per management unit. The proponent is of the view that the east coast of Exmouth Gulf is a category B area under Guidance Statement No. 29 and their proposal design reflects their commitment to minimise mangrove impacts to levels below one per cent per management unit. Advice from the DEC indicates that regional significance automatically elevates the Exmouth Gulf east coast mangroves to the status of category A under Guidance Statement No. 29. If this was the case no clearing of mangroves would be considered appropriate.

The EPA is of the view that while the limited scale of direct clearing in this case is acceptable, climate induced sea level rise and potential changes to groundwater hydrology and nutrient availability could increase levels of algal mat and mangrove disturbance well over those affected by direct clearing. These issues are addressed in Sections 3-2, 3-3 and 3-4.

Summary

The EPA notes;

- The proposed layout of infrastructure which minimises direct clearing of algal mat and mangrove communities; and
- The proposed areas of direct clearing of algal mat and mangrove communities are acceptable.

The EPA however, is of the view that the levels of uncertainty associated with potential indirect clearing resulting from impacts associated with sea level rise, potential changes to groundwater hydrology and nutrient availability pose a significant risk of causing unacceptable losses of algal mat and mangrove communities. The EPA therefore concludes that the proposal does not meet the EPA's objective to *maintain the abundance, diversity, geographic distribution and productivity of flora at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.*

4.2.4 Subtidal benthic communities

Description

A combination of aerial photography and ground-truthing techniques were used to map subtidal benthic communities over an area of 55.5 square kilometres around Hope Point. Soft sediments cover 93 per cent of the sea bed and support mostly sparse seagrass communities with some areas of dense sea grass to the south and

inshore of Hope Point. Hard substrates support a mixture of algal, coral and sponge assemblages. The marine flora and fauna found on the east coast is typical of that found in turbid environments elsewhere on the Pilbara coast (Hutchins *et al.* 1996).

The proposal would require a dredged channel measuring 1.65 kilometres long, between 125 and 143 metres wide and to a depth of 3.5 metres below chart datum. The dredged channel would have two sections:

- an inshore section requiring the removal of 240,000 cubic metres of primarily limestone pavement. This section would be dredged using a cutter suction dredge but an excavator and rock bucket would be used to extract limestone from shallow near-shore areas;
- an offshore section requiring 135,000 cubic metres of primarily course sands to be removed by cutter suction dredging.

Large blocks of limestone extracted from the harbour and inshore section of the dredge channel would be used to armour salt pond levee walls. Finer sediments would be pumped ashore into settling ponds. Some of the fine material would be used for road material and other infrastructure and the rest would be used to construct an elevated basement for the proposed salt stockpile area. The proponent has indicated that return water from dredged and excavated sediment settling ponds would be discharged through the constructed harbour at background water quality levels. Return water is discussed in section 3.5 of this report.

Dredge plume modelling was carried out to estimate plume characteristics and sediment settling. The model predicts that an area of 17 hectares would be subject to direct permanent loss of benthic primary producer habitat with an additional 14.5 hectares subject to reversible losses. Model outputs also predict that the plume would drift north and east with tidal exchange into mangrove creeks along the way. Peak concentrations adjacent to the dredge would be equivalent to sediment thicknesses of approximately seven millimetres, rapidly decreasing to less than one millimetre within two kilometres (APASA, 2007).

Based on the model output, the proponent is of the view that levels of deposition are unlikely to cause any adverse impacts on adjacent habitats or on a nearby aquaculture lease, which is currently not being utilised. In recognising the importance of sub-tidal benthic primary producer habitats, the proponent has realigned the dredge channel to minimise impacts on adjacent coral and algal communities. The proponent has also committed to:

- Undertake dredging during the winter when the seagrasses are dormant;
- Using sediment curtains to contain the sediment plume within the dredging area;
- Use performance indicators, targets, coral stress thresholds, and management responses in a Dredge Management Plan; and
- Pumping all dredged sediments to shore-based sedimentation ponds for storage, settlement and water quality management.

Submissions

Submissions relating to sub-tidal benthic communities raised the following points:

- Dredging and ongoing barge movements will increase turbidity resulting in shading or smothering of benthic primary producer habitat and affecting

water quality. Silty bottom sediments on the Gulf floor are likely to be mobilised by repeat dredging operations causing smothering of marine benthic communities.
- The dredge channel will cause the loss of sparse seagrass which is dugong habitat.

Assessment

The dredge plume model was run to simulate what the proponent considers to be a worst case scenario, being a period of prolonged south-westerly and westerly winds such that onshore flow was at a maximum. However, the following issues have been raised in relation to the applicability of model outputs:

- The apparently unverified modelled weather and current patterns used to drive the plume model are based on summer patterns but the dredging program is planned for the winter months;
- The plume model does not take account of re-suspension of previously settled particles by currents or wave action even in the very shallow inshore waters;
- Of the wide range of background turbidity levels presented, the background level used to determine likely effects is neither identified nor justified;
- The modelled dredged material is 305,250 cubic metres not the revised dredge amount of 375,000 cubic metres; and
- The channel alignment has changed since running the model.

The EPA also notes that the model is precautionary in that it assumes that all sediments from the inshore section of the dredge channel would be fine and powdery and that no account has been taken of the proponent's plan to use a sediment curtain or a rock bucket rather than a grinding technique to remove a proportion of the rock material.

Based on the dredge plume modelling, cumulative sedimentation levels have been used to delineate two areas:

- *reversible losses* - turbidity up to the 95th percentile of background, which includes the channel itself and up to 250 metres from the channel;
- *physiological stress* – turbidity up to the 80th percentile of background, extending out to approximately 2.5 kilometres from the dredge channel.

Background levels however, have not been defined, and the criteria used to determine impacts is not provided. Therefore the biological meaning of the two categories defined above cannot be determined and both the area and intensity of effect remain uncertain.

An assessment of impacts in accordance with EPA Guidance Statement No. 29 determined that the areas of each habitat subject to direct and permanent losses were below one percent of the areas of each habitat within the mapped management unit. However, the area of 'reef with algae' subject to both direct and permanent losses and reversible losses (i.e. within the 95th percentile of background, contour) were about eight per cent of the area of this habitat within the mapped management unit. The proponent subsequently realigned the dredge channel to minimise impacts on 'reef with algae' habitat areas.

The combined assumptions on which the dredge plume modelling was based, and the apparent lack of analysis relating to the intensity of impacts, reduces the level of

confidence in the model outputs. Although the model outputs provide an indicative assessment of effects, it is recognised that some of the assumptions would have overestimated impacts, and it is considered unlikely that environmental impacts caused by turbidity alone would be significantly greater than those predicted. It has also been noted that the proposed dredging program is relatively small, prevailing currents would generally take the plume northwards away from the main dugong habitat area and it would be limited to a four month period when seagrasses are dormant. However, turbidity comprises only one component of the potential impacts associated with dredging. An assessment of chemical release in section 3.5 of this report concludes that uncertainties associated with the potential release and management of acid and heavy metals at dredge and excavation sites, and from return water pose an unacceptable risk to inshore communities.

Summary
The EPA notes that:

- The proposed dredging program is relatively small;
- Prevailing currents would generally take the plume northwards away from the main dugong habitat area; and,
- Dredging would be limited to a four month period when seagrasses are dormant.

The EPA however, is of the view that the proponent has failed to demonstrate that potential chemical release associated with dredging can be managed to maintain water and sediment quality in areas of subtidal benthic communities. The EPA therefore concludes that the proposal does not meet the EPA's objective to *maintain the abundance, diversity, geographic distribution and productivity of flora at species and ecosystem levels through the avoidance or management of adverse impacts and improvement in knowledge.*

3.8 Relevant environmental principles

In preparing this report and recommendations, the EPA has had regard for the object and principles contained in s4A of the *Environmental Protection Act (1986).* Appendix 3 contains a summary of the EPA's consideration of the principles.

4. Other Advice

Potential Future Expansion

If the project were to proceed, there is a likelihood that the proponent would wish to expand the proposed 4.2 million tonne per annum (Mtpa) solar salt farm proposal to produce up to ten Mtpa of salts in the future. The proposal originally referred to the EPA was for the production of ten Mtpa of salts and the following statement within the proponent's ERMP for that original proposal supports the viewpoint that future expansion is likely to be sought;

> *"It will be necessary for Straits to establish a capacity in the same order of magnitude as* [other] *major producers (i.e. up to 10Mtpa) to be competitive over the long term".*

The Minister for the Environment should consider this possibility when determining whether the proposal should be allowed to go ahead. While an expansion over 4.2 Mtpa is not part of the proposal currently before the EPA, should market forces indicate that an expanded salt field would be commercially attractive, it is likely that a separate referral for an expanded footprint and production rate will be submitted.

The EPA considers the known impacts and residual uncertainties associated with the assessed 4.2 Mtpa proposal to be unacceptably high. Many of these impacts and risks are directly related to the size of the development footprint, the proportional length of coastline affected and the quantities of materials and natural resources consumed. An expanded salt field beyond 4.2 Mtpa would therefore be expected to have further unacceptable cumulative impacts.

5 Conclusions

Having considered the proponent's Environmental Review and Management Programme report and supplementary information, public and government agency submissions, separate expert advice and the proponent's response to submissions, the EPA has concluded that the proposed solar salt farm is located in an area that presents unacceptably high risks of environmental harm to wetland values and unacceptable levels of uncertainty in relation to long term management of bitterns.

The whole of the east coast of Exmouth Gulf, including all of the salt flats and in-shore waters, are listed as a wetland of national importance in *A Directory of Important Wetlands in Australia* (ANCA, 1993). The EPA considers that it is environmentally unacceptable to locate a 17,765 hectare salt field within a wetland of national importance. While the salt farm is proposed to be largely located on an area of apparently bare salt flats, these flats form an integral part of the wetland ecosystem and land unit supporting the algal mats and mangroves which underpin the productivity of the wetland and Exmouth Gulf. Disturbance on the salt flats could have serious and irreversible adverse impacts on the algal mats and mangroves.

The EPA recognises wetlands that are listed in *A Directory of Important Wetlands in Australia* as 'critical assets' (EPA, 2006) representing the most important environmental assets in the State and requiring the highest level of protection. The status of the site as a critical environmental asset, together with the extent of predicted impacts, the high degree of residual uncertainty and the unacceptably high risks posed by the proposal have lead the EPA to conclude that the proposal is environmentally unacceptable.

The key areas where significant impacts or risks of impacts have been identified are:

- Loss of biodiversity and wetland values in a listed wetland of national importance;
- Significant loss and fragmentation of benthic primary producer habitat and associated ecosystem services as a result of salt pond levee walls blocking the distributional adjustments of algal mat and mangrove communities in response to sea level rise.
- Potential loss of regionally significant mangroves and algal mats caused by the mobilisation of hypersaline groundwater

- A high level of uncertainty in relation to the proponent's ability to manage the ongoing production of over 1 million cubic metres per annum of bitterns C, which is toxic to marine biota and therefore likely to degrade wetland and biodiversity values should bitterns discharge occur either accidentally or be required to maintain salt farm production in the long term;
- Potentially significant and damaging changes to nutrient availability and delivery to coastal waters, affecting productivity in Exmouth Gulf; and
- Potential release of acid and heavy metals to coastal wetland environments during dredging operations and from stored acid sulphate sediments following excavation.

The proponent has not been able to demonstrate to the EPA that the environmental values of the area could be maintained with a high degree of certainty, nor that the risks to those values would be acceptably low in the long term.

Based on this assessment, the EPA does not believe that the proposal could be made environmentally acceptable and recommends that the proposal should not be permitted to proceed. Accordingly, the EPA has not recommended any conditions as it does not consider that the current proposal could be implemented in an environmentally acceptable manner.

6 Recommendations

The EPA submits the following recommendations to the Minister for the Environment:

1. That the Minister considers the report on the relevant environmental factors and principles the EPA considered relevant to the proposal, as set out in Section 3;
2. That the Minister notes that the EPA considers that a 17,765 hectare salt field should not be located in the midst of a wetland of national significance that is a critical environmental asset;
3. That the Minister notes that the EPA has concluded that the proposal cannot meet the EPA's environmental objectives and is considered environmentally unacceptable, particularly with regard to the risk of impacts to, biodiversity values and ecosystem functionality within a listed wetland of national significance, regionally significant mangrove communities, and water quality within an area recommended for 'maximum' water quality protection.
4. That the Minister notes that the EPA has not included in this Report "*conditions and procedures to which the proposal should be subject, if implemented*" because the EPA holds the view that the proposal should not be implemented;
5. That the Minister not issue a statement that the proposal may be implemented;
6. That the Minister consider taking a proposal to Cabinet for the removal of the Temporary Reserve for salt production and instead, the salt flats and coastal environment on the eastern side of Exmouth Gulf be considered for reservation consistent with the recommendations in the report of the Marine Parks and Reserves Selection Working Group (CALM, 1994); and
7. That the Minister notes the EPA's other advice presented in Section 4 in relation to the potential for future expansion if consideration is given to approving the construction of the solar salt farm which is the subject of this assessment report.

Appendix 1

List of submitters

Organisations:

1. Aquaculture council of Western Australia
2. Aquarium Specimen Collectors Association of Western Australia Inc.
3. Cape Conservation Group
4. Conservation Council of Western Australia
5. Department of Environment & Conservation
6. Department of Fisheries Western Australia
7. Department of Industry and Resources
8. Department of Planning and Infrastructure
9. Department of Water
10. Exmouth Professional Fisherman's Association
11. Fathom 5 Marine Research
12. Halt the Salt
13. Marine Parks and Reserves Authority
14. Minister for Fisheries
15. Minister for Indigenous Affairs
16. MG Kailis Group
17. North West Cape Exmouth Aboriginal Corporation
18. Office of Native Title
19. Pearl Producers Association
20. Western Australian Recreational and Sportfishing Council (Inc.) (RECFISHWEST)
21. Tourism Western Australia
22. Western Australian Fishing Industry Council
23. Western Australian Museum
24. Western Australian Naturalists' Club Inc.
25. Wetlands Research Association
26. Wildflower Society of Western Australia
27. Yamatji Marlpa Barna Baba Maaja Aboriginal Corporation (Yamatji Land and Sea Council)

Proforma submissions were prepared by 'Halt the Salt', the Cape Conservation Group and the Wilderness Society. The EPA received a total of 2562 proforma responses.

A petition with 40 signatures was received from the Kalbarri Offshore Angling Club.

Individuals:

1. Courtney Barnes
2. Doreen Blum
3. Helen Barnes
4. Jennie Cary
5. Colin Cameron
6. S. Edwards
7. Tanya Farquhar
8. Eileen Fewtrell
9. Tony Howard
10. Astrid Herlihy
11. Nigel Harman

12. David James
13. Ric Karniewicz
14. Kate Macgregor
15. Otto Mueller
16. Myles Mulvay
17. Jenifer Pommeriin
18. Simon Reeve
19. Sharon Richards
20. Jean Stretch
21. A. Stewart
22. Julie Throne
23. Athol Webb
24. Jamie Wilson
25. Margaret and Paul Wilson

The EPA received four confidential submissions.

Appendix 2

References

ANZECC, 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Volume 1. Australian and New Zealand Environment and Conservation Council, Agricu Resource Management Council of Australia and New Zealand.

ANZECC, 2000a. Code of Practice for Anti-Fouling and In-Water Hull Cleaning and Maintenance. Australian and New Zealand Environment and Conservation Council.

International Maritime Organisation, 2001. International Convention on the Control of Harmful Anti-fouling Systems on Ships. To enter into force on 17 September 2008.

Ahern, C.R., McElnea, A.E. and Sullivan, L.A., 2004. Acid Sulfate Soils Laboratory Methods Guidelines. In Queensland Acid Sulfate Soils Manual 2004. Department of Natural Resources, Mines and Energy, Indooroopilly, Queensland, Australia.

ANCA, 1993. A Directory of Important Wetlands in Australia, Australian Nature Conservation Agency, Canberra.

APASA, 2007. Yannarie Salt Field Environmental Investigations: Mixing and Dilution of Bitterns C Discharge. Report prepared for Straits Salt. Perth Western Australia.

Ayukai, T., and Miller, D., 1998. Phytoplankton Biomass, Production and Grazing Mortality in Exmouth Gulf, a Shallow Embayment on the Srid, Tropical Coast of Western Australia. *Journal of Experimental Marine Biology and Ecology*, **225** : 239 – 251.

Biota, 2005. Yannarie Salt Project: Mangrove and Coastal Ecosystem study – Baseline Ecological Assessment. Unpublished report to Straits Salt Pty Ltd., Perth.

Biota, 2008. Yannarie Solar Project: Additional Flora and Vegetation Assessment 2007. Report prepared for Straits Salt Pty Ltd.. Perth, Western Australia.

Biota, 2008a. Yannarie Solar Project Subterranean Fauna Assessment. Report prepared for Straits Salt. Perth, Western Australia.

Brown, R.G., 1988. Holocene sediments and environments, Exmouth Gulf, Western Australia. In: Purcell, P.G., Purcell, R.R. (Eds.), The North West Shelf, Australia Proceedings of Petroleum Exploration Society. Australia Symposium, Perth.

Brunskill G.J., Orpin, A.R., Zagorskis, I., Woolfe, K.J., and Ellison, J., 2001. Geochemistry and particle size of surface sediments of Exmouth Gulf, Northwest Shelf, Australia. Continental Shelf Research, 21: 157 – 201.

Bruun, P., 1988. The Bruun Rule of erosion by Sea-Level Rise: a Discussion of Large-Scale Two- and Three-Dimensional Usages. Journal of Coastal Research, **4**: 627 – 648.

CALM, 1994. A Representative Marine Reserve System for Western Australia, Report of the Marine Parks and Reserves Selection Working Group, Department of

Conservation and Land Management, Perth.

Cahoon D.R., and Lynch, J.C. 1997. Vertical accretion and shallow subsidence in a mangrove forest of southwestern Florida, U.S.A. Mangroves and Salt Marshes 1: 173-186.

Church, J.A., Gregory, J.M., Huybrechts, P., Kuhn, K., Lambeck, K., Nhuan, M.T., Qin, D. and Woodworth, P.L, 2001. Changes in Sea Level. Climate Change 2001. The scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change, Houghton, J.T., Ding, Y., Griggs, D.J., Noguer, M., van der Linden, P.J. and Xiaosu, D., (Eds.), Cambridge University Press, Cambridge, 639 – 693.

DEC, 2007. Watching Whales. Brochure, Department of Environment and Conservation. Perth, Western Australia.

DEC, 2006. Draft Identification and Investigation of Acid Sulfate Soils. Department of Environment and Conservation, Perth, Western Australia.

DEC, 2004. Treatment and management of disturbed ASS. Department of Environment and Conservation, Perth, Western Australia.

Dear, S.E., Moore, N.G., Dobos, S.K., Watling, K.M. and Ahern, C.R., 2002. Soil Management Guidelines. In Queensland Acid Sulfate Soil Technical Manual, 2004. Department of Natural Resources and Mines, Indooroopilly, Queensland, Australia.

DoE, 2006. Pilbara Coastal Water Quality Consultation Outcomes: Environmental Values and Environmental Quality Objectives. Department of Environment, Perth, Western Australia.

DoF WA, 2002. Draft Fisheries Environmental Management Plan for the Gascoyne Region. Department of Fisheries, Perth, Western Australia.

EPA, 1975. Conservation Reserves for Western Australia. System 9 Report. Environmental Protection Authority, Western Australia.

EPA, 2000. Environmental Protection of Native Vegetation in Western Australia. Position Statement No. 2. Environmental Protection Authority. Perth, Western Australia.

EPA, 2001. Protection of Tropical Arid Zone Mangroves Along the Pilbara Coastline. Guidance Statement No. 1. Environmental Protection Authority, Western Australia.

EPA, 2004. Benthic Primary Producer Habitat Protection for Western Australia's Marine Environment. Guidance Statement No. 29. Environmental Protection Authority, Western Australia.

EPA, 2006. Environmental Offsets. Position Statement No. 9. Environmental Protection Authority, Western Australia.

Gordon, D.M., Bougher, A.R., LeProvost, M.I., 1995. Use of Models for Detecting and Monitoring Change in a Mangrove Ecosystem in Northwestern Australia. Environmental International, **21**: 605 – 918.

Hanson, C.E., Pattiaratchi, C.B. and Waite, A.M., 2005. Sporadic Upwelling on a Downwelling Coast: Phytoplankton Responses to Spatially Variable Nutrient Dynamics Off the Gascoyne Region of Western Australia. Continental Shelf Research, **25**: 1561 – 1582.

Hutchins, J.B., Slacksmith, S.M., Bryce, C.W., Morrison, S.M. and Hewitt, M.A., 1996. marine Biological Survey of the Muiron Islands and the Eastern Shore of Exmouth Gulf, Western Australia, WA. Western Australian Museum Report for the Ocean Rescue 2000 program. Perth.

Jenner, K.C.S., and M-N-M Jenner, 2005. Distribution and Abundance of Humpback Whales and Other Meg-Fauna in Exmouth Gulf, Western Australia, During 2004/2005. Report prepared for Straits Salt. Perth.

Jenner, K.C.S., and M-N-M Jenner, 2006. Pilot Study Report 2006. Techniques Used to Describe Humpback Wale Population Parameters in Exmouth Gulf Western Australia. Report prepared for Straits Salt. Perth.

Kangas, M., Parry, J., Harris, D., Webster, F., Tomplinson, T., Robertson, A., and Sweetman, G., 2007. Seagrass Monitoring – Exmouth Gulf March 2005 and 2006. Department of Fisheries Western Australia Unpublished Report. Perth, Western Australia.

Kenyon, R.A. and Loneragan, N.R., 2004. The Exmouth Gulf Prawn Fishery: Threats From a Proposed Mineral Salt Project. CSIRO Marine Research. Report prepared for the MG Kailis Group. Cleveland, Queensland.

May, J.E. and McKenzie, N.L., 2003. A Biodiversity Audit of Western Australia's 53 Biogeographic Subregions in 2002. Department of Conservation and Land Management. Western Australia.

McCauley, R.D. and Maggi, A., 2005. Yannarie Salt Project, Modelled Underwater Noise in Exmouth gulf from Proposed Yannarie Marine Activities. Curtin University. Report prepared for Straits Salt. Perth, Western Australia.

McKinnon, A.D., and Ayukai, T., 1996. Copepod Egg Production and Food Resources in Exmouth Gulf, Western Australia. Mar, Freshwater Res., **47**: 595 – 603.

Nicholls, R.J., Wong, P.P., Burkett, V.R., Codignotto, J.O., Hay, J.E., McLean, R.F., Ragoonaden, S. and Woodrooffe, C.D., 2007. Coastal Systems and low-lying areas. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Parry, M.L., Canziani, O.F., Palutikof, J.P., van der Linden,P.J. and Hansen, C.E, (Eds.), Cambridge University Press, Cambridge, UK, 315 – 356.

Nott, J., 2006. Tropical Cyclones and the Evolution of the Sedimentary Coast of

Northern Australia. Journal of Coastal Research, **22**: Vol. 1, 49-62.

Oceanica, 2005. Physical Environment of the Yannarie Salt Project Area. Report prepared for Straits Salt, Perth, Western Australia.

Oceanica, 2008. Yannarie Solar, Hope Point Habitat Mapping. Report prepared for Straits Salt, Perth, Western Australia.

Paling, E.I., and McComb, A.J., 1994. Cyanobacterial Mats: A possible Nitrogen Source for Arid-Coast Mangroves. International Journal of Ecology and Environmental Sciences, **40**: 147 – 153.

Parsons Brinckerhoff, 2008. Hydrogeological Investigation of Supratidal Flats, Yannarie Solar Project. Report prepared for Straits Salt Pty Ltd., Perth, Western Australia.

Preen, T., 2001. Dugong, Boats, Dolphins and Turtles in the Townsville – Carwell Region and Recommendations for the Boat Traffic Management Plan for the Hinchinbrook Dugong Protection Area. Research publication No. 67. Great Barrier Reef Marine Park Authority, Australia.

Seminiuk, V., 1993. The Pilbara Coast: a Riverine Coastal Plain in a Tropical Arid Setting, Northwestern Australia. Sedimentary Geology. **83**: 235 – 256.

Shaw, J. 2002. Fisheries Environmental Management Plan for the Gascoyne Region - Draft Report. Fisheries Management Paper No. 142. Department of Fisheries, Perth, Western Australia.

Smith, S.V. 1984. Phosphorus Versus Nitrogen Limitation in the Marine Environment. Limnol. Oceanogr. **29**(6): 1149 – 1160.

Straits Salt, 2006. Environmental Review and Management Programme. Volume 1 Environmental Review. Perth, Western Australia.

Straits Salt, 2008. Response to Submissions, January 2008. Perth, Western Australia.

Straits Salt, 2008a. Modified Proposal, Yannarie Solar Environmental Review and Management Programme. Perth, Western Australia.

Straits Salt, 2008b Yannarie Solar Projec Draft Environmental Management Plans. Perth, Western Australia.

Straits Salt, 2008c. Response to Submissions, May 2008. Perth, Western Australia.

Thackway, R. and Cresswell, I. 1995. An Interim Biogeographic Regionalisation for Australia: a Framework for Setting Priorities in the National Reserves System Cooperative Program Version 4. Australian Nature Conservation Agency, Canberra.

U.S. Army Corps. Of Engineers, 2002. Coastal Engineering Manual, Engineer Manual 1110-2-1100, U.S. Army Corps. Of Engineers, Washington, D.C. design standards

Van de Graaff, W.J.E., Denman, P.D. and Hockings, R.M., 1975. Emerged Pleistocene Marine Terraces on Cape Range, Western Australia. Geological Survey of Western Australia Annual report 1975, pp. 62 – 69.

WA. Government, 1997. Wetlands Conservation Policy for Western Australia. Government of Western Australia.

WAPC, 2003. Statement of Planning Policy No. 2.6: State Coastal Planning Policy. Western Australian Planning Commission, Perth.

WAPC, 2004. Ningaloo Coast Regional Strategy Carnarvon to Exmouth. Western Australian Planning Commission, Perth.

Appendix 3

Summary of identification of relevant environmental factors and principles

PRINCIPLES		
Principle	**Relevant Yes/No**	**If yes, Consideration**
1. The precautionary principle *Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.* *In application of this precautionary principle, decisions should be guided by –* *(a) careful evaluation to avoid, where practicable, serious or irreversible damage to the environment; and* *(b) an assessment of the risk-weighted consequences of various options.*		
	Yes	In considering this principle, the EPA notes that the proposal has the potential to: • Significantly degrade biodiversity and wetland values within a listed wetland of national importance that is also identified as a critical environmental asset; • Significantly degrade water quality within an area designated for 'maximum' water quality protection; • Fragment and deplete potential habitat of 'regionally significant' mangrove communities; • Interrupt nutrient delivery to Exmouth Gulf causing disruption to ecosystem function and ecosystem services. Conservation status, water quality protection, sea level rise and nutrient delivery have been identified as relevant environmental factors and are discussed in the body of the report.
2. The principle of intergenerational equity *The present generation should ensure that the health, diversity and productivity of the environment is maintained and enhanced for the benefit of future generations.*		
	Yes	In considering this principle, the EPA notes that: • there are no salt flat ecosystems within the existing conservation reserve system in the Cape Range Sub-region of the Carnarvon Bioregion; and, • the development of a large scale salt farm in the middle of the salt flats on the east coast of Exmouth Gulf would preclude the opportunity to protect the largest and most intact salt flat and coastal ecosystem for future generations. The conservation and reserve status of the coastal wetlands are considered relevant environmental factors and are discussed in the body of the report.
3. The principle of the conservation of biological diversity and ecological integrity *Conservation of biological diversity and ecological integrity should be a fundamental consideration.*		
	Yes	In considering this principle, the EPA notes: • The potential for loss and/or fragmentation of regionally significant mangrove communities because of potential mobilization of hypersaline groundwater and likely distributional adjustments associated with sea

PRINCIPLES		
Principle	**Relevant Yes/No**	**If yes, Consideration**
		level rise; • The toxicity of bitterns to marine flora and fauna; • The vulnerability of indigenous marine biota to the introduction of marine pests; and, • The importance of Exmouth Gulf as marine turtle, dugong and humpback whale habitat and their vulnerability to impacts from vessel operations and shipping. An assessment of impacts associated with sea level rise, management and discharge of brines and bitterns, together with acoustic emissions, vessel strike and introduced marine fauna are discussed in the body of the report.
4. Principles relating to improved valuation, pricing and incentive mechanisms *(1) Environmental factors should be included in the valuation of assets and services.* *(2) The polluter pays principles – those who generate pollution and waste should bear the cost of containment, avoidance and abatement.* *(3) The users of goods and services should pay prices based on the full life-cycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste.* *(4) Environmental goals, having been established, should be pursued in the most cost effective way, by establishing incentive structure, including market mechanisms, which enable those best placed to maximize benefits and/or minimise costs to develop their own solution and responses to environmental problems.*		
	Yes	The proposal involves storing potentially acid sulphate soils in an onsite containment cell. The proponent should bear the cost of appropriate cell construction and long term management (including maintenance, contingency measures). The management of acid sulphate soils is a relevant factor discussed in the report.
5. The principle of waste minimisation *All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment.*		
	yes	The proponent has indicated that: • Solid wastes would be removed and recycled or disposed of offsite by a licensed contractor; • Treated waste water would be disposed via waste water treatment systems on site; • Waste oils and other liquid wastes would be removed by licensed contractors for recycling. The proponent has indicated their intention to develop marketable products from the bitterns. The long term management of bitterns is considered arelevant factor and is discussed in the body of the report.

Preliminary Environmental Factors	Proposal Characteristics	Government Agency and Public Comments	Identification of Relevant Environmental Factors
POLICY FRAMEWORK			
Policy framework and conservation status	In 1970 an area on the salt flats was designated a Ministerial Temporary Reserve (70/535) for potential future solar salt and gypsum production. . The conservation significance of the east coast of Exmouth Gulf was recognised in 1993 by its listing as a wetland of national importance in *A Directory of Important Wetlands in Australia* (ANCA, 1993*).* The conservation values of the east coast of Exmouth Gulf are also recognised in other Government publications, policies and guidelines including: The mangroves are of 'regional significance' in EPA Guidance Statement No. 1. (EPA, 2001). The area has been recommended for reservation in the report entitled *A Representative Marine Reserve System for Western Australia* by the Marine Parks and Reserves Selection Working Group referred to as the Wilson Report (CALM, 1994). The coastal waters along the east coast of Exmouth Gulf have been recommended for the 'maximum' level of ecological protection in the Department of Environment document *Pilbara Coastal Water Quality Consultation Outcomes*, (DoE, 2006). Humpback whales, dugong and both green and hawksbill turtles are all listed as specially protected	<u>Department of Environment and Conservation</u> • This project would severely compromise the conservation values of one of the largest and last intact examples of sabkha in Western Australia. • The proposal represents 32 per cent of the salt flat land-form within Ashburton. The proponent should provide an estimate of the project's primary footprint as a percentage of remaining salt flat systems along the Pilbara coast. The EPA should take account of the lack of representation of salt flats in the conservation reserve system. • The project area is within the Marine Parks and Reserves Selection Working Group report candidate marine conservation reserve – an intact example of WA arid zone coastal salt flat ecosystems. • The Biodiversity audit identifies 'bare areas mudflats' as a high priority for reservation with none currently included in the conservation reserve system. • In the Cape Range Subregion, only 2.2 per cent of the area is protected in conservation reserves. • The proponent needs to discuss and address the potentially negative impacts associated with the increase in employees and families using local conservation reserves and provide strategies in consultation with DEC to avoid or manage adverse ecological impacts. • The east coast of Exmouth Gulf is one of the last remaining near-pristine areas where wilderness experiences remain. Much of Pilbara coast is already industrial and has lost its wilderness values. The proposal will significantly reduce wilderness values in perpetuity. • …"this proposal would preclude future opportunities to conserve an outstanding area of a largely intact arid zone coastal ecosystem type…. • DEC notes that Straits Salt would require works approval under categories 14 and 58A and possibly 85, 85B, 12 or 70 and 67 or 87 under schedule 1 of the *Environmental Protection Regulations 1987*. To commence operations, Straits would be required to apply for an EPA Act licence under the same categories prior to the commencement of operations. <u>Marine Parks and Reserves Authority</u> The ecosystem type found in this area of Exmouth Gulf is not represented in the formal reserve system and this proposal eliminates any opportunity of securing this ecosystem and the marine fauna and flora it supports in the future. The Yannarie Solar proposal directly alienates the Marine Parks and Reserves	Conservation status and policy framework has been identified as a key environmental factor and are assessed in Section 3.1 of the report.

	under the *Wildlife Conservation Act 1950*, and occur in Exmouth Gulf or along its eastern shores. Other specially protected and migratory species also regularly use the area. The coastal waters have been a permanent nursery closure area for trawling since 1983 and they were recommended as a 'Fish Habitat Protection Area' in the draft *Fisheries Environmental Management Plan for the Gascoyne Region* (Shaw, 2002). The *Ningaloo Coast Regional Strategy Carnarvon to Exmouth*, (WAPC, 2004) recommends that the southern and south-eastern mangrove areas of Exmouth Gulf and adjacent coastal waters become marine protected areas. EPA Position Statement No. 9, *Environmental Offsets* (EPA, 2006). identifies wetlands listed in *A Directory of Important Wetlands in Australia* (ANCA, 1993) as 'critical assets' which represent the most important environmental assets in the State that must be fully protected and conserved.	Selection Working Group report candidate marine conservation area. <u>Department of Planning and Infrastructure</u> There is a potential land use conflict by allowing an extractive industry to be established in an area identified as being of high nature conservation value and a priority for inclusion in Western Australia's marine reserve system. The *Ningaloo Coast Regional Strategy Carnarvon to Exmouth* provides the framework for planning for sustainable tourism and land use on the Ningaloo coast including Exmouth Gulf. This strategy identifies the southern and eastern mangal areas of Exmouth Gulf and adjacent waters as recommended marine protected areas. It is considered that the proposed salt operation would be inconsistent with the recommendation that the eastern side of Exmouth Gulf be included in the marine conservation system. <u>Department of Fisheries</u> The eastern waters of Exmouth Gulf have been recommended as a Fish Habitat Protection Area in the draft Department of Fisheries report *Fisheries Environmental Management Plan for the Gascoyne Region – 2002*. The eastern side of the Gulf has been closed to trawling since 1983. <u>Department of Water</u> The development is within an area identified in the Directory of important wetlands in Australia. EPA position statement 9 states that Conservation Category Wetlands are "critical assets" and must be fully protected and conserved. Proposal will adversely effect the environmental function of the wetland. The proponent has not discussed the value and the impact of the loss of this Nationally Important Wetland. It should be considered as a major asset that would be adversely impacted by the project. The DoW requests that the EPA considers whether the changes to this wetland as a result of the project are consistent with the EPA's principles. <u>Tourism Commission</u> This proposal is for an industrial development in one of Western Australia's most iconic nature based tourism regions. The proposal does not allay fears that it poses a threat to the conservation value in the area and that environmental impacts are likely to be adverse to the current, and expanding nature based tourism industry in this area. <u>Conservation commissions</u> The proposal would preclude future opportunities to conserve an outstanding area of a largely intact coastal ecosystem type with significant potential as an area for economically important nature based tourism.	

		Based on the area's biodiversity values - the Conservation Commission endorses the view that the proposal should not receive environmental approval. <u>Public</u> Many of the issues listed above that were raised by decision making authorities and other government agencies were also identified in private submissions. Additional issues raised in private submissions are listed below. • The area of the proposed Yannarie Solar development is committed to the Comprehensive, Adequate and Representative reserve system. • Six animal species that are listed as of special conservation significance use the general area. • The Yannarie wetland system mangal is internationally one of the largest contiguous stands of mangroves outside the wet tropics. • The vision statement in the Ningaloo Coast Regional Strategy includes "*to develop..tourism region of international significance focusing on its unique natural features..retains the sense of wilderness …development…industries… complementary to this vision..encouraged*". How is the Straits proposal compatible with this vision? • Concerns about viewshed associated with bulk carriers, lights and changing visitor perceptions of the region to an industrial port. • The Pilbara coast is the most arid part of coastal Australia and is therefore of national significance • This area warrants protections in the interests of intergenerational equity. • The proposal poses considerable threats to the future of existing tourism, fishing and pearling industries. • This proposal is within the State Government's World Heritage Consultative Committee preferred boundary. • The globally unique Yannarie delta is of geoheritage value and the salt farm development would both destroy the seaward part of the Yannarie delta and divide the seaward from the prodelta components of the delta system. • Pilbara is one of seven tropical arid coasts worldwide. Wave dominated deltas are the common form in the Pilbara so Yannarie is globally unique. The area is also globally unique in that dune fields rarely intersect the coast in a protected Gulf as they do on the East shore of the Gulf. • The east coast of Exmouth Gulf is an unusual delta, with a river and linear dune interaction, and a plethora of small basin wetlands developed in the inter-dune swales. • Placement of solar salt farm on the delta essentially results in destruction	

		of the seaward part of this unique delta of geoheritage significance. The delta is an holistic total entity. The proposed solar salt pond will be located in the tidal plain of the delta system leaving the delta plain and prodelta systems separate from each other. • The ERMP has not addressed geoheritage nor landscape importance of the area and has not seen the total picture of what constitutes a delta. The statement on Page 14, chapter 5 of the ERMP "*there is sufficient area remaining for geo-heritage values to be retained*" is not justified. • The proponent has attempted to downplay the significance of the area by promoting a 'vacant ecosystem hypothesis' for the supra-tidal flats. • The state is currently involved in contentious moves to forcibly acquire the coastal and riparian portions of pastoral leases under the pretence of better managing those areas for conservation, recreation and tourism. This proposal if allowed would make a mockery of such claims.	
BIOPHYSICAL			
Flora and vegetation communities	Terrestrial vegetation is within the Cape Range subregion of the Carnarvon Bioregion. The majority of vegetation is in good or excellent condition, but two species of introduced plants were recorded. The proposal requires the direct clearing of 157 hectares of terrestrial vegetation. No species of Declared Rare Flora, priority species, or species of significance under the *Environmental Protection and Biodiversity Conservation Act 1999* were recorded in the project area. TEC listing for the area are incomplete, but none of the vegetation types recorded are Priority Ecological communities. One plant assemblage, characterised by *Melaleuca cardiophylla* shrubland, occurs	<u>Department of Environment and Conservation</u> • The proponent should assess potential clearing for land-based access through Giralia Station. • The DEC Biodiversity Audit document (May and McKenzie, 2003), identifies the islands of Exmouth Gulf and mangroves on the east coast of the Gulf as being of high conservation value. • 'Bare areas; mudflats' and' bare areas; claypans' are identified as of high priority for reservation in the Biodiversity Audit. • The majority of vegetation within the project area is generally in "very good to excellent condition". • Water pooling behind the weir could affect an additional 151 hectares of vegetation. • Flora and vegetation surveys were not carried out after rain and therefore don't sample ephemeral species. Additional information is required regarding seasonality of vegetation. • Recent findings indicate that claypan communities along the Pilbara coast display high levels of endemic freshwater invertebrates. The proponent has not considered the potential impacts of the solar salt development on claypan invertebrate fauna at Exmouth Gulf. <u>Department of Water</u> Diversion, flood-out areas and impacted terrestrial vegetation have not been identified in the project footprint. <u>Public</u>	Flora and vegetation have been identified as key factors for this assessment and are considered in more detail in Section 3.7.1.

	only at Hope Point within the study area but this is not proposed to be cleared. Claypans have been identified as priority ecosystems for reservation within the Cape Range Subregion (May and McKenzie, 2003). The proposal would include the excavation of clay from a total area of 75 hectares of claypans. No more than five percent of any vegetation type within a 13,000 hectare mapped area is proposed to be cleared for the Yannarie development.	Many of the issues listed above that were raised by decision making authorities and other government agencies were also identified in private submissions. Additional issues raised in private submissions are listed below. • The statement that flora and vegetation will be progressively surveyed prior to construction is inadequate. Without surveys, how can statements about there being no impacts on DRF and TECs be made? • The proponent should explain how the 3 species of DRF in the region and the 26 species of priority flora will be protected. • The statement that coolibah communities (of conservation significance) won't be affected is not supported. • Comprehensive year-round baseline data are required. • A lack of regional data should result in suspension of the project until this information is available. • The assessment of flora and vegetation should be delayed until the results of the DEC Giralia survey are available to provide a regional perspective. • The proponent needs to provide information about the frequency of maintenance dredging, (in relation to ongoing requirements for clay).	
Terrestrial fauna	A total of 138 vertebrate taxa, including 57 bird species were recorded during surveys of the Yannaire Solar region. 12 native mammal species, 58 native reptile species and 5 native amphibians have been recorded from the area. 54 species of mangrove and literal birds were recorded, 20 of which were migrants from breeding grounds in the northern hemisphere and 28 are listed as migratory species under the *Environmental Protection and Biodiversity Conservation Act* 1999. Hope Point is one of the roost sites for migratory shore birds. The area ranks as of international importance for five species of shore birds. Of the 16 species of conservation	<u>Department of Environment and Conservation</u> • The proponent's consideration of impacts on terrestrial fauna focuses on site prep, vehicle and equipment movement plus noise emissions. They should also assess other impacts e.g. lighting, habitat fragmentation and alterations to hydrology. • Impacts on mulgara need to be determined because this is a threatened species likely to occur in the project area. • Discussion about impacts on waders is inadequate. • In relation to birds, the proponent should consider: light emissions; creation of modified or artificial habitat by constructing salt ponds and borrow pit lakes; indirect impacts to mangrove habitat and infrastructure such as power lines and towers affecting flight and nesting patterns. • Wildlife corridors and linkages requires further clarification • Feral animal control programs need to be developed in consultation with, and to the satisfaction of, DEC. <u>Marine Parks and Reserve Authority</u> The east coast of Exmouth Gulf has been identified as internationally significant habitat for five species of migratory shorebirds. <u>Public</u> Many of the issues listed above that were raised by decision making authorities and other government agencies were also identified in private submissions.	Habitat loss and fragmentation are considered the greatest threats to terrestrial fauna. Although terrestrial fauna are not considered in detail in the body of the report, vegetation or habitat clearing, is assessed in Section 3.7.1 of the report.

	significance under Western Australian and Commonwealth Government legislation that potentially occur in the region, half are considered unlikely to occur in the Yannarie Solar area. Of the eight species that may occur, two; the rainbow bee-eater (Priority 3) and the Australian bustard (Priority 4), have been recorded during proponent surveys. None of the terrestrial bird species represent endemic or regionally restricted taxa. Five species of introduced mammals were recorded; sheep, cattle, mouse, cat and fox.	Additional issues raised in private submissions are listed below. • A single ten day fauna survey is inadequate. More fauna research should be conducted. Fauna surveys were not consistent with EPA Guidance 56 or EPA Position Statement 3. • We are pleased to see that botanical data has now been collected at reference sites outside the area of impact, but Yannarie Solar is still proceeding without adequate botanical research. • Weed management has not been adequately addressed. • The proponent needs to research indirect impacts on fauna and management of these impacts. e.g. fragmentation of mangroves for bat populations and ground water flow, creeks & drainage for frogs. • No bat surveys have been done, yet one species that is likely to be present is Priority 1. • An increase in wader use of existing salt fields indicates a shifting baseline. A statement in the ERMP that the project will create a potential benefit for migratory birds is misleading. • Risks to birds are higher for this proposal than other Pilbara salt fields because there will be stored bitterns. Birds alighting on this medium are likely to be caked with adhesive bittern fluids which could bind the feathers and prevent flight. Bitterns is also highly toxic so birds may die trying to preen. • Port Hedland salt field now supports most of wintering habitat for the eastern population of the broad-billed sandpiper. Attracting migratory shorebirds to solar salt project may carry with it perpetual long-term conservation responsibilities. • Vehicle movement should be restricted to daylight to minimise road kills.	
Subterranean fauna	Limestone occurs within the study area. Ground disturbing activities and altered ground water hydrology have the potential to impact short range endemic subterranean fauna that potentially live in limestone and other substrates. Nineteen bores were drilled in locations targeting potential impact areas, and geologically	<u>Department of Environment and Conservation</u> • The proponent has not implemented the agreed scope of works for subterranean fauna investigation and therefore has not provided a high level of certainty that the risks to subterranean fauna can be considered low. • However, based on preliminary survey results, stygofauna and troglofauna biodiversity are unlikely to be significant issues for this project. <u>Department of Water</u> DoW is satisfied that there is a low impact level in regards to any subterranean ecosystems present, given the observed highly saline samples collected.	Subterranean fauna has been identified as a key environmental factor for this assessment and is considered in more detail in Section 3.7.2.

	similar sites outside the project footprint. Based on high levels of salinity in the groundwater, and the lack of suitable cracks and tunnels in the rocks sampled, the proponent concluded that the substrates do not provide suitable habitat for subterranean fauna species.	<u>WA Museum</u> Stygofauna occur in hypersaline conditions. Very fine endemicity is characteristic of both terrestrial and aquatic subterranean fauna. <u>Public</u> Many of the issues listed above that were raised by decision making authorities and other government agencies were also identified in private submissions. Additional issues raised in private submissions are listed below. • Impacts on subterranean fauna cannot be ascertained in the absence of an adequate understanding of the hydrogeology. • Fauna sampling should have been carried out. Without it, the confidence levels for this risk-based assessment cannot be considered high.	
Benthic primary producer habitats	**Mangrove & algal mat communities** The development proposal would require the clearing of two hectares of mangroves and 17 hectares of algal mat communities. Five living mangrove associations and one dead mangrove association were identified in the 11,154 hectares of mapped mangroves along the east coast of Exmouth Gulf. Clearing would impact two of the living associations of which no more than 0.1 per cent of either association would be directly impacted. 8054 hectares of algal mats have been mapped and the clearing of 17 hectares is equivalent to 0.2 per cent of this area. The proponent has committed to rehabilitate two hectares of mangroves after construction of the salt field.	Most submissions that raised issues relating to mangrove and algal mat communities focused on potential indirect clearing associated with sea level rise, potential disruptions to hydrology and potential alterations to nutrient availability. These issues are addressed in Sections 3-2, 3-3 and 3-4 of this report. <u>Department of Environment and Conservation</u> • Bryozoans form terrace reefs which are unusual and are only known from the east coast of the Gulf. • Seagrass distribution and dugong habitat associations should be determined. Dredge channel alignment is through sparse seagrass which is dugong habitat. • The proponent indicates that 17 hectares of subtidal benthic communities would be directly impacted by dredging but doesn't provide information about the significance of this area, e.g. as habitat for dugong, turtles etc. • The proponent should consider impacts of water diversion on mangrove dependence on ground and surface water. Groundwater contribution to maintaining algal mats and mangroves has not been explored. • Middle east studies confirm associations between sabkhas (salt flats) and seagrass and macro-algal beds and indicate long-term ecological impacts from modification of sabkhas. • There is insufficient certainty that mangroves will be protected in the long-term. • The proponent should provide information on hydrogeology – impacts to algal mats from groundwater seepage from salt ponds and changes to surface and groundwater flows. • The proponent should investigate potential risks of seepage from bitterns	Benthic primary producer habitats have been identified as key factors for this assessment. Mangrove and algal mat communities are considered in Section 3.7.3 and subtidal benthic communities are considered in Section 3.7.4 of the report.

	Indirect clearing caused by sea level rise or altered ground water hydrology have the potential to impact significantly larger areas of algal mat and mangrove communities. **Subtidal benthic communities** Subtidal benthic communities were mapped over an area of 55.5 square kilometres around Hope Point. Soft sediments cover 93 per cent of the sea bed and support mostly sparse seagrass communities. Hard substrates support a mixture of algal, coral and sponge assemblages. The proposal would require a dredged channel measuring 1.65 kilometres long, between 125 and 143 metres wide and to a depth of 3.5 metres below chart datum. Dredge plume modelling was carried out to estimate plume characteristics and sediment settling. The model predicts that an area of 17 hectares would be subject to permanent loss of benthic primary producer habitat with an additional 14.5 hectares subject to reversible losses.	ponds on groundwater systems, tidal creeks, mangroves and algal mats. • There is likely to be interconnectivity between benthic primary producer habitats in the Gulf and Ningaloo Marine Park. • The proponent's documents do not provide adequate discussion relating to the values of salt flats. DEC considers the values of the salt flats are substantially underestimated. • Salt flats are colonised by microscopic algae. Their importance in the food chain is largely unstudied and their contribution to carbon fixation is unknown. <u>Department of Industry and Resources</u> The habitat map for the proposed shipping channel at Hope Point should include a 'zone of reversible losses' of the benthic primary producer habitat. <u>Marine Parks and Reserve Authority</u> Clearing for infrastructure will result in the loss of regionally significant arid zone mangrove communities, sea grass, macro algae and algal mats. These communities provide important fauna habitat and are key primary producers. <u>Department of Fisheries</u> More consideration should be given to the frequency of maintenance dredging and where dredge spoil would be disposed to. <u>Public</u> Many of the issues listed above that were raised by decision making authorities and other government agencies were also identified in private submissions. Additional issues raised in private submissions are listed below. • Mangroves on the east coast of the Gulf are healthy because they benefit from frequent localised summer thunder storms which develop because of prevailing westerly winds and the proximity of Cape Range and the Gulf waters. • Dredging and ongoing barge movements will increase turbidity resulting in shading or smothering of benthic primary producer habitat and affecting water quality. Silty bottom sediments on the Gulf floor are likely to be mobilised by repeat dredging operations causing smothering of marine benthic communities. • Dredging and large ships will increased turbidity resulting in shading or smothering of BPPH and affecting water quality • There is a density dependent reduction in the birth-rate of dugong related to seagrass shortages. Dredging impacts will remove seagrass. • No large areas of shallow substrates that might support dense seagrass were found to the west and north-west offshore from Hope Point. But	

		Cyclone Vance had gone through just nine months earlier and no follow up mapping was done. • The proponent should map the benthic primary producers and relate their distribution to juvenile prawns. This should run over several years to estimate natural variability. • Fossil coral reef limestones with unusual combinations of corals and macroalgae occur in subtidal environments adjacent to the proposed development. • Loss of algal mats because of seeped hypersaline waters would reduce nitrogen and carbon supply to mangle and inter-tidal consumers, reduce productivity of inshore tidal creek environments and remove critical structure of marine nursery. Mangrove populations of passerines and bats would also decline. • Seagrasses in Exmouth Gulf are several kilometres from the proposed evaporation ponds and are mostly subtidal. They are therefore unlikely to be directly impacted, but bitterns impacts not known • The prawn fishery depends heavily on continuation of vegetation mosaics in shallower waters on the East coast. Changes to this vegetation will impact prawns. • The proposal is likely to reduce sediment deposition because of diverted surface flows and this is likely to cause a decline in seagrass and erosion of areas that are currently broad and shallow banks.	
Marine fauna	**Marine mega-fauna** The central and western areas of Exmouth Gulf form a significant resting area for southward migrating humpback whales. Dugong and marine turtles, in particular juvenile green turtles, use primarily the shallow eastern coastal waters of the Gulf. The proposal would involve the movement of ships including bulk carriers, through the whale resting area. Barges powered by tugs would move across the preferred dugong and turtle habitat areas into the whale resting area to offload salts onto bulk carriers.	<u>Department of Environment and Conservation</u> • A Queensland University study has found a new genus of goby associated with algal mats. Impacts on this species should be considered by the proponent. • Cow/calf pods are more sensitive to noise than adult whales and more research is required on this issue. • Large scale movements of dugong occur between Shark Bay and Exmouth Gulf. • Detailed mapping of dugong activities should be undertaken to find out which areas are important for feeding, lekking, travelling, shelter, breeding, calving and thermal refuges. Boating traffic should be managed to avoid impacts on these areas when the animals are most vulnerable. • There is no discussion in the ERMP of the significance of Gulf and Pilbara dugong populations at a regional, State or national level. • The majority of turtles using the east coast of Exmouth Gulf are juvenile greens. There are also some loggerheads and hawksbills. The proponent	Vessel noise and vessel strike are considered significant environmental factors and are discussed in Sections3.6.1 and 3.6.2 of the report respectively. The pumping of sea water from Dean's Creek is considered in Section 3.4.3 of the report.

	The proponent has committed to implement vessel speed limits and has made a commitment not to upload salts onto bulk carriers within the high priority humpback whale area during the peak whale migration period. Impacts of shipping on marine mega-fauna could be caused by acoustic emissions from ships, in particular the noise of tugs maneuvering barges along side bulk carriers. The proponent has undertaken acoustic emission modelling and compared the sound levels likely to be received with known impacts on mega-fauna species. Vessel strike is another potential impact of shipping on marine mega-fauna with significant impacts on dugong populations recorded in Queensland. **Seawater pumping** The solar salt farm relies on the inflow of 148 million cubic metres of sea water per year which would to be pumped from Dean's Creek at the southern end of the salt field. Natural levels of salinity in the inshore creeks like Deans Creek are higher than further offshore. The pumping of large volumes of sea water from Dean's Creek has the potential to reduce salinity in the creek by drawing increased amounts of low salinity sea water into the creek. Some marine fauna may have adapted to, and rely on the higher salinities characteristic of the tidal mangrove creeks.	should develop a thorough understanding of marine turtle habitat associations, feeding patterns, migration and linkages with nesting populations. • Prime turtle nesting and foraging habitats in other parts of the Pilbara are degraded. An assessment of accumulative impacts is warranted and a precautionary approach to development is recommended. • Vessel strike, entrapment, light overspill and glow should be evaluated in relation to marine fauna. • The proposed 10 knot speed limit is based on Hinchenbrook Island recreational boats but these limits may not be appropriate for larger commercial vessels. • The impact of entrainment would be difficult to predict and could have a high degree of seasonality in species that have short spawning windows. <u>Department of Fisheries</u> • Exmouth Gulf is important; - habitat for juvenile prawn species and pearl oyster; - nursery for commercial and recreational fish species; - for aquaculture and pearling leaseholders - important for species other than fish including turtles, dugongs, whales and migratory wading birds. • If the proposal proceeds, a condition should be imposed that requires the proponent to monitor entrainment levels at the pump stations and if found to be significant, modify pumping activities to decrease levels of entrainment. • Sustained pumping during the first six week start-up period needs to be considered in more detail and should avoid prawn spawning periods. • There is a discrepancy in relation to local and regional significance of entrainment and there is no explanation as to why local scales are not provided. Need to justify estimates provided. • Pumping needs to take account of seasonal prawn larvae levels during October to February. • ERMP statement that the proportion of organisms entrained cannot be estimated is not acceptable and needs further work to more accurately predict entrainment. <u>Marine Parks and Reserve Authority</u> The Exmouth Gulf ecosystem provides a habitat for marine fauna including whales, sharks, fish, marine turtles and dugong. Many species are ecologically significant and protected under the *Environmental Protection and Biodiversity*	

	The impacts of sea water pumping on tidal flows in Dean's Creek were modelled. The results indicated that pumping would draw an average 4.3 per cent of the monthly tidal prism of the creek. The sea water intake pump in Dean's Creek would entrain smaller marine animals unable to swim against the pump generated current. The proponent has estimated that at a regional scale, pumping seawater from Dean's Creek would result in the entrainment of about 0.35 per cent of all small biota in the tidal prism.	*Act*. The proposed extraction of large quantities of seawater could entrain large volumes of larvae and plankton in the evaporation ponds with unquantified effects on the remaining ecosystems of the Gulf. <u>Tourism Commission</u> Mega-fauna on which tourism relies is sensitive to shipping and recent research in Shark Bay identified the need to reduce the number of licensed cruise boat tour operators from two to one to prevent a decline in dolphin breeding. Exmouth Gulf is an important recreational asset as well as an important fish and sea mammal nursery. The area is also an important resting area for whales on their migratory journeys along the WA coast. Any loss of fish breeding stock in the Exmouth Gulf would have a detrimental affect on visitation to the region by the recreational fishing community. <u>Public</u> Many of the issues listed above that were raised by decision making authorities and other government agencies were also identified in private submissions. Additional issues raised in private submissions are listed below. • Underwater noise would cause at least some displacement of whale cows and calves. • The population of dugong in the north-west of WA is part of the largest in the world. • Dugong are vulnerable to boat strike while in the dredge channel and barge route, which cross an important feeding ground. • The ERMP states that assessment of the rate of entrapment will be made once production has commenced, AFTER approval. This is unacceptable. This issue needs to be addressed through modelling and from experiences at other salt fields. • Prawn larvae are able to survive in hyper-saline water of 50-60 parts per thousand where some predators cannot. A reduced salinity caused by the pumping of high salinity sea water could allow larval predators to enter previously uninhabitable areas, essentially eradicating the nursery grounds. • High fisheries productivity is related to the hyper-saline nature of the eastern shoreline. The growth rates of prawns are dependant on optimal salinities. • Post larval prawns are designed to maximise their movement into nursery areas. Pump generated flows can therefore be expected to significantly magnify the numbers of post larvae trapped by the proposed pumping system and decrease prawn survival and production. • Need a sophisticated spatial model of the hydrology and local water	

		movement patterns throughout the Gulf. The model needs to be capable of predicting salinity changes down to 1 – 2 ppt and local changes in tidal flows to assess the impact on prawn post larval entrapment and offshore juvenile migration. • The management plans provide no action that could realistically be taken to protect marine wildlife once the Gulf has become another industrial port. Straits commitment to fund research programs does not change the risk profile. • An undescribed species of fish which is also likely to be a new genus in the family Gobiidae inhabits the pooled water that remains on the cyanobacterial mats after the tide has ebbed.	
Introduced marine organisms	The National Oceans Office database identifies over fifty non-indigenous marine species (NIMS) in the Pilbara Nearshore Bioregion However, no survey data are available on the status of NIMS in Exmouth Gulf. Shipping can introduce NIMS in ballast water and from fouling organisms and some NIMS have the capacity to rapidly disrupt natural ecosystems and commercial fisheries. All vessels from overseas are required to exchange ballast water outside Australia's territorial limit (12 nautical miles). Anti-fouling paints are used to control the settlement and growth of fouling organisms. However, anti-fouling paints are toxic and can cause contamination of sediments. The Department of Fisheries is the lead agency for managing risks associated with NIMS in Western Australia. Hull cleaning and accredited inspections are required by this agency when the risks of	<u>Department of Environment and Conservation</u> Barges and dredges should be subject to detailed risk assessment because: • AQIS deals primarily with ballast water management; • Dredges and barges are slow moving; and • It is likely that maintenance dredging will be required. DEC supports: • Best practice anti-fouling systems; • Inspection of vessels in dry dock by a suitably qualified person; • Clear and immediate responses prepared in a Marine Management Plan. • Need to establish baseline data on native and introduced species in the Gulf prior to assessment. <u>Department of Fisheries</u> It is strongly recommended that the proponent should develop a more thorough NIMS and disease management strategy, including a risk assessment of all vessels to be used in the proposed operations and appropriate mitigation and management commitments. DoF consider dredges pose the biggest risk. The proponent needs to include response requirements should NIMS be found. Aquaculture is at particular risk and should be considered in detailed management arrangements for NIMS, including compensation. <u>Public</u> Many of the issues listed above that were raised by decision making authorities and other government agencies were also identified in private submissions. Additional issues raised in private submissions are listed below. • Ballast water management relies on an honour system which is too risky	Introduced marine organisms is considered to be a key environmental factor and is discussed in Section 3.6.3 of the report.

	introductions are high. The risk of foreign organisms becoming established in new ports following their discharge in ballast water or from hull fouling is greatly increased if the ports have similar environmental conditions. Many of the bulk carriers for salt export would be from similar environments in South-East Asia, China or India. A dredge would be required during construction and this might come either from overseas or from a dredging program elsewhere in Australia. The proponent has committed to implement measures to minimise the risk of NIMS introductions to Exmouth Gulf.	for Exmouth Gulf. • There is a need to establish a baseline on native and introduced species in the Gulf prior to assessment. • There is no formal management strategy for bio-fouling. A State management strategy for bio-fouling is required prior to the proposal being considered. • Better assessment is needed of which pest species have the greatest potential to become established and disrupt fisheries. These should then require detailed management and emergency response plans. • Vessels from high risk areas or with a history of high risk activities like dredging should be inspected in dry dock by a suitably qualified person. • The financial consequences of NIMS is potentially devastating for the prawn and pearling industries. • The freedom to transfer juvenile pearl oysters depends on maintaining their disease and NIMS free status. The presence of NIMS would trigger the pearl oyster translocation protocol with significant operational and financial implications for the pearling industry. • The prawn industry could be impacted by disease, toxicity or direct competition. • Cyanobacteria, photosynthetic and non-photosynthetic sulphur bacteria, sulphate reducing bacteria, microalgae and other organisms grow in the salt ponds. In Dampier, cyanobacteria produce a polysaccharide slime and the risk to local habitats from the escapement of micro-organisms and their products from within evaporation ponds is not known. • It is not sufficient to state that all ships will adhere to the International Maritime Organisation (IMO) guidelines, the *Commonwealth Quarantine Act 2000* and Australian Quarantine and Inspection Service (AQIS) Ballast Water Management Requirements. • There is no formal management strategy for biofouling. There needs to be developed a State management strategy for bio-fouling prior to the proposal being considered. • Currently several major Australian ports contain invasive alien species which risk further spread within Australia. • NIMS transfer can take place between ships. Despite international ships loading offshore at a transhipment road, invasive species might transfer to the loading barges and reach favourable habitats in the Gulf. • The Exmouth Maxima pearl industry is currently suffering major problems with an introduced virus of unknown origin which demonstrates the	

		vulnerability of this industry to NIMS	
Surface water	Two ephemeral watercourses, the Yannarie and Rouse Rivers, drain the hinterland and discharge onto the salt flats adjacent to the proposed development. Each river has two outlet channels known simply as North and South. The expected flows from each of the four channels have been modelled for a range of rainfall scenarios. Because the rivers flow through a sand dune system prior to discharge onto the salt flats, results of the surface water flow modelling indicate that the river systems only discharge to Exmouth Gulf during at least 20 year average recurrence interval (ARI) events. Yannarie Solar would require the construction of a weir across Yannarie North channel, and the proposed salt pond footprint would block the direct flow of surface water discharge to 30 kilometres or 38 per cent of the mangrove shoreline along the east coast of Exmouth Gulf. Results of the proponent's flow models for Yannarie and Rouse Rivers indicate that Yannarie South is the dominant channel comprising approximately 37 per cent and 67 per cent of the total outflow for 100 year and 20 year ARI events respectively. This channel discharges at the southern end of the proposed salt field. According to the surface flow modelling, Yannarie North discharges about 25 per cent of the total surface	<u>Department of Environment and Conservation</u> • Detail of diverted surface water flows showing patterns of water past the choke point should be provided and the potential for erosion assessed. • The importance of surface water flows for groundwater recharge is uncertain. • It is likely that surface waters contain important nutrients and contribute to ground water recharge. • Proponent statements that disruption to surface water flows would not be significant are of questionable validity. • Infrequent flood events could be important. • The proponent should investigate possible failure of the weir. • Surface water quality has not been sampled. • There is insufficient assessment of the ecological consequences of diverting surface flows. • The consequences of disrupting the flow of water across the salt flats by constructing salt harvesting ponds are poorly understood but include reduced nutrient inputs into the prawn nursery area in the adjacent near-shore environment. <u>Department of Industry and Resources</u> The diversion and redirection of inland storm water flows and directing the water to specific points rather than natural breakout points may lead to increased degradation in these areas and there is limited information provided on how erosion and other impacts will be minimized. <u>Department of Fisheries</u> • It remains unclear how significant overland flows are, to the productivity of Exmouth Gulf. • There is evidence for linkages between overland flows and increased productivity. • Impacts on productivity from levee banks making flow go north or south are not clear and are not adequately addressed in the ERMP <u>Department of Water</u> The proposed project footprint would still allow outflows from Rouse Creek and Yannarie River across the flats to the sea.	Surface water flows, as a source of nutrients to Exmouth Gulf has been identified as a key environmental factor and is discussed in Section 3.3. The impact of altered flood regimes on terrestrial vegetation as a result of the construction of a dam and diversion of Yannarie North channel has been identified as a key environmental factor and is discussed in Section 3.7.1.

	water outflow. This would be diverted north to the Rouse South discharge channel, more than doubling the outflow from this outlet. Rouse South and Rouse North would discharge to the north of the salt pond footprint. The proponent is of the view that there is an hydrological disconnect between the hinterland surface water and Exmouth Gulf. The proponent is therefore of the view that periodic surface water flows provide an insignificant source of nutrients to Exmouth Gulf.	Surface water hydrology around the containment bunds would need active management throughout the life of the project, given cyclonic frequency and predicted climate change. <u>Marine Parks and Reserve Authority</u> The implications of altered surface water flows on nutrient input to the Gulf are largely unknown. <u>WA Museum</u> Episodic inputs of nutrients may be crucial for ecosystem functioning. <u>Public</u> Many of the issues listed above that were raised by decision making authorities and other government agencies were also identified in private submissions. Additional issues raised in private submissions are listed below. • Deltas are not fixed in time because of channel switching and migration. • Storm water run off modelling lacks any contribution from a region of land (approx, 50km by 24km in area) located between the two main catchments of the Rouse and Yannarie systems with no explanation for this excluded region. • Catchment modelling needs to be continued close enough to the coast to show flows from sub-catchments near the shore in smaller events.	
Ground water	Ground water hydrology in the development area is governed by the proximity to the Yannaire River and Rouse Creek systems in the east and the coast in the west. The Yannarie River represents the most significant source of recharge to the superficial aquifer. Discharge from the superficial aquifer is via through flow towards the west. The superficial aquifer is between 2.6 and 5 metres thick and is of low permeability marine and terrestrial sediments. Beneath the superficial aquifer, is a clay layer of such low permeability that the deeper aquifer beneath is considered unconnected. Water from the superficial and deeper	<u>Department of Environment and Conservation</u> • Interconnectivity of groundwater between mainland remnants, primary producer habitats and aquifers below supratidal flats should be investigated. • The proponent should undertake studies on surface water flows in relation to groundwater recharge, salinity regime and nutrient delivery over long time frames. • Further studies should be undertaken to investigate groundwater seepage and the ecological function of salt flats to mangroves, algal mats and island vegetation. • The relationship between groundwater and coastal primary producers is not known. • The level of uncertainty relating to groundwater and the release of heavy metals from within the sabkha should be investigated further. <u>Department of Fisheries</u> There is uncertainty regarding the role that highly saline groundwater could have on the near shore Gulf environment, and any uncertainty related to this issue should be thoroughly investigated and be subject to independent review by	The potential mobilisation of hypersaline, metal and nutrient rich superficial groundwater towards algal mat and mangrove communities is considered a key environmental factor and is discussed in Section 3.4.1. Nutrient delivery to Exmouth Gulf is also considered a key environmental factor and groundwater as a potential source of nutrients is discussed in Section 3.3.

	aquifers have difference chemical characteristics. The superficial aquifer is just 0.2 to 1 metre below the ground surface beneath the salt flats and is influenced by evaporation which results in high concentrations of salts and some other constituents such as nutrients and metals. Flow rates in the superficial aquifer are characteristically slow because of low levels of recharge, high rates of evaporation and low permeability in the sediments. However, following major rain events, sheet surface flows over the salt flats are likely to add to groundwater recharge and increase groundwater mobilisation. The construction of salt ponds will increase the hydrostatic head of water over a 17,765 hectare area of the salt flats with the potential of mobilising the hypersaline, metal and nutrient rich superficial groundwater towards algal mat and mangrove communities further west.	hydrological experts. <u>Department of Water</u> • A change to surface flows due to diversion might impact groundwater recharge behind the project area. This relationship needs to be well understood. • There is unlikely to be significant vertical flux of brines between superficial and deeper aquifers. • No fresh or brackish aquifers have been identified in drilling, so there is no freshwater resource to protect for the environment or other users. • No offshore springs have been identified in investigations to date, but these may occur and may contribute to the specific habitat of the Gulf. <u>WA Museum</u> Limestone in mainland remnants may allow unregulated flow between different production units. It is not clear whether limestone in mainland remnants would be bunded. Much of the area appears to be underlain by an old delta. <u>Public</u> Many of the issues listed above that were raised by decision making authorities and other government agencies were also identified in private submissions. Additional issues raised in private submissions are listed below. • Stratigraphy is the basis to proper understanding of groundwater functioning and the proponent has got it fundamentally wrong. Pleistocene limestone underlies many of the nearshore islands of the Pilbara Coast. Drilling along several transects from Giralia Bay through to Tent island has shown that limestone underlies the tidal flats. There is stratigraphic complexity with ribbons, lenses and sheets of sand, muddy sand and mud. • The model of sedimentation for Yannarie River delta is incorrect. The stratigraphic units have a complex array of geometry and lithology and they form the basis of the aquifer units in the area. Therefore the array and distribution of aquifers in region are also complex. • A limestone aquifer on the eastern flank of the Gulf is probably the largest in the Pilbara from which beneficial usage of water might be drawn in the future. The proposal could recharge this aquifer with saturated brine and clog it with aggregated clays. • There is not enough information on the hydrology of the area and how it functions. It is crucial to understanding the hydrology; the interplay between marine flooding, evaporation, rainfall events, freshwater discharge and subterranean discharge plumes. None of this has been independently determined.	

		• There is vugular porosity amounting to 10 – 50 per cent of the rock which translates to a substantially porous and permeable aquifer.' • Information on the permeability of the surficial sediments is unsatisfactory.	
Coastal processes; relative sea level	Relative sea level and patterns of inundation are influenced by: • coastal geomorphology, • geological processes, • tides, and other waves; and • climate. Surface slopes are 1:5000 to 1:10,000 and elevations are only about 0.2 to 0.3 metres higher at the inland boundary of the flats compared with the edge of the algal mats. Weather has a strong influence on sea levels. Extreme sea level events are associated with storms. One cyclone passes within 100 kilometres of the North West Cape every one or two years and the area has been impacted by a severe cyclone approximately once every 25 years. Proposed salt and bitterns ponds, water intake pumps, harbour infrastructure and salt stockpiles are within the area that was inundated by the Cyclone Vance storm surge in 1999. Cyclone Vance is estimated to have struck the coast less than one and a half hours after low tide so is unlikely to represent the worst case scenario. The patterns of present day tidal	<u>Department of Environment and Conservation</u> • The proponent has not adequately addressed climate change risks or the need for climate change adaptation in the design and management of the project. • The proponent has not modelled the potential risks or undertaken a risk assessment to address the impacts of changes in coastal processes and ecosystem function associated with sea level rise. • The geometry of the continental shelf in this area and the orientation of Exmouth Gulf appear to be favourable for focusing tsunamis generated by earthquakes in the Indonesian archipelago into Exmouth Gulf. • Sea walls have the potential to adversely impacts regionally significant arid zone mangrove communities by restricting their spatial adjustment to sea level rise. • The proponent should refer to the most up-to-date sea level predictions, use the most appropriate modelling to estimate sea level response in Exmouth Gulf and take a conservative approach to the development design. • The Bruun Rule is not appropriate for setback analysis on muddy shores and its use in this case should be peer reviewed. • Salt pond load and potential to depress sediments should be considered in relation to sea level. • Modelling of impacts should take account of the worst case scenario with combinations of storm surge, wind and high tide, plus climate change. • Scientific papers indicate there is little evidence of coastal sediment trapping and the mangroves might therefore be diminishing. This issue is not adequately considered. • Storm surge deflection from sea walls could enhance ebb flows causing erosion. • Areas surrounding the proposed salt field will be inundated when sea level rises with significant risks in relation to storm surge, cyclonic conditions and tidal impacts on the sea walls. • Data provided by van de Graaff et al., 1975, suggest that the rate of tectonic uplift in the area could be of the order of about 0.2 mm/year.	The potential impact of relative sea level on algal mat and mangrove communities is considered a key environmental factor and is discussed in Section 3.2.

	and storm related inundations are unlikely to remain static during the next century, due to climate change. The proponent has prepared contour maps of the salt flats showing potential distributions of algal mat and mangrove communities for 0.3 metre, 0.5 metre and 1 metre sea level rise scenarios. These maps demonstrate that the proposed location of salt pond levee walls coincides with tidal inundation regimes that, following sea level rise, are likely to be suitable for algal mat and mangrove community colonisation . Relative sea level can also be influenced by tectonic activity and the accumulation, erosion and subsidence of sediments. Sediment accretion and subsidence commonly occur in mangroves and on deltas. Sediment accumulation in Exmouth Gulf is very low and the coast appears to be mildly erosive. The proponent has put forward the view that tidal activity is the predominant particulate transport mechanism and there is no large-scale long-shore sediment transport in the near shore area. The weight of the salt ponds is not expected to cause subsidence.	• Longer term changes in relative sea level are likely to cause significant changes in groundwater flow and the evaporative processes on the salt flats. • Mangroves might cover larger areas of the salt flats with higher sea levels and the proposed development is likely to preclude growth in areas that would otherwise have provided habitat for mangrove and algal mat communities. • The proposed salt ponds will fragment mangrove and algal mat communities that adjust to sea level rise. • While it is possible that mangroves will vegetate the whole salt flat as a result of sea level rise, the salt flats may remain unsuitable for mangrove colonisation (e.g. due to soil salinity/structure). In this case, just a fringe of mangroves might migrate landward as sea level rises. <u>Department of Fisheries</u> There is an extreme inundation risk from cyclonic weather and associated ocean conditions. Trawlers have been stranded well inland by tidal surges in the past. The proponent should provide a much more thorough risk analysis and hydrographic modelling of cyclonic tidal surges to demonstrate that the proposed infrastructure can withstand these severe conditions. <u>Department of Planning and Infrastructure</u> • The DPI recommends that the EPA use the objectives and guidelines of *State Coastal Planning Policy 2.6* (SPP2.6) when considering the impacts of coastal processes on the proposed development and the implications for development setbacks and the structural integrity of proposed infrastructure. • SPP2.6 contains guidelines for the determination of setbacks that protect development from coastal processes by absorbing the impact of severe storms including cyclones, allowing for shoreline movement, sea level rise and the fluctuation of natural coastal processes. • It should be noted that SPP2.6 states that the Bruun Rule is to be applied only to sandy shorelines and that for other shore types, the setback for sea level rise should be assessed in regard to local geography. • In the pre-development scenario, DPI would expect the extent of inundation for a 0.38 metre sea level rise at this site to be extensive. The response of the shoreline to this sea level rise is likely to be complex and should be considered in significantly more detail by the proponent. • The proponent should be asked to provide: - a detailed assessment of shoreline response to sea level rise over an appropriate planning period at the site, in both the pre-development	

		and post-development scenario. - An assessment of the development setback in terms of the severe cyclonic impact, historic shoreline change and sea level rise. <u>Department of Water</u> Flood and storm surges could inundate the project area. Inundation potential should be modelled and assessed by the Department of Planning and Infrastructure. <u>Public</u> Many of the issues listed above that were raised by decision making authorities and other government agencies were also identified in private submissions. Additional issues raised in private submissions are listed below. • Salt ponds will reduce by approximately one quarter to one third the available potential mangrove habitat that may occur due to sea level rise. • Development planning ignores local variations in sediment cell behaviour and inter-annual and longer variations in ocean climate. • Existing mangrove creeks could vanish with sea level rise and this could impact nursery areas for prawns and other organisms. • Sea level rise could damage a section of the mangroves allowing increased storm wave energy to have greater influence on the salt flats. • Sea level rise is inevitable and estimates used in the Statement *of Planning Policy 2.6* (2003) are out of date and not precautionary with respect to more recent predictions. • Sea level is rising at a much faster rate than was previously anticipated. • Before Cyclone Vance, there was a debris line of tree trunks from previous cyclones. The measured vertical height of this debris line was 10 metres above high water mark. • The diversion of surface waters (associated with hinterland river diversions) may cause erosion of mangrove communities due to the reduction in terrestrial sediment supply. • Modelling should be carried out to examine both changes in runoff patterns/erosion of the channels and banks and sediment movements which generate turbidity in the Gulf. • Analysis of the Yannarie River delta should proceed with an understanding of long term Holocene and longer term Quaternary processes, not just a study of a single Cyclone – Vance.	
Coastal processes; nutrient delivery	The growth of photosynthetic organisms is often limited by nitrogen or other nutrients. Some nutrients are recycled within the	Some of the submissions about nutrient delivery have been summarised above in the sections on surface and ground water. <u>Department of Environment and Conservation</u>	Nutrient delivery to Exmouth Gulf is considered a key environmental factor and is discussed in Section

	Gulf ecosystem. Other are sourced from externally. Algal mats fix atmospheric nitrogen which is then lost principally as organic nitrogen during high spring tides and surface flushing by rain. Exmouth Gulf receives occasional sediment-laden waters during flood events following cyclones. Storms also disturb marine sediments which are likely to release nutrients to the Gulf ecosystem. Pulses of productivity are sometimes reported to follow surface water flood events. Two ephemeral watercourses, the Yannarie and Rouse Rivers, drain the hinterland and discharge onto the salt flats adjacent to the proposed development. The expected flows from each have been modelled for a range of rainfall scenarios. Nutrient levels in the ephemeral rivers draining the hinterland have not been measured. The Yannarie Solar proposal includes damming and diverting a river channel and the salt pond footprint would block the direct flow of surface water discharge to 38 per cent of the mangrove shoreline along the east coast of Exmouth Gulf. Elevated nitrogen levels also occur in the superficial groundwater beneath the salt flats. When inundated, the connection between the superficial aquifer and waters flowing over the	• Further studies should be conducted into microbial activity within the sabkha, the contribution of nutrients to the Gulf from this source and the impact of eliminating the area of salt pond micro-flora from the system. • Peer reviewed studies of nutrient pathways ideally straight after major storms should be carried out. • Rapid recovery of seagrass after cyclone damage might have been a result of nutrient influx. • The relationship between surface and ground water is unclear, making the prediction of impacts difficult. Nutrient transport from ground water has not been investigated. • A preliminary analysis of groundwater investigation data for the area suggests that shallow groundwater discharges about 1200 kilograms per year of nitrogen from Yannarie Flats or about 34 kilograms per kilometre of coast per year. However, sheet flow across Yannarie Flats during cyclones is likely to carry much larger nitrogen loads into Exmouth Gulf derived from the leaching of nitrogen stored within evaporates and shallow sediments in the area. • The proponent has not adequately addressed concerns raised in relation to the potential alteration to surface flows and the hydrology of the superficial aquifer which has the potential to result in changes to coastal processes, increased release of heavy metals and loss of productivity to the nutrient limited Exmouth Gulf ecosystem. • Studies elsewhere indicate that the supratidal flats have an important ecosystem function in nutrient cycling, as a sink for heavy metals and the transport of nutrients during storm events. • Tidal creeks convey nutrients to offshore areas and the impact of diverted water on this function has not been considered. <u>Department of Fisheries</u> • The tidal creeks and supra- tidal salt flats and intertidal mudflats are the source of much of the nutrients that support the valuable prawn fishery in the Gulf. • Decreased productivity of the Gulf may result in a gradual decrease in prawn catches. • Without further research, the Department of Fisheries believes that there is a high level of uncertainty related to the possible impacts of altered hydrological processes and associated nutrient delivery to the Gulf. • There is a likely link between cyclonic events and increases in	3.3.

	surface has the potential to provide another pathway for the release of groundwater nutrients. The surface water flow modelling indicates that surface flood events that drain the hinterland occur only after storms of 20 year ARI or greater magnitude. The proponent has also indicated that hinterland soils are nutrient poor and they therefore hold the view that flood events are unlikely to contribute significant amounts of nutrients to the Gulf system.	productivity of both seagrass and algal communities and while a high degree of uncertainty remains with respect to the impact of the proposal on the hydrology of the area this Department cannot support the development. <u>Public</u> Many of the issues listed above that were raised by decision making authorities and other government agencies were also identified in private submissions. Additional issues raised in private submissions are listed below. A large number of public submissions expressed the view that periodic surface water floods from the hinterland to Exmouth Gulf provide an important source of nutrients for the mangrove and Gulf ecosystems. Several of these submissions made reference to a photograph of the surface flood following Cyclone Bobby in 1995 which shows sediment laden sheet flow from the hinterland across the salt flats and out into the Gulf. This photograph is presented as Figure four in the report. • Although cyclones do not occur every year, infrequent events can still be vital ecosystem drivers and should be understood as a constant force shaping the Gulf's communities. • inputs cannot be discounted. • Contained water in the constructed weir will cause nutrients and sediments to drop out of flood waters prior to reaching the Gulf. • Increased productivity follows cyclonic events and seagrass recovered rapidly following Cyclone Vance. • The surface water flow model has not been verified. • Although the surface water flow model predicts that flows from the hinterland will not reach the Gulf following ARI events less than 20 year ARI, local records indicate that flood events occur much more frequently than approximately once every 20 years. • Pulsed productivity may be supported by re-suspension of nutrients in Gulf sediments. • Small changes in nutrient cycling due to changed runoff may significantly affect the productivity of epiphytes growing on the seagrasses. • Zooplankton biomass and grazing pressure appear to be far in excess of available phytoplankton production. • Periodic small flushes of storm waster, associated nutrients and suspended sediments from the land surface are certain to be important to the ongoing health of the mangroves.	

		• The only way to determine relative proportions of terrestrial and marine nutrients in the Gulf is through nitrogen and carbon stable isotope analysis. This was required in the scoping document. • Results of a stable-isotope survey conducted by 'Halt the Salt' were: - Representative groups of consumers in the Gulf are deriving their energy primarily from macro-algae and to a lesser extent seagrasses; - Most of their nitrogen is from recycled organic forms (e.g. ammonia); - Spring tidal microbial mat material was not contributing carbon or nitrogen directly to the open water consumers of the Gulf; - Oceanic sources of nitrate nitrogen were probably contributing to the phytoplankton biomass of the Gulf waters but not directly to the estuarine food-chain; - For much of the time, production in the Gulf appears to be based on recycling of nutrients. But they are probably recharged at some stage and the potential importance of infrequent, aperiodic terrigenous inputs cannot be discounted. • A repeated stable isotope survey within a few months of flood-out event may be useful in testing for intermittent terrigenous nutrient subsidies. • Regular pulses of nutrients enrich seagrass beds used as nurseries by prawns and other marine fauna. • Phytoplankton abundance is low compared to the biomass of grazing zooplankton suggesting the Gulf receives carbon and nitrogen subsidies from non-oceanic sources or from pulses of nutrients (eg upwellings or floods). • Seagrasses all but disappeared after Cyclone Vance. But they have regenerated. Seagrass biomass peaked in 2003 and at most sites has since declined again. A succession of seagrass species occurred during recovery. This subsequent decline suggests that cyclones are important in maintaining the productivity of the Gulf.	
POLLUTION			
Brines and bitterns management	The salt production process would involve seawater passing through a series of ponds covering a total area of 8,434 hectares. The concentrated brine would then enter small crystalliser ponds in which the salt crystals would be grown. The waste product from this process is called bitterns. The	<u>Department of Environment and Conservation</u> • In the event that resource recovery and other disposal options prove not to be feasible, bitterns discharge to Exmouth Gulf could lead to significant environmental impacts. • DEC is not confident that the proponent has a substantial irrevocable commitment to avoid bitterns discharge. • The ERMP does not contain enough information on the economic and technical viability plus environmental acceptability of discharging bitterns.	Three components of salinity and bitterns management were identified as key factors and are presented in the report: • discharge of contained brines and bitterns is in Section 3.4.1; • long term bitterns management is in Section

	total area set aside for ponds to process and store bitterns would be 8,235 hectares. Bitterns contains high concentrations of magnesium salts and other toxic constituents. It is very dense and does not mix easily with water. Wildlife, in particular shore birds, are attracted to salt ponds at other Pilbara salt fields and there is the potential for both feather damage from crystallised salts and poisoning from subsequent preening. Seepage of ponded brine and bitterns through constructed levee walls and floor sediments occurs at other salt farms. Filled ponds can also result in the mobilisation of hypersaline groundwater as a result of hydrostatic pressure exerted by ponded brine and bitterns. This has occurred at another solar salt farm in the Pilbara, resulting in mangrove deaths some distance from the levee walls. A commitment has been made not to construct levee walls any closer than 100 metres from the algal mat communities. Salt field levees have failed at other salt fields in the Pilbara. The cause of failure has been the overtopping and subsequent erosion of levee walls from waves generated within salt ponds. The seaward outer walls would be designed to prevent wave run-up	• The EPA should seek independent expert advice on the bitterns recovery strategy presented. • The structure of levees must be designed to withstand strong surface flows associated with 1 in 100 year ARI events. • Incorrect background data were used to determine whether bitterns discharge and mixing would result in salinity and magnesium concentrations significantly above background levels. • Predicted magnesium and salinity concentrations in bitterns plume modelling were above background levels indicating that exceedance of background levels is likely to be much higher and more frequent than predicted in the modelling provided. • The proponent should: - verify that bitterns management areas can be managed to avoid breaches in levee walls and overtopping; - model impacts associated with failure of bitterns storage; and - undertake ecotoxicity testing. • The frequency, duration and intensity of exceedance events has not been discussed or modelled nor has this necessary information been translated into a discussion on ecological consequence. • Bitterns plume modelling indicated the potential for flooding tides and prevailing winds to force the emergent plume back onto the coast of Hope Point. Therefore the plume had the potential to drift north and remain inshore. • The proponent does not discuss how they would manage the possibility of a bitterns plume not continuing to mix sufficiently resulting in its intensification on the coast. Under low energy conditions, dense bitterns is likely to be trapped in the bathymetric low points at concentrations that are likely to be lethal to most marine life. • Bitterns has acute toxic effects on most aquatic species due to hyper-salinity and alterations in the ionic composition of the brine. • The dilution of bitterns is often very difficult because of the density difference between bitterns and sea water. Without adequate dilution, discharged bitterns could end up sitting on the seafloor killing the local benthic environment through high salinity, magnesium toxicity and anoxia. • Chemical and physical changes occur in hyper-saline soil material on excavation and oxidation. These changes typically include the loss of cohesivity and structural strength. • The size of the proposed bitterns storage area is very large to be used	3.4.2; and • salt production and transport is in Section 3.4.3.

	and overtopping for a 1 in 50 year ARI storm event and to withstand a 1 in 100 year ARI event. The proposal is described as having at least a 60 year operational life and the overtopping of levee walls is therefore likely during that time. The current proposal does not include the discharge of bitterns to Exmouth Gulf. The proponent is conducting research to develop products and markets for bitterns products. However, bitterns discharge plume modelling was provided to assist the EPA with its assessment of environmental risk should their research not provide sufficient markets to dispose of bitterns products beyond the first ten years of operation.	as a toxic waste storage facility. The risk, over the long term of attracting migratory waders and other birdlife to the area would not be insignificant. • The potential for bioaccumulation should be investigated. • The proponent should investigate the potential release and associated risks of heavy metals from within the sabka (salt flat habitat). Sediment sampling should be undertaken. • Catastrophic failure of bitterns storage walls poses a significant risk to the ecological health of any part of the environment it comes into contact with. • The proponent should model pond wall failure and the release of hypersaline and toxic waste to provide information on potential ecological and biodiversity consequences of catastrophic failure of bitterns pond levees. • The proponent should do risk assessment of storage seepage, accidental bitterns discharge and tide surge and flooding release on groundwater systems, tidal creeks mangroves and algal mats. • A reduction in salinity as a result of pumping from Dean's Creek is unlikely to occur. <u>Department of Industry and Resources</u> Advice on the geotechnical aspects of levee banks will be sought from DoCEP if the project proceeds to the Mining Proposal stage. The design and construction of the levee banks will need to meet DoCEP requirements. DoIR considers that the options for the final discharge of bitterns will need to be considered prior to the start of the project construction. <u>Department of Planning and Infrastructure</u> The engineering details of levee walls have not been provided to assess the proponent's claim that 'catastrophic failure of the levees is 'highly unlikely'. The proponent should be asked to provide: - design report including the structural design of the external seawalls; - conditions performance of the seawall under events that exceed design; - proposed maintenance of the seawall. <u>Department of Fisheries</u> • A significant risk to Exmouth Gulf is the future possibility of bitterns discharge into coastal creeks and waters. Fisheries does not support any bitterns release. • The proponent should provide an alternative disposal of bitterns if markets don't work out.	

		• The proponent should undertake a risk assessment of seepage, accidental bitterns discharges and tide surge plus flood release. • Impacts on near-shore salinity due to pumping is not adequately assessed. Any change to the salinity levels caused by the pumping of seawater may have flow on impacts for the marine environment. • The chemical composition of bitterns is toxic to invertebrates such as prawns and pearl oysters that are the mainstay of the commercial fisheries in the region. <u>Marine Parks and Reserve Authority</u> There is a high probability that bitterns would be released through natural storm processes and bitterns accumulation poses a future disposal threat to the area. The release of bitterns either intentionally or as a result of natural processes, is likely to have a significant negative impact on the ecology of the Gulf and it is unacceptable that this matter has been left as a future problem. <u>Public</u> Many of the issues listed above that were raised by decision making authorities and other government agencies were also identified in private submissions. Additional issues raised in private submissions are listed below. • Uncertainty over hydrological linkage between salt ponds and Exmouth Gulf should be investigated thoroughly and independently reviewed by hydrological experts. • The discharge of undiluted bitterns into a marine environment, either though deliberate discharge or by accidental seepage can cause widespread environmental harm through magnesium toxicity, anoxia and hydrogen suphide poisoning. • The storage of large quantities of toxic bitterns in a sensitive environment is unacceptable because its release could be catastrophic, killing vast numbers of marine species. • The bitterns ponds could become a death trap for birds with salts caking onto feathers and subsequent preening causing poisoning. • Risks to birds are higher for this proposal than other Pilbara salt fields because there will be stored bitterns. Birds alighting on this medium are likely to be caked with adhesive bittern fluids which could bind the feathers and prevent flight. Bitterns is also highly toxic so birds may die trying to preen. • Significant loss of birds and other wildlife has been observed in super saline ponds in the Exmouth and Pilbara region when they attempt to satisfy their thirst in such ponds. Predatory birds in particular become	

		entrapped in brine sludge upon landing. • There is no information on the hydraulic conductivity in situ. This could allow some understanding of risk-laden rapid migration of hypersaline groundwater. Bulk density and penetration resistance of the material have not been characterised. Infiltration can be slowed by compaction, the potential to do this should be established. Gilgai expansion and heave of sodic clay subsoils – consideration should be given to its swell-shrink character. • There is a complex of stratigraphic/lithologic units that can act as conduits for plumes of supersaline water. Any limestone in the subsurface will have the potential to accelerate the delivery of this supersaline water. • Mangroves at a solar salt production facility at Port Hedland suffered defoliation and death in the vicinity of levees (Gordon et al., 1995). Following the construction of ponds, the soil water table rose to the surface, water-logging the mangroves and the salinity of already saline soil water increased by 50 per cent. • Large scale mangrove mortalities have been shown to be associated with the formation of concentrator ponds in Port Hedland. The ponds were constructed in the mid 1990s and significant mangrove mortalities (many hectares) were still found to be occurring in 2005, some more than one kilometre from the bund wall. • Evaporation ponds with a relatively high hydraulic head will result in seepage plumes of dense saline water into the underlying sediments, which will discharge seawards, emerging from under the tidal flats. This discharge will fundamentally alter the ecosystem of the tidal flats from a microbial perspective and for macrobiota such as invertebrate fauna and mangroves. • The east coast of Exmouth Gulf will provide the first location in tropical WA where a continuous frontage of mangroves will intersect the hypersaline water discharge from a proposed solar salt ponds. • Sea level rise could damage a section of the mangroves allowing increased storm wave energy to have greater influence on the salt flats. • Sea level rise projections result in a high level of uncertainty with regard to increased risks of leachate and levee failure. • An increase in seepage of up to 25 per cent and a decrease in structural integrity might occur if hypersaline clays are used for construction. • Microbial mats accumulate large amounts of heavy metals which risk being released and discharged to near-shore environments. • Seeped waters would not only contain extremely concentrated salts, they would also contain toxic concentrations of fluoride and heavy metals that could bio-accumulate such as selenium.	

		• Until satisfactory proposals for responsible management of the toxic waste or bitterns are established and discharge options are carefully evaluated, the entire proposal for salt production should be rejected. • Feasibility of 100 per cent resource recovery of the bitterns produced is very unlikely. • It is unlikely that bitterns storage or release into Exmouth Gulf could be managed to achieve acceptable environmental outcomes. • The proposal could alter salinity in the fish and prawn nursery in several ways: - Predicted seepage of brine from numerous points along the seawall; - Extraction of large amounts of high salinity water from the Eastern Gulf and its replacement with lower salinity waters. • Bitterns are known to cause fish kills and have been associated with the deaths of more than 90 turtles in an incident in Baja California. • The area of influence of bitterns if it is discharged to the Gulf is likely to be roughly equivalent to the terrestrial footprint of the project. • Why can't the salt from the Perth desalination plant be harvested as an alternative source of salt to this proposal with all its associated environmental issues? • Based on the information provided, there is insufficient limestone available locally to construct the salt field levee walls and other infrastructure.	
Salt and fuel spills	**Salt spills** Salt spills could occur during transportation by truck, conveyor or barge and during salt transfer both onto barges and onto bulk carriers from barges. The use of roads along external levee walls would be minimised for the transportation of salt. The conveyor would be located within the infrastructure corridor and over constructed levees. The proponent has indicated that barges would be custom designed	<u>Department of Environment and Conservation</u> The setback for storing fuel at Dean's Creek is not considered adequate. Shipping through Marine Protected Areas, including Ningaloo Marine Park, past the Murion Islands and into Exmouth Gulf poses risks of fuel spills. Information presented is considered unsatisfactory. The proponent needs to undertake a risk assessment of oil spills including dispersion modelling of worst case scenario and details of environmental implications. <u>Department of Fisheries</u> There is the potential for salt spill in the main trawling area where tiger prawn spawning occurs. The proponent needs to present management arrangements for salt spillage including an assessment of impacts on marine fauna and flora. <u>Marine Parks and Reserve Authority</u> Fuel requirements of the pumping stations have the potential to pose a	Salt spill is considered a key environmental factor and is discussed in Section 3.4.3 of the report.

	with high side boards to prevent spillage when underway. The barges would have a conveyor system installed to unload directly to bulk carrier ships. **Fuel spills** The proponent estimates that 50 tonnes of diesel would be delivered by boat from Exmouth or Barrow Island each week. The fuel would be unloaded within the excavated and enclosed harbour at Hope Point. Two fuel farms would be constructed; the fuel farm on Main Island would store 220,000 litres of diesel, the fuel farm at Hope Point would store 140,000 litres of diesel. Both stores would be higher than eight metres AHD. A third small fuel store would be constructed at Dean's Creek housing 14,000 litres of diesel. This fuel would be stored in a self-bunded tank. It would be considered temporary until power was connected to the generators on Main Island. The fuel storage facility at Dean's Creek would then be removed.	significant risk to the environment from fuel spillage. <u>Public</u> Many of the issues listed above that were raised by decision making authorities and other government agencies were also identified in private submissions. Additional issues raised in private submissions are listed below. • The proponent needs to present management arrangements for salt spillage including an assessment of impacts on marine fauna and flora, especially as spills could take place in trawling and tiger prawn spawning areas.	
Acid sulphate sediments	Sediment disturbance during dredging and excavation can result in the oxidation of acid sulphate soils (ASS) resulting in acidity and heavy metal contamination. Salt flats sediments would not be disturbed during construction and no dewatering would be undertaken during excavation. However, dredging and excavation for the Hope Point	<u>Department of Environment and Conservation</u> • The proponent should undertake an analysis of risks and consequences of disturbing acid forming materials. • A map should be provided showing acid sulphate soils overlaid with proposed areas of disturbance. • Proponent documents don't include details about how excavated acid sulphate soils would be managed. • If acid sulphate soil material is disturbed, it will discharge iron to the Gulf. This, with sulphate reducing bacteria, generates biochemical precipitates with high concentrations of colloidal iron monosulphate	The potential for acid sulphate soils to impact water quality is considered a key environmental factor and is discussed in Section 3.5 of the report.

	harbour and entrance channel, Dean's Creek pumping station and construction clay from claypan borrow pits on the hinterland have the potential to disturb ASS material. All sediment samples from proposed excavation sites had sulphate concentrations above the WA State and national action criterion, confirming that they are potentially acid forming. The proponent has estimated what they consider to be a worst case scenario of 85,000 cubic metres of ASS material to be disturbed. Disturbed ASS material is proposed to be brought on shore where it would be partially neutralised and capped above the water table.	minerals (MBOs). MBOs can smother benthic communities and will rapidly deoxygenate and release heavy metals if disturbed. • The volume of lime required for management of acid generating material and the source of lime should be provided. • Clay borrow pits at the Onslow salt field looked yellow which is likely to be caused by acidity and high concentrations of sulphur with bioavailable metals. <u>Department of Industry and Resources</u> • In relation to an ASS Management Plan, stockpiled ASS material must be appropriately contained. • Baseline surveys for acid sulphate soils need to be conducted prior to the lodgement of the Mining Proposal to the Department of Industry and Resources rather than just prior to construction. • It is unclear what depth of water cover will be used for a wet cover system to cap acid generating soils, and how this is to be maintained given the high evaporation rate in the area. • Trials are recommended to test the efficiency and whether sufficient material is available to neutralise via mechanical mixing. • Stored ASS material should be lined with a compacted clay liner and crushed lime. <u>Marine Parks and Reserves Authority</u> Disturbance to the soil for site preparation and construction of infrastructure is likely to expose acid sulphate soils which would potentially impact the surrounding marine environment. <u>Public</u> Many of the issues listed above that were raised by decision making authorities and other government agencies were also identified in private submissions. Additional issues raised in private submissions are listed below. • Appropriate and thorough testing has not been conducted in relation to acid sulphate soils. The proponent's assessment and management of acid sulphate soils is inadequate in relation to dredge material disposal infrastructure. • Quantitative and adequately justified estimates of the volumes of acid forming material should be provided. • Acid generating capacity needs to be determined though lab testing not just field testing. • A conservative approach should be adopted regarding the re-use of treated soils for fill in borrow pits or fill for haul roads.	

		• Monitoring should be conducted during the construction phase of the seawater pumps and the barge harbour. • Soil bores need to be installed to provide data on acid sulphate soils before assessment is complete. • The limestone at Hope Point is porous so dewatering will spread into the surrounding area. Pumped water will need to be managed to remove acidity and treat iron and aluminium precipitates. • Acid sulphate soil management commitments should be consistent with national standards. • It is not good practice to deal with issues like acid sulphate soils after EPA assessment. • In anaerobic water beneath salt flats, gypsum provides an oxygen source for the respiration of geobacteria enabling them to use organic matter leaching to that zone. Depositions of suphide minerals, or pyrites, follow as the end product. Many transition metal elements co-deposit. Their disturbance causes problems leading to acidity and the release of metals.	
Greenhouse gas emissions	The main source of greenhouse emissions would be six, one megawatt diesel generators. This, in addition to the use of heavy vehicles and vessels has been estimated would produce 43,500 tonnes of carbon dioxide equivalent emissions per year. The proponent has indicated that renewable sources of energy would be assessed and employed where feasible.	<u>Department of Environment and Conservation</u> The proponent should assess greenhouse gas emissions associate with possible changes to ecology e.g. loss of mangrove communities. <u>Public</u> The greenhouse emissions section should be expanded to show how the proposal meets the objectives of the Western Australian Greenhouse Strategy.	The EPA has not identified greenhouse gas emissions as a key environmental factor.
Liquid and solid waste disposal	The proponent has indicated that waste oils and oil filters, degreasers and detergents, radiator fluid and coolants, brake fluid and brake pads, batteries and tyres would be removed by licensed contractors for recycling. General litter and refuse and non-hazardous construction waste would be collected by a licensed operator and disposed of offsite.	<u>Public</u> The desalination plant will produce not only bitterns but also toxic metals. A small amount of solid waste will be produced as well. Discharge options need careful evaluation. Food and human wastes must not be disposed of in the ocean.	The EPA has identified bitterns management as a key environmental factor which is discussed in Section 3.4.2 of the report. Other forms of liquid and solid waste have not been considered in more detail in the report.

	Treated wastewater and sludge would be disposed via water treatment plants.		
SOCIAL SURROUNDINGS			
Cultural heritage	The project area is subject to two Native Title claims. Four archaeological sites have been identified within the project area. The proponent has undertaken some surveys of the project area with local Aboriginal people. There are no known sites of European heritage value within the project area.	<u>Department of Indigenous Affairs (DIA)</u> The ERMP contains inadequate and incorrect information about Aboriginal heritage matters. The following issues need to be addressed by the proponent: • The DIA has no record of reports done by Archae-Aus in 2005 to verify the statements made within the draft ERMP. • The sites located on Figures 7-6 and 7-7 within the ERMP have not been registered with the DIA. • The removal of artefacts pictured in the photo in Figure 7-8 may be in breach of the *Aboriginal Heritage Act* (AHA). • The proponent needs to provide the methods to be used to protect Aboriginal sites. • The proponent needs to describe procedures to be followed if an Aboriginal archaeological or ethnographic site is impacted. This should cover incident reporting, recording and procedures for permission to use the land upon which the site was located in accordance with Section 18 of the AHA. Operational procedures should also be included to ensure that works cease and the appropriate authorities are notified if human skeletal remains are found. <u>Office of Native Title</u> The site of the proposed development falls within the boundaries of the Thalanyji and the Gnulli native title determination applications. It is likely that if the development is to go ahead, there will be native title implications.	The proponent is required to comply with Section 18 of the *Aboriginal Heritage Act*. The EPA has not identified threats to cultural heritage values as a key factor for this assessment.
Fisheries	The Exmouth prawn fishery has operated for over 40 years. It is Western Australia's second largest prawn fishery with a sustainable catch of between 771 and 1,276 tonnes of prawns per annum with a value of about $15 to 20 million. The fishery targets western king prawns, brown tiger prawns and also endeavour prawns and occasionally banana prawns. The fishery has adopted a number	<u>Department of Fisheries</u> • Pearling is vulnerable to development because it is long term and because it is sensitive to: - Reduction in nutrients associated with surface flow diversions; - Changes to salinity from saline groundwater seepage - Introduced marine species. • Location of ship moorings in the main trawling grounds would permanently reduce the fishing area. • The proponent needs to undertake consultation with fishermen in relation to mooring sites and to demonstrate that alternative sites have been investigated.	The EPA has identified nutrient delivery, the management of brines and bitterns, plus acid sulphate sediments as key issues for the maintenance of water quality. Each of these issues is considered in detail in Sections 3.3, 3.4 and 3.5 of the report respectively. Mangrove communities and creeks provide important habitat for juvenile prawns and commercial fish

	of management regimes to maintain catch levels within sustainable limits. Fishing is restricted seasonally opening in early April and closing in mid to late November. The number of prawn fishing licenses is limited to 17 and there is an extensive prawn nursery area which is closed to trawling. Other commercial fisheries in Exmouth Gulf include: • Blue swimmer crab fishery; • Tropical rock lobster fishery; • Marine aquarium managed fishery; and • Beach seine fishery. Pearling in Exmouth Gulf involves both the capture of wild pearl oysters by diving, and the cultivation of pearl oysters on pearl farms. After collection and seeding, wild pearl oysters are returned to net panels on bottom longlines at holding sites. 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. Pearls are harvested during winter months. There is significant potential for aquaculture in Exmouth Gulf. The sustainability of fisheries, aquaculture and pearling rely on habitat protection including nursery habitats, water quality and the continuing supply of nutrients. The Exmouth Gulf area offers a	• Exmouth Gulf Prawn Fishery is one of the State's most significant from an economic perspective. There are 17 managed fishery licenses and the fishery can sustainably produce between 771 and 1,276 tonnes of prawns per year. • The Exmouth Gulf pearl fishery produces world class South Sea pearls. • Collection of pearl oysters for seeding still occurs despite the trend to increased use of hatchery produced oysters. • High water quality is critical to the health of the pearl oyster. • Communication and consultation with pearl oyster fishers and recreational fishers would be essential if the proponent is to minimise impacts and promote understanding and harmony. • Department of Fisheries would like to see management mechanism such as compensation packages for commercial fishers if the proposed development impacts the fishery. • The proponent should consult with recreational fishers to explain proposal. <u>Public</u> • Post larval prawns become tidally cued. Postlarvae recruit to obligate inshore nursery habitat. Juvenile prawns, shelter and grow in the littoral zone until they emigrate to deeper waters. Nursery habitats of juvenile commercial penaeid prawns mostly do not overlap: - Tiger and endeavour prawns use seagrass; - King prawns use sandy substrates; - Banana prawns use mangroves. • Juvenile prawn habitats in Exmouth Gulf extend from intertidal saltflats, mangrove communities, through seagrass and shallow-substrate habitats down to a depth of about 5-8 meters offshore. • High fisheries productivity is related to the hyper-saline nature of the Gulf's eastern shoreline. High salinities are also thought to enhance survival of juvenile prawns by limiting potential predators. • Juvenile pearl oysters freedom to transfer only while disease free and no exotic pests. – risk of introductions of pest and disease too high • The aquaculture industry is at risk from NIMs in particular the Green mussel and black stripe mussel. The presence of NIMs would trigger the pearl oyster Translocation Protocol with significant operational and financial implications for the pearling industry. • Barge/tug and shipping movements are over areas of the trawl fisheries –	species. The protection of mangrove communities in relation to relative sea level has been identified as a key environmental factor which is considered in Section 3.2 of the report.

	wide range of recreational fishing experiences and is one of the main draw cards for tourism in the Exmouth area.	ship movements and anchoring areas are focussed in locations where prawns aggregate and fishing is most intense. • Dredging for harbour could alter local drainage patterns, current directions and water circulation. • Sceptical about the proposed mitigation measure of allowing fishing access to pond zero. Other salt operators used to allow access but stopped it because of health and safety requirements. • The east side of Exmouth Gulf has been identified as a potential wilderness fishing area to preserve that unique experience • The Yannarie mangrove system is a vital nursery area for many forms of marine life including finfish and crustaceans. The wide variety of recreational fishing opportunities in Gulf; from nearshore to reefs, mangrove creeks and deep water etc. all depend to some extent on juvenile recruitment from the Eastern side of the Gulf.	
Decommissioning	The Yannarie Solar proposal is described as having a life of at least 60 years. The Preliminary Closure Plan for the Yannarie proposal outlines a series of options for decommissioning the salt farm. These include the complete removal of levee wall material from the salt flats to simply breaching the levee walls or using some of the ponds for alternative purposes such as aquaculture.	<u>Department of Environment and Conservation</u> It is important that the costs associated with decommissioning and restoration be provided by the proponent and taken account of in the decision-making process. <u>Department of Industry and Resources</u> If roads are to be handed over to the local pastoralist, this would need to be ratified by the Pastoral Lands Board. The third broad site closure objective needs to be expanded to include environmental objectives. This should include that the area will be stabilised with resilient, perennial, self-supporting vegetation comprising local provenance species where appropriate. <u>Private</u> The proponent needs to commit to returning the area to the same condition as it was prior to development, particularly with respect to ground water regimes and quality. This project is vulnerable to economic and / or environmental failure at any time. The cost of appropriate remediation is very high and it is hard to imagine a bond large enough to properly remediate this footprint	Decommissioning has not been identified as a key environmental factor for detailed assessment within the body of the report.

Appendix 4

Summary of Submissions and
Proponent's Response to Submissions